SECTION 1.6

Enclosed in its entirety are the company's Isotope Shop Procedures. These procedures represent Advanced Medical Systems' Radiation Safety Program. These procedures have been reviewed and rewritten to comply with current 10CFR regulations. The Isotope Shop Procedures have been numbered to be consecutive. Included in the ISP Manual is a cross reference to the prior ISP numbering system.

ADVANCED MEDICAL SYSTEMS, INC.

ISP MANUAL

LONDON ROAD ISOTOPE FACILITY SAFETY AND PROCEDURES MANUAL

ISSUE DATE January, 1995

FOREWARD

IT IS THE INTENT OF THIS MANUAL TO PROVIDE ALL ADVANCED MEDICAL SYSTEM, INC. EMPLOYEES AND CONTRACTORS WITH THE INSTRUCTIONS AND OPERATIONAL PROCEDURES NECESSARY TO INSURE THAT RADIATION EXPOSURE IS KEPT AS LOW AS REASONABLY ACHIEVABLE (ALARA).

EVERY PERSON WORKING IN THE ISOTOPE FACILITY AT LONDON ROAD SHALL BE FAMILIAR WITH, AND ADHERE TO, THE INSTRUCTIONS AND PROCEDURES HEREIN.

REVISIONS AND ADDITIONS WILL BE MADE AS REQUIRED AND ALL PERSONNEL WILL RECEIVE NOTIFICATION OF THE CHANGES.

THIS MANUAL IS NOT INTENDED TO REPLACE THE NUCLEAR REGULATORY COMMISSION REGULATIONS AS PUBLISHED IN 10CFR AND SHOULD BE READ IN CONJUNCTION WITH 10CFR.

THIS MANUAL SUPERSEDES ALL PREVIOUS EDITIONS.

Robert Meredith — APPROVAL

1-95 — EFFECTIVE DATE

TABLE OF CONTENTS

CHAPTER 1 - DESCRIPTION OF THE ISOTOPE FACILITY

This chapter describes the physical aspects of the isotope facility, its construction, safety features and evaluation of shielding. It also presents floor plans of the facility as an aid in identifying specific areas that are referenced in later chapters of this manual.

INTRODUCTION

The design of the facilities follows the philosophy of containment of activity within small working areas. Health and safety considerations have been based on minimum hazard in Restricted Areas and zero hazard in Controlled and Unrestricted Areas, with confinement of emergency situations to the Isotope Shop Area (ISA).

The Isotope Facility is situated on 6.3 acres of land which lies on the boundary between industrial and residential areas. Because of the proximity to these areas, special care has been exercised in planning the safety program. The Isotope Shop Area is located in the south end of the building on the first floor. There are no windows in the ISA because windows were felt to be of questionable value for the following reasons:

1) Safety considerations and protection against unauthorized entry into the ISA.
2) The maintenance of proper air flow balance.
3) Uniform lighting is difficult to maintain.
4) The special procedures required for cleaning windows inside Restricted Areas and the possible radiation hazards of cleaning windows on the outside.
5) The noise transmission of windows from the adjacent railroad tracks.

The one story projection of the southwest corner of the building contains the stairwell to the basement and the Source Storage Garden. The door located in this stairwell is for emergency exit use only. It will set off an alarm upon opening.

Starting on page 16 are floor plans of the London Road Isotope Facility. The first floor of the facility contains the Isotope and Shielded Work Areas. The Restricted Areas are enclosed by the heavy dashed line. The location of the heavy shielding for the Shielded Work Room and the Cell provides an unbroken radiation barrier between the Isotope Areas and the high occupancy areas of the rest of the building.

The activity centers of the facility are the Hot Cell, the Shielded Storage Room, the Isotope Shop Area, Isotope Shop Warehouse, the Isotope Storage and Irradiation Facility (Garden) and the offices.

The areas in which radioisotopes are handled are accessed through a changing area located in the southeast corner of the building.

THE SHIELDED WORK ROOM

The Shielded Work Room has a minimum of three (3) feet of concrete shielding and a labyrinth entrance. The broad corridor through the labyrinth permits large objects to be moved into and out of the room.

This room may be used for development, manufacture and testing of equipment or storage of radioactive material.

HOT CELL

The Hot Cell was designed and equipped to encapsulate the largest sources used for medical therapy and industrial radiography. Advanced Medical Systems no longer encapsulates Cobalt into sources. With the exception of the shielding walls, virtually every item in the cell structure is removable to permit changes which the future may require.

The Hot Cell is six (6) feet square inside, five and a half (5 1/2) foot concrete walls and four (4) foot floor and ceiling. The floor pan is stainless steel and the inside walls are one quarter (1/4) inch steel plate up to a height of eleven (11) feet. The cell is closed at the rear by a forty two (42) ton hinged door which provides a full six (6) foot wide entrance to the cell when open. Two small access ports are available for insertion and withdrawal of items less than three (3) inches in diameter. These access ports are located between the Isotope Shop Area and the Hot Cell. Observation of cell operations is possible through a sixty (60) inch glass and zinc bromide window. Remote handling is accomplished with a pair of Model 8 Manipulators and a two (2) ton overhead crane.

All cell operating controls are located on the cell face so that normal operation does not require entry into the Contaminated Isotope Areas. The Isotope Areas may be observed from the Cell Control Area by a window through the southeast corner of the cell in line with mirrors placed against the south wall. The Isotope Areas are connected to the Cell Control Area by an intercom system.

The viewing window for the cell is removable from outside the cell. The viewing components consist of an eight (8) inch inside coverplate of non-browning glass, a two (2) inch plate glass, forty eight (48) inches of zinc bromide solution and a two (2) inch outside coverplate of laminated safety glass. This construction provides shielding equivalent to sixty six (66) inches of one hundred fifty (150) lb/ft^3 concrete with only two (2) glass/zinc

bromide interfaces. The entire metal structure in contact with the zinc bromide solution is coated to prevent introduction of impurities which might cloud the zinc bromide solution. The window was designed and constructed in 1984 by Hot Cell Services Corporation, Kent, Washington.

To reduce the potential of an electrostatic discharge of the Cell window, a grounding strap has been placed on the Hot Cell window at electrical ground. Therefore, any electrostatic charge on the window and frame will be shunted to ground.

The Model 8 Master Slave Manipulators are mounted above the window using the roller tube mounts. The roller tubes are positioned on twenty eight (28) inch centers in concrete within a twenty four (24) by fifty eight (58) inch steel-lined opening in the cell wall. This method of mounting in an oversized opening will permit installation of new types of manipulators as they become available or relocation of the present manipulators to a different centerline, if required by future operating conditions.

The cell door is located at the rear of the Hot Cell and opens into the Decontamination Room. The door is an internally braced steel tank filled with concrete. The upper and lower stub shafts are mounted on bearings which permit the door to rotate about a vertical line through one end without touching the floor or ceiling at any point. This construction permits a smooth unbroken level floor into the cell over which heavy shipping containers can be easily moved. The forty (40) ton door is removable in case of bearing failure, but due to the low rotational speed and infrequent operation, a long service life is anticipated. The turntable upon which the door rides contains a heavy duty bearing mounted on a hemispherical balljoint to permit alignment of the lower bearing with the upper bearing. The upper hinge has the bearing mounted in a block which can be moved by means of wedges and power screws to obtain the necessary alignment for a true axis of rotation. The stub shaft connecting the upper hinge to the door is removable through a nine (9) foot vertical tube to the second floor. The upper bearing is a sealed unit and should require no lubrication. The lower bearing, at floor level, may become dirty or contaminated even though a neoprene wiper rides the edge of the turntable. The lower bearing may be lubricated, or flushed and lubricated if dirty or contaminated, by means of a tube which runs beneath the floor to the service trench on the south side of the cell. The door is opened and closed electrically by means of a motor mechanism mounted on the outside of the door. An electrical interlock prevents the electric door drive from being actuated until the switch at the cell face and the drive motor switch are simultaneously operated. Release of either button stops the door from opening. This safety feature makes it impossible for the cell door to be opened without the knowledge and consent of the Cell Operator or for the cell to be opened by a person working alone.

The two (2) ton overhead crane inside the Hot Cell is electrically powered and controlled. In order to cover the six (6) foot square floor area of the cell with a minimum of travel, an electrically powered trolley was mounted on an I-beam rail which can be rotated 180^0 degrees. The crane assembly is mounted in a removable plug in the cell ceiling.

Storage facilities for isotopes within the cell are provided by two (2) containers inserted in steel sleeves in the floor.

Two (2) prefilters for the Hot Cell are mounted just above the viewing window.

As mentioned previously, the Hot Cell is shielded by five and a half (5-1/2) feet of concrete with one quarter (1/4) inch steel plate on the inside faces. The shielding thickness was chosen as sufficient to handle the largest sources currently available with complete safety and to provide adequate shielding for the larger sources the future may require. Calculations indicate that the shielding is adequate for 1.5 million Curies of Cobalt-60.

HOT CELL SUPPORTING FACILITIES

The facilities supporting the operation of the Hot Cell are primarily concerned with the safety considerations necessary when this type of facility is located in a populated area. Every effort has been made to eliminate possible exposure of the public to radiation or radioactive material.

The air handling system has received special attention due to the location of a residential area within a block of the facility. The facility has separate air conditioning systems for the isotope areas, first floor office control area, second floor office area, and the lobby and reception area. The Isotope Shop Area and Hot Cell have a once-through airflow system with carefully balanced flow gradient to the Hot Cell as the low pressure point of the system. The supply air to the isotope areas is filtered through prefilters before entering the building. The heavy burden of industrial air wastes, from neighboring plants and the railroad tracks, is removed at the point where filter changing is accomplished with the least difficulty. The supply air is distributed to the isotope areas by ventilation ducts containing manually adjustable dampers. The airflow pattern is adjusted initially by balancing the supply and exhaust systems to obtain the desired flow pattern and periodic checks of manometers are made to assure the desired pattern is maintained. The doors at either end of the change area are electrically interlocked to prevent simultaneous opening which might disturb the airflow pattern. The

doors at either end of the air lock, which are used to move shipping containers in and out of the isotope areas, are similarly interlocked. The exhaust system has two (2) centrifugal blowers which are located on the second floor directly above the Hot Cell. Both blowers exhaust through separate filters and a common high-velocity stack. The larger blower removes air from all isotope areas, except the Hot Cell, and requires a 2 x 2 array of absolute filters. The exhaust fan for the Hot Cell is independently operated and has a high temperature prefilter and a single absolute filter. The balanced air flow pattern is from the change areas through the Isotope Shop Area to the Decontamination Room and finally to the Hot Cell. The Hot Cell exhaust fan is driven by a two (2) speed motor which is controlled by the position of the double doors connecting the Decontamination Room with the Isotope Shop Area. With the doors closed the fan operates at low speed and the Decontamination Room receives its air supply through a duct at the south side of the doorway. When the door is opened the supply air is diverted from inside to outside the Decontamination Room by means of a switch which also increases the Hot Cell exhaust fan capacity by about 100%. This prevents reverse flow of the potentially contaminated air of the Decontamination Room into the lower level Isotope Shop Area.

The air handling system is under continuous control by a monitoring and safety system. The air sampling tube is mounted across a diameter of the air exhaust stack about eight (8) feet above roof level. An air monitor located in the Clean Equipment Room with monitoring instrumentation located in the Hot Cell Control Area draws a continuous sample of four (4) to five (5) cubic feet per minute (cfm) for analysis. Any increase of activity above the preset level immediately stops the exhaust fans and the supply fan. The control system also includes automatic shutdown of either exhaust fan if a sudden pressure drop occurs across its absolute filters, indicating a rupture to the filter media.

The Decontamination Room provides space for opening the cell door without disturbing the air flow through the cell.

The original design of the facility had all drains on the first floor of the Restricted Area, with the exception of the toilet drains, connected to stainless steel holding tanks located in the Shielded Waste Room in the basement of the facility. Circa 1986, these drains were modified to route water to a plastic holding tank in the front basement. This plastic holding tank does not drain and holds water for evaporation.

The original floor drains in the basement were connected to the municipal sanitary system. These drains are sealed with concrete.

The Shielded Waste Hold-Up Tank Room which is not used is curbed twenty four (24) inches high to prevent waste water from running into the sanitary sewer in the event of a leak in one of the holding tanks. The holding tanks had a total capacity of six hundred (600) gallons and the curbed floor area, which has no drain, has a capacity of approximately twenty four hundred (2,400) gallons. Circa 1988, this room was sealed with all services to and from the room disconnected.

The operation of the air handling equipment, the monitoring facilities and the liquid waste facilities is insured in the event of electrical power failure by a natural gas burning emergency generator with automatic rapid changeover. An emergency lighting system is also powered by this generator.

All safety and monitoring devices are connected to an alarm panel in the Cell Control Area. Separate lights for each controlled item are always lit on the panel so that faulty operation of the panel itself is indicated by no light. When a controlled item malfunctions, the alarm light increases in intensity and flashes on and off until an acknowledgement button is depressed. An audible alarm also sounds on the first and second floors until acknowledged. This type of alarm will therefore indicate the difficulty even though it has corrected itself before the operator has checked the panel and the alarm signal will be erased only when the acknowledgement button has been depressed.

Alarms for fan shutdown, excessive heat or cold are also transmitted to a local alarm monitoring company so that malfunctions during non-working hours are reported to a responsible person.

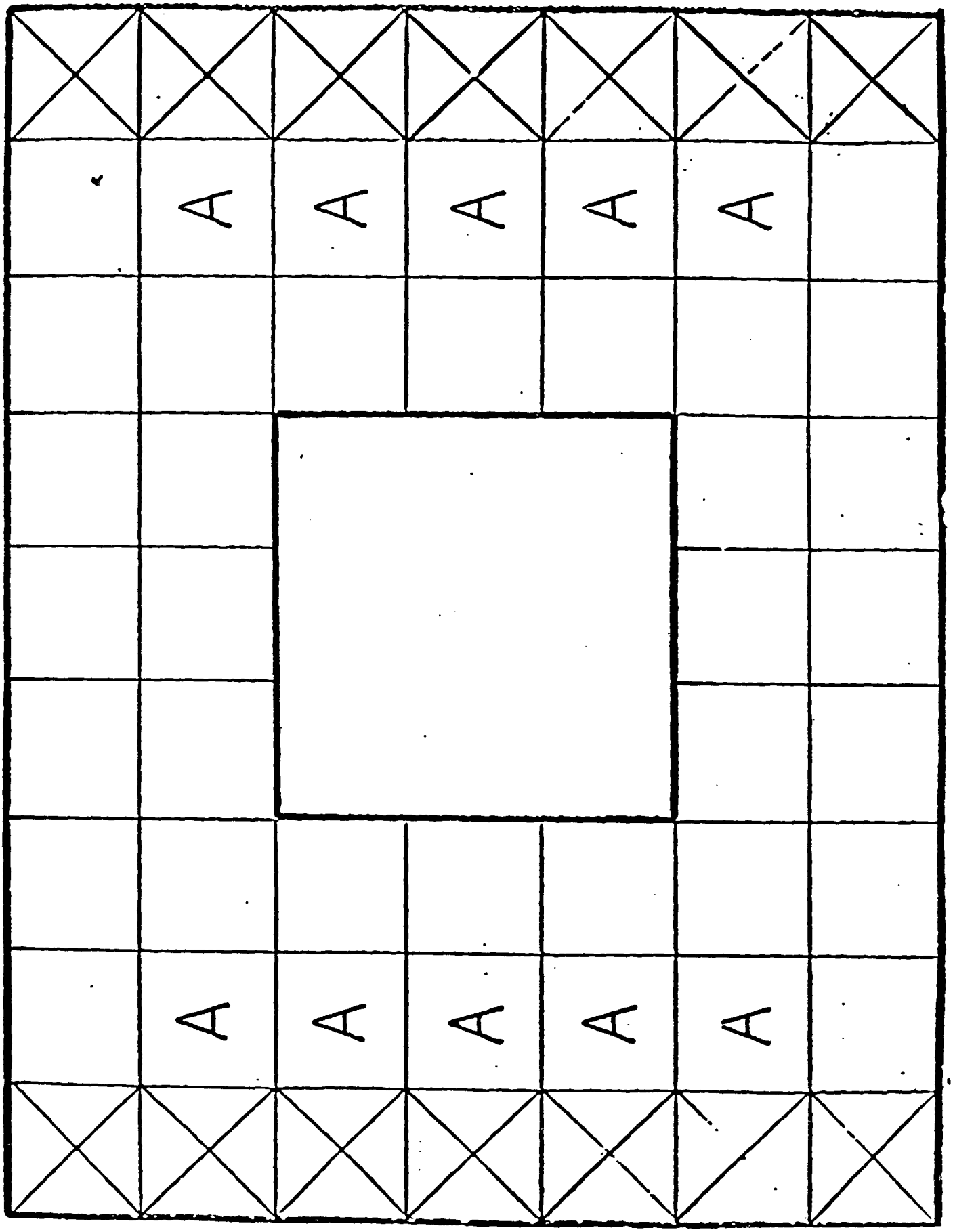
STORAGE GARDEN AND IRRADIATION FACILITY

The facility is located in the southwest corner of the building and contains vertical storage tubes in a six (6) foot square well extending from the first floor level to the basement floor level. An L-shaped shield around the well is provided by two (2) sand filled shield rooms that are accessible through manholes in the first floor. Coarse concrete sand with a bulk density of one hundred twenty seven (127) lb/ft^3 was used as the shielding material for a number of reasons. Immediate shielding requirements are easily handled by the use of sand, which can be replaced easily by a higher density material in the future, if desired. The rooms have been waterproofed and a well drilling point extends to the basement floor level beneath each manhole cover so that temporary additional shielding may be obtained by flooding the voids of the sand with water. Flooding increases the shield density by seven (7) lb/ft^3. If storage needs ever require it, the rooms can be emptied and filled with concrete, steel shot or other higher density material.

The Storage Garden is constructed with fifty four (54) vertical storage tubes in a rectangular array. The tubes are arranged in a 7 x 9 array with the center nine (9) spaces left open (see next page). The center space is fitted with an irradiation plug which can be used to irradiate objects up to eight and one half (8 1/2) inches square by twelve (12) inches high. Each of the tubes marked "A" can also be used for irradiation by placing sources in the four (4) tubes around each which have a common side. The two (2) outer rows of seven (7) tubes, marked by crosses, extend about two (2) feet below the bottom of the tubes in the central 7 x 7 array. This permitted installation of an irradiation facility beneath the garden with two (2) parallel rows of sources between which objects up to a seventeen (17) inch cube can be irradiated.

The source storage tubes terminate in a metal container through which cooling air is drawn from the room through the garden to the absolute filter exhaust system.

SOURCE STORAGE GARDEN ARRAY



PRELIMINARY EVALUATION OF CELL SHIELDING

On November 13, 1959, a shipping container containing 17,557 Curies in two (2) bulk capsules and 4550 Curies in three (3) therapy capsules (total 22,107 Curies) was opened inside the cell and the capsules placed on the cell table. A radiation survey of the areas around the cell was performed by a Victoreen Model 592 portable survey meter.

For the most part, there was no measurable increase in radiation levels with the exceptions noted below:

1) Cell Control Area (east wall of cell) - no measurable increase above background.

2) Shielded Work Room Corridor (north wall of cell) - no measurable increase above background.

3) Isotope Shop Area (south wall of cell) - no measurable increase above background.

4) Decontamination Room (west wall or door of cell) - primary leakage at surface of the door midway up on the door was negligible. Scatter leakage through the 1/8 to 1/4 inch clearance between the floor and the door was a maximum of 40mR/hr. Maximum leakage through a two (2) inch opening at top of cell door was 600mR/hr.

5) Cell Machinery Room (above cell) - maximum leakage of 5mR/hr at hoist support plug in the floor of the room.

6) Waste Storage Room (beneath cell) - no measurable increase.

To evaluate the adequacy of shielding in the floor storage plugs, the two (2) bulk capsules (17,557 Curies) were placed in the front plug and two (2) therapy sources (3,710 Curies) were placed in the rear plug. Measurements were made inside the cell and in the Waste Room below the cell.

1) Inside Cell - maximum leakage was 300mR/hr at the crack between the plug and floor. At floor level in the center of the port plug leakage was 22mR/hr. At waist height over the cell area maximum was 35mR/hr, minimum was 8mR/hr.

2) Waste Room - maximum leakage was 300mR/hr at the ceiling directly beneath the front plug. At head height maximum was 100mR/hr. At waist height maximum was 35mR/hr, minimum was 2mR/hr.

It should be pointed out that these high readings occur only in Restricted Areas that are not entered when the cell is in operation except for emergencies. These areas are the Decontamination Room, Cell Machinery Room and the Waste Storage Room.

PRESSURE GRADIENT BETWEEN CELL AND CONTROL AREA

The air handling system for the Isotope Shop Area has been carefully balanced to maintain the Cell at negative pressure relative to all other rooms in the building. The remainder of the Isotope Restricted Areas are at negative pressure relative to the Cell Control Area, but slightly above the pressure inside the Cell. These pressure gradients are maintained by supplying less air to the Isotope Shop Area than is removed by the exhaust system (slight negative pressure) and by supplying more air to the Cell Control Area than is removed by its exhaust system (slight positive pressure).

The pressure gradient between the Cell and Cell Control Area is indicated by the inclined tube manometer located directly over the cell window. Normal operation of the system provides a pressure differential of 0.2 to 0.4 inches of water absolute, the exact value depending upon whether fans are on high or low speed, cell door is open or closed, etc.

Experimentation has shown that the Cell pressure remains negative under virtually all abnormal operating conditions, even when all exhaust fans in the Isotope Shop Area are off. (The Cell Control Area is still pressurized by the independent system supplying this area).

In the event of fire or explosion inside the Cell, or in the other areas of the Isotope Shop Area, there may be a brief reversal of pressure gradient. This should cause little or no problem in the Cell Control Area, however, since virtually all of the normal air leakage into the Cell is through the transfer duct over the cell door and the air spaces around the cell door, any rapid pressure rise inside the Cell might be expected to relieve itself along these paths of least resistance.

Any resultant contamination problems would then be confined to Restricted Areas. Since the fans are well shielded from these areas by solid concrete, up to four (4) feet thick, and since the ductwork from the Cell to the fan runs a tortuous path through solid concrete, the exhaust ductwork should remain intact and the exhaust system continue operating.

EVALUATION OF CELL FILTERS IN FIRE OR EXPLOSIONS INSIDE THE CELL

The filters handling the exhaust from the Isotope Shop Area and Hot Cell are Cambridge Absolute Filters Type 1F-1000-2 (or equivalent) that are of fire-proof construction and rated for 800^{0}F continuous service and should remain in-service even during a fire.

In the event of fire or explosion damage inside the Hot Cell, the following events will occur automatically:

A. An in-line smoke/heat detector located in the exhaust trunk from the Hot Cell would secure the Hot Cell and the Isotope Shop exhaust fans and the Isotope Shop supply fan. The associated low leakage spring shut automatic dampers will shut. All forced and induced air flow within the Hot Cell and Isotope Shop Area will cease.

The filters are rigidly mounted in angle frames and most probably the filter media would be ruptured before the filters yield in their frames.

SAFETY FEATURES

I. Master Alarm System

Six (6) safety and monitor devices are connected to the Master Alarm Panel in the Cell Control Area and to the Remote Alarm Panel in the Isotope Shop Area. The separate red lights for each controlled item are always dimly lit on the panel so that faulty operation of the panel itself is indicated by no light. When a controlled item malfunctions, the alarm light is increased in intensity and flashes on and off. In addition, a loud buzzer sounds on and off in synchronism with the flashing lights. This will continue until the acknowledgement button is depressed causing the buzzer to stop and the flashing light corresponding to the malfunctioning item to change to a steady bright red. The alarm can be erased only by correcting the difficulty after depressing the acknowledgement button. In addition, two (2) other warning lights show on the Master Alarm Panel; one for the Equipment Room door and for the Cell Machinery Room door on the second floor, and the other for the basement door in the Isotope Shop Area. These will indicate steady bright red lights when the doors have been opened and indicate to the Hot Cell Operator that personnel are in this area. Evaluation tests indicated that no unusual hazards exist in these areas under normal Cell operating procedure, but the precautions should be taken nevertheless.

On five (5) of the six (6) major systems, any alarm is transmitted to the local alarm monitoring company so that malfunctions during non-working hours are reported to a responsible person. The emergency generator will not trip the other five (5) alarms if it restores power before the fans stop.

The following are the six safety and monitoring systems and the conditions which will cause the alarm:

A. Cell Exhaust Fan

1. Shut down from lack of power or switch turned off.
2. Sudden pressure drop across air filter indicating a ruptured filter.
3. Improper pressure across filter indicating broken belts, fan inoperative, plugged filter or in-line manual damper is shut.
4. Excessive radiation on the air monitor.

B. Isotope Shop Area Exhaust Fan

1. Shut down from lack of power or switch turned off.
2. Sudden pressure drop across air filters indicating a ruptured filter.
3. Improper pressure across filter indicating broken belts, fan inoperative, plugged filter or in-line manual damper is shut.
4. Excessive radiation on the air monitor.

C. Air Monitor

Excessive airborne particulate levels above setpoint as indicated on the effluent air monitor system or electronic malfunction of monitoring equipment.

D. Cell Temperature

Two (2) thermostats, one located in the Cell Control Area and the other located in the Decontamination Room immediately behind the Cell, are set to give an alarm signal for temperatures below 40^0F or above 85^0F.

E. Supply Fan Freeze Up

A thermostat in the intake system after the heaters will give an alarm signal for temperatures below 50^0F.

F. Emergency Generator

Signal given on power failure when generator starts.

II. Hot Cell Systems

A. Door Interlock

An electrical interlock secures the door in the closed position until two (2) switches, one on the outside of the door and one on the cell face in the Cell Control Area, are depressed simultaneously. This safety feature makes it impossible for the Cell door to be opened without the knowledge and consent of the Cell Operator or for the door to be opened by a person working alone.

B. Cell Probe

A high energy probe, Victoreen Model 550 Series (or equivalent) is used within the Cell to locate loose Cobalt-60 pellets and other high radiation levels. It is connected to a Victoreen Model 510 Rate meter (or equivalent) located on the Cell face in the Cell Control Area. The rate meter is auto-ranging up to 2000R/min.

C. Gamma Alarm

A Technical Operations Gamma Alarm Model 492C (or equivalent) is mounted opposite the Cell face in the Cell Control Area. Since it is connected to a loud buzzer, it gives both an audible and a visual alarm (flashing red light) continuously when radiation levels are in excess of the preset level of approximately 2mR/hr. The gamma alarm features fail safe circuitry to provide a signal at all times. Failure of any element either turns on the red lamp or turns off the green (safe) lamp, signalling improper operation.

III. Decontamination Room

A. The Hot Cell Exhaust fan is driven by a two speed motor which is controlled by the position of the double doors connecting the Decontamination Room with the Isotope Shop Area. With the doors closed the fan operates at low speed which is indicated by a red light on the locked switch control at the Cell face. With the doors opened the fan speed is increased for about 100% greater capacity. This prevents reverse flow of potentially contaminated air of the Decontamination Room into the Isotope Shop Area. High speed mode is indicated by a yellow light on the locked switch control at the Cell face.

IV. Isotope Shop Area

A. Gamma Alarm

A Technical Operations Gamma Alarm, Model 492D (or equivalent) is mounted on the west wall between the Storage Garden and the Decontamination Room adjacent to the source transfer operation. This will give a visible flashing red light when radiation exceeds the preset level of 5mR/hr.

B. Basement Door

When the basement door is opened, a steady red light turns on above the door. Also, a steady red light shows on the Master Alarm Panel.

C. Air Locks

1. The doors at either end of the Change Area are electrically interlocked to prevent simultaneous opening which might disturb the air flow pattern. The entrance to the Change Area from the Cell Control Area is an air lock by itself. The first door is interlocked with the door on the opposite side of the Change Area leading into the Isotope Shop Area.

2. The air lock on the west side of the Isotope Shop Area has three (3) electrically interlocked doors. One set of doors leads to the Isotope Shop Area; one set leads to the Isotope Warehouse, and the last set on the north side of the air lock leads to the Restricted Area. When the Isotope Shop Area doors are open, the other two doors cannot be opened. When one of the other two doors is open, the Isotope Shop Area doors cannot be opened.

V. Equipment Room

A. This room is directly above the Shielded Work Room. This room contains the heating and intake air fan as well as the air conditioners. The floor is shielded with two (2) feet of concrete. A Technical Operations Gamma Alarm, Model 492B (or equivalent) set at approximately 2mR/hr is mounted in the center of the room. It remotely indicates a signal above the entrance to the room. No one is permitted to enter this room without permission of the Radiation Safety Officer (RSO) or designee. In addition, when the door is opened, a steady red light shows on the Master Alarm Panel.

CAUTION: Personnel are not permitted in this room when there is no signal white light or when there is a red light.

VI. Doors

A. Only authorized personnel have access to keys to any Restricted Areas. Doors to Restricted Areas are kept locked at all times. This includes the following:

1. Air lock from Cell Control Area to Change Area.

2. Doors from the Shop Area to the air lock.

3. Doors from the Warehouse to the above air lock.

4. Doors from the air lock to Isotope Shop Area.

5. Doors from the Warehouse to the Shop Area on the northeast side of the Warehouse.

6. Equipment Room on second floor.

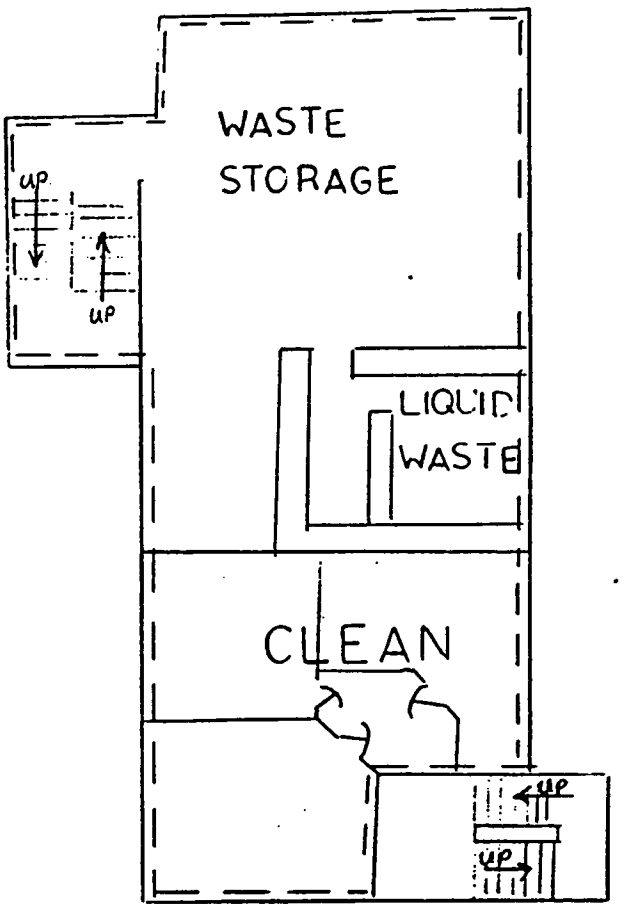
7. Cell Machinery Room on second floor.

8. Room adjacent to Cell Machinery Room.

9. Basement door opening to clean side of basement.

10. In addition to above, the perimeter of the entire facility is tied in with a local alarm monitoring company.

BASEMENT RESTRICTED AREA

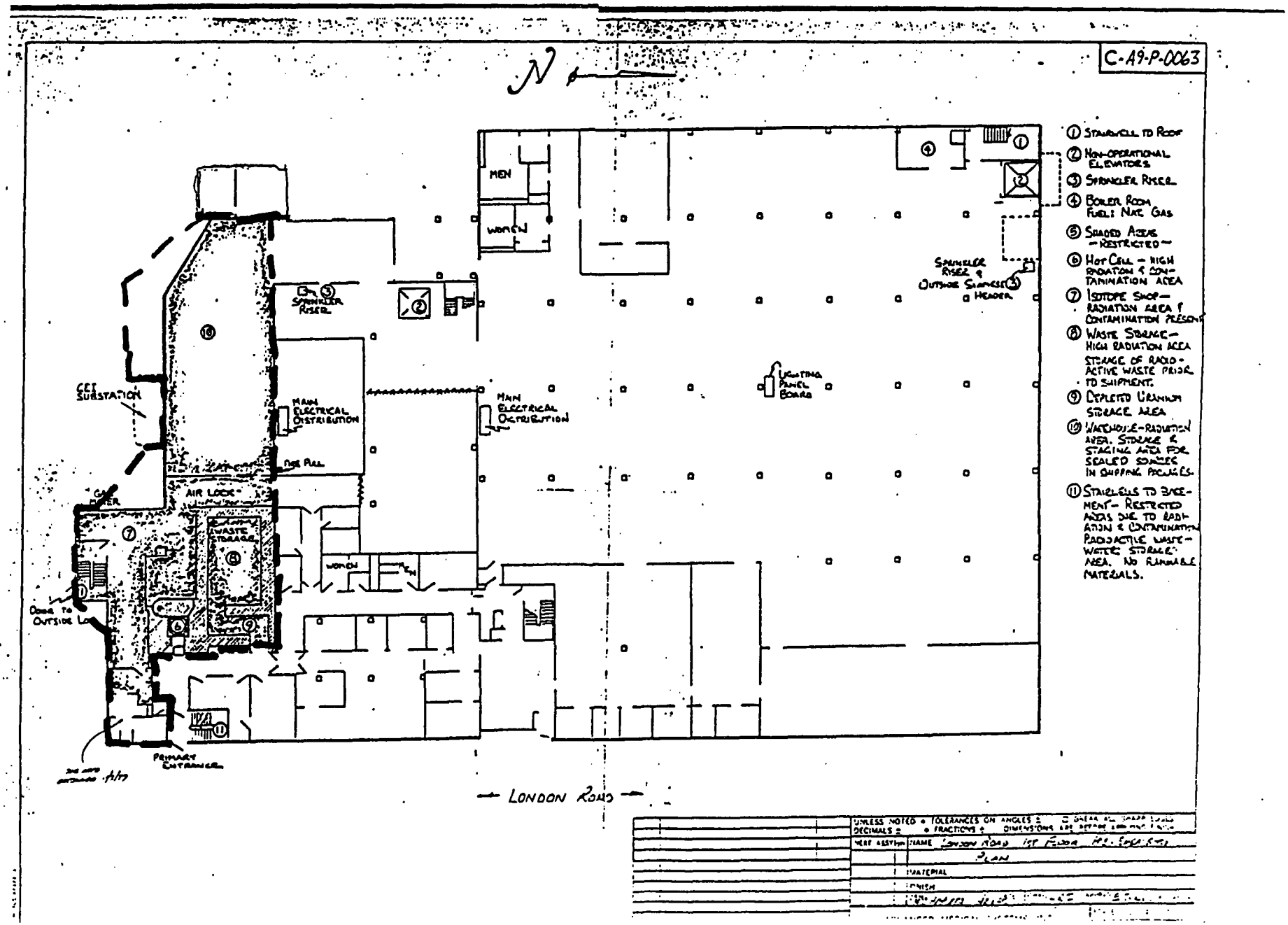


---INDICATES RESTRICTED AREA
CONTROLLED ACCESS

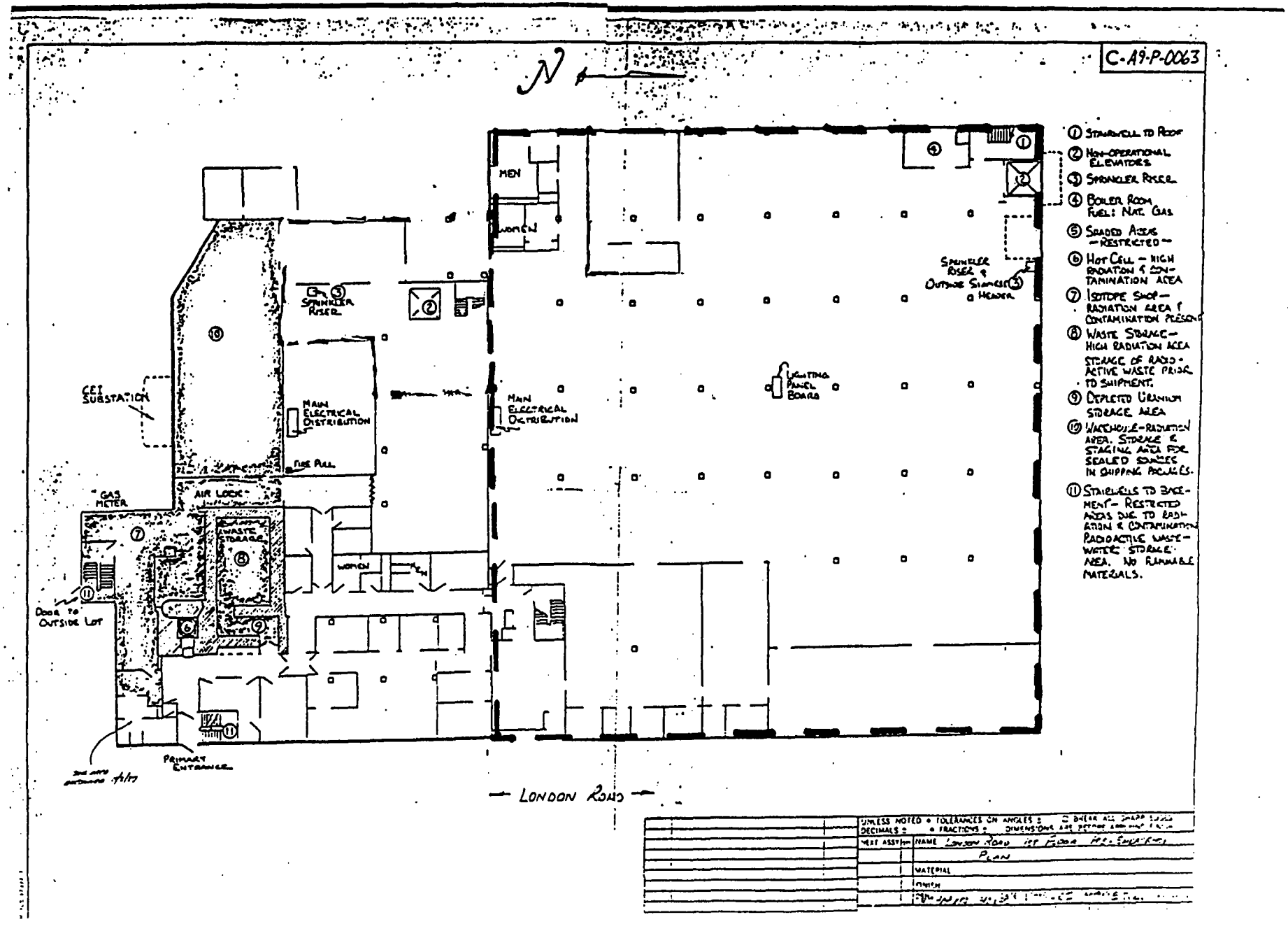
BASEMENT

SCALE 1/16"

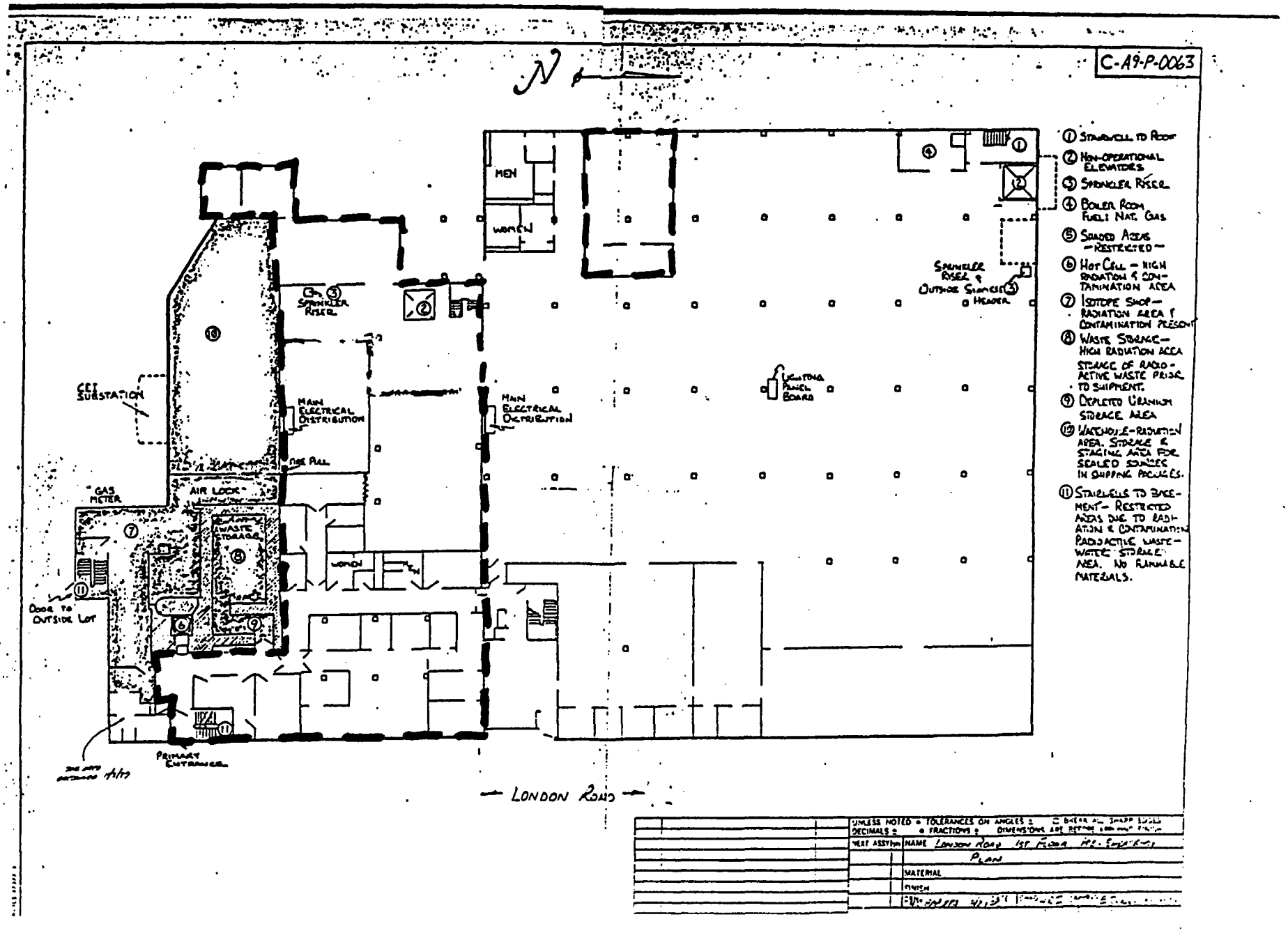
FIRST FLOOR RESTRICTED AREA



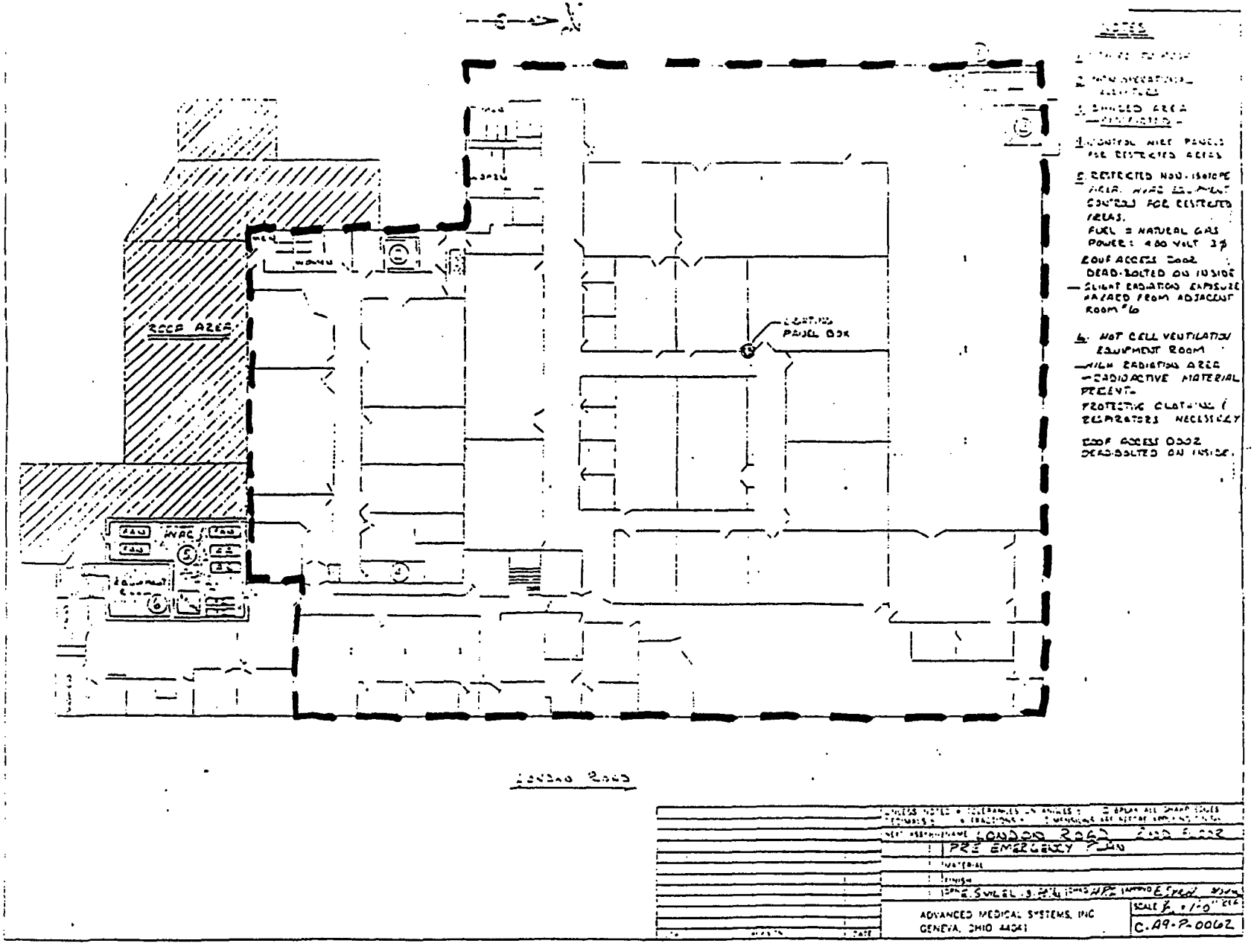
FIRST FLOOR UNRESTRICTED AREA



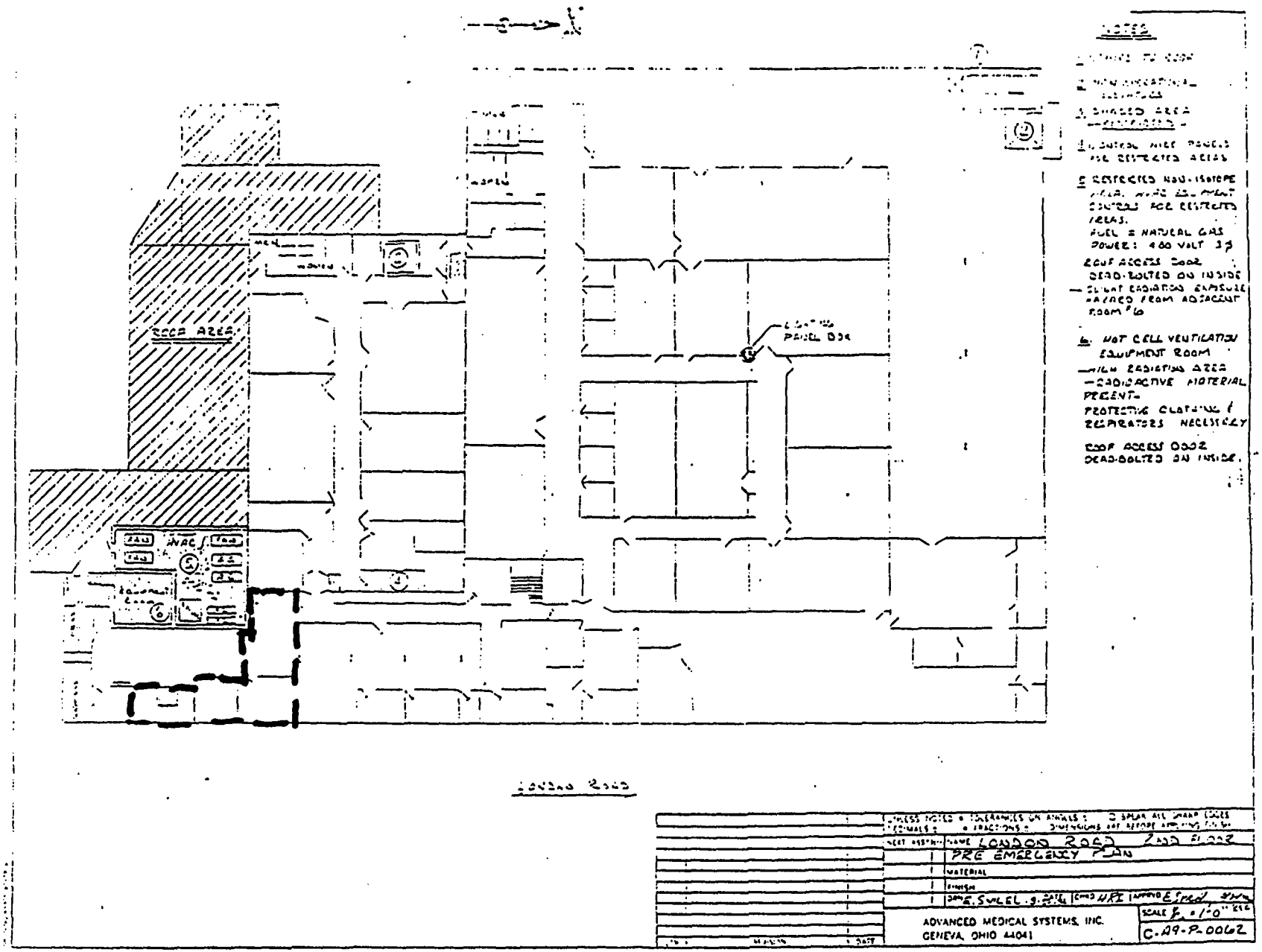
FIRST FLOOR CONTROLLED AREAS



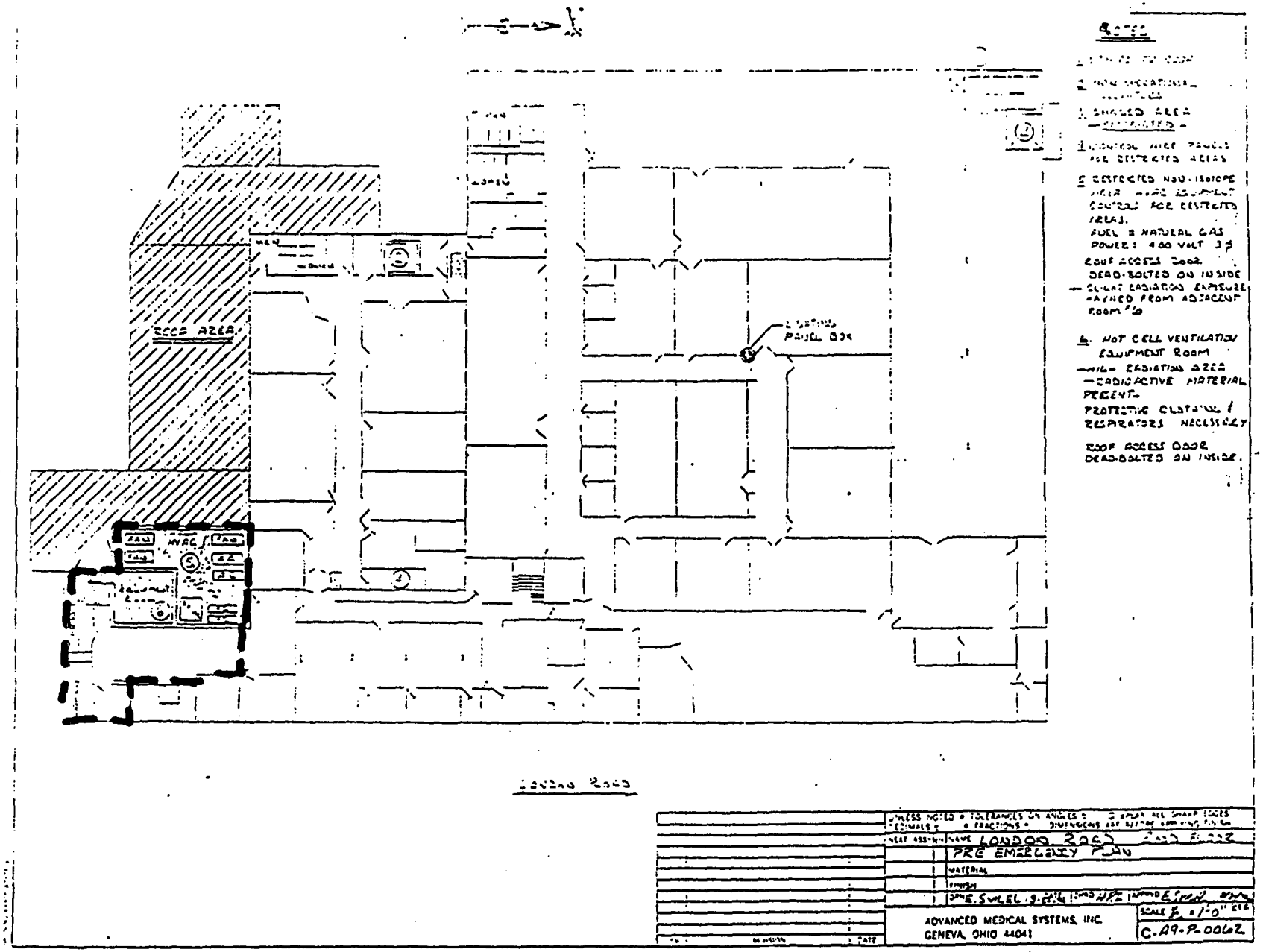
SECOND FLOOR UNRESTRICTED AREA



SECOND FLOOR CONTROLLED AREA



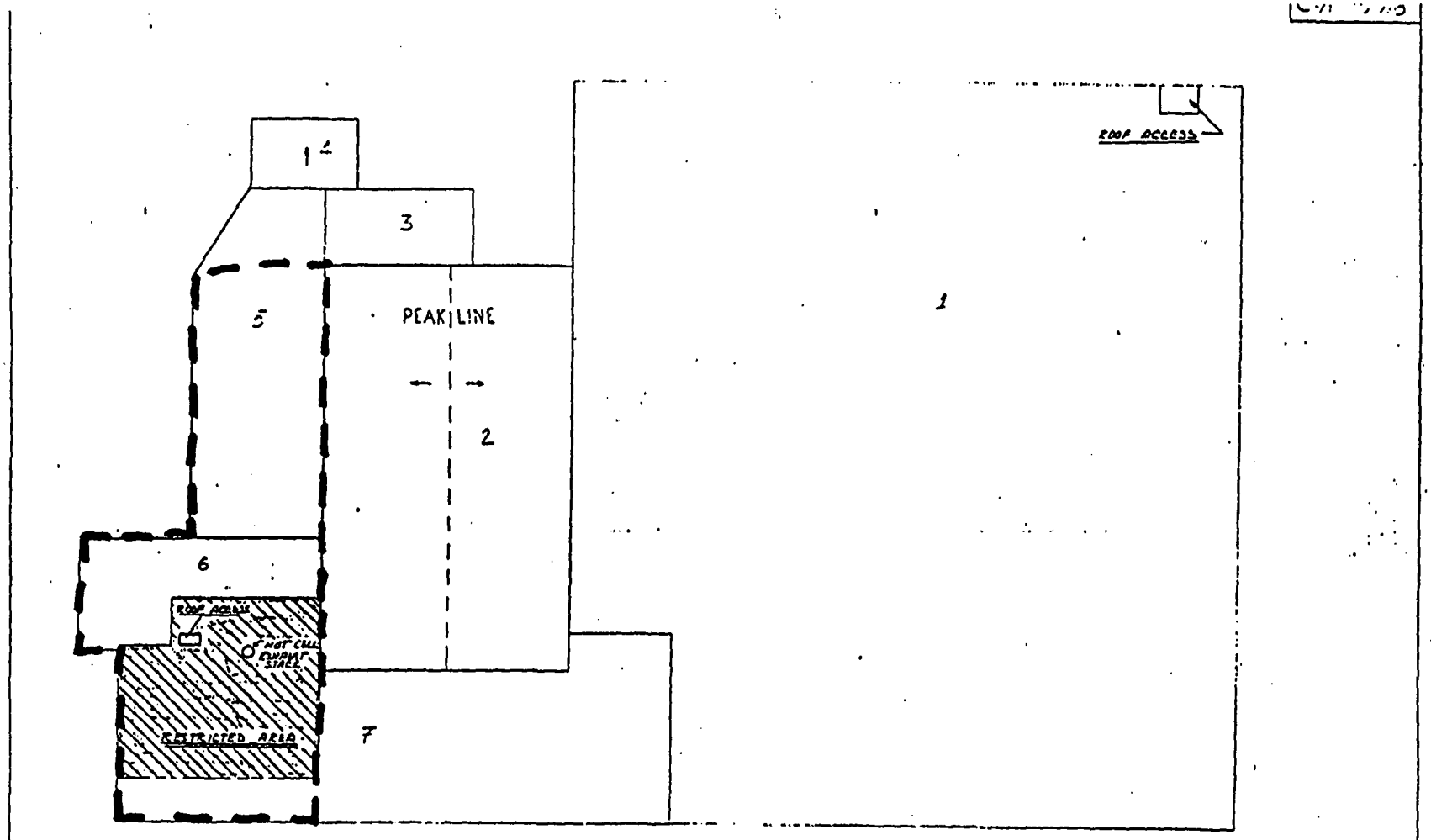
SECOND FLOOR RESTRICTED AREA



ADVANCED MEDICAL SYSTEMS, INC.
GENEVA, OHIO 44041

C-A9-P-0062

ROOF RESTRICTED AREA



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2	1958	GABLE	WOOD	RI. ASPH.	1985	
3	1960	FLAT	STEEL	ASPH/[illegible]		
4	1960	FLAT	STEEL	" "		
5	1958	FLAT	STEEL	ASPH/[illegible]	1981	
6	1958	FLAT	STEEL	ASPH.		
7	1958	FLAT	CONCRETE	ASPH [illegible]		

LTR	REVISION	BY/DATE
A	ADD ROOF ACCESS [illegible] DATE	BY/DATE

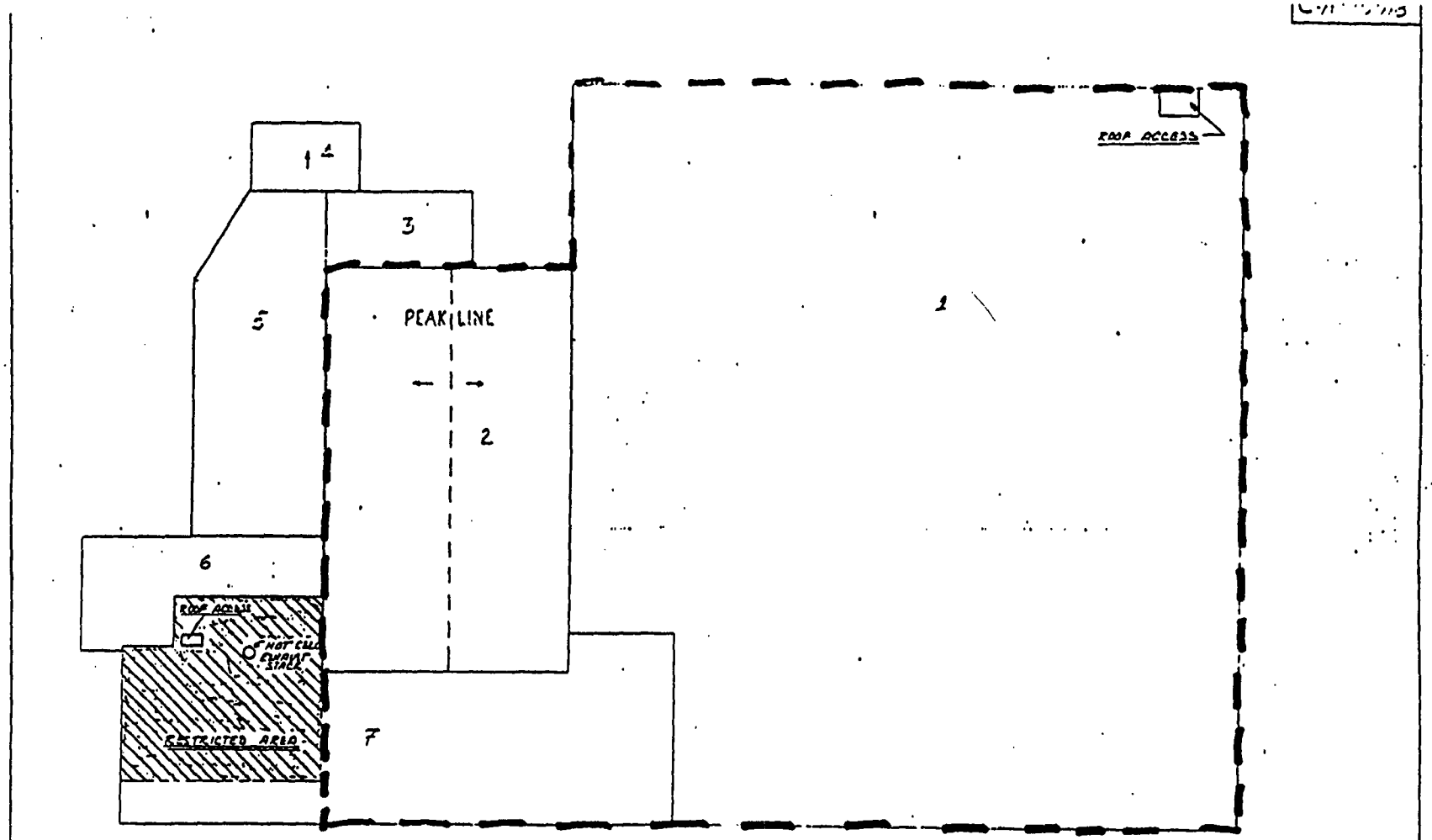
UNLESS NOTED ± TOLERANCES ON ANGLES ± ☐ BREAK ALL SHARP EDGES
DECIMALS ± ± FRACTIONS ± DIMENSIONS ARE BEFORE APPLYING FINISH

NEXT ASSY | NAME LONDON ROAD FACILITY
ROOF LAYOUT
MATERIAL
FINISH
DRN KA 9/84 DATE | CHKD. | APPROVED

ADVANCED MEDICAL SYSTEMS, INC.
GENEVA, OHIO 44041

SCALE 1/8 = 1'-0"
C-A9-R-3019

ROOF UNRESTRICTED AREA



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2	1958	GABLE	WOOD	RI. ASPH.	1983	
3	1960	FLAT	STEEL	ASPHALT		
4	1960	FLAT	STEEL	" "		
5	1958	FLAT	STEEL	ASPHALT	1981	
6	1958	FLAT	STEEL	ASPH.		
7	1958	FLAT	CONCRETE	ASPH. STONE		

UNLESS NOTED ± TOLERANCES ON ANGLES ± DECIMALS ± ± FRACTIONS ± DIMENSIONS ARE BEFORE APPLYING FINISH ○ BREAK ALL SHARP EDGES

NEXT ASSY | NAME LONDON ROAD FACILITY

MATERIAL

FINISH

DRN KA 9/6/91 DATE CHKD. APPROVED

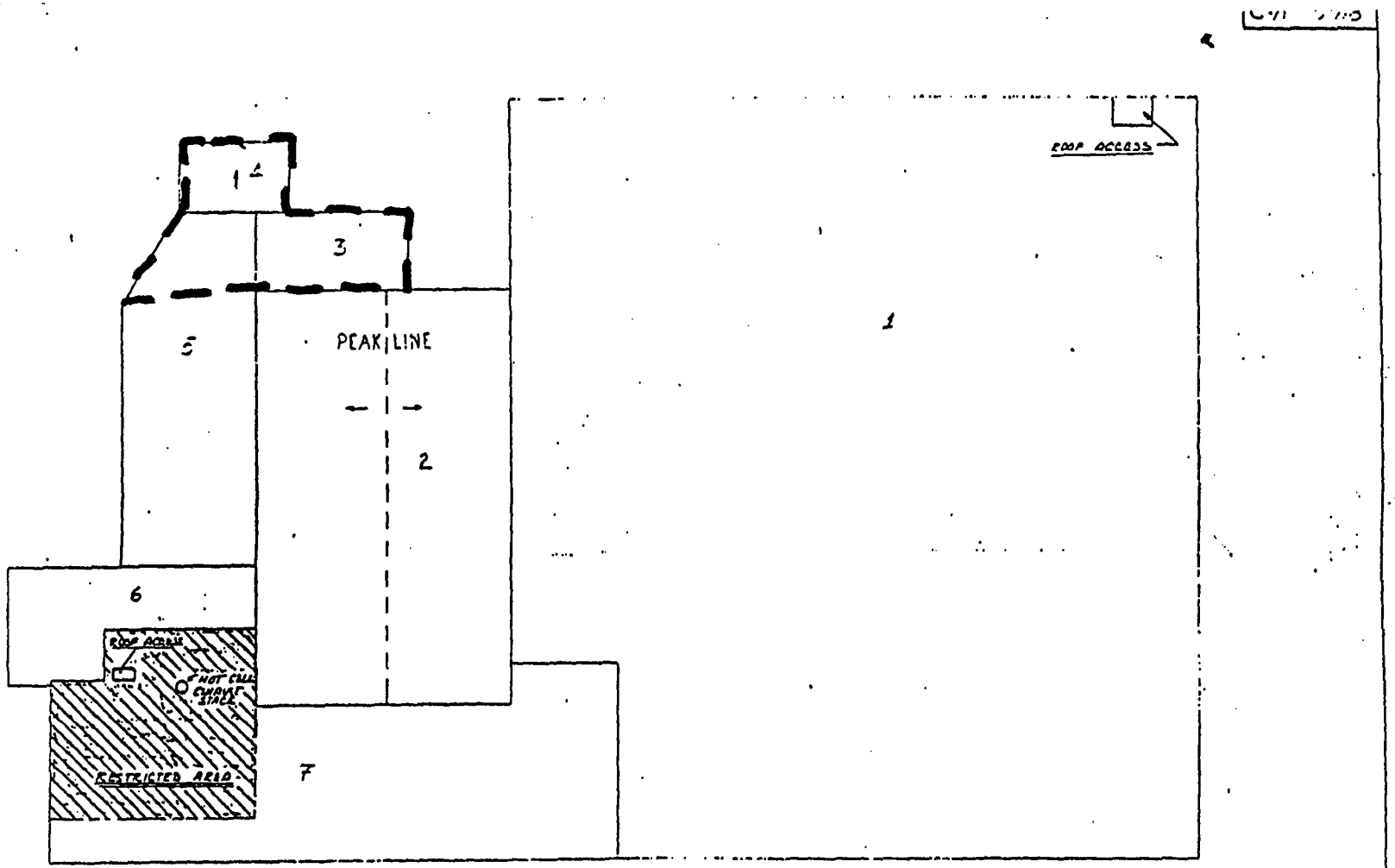
ADVANCED MEDICAL SYSTEMS, INC.
GENEVA, OHIO 44041

SCALE 1/8" = 1'-0"

C-A9-R-2018

A ADDED ROOF 7 PER SITE — 9/6/91

ROOF CONTROLLED AREA



ROOF	AGE	TYPE	DECK	COVER	REPAIRS	RECOVERED
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2	1958	GABLE	WOOD	BI. ASPH.	1983	
3	1960	FLAT	STEEL	ASPH.		
4	1960	FLAT	STEEL	" "		
5	1958	FLAT	STEEL	ASPH.	1981	
6	1958	FLAT	STEEL	ASPH.		
7	1958	FLAT	CONCRETE	ASPH.		

LTR	REVISION	BY/D. DATE
A	ADDED AREA OF ROOF	

UNLESS NOTED ± TOLERANCES ON ANGLES ± ○ BREAK ALL SHARP EDGES
DECIMALS ± ± FRACTIONS ± DIMENSIONS ARE BEFORE APPLYING FINISH

NEXT ASSY | NAME LONDON ROAD FACILITY
ROOF LAYOUT
MATERIAL
FINISH
DRN RA 9/28/83 DATE | CHKD. | APPROV.

ADVANCED MEDICAL SYSTEMS, INC.
GENEVA, OHIO 44041

SCALE 1/16 = 1'-0"
C-A9-R-3018

PERSONNEL EXPOSURE POLICY

It is the policy of Advanced Medical Systems, Inc. (AMS) that exposure of personnel to ionizing radiation be kept As Low As Reasonably Achievable (ALARA) and always within the limits of 10CFR20. This chapter outlines the limits and procedures to be used by all AMS employees to maintain exposure ALARA.

PERSONNEL EXPOSURE MONITORING

For monitoring personnel exposure, the following guidelines are in effect:

I. Self Reading Pocket Dosimeters (SRPD)

A. SRPDs are available in the following ranges: 200mR, 1R and 5R.

B. All personnel should wear a 200mR SRPD while at the Isotope Facility. At a minimum, it is to be read at the end of each working day.

C. The 1R and 5R SRPDs are for use in any instance where work is performed in areas or with materials which may cause a whole body exposure equal to or greater than 100mR in one hour. They may be worn in conjunction with a 200mR SRPD. SRPDs should be read at least once every fifteen (15) minutes during such work or more frequently depending on the type of work and exposure rates involved.

D. All SRPD readings are to be recorded on the Monthly Dosimeter or Visitors Log book at the end of each working day. This Log is used to keep track of personnel exposure on a continual basis and is reviewed by the Radiation Safety Officer (RSO) at least monthly.

II. Film Badges

A. Film badges are supplied by a commercial service. They shall be worn by any personnel working in a Radiation Area of the Restricted Area and are to be worn within an inch of a 200mR SRPD by all Isotope personnel.

B. Film badges are processed at least weekly.

C. Film badges are issued to non-AMS personnel when all of the following conditions are met:

1. They will perform work related to facility operations and the work is performed in a Restricted Area.

2. The individual is likely to receive more than 125mrem during the entire year from exposure to sources of radiation and radioactive material at the London Road facility.

3. Training has been conducted and signed by the individual and the RSO or designee.

III. Extremity Dosimetry - Thermo Luminescent Dosimeters (TLD)

A. Finger ring TLDs are worn by all Isotope personnel when handling radioactive materials.

B. Additional TLDs are available for extremity monitoring (i.e. head, feet, etc.)

C. Extremity TLDs are processed at least monthly.

D. All dosimetry reports are reviewed by the RSO and maintained as permanent record of personnel exposure.

IV. Audible Dosimetry or Alarming Dosimeters

A. These devices are to be worn by Isotope personnel when directed by the RSO. Typically these devices are used in activities that have high exposure potential (i.e. Cell entries, etc.).

PERSONNEL EXPOSURE LIMITS

The following limits for personnel exposure to ionizing radiation are in effect for AMS Isotope personnel. Members of the public allowed access to Restricted Areas of the facility are subject to the exposure limits of 10CFR20.1301.

I. Total Effective Dose Equivalent (TEDE)

A. An administrative Total Effective Dose Equivalent limit of four and a half (4.5) rem/year is in effect.

B. Personnel are responsible for tracking their exposure and maintaining their exposure within administrative limits.

C. The RSO shall periodically review individual exposure records and conditions under which the exposure was received.

II. Extremity Exposure

A. Extremity exposure shall be controlled within 90% of the limits of 10CFR20.1201.

B. Personnel are responsible for tracking their exposure and maintaining their exposure within the administrative limits.

C. The RSO shall periodically review individual exposure records and conditions under which the exposure was received.

III. Internal Exposure

A. Internal exposure is most likely to occur from work in areas of potential airborne contamination. This type of exposure shall be monitored by calculating DAC-hrs and intake for each individual working in any such area as follows:

$$\frac{\text{concentration of air sample}}{1.0 \times 10^{-8}} \times \text{time in area} = \text{DAC-hrs}$$

Time in area x 2 x 10^4 x concentration of sample = Intake

B. The administrative limit for Internal Exposure is 200 DAC-hrs/year. The sum of the External and Internal exposure should not exceed the administrative TEDE. In the event that these limits are exceeded, the RSO shall review all circumstances involved to determine any necessary actions.

C. Individuals are responsible for maintaining their exposure within these limits.

D. Internal exposure shall also be monitored by periodic Whole Body Counts performed by a commercial service.

IV. Exposure Control for Minors, Declared Pregnant Women and Members of the General Public

A. The annual occupational exposure for minors shall not exceed 10% of any annual dose limit for adults as specified in 10CFR20.1201.

B. The occupational exposure for a Declared Pregnant Woman shall not exceed 500mrem TEDE during the entire gestation period. It is the responsibility of the woman to declare pregnancy in writing to AMS.

C. The TEDE to members of the public shall not exceed 100mrem in one calendar year from external sources of radiation from the London Road facility. If a member of the public is given access to a Restricted Area, the limits for members of the public continue to apply to these individuals.

RADIATION AND CONTAMINATION SURVEY REQUIREMENTS

This section provides guidelines for survey frequencies and radiation and contamination action levels. Also described are uses and controls for Restricted and Controlled Areas within the Isotope Facility.

I. Controlled Area Action Levels

A. A Controlled Area is any area within the facility which requires minimal precautions for entry regarding radiation exposure or contamination levels. Radiation and contamination surveys are to be performed:

1. At least twice a month.
2. Immediately after any evolution which may raise exposure or contamination levels above the action levels.

B. Action Levels

1. 0.5mR/hr in occupied areas.
2. 1000 dpm/100cm^2 loose surface contamination.

C. If any of these levels are exceeded, notify the RSO as soon as possible and proceed with any or all of the following actions:

1. Restrict access to the area in accordance with survey results.

2. Determine and remove the source of radiation, if possible, and resurvey.

3. Determine the source of contamination, decontaminate and resurvey.

II. Restricted Area Action Levels

A. Radiation and contamination surveys are to be performed at least monthly or immediately after any evolution which may significantly change radiation or contamination levels. Restricted Areas within the Isotope Facility may fall under one or more of the following:

1. Contaminated Area - Any area where contamination levels are permitted above 1000 dpm/100cm^2.

2. Radiation Area - Any area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 5mrem in one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

3. High Radiation Area - Any area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent of 100mrem in one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

4. Very High Radiation Area - Any area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500rads in one hour at one meter from a radiation source or from any surface that the radiation penetrates.

5. Airborne Radioactivity Area - Any area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations-

   a. In excess of the Derived Air Concentrations (DACs) specified in Appendix B to 10CFR 20.1001-20.2401, or

   b. To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the Annual Limit on Intake (ALI) or 12 DAC-hours.

6. All of these areas shall be posted in accordance with the requirements in 10CFR20.

B. Action Levels for Restricted Areas

1. Surface contamination - 40,000 dpm/100cm^2 (except Hot Cell). Contamination levels exceeding this amount should be decontaminated. A survey of the decontamination results shall be documented and forwarded to the RSO for review and filing.

2. Radiation levels - Areas shall be posted in accordance with the levels stated above (i.e. Radiation Area, High Radiation Area or Very High Radiation Area). Where practical, sources of radiation shall be moved or shielded to maintain personnel exposure ALARA.

3. Airborne levels - Posting is required for areas that could exceed the levels defined in the definition of an Airborne Area. Portable air samples are required for entry into these areas. Respiratory protection may be required for entry into these areas.

C. Hot Cell Entry and Action Levels

1. The Hot Cell is the only accessible potential Very High Radiation Area within the Isotope Facility. Each entry requires a job specific Radiation Work Permit (RWP) and specific permission of the RSO. It is preferred that the RSO be on-site for all Cell entries. If the RSO is not available, the Senior Isotope Handler may supervise the Cell entry with prior specific authorization of the RSO.

2. The Hot Cell is surveyed remotely with a Victoreen Model 500 Ratemeter (or equivalent). Monitoring is performed continuously during all phases of source production and remote decontamination operations. Although Hot Cell operations have been very limited since January 1988, recent experience indicates that levels of 1,000mR/minute or less should be maintainable during operations (source material in storage plugs).

3. Hot Cell entries shall be performed in accordance with ISP-14.

D. Schedule of Routine Safety Assurance Checks

The following is a schedule of minimum frequency requirements for all routine safety functions performed at the Isotope Facility.

1. Daily

   a. Read air monitor chart and time delay.
   b. Read Hot Cell and Isotope Lab pressure differential.
   c. Check alarm board for red lights.
   d. Check gamma alarm lights.
   e. Visual inspection and response check of survey instruments.
   f. Check source inventory.
   g. Read and record SRPD readings.

2. Weekly

   a. Whole body film badge change.

3. Semi-Monthly

   a. Emergency generator test.
   b. Controlled Area radiation and contamination surveys.
   c. Test emergency lighting.

4. Monthly

   a. Gamma alarm function test.
   b. Stack air monitor sample analysis.
   c. Emergency generator battery check.
   d. Area TLD change.
   e. Extremity TLD change.
   f. Restricted Area surveys.
   g. Waste Holdup Tank Room visual inspection.
   h. Conduct a fire and safety check of entire facility.

5. Quarterly

   a. Radiation survey of sanitary sewer.
   b. Stack Air Monitor check source response check.

6. Semi-Annually

   a. Calibration of portable survey instruments in use.
   b. Radiation and contamination survey of unused facility areas.
   c. Radiation and contamination survey of facility perimeter.
   d. Calibration source leak test.
   e. Isotope decay inventory.

7. Annually

   a. Submit required reports to the Nuclear Regulatory Commission (NRC).
   b. Radiation Safety Program review as per ISP-17.
   c. Respiratory Protection Program review as per ISP-39.
   d. Refresher training for isotope facility personnel.

8. Biennial

   a. Independent audit of AMS records and procedures.
   b. Emergency Plan drill.

9. 5-Year Scheduling

   a. Physical inventory of all isotopes at AMS London Road.
   b. Physical inspection of Hot Cell automatic damper seals.

10. Each Use

   a. Personnel monitoring for contamination upon leaving a Contaminated Area or after handling contaminated material.
   b. Surveys of areas where there has been a potential change in radiation, contamination or airborne levels.

CHAPTER 3 - PROCEDURES FOR HANDLING RADIOISOTOPES

HAZARDOUS QUALITIES OF ISOTOPES

All use of isotopes is to be considered hazardous and requires prior approval by the Isotope Committee. Special care must be exercised in handling isotopes.

The use of Cobalt-60 requires careful planning of operations since it is a penetrating gamma radiation emitter.

Depleted Uranium is used as shielding material in source head construction. This material is purchased in the final form. This material is nickel plated. No machining is done after receipt, therefore, a low hazard is presented.

The Cobalt-60 will be in the form of solid metal encapsulated in a source capsule.

AMS currently purchases Cobalt-60 in sealed source form only.

Unencapsulated Cobalt-60 is stored in screw-top capsules. The company posseses this type of Cobalt incident to transfer to a third party. Advanced Medical Systems no longer encapsulates Cobalt-60. The sealed sources are used or handled with loading equipment only in the Controlled Isotope Shop Area or the Shielded Work Room.

EXTERNAL HAZARDS

I. General Operation Procedures

When working with sources of penetrating radiation, the following steps will help maintain exposures ALARA:

A. Plan each step of the operation thoroughly in advance.

B. Keep as far away from the source as practical at all times.

C. Avoid getting radioactive material on the hands. Hands should be kept at a safe distance from the source, as even small sources will cause burns if the distance is close enough.

D. Interpose a proper shield between you and the source whenever practical.

E. Obtain actual exposure data with the proper monitoring instruments.

F. Know the properties of the material you are going to work with.

G. Attempt to positively identify the radioactive material and determine the activity.

H. Consult frequently with the Radiation Safety Officer.

II. Specific Procedures

A. Source Transfer Operations

In any operation involving movement of a source, from one container to another, there is a momentary period of higher radiation intensity as the source crosses the fine gap between containers. For this reason, the area around any transfer operation must be cleared of all personnel not required for the transfer and the operating personnel must observe appropriate procedures.

B. Entering the Liquid Waste Storage Room

The room is sealed and will not be unsealed until its radiation levels are low enough to permit decontamination.

C. Entering the Hot Cell - See ISP-14.

D. Entering the Equipment Room

This room is located directly above the Shielded Work Room and has adequate floor shielding for our operations. A gamma alarm in the Equipment Room gives a red signal if the radiation level exceeds 2mR/hr and remotely indicates the signal above the entrance to the room.

CAUTION: When there is no white signal light or there is a red light personnel are not permitted in this room until cleared by the RSO.

INTERNAL HAZARDS

Deposition of radioactive materials in the body may from ingestion, inhalation and absorption through the skin. It must be remembered that, apart from the accidental swallowing of a radioactive solid or solution, ingestion may take place quite unnoticed over long periods of time through contaminated food, cigarettes or other articles brought to the mouth. The presence of

radioactive dust or spray in a laboratory may lead to similar chronic intake through inhalation. The following procedures are designed to prevent these internal hazards:

I. General Operating Procedures

A. Do not eat, drink or smoke in any Restricted Area or when handling any radioactive source.

B. Personnel with open cuts or lesions shall obtain permission from the RSO prior to working in potentially Contaminated Areas.

C. Never handle radioactive material with bare hands. Forceps, rubber gloves or some other interposing device should always be used.

D. General air ventilation shall be maintained.

E. Local exhaust ventilation is mandatory.

F. All effluents from local exhaust systems and from Restricted Areas must be properly filtered before being discharged to the outside.

G. Know the properties of the material with which you are to work and attempt to identify and determine its activity.

H. Plan ahead each step of the operation prior to entry into the Restricted Area. This should include actions to be taken in the event of emergencies.

I. Frequent house cleaning and good personal hygiene practices are essential.

J. Isotope shop surfaces are designed to prevent the accumulation of dust and must be kept clean.

K. Consult frequently with the Radiation Safety Officer.

II. Specific Operating Procedures

A. Cell and Decontamination Room - Respirators and proper protective clothing must be worn in these areas.

B. Liquid Waste Storage and Processing Room

These rooms are sealed and will not be unsealed until their radiation levels are low enough to permit decontamination.

III. Accidents and Emergency Techniques

In the event of accidental leakage or spillage from potentially hazardous amounts of radioactive material, the following measures should be taken at once:

A. Stop the leak or spill taking care not to put yourself in a hazardous situation.

B. Where liquids or solids are involved, no immediate attempt should be made to clean up the area.

C. Local exhaust ventilation should be maintained where radioactive gases are involved. Ask the RSO whether the building ventilating system should remain on.

D. Everyone should leave the room and the doors should be closed and locked.

E. If powdered sources are involved, the doors and all the other openings leading into the room should be sealed with wide masking tape or other suitable material.

F. It shall be assumed that all personnel within the accident area have been contaminated until checked out with adequate monitoring equipment.

G. Entrance to the Contaminated Area is prohibited until the RSO can be called in and his advice followed.

PROTECTIVE CLOTHING

The company furnishes a complete change of clothing which must be worn by any personnel performing work in a Restricted Area where radioactive contamination is known to exist or is suspected.

CHAPTER 4 - STORAGE OF ISOTOPES

GENERAL STORAGE PROCEDURES

A. All radioactive isotopes must be stored in areas specifically designated for them by the RSO.

B. Storage facilities have been predicated on the type of emitter involved and the quantity being stored.

C. No solution is to be stored uncovered. Dry materials are to be placed in dust-tight containers.

D. Place glass containers in an unbreakable outer container large enough to contain the volume of material should the glass break.

E. If the storage area contains radioactive gases or materials which decay with the formation of such gases, make certain that the local exhaust ventilating system is in operation prior to opening.

F. Should temporary storage outside of permanent storage areas be necessary, consult first with the RSO. Proper posting is required.

POSTING

A. Posting requirements of current regulations must be observed.

B. Posting signs, tags and labels of the approved type must be used and are available from the RSO.

SPECIFIC STORAGE PROCEDURES

I. Storage Garden

Isotopes to be placed in the garden must be in a welded capsule.

CAUTION: The transfer cask must be used to remove storage rods, even when empty, since this operation otherwise opens an unshielded air path into the source region.

II. Liquid Waste Storage Room

This room is sealed and will not be unsealed until its radiation levels are low enough to permit decontamination.

III. Cell

The storage containers provided in the floor of the Cell may be used for radioisotope storage.

IV. Shipping Containers

Radioisotopes may be stored in shipping containers as long as labeling and safety requirements are met.

CHAPTER 5 - TRANSPORTATION OF ISOTOPES

Transferring or shipping of licensed quantities of isotopes outside the company itself, should be authorized only by the Isotope Committee. Transportation of these isotopes to other areas, or from one area in the building to another, for the purpose of research or development work is permissible when such transportation procedures have been covered by the RSO in the initial programming of the work.

GENERAL TRANSPORTATION PROCEDURES

A. All radioactive isotopes must be transported in containers that are suitably designed for use as temporary or permanent storage.

B. If isotopes are in glass containers, transportation containers must be large enough to contain the volume of material should the glass break. If gases are involved, containers must have a tight seal.

C. Material must never be left unattended during transportation between facilities.

D. Whenever practical, transport isotopes through the building at periods of least congestion and use the most direct route practicable.

E. All licensed by-product material being transported must be labelled as prescribed by current regulations.

SPECIFIC TRANSPORTATION PROCEDURES

A. Receiving of Isotopes - All incoming shipments of radioisotopes are to be received at the London Road facility. Radiation monitoring of the article is required before removing from the truck. Operating procedure ISP-16 specifies the actions to be performed when isotopes are received.

B. Shipment of Isotopes - Outgoing shipments of radioactive isotopes are to be prepared for transportation by individuals authorized under AMS's NRC license. All packages must comply with current NRC and Department of Transportation (DOT) regulations. Quality assurance procedure QA1014 specifies the actions to be performed when preparing a shipment. For depleted Uranium, refer to operating procedure ISP-28. Once properly packaged, any authorized AMS employee may release a radioactive shipment to the carrier.

C. Preparing Source Exchange Containers for Shipment.

1. Before loading with a radioisotope (if applicable), the accessible internal surfaces should be given a wet smear contamination check and cleaned, if necessary, to meet current Regulatory Standards.

2. The container mechanism (if any) will be checked for proper function and repaired if necessary.

3. The container and its mechanisms (if any) will be inspected for integrity and proper mechanical functions in accordance with manufacturer's drawings, descriptions, certificates and check lists. Repairs will be made when necessary.

AREA MONITORING

A. All area monitoring will be performed under the direction of the RSO, who will review the results.

B. A survey instrument compatible with the energy and intensity of the radiation anticipated must be used.

C. Written records of all surveys will be maintained indicating dose rate in mR/hr unless otherwise noted.

PERSONNEL MONITORING

A. All personnel entering Restricted Radiation Areas must wear approved film badges and self-reading pocket dosimeters (SRPD) with a range of 0 to 200 mR. An additional SRPD with a range of 0 to 1000 mR or greater may be required depending on the anticipated dose rate in the area to be entered.

B. If work is to be performed where there is a possibility that the hands and forearms may be exposed to a dose rate in excess of 100mR/hr, a thermoluminescent finger ring dosimeter must be worn.

C. Work in high dose areas will be proceeded by a survey with appropriate monitoring equipment and an estimated total accumulated exposure determined. The SRPD will be read at intervals consistent with the anticipated dose rate to determine that the actual exposure is not greater than the anticipated exposure.

D. Alarming dosimeters are also available to monitor personnel exposure in high dose rate areas.

E. Personnel monitoring equipment will be protected against contamination while being used in a high Contamination Area. Sealing in a plastic bag is usually sufficient.

F. Whole body contamination checks are mandatory before leaving a Contaminated Area. All personnel shall check themselves for possible contamination before redressing into street clothing. This check will be done by slowly scanning over the entire body with a GM type probe connected to a count rate meter. Listen to the audible clicks and observe the meter deflection while scanning, any reading greater than 100 cpm above background is <u>not</u> acceptable. Pay particular attention to the hair, neck, ears, nostrils, hands, fingernails, feet and ankles. If contamination is detected, decontaminate as per Chapter 7 of this manual.

CHAPTER 7 - CONTAMINATION CONTROL AND WASTE DISPOSAL

GENERAL

Radioactive contamination may be defined as radioactive material in places where it is not wanted. Because of the wide range in the magnitudes of radiation involved, the impossibility of neutralizing radiation, the invisibility of radiation and the difficulties inherent in cleaning up minute amounts of material, the job of decontamination is no simple matter.

DECONTAMINATION PROCEDURES

I. Action in the event of a spill

A. Where gross contamination from a spill or leak has occurred, proceed as outlined in Chapter 3 Section III. RSO has the authority to deviate from standard operating procedures if the situation warrants.

Accidents and Emergency Techniques

In the event of accidental leakage or spillage from potentially hazardous amounts of radioactive material, the following measures should be taken at once:

A. Stop the leak or spill taking care not to put yourself in a hazardous situation.

B. Where liquids or solids are involved, no immediate attempt should be made to clean up the area.

C. Local exhaust ventilation should be maintained where radioactive gases are involved. Ask the RSO whether the building ventilating system should remain on.

D. Everyone should leave the room and the doors should be closed and locked.

E. If powdered sources are involved, the doors and all the other openings leading into the room should be sealed with wide masking tape or other suitable material.

F. It shall be assumed that all personnel within the accident area have been contaminated until checked out with adequate monitoring equipment.

G. Entrance to the Contaminated Area is prohibited until the RSO can be called in and his advice followed.

PROTECTIVE CLOTHING

The company furnishes a complete change of clothing which must be worn by any personnel performing work in a Restricted Area where radioactive contamination is known to exist or is suspected.

II. Personnel Decontamination

A. Immediately remove all contaminated clothing and place in properly labeled plastic bags for subsequent evaluation by the RSO.

B. Notify the RSO who will prescribe the decontamination method.

III. Area Decontamination - Non Expendable Equipment

A. Any area or item from which a one hundred (100) cm^2 wipe indicates contamination of 40,000 dpm or more will be cleaned as soon as practical after the work causing the contamination is completed (with the exception of Very High Radiation Areas).

B. Appropriate decontamination methods as prescribed by the RSO will be used.

C. On porous surfaces, a HEPA vacuum cleaner may be used as prescribed by the RSO.

IV. Handling of Contaminated Expendable Material

A. Package for safe handling.

B. Properly label according to the hazard.

C. Treat as waste.

WASTE DISPOSAL

I. Liquid Radioactive Waste

No liquid radioactive wastes should be generated at the facility.

II. Solid Radioactive Wastes

Waste involving long-lived isotopes shall be packaged for safe handling and temporarily stored in special containers prior to shipment to a commercial waste disposal service.

LIQUID WASTE STORAGE SYSTEM

I. Description of Facility

Liquid radioactive waste is not generated in the normal operation in the Isotope Facility.

The original design of the facility had all drains on the first floor of the Restricted Area of the facility, with the exception of the toilet drains, connected to stainless steel holding tanks in the Shielded Waste Room in the basement of the facility. Circa 1986, these drains were modified to go to a plastic holding tank in the front basement.

The original floor drains in the basement were connected to the municipal sanitary system. These drains are plugged with concrete.

The Shielded Waste Room, shielded by thirty (30) inches of high density concrete walls, is curbed twenty four (24) inches high to prevent waste water from running into the sanitary sewer in the event of a leak in one of the holding tanks. The holding tanks have a total capacity of six hundred (600) gallons and the curbed floor area, which has no drain, has a capacity of approximately twenty four hundred (2,400) gallons. Circa 1988, this room was sealed with all services to and from the room disconnected.

Any liquid radwaste that comes into the company's possession through abnormal circumstances will be controlled and managed on a case-by-case basis.

CHAPTER 8 - EMERGENCY ACTION PROCEDURES

ACCIDENTS AND EMERGENCY NOTIFICATIONS

I. Immediate Action

In the event of an emergency, the first concern is to remove yourself from danger as rapidly as possible. If others are working in the area and may not be aware of the emergency, they must be notified immediately by whatever means is necessary. As soon thereafter as possible, the emergency notification procedures should be followed by yourself or someone instructed by you. In all cases, the RSO or designee shall be notified as soon as practical and implement the Emergency Pre-Plan.

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE
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REVISION - 01/95

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

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REVISION - 01/95

This sheet is provided as a cross reference to prior ISP manuals.

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

AREA SURVEY PROCEDURE

ISP-2 Rev. 01/95

1.0 PURPOSE: To standardize the method used for performing radiation and contamination surveys.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Observe all posted requirements for Restricted Areas.

2.2 Ensure survey instruments are in calibration and good working order prior to use.

2.3 Care must be used when handling smear samples to prevent spreading contamination or cross-contaminating samples.

2.4 The following information should be recorded for each survey performed:

ALL SURVEYS	CONTAMINATION SURVEYS
Date	Background cpm
Time	Counter Efficiency
Performed by	Counting time
Reason for survey	
Area surveyed	
Instrument(s) used (Serial #, Calibration due date)	

2.5 All surveys are Legal Records, therefore, it is of the utmost importance that all information is neatly and accurately recorded.

2.6 Do not hesitate to add additional information onto survey forms (i.e. oil on floor, lights burnt out, etc.).

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Radiation Surveys.

3.1.1 For general area dose rates, walk slowly around the area being surveyed while holding the probe at waist level. Record the highest dose rate in the appropriate units (normally mR/hr).

3.1.2 For contact readings, hold the probe within one (1) inch of the surface and record the dose rate, noting that it is a contact reading.

3.1.3 All readings less than 0.1 millirem per hour should be recorded as <0.1mR/hr.

3.1.4 For Hot Spot surveys, walk slowly around the area to be surveyed, determine the area of highest radiation, obtain a contact reading and record the location and dose rate.

3.2 Contamination Surveys.

3.2.1 Using moderate pressure, wipe a dry smear over a 100 cm^2 area (100 cm^2 = 4" x 4" area or a 16" long S-shape of that area).

3.2.2 Record the smear locations using one of the following methods:

a. List: Accurately record the location on a list of smear locations for the survey being performed.

b. Map: Use a number to indicate the smear location on a map of the area being surveyed. Smears should be noted on maps in the following manner:

Circle - horizontal surfaces
Square - vertical surfaces

3.3 Action Levels.

3.3.1 Loose Surface Contamination:

a. Restricted Areas - 40,000 dpm/100 cm^2.

b. Controlled Areas - 1,000 dpm/100 cm^2.

c. Unrestricted Areas - 1,000 dpm/100 cm^2.

3.3.2 Radiation Levels:

a. Controlled Areas - 0.5mR/hr general area.

b. Unrestricted Areas - Not to exceed one hundred (100) mrem exposure to the general public in one (1) year.

3.3.3 Actions required if limits are exceeded.

a. Restrict access to the area.

b. Notify the RSO.

c. Determine the cause of the excess radiation or contamination levels.

d. Decontaminate and resurvey.

e. Shield or remove the source of radiation and resurvey.

f. If the above actions cannot be accomplished before the end of the day, the area should be posted and secured according to the degree of the hazard.

NOTE: In the event that levels cannot be immediately reduced, all actions taken should be recorded and forwarded to the RSO for review. The RSO shall conduct and document an investigation of the conditions and circumstances involved.

3.3.4 Frequency of Surveys.

a. Controlled Areas should be surveyed semi-monthly.

b. Restricted Areas should be surveyed at least monthly.

c. Any area in which radioactive material is in use should be surveyed at least weekly.

3.3.5 Areas to be Surveyed.

a. The attached data sheets list the minimum areas to be surveyed. These surveys should be completed in their entirety at the specified frequency regardless of other surveys performed.

b. Surveys performed in addition to the minimum areas and frequencies should be recorded on separate data sheets.

c. All surveys should be forwarded to the RSO for review and filing.

CONTROLLED AREA SURVEY DATA SHEET

ISP-2A

LOCATION	RAD LEVEL	GCPM	CCPM	DPM
FIRST FLOOR				
1. Outside Clean Equipment Room	_____	____	____	____
2. Top Landing of Front Stairwell	_____	____	____	____
3. Entrance Level of Stairwell	_____	____	____	____
4. Basement Level of Stairwell	_____	____	____	____
5. Outside Change Room Interlock Door	_____	____	____	____
6. Manipulator Control Station	_____	____	____	____
7. Cell Control Office	_____	____	____	____
8. Hall in Front of Office	_____	____	____	____
9. Doorway Outside Shielded Work Room	_____	____	____	____
10. Conference Room - East	_____	____	____	____
11. Conference Room - West	_____	____	____	____
12. Hallway to Cage Area	_____	____	____	____
13. Outside Airlock Doors	_____	____	____	____
14. Outside Counting Room	_____	____	____	____
15. South of Counting Station	_____	____	____	____
16. Counting Station	_____	____	____	____
17. West Doorway Inside Counting Room	_____	____	____	____
18. Outside Isotope Warehouse Overhead Door	_____	____	____	____
19. Loading Dock Area	_____	____	____	____
20. Scale Area	_____	____	____	____
21. Fire Door to Warehouse	_____	____	____	____
22. East Side of LLWS Area	_____	____	____	____
23. Middle of LLWS Area	_____	____	____	____
24. West Side of LLWS Area	_____	____	____	____

Performed by: _____ Date: _____

SURVEY METER: _____ S/N: _____ CAL DUE: _____

COUNTING INST.: _____ S/N: _____ CAL DUE: _____

COUNTING EFFICIENCY: _____% BACKGROUND: _____CPM

ACTION LEVELS: 1000 DPM/100CM^2
0.5MR/HR

Reviewed by RSO: _____ Date: _____

CONTROLLED AREA SURVEY DATA SHEET

ISP-2B

LOCATION	RAD LEVEL	GCPM	CCPM	DPM
FIRST FLOOR				
1. Change Room Near Lockers	_____	____	____	____
2. Change Room Near Showers	_____	____	____	____
3. Change Room Near Sinks	_____	____	____	____
4. Change Room Entrance to ISA	_____	____	____	____
5. Warehouse Office - East	_____	____	____	____
6. Warehouse Office - Center	_____	____	____	____
7. Warehouse Office - West	_____	____	____	____
8. Cage Area - East	_____	____	____	____
9. Cage Area - Center	_____	____	____	____
10. Cage Area - West	_____	____	____	____
11. Outside Isotope Warehouse	_____	____	____	____
SECOND FLOOR				
1. Outside Washroom Door	_____	____	____	____
2. Office at Southeast Corner	_____	____	____	____
3. East Wall Near Stairwell	_____	____	____	____
4. Center of Office Area	_____	____	____	____
5. Northwest Corner of Office	_____	____	____	____
6. Outside Clean Equipment Room	_____	____	____	____

Performed by: _____ Date: _____

SURVEY METER: _____ S/N: _____ CAL DUE: _____

COUNTING INST.: _____ S/N: _____ CAL DUE: _____

COUNTING EFFICIENCY: _____% BACKGROUND: _____CPM

ACTION LEVELS: 1000 DPM/100CM^2
0.5MR/HR

Reviewed by RSO: _____ Date: _____

RESTRICTED AREA SURVEY DATA SHEET

ISP-2C

LOCATION	HOT SPOT	RAD LEVEL	GCPM	CCPM	DPM
1. HEPA Room North					
2. HEPA Room Middle					
3. HEPA Room South					
4. Stairs to HEPA Room					
5. Doorway to Washroom					
6. Doorway to Frisking Station					
7. Middle of Large Office					
8. Inside Doorway to Stairwell					
9. Inside Doorway of CER					
10. West of Boiler in CER					
11. Inside Doorway to Roof of CER					
12. Outside ISA Door					
13. ISA/Cell Wall					
14. ISA/Decon Room Wall					
15. West Wall Near SEC					
16. Source Garden					
17. Top Landing to Basement					
18. ISA/Landing to Basement					
19. Outside Basement Door					
20. Hallway Outside WHUT Room					
21. By WHUT Room Entrance					
22. North Side of Back Basement					
23. West Side of Back Basement					
24. Outside Decon Room Doors					
25. By Hot Cell Door in Decon Rm.					
26. Outside Airlock Doors					
27. Dirty Side of Airlock					
28. Clean Side of Airlock					
29. Inside Airlock Doors to Cage					
30. By Airlock Doors in Isotope Warehouse					
31. East of Isotope Warehouse					
32. Middle of Isotope Warehouse					
33. West of Isotope Warehouse					
34. Tank Room Front Basement					
35. Entrance Hall of Front Bsmt.					
36. Chart Room in Front Basement					
37. Back Entrance to Front Bsmt.					

Performed by:_____ Date:_____

SURVEY METER: _____ S/N: _____ CAL DUE: _____
COUNTING INST.: _____ S/N: _____ CAL DUE: _____
COUNTING EFFICIENCY: _____% BACKGROUND: _____cpm

ACTION LEVELS: 40,000 dpm/100cm^2
Areas >100MR/HR must be locked and posted as a High Radiation Area.

Reviewed by RSO: _____ Date: _____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

COUNTING INSTRUMENT CHECKS AND USAGE

ISP-3 Rev. 01/95

1.0 PURPOSE: To provide a standard guide for performing daily checks and usage of counting instruments.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Daily checks are to be performed prior to first use of counting instruments each day.

2.2 Use appropriate care when handling reference standard sources.

3.0 INSTRUCTIONS:

3.1 Daily Checks.

3.1.1 Turn instrument on and allow at least a fifteen (15) minute warm up period.

3.1.2 Count background for twenty (20) minutes with a clean sample holder in place and determine the background cpm (counts/20). Record the background cpm in the BKG CPM block on Form ISP-4A.

NOTE: Well counter background should be less than 30 cpm. Scalar background should be less than 45 cpm. A higher background indicates the possibility of a contaminated probe or undesirable source of radiation nearby. Correct as necessary.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-21-95

3.1.3 Count the reference standard for five (5) minutes and determine source cpm. Record the source cpm and the instrument settings on Form ISP-4A.

3.1.4 Compare the source cpm to the calculated values of the source provided for the month. An acceptable range of +/-10% is given. If the source counts are not within the limits, notify the RSO and adjust the instrument according to the manufacturers specifications.

3.1.5 Calculate the Minimum Detectable Counts (MDC). Record the MDC in the MDC block provided on Form ISP-4A.

$$MDC = 2.71 + 3.29 \times \sqrt{\frac{Cb}{Tb} + \frac{Cb}{Ts}}$$

Cb = Background cpm
Tb = Background count time
Ts = Sample count time

3.2 Counting Samples

3.2.1 Ensure all checks described in Section 3.1 have been satisfactorily completed prior to use.

3.2.2 Smear samples.

a. Place smear in vial (well counter) or planchette (scalar) and count for one (1) minute.

b. Determine activity as follows:

$$dpm = \frac{(\text{sample cpm}) - (\text{background cpm})}{(C_{eff})}$$

The counter efficiency (C_{eff}) is posted on the calibration sticker.

3.2.3 Air samples (taken in accordance with ISP-10).

a. Place sample filter face up in planchette and count for five (5) minutes. Determine sample cpm.

b. Determine activity as follows.

If cfm is used, convert to milliliters

sample volume = flow rate (cfm) x time (min.) x 2.83×10^4 (conversion factor)

$$\text{uCi/ml} = \frac{\text{(sample cpm) - (bkg cpm)}}{\text{(sample volume)}(2.22 \times 10^6)(C_{eff})}$$

* If (sample cpm) - (bkg cpm) is less than the Minimum Dectectable Counts (MDC), than use the MDC in its place.

NOTE: The MDC is located on the Daily Instrument Checklist, Form ISP-4A.

3.3 Submit completed Form ISP-4A to the RSO for review.

DAILY INSTRUMENT CHECKLIST

ISP-3A

INSTRUMENT:_____ SER#:_____ EFF.:_____ CAL DUE:_____

DATE	BKG CPM	SOURCE CPM	MDC	SETTINGS	INITIALS

1. Count background for 20 minutes.
2. Count source for 5 minutes.
3. Note H.V. setting for MS-3 / Peak Energy for Spectroscalar.

Performed by: _____ Date: _____

Reviewed by RSO:_____ Date: _____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

DAILY CHECKLIST

ISP-4 Rev. 01/95

1.0 PURPOSE: To provide a formal checklist for daily routine checks of equipment functions and safety instruments.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 These checks are to be performed each working day that Isotope Shop personnel are in the facility.

2.2 If gamma alarm light is flashing red or an audible alarm is heard, do not enter the area until a survey meter check verifies the degree and source of radiation.

3.0 INSTRUCTIONS:

3.1 Enter week starting and ending dates on Form ISP-5A.

3.2 As each check is performed, the individual shall initial in the appropriate day block.

3.3 Any problems encountered during a check will be noted in the Comments section of the form and reported to the RSO.

3.4 Any check not performed (day off, instruments not used, etc.) should be marked N/A for that day.

3.5 At the end of the week, submit the completed form to the RSO for review.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

DAILY CHECKLIST

ISP-4A

Week starting:_____
Week ending:_____

	MON	TUE	WED	THU	FRI	SAT	SUN
Inspect air monitor chart for abnormal readings.	___	___	___	___	___	___	___
Air monitor time delay @5 min	___	___	___	___	___	___	___
Cell/Cell Control Area manometer reading 0.2-0.4.	___	___	___	___	___	___	___
Six Alarm board alarm lights dimly lit. None brightly lit.	___	___	___	___	___	___	___
Green light-Cell Control Area gamma alarm.	___	___	___	___	___	___	___
Green light-ISA gamma alarm.	___	___	___	___	___	___	___
Boiler-A/C system functioning.	___	___	___	___	___	___	___
Green light-Clean Equipment Room gamma alarm.	___	___	___	___	___	___	___
Blowdown air compressors	___	___	___	___	___	___	___
Stack sampler flow & pressure.	___	___	___	___	___	___	___
Well counter & scaler checks.	___	___	___	___	___	___	___
Inventory check sources.	___	___	___	___	___	___	___
Response check survey inst.	___	___	___	___	___	___	___

COMMENT:_____

_____

_____

_____

_____

_____

Performed by: _____ Date: _____

Reviewed by RSO: _____ Date: _____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

SEMI-MONTHLY CHECKLIST

ISP-5 Rev. 01/95

1.0 PURPOSE: To provide a formal checklist documenting the performance of routine radiological and safety monitoring functions.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 These checks are to be performed semi-monthly.

2.2 Use appropriate procedures when performing these checks.

3.0 INSTRUCTIONS:

3.1 Enter period covered on Form ISP-6A.

3.2 As each check is performed, the individual shall initial and date the appropriate block.

3.3 Any problems encountered during a check will be noted in the Comments section of the form and reported to the RSO.

3.4 At the end of the period covered, submit the completed form to the RSO for review.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

SEMI-MONTHLY CHECKLIST

ISP-5A

Period from:_____ to:_____

	INITIALS	DATE
Perform Controlled Area Survey (ISP-2)	_____	____
Test the emergency generator as follows:		
Activate generator start circuit and allow generator to run at least five (5) minutes.	_____	____
Verify alarm response.	_____	____
Return test switch to normal.	_____	____
Reset timer to five (5) minutes.	_____	____
Test battery powered emergency lighting:		
Outside Cell Equipment Room	_____	____
Outside Clean Equipment Room	_____	____
Cell Control Area	_____	____
Isotope Shop Area	_____	____
Isotope Warehouse	_____	____
Cage Area	_____	____

COMMENT:_____

_____

_____

_____

_____

_____

_____

_____

Preformed by: _____ Date: _____

Reviewed by RSO:_____ Date: _____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

MONTHLY CHECKLIST

ISP-6 Rev. 01/95

1.0 PURPOSE: To provide a formal checklist documenting the performance of routine radiological and safety monitoring functions.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 These checks are to be performed monthly.

2.2 Keep Cobalt-60 source in shield when not in use. Do not point active end at any part of the body.

3.0 INSTRUCTIONS:

3.1 Enter the month and year on Form ISP-6A.

3.2 As each check is performed, the individual shall initial and date the appropriate block.

3.3 Any problems encountered during a check will be noted in the Comments section of the form and reported to the RSO.

3.4 At the end of the month, submit the completed form to the RSO for review.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

MONTHLY CHECKLIST

ISP-6A

Month:_____ Year:_____

	INITIALS	DATE
Restricted Area surveys (ISP-2)	_____	____
Air monitor system check (ISP-7)	_____	____
Test operation of gamma alarms by placing the Cobalt-60 source at the distance determined by computerized program. Attach computerized printout.	_____	____
Isotope Shop visual	_____	____
Cell Control Area audible and visual	_____	____
Clean Equipment Room visual	_____	____
WHUT Room integrity visual	_____	____
Emergency generator battery check (ISP-10)	_____	____
Visual inspection of Hot Cell and Isotope Shop exhaust fans, HEPA filter systems and associated ductwork.	_____	____
Change out extremity TLDs	_____	____
Change out area TLDs	_____	____
Conduct a fire and safety check of facility	_____	____

COMMENT:_____

_____

_____

_____

_____

_____

_____

Performed by: _____ Date: _____

Reviewed by RSO: _____ Date: _____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

AIR MONITOR SYSTEM CHECK

ISP-7 Rev. 01/95

1.0 PURPOSE: To ensure that the air monitor system is functioning properly.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure is a routine safety check. It is to be performed monthly or any time there is an abnormal increase on the monitor.

2.2 The filter paper removed is to be considered a contaminated item. Proper handling procedures must be followed to limit personnel exposure and to prevent the spread of contamination.

2.3 The RSO is to be promptly notified of any system malfunctions.

3.0 INSTRUCTIONS:

3.1 Shut down the air sample vacuum pump.

3.2 Advance the filter paper and remove the old filter. Record the date and time on Form ISP-8A.

3.3 Restart the air vacuum pump.

3.4 Determine the total elapsed time (in minutes) since the last check was performed.

3.5 Calculate the total volume of air in milliliters.

Volume of air = Flowrate x Elapsed time.

Flowrate = 4 cfm or 1.133×10^5 ml/min.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.6 Count the old filter in a well counter and record the activity in cpm on Form ISP-8A.

3.7 Calculate activity per ISP-4.

3.8 Calculate the average concentration of activity in the discharged air as follows:

$$uCi/ml = \frac{\text{filter cpm - bkg cpm}}{(\text{total volume})(2.22 \times 10^{6})(C_{eff})}$$

3.9 The average concentration of discharged air should not exceed 5×10^{-11} uCi/ml.

3.10 Record all information of Form ISP-8A and submit the form to the RSO for review.

AIR MONITOR SYSTEM CHECK

ISP-7A

SAMPLE DATA

DATE:_____ TIME:_____

DATE LAST CHECK:_____ TIME:_____

TOTAL ELAPSED TIME:_____minutes

TOTAL VOLUME:_____milliliters

COUNTING DATA

COUNTER:_____ SER #:_____ CAL DUE:_____

EFF:_____ BKG:_____ MDC:_____*

COUNTED BY:_____DATE/TIME:_____

GCPM:_____ CCPM:_____ ACTIVITY:_____uCi/ml

$$\text{ACTIVITY} = \frac{\text{CCPM}}{(2.22 \times 10^6)(C_{eff})(\text{volume})}$$

COMMENTS:_____

_____

_____

_____

_____

_____

_____

*Ref: ISP-4

Performed by: _____ Date: _____

Reviewed by RSO: _____ Date: _____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

AIR MONITOR CALIBRATION

ISP-8 Rev. 01/95

1.0 PURPOSE: To ensure that the air monitor system is functioning properly.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure is a routine safety check. It is to be performed quarterly.

2.2 Use care when handling source to prevent damage.

3.0 INSTRUCTIONS:

3.1 Notify ADT prior to performing this procedure.

3.2 Set alarms at the maximum set points to avoid spurious alarms.

3.3 Record background level for ten (10) minutes by removing probe from air monitor. Use extreme caution to protect the probe and associated wiring from damage.

3.4 Set the ratemeter to X10 range.

3.5 Place the source against the probe face and allow the system to record for ten (10) minutes.

3.6 Determine detector efficiency (C_{eff}) as follows:

$$C_{eff} = \frac{\text{Source cpm - Background cpm}}{\text{dpm of Source}}$$

3.7 Compare the ratemeter, chart recorder and ampmeter for similar readings.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.8 Set the alarm trip points to a value slightly below the source readings and verify proper alarm responses on the Master Alarm Panel and ADT Control Panel.

3.9 Remove the planchet source, replace the probe and set the alarm set point as follows:

Sample Volume (SV) is based on continuous operation for twenty four (24) hours at four (4) cfm, therefore;

$$SV = 4\ \frac{cf}{min} \times 24\ hrs \times \frac{60\ min}{hour} \times 2.83 \times 10^{4}\ \frac{ml}{cf} \quad \text{or,}$$

Sample Volume = 1.63×10^{8} milliliters

$$C_{cpm} = (1.0 \times 10^{-8})(SV)(2.22 \times 10^{6})(C_{eff})$$

C_{cpm} is the value above background that the alarm set point should be set.

3.10 Report any discrepancies to the RSO immediately for the appropriate actions or repairs.

NOTE: The ratemeter is calibrated separately every six (6) months.

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

PORTABLE AIR SAMPLES

ISP-9 Rev. 01/95

1.0 PURPOSE: To provide a standardized method of monitoring airborne contamination levels under various working conditions.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Air samples shall be performed during, but not limited to, the following:

a. Hot Cell opening.

b. Work performed in areas having >40,000 dpm/100cm^2 loose surface contamination.

c. Work in areas where the potential exists to exceed 1.0×10^{-8} uCi/ml airborne activity.

d. As directed by the RSO.

2.2 Use care when handling air samples to prevent the spread of contamination or cross-contaminating samples.

3.0 INSTRUCTIONS:

3.1 All portable air samplers should be operated in accordance with the manufacturers instructions.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.2 The air sample should be taken as close as practicable to the breathing zone for the area where the work is being performed. All steps possible shall be taken to ensure the most representative sample is obtained. If an air sample in the breathing zone is impractical, place the air sampler down wind of the work area, but as close as possible to the work area without interfering with personnel.

3.3 Complete the appropriate section of the Internal Exposure Tracking Form, Form ISP-9A for each individual that the air sample was taken for.

3.4 Calculate activity per ISP-3.

3.5 Calculate air sample concentration as follows:

$$uCi/ml = \frac{\text{sample cpm - bkg cpm}}{(\text{sample volume})(2.22 \times 10^{6})(C_{eff})}$$

3.6 In twenty four (24) hours, calculate the activity of the sample again and record the results.

3.7 Complete Form ISP-9A, for BZAs, or Form ISP-9B, for general area air samples, as appropriate.

3.8 Submit Form ISP-9A or 9B to the RSO for review.

INTERNAL EXPOSURE TRACKING

ISP-9A

NAME:_____ SSN:_____

SAMPLE DATE:_____ RWP:_____

SAMPLER DATA

SAMPLER:_____ SER #:_____ CAL DUE:_____

FLOW RATE:_____ VERIFIED BY:_____ DATE/TIME:_____

TIME ON:_____ TIME OFF:_____ TOTAL TIME:_____

TOTAL VOLUME:_____milliliters

COUNTING DATA

COUNTER:_____ SER #:_____ CAL DUE:_____

EFF:_____ BKG:_____ MDC:_____*

COUNTED BY:_____DATE/TIME:_____

GCPM:_____ CCPM:_____ ACTIVITY:_____uCi/ml

$$\text{ACTIVITY} = \frac{\text{CCPM}}{(2.22 \times 10^{6})(C_{eff})(\text{volume})}$$

24 HOUR DECAY:_____uCi/ml

DAC-HR CALCULATION

Performed by:_____ DATE/TIME:_____

DAC-HR:_____ INTAKE:_____uCi

$$\text{DAC-HR} = \frac{\text{Activity} \times \text{Time (hrs)}}{1.0 \times 10^{-8}}$$

INTAKE = (Time min.) X (2.0×10^{4} ml/min) X (Activity)

* Ref: ISP-4

Reviewed by RSO:_____ Date:_____

AIR SAMPLE CALCULATION

ISP-9B

LOCATION:_____

SAMPLE DATE:_____ RWP:_____

SAMPLER DATA

SAMPLER:_____ SER #:_____ CAL DUE:_____

FLOW RATE:_____ VERIFIED BY:_____ DATE/TIME:_____

TIME ON:_____ TIME OFF:_____ TOTAL TIME:_____

TOTAL VOLUME:_____milliliters

COUNTING DATA

COUNTER:_____ SER #:_____ CAL DUE:_____

EFF:_____ BKG:_____ MDC:_____*

COUNTED BY:_____DATE/TIME:_____

GCPM:_____ CCPM:_____ ACTIVITY:_____uCi/ml

$$\text{ACTIVITY} = \frac{\text{CCPM}}{(2.22 \times 10^6)(C_{eff})(\text{volume})}$$

24 HOUR DECAY:_____uCi/ml

COMMENTS:_____

_____

_____

_____

_____

*Ref: ISP-3

Performed by: _____ Date:_____

Reviewed by RSO: _____ Date:_____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

EMERGENCY GENERATOR BATTERY CHECK

ISP-10 Rev. 01/95

1.0 PURPOSE: To ensure that the battery used to start the emergency generator is in good working order.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Observe all posted instructions when working in Controlled Areas.

3.0 INSTRUCTIONS:

3.1 Check battery terminals for corrosion and clean as necessary.

3.2 Check battery terminals for tightness to ensure there is no slippage.

3.3 The battery is a maintenance-free type and requires no water.

3.4 If battery performance is suspect, check battery voltage with a voltmeter to ensure proper level of charge. If battery is less than twelve (12) volts, check operation of the battery charger.

3.5 Report any problems to the RSO to determine actions necessary to correct any discrepancies.

3.6 Document battery check on Form ISP-6A.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

ENTERING THE HOT CELL

ISP-11 Rev. 01/95

1.0 PURPOSE: To provide for proper evaluation of the radiation hazard to personnel and to insure that all work performed is planned before exposure takes place.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure is to be followed each time the Hot Cell door is opened.

2.2 The Hot Cell is a Restricted Area of high activity. All safety procedures are to be followed in order to keep personnel exposure ALARA.

2.3 This procedure requires a minimum of three (3) individuals.

1. One to enter the Hot Cell.
2. One to act as an assistant.
3. One in the Cell Control Area to monitor activities and time.

2.4 Badges, dosimeter and survey meter should be sealed in plastic bags to prevent contamination.

2.5 The RSO must be physically present to supervise the operation and to verify that the Hot Cell entry operation is reasonably safe to prevent an overexposure.

2.6 No individual should enter the Hot Cell unless they have been adequately trained.

2.7 An RWP is required for all work inside the Hot Cell.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Preparations for an Entry

3.1.1 All isotopes must be placed in the shielded floor containers and the container lids put in place.

3.1.2 The Hot Cell should be remotely decontaminated as completely as practicable. The remote manipulators are to be used to wipe all accessible areas.

3.1.3 Remove all waste that can be passed out through the Hot Cell ports.

3.1.4 An air sample should be taken as per ISP-9.

3.1.5 Perform a radiation survey of the expected work area(s) using a remote instrument and probe.

3.1.6 A plan of action shall be formulated and approved by the RSO. It must include the following:

a. The tasks to be performed should be evaluated to minimize personnel exposure.

b. Personnel radiation exposure records should be reviewed to insure that the exposure limits of 10CFR20.1201 will not be exceeded. The alarming dosimeters will be set to alarm at an accumulated dose equal to one half (1/2) (4500mrem minus total dose for the year) or as determined by the RSO. When the alarming dosimeter alarms, the individual should immediately leave the Hot Cell and not reenter until the exposure is assessed and a determination is made that it is safe to reenter.

c. Individuals will be assigned specific tasks to perform.

3.1.7 The plan of action will be reviewed with all participants. As needed, additional training will be offered in the proper techniques to be used as well as in the operation of equipment.

3.2 Opening the Hot Cell

3.2.1 Maintain communications via intercom for the complete entry.

3.2.2 Open the Hot Cell door. This requires simultaneous operation of the two (2) interlock switches - one on the Hot Cell door and one in the Cell Control Area.

3.2.3 Verify radiation levels by taking a survey meter reading at the door opening. If the radiation level is less than 20R/hr, work may proceed.

CAUTION: If the reading is greater than 20R/hr, then the door must be closed immediately and personnel must withdraw to the Isotope Shop Area. Further efforts to remotely decontaminate the Hot Cell will be made. If this fails, all further action must be submitted to and approved by the Chairman of the Isotope Committee.

3.3 Entering the Hot Cell

3.3.1 Unless unavoidable, only one individual should be in the Hot Cell at any particular moment.

3.3.2 The time that an individual is in the Hot Cell should be monitored by the individual in the Cell Control Area.

3.3.3 Personnel should monitor exposure periodically as directed by the RSO.

3.3.4 Complete the work assignment.

3.4 Close the Hot Cell Door

3.4.1 Protective clothing is to be removed on the contaminated side of the step-off pad.

3.4.2 Perform a whole body frisk at determined frisking station.

3.4.3 Notify the RSO of any abnormalities.

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

EXHAUST FILTER CHANGE IN THE CELL MACHINERY ROOM

ISP-12 Rev. 01/95

1.0 PURPOSE: To provide a detailed description of a routine maintenance task that must be performed in a High Radiation Area. To insure that proper protective measures are taken.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure is to be followed each time the filters are changed.

2.2 The Cell Machinery Room is a Restricted Area of relatively high activity. Changing filters may create high levels of airborne contamination.

2.3 This procedure requires a minimum of two (2) individuals.

a. One to enter the Cell Machinery Room.
b. One who remains outside and acts as an assistant.

2.4 A breathing zone air sample shall be taken during the entire working period.

2.5 Film badges, dosimeters and survey meter must be sealed in plastic bags to prevent contamination.

2.6 A specific RWP is required for this job.

2.7 The RSO or designee shall monitor this entire operation.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Ensure all isotopes in the Hot Cell are removed or placed in the shielded floor containers.

3.2 Tape plastic or wrapping paper over the landings and steps immediately outside the Cell Machinery Room.

3.3 All doors in the area shall be kept closed at all times except for necessary passage of personnel or equipment and supplies.

3.4 Enter the room and evaluate the radiation level using a calibrated high range detector. A pre-entry air sample is not required for this particular job. The individual acting as the assistant also monitors the time.

3.5 Notify ADT that the fans will be shut down.

3.6 Begin the breathing zone air sample.

3.7 Re-enter the room and commence work.

3.8 With the fans running, the exposed ductwork on the intake side of the filters should be tapped to loosen dust particles. The fans will draw the particles into the filters.

3.9 Shut down the Hot Cell fans.

3.10 Filter removal.

3.10.1 Remove the bolts from the side to the Hot Cell HEPA shroud. Take care not to drop the shroud cover.

3.10.2 Carefully remove the prefilter on the right side of HEPA by sliding it toward you.

3.10.3 Place the prefilter in a plastic bag.

3.10.4 Remove the top and bottom latches for the HEPA filter.

3.10.5 Draw the filter out, placing the pre-cut cardboard cover on the intake side.

3.10.6 Place the filter into a plastic bag held by the assistant at the doorway. Take care not to contaminate the outside of the bag by allowing it to be touched by either the filter or the individual inside the room.

3.10.7 Seal the bag and place it in a special radioactive filter box.

3.10.8 The assistant now seals the box and sets it on a piece of paper as far away as possible.

3.11 Record personal dosimeter readings and resurvey the area. The RSO will review these readings and authorize further work.

3.12 Filter installation.

3.12.1 The new filter is passed into the room and installed, paying close attention to the proper direction of airflow.

3.12.2 Install a new prefilter.

3.12.3 Bolt the filter into place, grease the fan motor and examine the belts for proper tension and wear. Replace the belts, if necessary.

3.12.4 Place the fan back into operation. Verify that it is operating properly. Check the pressure differential and record the reading.

3.13 Shut down the Lab exhaust fan.

3.14 Repeat steps 3.10, 3.11 and 3.12.

NOTE: The filters for this fan are a bank of four (4) in a 2 X 2 array, mounted on a cart which rolls out from the shrouds. When the new filters are installed, it is necessary to tape the joints between filters to prevent leakage.

3.15 Stop the breathing zone air sample, remove the filter paper and package for evaluation.

3.16 Job completion.

3.16.1 Remove trash and tools from the area.

3.16.2 Remove protective clothing and place it in the waste receptacle inside the HEPA Room. Step out of the area and shut the door.

3.16.3 Place respirator in a separate bag and seal the bag.

3.16.4 Place the shoes in a third plastic bag and seal the bag.

3.16.5 Put on clean coveralls.

3.16.6 Carefully remove the taped down paper or plastic and seal it inside a plastic bag.

3.16.7 Place all waste bags inside waste disposal cartons and seal the cartons.

3.16.8 Perform a whole body frisk before leaving the area.

3.16.9 Proceed to the Locker Room for removal of coveralls, another whole body frisk and donning of street clothes.

3.16.10 Notify ADT that the fans are again operational.

3.16.11 Perform a contamination survey of the steps to the Cell Machinery Room, the floor of the outer area and in any other area where personnel involved in this operation may have walked.

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

RECEIPT OF RADIOACTIVE MATERIAL

ISP-13 Rev. 01/95

1.0 PURPOSE: It is the intent of this procedure to meet the requirements of 10CFR20.1906 for receipt of radioactive material.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure applies to all incoming shipments of radioactive material.

2.2 This procedure should be performed within three (3) hours of receipt of shipment.

3.0 INSTRUCTIONS:

3.1 Prior to removing package from transport vehicle:

3.1.1 Inspect container, markings and shipping papers. Note radiation levels.

3.1.2 Report any discrepancies to driver and RSO.

3.1.3 Record the carrier name, trailer number, shipper and city of origin on the Radioactive Material Receipt, Form ISP-13A.

3.2 Survey Procedures

3.2.1 Record the following on Form ISP-13A:

a. Package contact radiation levels.

b. Radiation level at one (1) meter from package.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

---

c. Contamination levels on package surfaces.

NOTE: When practical, the survey should be performed prior to signing any receipt forms from the carrier.

3.3 Move the container to the Isotope Warehouse for further disposition.

3.4 If a radioactive source is included in the shipment, record the next R# in the upper right hand corner of Form ISP-13A. (R# can be found in the Returned Source Logbook.)

3.5 If the container is empty, note this in the upper right hand corner of Form ISP-13A.

3.6 Complete the balance of Form ISP-13A and forward to the RSO for review and filing.

RADIOACTIVE MATERIAL RECEIPT

ISP-13A

R#_____

Carrier Name:_____ Trailer No.:_____

Name of Shipper:_____

City of Origin:_____

RADIATION SURVEY

_____mR/hr on contact (200mR/hr maximum)

_____mR/hr @ 1 meter from surface (10mR/hr maximum)

CONTAMINATION CHECK

Container surface _____dpm/100ccm^2 (220 maximum)

Truck bed _____dpm/100cm^2 (220 maximum)

ISOTOPE RECORD

Isotope Name: _____ Form: _____

Curies _____ on _____

RECORDS

Container Type: _____ Container Ser.#: _____

Source Cat.#: _____ Source Serial or Capsule #: _____

COMMENTS: _____

_____

_____

_____

Received by: _____ Date: _____

Reviewed by RSO: _____ Date: _____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

ALARA PROGRAM

ISP-14 Rev. 1/95

1.0 PURPOSE: AMS is committed to keeping exposures (individual and collective) As Low As Reasonably Achievable (ALARA). In accord with this commitment, we hereby describe an administrative organization for radiation safety. The organization will include an Isotope Committee and a Radiation Safety Officer (RSO).

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Modifications to operating and maintenance procedures and to equipment and facilities will be made where they will reduce exposures unless the cost, in our judgement, is considered to be unjustified. We will be able to demonstrate, if necessary, that improvements have been implemented where reasonable. Where modifications have been recommended but not implemented, we will document the reasons for not implementing them.

2.2 In addition to maintaining doses to individuals as far below the limits as is reasonable achievable, the sum of the doses received by all exposed personnel will also be maintained ALARA. It would not be desirable, for example, to hold the highest doses to individuals to some fraction of the applicable limit if this involved exposing additional people and significantly increasing the sum of radiation doses received by all involved individuals.

2.3 We will inform our personnel of our commitment to the ALARA concept.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Isotope Committee

3.1.1 The Isotope Committee should include representatives from management, safety, engineering, purchasing and the RSO.

3.1.2 The Isotope Committee should meet quarterly.

3.1.3 Duties and responsibilities.

a. Be familiar with all pertinent NRC regulations, the terms of the license, its amendments and supporting documents.

b. Determine the need for license amendments, review the content of all proposed amendments and insure that the license is amended prior to implementation of changes.

c. Review and approve all requests for purchase and use of radioactive material within the company.

d. Review the qualifications of all individuals who use radioactive material to insure that they are capable of performing their duties safely and in accordance with the regulations and the conditions of the license.

e. Delegate to the RSO the authority to enforce safe plant operation and the ALARA Program.

f. Support the RSO in those instances where it is necessary to assert his authority. Where the RSO has been overruled, the Isotope Committee will record the basis for action in the minutes of the quarterly meeting.

g. Encourage all employees to review current procedures and develop new procedures, as appropriate, to implement the ALARA concept.

h. Perform a quarterly review of occupational radiation exposure. The principal purpose of this review is to assess trends in occupational exposure as an index of the ALARA Program quality and to decide if action is warranted.

i. Evaluate the company's overall efforts for maintaining exposures ALARA on an annual basis. This review will include the efforts of the RSO, authorized users and workers as well as those of management.

j. Recommend remedial action to correct any deficiencies identified in the radiation safety program.

k. Maintain written records of all committee meetings, actions, recommendations and decisions. The RSO should retain the records.

l. Relative to the isotope operation, approve all new operating procedures or changes to existing operating procedures.

3.2 Radiation Safety Officer (RSO)

3.2.1 The RSO shall have knowledge of the origin of radiation exposures in the facility.

3.2.2 Periodic reviews.

a. Perform an annual review of the radiation safety program for adherence to ALARA concepts. Reviews of specific procedures may be conducted on a more frequent basis.

b. Review at least quarterly the radiation exposures of authorized users and workers to determine that their exposures are ALARA.

c. Review radiation level survey records qarterly. The RSO will review the radiation levels in Controlled and Restricted Areas to determine that they were at ALARA levels during the previous quarter.

3.2.3 Education responsibilities for ALARA Program.

a. The RSO will schedule briefings and educational sessions to inform workers of ALARA Program efforts.

b. The RSO will ensure that authorized vendors, workers and ancillary personnel who may be exposed to radiation will be instructed in the ALARA philosophy and informed that management, the Isotope Committee and the RSO are committed to implementing the ALARA concept.

3.2.4 Cooperative efforts for development of ALARA procedures.

a. The RSO will be in close contact with all users and workers in order to develop ALARA procedures for working with radioactive materials.

b. The RSO will establish procedures for receiving and evaluating the suggestions of individual workers for improving health physics practices and will encourage the use of those procedures.

3.2.5 Reviewing instances of deviation from good ALARA practices.

a. The RSO will investigate all known instances of deviation from good ALARA practices, and if possible, will determine the causes. When the cause is known, the RSO will evaluate changes in the program to maintain exposures ALARA.

3.2.6 Equipment and supplies.

a. The RSO is responsible for insuring that proper equipment and supplies are available, maintained in good working order and are used properly.

3.3 Persons Who Receive Occupational Radiation Exposure

3.3.1 The workers will be instructed in the ALARA concept and its relationship to working procedures and work conditions.

3.3.2 The workers will know what recourses are available if they feel that ALARA is not being promoted on the job.

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

CONTROL OF TRANSIENT COMBUSTIBLES

ISP-15 Rev. 1/95

1.0 PURPOSE: To establish the administrative controls for the use of essential transient combustible materials, the temporary staging of transient combustibles and control of hot work (i.e., welding and cutting operations).

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure applies to transient combustible materials placed or staged inside a Controlled Area.

2.2 Limitations and controls are placed on transient combustibles to avoid unnecessary fire hazards and to prevent overtaxing fire suppression capability.

2.3 The handling, use and temporary staging of ordinary transient combustible materials or other combustible supplies shall be governed by the RSO.

2.4 The RSO is responsible for control of transient combustibles and hot work in Restricted Areas.

2.5 The RSO is responsible for review of designated storage areas to determine limitations of existing fire protection features and/or recommend additional fire protection features.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Transient Combustibles

3.1.1 General provisions for the use of transient combustibles are as follows:

a. Transient combustibles should be removed or protected from ignition sources in all areas.

b. In accordance with radwaste ALARA concerns, combustible packing materials should be removed or containerized prior to transport of the item into its appropriate storage area.

c. The use and storage of flammable and/or combustible liquids, such as copier toner and cleaning supplies, and ordinary combustibles in office areas do not require authorization by the RSO. Flammable/combustible liquids in office areas must be in their original shipping container or other approved flammable liquid container.

3.1.2 The following areas should be reviewed by the RSO prior to staging transient combustibles. In all cases, the staging is for work to be performed and not for storage of transient combustibles.

a. Isotope Shop Area.

b. Hot Cell Ventilation Room.

c. Clean Equipment Room.

d. Decontamination Room.

e. Basement Areas.

f. Isotope Airlock.

3.2 Special Requirements for Handling Flammable Liquids

3.2.1 All AMS employees must follow the guidelines for handling flammable liquids.

a. When flammable liquid is being dispensed, a well ventilated area, free from possible ignition, should be provided between the dispensing equipment and the container being filled.

b. All spills involving flammable liquids must be disposed of quickly and safely by appropriate means such as absorption and cleaning. Spills should be reported to the RSO immediately.

NOTE: Any material used to clean a spill should be disposed of properly.

c. While flammable liquids are not being used, the contents should remain covered in their containers.

d. Smoking should not be permitted in any area where flammable liquids are stored or handled.

e. UL listed safety cans should be used for storing and dispensing small quantities of flammable liquids in the facility.

f. When not in use, safety cans containing flammable liquids should be stored in a flammable liquids storage cabinet. Cabinets shall be labeled in conspicuous lettering "Flammable Storage Cabinet".

3.3 Special Requirements for Handling Flammable Gases

3.3.1 All AMS employees must follow the guidelines for handling flammable gases.

a. In areas where flammable gases are used and/or handled, smoking should not be permitted.

b. Flammable gases should be removed from the buildings or returned to a designated storage area upon completion of the job activity.

3.4 Special Requirements for Handling Flammable/Combustible Materials

3.4.1 Ordinary combustible limits, up to one hundred (100) pounds, are intended to identify single trash collection containers that are emptied on a regular basis. Ordinary combustibles staged to support job activities must be stored in non-combustible containers and removed at the completion of the job activity.

3.4.2 Protective clothing limits, up to fifty (50) sets, are intended to allow short term staging of protective clothing only when immediately needed to support non-routine work activities.

3.4.3 To allow for decontamination of the Hot Cell and associated equipment, approximately one (1) box of cleaning towels can be in the Hot Cell. To reduce ignition sources during source related activities, the paper towels should be removed or stored in covered containers to prevent ignition.

3.4.4 The RSO or designee should be contacted anytime flammable/combustible materials are staged in safety-related areas to determine the need for authorization.

3.5 Designated Storage Areas

3.5.1 AMS personnel in need of designated storage areas should notify the RSO for instructions.

3.5.2 The RSO or designee should inspect areas where combustibles are stored, on a monthly basis, to ensure that all containers are properly sealed.

a. This inspection should be documented on Form ISP-15A and Form ISP-15B.

b. Any deficiencies should be documented on Form ISP-15C.

3.6 Conducting Hot Work

3.6.1 All personnel should notify the RSO prior to commencing any hot work at the London Road facility. Under most circumstances, a fire watch will be utilized.

3.6.2 The primary responsibility of the fire watch is to ensure the hot work does not cause ignition of any material other than what is being worked on. This responsibility relates to the area of work and adjacent areas (i.e., other sides of walls, if the potential exists).

3.6.3 The fire watch should use appropriate protective devices and have an appropriate fire extinguisher. The fire watch should not look at flame or welding arc.

MONTHLY FIRE INSPECTION LOG

ISP-15A

FIRST FLOOR

	1		2		3		4		5		6		7		8	
	S	U	S	U	S	U	S	U	S	U	S	U	S	U	S	U
Area/Floor																
Electrical																
Housekeeping																
Non-Designated Storage																
Trans. Comb. Containment																
Fire Protection Equipment																
Observed Conditions																
Miscellaneous																

Isotope Shop should be inspected in conjunction with Restricted Area survey.

Area Description:

1. Isotope Shop, High Level Storage and Locker Room Area.
2. Cell Control Office Area.
3. Conference and Office Area.
4. Isotope Warehouse Area.
5. Loading Dock Area.
6. Cage and Count Room Area.
7. Large Warehouse Area.
8. Storage Office Area.

Comments: _____

_____

_____

_____

Performed by: _____ Date: _____

Reviewed by RSO: _____ Date: _____

MONTHLY FIRE INSPECTION LOG

ISP-15B

SECOND FLOOR, BASEMENT, ATTIC

	1		2		3		4		5		6		7		8	
	S	U	S	U	S	U	S	U	S	U	S	U	S	U	S	U
Area/Floor																
Electrical																
Housekeeping																
Non-Designated Storage																
Trans. Comb. Containment																
Fire Protection Equipment																
Observed Conditions																
Miscellaneous																

Basement, HEPA Room and Clean Equipment Room should be inspected in conjunction with Restricted Area survey.

Area Description:

1. Basement Clean/Hot Area.
2. HEPA Room Area.
3. Clean Equipment Room Area.
4. Offices/HEPA Room Area.
5. Mezzanine Office Area.
6. Second Floor Lab Area.
7. Second Floor Storage Area.
8. Attic Area.

Comments: _____

_____

_____

_____

Performed by: _____ Date: _____

Reviewed by RSO: _____ Date: _____

FIRE INSPECTION REPORT

ISP-15C

Date: _____

ELECTRICAL

Wiring/Emergency Lighting	____	Temp. Installations	____
Circuits/Fuses/Junction Boxes	____	Minimum Clearance	____
Cords/Motors/Small Appliances	____	Other	____

HOUSEKEEPING

Accumulation of Rubbish	____	Leaking Equipment	____
Work Area Cleanliness	____	Other	____

NON-DESIGNATED STORAGE

Combustible Liquids	____	Compressed Gases	____
Flammable Liquids	____	Other	____
Packing Materials	____		

FIRE PROTECTION

Fire Extinguishers	____	Fire Alarms	____
Sprinkler/Standpipe System	____	Fire Doors	____
Damaged/Blocked Equipment	____	Other	____

OBSERVED CONDITIONS

Improper Use of Flammable Liquids	____
Impaired Fire Protection Devices/Systems	____
Protective Clothing Stations/Supply Areas	____
Designated Storage Areas	____

MISCELLANEOUS

Blocked Aisleways	____	Blocked Doorways	____
Abandoned Flammables	____	Other	____
Abandoned Combustibles	____		

Description of Deficiency: _____

_____

_____

_____

Deficiency to be Resolved by RSO: _____

_____

_____

Reported by: _____ Date: _____

Reviewed by RSO: _____ Date: _____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

PREPARATION OF USED SOURCES FOR RESALE

ISP-16 Rev. 01/95

1.0 PURPOSE: To establish the inspection criterion for assuring that used sources meet the requirements of the Nuclear Regulatory Commission.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure is to be followed when preparing any used radioactive source for resale.

2.2 This inspection procedure is to be performed in the Hot Cell.

3.0 INSTRUCTIONS:

3.1 Inspection

3.1.1 Remove the outer international standard source capsule.

3.1.2 Visually examine the welded source capsule for weld defects or other damage.

3.1.3 Examine the outer capsule for damage to the threads or spanner wrench holes.

3.1.4 Any defects found shall cause the source to be rejected for resale until repairs have been made.

3.2 Leak Testing.

3.2.1 Perform a leak test of the welded source capsule per the smear test of ANSI N542 - 1977, A2.1.1 or A2.1.2.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.2.2 No source shall be resold if an activity of greater than 0.005 microcuries of removable contamination is discovered.

3.3 Reassembly.

3.3.1 If the source passes the inspection and leak testing procedures, it shall be reassembled and processed the same as a newly manufactured source.

3.4 Record Keeping Requirements.

3.4.1 Record the following used source information on Form ISP-16A:

a. Date of inspection.

b. Date of leak test and results.

c. Manufacturer's name, model and serial number.

d. Quantity of Curies contained and date of evaluation.

e. Diameter of the active source as specified by the manufacturer.

f. The measured radiation output in REM/hr.

g. Customer's name, address and license number of person or facility authorized to receive this used source.

h. For export sales, include the country and name of the facility.

3.5 Shipment of a used source shall be made only in USNRC approved packages. Packaging and labeling requirements of DOT shall be adhered to.

USED SOURCE FOR RESALE RECORD

ISP-16A

SOURCE DATA

Manufacturer's Name:_____

Model Number:_____ Serial Number:_____

Date of Inspection:_____ Leak Test Results:_____

Quantity of Curies:_____ Date of Evaluation:_____

Diameter of Active Source:_____

Radiation Level:_____REM/hour Date:_____

BUYER'S INFORMATION

* Customer:_____

_____

_____

_____

_____

_____

_____

Customer's License Number:_____

* *Include facility name, address (including country), person or facility authorized to receive the source and any other information available (i.e. phone number of responsible receiving party).*

COMMENTS:_____

_____

_____

_____

Reviewed by RSO:_____ Date:_____

ADVANCED MEDICAL SYSTEMS OPERATING PROCEDURE

AGREEMENT STATES NOTIFICATION FOR SERVICE WORK

ISP-17 Rev. 01/95

1.0 PURPOSE: To provide a uniform procedure for notification to Agreement States of the intent to install, service, repair, maintain or exchange sources in teletherapy equipment containing radioactive materials.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure is to be followed each time licensable work is required in any of the following states:

Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Illinois, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Mississippi, Nebraska, Nevada, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Oregon, Rhode Island, South Carolina, Tennessee, Texas, Utah and Washington.

2.2 Written notification is required prior to the work date.

2.3 Different states require different amounts of prior notification time. Verify the current state notification requirements by contacting the numbers listed in Attachment B.

2.4 Emergency work can be done sooner by obtaining permission via telephone and confirming in a letter.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Determine that the notification is required by referring to the flow chart in Attachment A.

3.2 Gather the following information required for notification:

3.2.1 Name and address of the hospital or job site and contact person.

3.2.2 Dates that the work will be done and the total days required to perform the work.

3.2.3 Description of the work to be done. State whether source removal is required or not.

3.2.4 USNRC license under which the work will be done.

3.2.5 Name of the service person who will be performing the work.

3.3 Make notification as follows:

3.3.1 If this is an emergency job, make a telephone call and request permission to perform the service, confirm state notification requirements for emergency service, and follow up with a confirming letter. Telephone numbers may be found in Attachment B.

3.3.2 If this is a routine job, contact the state agency for the specific notification requirements and mail a notification letter. A standard format letter may be found attached to this procedure. The letter must contain all the information in Section 3.2 as well as any additional information requested by the state agency. In addition, a copy of the NRC license must be attached to the letter. A list of current mailing addresses may be found in Attachment B.

3.4 Additional Requirements

3.4.1 Send a copy of all letters written as a result of this procedure to the RSO and to the scheduled service person.

3.4.2 Rescheduling - Once notification has been given, if the job must be rescheduled, the state must be notified by telephone and informed of the changes. Individual states may require corrected written notification.

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

SOURCE INSTALLATION AND EXCHANGE PROCEDURES USING CATALOG 3320-3320 AR LOADING AND EXCHANGE CONTAINERS AT AUTHORIZED THIRD PARTY FACILITIES

ISP-18 Rev. 1/95

1.0 PURPOSE: To provide a procedure for the safe transfer or exchange of high output Cobalt 60 sealed sources at authorized third party facilities.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure is applicable to source transfers or exchanges performed at customer sites on a variety of Picker and AMS manufactured teletherapy/radiography equipment.

2.2 This procedure requires two (2) individuals, a Class 1 Service Engineer and an assistant. The Class 1 Service Engineer has been specifically approved by the NRC to perform this procedure. The person assisting must be agreeable to the task and have received Part 19.12 training for this procedure.

2.3 Sources should be exchanged only by, or in the physical presence of, persons specifically licensed by the NRC or an agreement state to perform these operations.

2.4 An individual licensed to perform source exchanges may perform only those operations described in the procedures.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

2.5 The person making the exchange is obligated to refuse to make an exchange should any condition or action present a situation wherein the exchange cannot be made within the limitations of these procedures.

2.6 Prior to the commencement of the operations outlined in this procedure, the licensee for whom the exchange is being performed will relinquish control over the use of, and the keys for, the equipment and its Controlled Areas to the licensed person performing the exchange. At such time as the source has been exchanged, and it has been determined by the licensed person performing the exchange that the equipment is in safe operating condition, control of the equipment and Controlled Areas will be returned to the licensee.

2.7 At certain times during this procedure (specifically during the actual source transfer), the Class 1 Service Engineer will be alone in the room. During these periods, it is important that communication between the engineer and assistant be maintained.

a. Visual communication may be possible by utilizing the closed circuit television equipment that is often installed in the room.

b. Audio communication may be possible by utilizing an intercom system.

3.0 INSTRUCTIONS:

3.1 Equipment Required

3.1.1 The following equipment is either shipped with the 3320/3320AR exchange container or hand carried to the job site:

1 - Audible Detector
1 - Victoreen 491 (or equivalent) survey meter
1 - Nuclear Associates Minimonitor II (or equivalent) survey meter
2 - 200mR Pocket Dosimeters
2 - 5R Pocket Dosimeters
1 - Dosimeter Charger
1 - Drawer "T" Handle
2 - Pair Disposable Gloves
1 - Pushrod Extension
1 - Swivel for Pushrod Extension
1 - Spring Loaded Pushrod Support

1 - Brass Head to Container Adapter
1 - Service Manual for specific unit
1 - Cable hoist, hand ratchet type (1/2 ton capacity minimum)
1 - Sling
Generous supply of paper towels, plastic bags and masking tape
Hand tools, as required
Hardware, as required
Shipping tags, labels and placards, as required

3.1.2 The following additional equipment is shipped only as needed:

1 - Hanger pull
1 - Collimator Lifting Fixture, service tools
1 - Head Tilting Wrench
1 - Head Bearing Locking Screws
1 - 1/2" Impact Wrench

3.2 Inspection and Source Exchange Container

NOTE: This procedure is to be followed once the source exchange container (SEC) has been removed from the shipping overpack.

3.2.1 Check the container for any signs of mishandling or damage.

a. If any damage is noted, immediately check for radiation leakage and contamination as outlined in Step 3.2.2.

b. If determined to be safe, take whatever action is necessary to repair the damage.

c. If the damage presents a safety hazard, call the Chairman of the Isotope Committee or the Radiation Safety Officer (RSO) for advice or assistance.

3.2.2 Perform a radiation survey of the container to determine if any point reads more than ten (10) mR/hr at one (1) meter.

a. If any point exceeds 10mR/hr at 1 meter, something is wrong.

b. Proceed carefully to find the cause, avoiding exposure to high radiation levels.

c. If the radiation level on the surface of the container is more than one (1) R/hr at any point, do not, under any circumstances, proceed without consulting with the Chairman of the Isotope Committee and/or the RSO.

3.2.3 Remove the bottom plate, the drawer cover plate and the top cover plate. Next, lift out the plug in the top cavity, wet smear the plug and replace the plug.

CAUTION: Keep away from the open top cavity as a highly collimated beam of radiation (10-100R/hr) is emitted when the plug is removed.

3.2.4 If any wet smear, after drying, indicates greater than 200 cpm above background, notify the RSO before proceeding.

3.2.5 Verify that the container is level and the bottom most part of the skid is between 11-3/4 inches and 12 inches above the floor.

3.3 Preparation of Unit for Source Exchange

3.3.1 Over the years, Picker and AMS have manufactured a variety of equipment involving various designs of source heads, collimators and stands, making available a large number of combinations. Refer to the appropriate manual for the unit being worked on. This procedure will deal with the handling of individual components.

3.3.2 Lock source shutter mechanism (shutter wheel) in the "beam off" position. See appropriate unit manual for locking instructions.

3.3.3 Remove the collimator (performing wet smear checks as indicated).

CAUTION: Removing a collimator creates an imbalance in the unit. Take precautions as outlined in the appropriate unit manual.

a. 3313 Series

This collimator weighs about 500 pounds. It should be maneuvered onto a soft pad on the floor or onto a "dolly" capable of handling the weight. The dust shield is part of the machine head, so no preliminary contamination check is necessary before removing.

b. 3347 Series

Take a wet smear of the periphery of the collimator bearing ring before removing. This collimator can be installed or removed in either one piece (200 lbs.) or in two pieces (100 lbs. each).

c. 3706 Series and 183435 Collimator

The collimator (but not the collimator bearing ring) may be removed before contamination check is made.

Perform a wet smear contamination check of the periphery of the collimator bearing ring before removing.

3.4 Prepare Machine Heads

3.4.1 Model #581, #581A, #581B Heads.

a. After collimator removal, pierce a small hole in the port dust shield through which a cotton swab stick can pass.

b. Take a wet smear contamination check.

c. Remove the dust shield and lead port block.

d. Insert the proper "head to source exchange container" adapter.

3.4.2 Model #583, #583A, #583B, #590, #590A and #590B Heads.

a. Remove "saddle" (where applicable) and take a wet smear of the exposed surface of the source wheel.

b. Place the appropriate "head to container" adapter on the container.

3.4.3 Model #590C, D, E, F, G and 182972A Heads.

CAUTION: Radiation leakage may be several R/hr on the bottom surface of the head when the collimator bearing ring is removed.

a. Insert the brass head-to-container adapter into the doughnut, align the center hole and secure together.

b. Immediately after the removal of the collimator and bearing ring, mount the doughnut to the bottom of the head. This will reduce the radiation leakage greatly and help to offset the imbalance condition.

3.5 Maneuver Head to Mate with Source Exchange Container

3.5.1 Model C-5000 and V-2000 Vertical-Spring Counterbalance Units.

a. Lock the yoke and head tilt movements. The stand will operate electrically and manually in the unbalanced condition.

b. Maneuver exchange container under head and lower head electrically until it is close to mating. Manually lower head until mated.

3.5.2 Model V-3000, V-4, V-8, V-9, V-10,000 - Vertical Weight Counterbalanced Units.

a. These units are delicately balanced and the head will rapidly rise to its upper limit if the collimator is removed without a restraining device. To prevent this rise, attach a cable hoist to the right side of the unit.

b. Remove the shrouds from the stand and then remove one of the 1/2-13 bolts holding the side columns to the base plate.

c. Using a longer 1/2-13 bolt, bolt the special sling provided in the kit to the column with the bolt through both loops in the ends of the sling.

d. Electrically lower the head as far as it will go.

e. Connect a cable hoist on the right hand side (viewing from the front) of the column between the sling and the top edge of the head support hanger.

f. Pull up on the hoist until it is snug.

g. The collimator may now be removed.

h. The head may be raised and lowered to mate with the container by using the cable hoist.

3.5.3 Model C-1000, C-2000, C-3000 Rotational - Magnetic Clutch Drive Units.

a. The magnetic clutch on the C-arm drive on these units will safely hold the C-arm in the vertical position after the collimator has been removed.

b. Engage the magnetic clutch.

c. Have assistant lend his weight to balance C-arm. Momentarily releasing magnetic clutch, rotate the C-arm so that the head is in the 12 o'clock position. Re-engage clutch.

d. Attach the appropriate "Head Tilting Wrench".

e. Remove the shroud from the left foot of the unit and attach cable hoist between left foot and C-arm behind head.

f. Have assistant maintain head tilting wrench horizontal. Unlock head bearing ring or yoke brake, drive or lock.

g. Take up on cable hoist lowering head to about 9 o'clock position. Maneuver container under head, insert proper adapter and mate.

3.5.4 Model C-4, C-8, C-9, C-10,000 and C-12 Rotational Chain or gear Driven Units.

a. These units can be maneuvered electrically after the collimator has been removed. Move unit in short arcs, adjusting head each time to keep bottom surface of head horizontal. Care must be taken not to damage yoke motor during mating operation. Move slowly.

b. Secure the head to the container.

3.5.5 Model C-10,000 Rotational - Chain or Gear Driven - Fixed Yoke.

a. The head must be removed from this unit to mate it with the container.

b. With the head at the 6 o'clock position, secure the yoke to hinge brackets on each side of the bed frame with chains or cable hoist. This is to keep the unit in "O" position. Using the special collimator lifting fixture and a gantry, remove the collimator and set aside on a soft pad.

c. Take a wet smear.

d. Mount special head lifting fixture to flat surface of head. Attach gantry hoist.

e. Remove head mounting bolts and index pins.

f. Lift head out of yoke and set on floor.

g. Attach lifting ears. Remove lifting fixture. Rotate head 180 degrees so that flat side is down.

h. Fix ears so head will not rotate. Lift head, insert proper adapter, and mate to container.

3.5.6 Cyclops Hydraulic Mobile and Jib Crane Stands.

a. These units can be maneuvered electrically in the unbalanced (collimator off) condition.

b. Mate head to container using proper head to container adapter.

c. Secure the head to the container.

3.5.7 Fixed Head Rotational Magnetic Clutch Drive.

a. Remove the stand covers from one side. The head will be at 5 o'clock or 7 o'clock during this operation. If at 5 o'clock, remove left hand covers. If at 7 o'clock, remove the right hand covers.

b. Check the stand to floor mounting bolts for tightness. If they are not tight, the unit could tip over during this procedure.

c. Remove shutter motor access cover from above and behind the head.

d. Remove the transformer and the cover and disconnect it from the terminal board.

e. Remove all the wires coming up from the slip rings to the terminal board.

f. Remove the stainless trim covers from the back of the head and disconnect the wires from the mercury switches and distance localizer assembly.

g. Construct a wood cradle to hold the head.

h. Swing the head around to the 5 o'clock position and position the head in the cradle (using padding to protect paint). Set the wheels of the dolly so that it can be pulled straight out away from the stand after the head is unbolted.

i. Place a 4,000 lb. come-along hook into the top of the C-arm access hole. The other hook of the come-along is fastened to the outside of the left toe. If the 7 o'clock position of the head allows more room for this procedure, the come-along is fastened to the right toe.

j. Take up on the come-along until the head rests firmly in the cradle. The come-along will prevent the barrier from swinging down once the head is removed.

k. Remove the allen screws holding the head to the ring to separate the head from the stand. When loosening the last two bolts, watch to see if the come-along tension is right. This is done by watching to see that the C-arm barrier are rigid and that the head is snug in the cradle.

l. In addition to the bolts that hold the head to the C-arm, there are two 3/8 inch centering pins holding the head. Use two screwdrivers to separate the head and C-arm.

m. The head is now pulled away from the C-arm. Pull from the dolly and not from the head or cradle. Pull the dolly straight out, or the motor assembly will be damaged. Move to an area out of the swing of the C-arm and barrier.

n. Replace the fixed head mounting ring with the rotating head mounting bearing ring and remount head. The unit can now be treated as a standard C-2000 unit with rotating head.

o. After the source exchange is completed, reverse the procedure, and remount the fixed head mounting ring.

3.6 Source Exchange Procedure Using Model 3320 AR Exchange Container

3.6.1 Perform and record a radiation leakage measurement on the surface of the top of the head. Mark the location for future reference.

3.6.2 Remove the 1/4-20 screw and square brass insert holding the bottom end of the pushrod in position. Install the pushrod extension onto the lower end of the pushrod by using a 10-32 x 1" socket head cap screw. Test for free movement of the pushrod by turning. If any binding is noticed, the screw holding the pushrod extension to pushrod is either not in far enough or is too long. The pushrod should have about 2" free vertical movement.

3.6.3 Insert the shaft of the "T" handle into the coil spring and screw this assembly all the way into the plunger, then back it out two (2) full turns. Mark the lower side of the drawer. When exchange is complete, this mark should be uppermost.

CAUTION: Do not loosen the drawer stop and pull out the drawer at this time, as this will greatly increase the radiation leakage above the container.

3.6.4 Place a Minimonitor II gamma survey meter (or equivalent) on the floor within easy view, about two (2) feet from the container. Set to X10 scale (full scale 100mR/hr). Place an audible detector at this same position.

3.6.5 Remove the shutter lock.

3.6.6 At this point, give the shutter operating key to the assistant and have him and all non-assisting personnel leave the room. The assistant should take a survey meter with him in case an emergency entrance is necessary.

NOTE: The following operations to be performed by the Source Engineer should be done from the supine position with the body kept as close to the casters of the exchange container as is possible. At no time should any part of the body, except the hands and the forearms, be raised above the bottom edge of the source drawer.

3.6.7 Loosen drawer stop screw.

CAUTION: Do not remove entirely.

3.6.8 Pull the drawer out to scribed line (approximately 1/4 inch beyond the indexing groove). Twist drawer slightly to verify that the safety bolt is in place in the drawer groove.

CAUTION: If safety bolt is not in proper place, the drawer could be inadvertently removed and the source exposed.

3.6.9 Gently push the "T" handle in as far as it will go.

3.6.10 Raise the pushrod gently until it can be felt that the source is up against the plunger tongue. Maintain this raised position and tighten the "T" handle until it stops. The spring tension of the "T" handle will hold the source in the plunger tongue. Lower pushrod.

3.6.11 Reach up with both hands and gently pull drawer out until it stops.

CAUTION: If drawer does not stop before 4-1/2 inch withdrawal, something is wrong and the drawer must be pushed back in.

3.6.12 Call to assistant to electrically open the shutter of the therapy head. The timer must be set at 30 minutes or more so that the shutter will not close during the exchange.

3.6.13 Gently raise the pushrod as far as it will travel, rotate it until its pins seat in the holes of the source capsule. (The swivel may be used for this.)

NOTE: If the pushrod will not engage the source, the shutter wheel is not in proper alignment. In this event, lower the pushrod and have the assistant close the shutter. Verify that room radiation levels are safe. Have the assistant come into the room, with the control key, and position himself above the therapy head. From this position, as directed by the source exchanger, he can manually open the shutter and adjust the stop when the pushrod engages the source.

CAUTION: The assistant should be warned to keep all portions of his body above the head to container junction.

3.6.14 Keeping a firm upward pressure on the pushrod, unscrew the old source.

a. If the old source is tight and will not unscrew with one hand pressure, place the spring loaded pushrod holder and the swivel between the pushrod and the floor.

b. Adjust spring pressure so that it takes both hands to lift it off the floor when in place under the pushrod and swivel. This frees both hands for loosening the old source.

c. If the source is still unmovable, a pipe wrench may be used on the pushrod.

NOTE: An impact wrench may also be utilized to break the source free. However, it should not be used to unscrew the source from the shutter.

3.6.15 After the source has been loosened, remove the pushrod holder again hold in place by hand. Unscrew source at least five (5) complete turns.

3.6.16 Turning the pushrod slightly, gently lower the pushrod to its bottom most position.

a. If the source is completely loose and follows the pushrod down into the container, a noticeable flash of radiation will be detected by watching the gamma survey meter as the source passes the joint between the head and the container.

b. In addition, an audible signal will be heard from the audible detector.

c. If no "flash" is noticed, the source did not follow the pushrod down, and the operation of unscrewing and lowering should be repeated until successfully completed.

3.6.17 With two hands, gently push the drawer in until the scribe line is just visible.

a. Unscrew the "T" handle two (2) full turns and release the new source from the plunger.

b. Lower pushrod to bottom most position (approximately 2" protruding from container).

3.6.18 Gently push the drawer into the innermost position. If necessary to close drawer, remove the pushrod extension.

NOTE: If pushrod pins are no longer in old source pinholes, the drawer will not close. Rotate pushrod to correct.

a. Slip the drawer stop over the end of the drawer and tighten the screw holding it in place.

b. Both sources are now safely stored in the exchange container and the radiation background should not be more than 20mR/hr at one (1) meter from the surface. Verify this with the survey meter.

3.6.19 Have the assistant close the shutter. Take possession of the shutter key.

3.6.20 Verify that the source has been removed from the head by surveying the top of the head.

3.6.21 If a Five Year Inspection and Preventive Maintenance is to be performed, proceed to perform the head and shutter related items at this time.

3.6.22 Once the head is reassembled, verify that the shutter mechanism is operating properly, then proceed to install the source.

3.6.23 Place a Minimonitor II gamma survey meter (or equivalent) on the floor within easy view about two (2) feet from the container. Set to X10 scale (full scale 100mR/hr). Place an audible detector on this same position.

3.6.24 At this point, give the shutter operating key to the assistant and have him and all non-assisting personnel leave the room. The assistant should take a survey meter with him in case an emergency entrance is necessary.

NOTE: The following operations to be performed by the Source Engineer should be done from the supine position with the body kept as close to the casters of the exchange container as is possible. At no time should any part of the body, except the hands and the forearms, be raised above the bottom edge of the source drawer.

3.6.25 Loosen drawer stop screw.

CAUTION: Do not remove entirely.

3.6.26 Pull the drawer out to scribed line (approximately 1/4 inch beyond the indexing groove). Twist drawer slightly to verify that the safety bolt is in place in the drawer groove.

CAUTION: If safety bolt is not in proper place, the drawer could be inadvertently removed and the source exposed.

3.6.27 Gently push the "T" handle in as far as it will go.

3.6.28 Re-install pushrod extension and raise the gently until it can be felt that the new source is up against the plunger tongue. Maintain this raised position and tighten the "T" handle until it stops. The spring tension of the "T" handle will hold the source in the plunger tongue. Lower the pushrod and old source.

3.6.29 Reach up with both hands and gently pull drawer out until it stops.

CAUTION: If drawer does not stop before 4-1/2 inch withdrawal, something is wrong and the drawer must be pushed back in.

3.6.30 Rotate drawer 180 degrees in whichever direction it will turn (it will only turn in one direction). This puts the new source in the upper position.

3.6.31 Reach up with both hands and gently push drawer in until the scribed line is just visible.

3.6.32 Loosen "T" handle two (2) complete turns.

3.6.33 Raise the pushrod gently until it can be felt that the old source is up against the plunger tongue. Maintain this position and tighten the "T" handle until it stops. The spring tension of the "T" handle will hold the source in the plunger tongue. At this point, both the old and new sources are in the drawer plunger tongue.

3.6.34 Reach up with both hands and gently pull drawer out until it stops.

CAUTION: If drawer does not stop before 4-1/2 inch withdrawal, something is wrong and the drawer must be pushed back in.

3.6.35 Rotate drawer 180 degrees in whichever direction it will turn (it will only turn in one direction). This returns the new source to the bottom position.

3.6.36 Again reach up with both hands and gently push drawer in until the scribed line is just visible. This places the new source over the pushrod so that it may now be removed from the drawer plunger tongue. At this point, the mark that was put on the drawer when the exchange was started should again be in the original position.

3.6.37 Raise the pushrod gently until it touches the source in the drawer tongue. Rotate pushrod until the pins seat.

a. While holding the pushrod in this position, loosen the "T" handle two (2) complete turns. The source will then be released and will follow the pushrod down when it is lowered.

b. Lower the pushrod. Again tighten the "T" handle to the limit. The new source is now resting on the pushrod.

3.6.38 Reach up with both hands and gently pull drawer out until it stops. Do not rotate drawer 180 degrees.

CAUTION: If drawer does not stop before 4-1/2 inch withdrawal, something is wrong and the drawer must be pushed back in.

3.6.39 Have assistant open the shutter.

3.6.40 The path to the shutter wheel is now clear for the new source. Gently raise the pushrod until the new source touches the shutter wheel. A flash of radiation will again be noticed on the meter as the source passes the joint between the head and the container. Maintaining a firm upward pressure, turn the pushrod in a tightening direction until the source has turned at least three and a half turns and becomes as tight as possible using one hand on the pushrod cross handle. Now lower the pushrod to the bottom most position. There should be no flash of radiation noticeable on the meter if the source is threaded in the shutter wheel.

3.6.41 Have assistant close the shutter. The radiation level showing on the survey meter should drop considerably when the shutter is closed.

3.6.42 Reach up with both hands and gently rotate the drawer 180 degrees in whichever direction it will turn. This puts the old source in the bottom position. Now push the drawer inward until the scribe line is just visible.

3.6.43 Lift the pushrod gently until it touches the source in the drawer tongue.

a. While holding the pushrod in this position, loosen the "T" handle two (2) complete turns. The source will then be released and will follow the pushrod down when it is lowered.

b. Lower the pushrod.

3.6.44 Gently push the drawer into its innermost position. Slip the drawer stop over the end of the drawer and tighten the screw holding it in place.

3.6.45 Remove the 10-32 x 1" cap head screw holding the pushrod extension to the pushrod. Raise the pushrod and insert 1/4-20 hex head screw and brass block. This secures the pushrod in its shipping position.

3.6.46 Attach the shutter locking bar.

3.6.47 Take possession of shutter operating key.

3.6.48 Perform a radiation leakage survey at the top surface of the head as previously marked. If the sources have been properly exchanged, this reading should be higher than the original reading.

3.6.49 Unmate the head from the container.

CAUTION: Keep body as far as possible from the open top cavity. The radiation levels in this area may be 10 to 100R/hr.

3.6.50 Remove adapter and insert plug into the container cavity.

3.6.51 Reinstall collimator to head.

3.6.52 Perform Beam Off Head Leakage Survey using appropriate data sheet. The average leakage shall not be greater than 2mR/hr at one (1) meter from the source, with no single spot exceeding 10mR/hr.

3.6.53 Complete the Five Year Inspection and PM.

3.7 Source Exchange Procedure for 3320 and 3320B Containers

NOTE: The Model 3320 container has only one source cavity and can be used only for loading and unloading a source.

The Model 3320B container is to be used for removing or loading a single Cesium source only.

The Picker Model 3320 and 3320 AR containers are easily converted to Model 3320B containers by replacing the Cobalt pushrod with a Cesium pushrod.

3.7.1 Inspect shipping container as per Step 3.2.

3.7.2 Prepare Model 592 machine head for source transfer.

a. Remove beam defining device (cone) per instructions in Section 8 of Picker Manual T55-226.

b. Perform a wet smear contamination check of the inner most diaphragm of the "cone" holder.

c. Lock the head in the upright position by using the lever on the right hand trunnion (see Figure 3, Manual T55-226).

d. Remove the decorative covers.

e. Remove cone holder (see Figure 8, Manual T55-266).

CAUTION: When cone holder is removed, the radiation leakage will increase in this area to as much as 300mR/hr. Do not stand or place hands unnecessarily close to this area.

f. Perform a wet smear contamination check of exposed section of shutter wheel.

g. Install head to container adapter.

3.7.3 Remove the shipping container top cavity plug.

3.7.4 Move the shipping container under the head.

3.7.5 Lower the head, maneuvering the container so that the head to container adapter enters the container top cavity. Lower until firmly seated. Secure machine head to exchange container.

3.7.6 Evacuate the room and turn source to "ON" position to make sure shutter works electrically. Close shutter.

3.7.7 Source Removal.

a. Place a Minimonitor II gamma survey meter (or equivalent) on the floor within easy view, about two (2) feet from the container. Set to X10 scale (full scale 100mR/hr). Place an audible detector at this same position.

b. Remove the shutter lock.

c. At this point, give the shutter operating key to the assistant and have him and all non-assisting personnel leave the room. The assistant should take a survey meter with him in case an emergency entrance is necessary.

NOTE: The following operations to be performed by the Source Engineer should be done from the supine position with the body kept as close to the casters of the exchange container as is possible. At no time should any part of the body, except the hands and the forearms, be raised above the bottom edge of the source drawer.

d. Loosen drawer stop screw.

CAUTION: Do not remove entirely.

e. Pull the drawer out to scribed line (approximately 1/4 inch beyond the indexing groove). Twist drawer slightly to verify that the safety bolt is in place in the drawer groove.

CAUTION: If safety bolt is not in proper place, the drawer could be inadvertently removed and the source exposed.

f. Raise pushrod until it touches shutter wheel, then lower about 1/2 inch.

g. Have assistant open the shutter and note the meter reading.

h. Raise pushrod until it touches the source.

i. Rotate until it engages the source.

j. Keeping firm upward pressure, rotate the pushrod to unscrew right hand threaded source, three and a half turns (3-1/2) or more.

k. If the old source is tight and will not unscrew with one hand pressure, place the spring loaded pushrod holder and the swivel between the pushrod and the floor.

l. Adjust spring pressure so that it takes both hands to lift it off the floor when in place under the pushrod and swivel. This frees both hands for loosening the old source.

m. If the source is still unmovable, a pipe wrench may be used on the pushrod.

NOTE: An impact wrench may also be utilized to break the source free. However, it should not be used to unscrew the source from the shutter.

n. Lower pushrod and source, noting the flash of radiation, indicated by the meter, as the source passes the point between the head and the container. When the source lowers into the container, the radiation level will drop significantly. If the level does not drop, it means the source has not been removed and lowered into the container. The removal sequence should be continued until the source is in the safe position in the container.

o. Push the drawer into the container and secure drawer stop. Check the area with a survey meter to ensure all is safe.

p. Unmate the machine head and container and insert lead plug into the container top cavity.

q. Check the source cavity in head for contamination.

r. Move the container a safe distance from the work area and proceed with repairs or maintenance on the head.

3.7.8 Source installation.

a. Remate head and container.

b. Place a Minimonitor II gamma survey meter (or equivalent) on the floor within easy view, about two (2) feet from the container. Set to X10 scale (full scale 100mR/hr). Place an audible detector at this same position.

c. Remove the shutter lock.

d. At this point, give the shutter operating key to the assistant and have him and all non-assisting personnel leave the room. The assistant should take a survey meter with him in case an emergency entrance is necessary.

NOTE: The following operations to be performed by the Source Engineer should be done from the supine position with the body kept as close to the casters of the exchange container as is possible. At no time should any part of the body, except the hands and the forearms, be raised above the bottom edge of the source drawer.

e. Loosen drawer stop screw.

CAUTION: Do not remove entirely.

f. Pull the drawer out to scribed line (approximately 1/4 inch beyond the indexing groove). Twist drawer slightly to verify that the safety bolt is in place in the drawer groove.

CAUTION: If safety bolt is not in proper place, the drawer could be inadvertently removed and the source exposed.

g. Have assistant open the shutter.

NOTE: The path to the shutter wheel is now clear for the new source. Gently raise the pushrod until the new source touches the shutter wheel. A flash of radiation will again be noticed on the meter as the source passes the joint between the head and the container. Maintaining a firm upward pressure, turn the pushrod in a tightening direction until the source has turned at least three and a half turns and becomes as tight as possible using one hand on the pushrod cross handle. Now lower the pushrod to the bottom most position. There should be no flash of radiation noticeable on the meter if the source is threaded in the shutter wheel.

h. Have assistant close the shutter. The radiation level showing on the survey meter should drop considerably when the shutter is closed.

i. Gently push the drawer into its inner most position.

j. Slip the drawer stop over the end of the drawer and tighten the screw holding it in place.

k. Unmate the head from the container.

CAUTION: Keep body as far as possible from the open top cavity. The radiation levels in this area may be 10 to 100R/hr.

l. Remove adapter.

m. Reinstall cone assembly head.

n. Perform Beam Off Head Leakage Survey using appropriate data sheet. The average leakage shall not be greater than 2mR/hr at one (1) meter from the source, with no single spot exceeding 10mR/hr.

o. Complete the Five Year Inspection and PM.

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

DEPLETED URANIUM HANDLING PROCEDURE

ISP-19 Rev. 1/95

1.0 PURPOSE: To provide a procedure for the safe handling of depleted Uranium, a radioactive material, during the manufacturing process for Cobalt teletherapy equipment.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure applies to the following parts:

C-46879	Uranium Shield
B-46411	Uranium Shutter Insert
C-58429A	Top Shield
C-58531A	Barrel Shield
C-58430	Wheel Shield

These parts are purchased already cast, machined, drilled and nickel plated. They present no hazard to personnel or property.

2.2 White gloves are to be worn at all times when it is necessary to handle these parts.

2.3 All manufacturing operations shall occur at facilities which are licensed to possess and use depleted Uranium.

3.0 INSTRUCTIONS:

3.1 Receiving

3.1.1 Upon receipt of a shipment of depleted Uranium parts, open the shipping containers and verify the quantity.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.1.2 Verify that a durable tag with the Radiation Symbol and the words "Caution Radioactive Material" is affixed to each container.

3.1.3 Complete receiving report and move the parts, in the container, to the Inspection Department.

3.2 Inspection

3.2.1 Remove the parts from the container and inspect to the print. Exercise care so as not to scratch through the nickel plating.

3.2.2 After inspection, replace the parts into the container and move the container to the Stock Room.

3.3 Storage

3.3.1 The parts are to be stored in a locked cabinet or container. The cabinet or container shall be clearly marked with the Radiation Symbol and the words "Caution Radioactive Material".

3.4 Sub Assembly

3.4.1 Part C-46879

a. Remove from storage and bolt it into the brass head casting which has attached a tag with the Radiation Symbol and the words "Caution Radioactive Material".

b. Proceed to have this subassembly welded, lead filled and final machine.

3.4.2 Part B-46411

a. Remove from storage and place the part inside the shutter rotor assembly (Part D-16423B).

b. Proceed to weld, lead fill and machine this assembly.

c. Etch the assembly with the words "Caution Radioactive Shielding - Uranium".

3.4.3 Part C-58429A

a. Remove from storage and bolt the part into the brass head casting.

b. Proceed to braze the top cap of the head on, and have the subassembly lead filled and final machine.

c. Attach the Radiation Symbol tag to the head.

3.4.4 Part C-58431A

a. Remove from storage and secure with screws into the shutter plug assembly (Part D-182546A).

b. Proceed to braze, lead fill and final machine.

3.4.5 Part C-58430

a. Remove from storage and place in the shutter wheel assembly (Part E-182548).

b. Proceed to weld, lead fill and final machine.

3.5 Shipment to Vendors

3.5.1 Only vendors possessing a valid Radioactive Material license may receive these parts and subassemblies containing these parts.

3.5.2 Ship only the number of parts required for the specific job.

3.5.3 Remind the vendor that no machining of the depleted Uranium is required or permitted.

ADVANCED MEDICAL SYSTEMS OPERATING PROCEDURE

EMERGENCY PROCEDURES FOR DEPLETED URANIUM

ISP-20 Rev. 01/95

1.0 PURPOSE: To provide instructions to individuals in the event of an emergency involving depleted Uranium.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Individual safety is always the prime concern. Do not place yourself at risk.

3.0 INSTRUCTIONS:

3.1 Fire

3.1.1 In the event of a fire in an area where depleted Uranium is stored, notify the Fire Department nearest you. Upon the arrival of fire fighting personnel, caution them that radioactive material (depleted Uranium) is present, advise them of its location and of the best route to that location.

3.1.2 Notify the Radiation Safety Officer (RSO) immediately, giving him complete details.

3.1.3 Do not permit fire fighters to enter a Radiation Area after the fire has been extinguished until a thorough examination can be made to evaluate the extent of damage to the radioactive material and possible contamination.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.2 Equipment Damage

3.2.1 In the event of physical damage to equipment containing radioactive material, notify the RSO immediately. The RSO will direct an evaluation of the damage and review the plan to repair or dispose of the equipment.

3.2.2 If it is obvious that the damage can be repaired without any risk to personnel, proceed with repairs.

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

PACKAGING AND LABELING DEPLETED URANIUM PARTS AND SUBASSEMBLIES

ISP-21 Rev. 1/95

1.0 PURPOSE: To ensure that the applicable regulations regarding the shipment of depleted Uranium are met.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure applies to each shipment of a depleted Uranium part, subassembly or assembly containing such a part.

2.2 Depleted Uranium is a radioactive material. Precautions for proper handling must be followed.

2.3 Do not guess at any data required. If assistance is needed, contact the RSO.

2.4 This procedure applies to each separate package containing depleted Uranium, even if part of a larger shipment.

2.5 By the definition given in 49CFR173.403(n), Depleted Uranium (DU) is an LSA (Low Specific Activity) material. As received from our supplier, DU parts are shipped as LSA in DOT Spec 7A Type A packages.

Once the DU components are incorporated into the machine head or rotor subassemblies, they can be shipped under 49CFR173.424, Excepted Articles, if all the pertinent requirements in 173.421 and 173.421-1 are met.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Excepted Articles (assemblies and subassemblies)

3.1.1 Package the item(s) to be shipped.

3.1.2 With the survey meter, perform a survey of all exposed surfaces of the package.

a. Verify that the highest surface reading is less than or equal to 0.5mrem/hr.

b. If it exceeds this limit, then repackage the items to reduce surface readings.

c. Record the highest surface reading found.

3.1.3 Take a smear of the package surface.

a. If removable contamination does not exceed 2,200 dpm/100cm^2 then the package qualifies as an excepted article.

3.1.4 Mark the outside of the package "Radioactive".

3.1.5 Certify the package as being acceptable for shipment by having the following written notice in or on the package:

"This package conforms to the conditions and limitations specified in 49CFR173.424 for excepted radioactive material, articles manufactured from depleted Uranium, UN 2909."

3.1.6 No other labeling, shipping paper or certification requirements are required for transportation. (49CFR173.424)

3.2 LSA Material (DU Parts)

3.2.1 Package the item(s) in a DOT Spec 7A Type A package. (Ref. 49CFR178.350)

NOTE: Type A packaging must be tested per 49CFR173.465. Documentation of the testing results must be on file. (49CFR173.415)

3.2.2 Mark the outside of each package as follows:

"USA DOT 7A TYPE A"
"RADIOACTIVE MATERIAL"

NOTE: Use letters at least one half (1/2) inch high.

3.2.3 Perform a survey of all exposed surfaces of the package.

a. Record the highest surface reading found.

b. Maximum reading is 200mrem/hr. (49CFR173.441)

3.2.4 Determine the Transport Index (see 49CFR173.403 (bb)) for the package by repeating the survey at a distance of one (1) meter from each point on the package surface and rounding the highest reading up to the first decimal place. The proper label to affix to the package is based upon both the radiation level at the surface of the package and the Transport Index. (49CFR172.403 (b))

NOTE: The label to be applied shall be the highest category required for either of the above determining conditions.

Transport Index	Radiation Level (surface)	Label
0	≤0.5mrem/hr	White I
≤1.0	>0.5mrem/hr but ≤50mrem/hr	Yellow II
>1.0	>50mrem/hr	Yellow III

a. Apply two (2) of the appropriate labels to the package, on any two opposing sides.

b. Enter the Transport Index on both labels.

3.2.5 Take a smear of the package surface. Removable contamination may not exceed 2,200 dpm/100cm^2. (49CFR173.443)

3.2.6 Determine the Curie content of the packaged parts.

NOTE: The Curie content of depleted Uranium is very small.

a. Refer to the following chart for the Curie content of one (1) part:

Part #	Curie/part
46411	0.0024
46879	0.0056
58429A	0.0385
58430	0.0064
58531A	0.0039
200670	0.0079

b. Multiply the number of parts by the Curie/part.

c. Enter this number on the labels.

3.2.7 Prepare the Bill of Lading

a. Shipment of LSA material requires the use of a hazardous material bill of lading.

b. Enter the description of the radioactive material as specified in 49CFR172.101 - "Radioactive material, low specific activity, n.o.s. UN2912, U238 Depleted Uranium Solid Form."

c. Enter the Curie content.

d. Enter the category of label applied to each package in the shipment (i.e. Radioactive I, II or III).

e. Enter the Transport Index assigned to each package in the shipment bearing Radioactive II or III labels.

f. Enter the total weight of the hazardous material.

g. Sign the shippers certification statement.

3.2.8 Placarding per 49CFR173.466 is required only for Radioactive III labeled material.

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

INSTRUCTIONS TO DRIVERS WHEN TRANSPORTING RADIOACTIVE MATERIAL

ISP-22 Rev. 1/95

1.0 PURPOSE: To provide instructions to drivers of vehicles transporting radioactive material.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Briefly, your cargo is a Cobalt-60 teletherapy source containing less than 13,700 Curies of radioactive pellets. The pellets are doubly encapsulated in a stainless steel cylinder. The cylinder is contained in a tungsten outer capsule, which in turn is inside either a lead filled teletherapy machine head or source exchange container. A wood and steel overpack protects the container or head. The complete package is approved by the Nuclear Regulatory Committee.

2.2 The material is not considered to be a "Highway Route Controlled Quantity" as defined in 49CFR173.403(1).

3.0 INSTRUCTIONS:

3.1 General Requirements

3.1.1 The vehicle is required to be placarded in accordance with 49CFR177.823.

3.1.2 The driver must comply with the rules in 49CFR Parts 390-397.

3.1.3 When located on a public street, highway or on the shoulder of a public highway, the vehicle must be attended by the driver.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.1.4 The vehicle must not be operated near an open fire or parked within three hundred (300) feet of an open fire.

3.1.5 The vehicle must not be parked on or within five (5) feet of the traveled portion of a public street or highway except for brief periods when it is impractical to do otherwise.

3.1.6 When fueling the vehicle, the engine must be off and a person must be in control of the fueling process.

3.1.7 If the vehicle is equipped with dual tires on any axle, the driver must stop the vehicle at least once every two (2) hours or one hundred (100) miles, whichever is less, and examine the tires. Tires must also be examined at the beginning of each trip and each time the vehicle is parked.

3.1.8 When loading the vehicle, the radioactive package should be placed as far as practicable from the vehicle cab. If more than one package is being loaded, attempt to use low level packages as shielding for higher level packages.

3.1.9 Packages must be blocked and braced to avoid shifting of position during transport.

3.1.10 Do not remain unnecessarily in the vehicle.

3.1.11 The cargo compartment of the vehicle shall remain locked at all times during transport (including stops) except when inspections may be necessary.

3.2 Emergency Actions

3.2.1 In the event of an emergency, such as a traffic accident, stay with the vehicle until it can be moved off the roadway to a safe area. You will need to be available to the local investigating personnel to answer questions concerning the nature of your radioactive cargo.

3.2.2 Notify Advanced Medical Systems at the earliest practical moment @ (216) 692-3270.

3.2.3 If any of the following occurs as a result of an accident, then the Department of Transportation (DOT) must also be notified at the earliest practical time @ (800) 424-8802:

a. A person is killed.

b. A person receives injuries requiring hospitalization.

c. Estimated damages exceed $50,000.

d. Fire, breakage, spillage or suspected radioactive contamination occurs.

INSTRUCTIONS TO DRIVERS OF EXCLUSIVE USE VEHICLES

ISP-22A

This vehicle is consigned exclusive (sole) use. The vehicle must remain closed at all times other than during loading or unloading or as exempted in ISP-22. Any loading, unloading or shifting of the load in the vehicle must be done under the cognizance of the consignor or designated agent.

Without first contacting the consignor and receiving approval:

DO NOT change the configuration of the packages on the vehicle.

DO NOT change the tractor being used to haul this vehicle.

DO NOT change the position of the fifth wheel.

DO NOT open any of the packages in this load or off load them anywhere except at the consignee's site.

Any loading or unloading must be performed under the supervision of personnel having radiological training and resources appropriate for safe handling of the consignment.

I have read or have been trained on ISP-22, Instructions to Drivers when Transporting Radioactive Material.

Driver:_____ Date:_____

Printed Name Signature

ADVANCED MEDICAL SYSTEMS OPERATING PROCEDURE

CALIBRATION OF PORTABLE RADIATION DETECTION INSTRUMENTS

ISP-23 Rev. 1/95

1.0 PURPOSE: The purpose of the procedure is to provide uniform and documented proof of calibration of the survey instruments and dosimeters used.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure applies to all survey meters and dosimeters in active use.

2.2 Calibration sources are to be stored only in Controlled Areas of the Isotope Facility.

2.3 Film badges and pocket dosimeters should be worn when calibrating equipment.

2.4 Keep as much distance from the calibration source as possible.

3.0 INSTRUCTIONS:

3.1 Calibration of Portable Survey Meters

3.1.1 Ensure meter is free of removable contamination and <1mR/hr fixed contamination.

3.1.2 Package the meter for shipment.

3.1.3 Ship the meter to a vendor for calibration.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.2 Calibration of Pocket Dosimeters.

3.2.1 Dosimeters may be calibrated in two ways:

a. Use of an outside calibration service.

b. Use of a commercially available dosimeter calibrator.

3.2.2 Set the dosimeter to zero and record the serial number on Form ISP-23A, Dosimeter Calibration Form.

3.2.3 Calculate the exposure rate of the calibrator and record on ISP-23A.

3.2.4 Calculate the exposure time by the following formula:

$$\text{Exposure time} = \frac{\text{3/4 dosimeter scale, mrem}}{\text{exposure rate, mrem/hr}}$$

3.2.5 Calculate the exposure by multiplying the exposure rate times the exposure time.

3.2.6 Place the dosimeter in one of the holes of the calibrator.

3.2.7 Expose the dosimeter to the calibration source for the calculated exposure time.

3.2.8 At the end of the exposure time, read and record the actual dosimeter reading on Form ISP-23A.

3.2.9 Calculate the accuracy of the dosimeter by the following formula:

$$\%\ \text{accuracy} = \frac{\text{calc. exposure-dosimeter reading}}{\text{calculated exposure}} \times 100$$

3.2.10 Any dosimeter with an accuracy greater than $\pm$15% shall be replaced.

3.2.11 Record all applicable information on Form ISP-23A.

3.2.12 Perform a Drift Check as follows:

a. Zero the pocket dosimeter.

b. Store the dosimeter in a low dose area.

c. After at least twenty four (24) hours, read the dosimeter.

d. Calculate the Drift by the following:

$$\% \text{ Drift} = \frac{\text{dosimeter reading}}{\text{dosimeter scale}} \times 100$$

e. The dosimeter passes the Drift Check if the % Drift is less than 2%.

3.2.13 Apply a dated calibration label to the dosimeter which indicates the next calibration due date.

DOSIMETER CALIBRATION FORM

ISP-23A

Calibration Source:_____ Exposure Rate:_____

Serial Number	Calc. Reading	Act. Reading	%Acc.	%Drift

Performed by:_____ Date:_____

Reviewed by RSO:_____ Date:_____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

DOSIMETRY PROCEDURE AND POLICY

ISP-24 Rev. 01/95

1.0 PURPOSE: This procedure describes the receipt, issue and processing of dosimetry.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Personnel whole body dosimetry is to be worn on the upper front torso of the body unless otherwise directed by the RSO.

2.2 Extremity dosimetry is to be worn on the finger of the hand closest to the source of radiation. If extremity dosimetry is not being used, it should be worn in close proximity to the whole body dosimetry.

2.3 Self Reading Pocket Dosimeters (SRPDs) are to be worn in close proximity to the whole body badge.

2.4 Ensure dosimetry is firmly attached to prevent loss.

3.0 INSTRUCTIONS:

3.1 Dosimetry Type.

3.1.1 AMS utilizes the dosimetry service provided by a commercial vendor.

a. Three types of badges are used, whole body film badge, finger ring TLDs and area TLDs.

b. Whole body film badges are issued for a one week period.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

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c. Finger ring TLDs (extremity dosimetry) are issued for a one month period.

d. Area TLDs, located at various locations throughout the facility, are issued for a one month period.

3.1.2 A commercial vendor supplies AMS with 200mR, 1R and 5R SRPDs.

3.1.3 Form ISP-24C may be used by personnel to track their pocket dosimeter readings.

3.2 Badge Groups.

3.2.1 Group I badges - these are primarily finger rings issued on a monthly basis. There are also a number of visitor film badges available.

3.2.2 Group II badges - these are monthly badges issued for area monitoring throughout the facility.

3.2.3 Group III badges - these are weekly film badges issued to London Road personnel.

3.3 Receipt of Badges.

3.3.1 Badges are sent directly to London Road. Upon receipt they should be checked to verify that the proper badges are included. Report any errors to the RSO.

3.4 Issuing assigned (imprinted with individual's name) badges.

3.4.1 New badges are to be exchanged as near as possible to the date printed on the badge. Badges may be exchanged prior to the date if the individual will be out of town on the printed date.

3.4.2 All badges should be exchanged before the end of the week in which the printed date falls.

3.4.3 Badge holders should not be exchanged unless they have been damaged.

NOTE: Badge holders are the property of the vendor and are chargeable to AMS if not returned at the termination of service.

3.5 Issuing Visitor Dosimetry.

3.5.1 Visitor badges and SRPDs should be issued to:

a. Non-employees who will be entering Restricted Area Radiation Areas of the Isotope Facility.

b. Employees without assigned dosimetry who will be temporarily working in a Radiation Area where receipt of a dose is likely.

3.5.2 For each visitor badge issued, a Dosimetry Log, Form ISP-24A, should be completed.

3.5.3 Visitor dosimetry is to be issued to only one individual. They may not be issued to anyone else.

a. Non-employee badges should be returned at the end of the visit.

b. Employee badges should be retained for the entire issue period, since the individual may have more than one occasion to work in a Radiation Area.

3.6 Sending Badges to the vendor for processing.

3.6.1 Badges (not holders), including controls, should be mailed directly to the vendor no later than five (5) working days after the exchange date.

3.6.2 All badges with the same date should be sent in together. This includes all unused visitor badges. <u>Do not hold up the badge return because one individual has not exchanged yet.</u> It is important that badges be processed in a timely manner.

3.6.3 Any badges exchanged after the regular mailing should be sent when received. <u>Do not hold until the following period.</u>

3.7 Monthly Summary of Badges Issued.

3.7.1 At the end of each month, a list of all badges issued and a copy of the Dosimetry Log, should be sent to the RSO. The green packing list may be utilized as the list, provided visitors names are written in besides the appropriate badge numbers.

3.7.2 The Dosimetry Log should be completed and a copy sent to the individual, if requested.

3.8 Corrections and Adjustments to Service.

3.8.2 All corrections and adjustments to the service will be made by the RSO or after his approval is obtained.

3.9 Missing or Lost Badges.

3.9.1 Any dosimetry lost or misplaced must immediately report to the RSO.

3.9.2 The personnel involved shall, if in a Restricted Area, immediately leave the area and contact the RSO.

3.9.3 The personnel involved should make a statement via the Lost Dosimetry Report, Form ISP-33B.

3.9.4 The RSO, after review of the circumstances, should assign a dose to the individual(s) involved.

3.9.5 Dosimetry may be reissued at this time.

3.9.6 Should badges previously reported as lost be found, they should be sent in for processing immediately.

3.10 Film Badge Reports.

3.10.1 Badge reports are sent to the attention of the Radiation Safety Officer. Anyone desiring to know their exposure should contact the RSO for that information.

DOSIMETRY LOG

ISP-24A

As a byproduct materials licensee, we are required by law to maintain certain records regarding personnel who may be exposed to ionizing radiation at the London Road Isotope Facility. Your cooperation is requested in providing the following information.

NOTE: Complete one form per badge issued.

NAME: _____
LAST FIRST M.I.

SOCIAL SECURITY NUMBER: _____

DATE OF BIRTH: _____

COMPANY OR ORGANIZATION: _____

_____

FILM BADGE NUMBER: _____

BADGE TYPE (circle one) WHOLE BODY - EXTREMITY

DATE OF BADGE: _____

ISSUE DATE: _____

MAILING ADDRESS: _____

_____

_____

_____

Exposure data as determined by dosimetry report for the period

_____ to _____ and recorded as follows:

REPORT DATE: _____

X-GAMMA EXPOSURE: _____

BETA EXPOSURE: _____

This report is furnished to you under the provisions of the Nuclear Regulatory Commission regulation 10CFR part 19. You should preserve this report for further reference.

LOST OR DAMAGED DOSIMETRY REPORT

ISP-24B

The following badge or badges issued to me have been lost or damaged:

BADGE NUMBER: _____ BADGE DATE: _____

BADGE NUMBER: _____ BADGE DATE: _____

BADGE NUMBER: _____ BADGE DATE: _____

DETAILS OF LOSS OR DAMAGE (INCLUDE WHERE, WHEN AND HOW):

_____

_____

_____

_____

_____

_____

_____

SIGNATURE: _____ DATE: _____

RSO'S ESTIMATE OF EXPOSURE ASSIGNED:

_____MREM (WHOLE BODY)

_____MREM (EXTREMITY)

BASIS FOR ABOVE ASSIGNED DOSE:

_____

_____

_____

_____

_____

_____

RSO: _____ DATE: _____

MONTHLY POCKET DOSIMETER LOG

ISP-24C

Name:_____
Month:_____

This form should be filled out for each work activity with radioactive material.

Date	Time	RWP #	WB Dose(mR)	Ext. Dose(mR)	WB to date

Reviewed by RSO:_____ Date:_____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

PACKAGING OF SOLID RADIOACTIVE WASTE

ISP-25 Rev. 1/95

1.0 PURPOSE: To ensure that solid radioactive waste is safely and properly packaged in preparation for shipment.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure applies to all contaminated solid material that must be disposed of at an authorized radioactive waste disposal site.

2.2 All waste is to be compacted in order to reduce the volume unless a significant airborne hazard will result.

2.3 No liquid material is to be packaged. The waste disposal site will not accept liquids. Liquids must be solidified using approved methods prior to transportation.

2.4 Full face respirators should be worn when handling and compacting material which has been in the Hot Cell.

2.5 To reduce airborne contamination, material which has been in the Hot Cell should be bagged before extensive handling or compaction.

2.6 Waste is to be packaged on an ongoing basis. It should not accumulate.

2.7 This procedure requires that protective clothing and personal dosimetry equipment be worn.

2.8 A breathing zone air sample shall be taken during compactor operation to verify adequate respiratory protection.

2.9 Minimize stay time near high level waste materials.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Compaction

3.1.1 Waste should be surveyed prior to compaction. Any material reading over 800mR/hr should be segregated and brought to the attention of the RSO.

3.1.2 After meeting all precautions and limitations, load the material into the compactor and compact it.

3.1.3 Once the compactor bag is filled, remove bag from compactor and tape down top flaps.

3.1.4 Survey the surfaces of the bag to insure that no part reads greater than 800mR/hr. If a reading is greater than 800mR/hr, mark the bag with the maximum radiation level found.

3.2 Packaging

3.2.1 Prepare a steel drum for loading by removing the lid, inserting a poly bag liner and placing the drum on kraft paper on the step off line in the air lock.

CAUTION: Be careful not to contaminate the drum.

3.2.2 A second individual, situated on the clean side of the airlock, is required for packaging.

3.2.3 Move the compacted waste bags out from the lab and place them inside the lined drum. Four bags will easily fit into one drum.

3.2.4 Survey the drum surfaces to insure that no reading is greater than 800mR/hr.

3.2.5 Fold the excess poly liner onto the top of the bags and replace the drum lid.

3.3 Contamination Control

3.3.1 Wipe down the drum exterior prior to surveying.

3.3.2 Smears of the drum exterior shall be taken and recorded on Form ISP-25A. Smears should be taken on the drum top and ring area, on the side of the drum and along the bottom of the drum.

3.3.3 No drum shall be removed from the airlock if any smears shows contamination in excess of 1,000 dpm/100cm^2.

3.3.4 If any smear indicates contamination greater than 1,000 dpm/100cm^2, then the drum must be decontaminated and resurveyed until the contamination levels are below the above limits.

3.3.5 If the drum surface contamination is below the limit, then it should be marked with an ID number and removed from the airlock to a low background area for surveying.

3.4 Survey

3.4.1 Survey the package surfaces and record on Form ISP-34A the highest readings found on the top, side and bottom surfaces. If the survey meter readings are in the upper 90% of the scale, the next higher scale should be used.

CAUTION: Readings that fall within 20% of the maximum (800mR/hr) will be verified with at least one other instrument.

3.4.2 Mark the package hot spot with spray paint.

3.4.3 Survey the package at a distance of one (1) foot from all surfaces. For purposes of documentation, divide the package into quadrants and record the highest reading in each quadrant on Form ISP-25A.

3.4.4 Compute the average of the four (4) quadrant readings and record on Form ISP-25A.

3.4.5 Survey the package at a distance of one (1) meter and record under Transport Index on Form ISP-34A.

NOTE: Not needed for LSA exclusive use.

3.5 Package Description

3.5.1 Apply a permanent ID number sticker to the package and record it on Form ISP-34A.

3.5.2 Weigh the package and record the weight.

3.5.3 Describe the contents of the drum (i.e. compacted trash, cell waste, cardboard, wood, used protective clothing, etc.).

3.5.4 Apply a "Class A Waste" label to the top of the package.

3.6 Storage

3.6.1 Transfer the package to the designated waste storage area and place it so that the ID number is readily visible.

3.6.2 High activity packages (greater than 200mR/hr contact) should be segregated from lower activity packages.

3.7 Documentation

3.7.1 Calculate the Curie content of the package using the 6CE formula following:

mR/hr@1foot = 6 x Curie content x Gamma Energy

$$\text{or Curies} = \frac{\text{mR/hr @ one foot}}{6 \times \text{Gamma Energy}}$$

EXAMPLE: For Cobalt-60

$$\text{Curies} = \frac{\text{mR/hr @ one foot}}{6 \times (1.33 + 1.17)} \quad \text{or} \quad \frac{\text{mR/hr @ one foot}}{15}$$

SOLID RADWASTE DATA SHEET

ISP-25A

Drum ID#:_____ Weight:_____

Contents:_____

_____

_____

SURVEY RESULTS

Meter used:_____ Ser.#:_____ Cal due:_____

Surface Readings

Top_____mR/hr Bottom_____mR/hr Sides_____mR/hr

Readings @ 1 foot (by quadrants)

_____mR/hr _____mR/hr _____mR/hr _____mR/hr

Average 1 foot reading _____mR/hr

Transport Index:_____ Curie content:_____Ci

SURFACE CONTAMINATION

Top_____dpm/100cm^2 Bottom_____dpm/100cm^2 Sides_____dpm/100cm^2

Highest smear _____dpm/100cm^2

Performed by:_____ Date:_____

Reviewed by RSO:_____ Date:_____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

SHIPMENT OF SOLID RADIOACTIVE WASTE

ISP-26 Rev. 1/95

1.0 PURPOSE: To ensure that the solid radioactive waste is Shipped in accordance with the current federal, state and local regulations and requirements.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure applies to all shipments of solid radioactive waste.

2.2 The shipment of radioactive material is a highly regulated activity. The shipper must be familiar with the current rules and regulations in order to prevent violations and penalties.

2.3 It is prudent to communicate with the Regulatory affairs personnel at the disposal site prior to shipment in order to answer any questions they may raise regarding the material being shipped and determine any special local requirements.

3.0 INSTRUCTIONS:

3.1 For Each Package or Container

3.1.1 Determine the radionuclide(s) present.

3.1.2 Determine whether the material is normal or special form. (49CFR173.403)

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.1.3 Determine the DOT subtype (type quality).

Subtype	Cobalt 60
Limited Quantity	≤0.007Ci
Type A Quantity	≤7Ci
Type B Quantity	>7 but <21,000Ci
Highway Route Controlled	>21,000Ci

3.1.4 Determine if the material is LSA.

a. Convert the activity to mCi.

b. Determine the A_2 value for each nuclide. (49CFR173.435)

c. Determine the LSA limit for each nuclide. (49CFR713.403(n))

NOTE: For Cobalt 60 the LSA limit is 0.3mCi/g.

d. Determine the weight of the package contents in grams. (454g/lb) Do not include the weight of the drum, cask, shielding, etc.

e. Determine specific activity for each nuclide by dividing total activity of nuclide by total gram weight of package contents.

f. For each nuclide, divide the specific activity, as determined in step e, by the LSA limit.

g. For single nuclide waste, if the result of step f is less than or equal to one (1), then the material qualifies as LSA.

h. For mixtures of nuclides, if the sum of the fractions determined in step f is less than or equal to one (1), then the material qualifies as LSA.

i. If the result in step f is greater than one (1), the material would be a Type A, B or HRC Quantity.

j. For LSA material, determine if it is an LSA Type A or LSA Type B quantity.

For each nuclide, divide the total activity, in Curies, by the A_2 value.

For single nuclide waste, if the result is less than or equal to one (1), the material is LSA Type A.

For mixtures of nuclides, if the sum of the fractions is less than or equal to one (1), the material is LSA Type A.

If the result is greater than one (1), the material is LSA Type B.

3.2 Determine the packaging required for transport

3.2.1 The following chart summarizes the type packaging required for each DOT subtype quantity.

DOT SUBTYPES	LIMITED QUANTITY	TYPE A QUANTITY	TYPE B QUANTITY	LSA TYPE A EXCLU-SIVE USE	LSA TYPE A NON-EXCLUSIVE USE	LSA TYPE B NON-EXLUSIVE USE	LSA TYPE B EXCLUSIVE USE
TYPE PACKAGING	STRONG TIGHT CONTAINER	TYPE A PACKAGING	TYPE B PACKAGING	TYPE A PACKAGING	STRONG TIGHT CONTAINER	TYPE B PACKAGING	TYPE A PACKAGING WITH NRC
REGULATORY AGENCY	DOT	DOT	NRC	DOT	DOT	NRC	NRC
<u>DOT REGS.</u>							
173.24	X	X	X	X	X	X	X
173.411		X	X	X	X	X	X
173.412		X	X	X except (a)(b)(d) & ( )		X	X
173.413			X			X	
173.415		X		X			
173.416			X			X	
173.465		X	X	X		X	X
173.466		X					
<u>NRC REGS.</u>							
71.43			X			X	X
71.45			X			X	X
71.51			X			X	
71.52							X
71.71			X			X	X
71.73			X			X	

Note that the steel drums typically used to contain radioactive waste are a DOT specification packaging; however, they do not qualify as Type A packaging. Therefore, they must either be transported in a Type A package or an exclusive use vehicle.

3.2.2 Multiple types of packages may be transported on the same vehicle as long as they are appropriate for the material being shipped.

3.3 Obtain the proper packaging and load the radioactive material.

3.4 Package Limits and Communication Requirements

3.4.1 The package may be any of the following:

a. Type A packaging with contents.

b. Type B packaging with contents.

c. Strong tight container containing either LSA Type A material or limited quantity material.

3.4.2 Radiation level limits.

a. Survey the package on all surfaces including the bottom. Readings that are equal to or greater than 80% of the maximum limits shall be verified with at least one other instrument. Document the results.

b. Packages with any reading equal to or greater than 90% of the maximum limits will not be released for shipment.

Strong tight containers containing LSA Type A quantity material that read equal to or greater than 90% of the maximum limits will be held for shipment in a cask with adequate shielding.

Casks that read equal to or greater than 90% of the maximum limits will have the particular material causing the high reading removed or repositioned in order to bring the reading down.

3.4.3 Contamination limits.

a. Smears shall be taken in the locations most likely to yield significant removable contamination.

b. The maximum permissible contamination limit is 2,200 dpm/100cm^2.

3.4.4 Specification marking

a. DOT subtypes "Limited Quantity" and "LSA exclusive use" are excepted from the specification marking requirements.

b. DOT subtypes "Type A", "Type B" and "Highway Route Controlled Quantity" are required to be marked with the following:

Proper shipping name and ID number
Consignee's or Consignor's name and address
Gross weight
"Type A", "Type B", "LSA", etc.

3.4.5 Labeling

a. DOT subtypes "Limited Quantity" and "LSA exclusive use" are excepted from the labeling requirements.

b. The proper label to be affixed is determined by surveying the package and applying the criteria of 49CFR172.403(c).

c. Multiple hazards must be so labeled.

3.4.6 Waste classification.

a. Each package of radioactive waste must be classified in accordance with the criterion of 10CFR61.55 and clearly labeled to identify its class.

b. Each package must meet the minimum requirements for waste packages as specified in 10CFR61.56.

3.5 Transport Vehicle Communication Requirements

3.5.1 Placarding requirements.

a. Verify that placards are attached to transport vehicle (all 4 sides) if it is carrying any package with a Radioactive Yellow III label or an exclusive use LSA shipment.

b. Verify that each placard is visible from the direction it faces.

c. Photograph all sides of the transport vehicle before release to document that all placards were in place.

3.5.2 Shipping paper requirements.

a. Bill of Lading must contain the following:

1. Proper shipping name prescribed for the material in 49CFR172.101 and 102.

2. The hazard class "Radioactive" if not included in the proper shipping name.

3. The identification number, "UN--" or "NA--".

4. The total quantity of the hazardous material covered by the description.

5. The name of each radionuclide.

6. A description of the physical and chemical form of the material, if not special form.

7. The activity contained in each package in the shipment in terms of Curies, millicuries or microcuries.

NOTE: If the Bill of Lading is accompanied by a manifest, then the total Curies in the shipment may be listed instead of individual packages.

8. The category of label applied to each package.

9. For a DOE or NRC approved package, a notation of the package identification marking.

10. A signed certification statement that the materials are properly classified, described, packaged, marked and labeled.

NOTE: In filling out the Bill of Lading, identify the hazardous material description by placing an "X" in the column captioned "HM".

b. Shipping manifest requirements.

Each disposal site has a shipping manifest document for itemizing the individual drums/packages that form the shipment. Instructions are provided with the documents. A copy of the completed manifest must accompany the shipment.

c. State notification forms.

The state(s) which have radioactive material disposal sites may have prior notification requirements, typically three (3) days prior to shipment. A copy of the notification form(s) must accompany the shipment.

d. State certification forms.

The state(s) which have radioactive material disposal sites may require that a state certification form be completed for each shipment. A copy of this certification form must accompany these shipments.

e. Drivers' instructions for the maintenance of exclusive use certification.

See ISP-22

3.6 Transport Vehicle Requirements

3.6.1 Non-exclusive use shipments.

a. No package shall exceed 200mR/hr on any surface and have a Transport Index in excess of ten (10).

3.6.2 Exclusive use shipments.

a. No package shall exceed one thousand (1,000) mR/hr on any surface.

b. Shipment shall be in a closed transport vehicle.

c. The package(s) must be secured within the vehicle so that its position remains fixed.

d. There shall be no loading or unloading operations between the beginning and the end of transportation.

3.6.3 The radwaste packages shall be loaded onto the transport vehicle in such a manner that the following radiation levels are not exceeded:

a. 200mR/hr at any point on outer surfaces of vehicle including top and bottom. For flatbed trailer, at any point on the vertical planes projected from the outer edges of the vehicle.

b. 10mR/hr at any point two (2) meters from the outer lateral surfaces of the vehicle (excluding top and bottom). For flatbed trailers, at any point two (2) meters from the vertical planes projected from the outer edge of the vehicle.

c. 2mR/hr in any normally occupied cab space.

d. The surveys required shall be made with properly calibrated instruments by at least two (2) individuals utilizing different instruments. Readings will be taken along the entire surface.

The results of the surveys will be compared and any discrepancies investigated. Readings equal to or greater than 80% of the maximum limits will be verified.

e. No vehicle with a reading equal to or greater than 90% of the maximum limits will be released for shipment.

f. A copy of the Transportation Vehicle Survey, Form ISP-26A, should accompany the shipment.

TRANSPORTATION VEHICLE SURVEY

ISP-26A

Shipment ID:_____ Shipment Date:_____

Meter used:_____ Cal Due:_____

Meter used:_____ Cal Due:_____

All readings in mR/hr

Comments: _____

_____

_____

_____

Maximum Allowable Readings

Surface - 200mR/hr
@ 2 meters - 10mR/hr
Cab - 2mR/hr

Performed by:_____ Date:_____

Performed by:_____ Date:_____

Reviewed by RSO:_____ Date:_____

ADVANCED MEDICAL SYSTEMS OPERATING PROCEDURE

SOURCE TRANSFER OUT OF HOT CELL AND SOURCE CALIBRATION

ISP-27 Rev. 1/95

1.0 PURPOSE: To ensure that sources are safely transferred between the various containers and storage areas in the Isotope Shop Area.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure is to be used whenever sources are transferred between the Hot Cell, transfer monster, exchange container(s) or calibration head.

2.2 This task should be performed under a RWP.

2.3 This work requires individuals to work in the Isotope Shop Area. All individuals should be made aware of the radiation and contamination levels in various parts of this area so as to maintain personnel exposure ALARA.

2.4 Personnel should be aware of the extremely high potential dose from an unshielded source and should be conscious of collimated beams emitted from shielded containers during the transfer process.

2.5 This procedure should be followed carefully and deliberately to minimize potential over exposures.

2.6 Individuals should be thoroughly familiar with the equipment used in this procedure. Practice runs using 'dummy' sources is mandatory before transfer of live sources is attempted.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Contamination Control

3.1.1 All equipment that the source should come into contact with should be cleaned prior to use.

3.2 Source Transfer Between Cell and Transfer Monster (TM)

3.2.1 Source storage in Hot Cell wall.

a. Insert from lab side one-3 source holder, top up, holes vertical, with disc in hole to be used, pinned to chromed extension, (2 pinhole side toward lab) pinned to hook pin rod.

b. Insert so that hook pin is just vertical inside the Hot Cell wall. Slanted area to be vertical and slanted left to right.

c. Using wooden hook tool, push rod assembly into the Hot Cell so that source may be placed in the holder cavity that contains the disc.

d. Insert source, threaded side up.

e. Pull assembly back into Hot Cell wall with the wooden hook tool.

f. Post written note in Lab and Cell Control Area as to source serial number and cavity location.

3.2.2 Hang Transfer Monster on Hot Cell wall.

a. Monster must be hanging square on the lift truck forks.

b. Chains must be of equal lengths.

c. Hooks must be in the same direction.

d. The Cell chute will be in alignment with the bottom TM rod.

NOTE: TM has two (2) rods in it. They are both lead filled for shielding purposes. It is important that once a source is trapped in the TM, these rods are not removed. High radiation beams could result.

3.2.3 Insert top TM rod into TM so that canter cavity is in vertical position. Note the red alignment marks on the TM and rod.

3.2.4 Align the rod pin hole with the innermost hold on the TM chute. This will place the center cavity in alignment with both TM push rods (top and bottom).

3.2.5 Screw extension onto lower TM push rod. When three (3) pinholes in push rod are showing, pin the top hole.

3.2.6 In this position, the push rod is clear of the TM lower rod.

NOTE: Pin in middle hole will lock TM lower rod but allow TM top rod to move. Pin in lower hole will lock both top and bottom TM rods.

3.2.7 Insert lower TM rod (note red alignment marks with hook barb pointing to the right) and hook onto rods in the Hot Cell wall.

3.2.8 Pull out on bottom rod until the chrome extension is visible.

3.2.9 Align the clear hole in extension (not the hole with the peg in it) with one (1) of the three (3) holes on the TM chute.

NOTE: Whichever TM chute hole is in alignment, means that the corresponding holder cavity is directly above the TM push rod.

3.2.10 Push upward on push rod to move the source into the upper TM rod. To avoid trapping the disc, drop the push rod 1/4 to 3/8 inch.

3.2.11 Pull upper TM rod out (towards operator) one (1) hole (#2 position) and pin it. This traps the source in the TM.

3.2.12 Verify that the disc has not been trapped by pushing the rod up. If the middle hole will not align, the disc is on top of the push rod and not under the source.

3.2.13 Reinsert TM lower rod into the TM by utilizing hook section (hook rotated 90^0 so hook will not engage).

a. Push in so that the outer pin holes line up.

b. The source holder and extensions are now back in Hot Cell wall.

3.2.14 Attach eyebolt to the end of the TM upper rod. Pin the lower TM rod through this eyebolt (lower TM rod should extend three (3) inches beyond the upper TM rod).

NOTE: It may be necessary to pin the upper TM rod in the #3 position to allow the bolt to pass into the lower TM rod. The source is located on the same side of the TM as the radiation symbol (decal).

3.2.15 Remove the lower push rod extension.

3.2.16 Lift TM off the wall using the lift truck.

3.2.17 Lock hand crank into position so that the TM rods are parallel to the floor.

3.2.18 Transfer TM to the hoist.

3.3 Source Transfer between TM and Source Exchange Container

3.3.1 Verify that the TM rods are pinned into place.

3.3.2 Remove lower TM push rod.

3.3.3 Rotate TM to be 90^0 to Source Exchange Container (SEC).

3.3.4 Using proper adapter, mate TM to SEC.

3.3.5 Lay clean paper or plastic on floor.

3.3.6 Individual performing exchange should wear disposable head cover in addition to other protective clothing.

3.3.7 Align the lower TM rod with the push rod (pin hole with innermost alignment hole). Remove pin so that the pin will not drop onto person.

3.3.8 Insert two (2) SEC push rods (dark iron first then stainless/chrome second).

3.3.9 Put handle in second hole from bottom.

3.3.10 Push SEC push rod into lower TM rod.

3.3.11 Rotate SEC push rod 90^0 so that the bar end of the handle is locked on the I-beam base of SEC and the rod will not drop down.

3.3.12 Push the upper TM rod into alignment and drop the source into SEC.

NOTE: Use a survey meter to verify that the source has been transferred.

3.3.13 Close SEC drawer.

3.3.14 Pull upper and lower TM rods partially out of TM and pin.

3.3.15 Lift TM off SEC and place on a pallet or designated storage supports. Be certain that the hook does not protrude and become damaged by contact with the floor or other objects.

3.4 Source Transfer between Exchange Container and Calibration Head

3.4.1 Put calibration head adapter into SEC (step side up).

3.4.2 Using overhead hoist, put head into place on top of SEC. Verify that shutter control switch is off.

3.4.3 Insert head plug cord into left side of orange painted receptacle. This will allow the shutter rotor to be electrically opened with the switch.

3.4.4 Lay clean paper or plastic on floor.

3.4.5 Individual performing exchange should wear disposable head cover in addition to other protective clothing.

3.4.6 Open SEC drawer.

3.4.7 Energize calibration head to open shutter.

3.4.8 Using single push rod, push source into head and engage threads for three and a half (3 1/2) turns.

3.5 Calibration of Source

3.5.1 Using overhead crane, lift the calibration head off the SEC and move it to the calibration stand in the Source Storage Garden Area.

3.5.2 Attach the three piece bottom adapter to the head and place the head on the calibration stand.

NOTE: Source calibration is performed by electrically opening the head shutter and exposing a probe for a long period of time. Shutter opening and closing is accomplished by utilizing a Gralab timer located near the Isotope Shop well counter. The shutter operating circuit consists of an orange painted receptacle in the calibration stand area, wired to a yellow plug cord in the timer area. The yellow plug must be inserted in the timer outlet receptacle with the switch in the open position. Operation of the timer on/off switch then controls the shutter circuit.

3.5.3 Verify that the timer is shut off.

3.5.4 Plug the calibration head into the orange receptacle.

CAUTION: If the shutter begins to open, unplug the head immediately.

3.5.5 Place the Victoreen 570 meter (or equivalent) on the shop well counter table, plug it in, turn it on and allow meter to stabilize for ten (10) minutes.

3.5.6 With no probe in the meter, charge and zero the meter. Insert the probe and twist 1/4 turn. Charge the meter again (this discharges probe). Remove probe from meter.

3.5.7 Place the probe in the holder beneath the calibration stand. Again twist 1/4 turn to seat the probe in the holder.

3.5.8 All personnel in the Isotope Shop should return to the timer area and remain there until calibration is complete.

3.5.9 With the timer control switch off, set the timer for the desired exposure time. Refer to Attachment 1, Counting Time Chart, for recommended times.

NOTE: The timer indicates 15 seconds per revolution of the sweep hand.

3.5.10 Turn the timer on.

a. A red light near the basement door should flash intermittently while the timer is on.

b. The calibration head shutter should open.

c. The gamma alarm light should change from green to red.

CAUTION: Do not go near the Calibration Area while these indicators are on.

3.5.11 Once the timer has turned off and the shutter has closed (verified by gamma alarm green light), retrieve the probe. Charge the meter (to rezero) then insert probe into meter. Record the reading and exposure time.

3.5.12 Record at least three (3) short and three (3) long readings. Readings should be consistent with each other.

3.5.13 On a Source Calibration Form, Form ISP-36A, record the following data:

a. Date, temperature (^{0}C), atmospheric pressure, meter S/N, probe S/N, long and short time period, long and short readings, and source S/N.

b. Submit the form for review.

c. Pass the form out of the Isotope Shop for calculation of the source output.

3.6 Source Transfer from Calibration Head to Shipping Container

3.6.1 Prepare a source exchange container to receive the source.

a. Remove top, bottom and drawer covers.

b. Take smears to verify container is clean.

c. Screw lifting bolt into top brass plug.

d. Place container on clean skid in airlock.

3.6.2 Bring container into Isotope Shop using a forklift.

3.6.3 Place clean paper or plastic on steel stand and place container on the stand.

3.6.4 Remove the top plug and insert adapter in container.

3.6.5 Unplug calibration head.

3.6.6 Using the overhead crane, lift the head off the calibration stand and remove the three piece adapter.

3.6.7 Position the calibration head on top of the container. Plug head plug cord into left side of orange painted receptacle.

3.6.8 Lay clean paper or plastic on the floor.

3.6.9 Open SEC drawer.

3.6.10 Energize the calibration head to open the shutter.

3.6.11 Using single push rod, engage source pin holes and unthread source from head.

3.6.12 Drop source into container, verifying transfer with a meter.

3.6.13 Close container drawer.

3.6.14 Mark container with label and source S/N.

3.6.15 Remove calibration head and adapter from container.

3.6.16 Replace the top brass plug and secure with lifting bolt. Also secure drawer plug with stop bracket.

3.6.17 Smear inside of head rotor assembly to verify that the source is clean.

3.6.18 Transfer exchange container to the airlock.

3.6.19 Smear exterior of container to verify that it is clean before transfer to other areas. Replace covers.

COUNTING TIME CHART

All short and long counting times are in seconds.

RHM	SHORT	LONG
1000	55	300
1200	50	270
1575	45	240
1800	35	195
2000	30	165
2400	25	150
3000	25	120
3044	25	115
3600	20	100
4000	20	90
4500	18	85
5000	17	75
6000	15	60
7000	12	50
7800	12	50
9000	10	45

SOURCE CALIBRATION DATA FORM

ISP-27A

Source Serial Number:_____

Meter Serial Number:_____ Probe Serial Number:_____

Short Time:_____seconds Long Time:_____seconds

Short Readings: _____R _____R _____R

Long Readings: _____R _____R _____R

Temperature: _____^{0}C

Pressure: _____

Collimator Factor: _____

Comments: _____

_____

_____

_____

_____

_____

_____

_____

_____

Performed by:_____ Date:_____

Reviewed by RSO:_____ Date:_____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

INSTRUCTIONS TO ANCILLARY PERSONNEL

ISP-28 Rev. 1/95

1.0 PURPOSE: To instruct part time or occasional workers on the presence, storage and use of radioactive materials and the associated safety precautions and procedures.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure applies to all part time or occasional workers who will be working in the Restricted Areas of the facility or in the vicinity of radioactive materials. It applies to both AMS and non-AMS personnel.

2.2 The RSO or designee shall be responsible for providing training to these workers.

2.3 Ancillary personnel will receive training prior to performing job assignments.

2.4 Refresher training will be provided on an annual basis to permanent AMS employees, unless the employee requests or the RSO insists upon a more frequent basis.

2.5 Ancillary personnel may be asked general questions relating to the training to determine their overall comprehension.

2.6 Personnel with a previous radiation exposure history should complete Form ISP-28A, Certificate of Prior Dose.

2.7 A copy of the signed record of training will be maintained at the Isotope Facility, and for AMS employees, also in their personnel file.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Outline of Worker Training.

3.1.1 Background discussion.

a. Radiation.
b. Radioactive contamination.
c. Airborne contamination.
d. Biological effects (acute and chronic).
e. Prenatal exposure (Reg. Guide 8.13).

3.1.2 Personal monitoring.

a. Film badges.
b. Pocket dosimeters.
c. Whole body frisking.
d. ALARA concept - time, distance, shielding.
e. Exposure limits - previous work history.
f. Expected exposure levels.
g. Right to receive exposure reports.

3.1.3 Facility tour.

a. Locations of Restricted Areas.
b. Areas of storage.
c. Areas of transfer.
d. Interpretation of signs and placards.
e. Areas of unauthorized entry.

3.1.4 Protective devices.

a. Protective clothing.
b. Respirators.
c. Fixed gamma ray detectors.
d. Shielding materials.
e. Equipment and tool monitoring.
f. Trained radiation workers.

3.1.5 Response to warnings and alarms.

a. Location of emergency exits.
b. Personal safety first.
c. Heed instructions of trained radiation worker.

3.1.6 The right to inquire or respond to any condition which they believe to constitute a violation of NRC Regulations.

CERTIFICATE OF PRIOR DOSE

ISP-28A

This certification is to be completed prior to the first entry into a Restricted Area during a work assignment under such circumstances that the individual could receive a dose in excess of 125mrem.

I certify that I have had no prior occupational dose during the current calendar year.

Printed Name:_____

Signature:_____ Date:_____

OR

I certify that my occupational dose for the current calendar year is _____mrem.

Printed Name:_____

Signature:_____ Date:_____

Comments:_____

_____

_____

_____

_____

_____

Reviewed by RSO:_____ Date:_____

STATEMENT OF TRAINING

ISP-28B

Name:_____ Soc. Sec. No.:_____

Employer:_____

I have been trained to Advanced Medical Systems Operating Procedure "Instructions to Ancillary Personnel", ISP-28, and Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure".

Comments: _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Signature of Trainee:_____ Date:_____

Signature of Trainer:_____ Date:_____

Reviewed by RSO:_____ Date:_____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

RADIATION WORK PERMITS

ISP-29 Rev. 01/95

1.0 PURPOSE: To provide instructions to personnel needed to prepare and use Radiation Work Permits (RWP). Radiation Work Permits are an integral part of AMS ALARA Program.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Radiation Work Permits are written to inform workers of the radiological conditions and controls associated with work within Restricted Areas.

2.2 Each individual is responsible for following the RWP and keeping track of thier dose.

2.3 The RSO or designee is resposible for ensuring that all Radiation Work Permits are prepared in accordance with this procedure.

3.0 INSTRUCTIONS:

3.1 Types of RWPs

3.1.1 Job Specific RWP - This type RWP is to be used for all entries into Radiation Areas, Contamination Areas and for all work in Controlled Areas that involves radioactive materials. These RWPs will be prepared for each job and will be terminated immediately following the completion of the work.

Prepared by: Robert Meschter Approved by: R Meschter

Date: 1-24-95

3.1.2 Extended RWP - This type RWP is to be used for all entries into Restricted Areas that do not require a job specific RWP. This type RWP may also be used for repetitive jobs such as routine surveys, training, etc. These RWPs will be terminated at one (1) year intervals or sooner if radiological conditions change such that additional controls are needed.

3.2 Initiating a Radiation Work Permit

3.2.1 Any employee wishing to enter a Restricted Area of the facility should ensure that the entry is covered by a current RWP. If not, the employee can initiate an RWP by completing the Description and Location of Work section of the RWP, Form ISP-29B, and submit the RWP to the RSO or designee for completion and possible approval.

3.2.2 The RSO or designee will complete the RWP, including the ALARA review, and activate the permit by signing and dating the form. Each RWP will be consecutively numbered and entered in the RWP Tracking Log, Form ISP-29A.

3.2.3 Each person who enters an area under an RWP must read and sign the RWP Sign In Sheet, Form ISP-29C. Each person signing this sheet acknowledges that they have read and understand the RWP requirements and precautions.

3.3 Use of a Radiation Work Permit

3.3.1 Prior to entering the area, workers shall:

a. Read and understand the RWP.

b. When appropriate, receive a prejob briefing from the RSO or designee.

c. Obtain radiation safety job coverage, if required.

d. Ensure sufficient exposure is available for the job.

e. Ensure they have met all the necessary precautions and have obtained the needed protective clothing and devices for the job.

3.3.2 During work, workers should:

a. Periodically read their self reading pocket dosimeter unless exposure is being tracked by timekeeping methods.

b. Wear protective clothing and devices properly.

c. Maintain exposures ALARA.

d. Stop work and exit the area if radiological conditions change significantly from those outlined in the RWP.

3.3.3 When exiting the area/job site, workers should:

a. Leave the area in a clean and unlittered condition by removing all tools and materials from the job site.

b. Use proper techniques to minimize the spread of contamination, including proper removal of protective clothing and proper use of step-off pads.

c. Perform a whole body frisk for personal contamination, paying particular attention to those areas of the body that could most likely become contaminated (hands, feet, face, knees, etc.).

d. Report any personal contamination or unusual exposures to the RSO or designee.

3.4 RWP Termination

3.4.1 RWPs will be terminated by the RSO or designee:

a. Upon completion of work.

b. Upon expiration of the RWP.

c. If the scope of work has significantly changed.

d. If the radiological conditions have significantly changed.

RADIATION WORK PERMIT TRACKING LOG

ISP-29A

RWP NO.	DESCRIPTION OF WORK	AUTH DATE	TERM DATE

REVIEWED BY RSO: _____ DATE: _____

RADIATION WORK PERMIT

ISP-29B

PERMIT NO.: _____
EXPIRATION DATE: _____ JOB SPECIFIC - EXTENDED (CIRCLE)

DESCRIPTION AND LOCATION OF WORK: _____
_____
_____
_____
_____

SURVEY INFORMATION

GENERAL AREA DOSE RATES (MR/HR): _____
MAXIMUM ACCESSIBLE DOSE RATES (MR/HR): _____
REMOVABLE CONTAMINATION LEVELS (DPM/100CM^2): _____

ALARA REVIEW

ESTIMATED TOTAL DOSE: _____ ACTUAL TOTAL DOSE: _____
___PREJOB BRIEFING ___POSTJOB BRIEFING PERFORMED BY: _____
DOSE REDUCTION TECHNIQUES TO BE EMPLOYED: _____
_____
_____
_____

DOSIMETRY REQUIREMENTS

___TLD/FILM BADGE ___FINGER RING ___SRPD(200MR) ___SRPD(1R) ___SRPD(5R)
___OTHER-SPECIFY: _____

PROTECTIVE EQUIPMENT

___COVERALLS ___LABCOAT ___HOOD ___RUBBER GLOVES ___BOOTIES ___RUBBERS
___RESPIRATOR ___TAPED SEAMS ___RADIATION SAFETY COVERAGE ___AIR SAMPLE
OTHER PRECAUTIONS AND SPECIAL INSTRUCTIONS: _____
_____
_____
_____
_____
_____

AUTHORIZED BY: _____

TERMINATED BY: _____

RWP SIGN IN SHEET

ISP-29C

RWP NUMBER: _____

Signing this document means that the worker has read and understands this Radiation Work Permit.

PRINTED NAME	SIGNATURE	REQ. DOS.	VER. BY	DOSE IN	DOSE OUT	DOSE
TOTAL DOSE THIS RWP SIGN-IN SHEET						

REVIEWED BY RSO: _____ DATE: _____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

RESPIRATORY PROTECTION PROGRAM

ISP-30 Rev. 1/95

1.0 PURPOSE: This procedure establishes guidelines for the use of respiratory protection at the Isotope Facility.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Engineering and process controls (contamination control, use of contaminants, ventilation and other controls) shall be used to the extent practical to minimize airborne hazards. When these are not practical to control levels, AMS shall increase airborne monitoring and limit the intake by individuals by the control of access, limitation of exposure times and the use of respiratory protection equipment.

2.2 Respirators should be worn when directed by the RSO.

2.3 Respirators should not be worn continuously for periods greater than two (2) hours.

2.4 Respirator relief should be a minimum of one (1) hour between each two (2) hours of use.

2.5 Respirator users may seek relief in the event of a respirator malfunction, physical or psychological distress, procedural or communication failure, a significant deterioration of operating conditions or any other condition that may require relief.

2.6 Quantitative fit testing is not used at AMS, therefore, no protection factors are utilized during respiratory equipment use.

Prepared by: Robert Meschter Approved by: R Meschter

Date: 1-24-95

2.7 All respiratory protection equipment shall be certified by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA).

3.0 INSTRUCTIONS:

3.1 Medical Evaluation of Personnel

3.1.1 Prior to first use and annually thereafter, each respirator user shall receive a medical examination.

3.1.2 The examining physician will complete a respirator examination report indicating whether or not an individual is physically qualified to wear a respirator.

3.1.3 As a minimum, the medical examination should consist of a medical history, physical exam and spirometry screening.

3.1.4 The medical history should consider the following:

a. Chronic obstructive and restrictive lung disease; chronic bronchitis, emphysema, pneumoconiosis, fibrothorax, asthma, etc.

b. Ischemic heart disease; coronary insufficiency and myocardial infraction.

c. Benign and accelerated hypertension.

d. Hemorrhagic disorders; vascular hemophilia, hypersplenism, thrombocytopenia, purpura, etc.

e. Thyroid disorders or cystic fibrosis.

f. Epilepsy grand mal, focal, etc.

g. Diabetes mellitus.

h. Cerebrovascular accidents.

i. Facial abnormalities.

j. Kidney diseases.

k. Conductive and sensorineural hearing loss.

l. Serious defects in visual acuity.

m. Ruptured ear drum.

n. Skin sensitivities.

o. Impaired or non-existent sense of smell.

p. Alcoholism.

q. Claustrophobia.

r. Other disabilities which could render respirator use a hazard.

3.1.5 When exposure to airborne hazards in addition to radioactive contamination is involved, the medical examination will be augmented to screen for prior exposure history and include tests and examination for symptoms specific to that hazard.

3.2 Respiratory Equipment Training Program

3.2.1 Prior to first use of a respirator and annually thereafter, users shall have completed a Training Program consisting of the following:

a. Discussion of the airborne contaminants against which the wearer is to be protected, including their physical properties, regulatory limits, physiological action, toxicity and means of detection.

b. Discussion of the construction, operating principles and limitations of the respirator and the reasons the respirator is the proper type for the particular purpose.

c. Instruction in procedures for ensuring that the respirator is in proper working condition.

d. Instruction in fitting the respirator properly and checking for adequacy of fit.

e. Instruction in the proper use and maintenance of the respirator.

f. Discussion of the application of various cartridges and canisters available for air purifying respirators.

g. Instruction in emergency action to be taken in the event of malfunction of the respiratory device.

h. Review of radiation and contamination hazards, including the use of other protective equipment that may be used with respirators.

i. Classroom and field training to recognize and cope with emergency situations.

j. Any other special training as needed for special use.

k. Hands on practice in donning and removal, as well as actions to be taken under emergency situations.

3.2.2 Complete Form ISP-30A, Respiratory Protection Training Record.

3.3 Respiratory Equipment Selection

3.3.1 Air purifying respirators shall not be worn in atmospheres containing less than 19.5% oxygen or Immediately Dangerous to Life or Health (IDLH). Additionally, these respirators shall not be worn in radioactive gaseous atmospheres.

3.3.2 The RSO in consultation with the Isotope Committee, when appropriate, shall specify the type of respiratory protection required.

3.4 Issuance and Control of Respirators

3.4.1 Upon receipt, all new respirators shoud be inspected and cleaned.

3.4.2 All radiological work involving respiratory protection shall be indicated on the RWP.

3.4.3 All respiratory equipment shall be maintained and issued by the Radiation Protection Department.

3.4.4 A list of all individuals qualified to wear a respirator should be maintained by the Radiation Protection Department.

3.4.5 When a non-disposable respirator is issued for use, the respirator number should be assigned to the requesting individual for that period of use. Where feasible, individuals should have permanently assigned respirators which have been marked indicating to whom it has been assigned.

3.4.6 Only individuals that have been medically screened and properly trained, for a specific type of respirator, shall be issued a respirator for use.

3.4.7 Any person that has hair (stubble, moustache, sideburns, beard, low hairline, bangs, etc.) which passes between the face and the sealing surface of the facepiece of the respirator, shall not be permitted to wear such a respirator.

3.4.8 Any person who has hair which interferes with the function of a respirator valve shall not be permitted to wear such respirator.

3.4.9 At no time during use may other items (i.e., temple bars, straps to glasses, head covering, etc.) which interfere with the seal of a respirator to the wearer be allowed.

3.4.10 Contact lens should not be worn with a fullface respirator.

3.5 Use of Respirator

3.5.1 Inspect the respirator before and after each use for the following:

a. Cracks in the straps and suspension.

b. Cracks/dryrot of facepiece material.

c. Cartridge mounts.

d. Integrity of inhalation and exhalation valves and seals.

e. Integrity of speaking diaphragms.

f. Lens (minimal scratches and no cracks).

g. Check filter radiation level - if greater than two (2) mR/hr, replace the filter.

3.5.2 Perform a Negative Pressure Test.

a. Close off the inlet opening of the canister by covering it with the palm of the hand, gentle inhale so that the facepiece collapses slightly and hold breath for ten (10) seconds.

b. If the facepiece remains in its slightly collapsed condition and no inward leakage of air is detected, the tightness of the respirator is satisfactory.

3.5.3 Perform a Positive Pressure Test.

a. If necessary, remove the exhalation valve cover, close off the exhalation valve with the palm of the hand and exhale gently so that a slight positive pressure is built up in the facepiece.

b. If no outward leakage of air is detected at the periphery of the facepiece, the face is satisfactory.

NOTE: Respirator is not to be used if the exhalation valve cover is not in place.

3.5.4 Radiation Protection personnel and crew supervisors shall be responsible for periodic observation of individuals who wear respiratory equipment while working. Any observed misuse, malfunctions, etc., shall be immediately reported to the RSO for corrective action.

3.6 Respirator Maintenance

3.6.1 The RSO will designate those individuals who may repair respirators or replace parts (other then filter replacement).

3.6.2 Respirators should be maintained daily, after use.

3.6.3 Sanitation and decontamination, if required, should be performed using alcohol pads.

3.6.4 Inspect valves (look for hair or lint affecting valve seal), elastic and rubber parts - replace or clean as required.

3.6.5 Survey the facepiece to ensure they do not exceed:

a. Loose surface contamination in excess of 1000 dpm/100cm^2.

b. Fixed contamination in excess of 0.2mrem/hr at one (1) inch.

3.6.6 Respirators should be packed and stored so that they are not damaged by adjacent equipment or twisted out of their normal configuration by improper storage.

3.6.7 Parts acquisition and replacement.

a. The RSO is responsible for acquiring and maintaining an inventory of spare replacement parts for respiratory equipment.

b. All parts shall be that specified by the manufacturer as being suitable replacements for that specific respirator.

3.7 Evaluation of Program Effectiveness

3.7.1 Workers are encouraged to relate any observed problems with respiratory protective equipment such as:

a. Inability to breathe without objectional effort.

b. Inadequate visibility.

c. Inability to communicate.

d. Inability to perform all tasks without undue interference.

e. Lack of confidence in the facepiece fit.

3.7.2 Supervisors are to monitor respiratory work in progress for any problems which might effect the reliability of the Respiratory Protection Program.

3.7.3 Evaluation of protection.

a. Any bioassay results correlated to air sampling data, should be reviewed. Evidence of uptakes linked to inhalation should be investigated, even if within permissible exposure limits.

b. Positive interior facepiece smear results should be investigated and may include bioassay analysis of the worker who last used the facepiece, when required.

3.7.4 Program evaluation.

a. The overall Respiratory Protection Program should be evaluated by the RSO, or by an outside auditor, on an annual basis.

RESPIRATORY PROTECTION TRAINING RECORD

ISP-30A

Name:_____ Soc. Sec. No.:_____

Employer:_____

I have been trained to Advanced Medical Systems Operating Procedure "Respiratory Protection Program", ISP-30.

Comments: _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Physical exam satisfactorily completed.

Verified by RSO:_____ Date:_____

Signature of Trainee:_____ Date:_____

Signature of Trainer:_____ Date:_____

Reviewed by RSO:_____ Date:_____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

ISOTOPE TECHNICIAN TRAINING PROGRAM

ISP-31 Rev. 01/95

1.0 PURPOSE: To develop a staff of training individuals capable of assisting the RSO and Isotope Handler by performing routing radiation safety-related checks and measurements.

2.0 SCOPE: This program is applicable to all individuals who will work independently in restricted areas at the London Road Isotope Facility for the performance of specified tasks.

3.0 OBJECTIVE: Upon completion of training, the candidate will be able to perform the following tasks:

A. Safety assurance checks specified in ISP-4 and Form 4A.

B. Receipt of radioisotope shipping containers.

C. Release of packaged radioactive materials for transportation.

D. Calibration of survey instruments and meters.

4.0 REQUIREMENTS:

4.1 The training program shall consist of (1) approximately 3 days of classroom instruction on basic radiation theory and safety practices; (2) approximately 2 days of training on the procedures, methods and precautions required to perform given tasks; and (3) approximately 1 month of on-the-job training.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

4.2 A trained health physicist and other qualified instructors, under the direction of the RSO, shall provide the classroom instructions. The job-specific training and the on-the-job training shall be coordinated by the RSO and supervised by the RSO or an approved Isotope Handler.

4.3 For the classroom instruction, a written examination(s) shall be administered to determine comprehension of the material presented. The examination(s) shall be prepared, administered and scored by the instructor. The minimum passing grade shall be 80%.

4.4 An oral (supported by quiz) walk-through, job performance exam will be administered after completion of the on-the-job training. The examination shall be prepared and administered by the RSO. The minimum passing grade shall be 80%.

4.5 A certificate shall be awarded to each candidate who successfully completes the training.

4.6 Candidates who do not successfully complete the primary training shall be given additional training and retested.

4.7 Refresher training shall be provided on an annual basis and whenever there is a change in duties, procedures or regulations.

4.8 Documentation of all training shall be maintained by the RSO.

4.9 Prior to assuming duties as an Isotope Technician, the candidate's qualifications must be reviewed and approved by the Isotope Committee.

5.0 PROGRAM OF INSTRUCTION

5.1 Basic Radiation Therapy and Safety Practices Course (24 Hours)

5.2 Job Specific Training

5.2.1 Radiation Surveys (1.5 Hours)

Knowledge of unrestricted and restricted areas;

Proper selection and operation of portable survey instrumentation;

Notification procedures; proper documentation and posting of areas.

5.2.2 Contamination Surveys (2.5 Hours)

Proper technique for sample collection;

Proper selection of counting equipment;

Smear counting and analysis procedures;

Isolation and proper tagging;

Procedures for performing personnel body contamination checks;

Notification procedures

5.2.3 Instrumentation (2 Hours)

Knowledge in procedures for operation and calibration of survey meters, counting equipment, air monitors;

Inspecting and tagging out inoperative instruments.

5.2.4 Air Monitoring (2 Hours)

Knowledge of operation and proper functioning of the permanent air monitoring system;

Location of sampling lines, use and operation of portable air samplers, inspection of air monitor chart and alarms;

Notification procedures.

5.2.5 Radiation Work Permit Coverage (1.5 Hours)

Obtain adequate information about the job;

Identifying, monitoring, mitigating and controlling direct radiation hazards;

Proper methods for locating and controlling contamination hazards;

Demonstrating proficiency in the use of anti-contamination clothing and respiratory equipment.

5.2.6 Waste Management (1 Hour)

Solid waste generation, handling, packaging for disposal;

Liquid waste management;

Designated waste handling and storage areas;

Notification procedures.

5.2.7 Radioactive Material Receipt/Shipping Procedures (1.5 Hours)

Survey and contamination requirements;

Documentation requirements - inventory control;

Handling and storage procedures, storage areas;

Notification procedures.

5.2.8 Emergency Action Plan (4 Hours)

Familiarization with facility alarm system and response activities of civil agencies;

Knowledge of Emergency Pre-Plan;

Maintenance and testing of emergency generator, fire pump;

Location of potential chemical and radiation hazards.

5.3 On-the-Job Training

5.3.1 Performance of each task as outlined in 3.0 a minimum of two times under supervision.

5.4 Copies of written quizzes, exams and evaluation forms are attached.

5.5 Documentation forms for job specific and on-the-job training are attached.

5.6 A certificate of training issued to Isotope Technician candidates who successfully complete the training program is attached.

ISOTOPE TECHNICIAN JOB PERFORMANCE EVALUATION 85 Points

Candidate: _____

Date: _____

RSO: _____

		SATISFACTORY	UNSATISFACTORY
1.	Daily Checks		
2.	Use of Survey Instruments		
3.	Use of Well Counter		
4.	Analysis of Wipes		
5.	Knowledge of Hazards		
6.	Generator Test		
7.	Air Monitor Calibration		
8.	Analysis of Air Samples		
9.	Gamma Alarm Settings		
10.	Air Monitor Calibration		
11.	Receiving Radioactive Material		
12.	Shipping Radioactive Material		
13.	Survey and Wipes		
14.	Calibration of Instruments		
15.	Application of RWP		
16.	Emergency Plans		
17.	Use of Anti-C Clothing		
18.	Personal Contamination		
19.	Methods for Reducing Exposure		
20.	Surface Contamination Limits		
21.	Decontamination Methods		

Comments:

ON-THE-JOB TRAINING RECORD FOR ISOTOPE TECHNICIANS

STUDENT NAME:_____

UNIT #	COURSE IDENTIFICATION	# HOURS	STUDY AIDE	LOCATION/DATE ATTENDED	TESTING RESULTS	STUDENT SIGNATURE	INSTRUCTOR SIGNATURE
ISP 4	Daily Checks						
ISP 2	Unrestricted Area Surveys						
ISP 2	Unrestricted Area Wipes						
ISP 5.1	Emergency Generator Test						
ISP 10	Generator Battery Check						
ISP 7	Air Monitor System						
ISP 6	Gamma Alarm Function						
ISP 6	Contaminated Water Level						
ISP 8	Air Monitor Calibration						
ISP 23	Survey Meter & Dosimeter Calibration						
ISP 13	Receipt of Rad. Material						
	Release of Rad. Material to Carrier						
ISP 2	Restricted Area Surveys						
ISP 2	Restricted Area Wipes						

Isotope Committee Review Date:_____

Comments:_____

_____

Member Officer Signature:_____

JOB SPECIFIC TRAINING RECORD FOR ISOTOPE TECHNICIANS

STUDENT NAME:_____

UNIT #	COURSE IDENTIFICATION	# HOURS	STUDY AIDE	LOCATION/DATE ATTENDED	TESTING RESULTS	STUDENT SIGNATURE	INSTRUCTOR SIGNATURE
1	Radiation Surveys						
2	Contamination Surveys						
3	Instrumentation						
4	Air Monitoring						
5	Radiation Work Permits						
6	Waste Management						
7	Rad. Material Receipt/Shipping						
8	Emergency Actions						

Isotope Committee Review Date:_____

Comments:_____

_____

Member Officer Signature:_____

Advanced Medical Systems, Inc.

121 North Eagle Street • Geneva, Ohio 44041
(216) 466-4671 FAX (216) 466-0186

CERTIFICATE OF TRAINING

ISOTOPE TECHNICIAN

This is to certify that _____ has successfully completed the Isotope Technician Training Program offered by Advanced Medical Systems, Inc.

The above-named individual has demonstrated to the Advanced Medical Systems, Inc. Isotope Committee that he/she can safely and competently perform the routine radiation safety procedures at the London Road Isotope Facility under U.S. Nuclear Regulatory Commission License No. 34-19089-01.

Signed,

_____
RADIATION SAFETY OFFICER

_____
Date

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

ISOTOPE HANDLER TRAINING PROGRAM

ISP-32 Rev. 01/95

1.0 PURPOSE: To develop a staff of trained individuals capable of handling sealed and unsealed sources of radioactive material at the London Road facility.

2.0 SCOPE: This program is applicable to all individuals who will work independently and/or who can supervise others in restricted areas at the London Road Facility.

3.0 OBJECTIVE: Upon completion of training, the candidate will be approved by the USNRC as a qualified Isotope Handler and will be able to safely perform the following tasks:

A. Operate the hot cell equipment.

B. Operate the source storage garden and related equipment.

C. Leak test and calibrate sources.

D. Install and remove sealed sources from machine heads and source exchange containers.

E. Maintain hot cell and related equipment.

F. Handle and package radioactive waste.

G. Prepare machine head and source exchange container shipping packages.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

4.0 REQUIREMENTS:

4.1 A prerequisite for the job classification is the successful completion of the Isotope Technician Program (see separate program for content).

4.2 The training program shall consist of (1) approximately 13 days of job-specific training on the procedures and equipment; and (2) approximately 3 months of on-the-job training.

4.3 Both the job specific and on-the-job training shall be coordinated by the RSO and supervised by a qualified Isotope Handler.

4.4 Oral and written examinations will be prepared and administered by the RSO. The minimum passing grade shall be 80%.

4.5 For on-the-job training, the performance of the candidate will be evaluated and documented by either the RSO or an approved Isotope Handler.

4.6 Candidates who are approved by the NRC will be awarded a Certificate of Training.

4.7 Candidates will continue their training until all of the above criteria has been met.

4.8 Refresher training shall be provided on an annual basis and whenever there is a change in procedures, regulations or the License.

5.0 PROGRAM OF INSTRUCTION

5.1 Prerequisites (15 Hours)

(1) Successful completion of Isotope Technician Training Program.

(2) Parts 5.2.1 - 5.2.3 of the Job Specific Training Program for Class 1 Service Engineers.

5.2 Job Specific Training

5.2.1 Isotope Facility Safety Procedures (6 Hours)

Review of ISP-1 Manual

5.2.2 LAB - Hot Cell Equipment (4 Hours)

Familiarization with manipulators and ancillary fixtures, etc.

5.2.3 LAB - Source Processing and Transfer (8 Hours)

Transfer out of cell;

Calibration;

Transfer out of Isotope Shop for shipment;

Contamination checks.

5.2.4 LAB - Storage Garden Operation (6 Hours)

Equipment;

Radiation hazards and safety.

5.2.5 LAB - Decontamination of Areas and Equipment (2 Hours)

Action levels and techniques.

5.2.6 Solid Waste Management (2 Hours)

Collection, packaging;

Processing for shipment, storage;

Documentation requirements.

5.2.7 Hot Cell Entry (1 Hour)

Review of procedure ISP-11.

5.2.8 Hot Cell Equipment Room (1 Hour)

HEPA Filter System;

Filter change procedure - ISP-12.

5.2.9 London Road Facility Security System (8 Hours)

Supervisory system - alarms, equipment;

Proper response - troubleshooting;

HVAC System;

Fire System.

5.3 On-the-Job Training

5.3.1 Performance of each task as outlined in 3.0 a minimum of two times under supervision.

5.3.2 Performance of source transfer procedures a minimum of six times.

5.4 Copies of written quizzes, exams and evaluation forms are attached.

5.5 Documentation forms for job specific and on-the-job training are attached.

5.6 A Certificate of Training issued to Isotope Handler candidates who successfully complete the training program is attached.

JOB SPECIFIC TRAINING RECORD FOR ISOTOPE HANDLERS

STUDENT NAME:_____

UNIT #	COURSE IDENTIFICATION	# HOURS	STUDY AIDE	LOCATION/DATE ATTENDED	TESTING RESULTS	STUDENT SIGNATURE	INSTRUCTOR SIGNATURE
1	ISP-1 Manual Review						
2	Solid Waste Management						
3	Hot Cell Entry						
4	Hot Cell Equipment Room						
5	Facility Systems						
LAB 1	Hot Cell Equipment						
LAB 2	Source Processing & Transfer						
LAB 3	Storage Garden Operation						
LAB 4	Decontamination						

Isotope Committee Review Date:_____

Comments:_____

_____

Member Officer Signature:_____

ISOTOPE HANDLER TRAINING RECORD

CANDIDATE_____

OUTLINE OF TECHNICAL TRAINING AND INSTRUCTION	INSTRUCTOR INITIALS	DATE PERFORMED
1. Work Authorization and Radiation Work Permit Requirements		
2. Use of Radiation Monitoring Equipment		
3. Familiarization with Hot Cell Ventilation System and Safety Interlock System		
4. Transfer of Inert Materials Into Hot Cell		
5. Slave Manipulator System - Use and Dexterity		
6. Purpose and Use of Hot Cell Ancillary Equipment a) Crane and Electromagnets b) Beam Scales c) Miscellaneous Tools and Fixtures		

CANDIDATE_____

OUTLINE OF TECHNICAL TRAINING AND INSTRUCTION	INSTRUCTOR INITIALS	DATE PERFORMED
7. Raising Hot Cell Floor Plug and Accessing Isotopes a) Floor Plug Removal b) Storage Capsule Identification c) Storage Capsule Removal		
8. Bulk Isotopes Storage and Floor Plug Insertion		
9. Decontamination of Cell Deck		
10. Source Receptacle Loading a) Use of Source Holder b) Application of Retaining Ring c) Inspection of Retaining Ring		
11. Transfer of source Into Cell Wall		
12. Hot Cell Decontamination and Waste Disposal		

CANDIDATE_____

OUTLINE OF TECHNICAL TRAINING AND INSTRUCTION	INSTRUCTOR INITIALS	DATE PERFORMED
13. Securing Hot Cell Equipment		
14. Transfer of Source to Transfer Monster from Cell Wall		
15. Source Transfer Between Transfer Monster and Source Exchange Container		
16. Source Transfer Between Exchange Container and Calibration Head		
17. Source Calibration and Documentation		
18. Source Surface Contamination Inspection		

CANDIDATE_____

OUTLINE OF TECHNICAL TRAINING AND INSTRUCTION	INSTRUCTOR INITIALS	DATE PERFORMED
19. Source Transfer Between Machine Head and Exchange Container		
20. Packing/Unpacking of Machine Head and Source Exchange Shipping Container		
21. Operation of Source Storage Garden		
22. Hot Cell Machinery Maintenance		
23. Solid Waste Packaging		

Advanced Medical Systems, Inc.

121 North Eagle Street • Geneva, Ohio 44041
466-4671 FAX (216) 466-0186

CERTIFICATE OF TRAINING

ISOTOPE HANDLER

This is to certify that _____ has successfully completed the Isotope Handler Training Program offered by Advanced Medical Systems, Inc.

The above-named individual has demonstrated to the Advanced Medical Systems, Inc. Isotope Committee that he/she can safely and competently perform the duties necessary in full compliance with the procedures and conditions of U.S. Nuclear Regulatory Commission License No. 34-19089-01.

Signed,

_____
RADIATION SAFETY OFFICER

_____
Date

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

INSPECTION AND PROCEDURE FOR CONTAINERS WITH OVERPACKS AUTHORIZED FOR THE SHIPMENT OF RADIOACTIVE MATERIAL

ISP-33 Rev. 01/95

1.0 REQUIREMENTS AND DESCRIPTION:

1.1 In order to comply with NRC/DOT regulations concerning shipment of radioactive materials, this inspection procedure must be completed for each shipment of radioactive materials prior to movement of the material to the carrier for transportation. Defects found during inspections must be corrected prior to material movement.

1.2 The requirements are applicable when moving radioactive material in authorized containers from one customer location to another, from the field back to the Isotope facility, to the field from the Isotope Facility.

1.3 Authorized Shipping Containers

1.3.1 Cobalt 60 Shipments

1.3.1.1 590C, D, E, F and G Head in Overpack No. 181375.

1.3.1.2 C-12 Head in Overpack No. D-MEH-00-00004.

1.3.1.3 3320 AR Exchange Container in Overpack No. 181361.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

1.3.2 Cesium 137 shipments - 3320B Exchange Container in Overpack No. 181361.

1.4 Audit

In accordance with 10CFR 71.137, the Radiation Safety Officer will make an audit of the maintenance of the containers and overpacks according to the checklist. The audit shall be on an unannounced basis at intervals not to exceed one (1) year.

2.0 INSPECTIONS

2.1 The Inspection Data Sheet for Radioactive Material Containers and Overpacks (QA1014A) must be completed and forwarded to the Radiation Safety Officer and Isotope Facility for audit and record retention. Field operations are to return the Inspection Data Sheet in the pre-stamped, self-addressed envelope along with the waybill copy of the return shipment.

2.2 The only personnel permitted to perform the inspection and maintenance are those individuals qualified under the conditions of the license. Repairs may be permitted by an outside contractor; however, these repairs must be inspected before use.

3.0 HEAD OR SOURCE EXCHANGE CONTAINER PROCEDURE

Perform each inspection step as indicated. Defects found during inspection must be corrected and reinspected. Repairs must be listed on the Data Sheet along with the signature of the inspector. A check mark (✓) is to be placed on the Stat Sheet after each step.

3.1 Make a wife survey of the external surface of the container. Field operations are to use a Victoreen 491 or equal to evaluate the wipe. The meter must read less than 220 DPM/100cm^2 when the wipe is held 1/4" from the Geiger Tube (Beta shield open). Factory operations are to use a well counter to determine wipe activity. Results must indicate 220 DPM/100cm^2 or less of removable contamination.

3.2 Perform a preliminary radiation survey of the container. Results should be 200mR/hour or less on the surface and 10mR/hour or less at 1 meter from the surface.

3.3 Verify that the shutter or drawer is locked.

3.4 Verify that the gaskets on 3320 AR are in good condition.

3.5 Inspect the lifting loops on 3320 AR. Loops must be in good condition, not bent, and welds must not exhibit cracks.

3.6 Inspect the container to insure there is no mechanical damage which will affect the radiation integrity of the unit.

4.0 OVERPACK PROCEDURE

Perform each inspection step as indicated. Defects found during inspection must be corrected and reinspected. Repairs must be listed on the Data Sheet along with signature of the inspector. A check mark (✓) is to be placed on the Data Sheet after each step.

4.1 Inspect the overpack for the following mechanical characteristics:

4.1.1 All wood joints inside the overpack must be tight. Tighten reinforcing bars if necessary.

4.1.2 The wood joints inside the overpack should be free of holes and voids. Holes can be filled with wood plugs.

4.1.3 Lifting loops should be free of damage.

4.1.4 Welds on the framework must be free of cracks and damage.

4.1.5 Inspect the skid runners for damage.

4.2 Inspect the container hold-down system to insure it is properly secure.

4.3 Inspect that the bolts securing the overpack cover to the skid are tight, but not stripped.

4.4 Inspect the package and insure it is seal wired.

4.5 Survey the package with container inside. The radiation level must be less than 10mR/hour at any point 1 meter from the surface of the container and 200mR/hour or less at the surface.

4.6 Inspect the outside package for the following labels:

4.6.1 Two yellow Radioactive III diamond labels filled out indicating the radioactive material, number of curies and transport index (maximum radiation units at 1 meter) as measured in 4.5. These labels must be on opposite sides of the package.

4.6.2 Verify that the overpack bears an 11" x 18" yellow sign with magenta lettering listing AMS, Cleveland, Ohio, U.S.A., part number of the overpack, Package I.D. Number, gross and empty weights, Made in U.S.A. and Radiation Symbols. All markings must be clear and legible.

4.6.3 Verify that the opening instructions have been included with the package.

AMS MODEL 181375 SHIPPING PACKAGE

USNRC CERTIFICATE OF COMPLIANCE NO. 5

COBALT HEAD SHIPPING CONTAINER

PACKING/UNPACKING

INSTRUCTIONS

IMPORTANT - READ CAREFULLY

Revised ./20/91

Revisic B - 8/1992

1.0 Preparing a source loaded head container (Model 1[illegible]75) for shipment.

Only properly qualified service engineers may remo[illegible] a loaded teletherapy head from a machine. Once the head is [illegible]moved and properly secured to the container base, the follow[illegible] procedure applies.

NOTE: QA Procedure 1014 and 1014A must be compl[illegible]l prior to shipment.

A. Position the tie down head assembly around t[illegible] machine head. Align the trunnion bolt holes with th[illegible]tie down bracket slots such that the tie down strap i[illegible] resting firmly against the machine head. (Use shim[illegible] underneath the tie down bracket and/or head in order t[illegible] achieve proper alignment.)

B. Secure the tie down head assembly by first t[illegible]ightening the bracket-to-pallet base bolts, then tigh[illegible]ing the bracket-to-head trunnion bolts. Verify tha[illegible] he strap is tight against the head.

C. Attach the wooden support pads into place a[illegible]nd the machine head.

D. With a lifting device capable of lifting 100[illegible] lbs., place the overpack in position over the head[illegible]n the pallet base.

E. Secure the overpack to the pallet base with[illegible]e four one inch bolts and eight 1/2 inch bolts.

F. Attach an appropriate shipping seal to one [illegible] the side lugs.

G. Perform a radiation survey of the package a[illegible]he surface (maximum reading 200 mR/hr). If the radiati[illegible]n levels exceed these limits, the package shall not b[illegible] released for shipment. Notify the Radiation Safety O[illegible]ficer for further instructions.

H. Apply the proper labels to the container. V[illegible]ify that the package content description and caution [illegible]rkings are visible.

I. Complete the shipping papers.
Copies of QA 1014 and 1014A, shipping paper[illegible]d other documentation should be returned to Advanced[illegible]edical Systems for record-keeping purposes.

J. All shipments of radioactive material destined for Advanced Medical Systems should be shipped to:

Advanced Medical Systems, Inc.
1020 London Road
Cleveland, OH 44110

2.0 Unpacking a source loaded head container (Model 18[illegible]375)

A. The package must be removed from the transport vehicle with material handling equipment of a capacity equal to or greater than the gross package weight of 4000 lbs.

B. Perform a radiation survey of the container to insure that the external radiation level does not exceed 200 mR/hr at the surface and 10 mR/hr at a distance of 1 meter from the surface. [If the level does exceed these limits, the appropriate NRC Regional Office and the final delivery carrier must be notified.]

C. Verify that the shipping seal is intact. The shipping seal may be removed only by a person qualified to install the equipment. Until such a person is present, the container should be stored in accordance with 10CFR20.

D. Upon the authorization of removal of the shipping seal, the overpack may be removed. Remove the four one-inch and eight 1-2-inch bolts securing the overpack to the pallet base (save hardware for reuse).

E. With a lifting device capable of lifting 1000 lbs., lift the overpack off the machine head and pallet base.

CAUTION: The machine head may not be removed from the pallet base until it has been moved into the room in which it is to be installed. This is to insure that the skid shield remains in place under the head.

F. Move the pallet base with head attached into the therapy room.

G. Remove the twelve bolts securing the tie down head bracket to the machine head and pallet base. (save hardware for reuse).

H. Remove the wooden support pads and slide the tie down head assembly forward, away from the machine head. The head installation including the removal of the machine head from the pallet base, may only be performed by a qualified service engineer.

3.0 Preparing an empty head container (Model 1813754) for shipment.

NOTE: QA Procedure 1014 and 1014A must be completed prior to shipment.

A. Bolt the skid shield into place on the pallet base

B. Bolt the tie down head bracket with attached wooden support pads, to the pallet base.

C. Place the overpack into position on the pallet base and secure it with the twelve bolts.

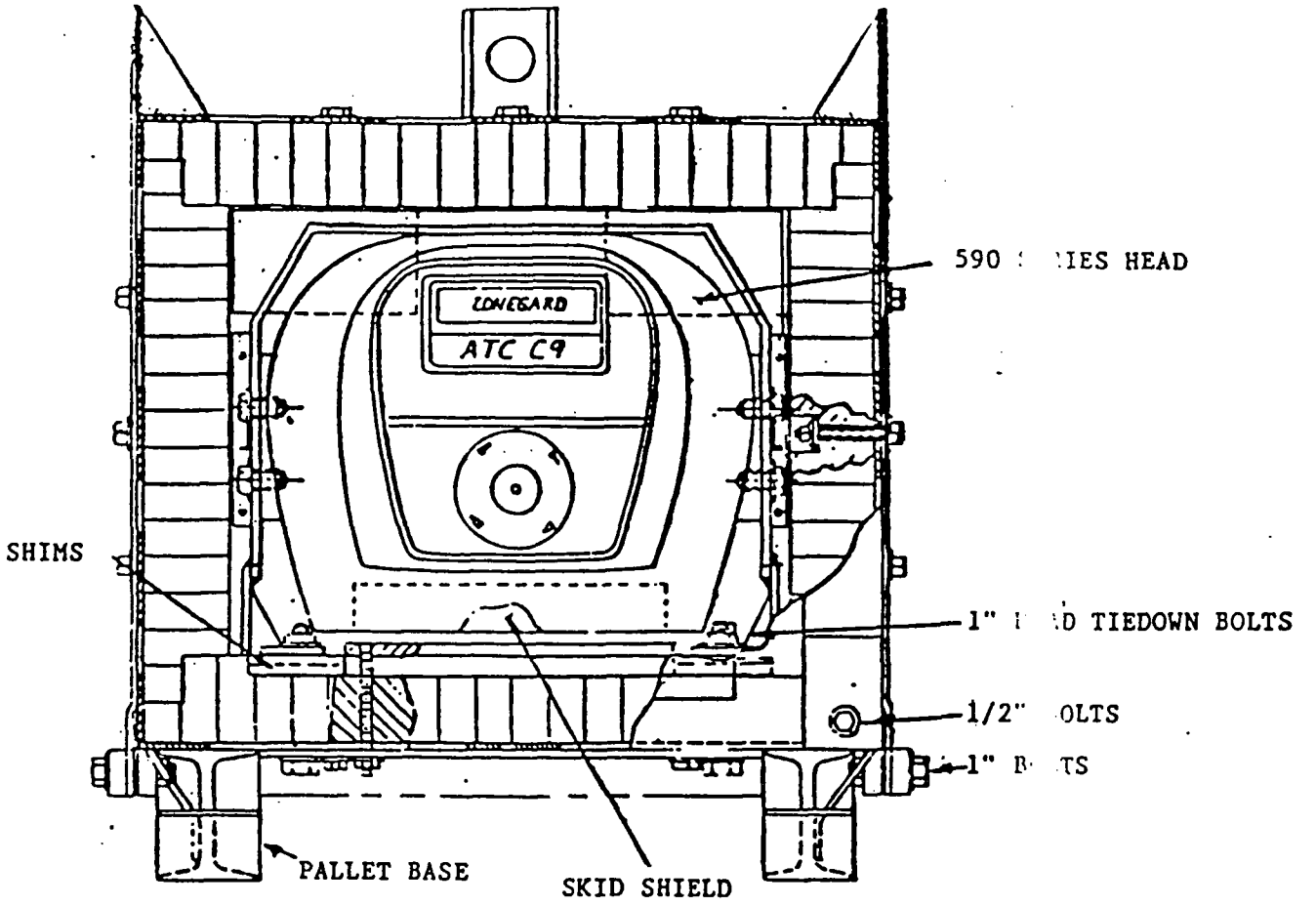
D. Mask out any "Radioactive Material" labels and marks (tape may be used).

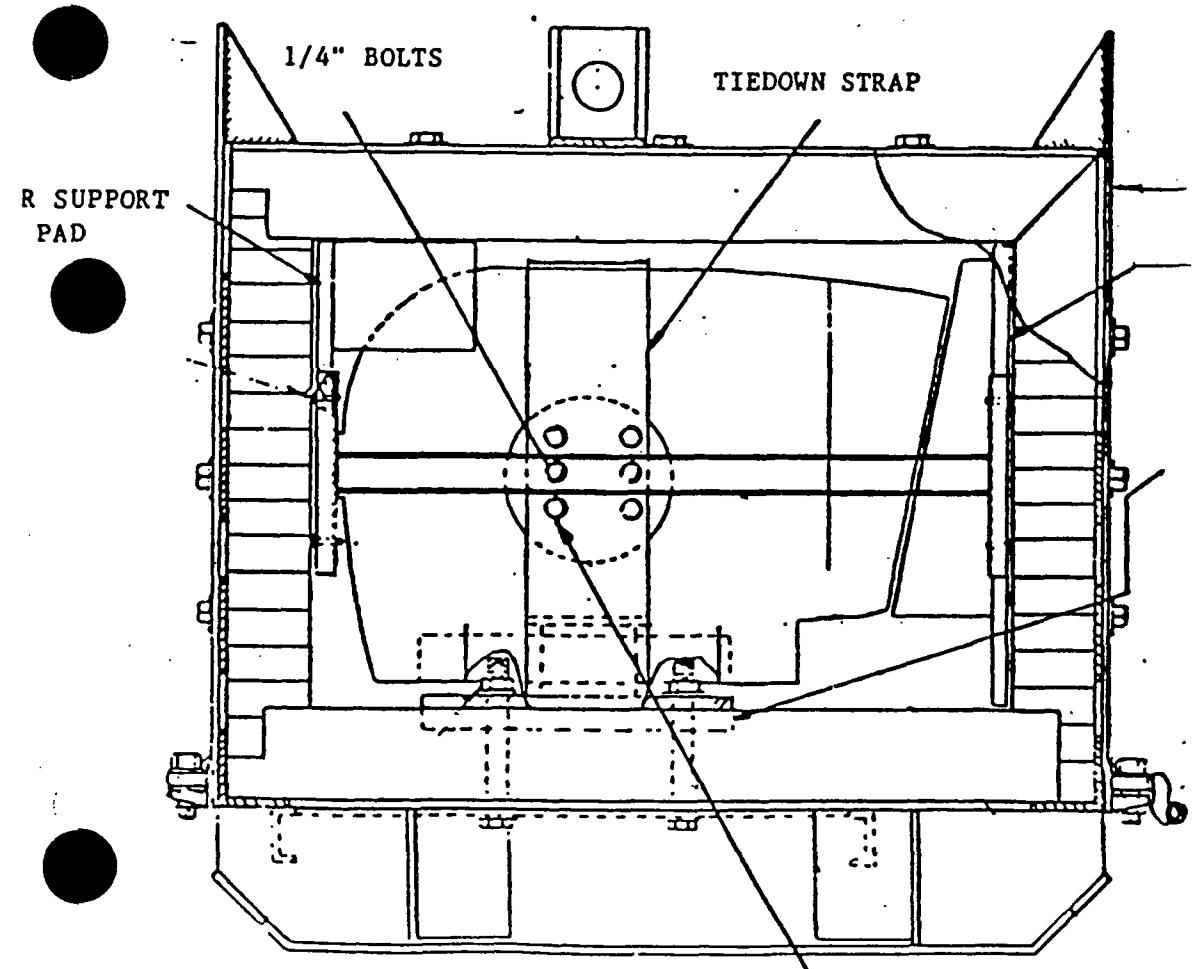
E. Remove the Radioactive Yellow III labels and apply "Empty" labels to the container.

F. Apply proper shipping labels.

All return shipments destined for Advanced Medical Systems should be shipped to:

Advanced Medical Systems, Inc.
1020 London Road
Cleveland, Ohio 44110


590 [illegible]IES HEAD
LONEGARD
ATC C9
SHIMS
1" [illegible]D TIEDOWN BOLTS
1/2" [illegible]OLTS
1" B[illegible]TS
PALLET BASE
SKID SHIELD


1/4" BOLTS
TIEDOWN STRAP
R SUPPORT PAD
[illegible]VERPACK
[illegible]RONT SUPPORT PAD
NOTE:
SHIM AS REQ'D.
[illegible]T PACKING TOTAL SHIM
[illegible]EIGHT NOT TO EXCEED
[illegible]/2"
P/N 200742 1 thru 5
P/N 200743 1 thru 5
[illegible]HIPPING SEAL
1/2" BOLTS

Control No _____

Source S/N _____

Source Shipment Documentation Checklist

for 181375 (head) Container

A. Pre-shipment Documents

1. Container inspection report (QA1014A) _____
2. Head survey sheet _____
3. Shipping tags or stencils _____
4. Work sheet _____

B. Service Engineer Package

1. Presentation folder with:
   a) Calibration certificate _____
   b) Decay Tables (2) _____
   c) Certificate of Wipe _____
   d) Source Warranty _____

2. Return documents

		returned
a) Five year inspection report	_____	_____
b) Head survey sheets (2)	_____	_____
c) Service ticket	_____	_____
d) Return Bill of Lading	_____	_____
e) Container Inspection Report (QA1014)	_____	_____
f) Diamond labels (2)	_____	NA
g) State Notification Letters	_____	NA

C. Customer file

The following should be in file before shipment:

1. AMS work order _____
2. Customer license _____
3. Calibration data sheets _____
4. Calibration certificate _____
5. Wipe data sheets _____
6. Wipe certificate _____
7. Source work sheet _____
8. Source shipment checklist _____
9. Consignee notification letter _____

The following should be placed in file once returned shipment is received:

10. Head survey sheet _____
11. Five year inspection report _____
12. Bills of Lading _____

D. Shipping Documents

1) Bill of Lading _____
2) Instructions to Driver (ISP-30) _____
3) Placards _____
4) Export only - Container Loading/Unloading Instructions _____
5) Export only - IAEA Certificate of Competent Authority _____

LOOSE SURFACE CONTAMINATION SURVEY

page_____ of_____

TE:_____ INST.:_____ S/N:_____ BKG._____ CPM

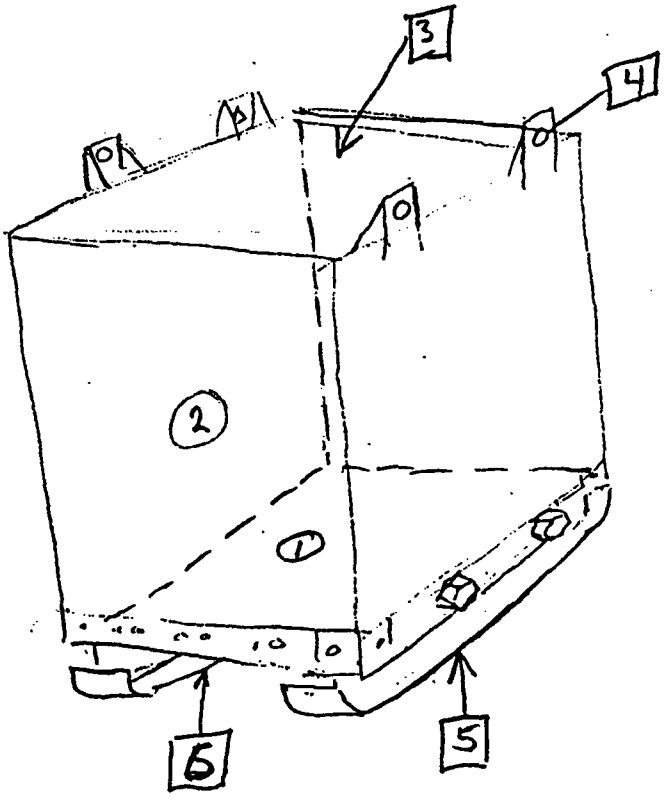
AE:_____ CAL. DATE:_____ C_{eff}_____ %

ME:_____ AREA/ITEM SURVEYED _____

Avg. smear area_____ cm^2

No.	G_{cpm}	C_{cpm}	DPM

DRAWING



○ INTERNAL SMEAR

□ EXTERNAL SMEAR

Comments #7 GROSS MASSLIN over All

Reviewed by_____

MODEL 181361 SHIPPING PACKAGE
USNRC CERTIFICATE OF COMPLIANCE NO. 5796
FOR
3320 SERIES
COBALT SOURCE EXCHANGE CONTAINER

PACKING/UNPACKING INSTRUCTION

IMPORTANT - READ CAREFULLY

ADVANCED MEDICAL SYSTEMS, INC.
ISOTOPE FACILITY
1020 LONDON RD.
CLEVELAND, OHIO 44110

Revised 1/87

INTRODUCTION

This procedure is intended to provide enough information to allow the handler of a radioactive source container to safely pack, unpack, load, or unload a 3320AR Source Transport Container.

WARNING

THE FOLLOWING PROCEDURES MUST BE CAREFULLY AND THOROUGHLY ADHERED TO AS TO AVOID EXPOSURE TO HARMFUL RADIATION AND/OR SERIOUS BODILY INJURY.

1.0 Unpacking a loaded source exchange container (Model 181361)

Upon receipt of the container at the destination the following general procedure applies:

A. The package must be removed from the transport vehicle with material handling equipment of a capacity equal to or greater than the gross package weight of 4000 lbs.

B. Perform a radiation survey of the container to insure that the external radiation level does not exceed 200 mR/hr at the surface and 10 mR/hr at a distance of 1 meter from the surface. [If the level does exceed these limits, the appropriate NRC Regional Office and the final delivery carrier must be notified.]

C. Verify that the shipping seal is intact. The shipping seal may be removed only by a person qualified to install the equipment. Until such a person is present, the container should be stored in accordance with 10CFR20.

D. Upon the authorized removal of the shipping seal, the overpack may be removed.
Remove the four 1 inch and twenty 1/2 inch bolts securing the overpack to the pallet base (save the hardware for reuse).

E. Remove the hex nuts from the thru rods, and the thru rods from the package.

F. With a device capable of lifting 1000 lbs., lift the overpack from the pallet base.

NOTE: The overpack fits very close to the inner package.

G. Remove the wooden jacket from the source exchange container. Do not allow the jacket to become wet or allow it to become misaligned due to rough handling (save the hardware for reuse).

H. Remove the four bolts securing the source exchange container to the pallet base.

I. With a lifting device capable of lifting 3000 lbs., lift the source exchange container off the pallet base.

J. Install the casters (shipped in a separate box) to the base of the source exchange container. Using the elevating wrench (shipped attached to the inside of the skid rail), adjust the casters so that the distance between the floor and the bottom of the skid rails is 11 3/4 ± 1/4 inches.

K. Move the source exchange container, still sealed, into the therapy room.

WARNING

THE CONCENTRATED WEIGHT ON THESE CASTERS WILL CRUMBLE MOST FLOOR SURFACES. SHEETS OF MASONITE SHOULD BE PLACED ON THE FLOOR FOR SURFACE PROTECTION (PLYWOOD WILL NOT SUFFICE, AS THE CASTERS WILL SINK IN AND MAKE MOVEMENT VERY DIFFICULT.) MASONITE SHOULD ALSO BE PLACED OVER DOOR SILLS TO FACILITATE CONTAINER MOVEMENT. DO NOT ATTEMPT TO USE THE MOMENTUM OF THE CONTAINER TO JUMP OVER DOOR SILLS OR OTHER SURFACE IRREGULARITIES. THE CASTERS WILL BE DAMAGED AND THE CONTAINER MAY TOPPLE OVER.

All further unpacking shall be performed by a properly qualified service engineer.

2.0 Preparing a loaded source exchange container (Model 181361) for shipment.

The following procedure applies once the source has been loaded into the 3320 source exchange container by a qualified service engineer.

NOTE: QA Procedure 1014 must be completed prior to shipment.

A. Inspect the source exchange container to insure that all components and covers are in place, bolted and seal wired.

B. Make a wipe survey of the external surfaces of the container.

C. Apply two Radioactive Yellow III labels to the container.

D. With a lifting device capable of lifting 1000 lbs., lift the container, remove the casters, and place the container on the pallet base, using orientation marks as a guide.

E. Carefully secure the wooden jacket around the container. Take care that the jacket is properly aligned with the container.

F. Insert the thru rods as a check for proper alignment. Secure the container to the pallet base with the four 1 inch bolts.

G. Remove the thru rods. Lower the overpack onto the pallet base, using the colored index markings for alignment. NOTE: There is only 1/4 inch clearance between the overpack and the jacket.

H. Insert the thru rods, seating the square ends to prevent rotation. Secure the thru rods with the hex nuts.

I. Attach the seal wire to the pallet base.

J. Perform a radiation survey of the package at the surface (maximum reading 200 mR/hr), and at 1 meter from the surface (maximum reading 10 mR/hr). If the radiation levels exceed these limits, the package shall not be released for shipment. Notify the Radiation Safety Officer for further instructions.

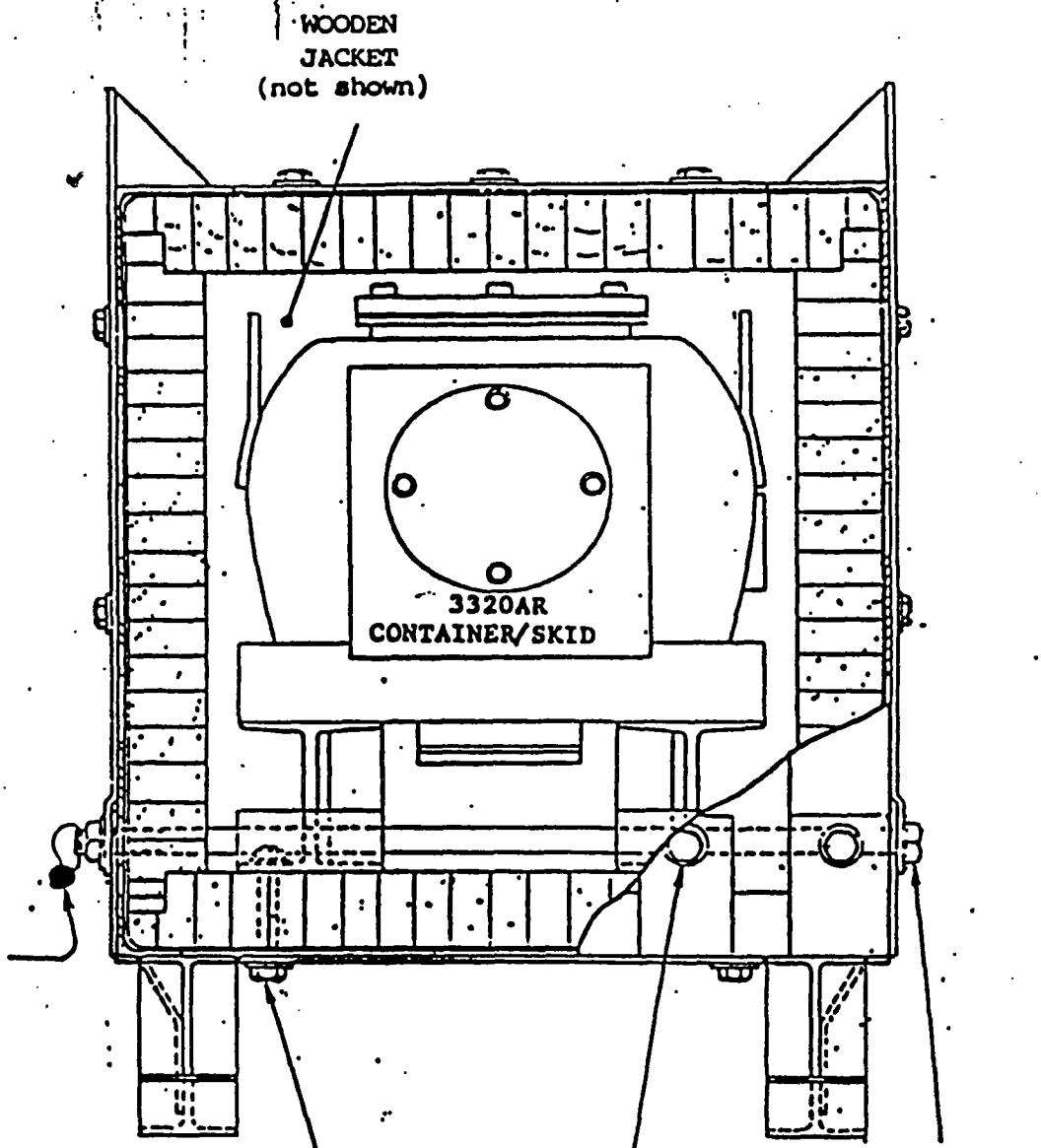
K. Apply the proper labels to the package. Verify that the package content description and caution markings are visible.

L. Complete the shipping papers.
Copies of QA 1014, shipping papers and other documentation should be returned to Advanced Medical Systems for record keeping purposes.

M. All shipments of radioactive material destined for Advanced Medical Systems should be shipped to:

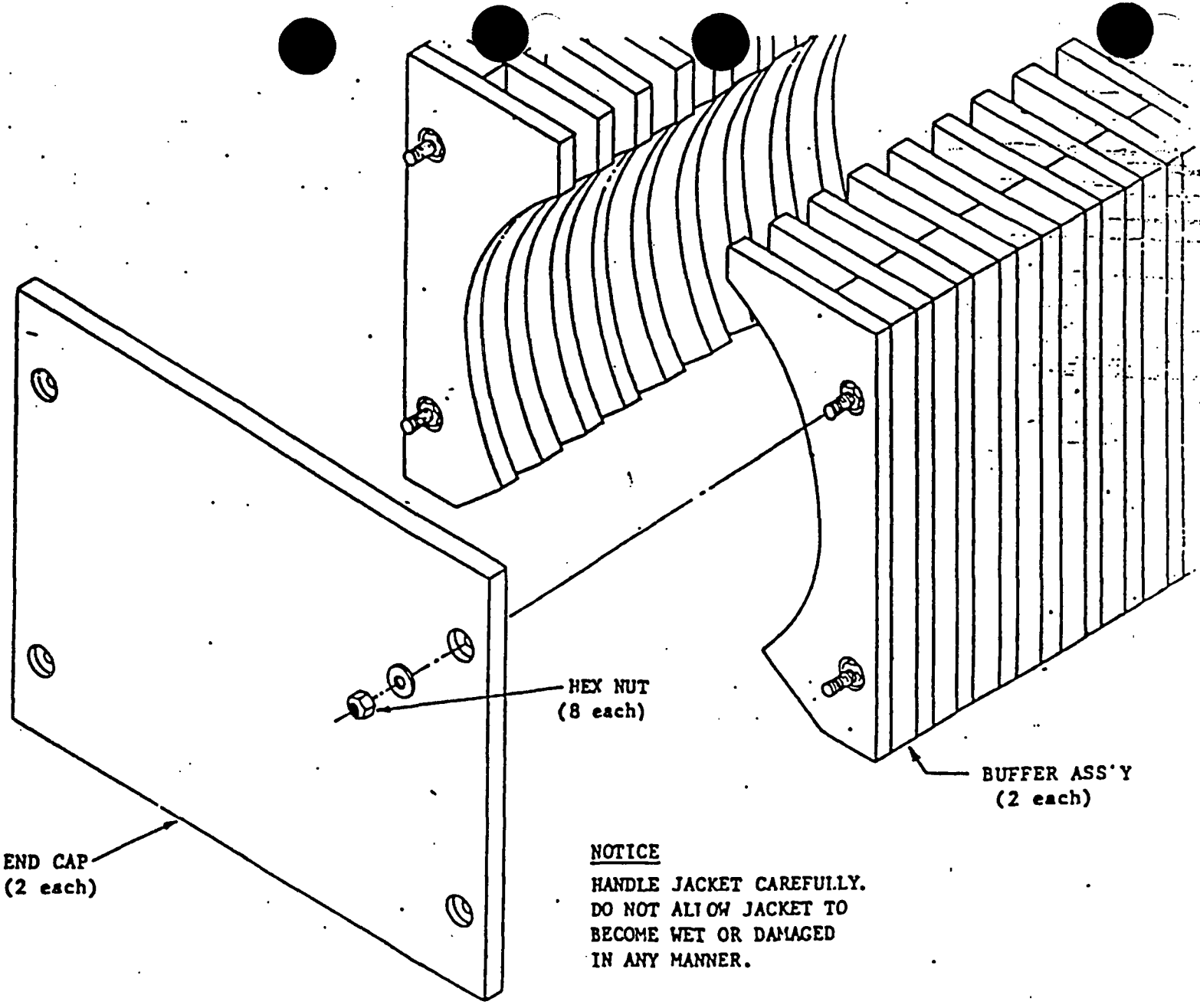
Advanced Medical Systems, Inc.
1020 London Road
Cleveland, Ohio 44110

3320AR SOURCE CONTAINER OVERPACK #181361



CAUTION

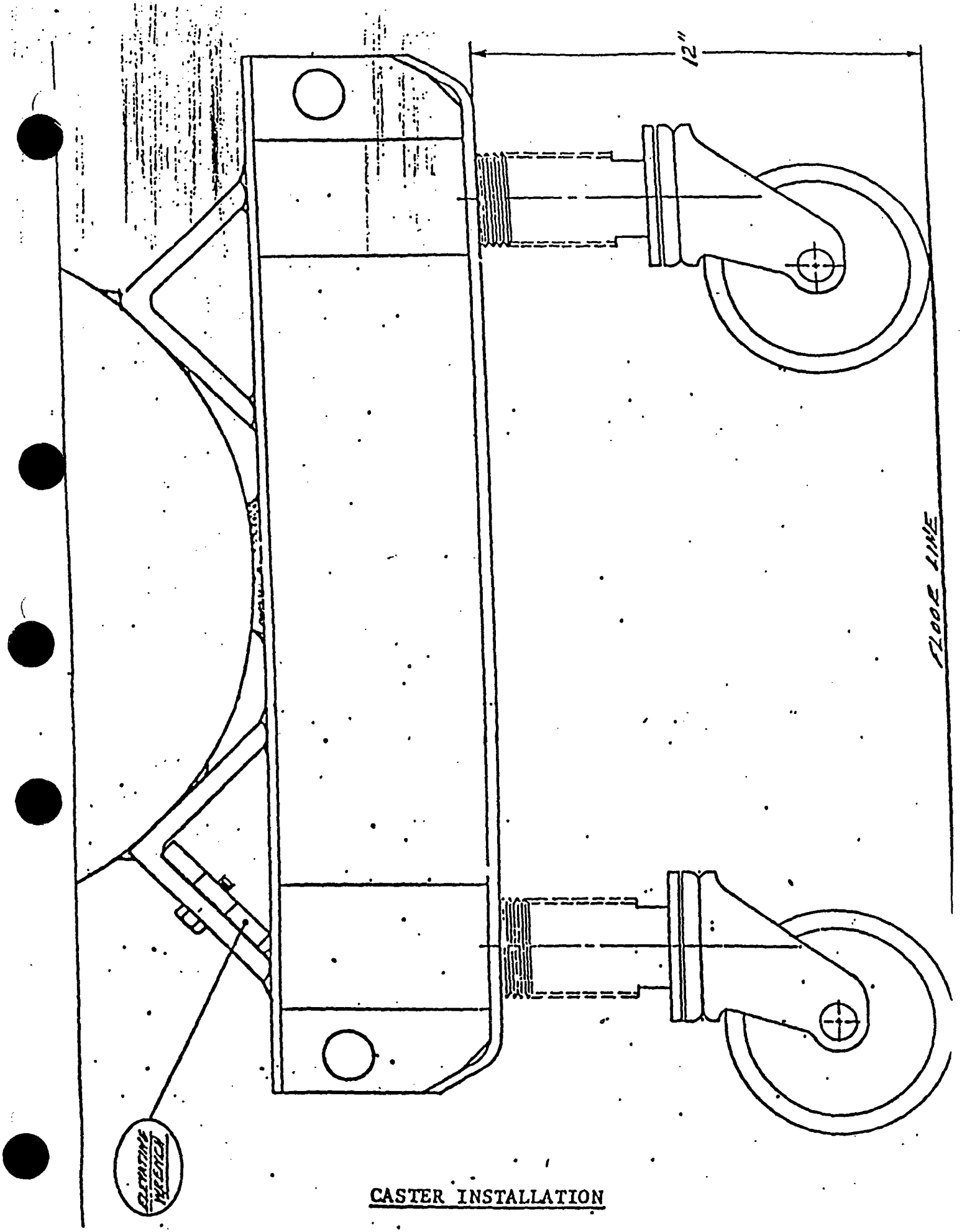
A RADIATION SURVEY MUST BE PERFORMED BEFORE REMOVAL OF A LOADED SOURCE CONTAINER FROM THE OVERPACK.



NOTICE

HANDLE JACKET CAREFULLY.
DO NOT ALLOW JACKET TO
BECOME WET OR DAMAGED
IN ANY MANNER.

WOODEN JACKET FOR 3320AR
SOURCE CONTAINER OVERPACK



CASTER INSTALLATION

SOURCE S/N

ADVANCED MEDICAL SYSTEMS

TITLE:
Exchange Container Contamination Control Record

Procedure No: QA 10148
Revision:
Date Issued: 3/20/87
Page 1 of 1

Prior to next use and/or shipment, the container must be wiped clean of contamination. Clean is considered to be less than 200 CPM above background, using the office well counter.

Take wipes on the following areas. Record the 1st wipe before cleaning, and all subsequently counted wipes for that particular area.

Container S/N_____ last contained source S/N_____

Background_____CPM

STD Activity_____uCi
STD Counts _____CPM

	1st Wipe	
A. Skid Runners bottom		
B. Skid Runners top		
C. Exterior Surface		
D. Cover- bottom		
E. Cover- top		
F. Cover- side		
G. Push rod		
H. Trap		
I. Drawer		
J. Drawer cavity		
K. Vertical hole		
L. Top plug		
M. Lifting Ears		

Date:_____ By:_____

Advanced Medical Systems — Quality Assurance Department

Prepared by	Approval	Revisions
	Howard R Steen	

RADIOACTIVE MATERIAL SHIPPING RECORD

Number QA [illegible]

Revision 0

Date Issued: Nov. 5, 1984

CUSTOMER: _____
LOCATION _____

CONTROL NUMBER

CERTIFICATE OF COMPLIANCE NO. _____

CERTIFICATE OF COMPLIANCE HOLDER: _____

CERTIFICATE IN OUR FILES _____

AMS REGISTERED USER: _____

DATE OF SHIPMENT _____

B/L NUMBER _____

SOURCE INFORMATION:

Isotope _____
Mfg./Cat.No. _____
Curies _____
Wipe Test Reading _____

Serial No. _____
Curies Date _____
Wipe Test Date _____

CONTAINER INSPECTION AND MAINTENANCE

CONTAINER INFORMATION

Model No. _____

Serial No. _____

	CHECK IF OK	REPAIR NOTES
Internal Contamination		
External Contamination		
Preliminary Radiation Survey		
Mechanical Functions		
Shutter or Drawer Locked		
Shutter or Container Sealed		
Gaskets in Good Condition (if any)		
Lifting Loops in Good Condition (if any)		
Tie Down Devices in Good Condition and Secured		
Casters in Good Condition		
Container Identification Legible		
Radiation Warning Signs		

Prepared by	Approval	Revisions
Norman Kelbley	Howard K Hsieh	0 Delete Kelbley, Reposition ID info.

Number QA 104A

Revision 0

Date Issued: Nov. 5, 1984

RADIOACTIVE MATERIAL SHIPPING RECORD

OVERPACK QA INSPECTION AND MAINTENANCE

OVERPACK INFORMATION

Model No. _____ Serial No. _____

	CHECK IF OK	INSTALLATION KIT	INITIAL
Mechanical Functions		Complete per O/M	
All Wood Joints Tight		Survey Meter	
No Holes or Voids		Model No.	
Lifting Loops in Good Condition		Serial No.	
Tie Down Devices in Good Condition and Secure		Date Calibrated	
Skid in Good Condition and Tight			
All Bolts Tight			
Overpack Identification Legible			
Overpack Sealed			
Maximum Radiation Level at 1m.	_____ mR/hr		
Maximum Radiation Level on Surface	_____ mR/hr		
Transport Index Labels Attached			
Opening Instructions Attached			
General Condition			

List Any Items in Need of Repair

_____

_____

_____

_____

_____

_____

_____

DATE INSPECTED: _____ INSPECTOR (Initials) _____

APPROVAL OF LICENSED PERSON _____

REPAIR NOTES: ******** Enter repairs made to bring container or overpack into proper condition. Include initials of individual(s) making repairs and date of repairs.

FIELD NOTE: THIS SHEET MUST BE RETURNED IN THE PRESTAMPED, SELF ADDRESSED ENVELOPE ALONG WITH THE WAYBILL. IN THE EVENT THE WAYBILL AND THIS SHEET ARE SEPARATED, RETURN THESE SHEETS AS INDICATED BELOW:

Advanced Medical Systems, Inc.
Radiation Safety Officer
1020 London Road
Cleveland, Ohio 44110

AUDIT DATE _____

Advanced Medical Systems Quality Assurance Department

Prepared by	Approval	Revisions
Norman Kelley	Howard R Hunter	

SOURCE S/N

ADVANCED MEDICAL SYSTEMS

TITLE:
Exchange Container Contamination Control Record

Procedure No: QA 10148
Revision:
Date Issued: 3/20/87

Prior to next use and/or shipment, the container must be wiped clean of contamination. Clean is considered to be less than 200 CPM above background, using the office well counter.

Take wipes on the following areas. Record the 1st wipe before cleaning, and all subsequently counted wipes for that particular area.

Container S/N_____last contained source S/N_____

Background_____CPM

STD Activity_____uCi
STD Counts _____CPM

	1st Wipe	
A. Skid Runners bottom		
B. Skid Runners top		
C. Exterior Surface		
D. Cover- bottom		
E. Cover- top		
F. Cover- side		
G. Push rod		
H. Trap		
I. Drawer		
J. Drawer cavity		
K. Vertical hole		
L. Top plug		
M. Lifting Ears		

Date:_____ By:_____

Prepared by	Approval	Revisions
	Howard R Owen	

Advanced Medical Systems is located in the Midwest Compact. Ohio is the first state within the Compact scheduled to open a radioactive waste disposal site. The earliest such a site is scheduled to open is 2002.

There are currently no other disposal sites to dispose of Advanced Medical Systems' radioactive waste until the Ohio site opens, at the earliest, in seven (7) years. The company, therefore, is forced to store its low-level waste on site at 1020 London Road. The company has developed a Waste Management Program using NRC Information Notice No. 90-09 as a guide.

Advanced Medical Systems' Waste Management and Storage Program is only an interim measure until a waste disposal site is opened for Ohio companies.

1. Identification of Waste

Advanced Medical Systems currently has on-hand approximately 29 curies of low-level dispersable radioactive waste.

1.1 Radioactive Material

We are requesting a possession limit of 40 curies for radioactive waste. The company feels this is adequate given current and future operating conditions. Therefore, there is no increase for the possession limit for extended storage of low-level waste. The estimated maximum capacity available to store waste is 22,000 cubic feet. The estimated maximum volume to be stored is 8,000 cubic feet.

The waste consists of the radionuclide Cobalt-60. The low-level waste currently stored on site is characterized as Class A and consists principally of solid waste. The company is actively seeking quotations from third parties for volume reduction of its current waste quantities of approximately 500 cubic feet. The company is investigating both supercompaction and incineration; however, no decision or commitment is being made by the company at this time to volume reduce its waste.

The non-radiological properties of the low-level waste are combustible materials; i.e., paper, plastic and cloth. All of this material is stored in either sealed 55-gallon drums or B-25 (steel) containers.

The company has no additional permits pending approval. The company does complete a Low-Level Radwaste Report for the Ohio Department of Health on an annual basis.

1.2 Plans for Final Disposal

As previously discussed, there is currently no disposal facility available to Advanced Medical Systems. Therefore, on-site storage has already begun. Advanced Medical Systems is located in the State of Ohio which is a member of the Midwest Compact which will be the governing authority for ultimate disposal of its waste. The absolute earliest the Ohio waste disposal site will open is the year 2002. There are currently legislative hearings being conducted on how the site will be selected. It is anticipated that this date will slip.

Once the site is open, Advanced Medical Systems will immediately begin making arrangements to dispose of its low-level radioactive waste. It is difficult at this time to estimate how long the waste inventory will take to be shipped to the site. Site protocol has not yet been developed.

Low level radioactive waste is stored in a portion of the basement, a shielded room, whose wall thickness is a minimum of three feet (3') and the Isotope Shop Warehouse. There is no waste processing equipment as all processing would be contracted to a third party. No flammable or explosive material is stored in or near any area which contains radioactive waste. The basement and shielded storage room air is processed by the building ventilation system which is HEPA-filtered and monitored with an isokinetic system.

The three (3) storage areas have a total volume capacity of 22,000 cubic feet. Anticipated annual volume of non-volume reduced waste is estimated to be approximately 300 cubic feet.

All storage areas are within the confines of the existing facility structure which are climate controlled. None of the waste storage areas have immediate access to the outside. The structure is a combination of cement, cement block, brick and cement and a steel roof. The structure provides exceptional weatherproof containment. All the interior rooms are locked and are designated and posted "Restricted Access". Access is controlled by the Radiation Work Permit System. All areas that contain radioactive waste are monitored through smoke or heat detectors or sprinkler system. Advanced Medical Systems' Emergency Plan recommends that any fires within a restricted area be fought with dry chemicals, Halon, CO_2 or equivalent. As all the waste is stored within sealed 55-gallon drums or B-25 (steel) containers, the likelihood of a fire involving dispersable radioactive material is extremely remote.

As the building temperature is maintained by the building's HVAC System, there should be no adverse effects to the extremes of temperature and humidity on the waste.

Advanced Medical Systems is located in Northeast Ohio. Natural hazards such as hurricane and flood are considered remote as are tornadoes. There is very little active industrial activity within the areas where the low-level radioactive waste is stored. Accordingly, the risk of an industrial accident carries an extremely low probability.

1.3 Packaging and Container Integrity

As previously discussed, waste is stored in DOT 17H 55-gallon drums, B-25 (steel) boxes, and within shielded rooms with minimum three-foot (3') thick concrete walls, ceilings/floor with a labrynth entrance. The waste is LSA DAW and imposes no hazard to the integrity of the containers.

The waste storage areas are currently surveyed for radiation and contamination and are visually inspected on a monthly basis. If waste packages were discovered to be leaking, they would manually be re-packaged.

1.4 Radiation Protection

All waste storage areas are designated restricted areas and posted per 10CFR20. Access is controlled via locked doors in the Radiation Work Permit System. Surveys and inspections are performed on a routine basis as prescribed in Advanced Medical Systems' Isotope Shop Procedure Manual. Waste is arranged to shield higher radiation level items with lower radiation level items.

Waste causing radiation levels in excess of 25mRem/hour on contact are stored in the basement and shielded storage room. Advanced Medical Systems does not anticipate any changes in the current personnel monitoring program.

Advanced Medical Systems currently has an NRC-approved Emergency Plan in effect. This Plan is being amended to reflect current operations at the facility. The amended plan is contained within this Application for License Renewal.

1.5 Maintaining of Records of Waste

Advanced Medical Systems does not receive any low-level radioactive waste from any third parties.

Records are maintained by implementation of a currently-approved facility procedure that identifies and records data pertaining to the waste generated and stored.

1.6 Training

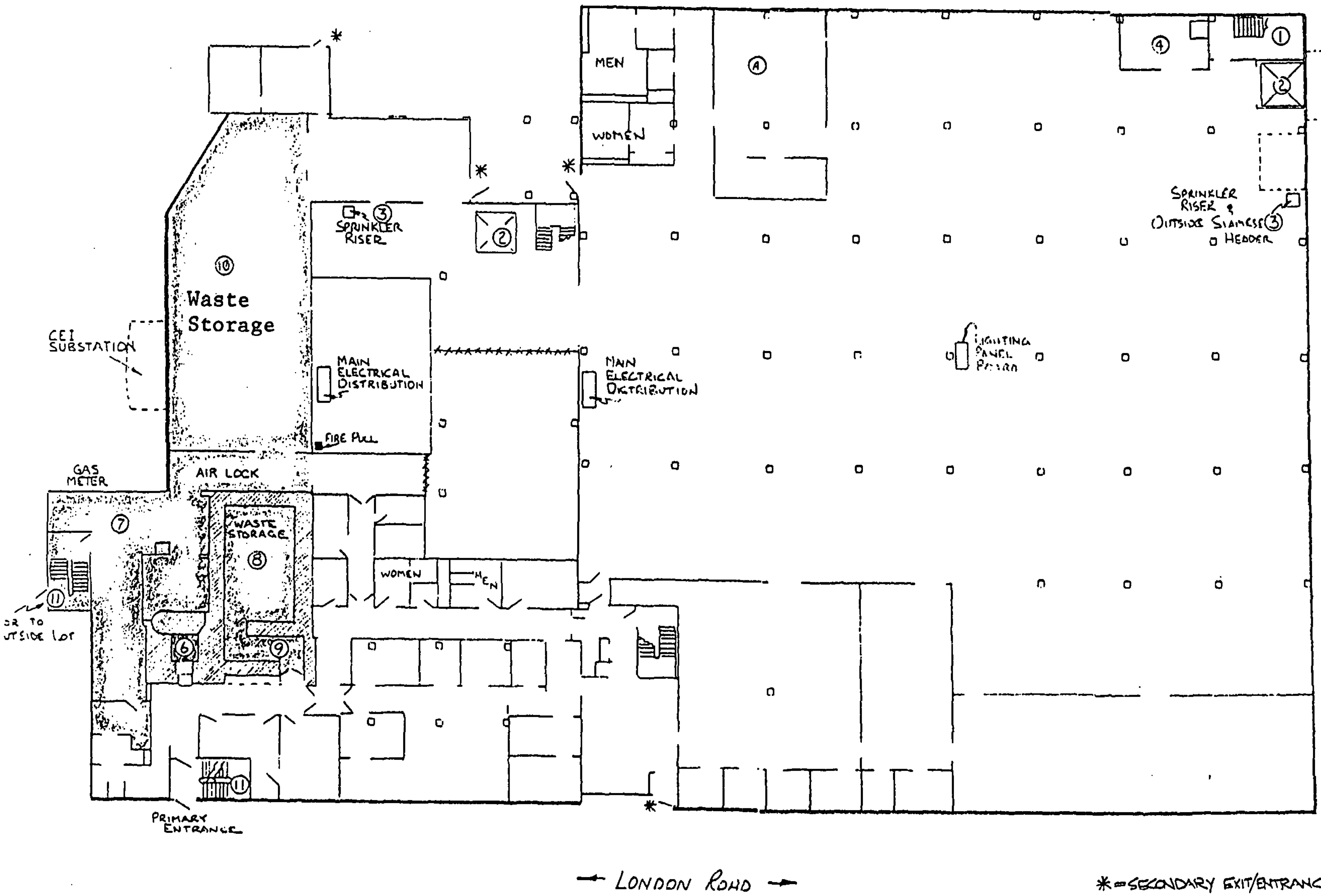
Advanced Medical Systems' Isotope Shop Procedure Manual contains several separate procedures for training company personnel in the packaging, handling, placement, inspection and monitoring of low-level radioactive waste. All personnel located at 1020 London Road are aware and are familiar with the company's Emergency Plan.

1.7 Financial Assurance

The company currently maintains a Decommissioning Funding Plan and corresponding financial assurance for its facility at 1020 London Road. Waste disposal costs are included within this Plan.

1.8 Emergency Preparedness

As previously discussed, the company currently maintains an Emergency Plan for its entire facility located at 1020 London Road. This Plan also contains a Risk Analysis prepared by a consultant which discusses both the likelihood and the effects of an emergency that would involve dispersable radioactive material. The consultant's conclusion is that there is not a very likely scenario for the release of radioactive material to the environment.



① STAIRWELL TO ROOF

② NON-OPERATIONAL ELEVATORS

③ SPRINKLER RISER

④ BOILER ROOM FUEL: NAT. GAS

⑤ SHADED AREAS ~RESTRICTED~

⑥ HOT CELL – HIGH RADIATION & CONTAMINATION AREA

⑦ ISOTOPE SHOP – RADIATION AREA & CONTAMINATION PRES

⑧ WASTE STORAGE – HIGH RADIATION AREA
STORAGE OF RADIOACTIVE WASTE PRIOR TO SHIPMENT.

⑨ DEPLETED URANIUM STORAGE AREA

⑩ WAREHOUSE – RADIATION AREA. STORAGE & STAGING AREA FOR SEALED SOURCES IN SHIPPING PACKAGE

⑪ STAIRWELLS TO BASEMENT – RESTRICTED AREAS DUE TO RADIATION & CONTAMINAT RADIOACTIVE WASTE-WATER STORAGE AREA. NO FLAMMAB MATERIALS.

✱ = SECONDARY EXIT/ENTRANCES FOR EMERGENCY USE

LTR	REVISION	DATE
A	REMOVED AREA 'E'	1/24/15

UNLESS NOTED • TOLERANCES ON ANGLES ± □ BREAK ALL SHARP EDGES
DECIMALS ± • FRACTIONS ± DIMENSIONS ARE BEFORE APPLYING FINISH

NEXT ASSY	QTY	NAME London Road 1st Floor Pre-Emergency Plan
		MATERIAL
		FINISH
		DRN N.C. BAAZER 8/24/ DATE · CHKD HRI · APPRVD E. SVEEL

ADVANCED MEDICAL SYSTEMS, INC.
GENEVA, OHIO 44041

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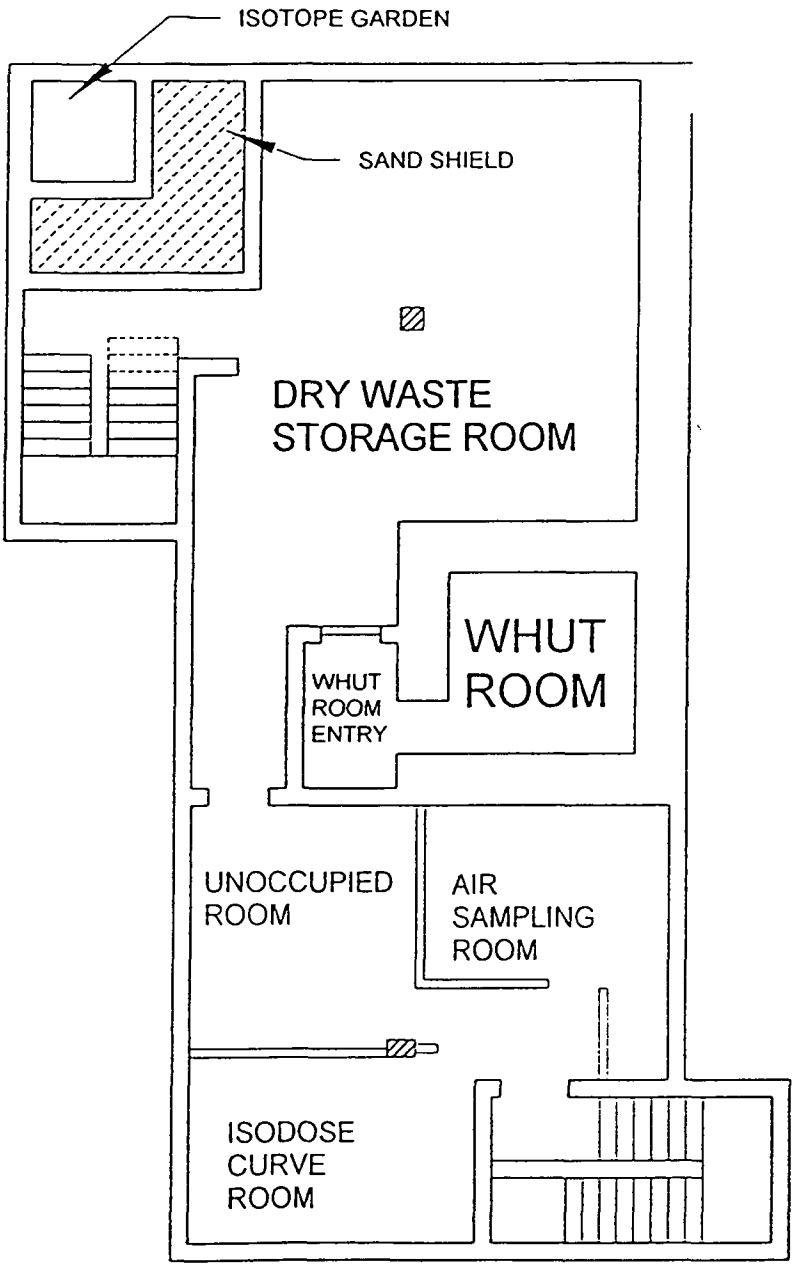


AMS Facility Basement

SECTION 1.8 - LICENSE FEES

The information contained in this License Renewal Application describes in detail the uses of the licensed material for License No. 34-19089-01. To briefly restate, Advanced Medical System requires a license to possess its current inventory of licensed material and to purchase sealed sources for resale.

Based on this information, the following are the Materials Licenses and fees for this renewal:

Source Material

2B) Licenses which authorize only the possession, use and/or installation of source material for shielding:

Renewal Application..... $ 160.00

Byproduct Material

3P) All other specific byproduct material licenses, except those in Categories 4A through 9D:

Renewal..... $ 680.00

TOTAL FEES	$ 840.00
PAID-CHECK #27819 11/29/94	2,200.00
PAID-CHECK #27919 12/28/94	740.00
OVERPAYMENT OF FEES	$(2,100.00)

SECTION 1.9 - SERVICE OPERATIONS

As Advanced Medical Systems is maintaining its licensed service operations, we will require the following license categories:

1. Authorizes the servicing of AMS/Picker units excluding source exchange;

2. Authorizes sealed source exchange;

3. Authorizes removal of the unit and head from customers' sites only;

4. Authorizes the handling of licensed material.

In addition, no licensee shall perform any service operations until they have completed the required training.

These service categories are essentially the same as in our current license and are required to be maintained as AMS may service, install and remove units in the domestic market.

SECTION 2 - EMERGENCY PLAN

Advanced Medical Systems has revised its Emergency Plan to accurately represent the current operating condition of the facility. In addition, a consultant has prepared a Risk Analysis given an emergency at the facility that would result in dispersable radioactive material being released. The consultant's report is enclosed and concluded an absolute worst-case incident at the facility would not require evacuation of nearby residences and businesses given the secure storage of the licensed material.

In addition, the Company has had several meetings with the Chief of Fire Prevention for the City of Cleveland. Several changes were suggested by both Advanced Medical Systems and the Fire Department which would aid the responding units. The suggested changes are as follows:

1) Each restricted area in the facility will have a separate zone. The restricted areas are:

   a) Hot Cell
   b) Isotope Shop Warehouse
   c) Airlock
   d) Isotope Shop Workshop
   e) Basement
   f) HEPA Room
   g) Clean Equipment Room
   h) High Level Waste Storage

   This would allow the responding units and Advanced Medical Systems' personnel to know the exact location of an emergency in a restricted area.

2) Section waterflow monitors will be installed on the two risers to further define the emergency area.

3) An enunciator panel will be installed in the Main Lobby entranceway. This will allow the responding unit to verify signal location. At the enunciator panel will be a legend and a facility layout.

4) Heat/smoke detectors will be installed to allow monitoring both above and below the ceiling tiles in the office area.

5) The local monitoring company will add a monthly maintenance test to the booster pump. The flow test will remain on a semi-annual basis. The monitoring company will continue the monthly inspector test and 2" drain test.

6) The cell office and Clean Equipment Room Gamma alarms will be connected to the monitoring company's system. Advanced Medical Systems' personnel will be the only notified party of a Gamma alarm.

7) The overhead fire door will be checked by a contractor for working condition and proper activation.

Completion time, per the monitoring company, for these changes is 8-12 weeks. Section 2.1.2 of the E-Plan will be updated once the system is updated.

These changes will aid the local emergency response teams in locating and determining the extent of the emergency.

The Fire Prevention Chief also expressed an interest in a joint exercise to ensure the local firehouse personnel are familiar with the facility. Advanced Medical Systems supports this request and it was mutually agreed that the drills and training be conducted after the monitoring system has been updated.

ONSITE RADIOLOGICAL CONTINGENCY PLAN

FOR THE

CLEVELAND, OHIO FACILITY

USNRC LICENSE NO. 34-19089-01

ADVANCED MEDICAL SYSTEMS, INC.

October 25, 1991

Revised May 27, 1992

Revised January, 1995

Approved: Robert Meschter

ROBERT MESCHTER
Radiation Safety Officer
Advanced Medical Systems, Inc.
121 North Eagle Street
Geneva, Ohio 44041

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

REVISION SHEET

Effective Date	Revision Letter	Pages Affected	Description of Change
10/18/91	Initial Release	All	Revised and Reformatted per Reg. Guide DG-3005
01/31/92	Revision "A"	1-7 1-8 2-7 2-8 2-9 3-1 3-2 3-3 4-2 4-3 5-1 5-2 5-5 5-6 6-1 7-1 8-1 8-2 9-1 9-2	Revised to Include Comments of Ohio Emergency Management Agency
05/27/92	Revision "B"	3-1 3-2 5-5 5-6 7-1 7-2	Revised and Reformatted per Reg. Guide DG-3005
		Appendix A: Emergency Contact Personnel Telephone List	Revised to Reflect Current Personnel
		2 3 5 7 9 12 13	Revised and Reformatted per Reg. Guide DG-3005

REVISION SHEET

Effective Date	Revision Letter	Pages Affected	Description of Change
01/95	C	IV	Add-Authority to Marshall the Resources to Control the Emergency
		All	Changed to Reflect Current Operations
		3-3	Add-Consultant's Hazard Analysis

STATEMENT OF POLICY

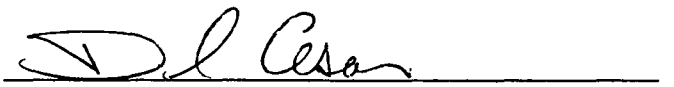
Authority and responsibility for the direction and control of emergency situations is hereby vested in the Radiation Safety Officer (RSO) of Advanced Medical Systems, Inc., London Road facility. The RSO's duties will include, but not be limited to, the following:

. . .Direct control of the situation, including termination of the emergency alarm condition;

. . .Management and coordination of the emergency response staff;

. . .Authority to obtain all information concerning the event;

. . .Authority to marshall the resources to control the emergency.

Approval: 

Advanced Medical Systems, Inc.
121 North Eagle Street
Geneva, Ohio 44041

INTRODUCTION

The London Road facility of Advanced Medical Systems, Inc., utilizes radioactive material for the resale and transfer to third parties of encapsulated Cobalt^{60} sources used in both teletherapy and radiography units. The material is used in accordance with U. S. Nuclear Regulatory Commission (USNRC) by-product license No. 34-19089-01. This license authorizes possession of up to 78K ci of Cobalt^{60} for resale and transfer of encapsulated sources. AMS's license also permits possession of up to 665 curies of Cesium-137 sealed sources and up to 4,040 Kg of depleted uranium (nickel plated) which is used as shielding material. There is an additional 15 curies of radwaste stored in certain restricted areas of the facility.

This plan has been prepared in accordance with Regulatory Guide 3.67 (Task DG-3005).

1.0 General Description of the Plant/Licensed Activity

This chapter provides an overview of the Advanced Medical Systems, Inc., London Road facility.

Section 1.1 is a description of the types of radioactivity handled
Section 1.2 is a description of the site and facility
Section 1.3 is a description of the processes used at the facility for handling radioactive materials.

1.1 Licensed Activity Description

The London Road facility of Advanced Medical Systems, Inc., posseses sealed and encapsulated sources of Cobalt^{60} for use in teletherapy and radiography machines manufactured by the Geneva, Ohio, facility. Sales are to USNRC licensed recipients or exported to other countries. The material is used under the supervision of the Radiation Safety Officer.

The types and quantities of licensed materials used or possessed by AMS are summarized below:

By-Product, Source or Special Nuclear Material	Form	Maximum Amount Allowed
Cobalt^{60}	Solid Metal (Bulk)	23,000 curies
Cobalt^{60}	Sealed Sources	75,000 curies
Cesium-137	Sealed Source	665 curies
Depleted Uranium	Nickel Plated	4,040 Kilograms
Cobalt^{60}	Sealed Calibration Sources	15 Millicuries

However, only approximately 29 curies of radioactive material are in a location and form that would allow the material to be dispersed in an emergency that would breach the facility. The majority of this dispersable radioactive material is stored in sealed 55-gallon drums or B-25 (steel) boxes.

1.2 Area and Facility Description

The London Road facility of Advanced Medical Systems, Inc., is a two-story controlled access building located at 1020 London Road on the east side of Cleveland, Ohio.

Figure 1-11 shows the region within approximately one (1) mile of the facility and identifies its relative proximity to near-site structures. Locations of schools, hospitals and fire stations are also shown on Figure 1-11.

The facility is located in a manufacturing and residential area. The areas to the west, south and east are mainly industrial facilities. The area to the north of the plant is a mix of small businesses and residential units.

The facility is approximately 80,000 square feet. Access to the property is from London Road which is located on the eastern edge of the property. In addition to a perimeter fence, site security is maintained by A.D.T. using remote security links.

Initial fire and emergency response is provided by the Cleveland City Fire Department. The Cleveland Fire Department HAZ-MAT team will respond to a radiation release at Advanced Medical Systems. Fire response is estimated to be within five (5) minutes.

Figure 1-8, First Floor, 1-9, Second Floor, and 1-10, Basement, are general building layouts of Advanced Medical Systems. Restricted areas are shaded. The entire basement is restricted.

Transient population within one (1) mile radius of the facility is primarily a function of employment associated with the surrounding factories/businesses.

1.2.1 Description of the Isotope Facility

The facility was specifically built as an Isotope facility for the manufacture of sealed sources. Rooms and restricted areas were designed to contain and confine emergency situations. **As AMS no longer manufactures sealed sources, the facility safeguards afford additional protection given current operations.**

The design of the facilities follows the philosophy of containment of activity within small working areas. Health and safety considerations have been based on minimum hazard in restricted areas and zero hazard in controlled areas. The Company actively strives to minimize restricted areas of the facility to confine emergency situations to the Isotope Shop Area.

The Isotope Facility is situated on 6.3 acres of land which lies on the boundary between industrial and residential areas. Because of proximity to these areas, special care has been exercised in planning the safety program. The Isotope Shop Area is located in the south end of the building on the first floor. There are no windows in the Isotope Shop Area because windows were felt to be of questionable value for a number of reasons. Safety considerations and protection against unauthorized entry into the Isotope Shop Area are simplified when there are no windows. The maintenance of proper air flow balance and of uniform lighting is also simplified. Other considerations were the noise transmission of windows from the adjacent railroad tracks and the special procedures required for cleaning windows inside controlled areas and the possible radiation hazards of cleaning windows on the outside.

The one-story projection of the southwest corner of the building contains the stairwell to the basement and the source storage garden. The door located in this stairwell is for emergency exit use only.

The enclosed layouts of the floor plans show the first floor of the facility which contains the isotope and shielded work areas. The controlled access areas are enclosed by the heavy dashed line. The location of the heavy shielding for the shielded work room, the cell provides an unbroken radiation barrier between the isotope areas and the high occupancy areas of the rest of the building.

The restricted activity centers of the facility are the high level hot cell, the shielded waste storage room and the isotope shop area and an isotope storage and irradiation facility (garden).

The areas in which radioisotopes are handled are reached through a changing area located in the southeast corner of the building.

1.2.2 The Shielded Waste Storage Room

The Shielded Waste Storage Room has minimum three (3) feet thick walls for concrete shielding and a labyrinth entrance. The broad corridor through the labyrinth entrance permits large objects to be moved into the room. The floor and ceiling are also concrete.

The room is used for storage of depleted uranium and RAD waste. Rad waste is packaged in 55-gallon drums. Used HEPA filters are also located in this closed room.

1.2.3 Hot Cell

The hot cell was designed and equipped to encapsulate the largest sources used for medical therapy and industrial radiography. AMS ceased source manufacturing in 1990.

The hot cell is six feet square inside, and has 5-1/2 foot concrete walls and 4 foot floor and ceiling. The floor pan is stainless steel and the inside walls are 1/4 inch steel plate to a height of 11 feet. The cell is closed at the rear by a 40-ton hinged door which provides a full 6-foot wide entrance to the cell when open. Numerous small access ports are located on the front and side faces of the cell, and a 20-inch square port opens from each side. Observation of cell operations is possible through a 60 inch glass and zinc bromide window. Remote handling is accomplished with a pair of Model 8 Manipulators and a 2 ton overhead crane.

All cell operating controls are located on the cell face, so that normal operation does not require entry into the contaminated isotope areas. The isotope areas may be observed from the cell control area by a window through the southeast corner of the cell in line with mirrors placed against the south wall. The isotope areas are connected to the control area by an intercom system.

The viewing window for the cell is removable from the outside of the cell. The viewing components consist of an 8 inch inside coverplate of non-browning glass, a 2-inch plate glass, 48 inches of zinc bromide solution and a 2-inch outside coverplate of safety glass. This construction provides shielding equivalent to 66 inches of 150 lb/ft^3 concrete with only two glass/zinc bromide interfaces. The entire metal structure in contact with the zinc bromide solution is coated to prevent introduction of impurities which might cloud the zinc bromide solution. The window was designed and constructed in 1984 by Hot Cell Services Corporation, Kent, Washington.

The Model 8 Master Slave Manipulators are mounted above the window using the roller-tube mounts. The roller tubes are positioned on 28-inch centers in concrete within a 24 by 58-inch steel-lined opening in the cell wall. This method of mounting in an oversized opening will permit installation of new types of manipulators as they become available, or relocation of the present manipulators to a different centerline if required by future operating conditions.

The cell door is located at the rear of the hot cell and opens into the decontamination room. The door is an internally braced steel tank filled with concrete. The upper and lower stub shafts of the door are mounted on bearings which permit the door to rotate about a vertical line through on end without touching the floor or ceiling at any point. This construction permits a smooth unbroken level floor into the cell over which heavy shipping containers can be easily moved. The 40-ton door is removable in case of bearing failure, but due to the low rotational speed and infrequent operation of the door, a long service life is anticipated. The turntable upon which the door rides contains a heavy-duty bearing mounted on a hemispherical ball-joint to permit alignment of the lower bearing with the upper

bearing. The upper hinge has the bearing mounted in a block which can be moved by means of wedges and power screws to obtain the necessary alignment for a true axis of rotation. The stub shaft connecting the upper hinge to the door is removable through a 9-foot vertical tube to the second floor level. The upper bearing is a sealed unit and should require no lubrication. The lower bearing, at floor level, may become dirty even though a neoprene wiper rides the edge of the turntable. The lower bearing may be lubricated, or flushed and lubricated if dirty, by means of a tube which runs beneath the floor level to the service trench on the south side of the cell. The door is opened and closed electrically by means of a motor mechanism mounted on the outside of the door. An electrical interlock prevents the electrical door drive from being actuated until the switch at the cell face and the drive motor switch are simultaneously operated. Release of either button stops the door opening. This safety feature makes it impossible for the cell door to be opened without the knowledge and consent of the cell operator, or for the cell to be opened by a person working alone. The two-ton overhead crane inside the hot cell is electrically powered and controlled. In order to cover the six-foot square floor area of the cell with a minimum of travel, an electrically powered trolley was mounted on an I-beam rail which can be rotated 180^0. The crane assembly is mounted in a removable plug in the cell ceiling.

Storage facilities for isotopes within the cell are provided by two containers inserted in steel sleeves in the floor.

As mentioned previously, the hot cell is shielded by 5-1/2 feet of concrete, with 1/4-inch steel plate on the inside faces. The shielding thickness was chosen as sufficient to handle the largest sources currently available with complete safety, and to provide adequate shielding for the larger sources the future may require.

As the hot cell does not contain any flammable material, there is virtually no possibility of fire or explosion within the cell.

1.2.4 Hot Cell Supporting Facilities

The facilities supporting the operation of the hot cell are primarily concerned with the safety considerations necessary when this type of facility is located in a populated area.

Every effort is made to eliminate possible exposure to the public.

The air handling system has received special attention due to the location of a residential area within a block of the facility. The facility has separate systems for the isotope areas, first floor office control area, second floor office area and the lobby and reception area. The isotope shop area and hot cell have a once-through airflow system with carefully balanced flow gradient to the hot cell as the low pressure point of the system. The supply air to the isotope areas is filtered through Aerosolve prefilters before entering the building. The heavy burden of

industrial air wastes from neighboring plants and the railroad tracks is therefore removed at the point where filter changing is accomplished with the least difficulty. The supply air is distributed to the isotope areas by ventilating ducts containing manually adjustable dampers. The airflow pattern is adjusted initially by balancing the supply and exhaust systems to obtain the desired flow pattern, and periodic checks of manometers are made to assure the desired pattern is maintained. The doors at either end of the change area are electrically interlocked to prevent simultaneous opening which might disturb the air flow pattern. The doors at either end of the air lock, which are used to move shipping containers in and out of the isotope areas, are similarly interlocked. The exhaust system has two centrifugal blowers which are located on the second floor directly above the hot cell. Both blowers exhaust through separate filters and a common high-velocity stack. The larger blower removes air from all isotope areas except the hot cell, and requires a 2 x 2 array of absolute filters. The exhaust fan for the hot cell is independently operated, and has a single absolute filter. The balanced air flow pattern is from the change areas through the Isotope Shop area to the decontamination room and finally to the hot cell. The hot cell exhaust fan is driven by a two-speed motor which is controlled by the position of the double doors connecting the decontamination room with the Isotope Shop area. With the doors closed, the fan operates at normal speed and the decontamination room receives its air supply through a duct at the south side of the doorway. When the door is opened, the supply air is diverted from inside to outside the decontamination room by means of a switch which also increases the hot cell exhaust fan capacity by about 50%. This prevents reverse flow of the potentially contaminated air of the decontamination room into the lower level Isotope Shop area.

The air handling system is under continuous control by a monitoring and safety system. The air sampling tube is mounted across a diameter of the air exhaust stack about eight feet above the roof level. An air monitor located in the hot cell control area draws a continuous sample of 5 cfm minimum for analysis. Any increase of activity above the present level immediately stops the exhaust fans and the supply fan. The control system also includes automatic shutdown of either exhaust fan if a sudden pressure drop occurs across its absolute filters, indicating rupture to the filter media.

The operation of the air handling equipment, the monitoring facilities and the liquid waste facilities is insured in the event of electrical power failure by a natural gas burning emergency generator with automatic rapid changeover. An emergency lighting system is also powered by this generator.

All safety and monitor devices are connected to an alarm panel in the control area. Separate lights for each controlled item are always lit on the panel so that faulty operation of the panel itself is indicated by no light. When a controlled item

malfunctions, the alarm light increases in intensity and flashes on and off until an acknowledgement button is depressed. An audible alarm also sounds on the first and second floors until acknowledged. This type of alarm will therefore indicate the difficulty even though it has corrected itself before the operator has checked the panel, and the alarm signal will be erased only when the acknowledgement button has been depressed.

Alarms for fan shutdown, excessive heat or cold are also transmitted to a local burglar alarm company so that malfunctions during non-working hours are reported to a responsible person or agency.

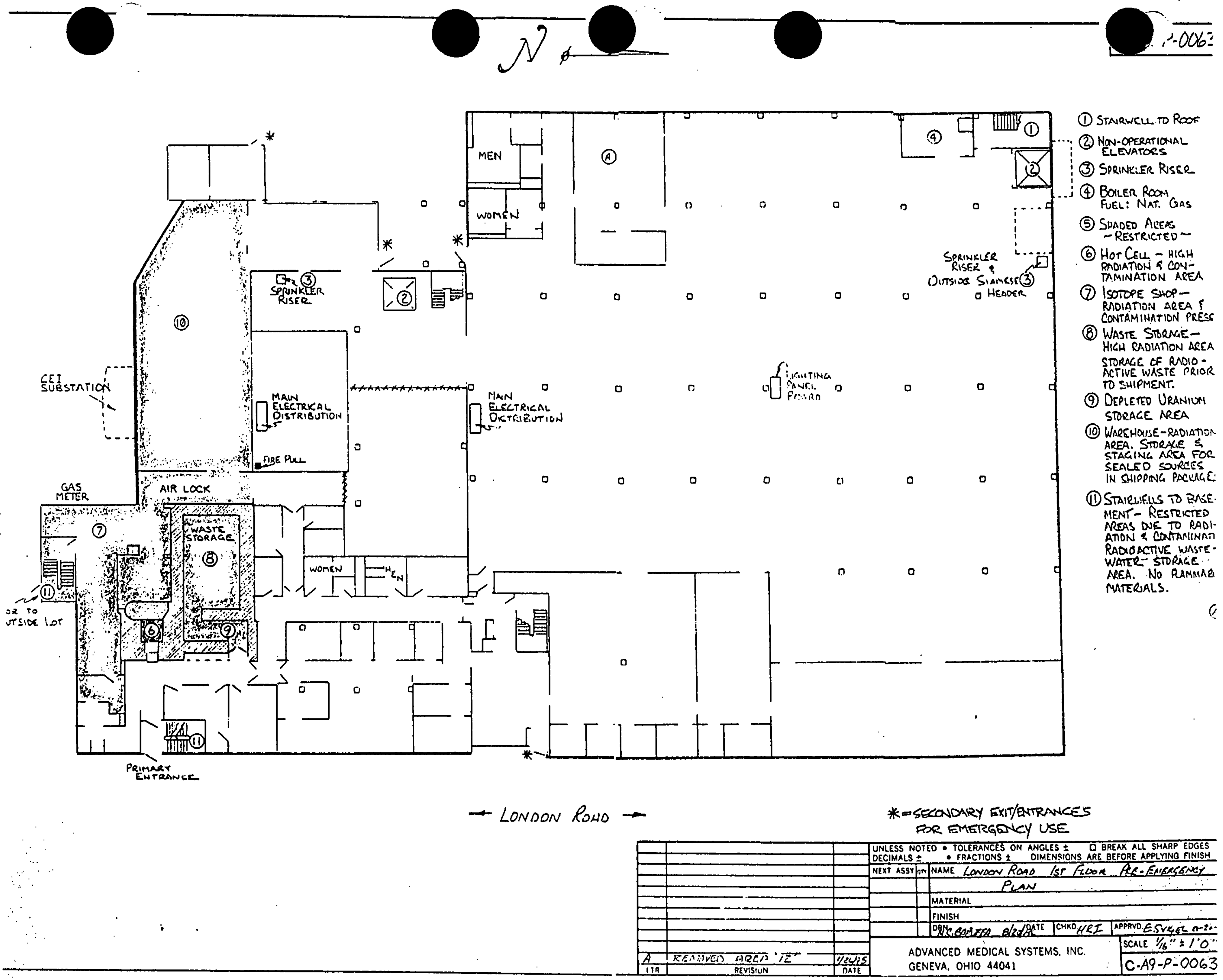
1.2.5 Storage Garden and Irradiation Facility

The facility is located in the southwest corner of the building and contains vertical storage tubes in a six foot square well extending from the first floor level to the basement floor level. An L-shaped shield around the well is provided by two sand filled shield rooms which are accessible through manholes in the first floor. Course concrete sand with a bulk density of 127 lb/ft^3 was used as the shielding material for a number of reasons. Immediate shielding requirements are easily handled by the use of sand, which can, of course, be replaced easily by a higher density material in the future, if desired. The rooms have been waterproofed and a well drilling point extends to the basement floor level beneath each manhole cover so that temporary additional shielding may be obtained by flooding the voids of the sand with water. Flooding increases the shield density by 7 lb/ft^3. If storage needs ever require it, the rooms can be emptied and filled with concrete, steel shot or other higher density material.

The storage "garden" is constructed with 54 vertical storage tubes in a rectangular array. The tubes are arranged in a 7 x 9 array with the center nine spaces left open. The center space is fitted with an irradiation plug which can be used to irradiate objects up to 8-1/2 inches square by 12 inches high. Each of the tubes marked "A" can also be used for irradiation by placing sources in the four tubes around each which have a common side. The two outer rows of seven tubes, marked by crosses, extend about two feet below the bottom of the tubes in the central 7 x 7 array. This permitted installation of an irradiation facility beneath the garden with two parallel rows of sources between which objects up to a 17 inch cube can be irradiated.

The source storage tubes terminate in a metal container through which cooling air is drawn from the room through the "garden" to the absolute filter exhaust system.

This area of the facility has an extremely low probability for an emergency situation.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N
MEN
WOMEN
A
4
1
2
10
3
SPRINKLER RISER
CEI SUBSTATION
MAIN ELECTRICAL DISTRIBUTION
FIRE PULL
MAIN ELECTRICAL DISTRIBUTION
LIGHTING PANEL BOARD
SPRINKLER RISER & OUTSIDE SIAMESE HEADER
GAS METER
AIR LOCK
7
WASTE STORAGE
8
6
9
11
WOMEN
MEN
OR TO OUTSIDE LOT
PRIMARY ENTRANCE
① STAIRWELL TO ROOF
② NON-OPERATIONAL ELEVATORS
③ SPRINKLER RISER
④ BOILER ROOM FUEL: NAT. GAS
⑤ SHADED AREAS ~RESTRICTED~
⑥ HOT CELL – HIGH RADIATION & CONTAMINATION AREA
⑦ ISOTOPE SHOP – RADIATION AREA & CONTAMINATION PRESS
⑧ WASTE STORAGE – HIGH RADIATION AREA STORAGE OF RADIOACTIVE WASTE PRIOR TO SHIPMENT.
⑨ DEPLETED URANIUM STORAGE AREA
⑩ WAREHOUSE – RADIATION AREA. STORAGE & STAGING AREA FOR SEALED SOURCES IN SHIPPING PACKAGE.
⑪ STAIRWELLS TO BASEMENT – RESTRICTED AREAS DUE TO RADIATION & CONTAMINAT RADIOACTIVE WASTE-WATER STORAGE AREA. NO FLAMMAB MATERIALS.
← LONDON ROAD →
* = SECONDARY EXIT/ENTRANCES FOR EMERGENCY USE
A REMOVED AREA 'E' 1/24/85
LTR REVISION DATE
UNLESS NOTED • TOLERANCES ON ANGLES ± ☐ BREAK ALL SHARP EDGES
DECIMALS ± • FRACTIONS ± DIMENSIONS ARE BEFORE APPLYING FINISH
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ADVANCED MEDICAL SYSTEMS, INC.
GENEVA, OHIO 44041
C-A9-P-0063

Figure 1-8

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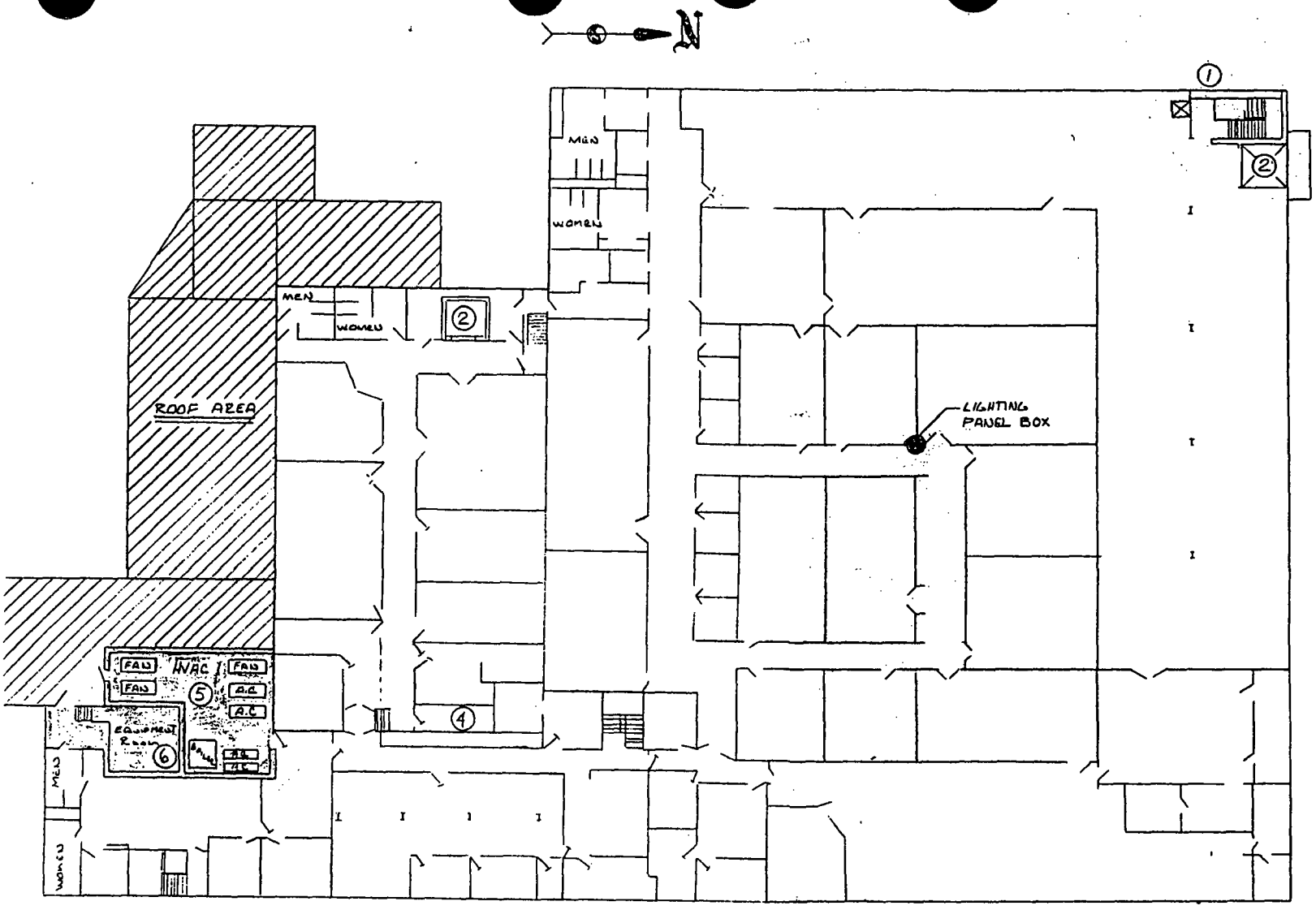

NOTES

1. STAIRS TO ROOF
2. NON-OPERATIONAL ELEVATORS
3. SHADED AREA —RESTRICTED—
4. CONTROL WIRE PANELS FOR RESTRICTED AREAS
5. RESTRICTED NON-ISOTOPE AREA. HVAC EQUIPMENT CONTROLS FOR RESTRICTED AREAS.
   FUEL = NATURAL GAS
   POWER: 480 VOLT 3Φ
   ROOF ACCESS DOOR DEAD-BOLTED ON INSIDE
   — SLIGHT RADIATION EXPOSURE HAZARD FROM ADJACENT ROOM #6
6. HOT CELL VENTILATION EQUIPMENT ROOM
   —HIGH RADIATION AREA
   —RADIOACTIVE MATERIAL PRESENT—
   PROTECTIVE CLOTHING & RESPIRATORS NECESSARY
   ROOF ACCESS DOOR DEAD-BOLTED ON INSIDE

Figure 1-9

LTR	REVISION	DATE

UNLESS NOTED • TOLERANCES ON ANGLES ± □ BREAK ALL SHARP EDGES
DECIMALS ± • FRACTIONS ± DIMENSIONS ARE BEFORE APPLYING FINISH

NEXT ASSY | QTY | NAME: LONDON ROAD 2ND FLOOR PRE EMERGENCY PLAN
MATERIAL
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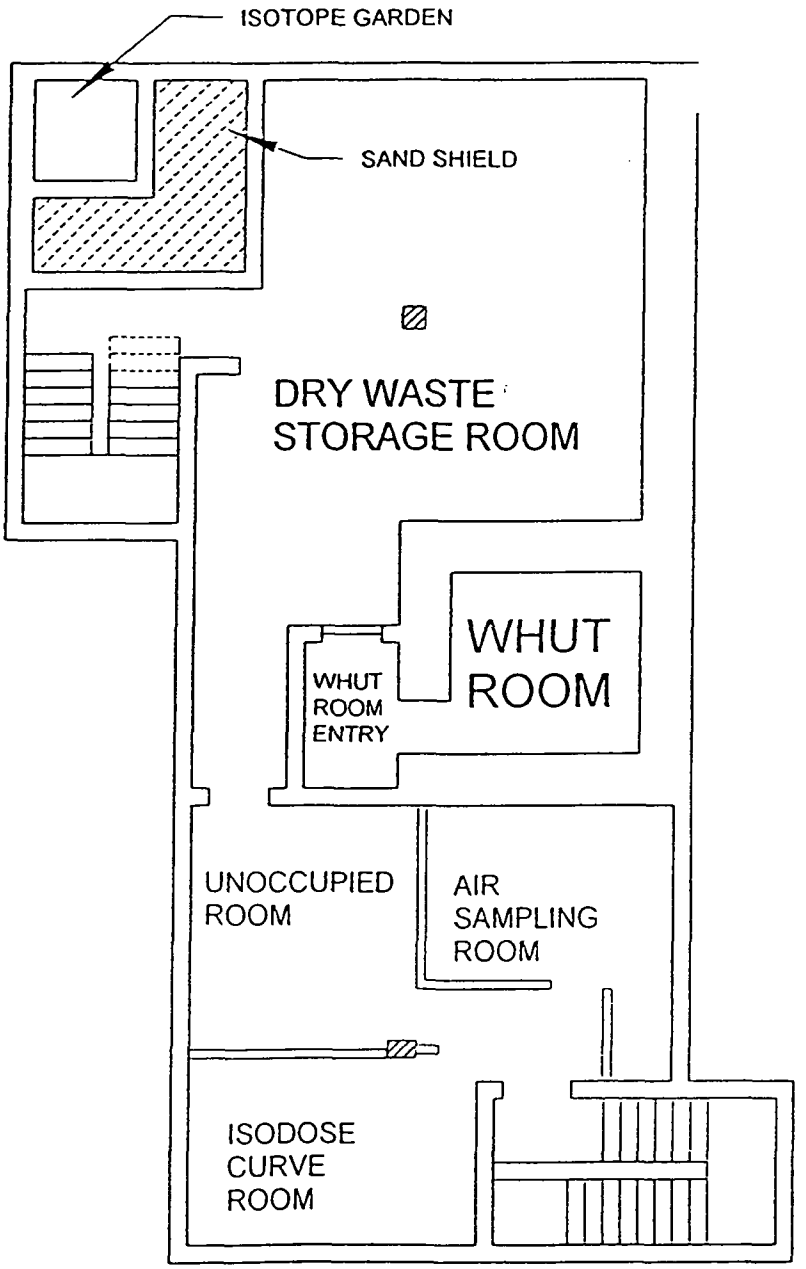
ADVANCED MEDICAL SYSTEMS, INC.
GENEVA, OHIO 44041

SCALE 1/8" = 1'-0"
C-A9-P-0062



AMS Facility Basement

Figure 1-10

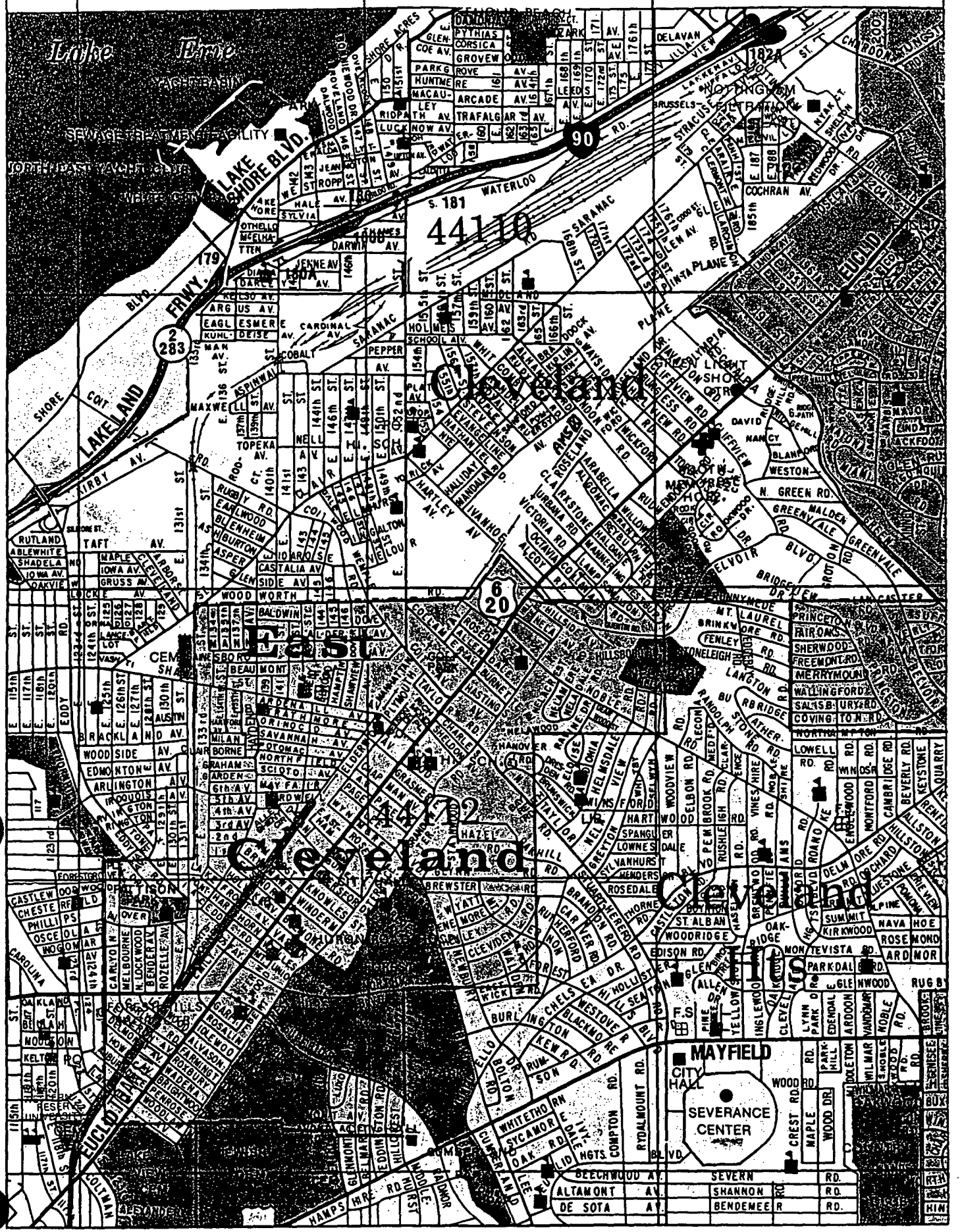


Figure 1-11

RAND McNALLY

Cleveland & Vicinity

StreetFinder®

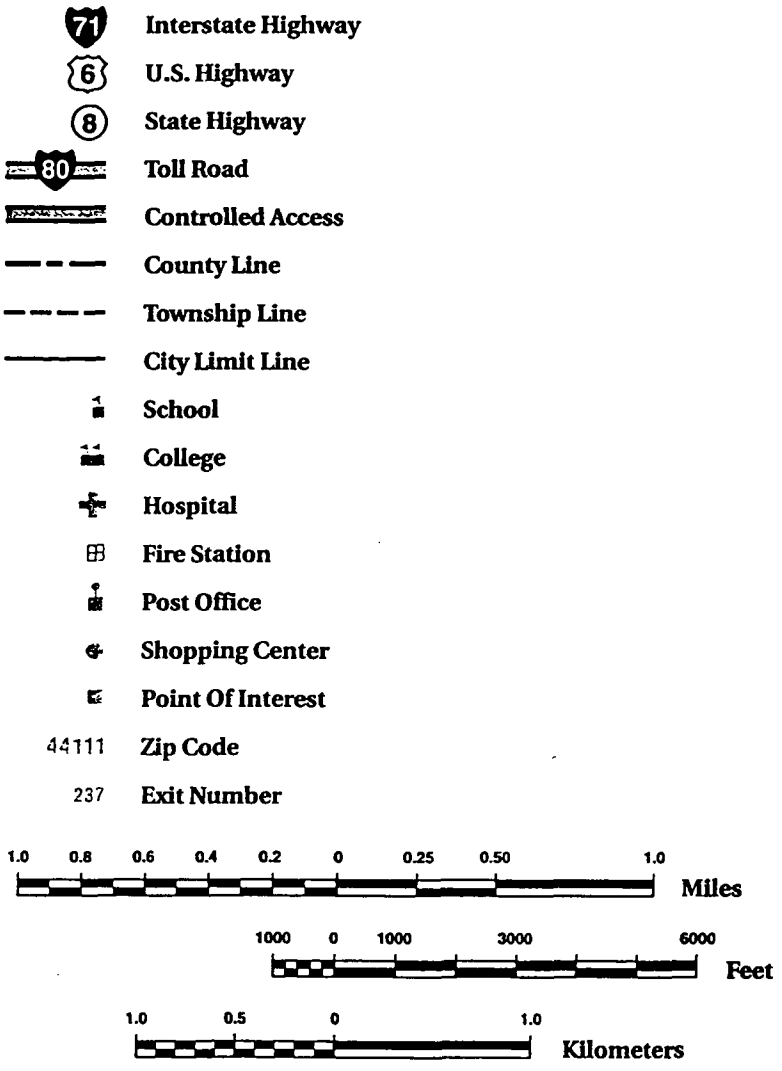


Figure 1-12

2.0 Engineered Provisions for Abnormal Conditions

This section describes facility process and central measures that are designed to detect accidental release, limit further releases and permit safe and prompt recovery actions.

2.1 Criteria for Accommodation of Abnormal Conditions

2.1.1 Operating Procedures

The company maintains Isotope Shop Procedures which discuss in detail the operating procedures for the facility. Facility personnel strictly follow the operating procedures (ISP's) and are well trained in these procedures, as well as overall plant safety. The operating procedures are designed to maintain conformance with accordance with certain operating federal regulations.

2.1.2 Alarm Systems and Release Prevention

The AMS London Road facility is equipped with a number of systems designed to prevent and detect releases of hazardous materials. These systems include ventilation, radioactive waste handling, fire alarms, personnel reporting, health physics procedures and stack monitors.

2.1.2.1 Master Alarm System

Six safety and monitor devices are connected to the Master Alarm Panel in the Cell Control area and to the Remote Alarm Panel in the Isotope Shop Area. The separate red lights for each controlled item are always dimly lit on the panel, so that faulty operation of the panel itself is indicated by no light. When a controlled item malfunctions, the alarm light is increased in intensity and flashes on and off. In addition, a loud buzzer sounds on and off in synchronism with the flashing lights. This will continue until the acknowledgement button is depressed, causing the buzzer to stop and the flashing light corresponding to the malfunctioning item to change to a steady bright red. The alarm can be erased only by correcting the difficulty after depressing the acknowledgement button. In addition, two other warning lights show on the Master Alarm Panel; one for the Equipment Room door and for the Cell Machinery Room door on the second floor, and one for the basement door in the Isotope Shop area. These will indicate steady bright red lights when the doors have been opened and indicate to the hot cell operator that personnel are in this area. Evaluation tests indicate that no unusual hazards exist in these areas under normal cell procedure, but the precautions should be taken nevertheless. On five of the six major systems, any alarm is transmitted to the local alarm monitoring company so that malfunctions during non-working hours are reported to a responsible person. The emergency generator will not trip the other five alarms if it restores power before the fans stop.

The following are six safety and monitoring systems and conditions which will cause an alarm:

A. Cell Exhaust Fan

1. Shut down from lack of power or switch turned off.

2. Sudden pressure drop across air filter indicating ruptured filter.

3. Improper pressure across filter indicating broken belts, fan inoperative or plugged filter.

4. Excessive radiation on the air monitor.

B. Isotope Shop Area Exhaust Fan

1. Shut down from lack of power or switch turned off.

2. Sudden pressure drop across air filters indicating ruptured filter.

3. Improper pressure across filter indicating broken belts, fan inoperative or plugged filters.

4. Excessive radiation on the air monitor.

C. Air Monitor

1. Excessive radiation on filter paper in air monitor or electronic malfunction of monitoring equipment.

D. Cell Temperature

1. Two thermostats, one located in Cell Control Area, and one located in Decontamination Room immediately behind the cell, are set to give an alarm signal for temperatures below 40^0 F. or above 85^0 F.

E. Supply Fan

1. A thermostat in the intake system after the heaters will give an alarm signal for temperatures below 50^0 F.

F. Emergency Generator

1. Signal given on power failure when generator starts.

Hot Cell Systems

A. Door Interlock: An electrical interlock secures the door in the closed position until two switches, one on the outside of the door and one on the cell face in the Cell Control Area, are depressed simultaneously. This safety feature makes it impossible for the cell door to be opened without the knowledge and consent of the cell operator, or for the door to be opened by a person working alone.

B. Cell Probe: A high energy probe, Victoreen Model 550 Series (or equivalent), is used within the cell to locate loose Cobalt^{60} pellets and other high radiation levels. It is connected to Victoreen Model 510 Ratemeter (or equivalent) located on the cell face in the Cell Control Area. The Ratemeter is autoranging up to 2000 R/min.

C. Gamma Alarm: A Technical Operations Gamma Alarm Model 492C (or equivalent) is mounted opposite the cell face in the Cell Control Area. Since it is connected to a loud buzzer, it gives both an audible and a visible alarm (flashing red light) continuously when radiation levels are in excess of the preset level of approximately 2 mR/hr. The Gamma alarm features fail-safe circuitry to provide a signal at all times. Failure of any element either turns on the red lamp or turns off the green (safe) lamp, signaling improper operation.

Decontamination Room

A. The hot cell exhaust fan is driven by a two-speed motor which is controlled by the position of the double doors connecting the Decontamination Room with the Isotope Shop area. With the doors closed, the fan operates at normal speed which is indicated by a yellow light on the locked switch control at the cell face. With the doors opened, the fan speed is increased for about 50% greater capacity. This prevents reverse flow of potentially contaminated air of the Decontamination Room into the Isotope Shop area. High speed mode is indicated by a red light on the locked switch control at the cell face.

Isotope Shop Area

A. Gamma Alarm: A Technical Operations Gamma Alarm, Model 492D (or equivalent) is mounted on the west wall between the storage garden and the decontamination room adjacent to the source transfer operation. This will give a visible flashing red light when radiation exceeds the preset level of 5 mR/hr.

B. Basement Door: When the basement door is opened, a steady red light turns on above the door. Also, a steady red light shows on the Master Alarm Panel.

C. Air Locks:

1. The doors at either end of the change area are electrically interlocked to prevent simultaneous opening which might disturb the air flow pattern. The entrance to the change area from the cell control area is an air lock by itself. The first door is interlocked with the door on the opposite side of the change area leading into the Isotope Shop area.

2. The air lock on the west side of the Isotope Shop area has three (3) electrically interlocked doors. One set of doors leads to the Isotope Shop area, one set leads to the warehouse and the last set, on the north side of the air lock, leads to the unrestricted area. When the Isotope Shop area doors are open, the other two doors cannot be opened. When one of the other two doors is open, the Isotope Shop area doors cannot be opened.

Equipment Room

A. This room is directly above the shielded work room. This room contains the heating and intake air fan as well as the air conditioners. The floor is shielded with two (2) feet of concrete. A Technical Operations Gamma Alarm, Model 492B (or equivalent) set at approximately 2 mR/hr. is mounted in the center of the room. It remotely indicates a signal above the entrance to the room. No one is permitted to enter this room without permission of the Radiation Safety Officer or Supervisor. Also, PERSONNEL ARE NOT PERMITTED IN THIS ROOM WHEN THERE IS NO SIGNAL GREEN LIGHT OR WHEN THERE IS A RED LIGHT. In addition, when the door is opened, a steady red light shows on the Master Alarm Panel.

Shielded Work Room

A. Gamma Alarm: A Technical Operations Gamma Alarm, Model 492C (or equivalent) set at approximately 5 mR/hr. is mounted at the end of the maze in the room. A remote indication over the entrance shows red when the radiation level is in excess of 5 mR/hr. and white when the radiation level is below the preset level.

Doors

A. Only authorized personnel have keys to any isotope area. Doors to restricted areas are kept locked at all times. This includes the following:

1. Air lock from cell control area to change area.

2. Doors from the shop area to the air lock.

3. Doors from the warehouse to the above air lock.

4. Doors from the air lock to Isotope Shop area.

5. Doors from the warehouse to the shop area on the northeast side of warehouse.

6. Equipment room on second floor.

7. Cell Machinery Room on second floor.

8. Room adjacent to Cell Machinery Room.

9. Basement door opening to clean side of basement.

10. In addition to above, the perimeter of the entire facility is tied in with a local alarm monitoring company (ADT).

2.1.2.2 Ventilation System

The facility has a HEPA ventilation system. All air from potentially contaminated areas within the building is exhausted through this HEPA filter system. The hot cell ventilation system is redundant. If one system fails, the air flow from the hot cell is diverted through the Isotope Shop filter system. The filter banks, located in the cell equipment room have appropriate filters in series. All systems discharge through a common stack penetrating the roof. The HEPA system is connected to various monitoring devices for both local and remote alarms. The ventilation system is connected to the emergency generator which will allow the system to function in case of a power failure.

As a result of these air exhaust systems, all radiation process areas are under negative pressure. The hot cell is also at a greater negative pressure with respect to the other process/work areas. The pressure differential between the inlet and outlet end of the exhaust filters is continuously monitored. A portable HEPA system is available for special isolated area use.

2.1.2.3 Radioactive Waste Handling

Solid radioactive waste is collected and placed in a designated container. The waste is surveyed, drummed and stored in restricted locations. Access to these areas is controlled. The packaging and shipment of radioactive wastes are controlled by procedures ISP-25 and ISP-26.

2.1.2.4 Fire Systems

The facility is equipped with a fire alarm system and is an integral part of the fire protection system. The fire alarms are activated by either alarm sensors, pull boxes or when the sprinkler system is activated. The alarm system is connected to a commercial alarm company that notifies off-site fire organizations. In the event of a fire, personnel follow established routes of evacuation from the effected areas.

2.1.2.5 Personnel Reporting

The processing and handling of radioactive material requires the presence of personnel. These individuals are an essential part of the accident alarm system, since the person associated with an abnormal event knows immediately when such a situation has occurred. Following an incident, the individual would immediately report the incident to his/her supervisor.

2.1.2.6 Health Physics Procedures

Personnel check radiation levels throughout the facility in three ways: with wipe tests, air sampling and survey meters. The periodic checks of radiation levels in areas in which radioactivity is handled, alert the RSO and personnel to potential problems. In addition to these area surveys, meters for monitoring area and personnel contamination are located in the work areas. These meters are always on, and, therefore, constantly monitor radiation levels in those areas.

2.1.2.7 Stack Monitor

The exhaust stack is equipped with a stack monitor and chart recorder. The stack monitor is also connected to the ADT alarm panel. A sufficient increase in activity above the preset level immediately stops the exhaust and supply fans. The activation point is set such that if averaged over one year, the air concentrations would be less than the applicable maximum permissible concentrations in air from Appendix B 10CFR Part 20.

2.1.3 Support System

This section describes various support systems, including facility structures, confinement barriers, fire suppression and shielding.

2.1.3.1 Structural Performance

The facility was designed and built to conform with standard building codes and permit requirements of Cuyahoga County. In addition, the hot cell is constructed of concrete and steel walls six-foot thick and a zinc bromide viewing window.

2.1.3.2 Confinement Barriers and System

Confinement barriers in use at the London Road facility include the hot cell, ventilation system, shipping containers/casks and radioactive waste storage systems. The primary confinement for the radioactive material is the container that holds it.

Radioactive sources are moved using lead shielded transfer containers. The Isotope Shop area is under a negative pressure with respect to its surroundings. The ventilation systems that keep these areas under negative pressure are equipped with HEPA filters that confine radioactive material.

Solid radioactive waste is collected, surveyed and packaged and stored in a limited-access area prior to disposal.

Radioactive material is also confined by the source capsule in which it is contained. The shipping and packaging in which the final product is placed, provides further confinement of the radioactive material. All packages conform to USNRC or DOT regulations.

2.1.3.3 Access and Egress of Operational Personnel and Emergency Response Team

During minor incidents, no evacuation will be required and response team access will be through normal access routes. The RSO's staff is responsible for normal facility monitoring and are quite familiar with these routes.

2.1.3.4 Fire and Explosion Resistance and Suppression

The facility is constructed of concrete and steel and is therefore fire resistant. There is only a remote probability of a facility breach is a restricted area from fire. All areas, except the hot cell, isotope shop and cell equipment room, are equipped with a sprinkler system. In addition, a detection system has been installed in all areas including the cell equipment room. The system detects a sudden rate of temperature rise or smoke and electronically signals the security company. They in turn report the incident to the local fire department. Pressurized fire extinguishers for various class fires are located throughout the facility. The small amount of highly combustible material within the facility are stored in fire and explosion proof cabinets.

2.1.3.5 Shielding

The hot cell is built of concrete and steel. The walls are 5-1/2 feet of concrete with a 1/4-inch steel plate on the inside faces. The cell is 6' x 6' x 11' high. It has a 4' floor and 4' ceiling. The cell is closed by a 402-ton hinged door that provides a 6' entrance into the cell when opened. The hot cell will provide adequate shielding for the amount of radioactive material that the facility is licensed to possess.

2.1.4 Central Operations

To ensure the proper functioning of systems throughout the facility, AMS routinely checks and documents the performance of these systems. These systems include the ventilation systems, air sampling system and security system.

The alarm monitoring company performs monthly checks of the alarm system.

2.2 Demonstration of Engineered Provisions for Abnormal Conditions

This section addresses the anticipated performance, under abnormal conditions, of the systems described in Section 2.1.

2.2.1 Process Systems

As described in Section 2.1.1, operational personnel are the key aspect of control. Since all operating personnel are well trained, these personnel are expected to perform as trained under normal and abnormal conditions.

2.2.2 Alarm Systems and Release Prevention

All of the systems presented in Section 2.1, ventilation, fire and evacuation alarms, personnel reporting, health physics procedures and stack monitor, are expected to perform, except under the most severe conditions. Under most conditions, the ventilation systems would confine radioactivity by keeping areas under negative pressure and by removing radioactivity from effluent air with filters. **Failure of the ventilation system will not result in radioactive release due to the damper system.** Under the most severe conditions, the ventilation system cannot be expected to confine radioactivity.

The fire and area alarms are functional at all times since they are regularly checked and receive power from emergency systems.

Staff personnel are present at all times during which radioactivity is handled, and would generally give the first notification that an abnormal or emergency situation had occurred. During an abnormal situation, personnel would conduct radiation level surveys, according to emergency procedures.

The stack monitor is expected to be operational in all but the most severe conditions. The system receives back-up power from the emergency generator.

2.2.3 Support Systems

Because the facility building was designed and constructed with shielding for radioactive material and conforms to standard building codes, it is expected to maintain its structural integrity under all but the most severe natural phenomena. The same is true of the confinement, shielding and barrier systems in use throughout the facility. The ventilation systems should also be operational under all conditions except those resulting from extremely severe natural phenomena.

2.2.4 Control Operations

Because the systems designed to prevent the release of radioactivity are routinely checked to ensure their integrity, these systems should be fully operational under abnormal conditions. The safety assurance program that ensures that systems designed to prevent the release of radioactivity meet their performance goals are listed in 2.1.4

3.0 Classes of Radiological Contingencies

3.1 Classification System

The classification system for radiological contingencies is that recommended by the USNRC in their standard format document for radiological contingency plans. Minor changes have been made so that the classification scheme reflects facility-specific conditions.

Section 3.3 of this plan relates the classification scheme to potential accidents within the AMS London Road facility.

3.2 Classification

3.2.1 Class I - Alert

Class Description	OffSite License Action
Events are in process or have occurred which involve an actual or potential minor degradation of the level of safety of the plant. Any releases are expected to be limited to a small fraction of those permitted by 10CFR Part 20.	1. Notify Ohio Emergency Management Agency, Columbus, Ohio, providing information contained in OEMA Radiological Incident Response Checklist, Attachment 2 to Emergency Preplan. 2. Notify the NRC Operations Center at (301) 816-5100 within one (1) hour of declaration of alert. 3. Augment resources and bring key personnel to stand-by status 4. Assess and Respond 5. Calculate periodic dose rates for actual release 6. Escalate to a more severe class if appropriate 7. Close out upon completion of duties

3.2.2 Class II - Site Area Emergency

Class Description	License Action
Events are in process or have occurred which involve actual or likely failures of plant functions needed for protection of the public. Offsite releases are not expected to exceed those permitted by 10CFR Part 20 except near the site boundary.	1. Notify OEMA, Columbus, and local authorities of site area emergency status and reason for emergency as soon as discovered. Provide OEMA with information requested in OEMA Radiological Incident Response, Checklist Appendix A, Exhibit 2. 2. Notify the NRC Operations Center at (301) 816-5100 within one (1) hour of declaration of site area emergency. 3. Augment resources and bring key personnel to stand-by status 4. Assess and respond 5. Conduct onsite monitoring 6. Provide dose estimates to offsite authorities for actual releases 7. Provide release and dose projections based on available plant condition information and foreseeable contingencies 8. Close out or reduce class of emergency based on results of actions

3.3 Range of Postulated Accidents

The range of accidents that can be postulated for the AMS London Road facility can be categorized as follows:

*Fire
*Natural disaster
*Vandalism

Fire

Fires in the AMS London Road facility are very unlikely due to: (1) The fire resistant nature of the structure; (2) the fire suppression system; (3) the small quantities of combustibles used in the operations; and (4) fire prevention program established at AMS. Minor fires, such as refuse fires, would most likely not result in release. Fires in the ventilation system are quite unlikely because the HEPA filters are fire-resistant and because of the lack of combustibles located in the hot cell. A fire that could result in major emergencies would be major fires engulfing large portions of the building. This scenario is unlikely as the majority of the facility is protected by a sprinkler system.

Major fires are extremely difficult to postulate due to their low probability of occurrence. Major fires have been included in this plan due to the potential for offsite impacts. Any major fire requiring building evacuation and offsite fire fighting assistance, will result in the RSO immediately declaring a "Site Area Emergency". The fire fighting crews will be monitored with personnel monitoring devices. Fire fighters and rescue teams entering the building will use appropriate respiratory equipment and will be accompanied by an AMS employee or offsite support personnel trained in the use of and equipped with portable radiation detection equipment. All persons leaving the building will be monitored to control contamination. Re-entry and recovery will be strictly controlled so to limit personnel exposures to regulatory limits.

It is recommended fires within restricted areas be fought with dry chemicals - CO_2, Halon or equivalent - to prevent possible run-off of contaminated water. Unrestricted areas can be suppressed with water. The water run-off would be uncontaminated as unrestricted areas have no detectable contamination.

Natural Disaster

The risk from tornadoes and earthquakes is in the low range in this area. If a tornado strikes or an earthquake causes visible damage to any of the AMS London Road building, the RSO will declare an "ALERT" condition. Escalation to a more severe class will depend on the results of assessments made through monitoring of the site.

Vandalism

While scavenging and vandalism of radioactivity is pluasible, it is not a likely scenario considering the lack of economic value of the materials.

3.4 Consultant's Report

Discusses each postulated accident in detail and dose assessment from a "worse-case" release of Cobalt-60 from the London Road facility.

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January 25, 1995

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Re: Dose Assessment from a "Worst-Case" Release of ^{60}Co from the London Road Facility

Dear Mr. Miller:

Pursuant to the request of Mr. David Cesar, I have performed a preliminary assessment of the maximum radiation dose to the nearest neighbor of Advanced Medical System's (AMS) London Road facility in the event of a catastrophic release of ^{60}Co from the facility. The purpose of this letter is to transmit my findings.

The potential radiation dose that workers or the general public may incur from exposure to radioactive materials is influenced by a number of factors. These include the amount of radioactivity involved, the types of radiation emitted by the material, the chemical and physical form of the material, the solubility of the material, the particle size distribution, the duration of the exposure, the inhalation pathways (including both airborne material and resuspended material), the ingestion pathways involving contaminated water, food stuffs and animal feeds, and the demographic and physiological characteristics of the population exposed.

It is my understanding that the inventory of dispersible radioactivity[1] at AMS has been assessed at approximately 29 curies, with about 15 curies contained in the basement (e.g., in steel drums and LSA boxes), about 10 curies in a high-level storage location, about one curie from decontamination efforts, and the remainder as residual contamination in the restricted areas as a result of past operations.[2] Potential accidents resulting in release of this radioactivity might include spills, rupture of containers, scavenging, fire, or explosion. The following is a brief discussion of the types of accidents and a qualitative assessment of their likely consequences.

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[1] The radioactivity contained in the hot cell was not included in this analysis since it is sealed inside a heavy concrete and steel containment that is not likely to be breached by conventional (e.g., fires) or esoteric (e.g., explosions) external means. Furthermore, a scenario for rupture from within cannot be postulated since the material itself (cobalt) is not flammable, and there are no flammable/combustable materials inside of the cell. Therefore, the ^{60}Co in the hot cell is not considered to be dispersible.

[2] Cesar, D., Advanced Medical Systems, Inc., personal communication to C. D. Berger, Integrated Environmental Management, Inc., January 17, 1995.

Loss of Control of Radioactive Materials

During handling of radioactive materials, rupture of a container or storage bin would result in release of the materials. However, the rupture of a single container within the facility walls would result in the release of only a fraction of the total activity at the site, and could be quickly cleaned up before contamination could spread. Although the major effect of such an accident would be short-term dispersion of the material within the AMS facility, the impact is not expected to be great, and no measurable off-site consequence is expected.

Fires are a common occurrence in man-made structures of all types and locations. In anticipation of the potential for fires, AMS maintains a fire safety program for routine and emergency operations. Furthermore, agreements with local fire departments will ensure that fires in the restricted areas are swiftly controlled using gas, rather than water, suppression systems. Finally, the form of the radioactive materials stored at AMS is incapable of combustion on its own, and no flammable materials are stored or used in the vicinity of storage locations. Therefore, dispersion of a significant quantity of radioactivity by fire is not considered to be a credible accident scenario.

Natural Disasters

At plants such as AMS, there is the potential for impacts to the environment as a result of unpredictable, non-routine natural events such as lightening-induced fires and/or natural disasters such as floods, tornadic storms or seismic activity. The types of accidents which might reasonably be expected to negatively impact the environment and the surrounding community are a tornado which destroys the AMS building and disperses radioactive material along its path, or a major storm erodes the structural integrity of the building such that radioactive materials are moved away from the plant along water (runoff) pathways. Although severe natural disasters could conceivably compromise the protective nature of the building and its radioactive materials storage areas, the geographic location of the facility is not predisposed to frequent occurrences of floods or tornadic storms. Also, the majority of the ^{60}Co inventory at the site is in primary containment (steel containers or cells) that is resistant to ready release. Furthermore, the physical form of the material (e.g., dense and insoluble) is not conducive to movement, and any activity released as a result of a tornado would be dispersed widely by the tornado. Even under the worst of such events, it is not likely that a significant quantity of radioactive materials would be released to the environment.

Scavenging or Vandalism

While scavenging of radioactivity at the AMS facility is plausible, it is not considered to be a likely scenario considering the lack of economic value of the materials in question, and the fact that the exposure of scavengers of significant quantities could be consequential while the exposure of the nearest off-site residents would be small. Another scenario would be for an intruder with a full gasoline tanker truck to enter the AMS facility by breaching the security system, enter the basement through locked doors, open the steel drums and LSA boxes, pump the entire contents of the tanker truck into them, and ignite the fluid.[3] Again, this is not a plausible scenario but it could result in a fraction of the stored radioactivity becoming immediately airborne, after which could be dispersed and

---

[3] The ability to create such an explosion by any other scenario in other restricted areas of the plant is deemed unlikely.

deposited in the vicinity of the plant depending upon atmospheric conditions at the time of the explosion.

Of all of the above, the single accident condition that is not readily controlled, and that might result in exposure of the general public, is the vandalism scenario. This condition, while unlikely, would create conditions that could not be quickly controlled by plant personnel or emergency workers, thus it is considered to be the "worst possible case".

To evaluate the impact of this case on a member of the general public, a radiological dose assessment must be performed. For this assessment, the CAP88-PC computer code was used. The CAP-88 (Clean Air Act Assessment Package-1988) model permits assessments of both collective population dose, and maximally exposed individual dose. CAP88-PC uses a modified Gaussian plume equation to estimate the average dispersion of radionuclides released from up to six sources, which may be either elevated stacks or uniform area sources.[4]

The program computes radionuclide concentrations in air, rates of deposition on ground surfaces, concentrations in food, and intake rates to people from ingestion of food produced in the assessment area. Estimates of the radionuclide concentrations in produce, leafy vegetables, milk and meat consumed by humans are made by coupling the output of the atmospheric transport models with the USNRC Regulatory Guide 1.109 terrestrial food chain models. A library of meteorological data for most major cities is supplied with the code. The following assumptions were used as input to the CAP88 code for estimating off-site doses from the worst-case accident scenario at the London Road facility:

- Meteorological data from Cleveland, Ohio (Cleveland Airport) were deemed applicable to conditions at the AMS plant.
- The annual average rainfall amount is 89.9 cm per year.[5]
- The annual average temperature is 10° C.[6]
- The emission source is assumed to follow a stack model with a ground level (one meter) release height.[7]
- A momentum plume rise was assumed.
- Agricultural usage fits an "Urban" scenario.

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4 U. S. Environmental Protection Agency, "User's Guide for CAP88-PC, Version 1.0", by Barry S. Parks, Report No. 402-B-92-001, Office of Radiation Programs, March, 1992.

5 World Almanac, Holt, Reinhart & Winston, New York, 1989.

6 World Almanac, Holt, Reinhart & Winston, New York, 1989.

7 This is a conservative assumption since the heat of the explosion will elevate the radioactivity significantly before it is dispersed off of the AMS property, which makes "plume touchdown" at a distance of 100 meters from the plant unlikely.

- The total activity released during the explosion is equivalent to the entire contents of the basement room, or 15 curies of ^{60}Co.
- A 5×10^{-3} release fraction for nonvolatiles in flammable liquid is assumed.[8]
- The fire is assumed to burn, uncontrolled, until the entire released fraction of 0.08 curies is dispersed.
- The distance to the nearest off-site receptor is 100 meters north of the AMS facility.[9]
- An annual-average release with no follow-up remediation of the local land area is assumed.[10]

The results of this assessment shows that the member of the general population that is nearest to the AMS facility might incur a radiation dose of 38 millirem within one year after this catastrophic event occurs. Attachment 1 contains the output report from the CAP88-PC code.[11] [12]

The International Commission on Radiological Protection (ICRP) provides guidance on when and how to institute countermeasures and recovery actions in the event of a major radiation accident.[13] However, the ICRP also acknowledges that the countermeasures and recovery actions themselves involve some risk to the public. Consequently, to ensure that the "cure is not more harmful than the illness", they have set a population dose limit below which they recommend that no follow-up action whatsoever be taken. The ICRP dose limit for early-phase countermeasures ranges from 500 to 5,000 millirem for sheltering, and 5,000 to 50,000 for evacuation. The lowest limit of 500 millirem is also consistent with the maximum permissible dose to maximally-exposed members of the general public promulgated by the USNRC.[14]

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8 NUREG-1140.

9 Cesar, D., Advanced Medical Systems, Inc., personal communication to C. D. Berger, Integrated Environmental Management, Inc., January 17, 1995.

10 It is conservative to assume that the entire annual average dose calculated by CAP88-PC is delivered over the duration of the release.

11 The intent of this assessment was to establish a conservative exposure scenario (i.e., well above the average case) that is still within the range of possibility. Whenever possible, assumptions to complete the dose assessment were selected conservatively such that the maximum reasonable dose would result.

12 The potential radiation dose to fire fighters and rescue workers was evaluated similarly, by assuming they remained constantly and continuously at a distance of eight (8) meters from the AMS facility until the entire release fraction of 0.08 curies is dispersed. If it is also assumed that the fire fighters received an entire annual-average dose from all pathways over the duration of the release, the maximum possible dose is estimated to be 422 millirem. However, this dose estimate is exceedingly conservative because the duration of the fire fighter's exposure is only a fraction of that of the resident, a fire fighter would wear protective clothing, and a fire fighter would not be subject to the same exposure pathways (e.g., ingestion of food products) as would the resident.

13 International Commission on Radiological Protection, "Protection of the Public in the Event of Major Radiation Accidents: Principles for Planning", ICRP Publication 40, 1984.

Therefore, for the worst-case accident scenario at the AMS site, wherein an individual 100 meters to the north of the facility might receive up to 38 millirem, countermeasures or recovery actions for purposes of protecting that individual are not indicated.

It is important to note, however, that the dose estimate of 38 millirem reflects the maximum exposure *potential* for the nearest off-site resident. The likelihood that such a dose would actually be incurred is remote, at best. From the assumptions made regarding exposure circumstances for the nearest resident, it is clear that no radiation dose in excess of what is considered safe by international standards groups[15] and regulatory agencies (USNRC[16], OSHA[17] and USEPA[18]) will occur. Even after application of generous assumptions, the radiological conditions in the immediate vicinity of the AMS facility in the event of catastrophic release are not conducive to adverse health effects.

I hope that this information is of interest to you. If I can answer any questions or provide you with additional information, please do not hesitate to call me at (301) 762-0502. It has been a pleasure assisting you in this effort, and I am looking forward to speaking with you again soon.

Sincerely,

Carol D. Berger, C.H.P.

94009

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14 (...continued)
14 Title 10, Code of Federal Regulations, Part 20.1301.

15 International Commission on Radiological Protection, "Radiation Protection - Recommendations of the International Commission on Radiological Protection ", ICRP Publication 26, 1976.

16 Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation".

17 Title 29, Code of Federal Regulations, Part 1910.96, "Ionizing Radiation".

18 Title 40, Code of Federal Regulations, Part 191.04(a)(1) "Environmental Standards for Management and Storage".

ATTACHMENT 1: CAP88-PC SUMMARY OUTPUT

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

S Y N O P S I S R E P O R T

Non-Radon Individual Assessment
Jan 24, 1995 4:04 pm

Facility: Advanced Medical Systems
Address: 1020 London Road
City: Cleveland
State: OH Zip: 44110

Effective Dose Equivalent
(mrem/year)

3.81E+01

At This Location: 100 Meters North
Source Category:
Source Type: Stack
Emission Year: 1995

Comments: Vandalism Scenario Involving the WHUT Room

Dataset Name: ams-fire
Dataset Date: Jan 24, 1995 4:04 pm
Wind File: WNDFILES\CLE1140.WND

MAXIMALLY EXPOSED INDIVIDUAL

Location Of The Individual: 100 Meters North
Lifetime Fatal Cancer Risk: 9.51E-04

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Dose Equivalent (mrem/y)
GONADS	4.27E+01
BREAST	3.88E+01
R MAR	3.33E+01
LUNGS	4.10E+01
THYROID	4.10E+01
ENDOST	3.48E+01
RMNDR	3.46E+01
EFFEC	3.81E+01

RADIONUCLIDE EMISSIONS DURING THE YEAR 1995

Nuclide	Class	Size	Source #1 Ci/y	TOTAL Ci/y
CO-60	Y	1.00	8.0E-02	8.0E-02

SITE INFORMATION

Temperature:	10 degrees C
Precipitation:	90 cm/y
Mixing Height:	1000 m

SOURCE INFORMATION

Source Number:	1
Stack Height (m):	1.00
Diameter (m):	0.00
Plume Rise Momentum (m/s): (Exit Velocity)	0.00E+00

AGRICULTURAL DATA

	Vegetable	Milk	Meat
Fraction Home Produced:	0.076	0.000	0.008
Fraction From Assessment Area:	0.924	1.000	0.992
Fraction Imported:	0.000	0.000	0.000

Food Arrays were not generated for this run.
Default Values used.

DISTANCES USED FOR MAXIMUM INDIVIDUAL ASSESSMENT

100

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

G E N E R A L D A T A

Non-Radon Individual Assessment
Jan 24, 1995 4:04 pm

Facility: Advanced Medical Systems
Address: 1020 London Road
City: Cleveland
State: OH Zip: 44110

Source Category:
Source Type: Stack
Emission Year: 1995

Comments: Vandalism Scenario Involving the WHUT Room

Dataset Name: ams-fire
Dataset Date: Jan 24, 1995 4:04 pm
Wind File: WNDFILES\CLE1140.WND

VALUES FOR RADIONUCLIDE-DEPENDENT PARAMETERS

Nuclide	Clearance Class	Particle Size (microns)	Scavenging Coefficient (per second)	Dry Deposition Velocity (m/s)
CO-60	Y	1.0	8.99E-06	1.80E-03

VALUES FOR RADIONUCLIDE-DEPENDENT PARAMETERS

Nuclide	DECAY CONSTANT (PER DAY)			TRANSFER COEFFICIENT	
	Radio-active (1)	Surface	Water	Milk (2)	Meat (3)
CO-60	0.00E+00	5.48E-05	0.00E+00	2.00E-03	2.00E-02

FOOTNOTES:
(1) Effective radioactive decay constant in plume; set to zero if less than 1.0E-2

(2) Fraction of animal's daily intake of nuclide which appears in each L of milk (days/L)

(3) Fraction of animal's daily intake of nuclide which appears in each kg of meat (days/kg)

VALUES FOR RADIONUCLIDE-DEPENDENT PARAMETERS

	CONCENTRATION UPTAKE FACTOR		GI UPTAKE FRACTION	
Nuclide	Forage (1)	Edible (2)	Inhalation	Ingestion
CO-60	2.00E-02	3.00E-03	5.00E-02	3.00E-01

FOOTNOTES:
(1) Concentration factor for uptake of nuclide from soil for pasture and forage (in pCi/kg dry weight per pCi/kg dry soil)

(2) Concentration factor for uptake of nuclide from soil by edible parts of crops (in pCi/kg wet weight per pCi/kg dry soil)

VALUES FOR RADIONUCLIDE-INDEPENDENT PARAMETERS

HUMAN INHALATION RATE	
Cubic centimeters/hr	9.17E+05
SOIL PARAMETERS	
Effective surface density (kg/sq m, dry weight)	
(Assumes 15 cm plow layer)	2.15E+02
BUILDUP TIMES	
For activity in soil (years)	1.00E+02
For radionuclides deposited on ground/water (days)	3.65E+04
DELAY TIMES	
Ingestion of pasture grass by animals (hr)	0.00E+00
Ingestion of stored feed by animals (hr)	2.16E+03
Ingestion of leafy vegetables by man (hr)	3.36E+02
Ingestion of produce by man (hr)	3.36E+02
Transport time from animal feed-milk-man (day)	2.00E+00
Time from slaughter to consumption (day)	2.00E+01
WEATHERING	
Removal rate constant for physical loss (per hr)	2.90E-03
CROP EXPOSURE DURATION	
Pasture grass (hr)	7.20E+02
Crops/leafy vegetables (hr)	1.44E+03
AGRICULTURAL PRODUCTIVITY	
Grass-cow-milk-man pathway (kg/sq m)	2.80E-01
Produce/leafy veg for human consumption (kg/sq m)	7.16E-01
FALLOUT INTERCEPTION FRACTIONS	
Vegetables	2.00E-01
Pasture	5.70E-01
GRAZING PARAMETERS	
Fraction of year animals graze on pasture	4.00E-01
Fraction of daily feed that is pasture grass	
when animal grazes on pasture	4.30E-01

VALUES FOR RADIONUCLIDE-INDEPENDENT PARAMETERS

ANIMAL FEED CONSUMPTION FACTORS	
Contaminated feed/forage (kg/day, dry weight)	1.56E+01
DAIRY PRODUCTIVITY	
Milk production of cow (L/day)	1.10E+01
MEAT ANIMAL SLAUGHTER PARAMETERS	
Muscle mass of animal at slaughter (kg)	2.00E+02
Fraction of herd slaughtered (per day)	3.81E-03
DECONTAMINATION	
Fraction of radioactivity retained after washing for leafy vegetables and produce	5.00E-01
FRACTIONS GROWN IN GARDEN OF INTEREST	
Produce ingested	1.00E+00
Leafy vegetables ingested	1.00E+00
INGESTION RATIOS:	
IMMEDIATE SURROUNDING AREA/TOTAL WITHIN AREA	
Vegetables	7.60E-02
Meat	8.00E-03
Milk	0.00E+00
MINIMUM INGESTION FRACTIONS FROM OUTSIDE AREA (Minimum fractions of food types from outside area listed below are actual fixed values.)	
Vegetables	0.00E+00
Meat	0.00E+00
Milk	0.00E+00
HUMAN FOOD UTILIZATION FACTORS	
Produce ingestion (kg/y)	1.76E+02
Milk ingestion (L/y)	1.12E+02
Meat ingestion (kg/y)	8.50E+01
Leafy vegetable ingestion (kg/y)	1.80E+01
SWIMMING PARAMETERS	
Fraction of time spent swimming	0.00E+00
Dilution factor for water (cm)	1.00E+00

4.0 Organization for Control of Radiological Contingencies

This chapter describes the organization for radiological contingencies, how the organization is activated and the authorities and responsibilities of the organization.

4.1 Normal Plant Operations

The RSO has overall responsibilities for all aspects of the facility.

4.2 Onsite Radiological Contingency Response Organization

This section describes the organizational structure and functions for radiological contingencies. The authority of the contingency organization to perform the functions described herein has received corporate approval as indicated by the Statement of Policy included with this plan.

4.2.1 Direction and Coordination

The RSO will be responsible for all offsite notification and reporting. In his absence, the emergency personnel on call will contact offsite authorities. The Emergency Manager, a role filled by the RSO, will have direct control over emergency operations. The Emergency Manager will serve as the first line of communication with the operating and emergency staffs.

Since some classes of radiological contingencies require that offsite authorities be informed of the situation, the RSO is necessarily involved in each of the contingencies. The class of contingency, however, does determine the level of onsite and/or offsite support needed to deal with the situation.

For radioactive material spills, the operational personnel report such an incident to the RSO. The RSO will assess the event and will take appropriate action. In general, the RSO will be capable of handling these situations entirely with no further onsite or offsite support.

In the event of a major fire or severe natural phenomenon, the RSO activates the onsite emergency response. The RSO also informs local/state authorities and the NRC of the situation.

4.2.2 Plant Staff Radiological Contingency Assignments

During an emergency, assignments for the contingency staff are on two levels: local and plant-wide. The RSO is responsible for plant-wide direction of emergency situations. The normal operational staff will provide initial reporting and information and further assistance as requested by the RSO.

4.2.2.1 Radiation Safety Officer (RSO)

The primary responsibility of the RSO will be:

*Coordination of first aid and medical transport
*Coordination of evacuation
*Coordination of offsite fire assistance
*Coordination of rescue operations.

Staff for medical assistance, fire fighting and rescue operations will be offsite personnel. Area personnel will aid in evacuation, including personnel accountability.

4.2.2.2 Radiation Safety Officer (RSO) and Supporting Staff

The primary responsibility of the RSO and the supporting staff will be the radiological protection of onsite and offsite personnel and assessment of the emergency. Specific responsibilities include:

*Assessment of accidental releases and doses
*Personnel monitoring (on and offsite personnel)
*Personnel and facility decontamination
*Radiological surveys
*Assisting in post-accident assessments
*Overall maintenance of the Radiological
*Contingency Plan

4.2.2.3 Facility Employees

Facility employees will serve as the first line of communication following radioactivity spills and will assist in evacuation and personnel accountability, as discussed above.

4.3 Offsite Assistance to Facility

In the event of a radiological emergency, it may become necessary to use offsite assistance to supplement the onsite emergency organization. Advanced Medical has arrangements with the local police and fire departments and with local hospitals and ambulance services to respond to these emergencies. Letters indicating to whom this plan has been sent are contained in an Appendix B to this plan. The RSO, through communications with facility employees, assesses the need for offsite support services. He, or his designee, contacts the appropriate offsite organization by telephone to request support.

4.4 Coordination with Participating Government Agencies

The State of Ohio Emergency Management Agency, located in Columbus, Ohio maintains a Governor's response team for radiation accidents.

5.0 Radiological Contingency Measures

This section provides a general description of the measures to be taken during a radiological contingency. The emergency procedures enclosed as an Appendix provide details of the steps to be taken.

5.1 Activation of Radiological Contingency Response Organization

The initial step in any emergency is the activation of the radiological contingency response organization. As described in Section 1.0 of this plan, all radioactive material processing involves operating personnel. As such, the initial reporting of most incidents will depend on these personnel. The activation steps taken from the initial incident through notification of the Emergency Manager/RSO will depend on the incident. Once the Emergency Manager/RSO is notified, further activation and communication will be his/her responsibility. Procedures detailing the activation of the response organization are included as an Appendix to this plan.

5.1.1 Initial Incident Reporting

The initial incident reporting for each type of accident is presented below.

Ventilation System Incidents

Failure of the ventilation system will result in evacuation of the affected area but does not constitute a radiological emergency. Any incident in which ventilation flow is stopped will be reported to the RSO by the individual observing the ventilation system problems. The RSO will perform an initial assessment of the incident.

Major Fire or Severe Natural Phenomenon

All incidents of this type will be reported to the Emergency Manager/RSO by plant personnel or the offsite security company. The personnel will be aware of fire through the fire alarm system and of severe natural phenomena by the phenomenon itself. Plant personnel will use the intercom system as the first line of communication. During normal working hours, the Emergency Manager/RSO will be contacted through office phones. During off hours, the Emergency Manager/RSO (or his alternate) will be contacted at home. Also during off hours, the RSO will contact other key personnel summoning them to the site as required.

5.1.2 Response Organization Activation

Incidents Other Than Major Fires and Severe Natural Phenomenon

For all such incidents the RSO will report immediately to the affected area and assess the situation. The RSO, based on his assessment, will determine what class of emergency, if any, is applicable. The action to be taken under each emergency class are outlined in Section 3.2 and detailed in the attached procedures. The RSO will contact by telephone the Director of Regulatory Affairs, the Cleveland Fire Department, the Ohio Emergency Management Agency and the USNRC, as detailed in Section 8.3. These parties will be instructed to place a return call and repeat the information provided by the RSO to authenticate the call.

Major Fires and Severe Natural Phenomenon

These classes of incidents are described in Section 3.3. The Emergency Manager/RSO will receive reports of these types of incidents from plant personnel or the offsite security company. The Emergency Manager/RSO will immediately declare an "ALERT". He will assure that the facility is being evacuated. He will instruct his personnel to assess the emergency via environmental monitoring. He will then activate the emergency response team and make offsite contacts as described above.

5.2 Assessment Actions

Assessment of the emergency condition will be the primary responsibility of the RSO. The initial step in each emergency sequence will be on initial assessment by the RSO. This assessment will be via three (3) methods depending on the severity of the accident:

1. Inspection
2. Release estimates
3. Air monitoring and dose monitoring

The simplest method is visual observation. For all incidents, the RSO will report to the affected area and determine what has happened. He will characterize the incident as a contained spill, ventilation system failure, fire or natural phenomenon. He will also assess the extent of physical damage and injuries.

For all but the most severe incident, the RSO will estimate the amount of radioactivity that has been released through inspection of process records and discussion with the operating personnel.

Air and dose monitoring is the most reliable assessment method. Air monitoring will be performed for all accidents of "Site Area Emergency". This type of monitoring will occur around the site as well as inside the structure to collect samples of airborne particulates in filter paper for analysis: (ie. air concentrations).

Throughout any emergency situation external doses will be monitored continuously for the purpose of protecting personnel. This monitoring will include personnel film badges and self-reading dosimeters as well as portable survey instruments.

5.3 Corrective Actions

As described in Chapter 3, there are three (3) types of accidents that have been postulated for the AMS London Road facility: spills, fire and natural phenomena. The corrective actions that follow each of these incidents are presented below. Similar corrective action will be taken for localized fires in which release of radioactivity are suspected. In addition, fires will not be of sufficient severity to cause breach of containment. Corrective action for ventilation failure is to have personnel restore proper airflow.

In the event of an all-engulfing fire or tornado or earthquake, there are essentially no corrective actions that can be taken. Actions to be taken are of a recovery nature, after the initiating event has ceased. One corrective action, however, is for the RSO to survey around the affected building to locate any contamination. If such areas are located, the RSO will mark and decontaminate them.

5.4 Protective Actions

This section discusses the action necessary to prevent or minimize exposure to radiation during the emergency.

5.4.1 Personnel Evacuation from Site and Accountability

The incident producing the emergency determines if building evacuation is necessary. When material is spilled inside the hot cell, evacuation will not be necessary. When material is spilled outside of the hot cell, that area will be evacuated. For any other emergency (fires, tornadoes, etc.), evacuation of the building will be immediately ordered. Personnel will follow established routes, and reassemble at designated areas as described in the attached procedures. The RSO or his designate will check for missing persons. At the assembly point, the RSO will survey individuals to determine whether any evacuees should be decontaminated. The RSO or his designate will also assess the need for medical attention.

5.4.2 Use of Protective Equipment and Supplies

Respiratory devices and protective clothing are located in various areas throughout the facility. This equipment is also part of the Emergency Response Kit located in the Advanced Medical Systems fire pumphouse approximately 300 feet west of the London Road facility on Mandalay Avenue. Personnel are trained in the use of the equipment as part of their initial radiation protection training. The RSO will determine the need for using this equipment. Appropriate respiratory devices will be worn for corrective action during fires. Protective clothing will be worn during corrective actions for any material spills. All other equipment will be used as needed.

5.4.3 Contamination Control Measures

To prevent further spread of radioactive materials and thereby minimize exposure due to these materials, the area in which the emergency occurred will be marked and secured by personnel under the direction of the RSO. Only personnel designated by the Emergency Manager/RSO will be permitted to enter the area.

Inside the marked area, the RSO will determine the extent and location of contamination and will appropriately mark those areas. Once the areas have been marked and decontamination operations have begun, full scale recovery operations will commence. In order for the facility to return to normal use, contamination must be controlled to the extent that personnel exposure will not exceed normal limits:

Loose surface contamination levels:

Restricted Areas	<40,000 DPM/100cm^2
Unrestricted Areas	<1,000 DPM/100cm^2

5.5 Exposure Control in Radiological Contingencies

The primary goal of radiological contingency response is to control personnel exposure. In the event of an emergency, however, it may be necessary for members of the emergency response team to receive exposures up to the EPA guidelines: i.e., less than 75 Rem for either a lifesaving action or less than 25 Rem for entry into hazardous areas to protect the facility or control fires.

5.5.1. Emergency Exposure Control

For any accident involving Cobalt^{60}, emergency workers are required to wear appropriate respiratory equipment. To remove injured persons, undertake corrective actions, perform assessment actions or provide first aid, exposures will be limited to 75 Rem. Preliminary decontamination of non-life threatening injured personnel will occur prior to transport, so that the medical and ambulance service personnel exposure will be less than 3 Rem in the event the injury is life threatening. The primary emphasis is on medical attention and secondary emphasis on decontamination. A total exposure of 75 Rem will be allowed for lifesaving activities.

5.5.2 Radiation Protection Program

The Emergency Manager/RSO is the only individual who can authorize workers to receive emergency radiation doses. During the emergency, trained workers will carry survey meters to determine dose rates in the areas in which they are working. The workers, therefore, may not work in areas where the dose rate multiplied by the amount of time spent in the area exceeds 5 Rem. For lifesaving activities, the dose rate multiplied by the amount of time spent in the area may not exceed 25 Rem.

5.5.3 Monitoring

All emergency response personnel, including firefighters, will wear self-reading dosimeters. Team members will also carry radiation survey meters and pocket dosimeters.

5.5.4 Decontamination of Personnel

Initial decontamination of personnel at the facility will consist of workers removing their normal protective clothing and depositing clothing in a specified location. If decontamination of injured personnel is required, it will be conducted at the contracted hospital. There, individuals will be decontaminated to background levels. Appropriate decontamination procedures and decontaminates will be used. Radioactive wastes generated during decontamination procedures will be deposited in standard radioactive waste containers or bagged in plastic until such containers are available.

5.6 Medical Transportation

Preliminary first aid will be provided by AMS personnel. All transportation of injured personnel will be provided by the City of Cleveland Fire Department or a commercial ambulance service. They may also provide limited first aid, if possible. Limited decontamination of persons with non-life threatening injuries may be performed by the RSO and his staff prior to transport as described in Section 5.5.4.

5.7 Medical Treatment

The following hospitals in the area of the facility are equipped to treat radiological emergency individuals. AMS has arrangements with the facilities to care for injuries involved radiological contamination.

HOSPITAL	APPROXIMATE TRAVEL DISTANCE	APPROXIMATE TRAVEL TIME
University Hospital 11100 Euclid Avenue Cleveland, OH 44106 Phone: (216) 844-3835	6 Miles	15 Minutes

The AMS staff member will provide information assistance as requested.

5.8 Recommended Fire Supression Method

It is recommended fires within restricted areas be fought with dry chemicals - CO_2, Halon or equivalent - to prevent possible run-off of contaminated water. Unrestricted areas can be suppressed with water. The water run-off would be uncontaminated as unrestricted areas have no detectable contamination.

6.0 Equipment and Facilities

This chapter describes AMS's equipment and facilities designated for use during a radiological emergency.

6.1 Control Point

During a radiological contingency with possible offsite impact, emergency response control will be conducted from the fire pumphouse on Mandalay Avenue, approximately 300 feet west of the facility. This location should be minimally affected by an accident inside the facility.

6.2 Communication Equipment

During normal operations at the London Road facility telephone and P.A. systems are used for communications. In addition, fire alarms, discussed in an earlier chapter, inform the personnel of the need to evacuate the building. During an emergency, the RSO would be working closely with the City of Cleveland Fire Department and their response teams, and communications would be made through their system at the site.

6.3 Facility for Assessment Teams

Assessment teams will also operate out of the fire pumphouse. The equipment and supplies located in this building are described in Section 6.4.

6.4 Onsite Medical Facilities and Contamination Control Equipment

Any injuries requiring medical attention will receive first aid from offsite ambulance crews, although initial first aid will be provided by onsite personnel. Injured individuals will be taken offsite to the facilities with which AMS has arrangements.

Offsite supplies for personnel decontamination are stored in the fire pumphouse located on Mandalay Avenue, approximately 300 feet west of the facility.

The supplies located in the fire pumphouse include:

Emergency Plan, Emergency Procedures and extra Report Forms
Frisker
Survey Meter
Flashlight
Batteries for above
Respirator
Air Sampler
100-foot Extension Cord
Pocket Dosimeters - 200Mr and 5R
Dosimeter Charger
Protective Clothing - Shoe Covers, Head Covers, Coveralls and Gloves
20-inch Masking Tape
Contamination Wipes, Soap, Spray Bottle
Rope, Signs and Placards
Ziploc Plastic Bags
Polydrum Liners - 6 Mil.
Marking Pens
Graphite Pencils
Survey Data Forms
Facility Drawings
Emergency Phone Numbers
$3.00 in Quarters
Building Keys

6.5 Emergency Monitoring Equipment

Equipment for assessing and handling the emergency include:

*Pocket Dosimeter and Dosimeter Charger
*Low and High Level Survey Meters
*Anti-Contamination Clothing and Respirators
*Friskers

All emergency equipment is calibrated and checked regularly according to normal ISP practices. Equipment should, therefore, be operational at the time of use.

7.0 Maintenance of Radiological Contingency Preparedness Capability

This chapter describes the administrative procedures for maintaining, reviewing and testing the radiological contingency plan.

7.1 Written Procedures

To ensure that the written implementing procedures for the radiological contingency plan uniformly address the duties and actions of each individual or group responding to an emergency condition, the Radiation Safety Officer has been designated as the planning coordinator for the Radiological Contingency Plan. In this capacity, the Radiation Safety Officer also reviews the Contingency Plan and procedures annually and updates them as needed. It is the responsibility of the Radiation Safety Officer to forward the Plan and procedures to all individuals responsible for implementing the Plan.

7.2 Training

Onsite operating personnel are introduced to their responsibilities during an emergency as part of their formal job training, which includes basic radiation protection. Since their only responsibility during an emergency is initial reporting of an abnormal occurrence, no further training is required. Staff with limited emergency responsibilities receive basic radiation protection training as well as limited emergency response training.

The Radiation Safety Officer will ensure onsite operating personnel are trained in basic radiation protection. The RSO will also provide training for emergency response.

7.3 Drills, Exercises and Communication Checks

AMS will conduct in-house drills with AMS personnel at the discretion of the RSO. These drills are designed to test AMS emergency response functions.

AMS will conduct full scale exercises with onsite and offsite personnel. These exercises will be conducted periodically. The interval will be determined through communication with all affected personnel and agencies participating in the exercise.

A full scale biennial exercise will be conducted with AMS emergency response personnel and offsite emergency response personnel. The NRC shall be invited to participate or observe this exercise. The NRC shall be provided with the exercise objectives and scenario at least sixty (60) days before the exercise. This is done to allow the NRC to comment on the exercise.

The RSO or alternate shall conduct quarterly communication checks with offsite response organizations. This is done to verify and update all necessary phone numbers.

7.4 Critiques

AMS will prepare a critique for each drill and exercise conducted. The critique will evaluate the emergency plan procedures, emergency equipment, personnel training and overall effectiveness. The RSO and/or the Isotope Committee will evaluate the critique or determine if any revisions to the emergency procedures, training or equipment need to be made.

7.5 Audits

AMS will have an annual audit to review our emergency response program. The audit will include the emergency plan procedures, training, equipment and supplies. Records associated with offsite support agencies in accordance with Section 7.3 above shall also be audited. Any discrepancy discovered during an audit will be addressed at the next quarterly Safety Committee meeting and corrective action initiated within 90 days of that Safety Committee meeting.

7.6 Maintenance and Inventory of Radiological Emergency Equipment, Instrumentation and Supplies

To assure that emergency equipment and instrumentation are in working condition and that the stock of emergency supplies is maintained.

These items will be inventoried and checked quarterly. Instruments will be calibrated twice yearly. Inoperable or missing equipment will be repaired or replaced as soon as possible.

7.7 Review and Updating of the Plan and Procedures

The RSO is responsible for reviewing the plan annually and/or amend the plan to reflect changes in facilities, personnel and processes. Revisions and updates to the plan will be transmitted to the USNRC and relevant emergency response agencies.

8.0 Records and Reports

8.1 Records of Incidents

All incidents which result in a declaration of any of the emergency classes discussed in Section 3.2 of this plan will be recorded and reported in accordance with emergency procedures. During the incident, records will be maintained so that an incident report, including the following, can be prepared:

*Cause of event
*Extent of damage and/or personnel injuries
*Radiological data
*Personnel and/or equipment (physical plant) involved
*Corrective action taken
*Offsite assistance requested and received
*Fraction of response equipment used
*Records of offsite contacts
*Re-entry/recovery plans

This information will be compiled on forms which will be used as post incident reports. These reports along with supporting documentation will be maintained as emergency records until the license is terminated. A Radiological Incident Response Checklist found in Appendix A, Attachment 2, will also be completed.

8.2 Records of Preparedness Assurance

Section 7.0 of this plan details the steps that will be taken to assure radiological contingency preparedness. Records documenting this preparedness will be maintained for a five (5) year period following the activity being recorded. These records will include:

*Attendance records of training and retraining
*Report forms and critiques for drills and exercises
*Inventory check-off sheets
*Test and maintenance records for emergency equipment
*Review and update records for the plan and procedures

All reviews and updates of the plan and associated procedures will be scheduled so that annual retraining will include all such changes.

8.3 Reporting Arrangements

Offsite reporting related to the radiological contingency plan will be the responsibility of the RSO and will include:

*The plan itself as well as updates
*Initial reporting and subsequent status updates for emergencies
*Post incident reports

For distribution of the plan and subsequent updates, a list of holders of the plan will be maintained. Individuals receiving the plan and update will acknowledge receiving the material.

Initial offsite reporting and subsequent status reports of radiological contingencies will be made by the RSO. The initial report will be made within one hour of the initiating event. The RSO will make the initial report in the following order:

1. State of Ohio Emergency Management Agency
2. U.S. Nuclear Regulatory Commission - Emergency Operations Center

The report will be made following specific procedures and will include the following information:

*Contingency Class
*The cause of the contingency
*The status of the facility
*Personnel exposure and injuries
*Offsite doses
*Recovery steps taken

Post incident reports will be prepared by the RSO and the support staff and submitted in accordance with Section 3.2 of this plan. The content of these reports is outlined in Section 8.1.

9.0 Recovery

Recovery from a radiological accident will involve re-entering the facility, restoring the facility and the resumption of normal operations. All of these activities will be conducted in such a way as to minimize personnel exposures and radioactivity releases.

9.1 Re-entry

Re-entry obviously applies to emergencies which involve evacuation. For minor, uncontained radioactive material spills (i.e., airborne contamination in the HEPA Room) limited areas will be evacuated. Re-entry will be made by the RSO's staff at the direction of the Emergency Manager/RSO to assess the level of contamination and to perform corrective actions (decontamination). The staff will be equipped with appropriate respiratory equipment to limit internal exposures. Whole body exposures will be limited to 3 Rem/quarter during re-entry and restoration following such an accident.

During a major fire, or immediately following a severe natural phenomena, re-entry will only occur to save human life. Exposures for re-entry personnel will be consistent with the EPA Emergency Worker and Lifesaving Activity Protective Action Guides (EPA 520/1-75/001) of less than 25 Rem whole body gamma for either emergency workers or lifesaving activities. The use of appropriate respiratory equipment by all re-entry personnel will limit hazards of inhaled radioactive material. Re-entry following such an accident will be at the direction of the RSO. Re-entry personnel will be equipped with portable radiation detectors.

The decision to re-enter the facility is based on an evaluation by the RSO and other supervisors that emergency conditions have terminated or have stabilized to a level that would safely permit re-entry. Re-entry teams will make the initial assessment of the extent of contamination and damage. This assessment will form the basis of plans for plant restoration.

9.2 Plant Restoration

During all plant restoration operations, all personnel radiation exposures will be kept as low as reasonably achievable (ALARA) so that the exposures will be below the limits of 10 CFR Part 20.

Restoration falls into three categories: regulatory compliance, maintenance and health and safety. The supervisor of each of these sections is responsible for plant restoration involving each of these categories. The specific restoration plans for these categories are presented below.

The Radiation Safety Officer ensures that:

*Contaminated areas have been defined and posted and decontamination operations are proceeding

*Radiation detection equipment, especially survey meters, are functioning properly and all restoration parties are trained and equipped with these meters

*Ensures that all enclosures and shielding used to contain radioactivity are functional

*Ensures that the ventilation systems and their associated alarms are functional

The RSO's staff will make certain that:

*Evacuation and fire alarms are functional

*The contents of the emergency lockers have been replenished

Based on information provided to the Emergency Manager/RSO by these individuals, the Emergency Manager/RSO will declare that the plant has been safely restored.

9.3 Resumption of Operations

Following the plant restoration, described in Section 9.2, operations will not be resumed until precautions have been taken to prevent recurrence of the incident. An investigation into the cause of the incident will be conducted by the RSO, who will report his/her findings to the Radiation Safety Committee. The investigation will identify any actions that could have been taken to prevent the accident, and the RSO will ensure that these actions are taken.

For all accidents other than minor spills, radiation surveys and engineering checks of all process, alarm and support systems will be conducted prior to the resumption of operations to be certain that all facility equipment conforms to the specifications described in Chapter 2 of this report.

APPENDIX A

EMERGENCY PRE-PLAN OPERATING PROCEDURES

ADVANCED MEDICAL SYSTEMS, INC.
1020 LONDON ROAD
CLEVELAND, OHIO 44110

REV. JANUARY, 1995

Contents

EMERGENCY CONTACT PERSONNEL
Advanced Medical Systems, Inc.

Primary:	OFFICE PHONE	HOME PHONE
Mr. Robert Meschter Radiation Safety Officer	216/692-3269	216/298-1462
Secondary:		
Mr. Stephen Haddock	216/692-3269	216/953-3966
Mr. Christopher Reed	216/692-3269	216/428-1424

Other Contact Personnel

AMS Geneva	Office:	216/466-4671		
Edward Svigel	Office:	216/466-4671	Home:	216/428-6096
David Cesar	Office:	216/466-4671	Home:	216/731-5235

Emergency Civil Response Agencies

University Hospital of Cleveland		216/844-3835
Cleveland City Fire Department	Dial	911 or 216/621-1212
Cleveland City Police	Dial	911 or 216/621-1234
Cleveland Emergency Medical Services	Dial	911 or 216/623-4545
Ohio State Highway Patrol		216/587-4305
ADT Security Services		216/526-9539
Ohio Emergency Management		614/889-7150
U.S. Nuclear Regulatory Commission - Region III		708/829-9500
Operations Center		301/816-5100

FIRE/EXPLOSION/MEDICAL EMERGENCY PROCEDURES

1.0 PURPOSE

This procedure is intended to define Advanced Medical Systems' administrative actions on discovery of a fire, explosion, responses to fires, use of fire alarms as well as medical emergencies.

2.0 SCOPE

This procedure applies to fire, explosion, or medical emergency within AMS' London Road facility during working hours as well as procedures to be followed by responding authorities during non-working hours.

3.0 RESPONSIBILITY

1. The Radiation Safety Officer (RSO) or a designated alternative will review this procedure with the Cleveland City Fire Department and Cleveland City Police. This plan shall be periodically updated and verified for correct information.

2. All training of affected personnel will be the responsibility of the Radiation Safety Officer or a designated alternate.

3. No one shall make any public announcements/statements concerning an emergency situation except the Director of Regulatory Affairs or designated alternate.

4. A review and update of all names and telephone numbers of personnel listed in this plan will be on a quarterly basis and will be the responsibility of the Director of Regulatory Affairs.

5. Any responsibility or action item assigned to an individual in this procedure may be performed by a designated alternate.

4.0 RSO EMERGENCY RESPONSIBILITIES

- Personnel evacuation
- Fire prevention
- Fire/safety inspections (monthly)
- Safety Committee meetings (quarterly)
- Fire fighter information assistance
- Overseeing of salvage operations (post emergency)

5.0 DEFINITIONS

5.1 Fire

Fire or combustion is an exothermic, self-sustaining reaction involving a solid, liquid and/or gas phase fuel. The process is usually associated with the emission of light. For purposes of this procedure, any incident that has potential to escalate into a fire condition or non-radiological emergency life-threatening situation shall be acted upon as a fire.

It is the policy of AMS that fire fighting by personnel be limited to fighting incipient stage fires. Incipient stage fires are defined as fires that can be controlled or extinguished with portable fire extinguishers or 1-1/2" hose streams without the use of self-contained breathing apparatus or personal protective equipment.

6.0 EMERGENCY CONTACT PERSONNEL

See Page 1.

7.0 GENERAL EMERGENCY PROCEDURES

7.1 Reporting an Emergency - General

In the event of an emergency, the following action should be taken by the person reporting such emergencies.

7.2 Applicability

All personnel on AMS property are responsible to report life or property-threatening emergencies.

7.3 Fire During Working Hours

It is recommended fires within restricted areas be fought with dry chemicals - CO_2, Halon or equivalent - to prevent possible run-off of contaminated water. Unrestricted areas can be fought with water. The water run-off would be uncontaminated as unrestricted areas have no detectable contamination.

The individual who discovers the fire shall:

1. Promptly notify the RSO and nearby personnel through the intercom system at the nearest available telephone.

2. The RSO or alternate will determine if fire will cause release of airborne activity to the environment. Based on this evaluation, the RSO will direct the manual dampers in the HEPA Equipment Room to be shut as long as there is no significant risk to personnel.

3. The ADT Security Services 24-hour supervisory electronics monitoring sound alarm system will call AMS prior to notifying the Fire Department.

4. Evacuate building and proceed to assigned area.

5. The RSO or designated alternate will notify the Cleveland City Fire Department at 621-1212. The RSO is to provide the following information:

   a. State your name and that you are calling from Advanced Medical Systems, Inc. at 1020 London Road.

   b. Describe the location of the fire.

   c. Describe the type of fire; i.e., what is burning.

   d. The approximate fire conditions; i.e., smoke only, smoke with flames, rolling smoke, etc.

   e. Describe any personnel injuries.

   f. If safe to stay at the telephone, will answer all questions and let the person answering hang up before you do.

PROVIDE EMERGENCY ASSISTANCE IF ABLE TO DO SO.

7.4 Fire or Explosion During Unoccupied Hours

1. Background

The 1020 London Road, Cleveland, Ohio facility is equipped with an ADT Security Services 24-hour supervisory electronics monitoring alarm system. In the event of a fire or explosion, the signal is automatically transmitted to the ADT Central Office and the proper response civil service group (Cleveland Fire and Police Depart- ments) is immediately notified. During working hours or periods when AMS personnel are occupying the facility, ADT also calls this location. During periods when the building is unoccupied, ADT calls key AMS emergency response personnel.

2. Procedures

a. In the event that local fire and police response groups reach the facility before the designated AMS representative, they have been advised to remain outside the building until either the AMS representative or the designated Cleveland City Fire Department Radiation Officer arrives.

b. In the event of the emission of detectable quantities of smoke or other gases, response personnel and agencies should remain upwind of the emergency site. Police should establish road blocks to prevent normal civilian traffic from passing through the downwind area.

c. Upon arrival, the AMS representative should confer with the civil authorities as to the nature of the emergency and establish a control point.

d. Verify the existence and location of radioactive materials.

e. Using locator floor plans, determine whether the fire/explosion is in restricted or non-restricted area.

f. If fire/explosion involves a restricted area, obtain emergency protection and detection equipment from the AMS pumphouse storage point.

g. Primary entry personnel should be issued and instructed in reading a survey meter and pocket dosimeters in order to make an initial radiation hazard survey. Pocket dosimeters must be zeroed prior to use. If radiation levels are acceptable, then additional fire fighters may be authorized to enter. Fire fighters must wear respiratory protection -- SCBA type. The maximum dose allowable to save equipment is 25 REM.

h. The RSO or alternate will determine if fire will cause release of high airborne activity to the environment. Based on this evaluation, the RSO will direct the manual dampers in the HEPA Equipment Room to be shut as long as there is no significant risk to personnel.

i. The best method of fire suppression in restricted areas would be determined by both professional firemen and AMS personnel. The method chosen should be the one least likely to spread contamination.

j. All fire fighting personnel should be monitored for contamination upon exiting the facility before leaving the site.

k. Exit contamination surveys will be performed to insure that the facility has been restored to a safe condition after an accident.

8.0 MEDICAL EMERGENCIES

The individual discovering the emergency shall notify the RSO who, in turn, shall:

1. Call the Cleveland Ambulance Emergency Medical Services at 911 or 623-4545 and/or provide the following information:

   a. Your name and that you are from Advanced Medical Systems located at 1020 London Road.

   b. Describe the problem.

   c. Answer all of their questions and let them hang up before you do.

PROVIDE EMERGENCY ASSISTANCE IF ABLE TO DO SO.

The first aid supplies are located in the Chemistry Lab.

9.0 MINOR INJURIES

1. Administer first aid to the injured victim.

2. Call or have an emergency call placed for ambulance service (911 or 623-4545) and notify the hospital of its impending arrival.

   a. Using a Frisker, assess the injured person for possible radioactive contamination.

   b. Remove contaminated clothing or cover patient with clean plastic and tape wrap.

3. If victim cannot be moved from the restricted area, the following procedures should be followed:

   a. Secure all sources of radiation near the location and access path to the victim.

   b. Roll out a Kraft paper path or similar clean floor covering to the victim for emergency response traffic.

c. Using a survey meter, determine the radiation dose rates in the response area.

d. Using a Frisker, assess the person for possible radioactive contamination.

e. Meet the emergency response team at the entrance and inform them of the situation including:

1. Nature of injury
2. Location
3. Dose rates
4. Contamination level
5. Need for exit contamination surveys

f. Escort the response team to the victim and advise of potential exposure points along the access path.

g. Conduct exit contamination survey to insure that the facility is in safe condition after an accident.

4. Prepare the transport vehicle for use by spreading plastic sheets in the area to be occupied by the patient.

5. Accompany the patient to the hospital if no further emergency exists or if backup AMS response personnel are at the AMS site.

6. The following equipment should be transported with the patient:

a. Survey meter
b. Frisker
c. Plastic waste bags and tape

7. Inform the ambulance personnel that the AMS representative should supervise the decontamination of the transport vehicle before its next response.

8. In all cases, the maximum dose allowable for lifesaving action is 75 REM.

10.0 POLICE EMERGENCIES

The individual discovering the emergency shall notify the RSO who, in turn, shall:

1. Call the Cleveland City Police Department at 911 or 621-1234.

a. State your name and that you are from Advanced Medical Systems, Inc. located at 1020 London Road.

b. Describe the problem.

c. Answer all questions and let them hang up before you do.

11.0 EVACUATION PROCEDURE

11.1 Decision

The decision to evacuate any section of the facility because of fire or other occurrence will be made by the RSO or his/her designee.

11.2 Notification

If time permits, the RSO will notify the Director of Regulatory Affairs located at the Geneva, Ohio office that a portion of the building has been evacuated.

11.3 Evacuation

1. Each employee will, if possible, shut off any electrical equipment being used, including coffee pot, before evacuating the premises.

2. Supervisory personnel will assemble their personnel in the parking lot and stand ready to assist in the control of the emergency.

3. The RSO is responsible for the communication of information to all personnel concerning the resumption of plant operation following an evacuation.

11.4 Training

It is the responsibility of the RSO to inform each employee of their emergency evacuation exit and their alternative exit(s).

11.5 Equipment Alarms

ADT maintains and is responsible for all fire detection and security equipment. ADT conducts monthly inspections and performs all necessary repairs.

12.0 GENERAL RULES FOR SECURITY BREACHES FOR RESPONDING LAW ENFORCEMENT AGENCIES AND ADT

AMS has ADT Security Service throughout the restricted and non-restricted areas of the London Road facility. During unoccupied hours, this system is armed and breaches of security are electronically transmitted to the ADT office. During occupied hours, these systems are disarmed to avoid the inadvertent transmission of alarm signals by the AMS staff.

12.1 Response

1. During occupied hours, any breach of security will be reported by AMS staff personnel to the Cleveland City Police Department at 621-1234.

2. During unoccupied hours, breaches in security are first detected by the ADT supervisory monitoring system.

3. ADT immediately calls AMS emergency response personnel.

4. ADT security personnel (armed guards) or local law enforcement agencies responding to and ADT call report to the London Road site and await the arrival of either trained emergency response personnel or an AMS representative.

5. An escorted and supervised search of the facility is conducted by the law enforcement officers and either an AMS representative or trained emergency response personnel.

6. If possible, the source of the security breach is determined and the nature or type of security breach recorded.

7. All locks and secured entrances are checked for status. If any of the secured systems have been damaged, they should be repaired before the building is vacated by the AMS representative.

8. All sources of radioactive materials storage are checked to determine tampering or accountability. This includes stored radioactive materials, instrument calibration sources and any source of depleted uranium shielding.

9. The AMS representative should check the supervisory panel to assure that all systems are functioning properly.

10. If a breach of security into restricted areas is detected, wipes of the floor areas will be taken to determine if any radioactive contamination has occurred.

11. Should either the theft of the radioactive material be detected or the release of radioactive contamination occur as a result of the security breach, the NRC will be notified according to the requirements of 10 CFR 20.

12. Following an all-clear situation, ADT systems are reset before exiting the facility.

13.0 GENERAL RULES FOR AMBULANCE-RESCUE SQUADS

REFERENCE: Based on DOE/EV-0020, Department of Energy, October, 1978

13.1 Background

1. Ambulance-rescue squad personnel are usually the first persons of the medical team to see the case of radiation exposure or radioactive contamination. Their first acts will vary in degree. Trained, knowledgeable co-workers, supervisors or health physicists are usually on hand.

2. When the accident has occurred, the health physicist, supervisor, co-workers and the patient(s) should be able to inform members of the rescue squad of the nature of the accident, number of patients and type of radiation exposure or radioactive contamination involved, and possible body areas that may be affected.

   A gross measurement of the amount of radiation involved may be available; such information is most helpful.

3. The maximum dose allowable for lifesavings actions is 75 REM.

13.2 General Rules

1. For the patient:

   a. Give lifesaving emergency assistance if needed.

   b. Secure pertinent information including any radiation exposure from those in attendance.

   c. Determine if physical injury or open wounds are involved. Cover wound with clean dressing; use elastic bandage to hold wound-cover in place; do not use adhesive.

   d. Cover stretcher, including pillow, with open blanket; wrap victim in blanket to limit spread of contamination.

   e. Notify the hospital by radio or telephone of available information.

2. For rescue squad personnel:

   a. Perform survey of clothing, ambulance, etc., on arrival at the hospital before undertaking further activity.

   b. If contaminated, discard clothing in container marked "Radioactive--Do Not Discard". Cleanse self by washing and/or showering, as appropriate.

c. If in contaminated area, rescue squad personnel must be surveyed by radiation-survey meter; measurements must be recorded. Cleansing must continue until responsible physician indicates person may leave.

14.0 GENERAL RULES FOR PHYSICIANS AND NURSES

REFERENCES: Based on DOE/EV-0017, 0018 and 0019, Department of Energy, October, 1978

14.1 Background

The content of each set of general rules will vary with the role of the user; i.e., ambulance or rescue squad, emergency room physician or nurse, or hospital administrator. Additional variations in standing orders can occur if a hospital has:

a. a pre-arranged procedure that is periodically updated and tested;

b. a staff of trained physicians, aides and technicians;

c. proper radiation-measuring equipment;

d. available space for isolation.

What follows is directed to meet the situation of a small community or rural hospital.

14.2 General Rules

If the ambulance or rescue squad that picks up the radiation accident case has a radio or telephone, the emergency room will be alerted to expect a patient who may have had radiation exposure or radioactive contamination.

It is the responsibility of the senior hospital emergency room person on duty, nurse or physician, on receipt of notification of the momentary arrival of a case involving radiation exposure or contamination, to:

a. Notify responsible staff physician or nurse and aides (trained health physicists or trained technicians from x-ray or nuclear medicine departments).

b. Get appropriate survey meter, if one is on hand in the hospital. If hospital has no meter, notify hospital administrator or responsible hospital official so he/she may obtain a survey meter and other pertinent equipment by calling the Police Department.

c. Notify the hospital administrator so he/she may seek expert professional consultation for technical management of the case.

d. If contamination is suspected, prepare separate space, using either isolation room or cubicle, if available. Some hospitals use the morgue, since the autopsy table lends itself to washing with water. The morgue entrance would then be used rather than the emergency room. When the morgue is used, the patient and his/her family must be reassured of why that space is used. If no separate space is available, cover a floor area immediately adjacent to the entranceway to the emergency room with absorbent paper. The area must be adequate for stretcher-cart, disposal hampers and working space for professional attendants. Mark and close off this area. If dust is involved, be prepared to shut off air circulation system to prevent spread of contamination.

Upon ambulance arrival, the responsible physician or nurse in the emergency room should:

a. Check patient on stretcher for contamination (preferably as stretcher is removed from the ambulance) by use of a survey meter.

b. If seriously injured, give emergency lifesaving assistance immediately.

c. Handle contaminated patient and wound as one would a surgical procedure: i.e., gown, gloves, cap, mask, etc.

d. If possible external contamination is involved, save all clothing and bedding from ambulance, blood, urine, stool, vomitus, and all metal objects (e.g., jewelry, belt buckles, dental plates, etc.). Label with name, body location, time and date. Save each in appropriate containers. Mark containers clearly, "Radioactive -- Do not Discard."

e. Decontamination should start, if medical status permits, with cleansing and scrubbing area of highest contamination first. If an extremity alone is involved, clothing may serve as an effective barrier and the affected limb alone may be scrubbed and cleansed. Initial cleansing should be done with soap and warm water. If the body as a whole is involved or clothing generally permeated by contaminated material, showering and scrubbing will be necessary. Pay special attention to hair parts, body orifices and body folds areas. Remeasure and record measurement after each washing or showering. Non-radioactive wash water waste may be flushed into community sewage system. Follow hospital procedures for radioactive liquid waste.

If a wound is involved, prepare and cover the wound with self-adhering disposable surgical drape. Cleanse neighboring surfaces of skin. Seal off cleansed areas with self-adhering disposable surgical drapes. Remove wound covering and irrigate wound with sterile water, catching the irrigating fluid in a basin. Washings can be marked and handled as described in Rule (d) above. Each step in the decontamination should be preceded and followed by monitoring and recording of the location and extent of contamination.

f. Save physicians', nurses' and attendants' scrub or protective clothing, as described for patients. Nurses, doctors and attendants must follow the same monitoring and decontamination routing as the patients.

g. The physician in attendance in the emergency room, if confronted with a highly contaminated wound with dirt particles and crushed tissue, should be prepared to do a preliminary simple wet debridement. An emergency minor surgical set should be used. Further measurements may necessitate sophisticated wound counting detection instruments supplied by the consultant who will advise if further definitive debridement is necessary.

h. AMS personnel should be able to inform the rescue squad of the nature of the accident, type of radiation exposure or radioactive contamination involved, and possible areas of the body that may be affected. A gross measurement of the amount of radiation involved is always helpful. An AMS representative may come to the hospital with the patient and can be a source of immediate consultation.

i. The emergency room's nurses' calm, assured, friendly greeting, attitude and conversations with the patient can be a tremendous aid.

j. The maximum allowable dose for lifesaving actions is 75 REM.

15.0 GENERAL RULES FOR HOSPITAL ADMINISTRATORS

REFERENCE: Based on DOE/EV-0019, Department of Energy, October, 1978

15.1 Background

The hospital administrator, in contrast to other members of the medical team, is particularly concerned with what the situation will do to his/her other patients or to the hospital as a physical plant, and that relationships with community organizations and specialists are vital.

15.2 General Rules

a. The hospital administrator or senior administrator on duty should inform the DOE and other public officials, such as town, city or county, and/or state health departments, police and fire departments, as appropriate. Before any accidents have occurred, he/she should establish telephone contact with appropriate DOE officials. They can always give immediate advice over the telephone on cleanup of accident site, equipment,etc., and put the hospital's physician in immediate contact with a physician-specialist with knowledge of such accidents. The specialist can be on his way to the hospital within minutes of the first telephone contact.

b. The hospital administrator should also know if the community's police or fire departments have survey meters and who has access to stockpiled civil defense supplies. He/she should also know whether police or fire departments in the community clear up public accident sites.

c. The hospital administrator should have the survey meters checked periodically to be sure that the equipment is operating and fresh batteries are available.

d. The maximum allowable dose for lifesaving action is 75 REM.

16.0 GENERAL RULES FOR HEALTH PHYSICISTS AND RADIOLOGICAL SAFETY OFFICERS

REFERENCE: (From Saenger, E. L., Medical Aspects of Radiation Accidents, USAEC, 1963)

1. When and if an accident is suspected, evacuate personnel and segregate them. Remove all personnel dosimeters and/or film badges immediately from exposed personnel. Read dosimeters and record the reading. Send dosimeters and film badges immediately to a safe area.

2. Notify Radiological Safety Officer who will then activate emergency plan.

3. Close off radiation area. Shut off air conditioning. Seal area if contamination is likely.

4. Evaluate situation in regard to:

   a. Extent of contamination
   b. Level of radiation exposure

5. Save all samples of clothing, blood, urine, stool, vomitus. Label with name, date, time. Send film badges for emergency processing by standard technique.

6. Portable battery-operated tape recorder will be very useful in collecting and storing information and for obtaining a complete history of the accident. It is often difficult to record all of the events, opinions and statements available in an emergency situation. The taped records can be typed later, thus providing a more complete history of the accident.

7. A camera will provide an excellent method of showing exactly what happened. If a movie camera is not available, suitable still photographs will be used.

8. In a major accident, management should obtain the aid of consulting health physicists. These individuals can also be found in neighboring installations and at Perry Nuclear Power Plant and will be essential for the proper handling of the accident during the first week, particularly if it is necessary to work a 24-hour day.

EMERGENCY RESPONSE KIT

Location: Advanced Medical Systems fire pumphouse located on Mandalay Avenue, approximately 300 feet west of the London Road facility.

Contents:

Frisker
Survey Meter
Flashlight
Batteries for above
Respirator
Air Sampler
100-foot Extension Cord
Pocket Dosimeters - 200MR and 5R
Dosimeter Charger
Protective Clothing - Shoe Covers, Head Covers, Coveralls and Gloves
2-inch Masking Tape
Contamination Wipes, Soap, Spray Bottle
Rope, Signs and Placards
Ziploc Plastic Bags
Polydrum Liners - 6 Mil.
Marking Pens
Graphite Pencils
Survey Date Forms
Facility Drawings
Emergency Phone Numbers
$3.00 in Quarters
Building Keys

RESPONSE NO._____

Ohio Emergency Management Agency

RADIOLOGICAL INCIDENT RESPONSE CHECKLIST

DATE_____ TIME_____ DUTY OFFICER_____

1. Incident Reported by _____ ( ) _____
NAME TELEPHONE

_____
TITLE AGENCY

2. Type of Incident:
_____ A. Improper Disposal/Handling
_____ B. Industrial
_____ C. Well Logging
_____ D. Power Plant (complete Initial Notification Form for the affected site - see TAB 4)
_____ E. Transportation: 1) Highway 2) Air 3) Rail 4) Water
_____ F. Other_____

3. Description of Incident_____

4. Incident Location_____

_____

5. Date and Time of Accident_____

6. Type of Material/Packaging Involved_____

7. Amount/Type of Contamination_____

8. Type of Assistance Required_____

9. Public or Private Property_____

10. Hazard to Public_____

11. Other Agencies Notified: _____
_____
_____

12. Response Team Members/Man-Hours_____
_____
_____

13. Resolution/Remarks:
(Continue on back)

(Rev. 10/90)

APPENDIX B

22" X 17" FACILITY DRAWINGS

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED: LONDON ROAD 2ND FLOOR PRE-EMERGENCY PLAN

DRAWING NO. C-A9-P-0062

WITHIN THIS PACKAGE...

01D-01

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED: LONDON ROAD 2ND FLOOR PRE-EMERGENCY PLAN

DRAWING NO. C-A9-P-0063

WITHIN THIS PACKAGE...

01D-02X

APPENDIX C

DISTRIBUTION LIST OF EMERGENCY AGENCIES RECEIVING A COPY OF THE CONTINGENCY PLAN

U.S. Nuclear Regulatory Commission	Region III 801 Warrenville Road Lisle, IL 60532-4351
Division of Fire Department of Public Safety	ATTN: Mr. Lloyd T. Root, Chief Fire Marshal City of Cleveland 1645 Superior Avenue Cleveland, OH 44114
Cleveland City Police Department	ATTN: Commander Robert Cermak City of Cleveland 601 Lakeside Road, Room 230 Cleveland, OH 44114
Ohio Emergency Management Agency, Inc.	ATTN: Mr. Larry Grove Radiological Branch Chief 2855 West Dublin-Granville Road Columbus, OH 43235-2206
University Hospital of Cleveland	11100 Euclid Avenue Cleveland, OH 44106

Advanced Medical Systems, Inc.

Decommissioning Cost Estimate for the London Road Site in Cleveland, Ohio

January, 1995

Revision 0

SCIENTIFIC ECOLOGY GROUP, INC.

Radiological Engineering & Decommissioning Services

Advanced Medical Systems, Inc.

Decommissioning Cost Estimate for the London Road Site in Cleveland, Ohio

Prepared by: Paul C Ely — 1-17-95

Paul C. Ely
Radiological Engineer

Date

Reviewed by: [signature] — 1-18-95

David M. Hall, Manager
Decommissioning Contract Services

Date

[signature] — 1-19-95

Al Johnson, Manager
Oak Ridge Operations

Date

Approved by: [signature] — 1/19/95

Donald R. Neely, Vice President
Radiological Engineering and
Decommissioning Services

Date

January 1995

PROPRIETARY STATEMENT

This document is the property of Advanced Medical Systems, Inc. and furnished with the understanding that the information herein will be held in confidence and will not be duplicated, used or disclosed either in whole or part without the written permission of Advanced Medical Systems, Inc.

SECTION 4 - WASTE HOLD-UP TANK ROOM INTEGRITY EVALUATION

As of the date of this submission, the WHUT Room Report has not yet been received. This report will be forwarded to the NRC upon receipt of finished document.

Bank One, Cleveland, NA
30 South Park Place
Post Office Box 268
Painesville Ohio 44077

BANK ONE.

January 24, 1995

Mr. John Grobe
U.S. Nuclear Regulatory Commission - Region 3
801 Warrenville Road
Lisle, IL 60532

Dear Mr. Grobe:

Please use this letter as confirmation that an irrevocable standby letter of credit for $1,800,000 has been approved for Advanced Medical Systems, Inc. by Bank One, Cleveland, NA. The letter of credit will have an expiration date of February 1, 1996, and will be automatically extended unless notice is provided by Bank One.

Bank One is completing the necessary documentation, and expects that the issuance of the letter of credit will be completed no later than February 1, 1995.

Please feel free to contact me at (216) 352-5698 if you have any questions.

Sincerely,

Jan E. Petrik
Vice President
Corporate Banking Division

JEP/pam

AMS TRAINING PROGRAM

ACADEMIC

TAB 1	General Policy Statements
	Instructors
TAB 2	Basic Radiation Safety Training Manual
TAB 3	Supplemental Radiation Safety Manual

PRACTICAL

TAB 4	Class 2 Service Engineer Program
TAB 5	Class 1 Service Engineer Program
TAB 6	Isotope Technician Program
TAB 7	Isotope Handler Program
TAB 8	Annual Refresher Training

16695

EXAMINATION POLICY

Copies of exmainations, quizzes, and answers will not be distributed to students prior to test.

After the exams are graded, they may be redistributed to the students for review; however, the exams will be collected and all copies retained by AMS for documentation purposes in the individual's C.V. files.

If retesting of a student is required, the format and questions will be altered before the next test. Revised tests will be at least equivalent to previous examinations.

TEXTS

The primary text utilized in the Basic Radiation Safety course is found after TAB 2. This text will be supplemental with the manual found after TAB 3.

AUDIO/VISUAL PRESENTATIONS

AMS intends to videotape all classroom and laboratory presentations, if possible. These videotapes may be edited and utilized for student review and refresher training. They are not intended to be used as primary training sessions.

INSTRUCTORS

The training program outlines, which are part of this manual, refer to instructors by job title or classification. The present qualified individuals who will be utilized as instructors are listed below by job title or classification. The credentials of these individuals follow:

Radiation Safety Officer	Robert Meschter
Engineering/Production Manager	Edward Svigel
Isotope Handler	Stephen J. Haddock

Qualified service engineers, used as instructors, shall have 6-12 months on-the-job experience and must be evaluated and approved by the RSO and Isotope Committee prior to becoming instructors.

EXPERIENCE ADDENDUM

ROBERT MESCHTER

I am familiar with the process and gamma sources used. I have provided radiation monitoring and surveillance during radiographic operations and know the 10 CFR 20 requirements specifically for posting and barricading areas during the operations. I can calculate dose rates and exposures based on source strength, distance, and time. Other nuclear experience includes radiological environmental sampling and analysis, knowledge of radon sampling, and operation and calibration of radiation measuring instruments such as G-M detectors, ion chambers, solid and liquid scintillators, etc.

Nuclear experience also includes "nuclear decontamination", or more specifically defined as those processes and methods for removing unwanted material from surfaces and equipment. My experience in this area includes the operation of liquid abrasive systems employing glass bead or cutting abrasives, CO_2 pellet blasting, Freon and other degreasing systems, ultra-sonics, ultra-high pressure water cleaning systems, and other solvent and chemical cleaning processes.

My nuclear background includes two (2) years chemistry laboratory experience. Primary duties in this area involved the operation of a water purification plant (Graver and Pennfield systems) and all sampling and analysis to insure Grade "A" demineralized water. Laboratory testing of samples included the measurement of chlorides, fluorides, conductivity, turbidity, dissolved oxygen, silica, suspended solids, pH, etc. Lab duties also included preparation of reagents and standards and the use of strong acids, caustics, and specialty chemicals such as Hydrazine. Measuring and test equipment experience includes pH meters, ion specific meters, Mettler balance, photometers, hydrometer, conductivity cells, etc. Electronic test equipment experience includes multimeters, oscilloscopes, Meggar and load banks. I also have general knowledge of electricity.

More specifically, my experience is:

Knowledge of 10 CFR Part 19 (§ 19.12) requirements and application sections of Part 20 (§§ 20.1101(a) and 20.1101), 33 (§ 33.13) and 35 (§ 35.21). Was involved in the development and provided Part 19 Radiation Safety instruction to radiation workers while employed at various nuclear power plants.

Hold an Associate of Science Degree in Radiological Health Technology. Have a broad working knowledge of Health Physics principles, practices, and regulations. Routinely reviewed ongoing procedures, proposed procedures, equipment at other facilities and Advanced Medical Systems. Recommended necessary changes for the safe use of radioactive materials and radiation producing devices.

Cognizant of potential airborne/surface contamination hazards when using unsealed sources. Aware that metallic cobalt forms oxides when exposed to air and will result in both airborne and surface contamination. Routinely conducted contamination (dry swipe) surveys and air-monitoring and provided instruction to workers on internal radiation protection, potential contamination risks, contamination control, and protection options.

Knowledge of 10 CFR Subpart H intent and requirements, Part 20 Appendix B derived limits, the ALARA concept, and contents of Advanced Medical Systems' Respiratory Protection Program. Received regular training covering respiratory protection in the workplace and included types of respirators, suitability, protection factors, permissible practice, Respiratory Protection Programs, and applicable regulations (OSHA 29 CFR 191C.134 and NIOSH/MSHA 30 CFR Part 11).

Knowledge of contamination hazards, contamination control, internal radiation protection, and decontamination procedures. Routinely provided instruction to workers and subordinates on the proper use, maintenance, and disposal of protective clothing: lab coats, disposable gloves/booties, and anti-c suits.

Knowledge of internal radiation protection, hood design and air cleaning devices. Routinely evaluated hoods at Livermore Laboratories for use with radioactive gases, vapors, and particulates; measured face velocities and determined air transport velocities; determined the effectiveness of, replaced, and disposed of rough and high efficiency (HEPA) filters; operated and maintained the glove box at various nuclear facilities.

Knowledge of 10 CFR Part 20 (Subpart K and Appendix F) and external and internal radiation protection. Involved in the planning and operation of the Perry Nuclear Power Plant Waste Storage Facility. Prepared procedures for the safe collection, transport, treatment (compaction of solidification), storage, and packaging for transfer to an authorized agent. Routinely supervised and was involved in the collection, transport, treatment, storage, packaging, and disposal of radioactive wastes at various nuclear plants.

Knowledge of organization, management, regulatory, and operational aspects of a Radiation Safety Program operating a Type A broad license. Knowledge of RSO/Radiation Safety Office's responsibilities and functions.

RESUME

ROBERT MESCHTER

EXPERIENCE

- 1994 - Advanced Medical Systems, Inc.; Radiation Safety Officer
  - Complete authority and responsibiity for the Isotope facility at 1020 London Road
  - Responsible for Radiation Safety
  - Responsible for regulatory compliance
  - Rewrote ISP Manual and participated in the rewrite of the Emergency Plan
  - Chairperson of the Isotope Committee
  - Member of the Management Committee and Safety Committee
- 1984 to 1993 - employed by the Cleveland Electric Illuminating Company at the Perry Nuclear Power Plant as a Senior Engineering Technician. Health Physics and other related duties during the past nine years included (but not limited to) engineering analysis and evaluations, project economic and cost benefit analysis, preparation of procurement specifications, bid proposal evaluations, procedure writing, correspondence preparation, emergency planning, regulatory issues review, technical and program reviews, and work crew supervision as assigned.
- 1975 to 1984 - employed in the commercial nuclear power industry in a variety of Health Physics and other related positions including health and safety technician, chemistry technician, consultant and engineering technician; member of American Nuclear Society and Health Physics Society (specific employers and dates available on request).
- The nuclear plants I have obtained training and experience at are as follows:
  - Duke Power, Oconee Nuclear Plant
  - Lawrence Livermore Laboratory
  - PSE&G, Salem Nuclear Plant
  - Jersey Central Power & Light, Oystercreek Nuclear Plant
  - Boston Edison, Pilgrim Nuclear Plant
  - Carolina Power & Light, HB Robison Nuclear Plant
  - TVA, Browns Ferry Nuclear Plant
  - SMUD, Rancho Seco Nuclear Plant
  - Connecticut Yankee, Haddam Neck Nuclear Plant
  - Alabama Power, Farley Nuclear Plant
  - LP&L, Waterford 3 Nuclear Plant
- Vietnam War Era Veteran, U.S. Navy, 1967 to 1972 - Honorable Discharge.

EDUCATION

- Associate of Science Degree in Radiological Health Technology, Central Florida Community College, 1975 - Graduated with Honors (GPA 3.9).

- Other training includes nuclear systems, engineering economics, Kepner-Trego Problem Solving and Decision Making, personal development, management and supervision, TQM, and various short technical seminars.

- Computer skills include work processing, Lotus spread sheet, 20/20 spread sheet, and the use of industry specific calculational computer codes. Former training in COBOL and FORTRAN languages.

DATE: January, 1995

CV for Edward L. Svigel
Engineering Manager
Advanced Medical Systems, Inc.
121 North Eagle Street
Geneva, OH 44041

I. Primary Function: To manage and supervise Engineering and related departments. Mechanical and electrical design of medical equipment to include R&D, test and evaluation, Quality Control and GMP compliance.

II. Organizational Relationship:

A. Reports to: General Manager

B. Manages: R&D, Manufacturing Department, Quality Control Department and draftsmen

C. Works with: Isotope Department, Service Department, Purchasing Department and Materials Control

III. Education:

A. B.M.E. - Gannon College - 1970

B. Communication/Electronics Staff Officers School - 1971

IV. Employment History:

Diamond Shamrock	1963-1965 Drafting
True-Temper - Central Engineering	1970-1976 Research Engineer
U.S. Army Signal Corps	1971-1973 Signal Officer
True-Temper Corporation	1976-1977 Plant Engineer
Gould/Engine Parts Division	1978-1982 Machine Design Engineer
Advanced Medical Systems, Inc.	1982-Present Engineering Manager

V. Previous Experience:

A. Design and development of fiberglass hammer handles, tennis racquets.

B. Design and development of automatic golf shaft straightening machine.

C. Project engineer for installation of Reverse Osmosis System.

D. Energy Conservation Engineer and Coordinator.

E. Supervisor of plant draftsmen and Quality Control technicians.

F. Supervision of Army Battalion Communications Radio Relay Section.

V. Previous Experience (Continued):

G. Deputy Chief of Fort Bliss Education Television Division - U.S. Army.

H. Project Engineer for purchase and installation of Carbon Absorption unit.

I. Designed, specified and purchased plating room equipment.

J. Supervised and coordinated rebuilds of elevator plating machines.

K. Designed special tools for use in areas of high radiation.

L. Supervised and coordinated GMP Program on medical equipment.

M. Coordinated and managed capital equipment purchases and moves.

N. Supervised the construction of 34 Cobalt units and 2 simulators.

O. Initiated ECO procedure per Title 21 and AMS Q.C./GMP Program.

STEPHEN J. HADDOCK
1170 East 337th Street
Eastlake, OH 44095
(216) 953-3966

WORK EXPERIENCE:

ADVANCED MEDICAL SYSTEMS, INC. - CLEVELAND, OHIO

Isotope Handler and Technician (May 1991 to Present)

Health Physics responsibilities included the following:
*Licensed on USNRC #34-19089-01 as a sealed source handler and Isotope Technician; assisted Radiation Safety Officer in all aspects of the facility's operation.
*Exposure to contaminated areas with contamination ranging from 100,000-200,000 dpm/100cm^2 throughout the room.
*Health physics support in high radiation areas with an accessible dose rates of 1-3 R/hr.
*Extensive hot cell maintenance and manipulator use experience.
*Transfer and handling of special by-product material with activities ranging from 2,000-9,000Ci Co^{60} and potential exposure of 3,000-10,000 Roentgens/hr. @ 1 meter.
*Equipment maintenance and calibration.
*Packaging radioactive waste.
*Shipping and receiving of radioactive material.
*Assisted in developing a Decommissioning Plan and Emergency Pre-Plan.
*Assisted in developing and implementing plan for replacement of HEPA filter system and for hot cell upgrades, repairs and maintenance.
*Responsibilities also included source fabrication; basic radiation safety for the facility; associated maintenance routines for Picker-AMS Cobalt-60 Teletherapy equipment; source transfers and shipments; physical inventorying of sealed sources and basic daily procedures of operation for the facility under AMS and Nuclear Regulatory Commission guidelines.

COYNE-KANGESSER - CLEVELAND, OHIO

Facility Coordinator (February 1990-May 1991)

Managed 15 employees, which involved hiring, payroll, termination and scheduling of personnel as well as marketing functions. Responsible for customer complaints, billing and deposits. Position included a high degree of confidentially and customer contact.

WORK EXPERIENCE: (Cont'd)

BALDWIN-WALLACE COLLEGE - BEREA, OHIO (1982-1986)

Athletic Trainer (1982-1986)

Part-time as a student athletic trainer with the Athletics Department. Duties included all facets of injury assessment including emergency procedures, first-aid including physical therapy and preventative procedures. Assisted doctors with field emergencies and physicals.

EDUCATION:

BALDWIN-WALLACE COLLEGE - BEREA, OHIO (1982-1986)

Bachelor of Arts--Health including 60 Credit Hours in Science Related Class and 58 Credit Hours in Teaching Related Classes
3.0 GPA in His Major

HONORS:

Dr. Robert H. Lechner Memorial Service Award

Recipient in 1984, 1985 and 1986. Awarded for outstanding service at Baldwin-Wallace College.

Baldwin-Wallace College Four-Year Honorary Letterman for Athletic Training from 1982 to 1986.

BASIC RADIATION THEORY
AND
SAFETY PROCEDURES

COURSE SYLLABUS
(Broad)

Topic	Time (Hours)
Mathematics Review	1
Basic Radiation Physics	6
Radiation Detection and Measurements	4
Biological Effects of Radiation	2
Radiation Protection Standards	2
Protection Against External Exposures	3
Protection Against Internal Exposures	3
Shipping and Receiving Radioactive Material	1
Emergency Procedures and Response	.5
Quizzes/Examinations	2-3

LABORATORY EXERCISES

Survey Meter Use and Care	1.5
Calibration of Survey Meters including Demonstration of Shielding and Distance	1.5
Radiation Measurements and Contamination Monitoring	1
Packaging, Shipping, and Receiving Radioactive Material	4

TRAINING RECORD

STUDENT NAME: _____

UNIT #	COURSE IDENTIFICATION	NO. HOURS	STUDY AIDE	LOCATION & DATE ATTENDED	TESTING RESULTS	STUDENT SIGNATURE	INSTRUCTOR SIGNATURE
LAB 1	Survey Meter Use & Care						
LAB 2	Calibration of Survey						
	Meters, Shielding &						
	Distance						
LAB 3	Radiation Measurements &						
	Contamination Monitoring						
LAB 4	Packaging, Shipping, &						
	Receiving Radioactive						
	Material						

Isotope Committee Review Date: _____

Comment: _____

_____

Member Officer Signature: _____

RADIATION SAFETY TRAINING

FOR

ADVANCED MEDICAL SYSTEMS PERSONNEL

I. Basic Radiation Physics

Atomic and Nuclear Structure
Ionization - Isotopes
Radioactivity

- Decay Process
- Types of Emissions
- Half-Life
- Curie
- Decay Formula - Use of Decay Tables

Properties of Alpha, Beta Particles, Gamma Rays, X-rays, and Neutrons
Interaction of Radiation with Matter
Radiation Dosimetry

- Definition of Terms (Roentgen, RAD, REM)
- Exposure Rate - Dose Rate
- Specific Gamma-Ray Constant
- Inverse Square Law
- Calculations

Background Radiation
Characteristics of Co-60 and Cs-137 Sealed Sources

II. Biological Effects of Radiation

Cells and Radiosensitivity
Somatic Effects

- Acute Exposures
- Chronic Exposures

Genetic Effects
Factors Affecting Biological Damage
Case Histories

III. Radiation Detection

Principles

- Ionization Method
- Scintillation Method
- Thermoluminescence
- Photographic Film Dosimetry

Instrumentation

- GM Survey Meters
- Pocket Dosimeters
- TLDs/Film Badges
- Detectors Used at AMS

Instrument Calibration
GM Saturation

IV. Radiation Protection Standards

History
Regulatory Agencies
NRC License
10 CFR Parts 19, 20, and 30
Regulatory Guides
ANSI Standards
Exposure Guides
Bioassay Program

V. Radiation Protection

Principles of Radiation Safety

- ALARA Principle
- Time, Distance, Shielding
- Personnel Monitoring
- Radiation Measurements
- Instrument Calibrations
- Required Postings

Receiving, Handling, Storage of Sealed Sources
Source Installation
Routine Use of Source in Device
Leak Testing Sealed Sources
Source Exchange
Source Inventory/Accountability
Packaging and Shipping Sources
Emergency Procedures
Stay Time Calculation
Shielding Calculation
Activity Calculations

VI. Hands on Activities

Each of the following procedures will be demonstrated by the instructor. In turn, each participant will be required to demonstrate their ability to perform the procedure properly:

Leak Testing Sealed Sources
Packaging Sealed Sources for Shipment
Use of a Survey Meter Including Care and Calibration
Air Monitoring
Contamination Monitoring

RELATIVE STRENGTHS OF

FORCES IN NATURE

Nuclear Force	1
Electromagnetic Force	10^{-2}
*Weak Force	10^{-13}
Gravitational	10^{-39}

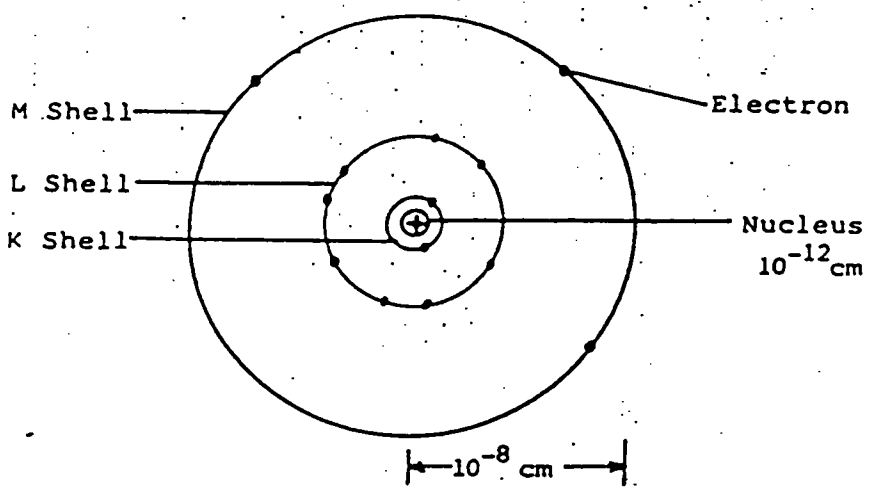
*weak force - an interactive force between the constituents of beta decay

Force = mass x acceleration

Work or Energy "ability to do work" = force x distance

An electron in orbit around the nucleus has potential energy due to being immersed in an electric field (the positive protons in the nucleus and the negative electrons in the electron orbits). It also has Kinetic energy because it is moving (has velocity). The total energy which holds the electron in orbit is the <u>binding energy</u>. To remove an electron from an atom, you must give it enough energy (work) to overcome its binding energy.

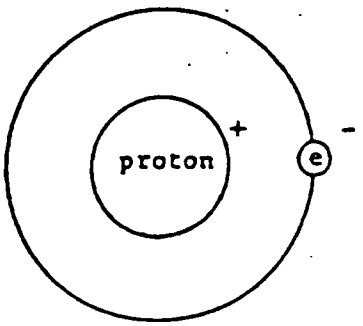
BOHR'S ATOMIC MODEL



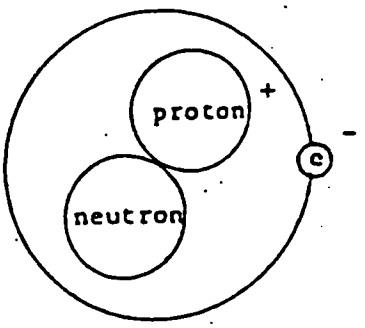
1 inch = 2.54 cm

10^{-8} cm = .00000001 cm

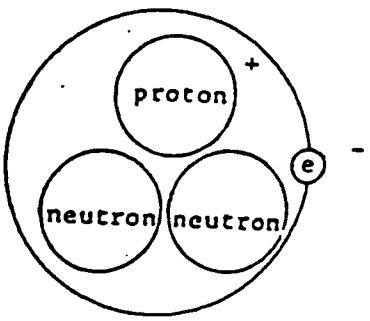
$$= \frac{1}{250,000,000} \text{ inch}$$



HYDROGEN ATOM (H)



DEUTERIUM (D)



TRITIUM (T)

CURRENT CONVENTION

FOR

ELEMENTAL NOTATION

$$^{A}_{Z}X$$

Where: X = chemical symbol

Ex: Co - Cobalt
Cs - Cesium

Z = atomic number

= number of protons and number of electrons for neutral atoms (net charge = 0)

Ex: $^{60}_{27}Co$

27 protons and 27 electrons

A = atomic mass

= number of protons and neutrons (nucleons) in the nucleus

Accordingly,

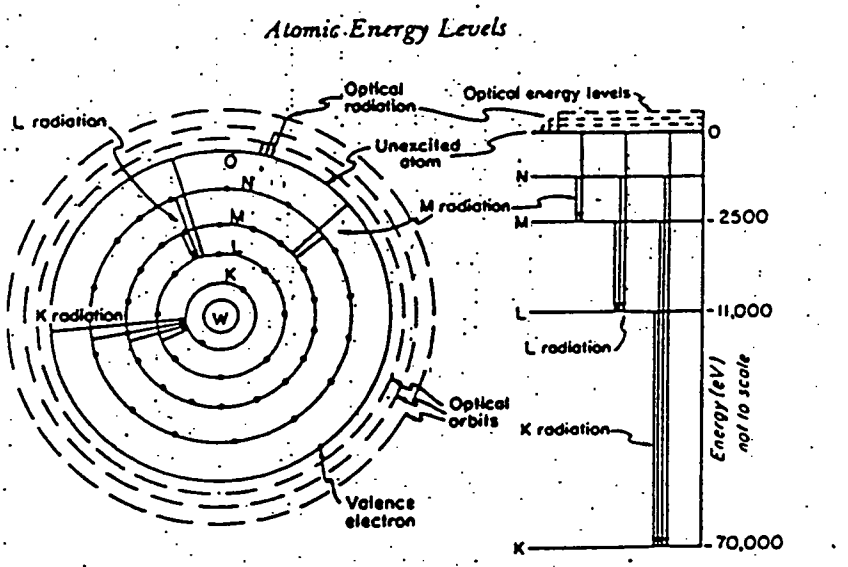
A - Z = number of neutrons in the nucleus

Ex: $^{60}_{27}Co$

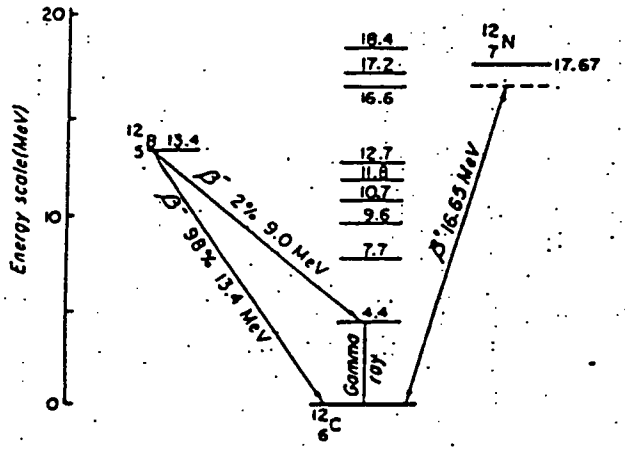
60 nucleons (neutrons and protons)

A - Z = 60 - 27 = 33 neutrons

ATOMIC ENERGY LEVELS

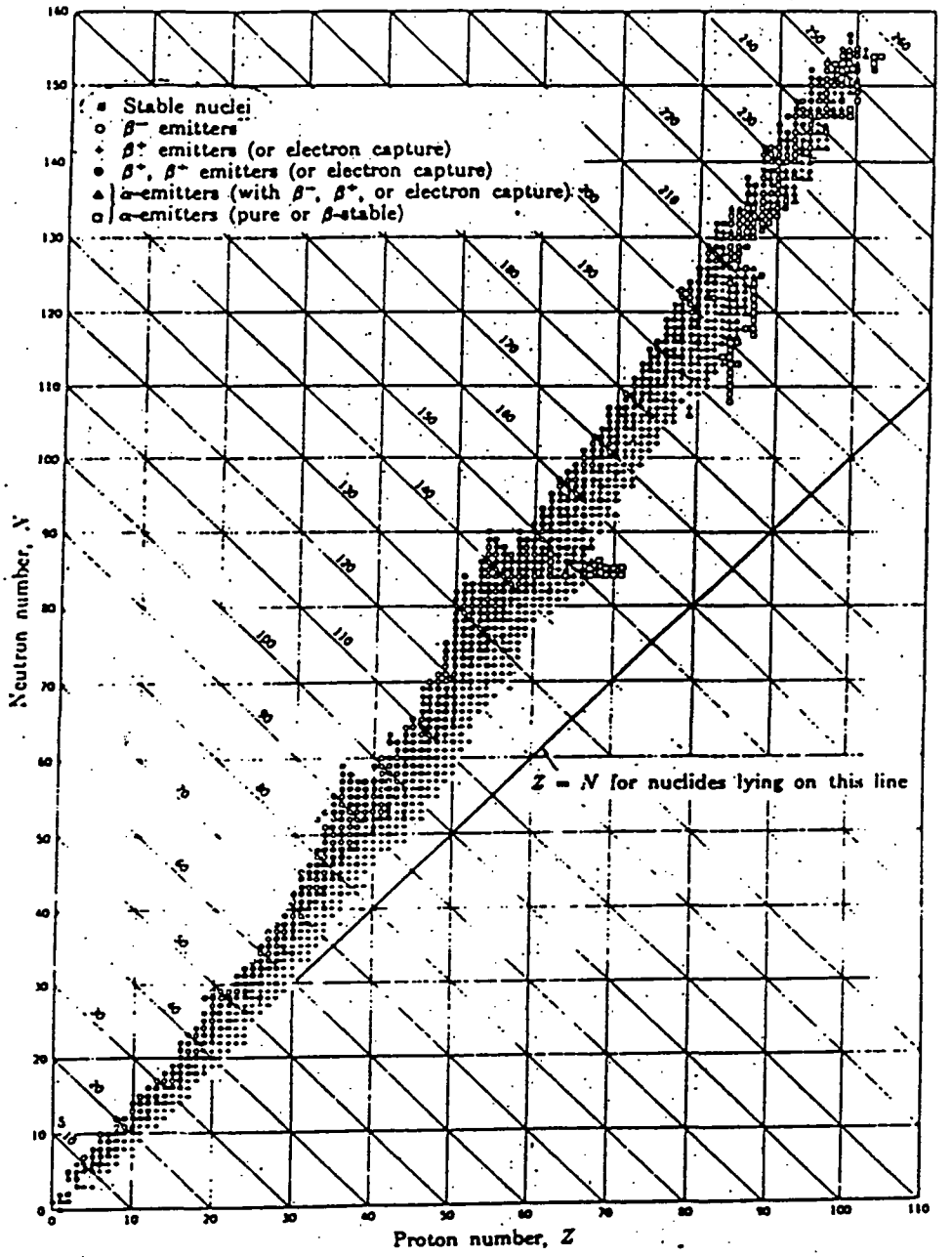


NUCLEAR ENERGY LEVELS



Energy level diagram for carbon 12.

CHART OF NUCLIDES



A plot of neutron number N versus proton Z for all all known nuclei, stable and unstable. A curve through the stable nuclei starts with N/Z = 1 for low-A nuclei and reaches a value of N/Z = 1.6 for high-A nuclei.

REF 1

RADIOACTIVITY

The Curie - A measure of radioactivity equivalent to 37 billion disintegrations per second. (Ci)

1 millicurie (mCi) = one thousandth of a curie

1 microcurie (uCi) = one millionth of a curie

The Becquerel - A measure of radioactivity equivalent to 1 disintegration per second. (Bq)

Unit Conversions

ACTIVITY			ACTIVITY		
1 terabecquerel	= 1 TBq	= 27 curies	1 kilocurie	= 1 kCi	= 37 terabecquerels
1 gigabecquerel	= 1 GBq	= 27 millicuries	1 curie	= 1 Ci	= 37 gigabecquerels
1 megabecquerel	= 1 MBq	= 27 microcuries	1 millicurie	= 1 mCi	= 37 megabecquerels
1 kilobecquerel	= 1 kBq	= 27 nanocuries	1 microcurie	= 1 μCi	= 37 kilobecquerels
1 becquerel	= 1 Bq	= 27 picocuries	1 nanocurie	= 1 nCi	= 37 becquerels

Factor	Prefix	Symbol
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

Advanced Medical Systems

Device Nominal Activity: _____ Ci
_____ Bq

RADIOACTIVE DECAY

$$A_{final} = A_{initial} \times e^{-\lambda \times t}$$

A = activity

$\lambda = \frac{.693}{\text{half-life}}$

t = decay period

e = base for natural log

= 2.71828 . . .

$$\log_e x = y$$

$$e^y = x$$

for ^{60}Co, the half-life ($t_{1/2}$) = 5.3 years

Example: What is the activity of a 5000 curie (Ci.) ^{60}Co sealed source after 15.9 years?

A_{final} = 5000Ci. x $e^{-(.693/5.3 \text{ years} \times 15.3 \text{ years})}$

= 5000Ci. x $e^{-2.079}$

= 5000Ci. x .125

= 625 Ci.

UNIVERSAL DECAY TABLE (REF 5)

The accompanying table can be used to determine the fraction of activity remaining of any radionuclide, from 0.001 half-life to 1.00 half-life. To use the table complete the following:

1. Divide elapsed time by the known physical half-life of the radionuclide under consideration ($t \div T_{1/2}$).
   NOTE: the same time unit must be used in each instance.

2. Use this answer (to three significant figures) in locating the percent of original activity remaining. The first two significant figures are listed on the vertical column at the left of the table: the third significant figure is listed on the horizontal across the tope of the table.

3. Multiply original activity by this percentage figure to obtain amount remaining.

Example: What is the strength of a 10 mCi ^{131}I source after 2 days?

1. $t \div T_{1/2} = 2 \div 8.1 = 0.247$

2. Fraction remaining from decay table = 0.84265

3. 10 mCi x 0.84265 = 8.43 mCi

	Activity remaining for $t + T_{1/2}$ from 0 to 1.00									
	.000	.001	.002	.003	.004	.005	.006	.007	.008	.009
	1.00000	.99931	.99861	.99792	.99723	.99654	.99585	.99516	.99447	.99378
.01	.99309	.99240	.99172	.99103	.99034	.98966	.98897	.98829	.98760	.98692
.02	.98623	.98555	.98487	.98418	.98350	.98282	.98214	.98146	.98078	.98010
.03	.97942	.97874	.97806	.97739	.97671	.97603	.97536	.97468	.97400	.97333
.04	.97265	.97198	.97131	.97063	.96996	.96929	.96862	.96795	.96728	.96661
.05	.96594	.96527	.96460	.96393	.96326	.96259	.96193	.96126	.96059	.95993
.06	.95926	.95860	.95794	.95727	.95661	.95595	.95528	.95462	.95396	.95330
.07	.95264	.95198	.95132	.95066	.95000	.94934	.94868	.94803	.94737	.94671
.08	.94606	.94540	.94475	.94409	.94344	.94278	.94213	.94148	.94083	.94017
.09	.93952	.93887	.93822	.93757	.93692	.93627	.93562	.93498	.93433	.93368
.10	.93303	.93239	.93174	.93109	.93045	.92980	.92916	.92852	.92787	.92723
.11	.92659	.92595	.92530	.92466	.92402	.92338	.92274	.92210	.92146	.92083
.12	.92019	.91955	.91891	.91828	.91764	.91700	.91637	.91573	.91510	.91447
.13	.91383	.91320	.91257	.91193	.91130	.91067	.91004	.90941	.90878	.90815
.14	.90752	.90689	.90626	.90563	.90501	.90438	.90375	.90313	.90250	.90188
.15	.90125	.90063	.90000	.89938	.89876	.89813	.89751	.89689	.89627	.89565
.16	.89503	.89440	.89379	.89317	.89255	.89193	.89131	.89069	.89008	.88946
.17	.88884	.88823	.88761	.88700	.88638	.88577	.88515	.88454	.88393	.88332
.18	.88270	.88209	.88148	.88087	.88026	.87965	.87904	.87843	.87782	.87721
.19	.87661	.87600	.87539	.87478	.87418	.87357	.87297	.87236	.87176	.87115
.20	.87055	.86995	.86934	.86874	.86814	.86754	.86694	.86634	.86574	.86514
.21	.86454	.86394	.86334	.86274	.86214	.86155	.86095	.86035	.85976	.85916
.22	.85857	.85797	.85738	.85678	.85619	.85559	.85500	.85441	.85382	.85323
.23	.85263	.85204	.85145	.85086	.85027	.84968	.84910	.84851	.84792	.84733
.24	.84675	.84616	.84557	.84499	.84440	.84382	.84323	.84265	.84206	.84148
.25	.84090	.84031	.83973	.83915	.83857	.83799	.83741	.83683	.83625	.83567
.26	.83509	.83451	.83393	.83335	.83278	.83220	.83162	.83105	.83047	.82989
.27	.82932	.82874	.82817	.82760	.82702	.82645	.82588	.82531	.82473	.82416
.28	.82359	.82302	.82245	.82188	.82131	.82074	.82017	.81960	.81904	.81847
.29	.81790	.81734	.81677	.81620	.81564	.81507	.81451	.81394	.81338	.81282
.30	.81225	.81169	.81113	.81057	.81000	.80944	.80888	.80832	.80776	.80720
.31	.80664	.80608	.80552	.80497	.80441	.80385	.80329	.80274	.80218	.80163
.32	.80107	.80051	.79996	.79941	.79885	.79830	.79775	.79719	.79664	.79609
.33	.79554	.79499	.79443	.79388	.79333	.79278	.79223	.79169	.79114	.79059
.34	.79004	.78949	.78895	.78840	.78785	.78731	.78676	.78622	.78567	.78513
.35	.78458	.78404	.78350	.78295	.78241	.78187	.78133	.78079	.78025	.77970
.36	.77916	.77862	.77809	.77755	.77701	.77647	.77593	.77539	.77486	.77432
.37	.77378	.77325	.77271	.77218	.77164	.77111	.77057	.77004	.76950	.76897
.38	.76844	.76791	.76737	.76684	.76631	.76578	.76525	.76472	.76419	.76366
.39	.76313	.76260	.76207	.76154	.76102	.76049	.75996	.75944	.75891	.75838
.40	.75786	.75733	.75681	.75628	.75576	.75524	.75471	.75419	.75367	.75315
.41	.75262	.75210	.75158	.75106	.75054	.75002	.74950	.74898	.74846	.74794

	Activity remaining for $t + T_{in}$ from 0 to 1.00									
	.000	.001	.002	.003	.004	.005	.006	.007	.008	.009
.42	.74742	.74691	.74639	.74587	.74536	.74484	.74432	.74381	.74329	.74278
.43	.74226	.74175	.74123	.74072	.74021	.73969	.73918	.73867	.73816	.73765
.44	.73713	.73662	.73611	.73560	.73509	.73458	.73408	.73357	.73306	.73255
.45	.73204	.73154	.73103	.73052	.73002	.72951	.72900	.72850	.72799	.72749
.46	.72699	.72648	.72598	.72548	.72497	.72447	.72397	.72347	.72297	.72247
.47	.72196	.72146	.72096	.72047	.71997	.71947	.71897	.71847	.71797	.71747
.48	.71698	.71648	.71598	.71549	.71499	.71450	.71400	.71351	.71301	.71252
.49	.71203	.71153	.71104	.71055	.71005	.70956	.70907	.70858	.70809	.70760
.50	.70711	.70662	.70613	.70564	.70515	.70466	.70417	.70368	.70320	.70271
.51	.70222	.70174	.70125	.70076	.70028	.69979	.69931	.69882	.69834	.69786
.52	.69737	.69689	.69641	.69592	.69544	.69496	.69448	.69400	.69352	.69304
.53	.69255	.69208	.69160	.69112	.69064	.69016	.68968	.68920	.68873	.68825
.54	.68777	.68729	.68682	.68634	.68587	.68539	.68492	.68444	.68397	.68349
.55	.68302	.68255	.68207	.68160	.68113	.68066	.68019	.67971	.67924	.67877
.56	.67830	.67783	.67736	.67689	.67642	.67596	.67549	.67502	.67455	.67408
.57	.67362	.67315	.67268	.67222	.67175	.67129	.67082	.67036	.66989	.66943
.58	.66896	.66850	.66804	.66757	.66711	.66665	.66619	.66573	.66526	.66480
.59	.66434	.66388	.66342	.66296	.66250	.66204	.66159	.66113	.66067	.66021
.60	.65975	.65930	.65884	.65838	.65793	.65747	.65702	.65656	.65611	.65565
.61	.65520	.65474	.65429	.65384	.65338	.65293	.65248	.65203	.65157	.65112
.62	.65067	.65022	.64977	.64932	.64887	.64842	.64797	.64752	.64707	.64662
.63	.64618	.64573	.64528	.64483	.64439	.64394	.64349	.64305	.64260	.64216
.64	.64171	.64127	.64082	.64038	.63994	.63949	.63905	.63861	.63816	.63772
.65	.63728	.63684	.63640	.63596	.63552	.63508	.63464	.63420	.63376	.63332
.66	.63288	.63244	.63200	.63156	.63113	.63069	.63025	.62982	.62938	.62894
.67	.62851	.62807	.62764	.62720	.62677	.62633	.62590	.62546	.62503	.62460
.68	.62417	.62373	.62330	.62287	.62244	.62201	.62157	.62114	.62071	.62028
.69	.61985	.61942	.61900	.61857	.61814	.61771	.61728	.61685	.61643	.61600
.70	.61557	.61515	.61472	.61429	.61387	.61344	.61302	.61259	.61217	.61174
.71	.61132	.61090	.61047	.61005	.60963	.60921	.60878	.60836	.60794	.60752
.72	.60710	.60668	.60626	.60584	.60542	.60500	.60458	.60416	.60374	.60332
.73	.60290	.60249	.60207	.60165	.60123	.60082	.60040	.59999	.59957	.59915
.74	.59874	.59832	.59791	.59750	.59708	.59667	.59625	.59584	.59543	.59502
.75	.59460	.59419	.59378	.59337	.59296	.59255	.59214	.59173	.59132	.59091
.76	.59050	.59009	.58968	.58927	.58886	.58845	.58805	.58764	.58723	.58682
.77	.58642	.58601	.58561	.58520	.58479	.58439	.58398	.58358	.58317	.58277
.78	.58237	.58196	.58156	.58116	.58075	.58035	.57995	.57955	.57915	.57875
.79	.57834	.57794	.57754	.57714	.57674	.57634	.57594	.57554	.57515	.57475
.80	.57435	.57395	.57355	.57316	.57276	.57236	.57197	.57157	.57117	.57078
.81	.57038	.56999	.56959	.56920	.56880	.56841	.56801	.56762	.56723	.56683
.82	.56644	.56605	.56566	.56527	.56487	.56448	.56409	.56370	.56331	.56292
.83	.56253	.56214	.56175	.56136	.56097	.56058	.56019	.55981	.55942	.55903
.84	.55864	.55826	.55787	.55748	.55710	.55671	.55632	.55594	.55555	.55517
.85	.55478	.55440	.55402	.55363	.55325	.55287	.55248	.55210	.55172	.55133
.86	.55095	.55057	.55019	.54981	.54943	.54905	.54867	.54829	.54791	.54753
.87	.54715	.54677	.54639	.54601	.54563	.54525	.54488	.54450	.54412	.54374
.88	.54337	.54299	.54261	.54224	.54186	.54149	.54111	.54074	.54036	.53999
.89	.53961	.53924	.53887	.53849	.53812	.53775	.53737	.53700	.53663	.53626
.90	.53589	.53552	.53514	.53477	.53440	.53403	.53366	.53329	.53292	.53255
.91	.53218	.53182	.53145	.53108	.53071	.53034	.52998	.52961	.52924	.52888
.92	.52851	.52814	.52778	.52741	.52705	.52668	.52632	.52595	.52559	.52522
.93	.52486	.52449	.52413	.52377	.52340	.52304	.52268	.52232	.52196	.52159
.94	.52123	.52087	.52051	.52015	.51979	.51943	.51907	.51871	.51835	.51799
.95	.51763	.51727	.51692	.51656	.51620	.51584	.51548	.51513	.51477	.51441
.96	.51406	.51370	.51334	.51299	.51263	.51228	.51192	.51157	.51121	.51086
.97	.51051	.51015	.50980	.50945	.50909	.50874	.50839	.50803	.50768	.50733
.98	.50698	.50663	.50628	.50593	.50558	.50523	.50488	.50453	.50418	.50383
.99	.50348	.50313	.50278	.50243	.50208	.50174	.50139	.50104	.50069	.50035
1.00	.50000									

RADIOACTIVE DECAY MODES

ALPHA DECAY - approximately 160 known radionuclides

- occurs primarily in heavier elements
- the disintegrating nucleus emits an alpha particle (α) which essentially is a helium nucleus

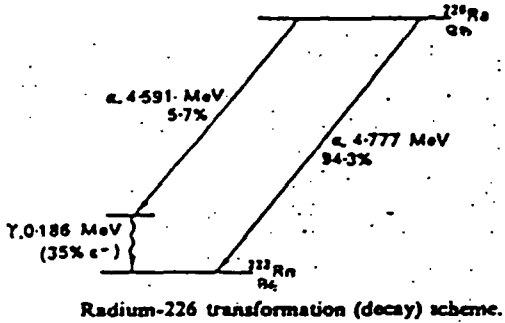
$$^{4}_{2}He^{2+}$$

Symbolically noted as:

$$^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He^{2+} + \text{Kinetic Energy of } \alpha \text{ particle}$$

Example:

$$^{228}_{90}Th \longrightarrow {}^{224}_{88}Ra + {}^{4}_{2}He^{++} + \text{Kinetic Energy}$$



Radium-226 transformation (decay) scheme.

BETA DECAY - approximately 1000 artificially produced

- lie above (B^-) and below (B^+ or E.C.) stability curve
- the disintegrating nucleus seeks nuclear stability by emitting a beta particle or capturing an orbital electron
- 3 types

Negatron Emission	-	B^-
Positron Emission	-	B^+
Electron Capture	-	E.C.

Negatron Decay

Negatron (B^-) decay occurs when an electron is created in and emitted from the nucleus

Symbolically noted as:

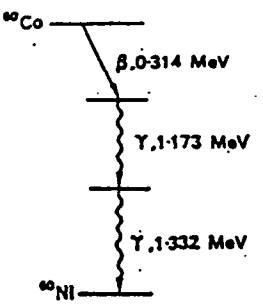
$$^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e\ (B^-) + \bar{\nu}\ \text{(antineutrino)}$$

caused by:

$$n \longrightarrow p + B^- + \bar{\nu}\ *$$

*the neutrino was discovered when observed beta energies were continuous and not discreet

Example:

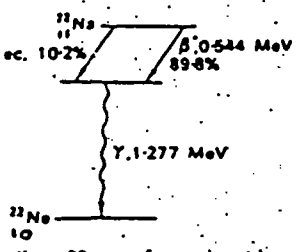


Positron (B^+) Decay

Positron decay occurs when a positron is created and emitted from the nucleus

$$ {}^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}e(B^+) + \nu \quad \text{(neutrino)} $$

Example:



Sodium-22 transformation (decay) scheme.

A positron is a unique creature in that it annihilates with an electron to form two .51 MeV photons.

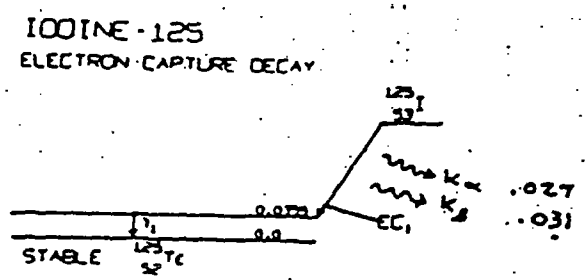
Electron Capture or K-Capture

- the disintegrating nucleus seeks nuclear stability by capturing an orbital electron
- $p + {}^{0}_{-1}e \longrightarrow n$

Symbolically noted as:

$${}^{A}_{Z}X + {}^{0}_{-1}e \longrightarrow {}^{A}_{Z-1}Y + K_{x\text{-ray}}$$

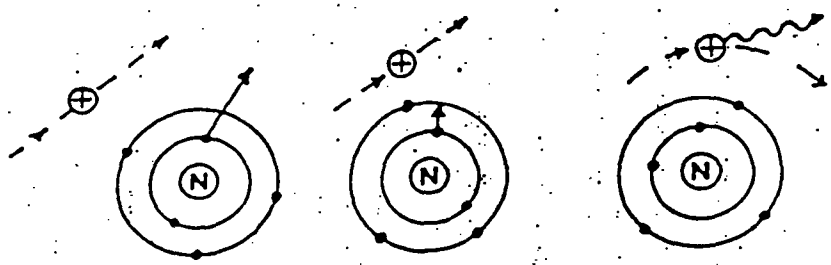
Example:



RADIATION INTERACTIONS

WITH MATTER

Charged Particle



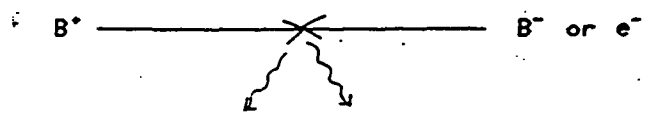
IONIZATION: Removal of electron

EXCITATION: Raising of electron

BREMSSTRAHLUNG: Electromagnetic radiation released

Energy Loss Mechanism

B^+ (Positron-Electron Annihilation)

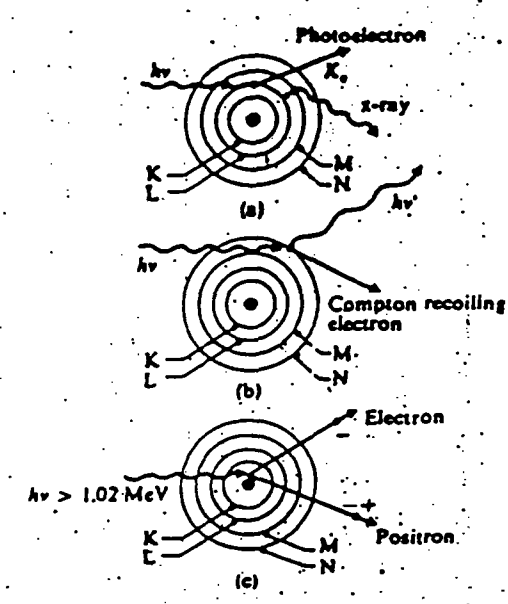


.51 MeV Photon .51 MeV Photon

Rules of Thumb

1. Alpha particles up to 7.5 MeV are stopped in the dead layer of normal skin.
2. Beta particles will penetrate about 4 meters in air per MeV of energy.
3. Beta particles will penetrate about 0.5 cm in soft tissue per MeV of energy.
4. Beta particles up to 70 keV are stopped in the dead layer of normal skin.

Photon - An electromagnetic wave with no charge and no mass (x-rays and gamma rays).



The three processes by which x and gamma rays most often interact with matter.

(a) Photoelectric process: the incident photon is absorbed by one of the inner electrons. The resulting photoelectron leaves its orbital. The vacancy created is filled by an outer electron jumping in, with simultaneous emission of x-ray.

(b) Compton process: the incident gamma ray interacts with one of the outer electrons and transfers a part of its energy to this electron.

(c) Pair production: the incident photon converts into an electron-positron pair in the coulombic field of the nucleus. THe positron annihilates with an electron.

NOTE: The probability of a particular type of interaction is related to the photon energy and the atomic number (density) of the target material.

Figure 3-5. Cloud chamber photograph of alpha, beta, and gamma ray tracks. (J.B. Hoag *Electron and Nuclear Physics*, courtesy D. Van Nostrand Co.) (H4)

RADIATION DOSIMETRY UNITS

Roentgen (R) (exposure) - A measure of electrical charge distribution in air

- 2.58×10^{-4} Coulombs/Kg$_{(air)}$

RAD (dose) - A measure of energy deposition in a medium by exposure to radiation.

- 100 ergs/gm$_{(medium)}$
- .877 Rads$_{(air)}$ = 1.0 Roentgen$_{(air)}$
- .877 Rads$_{(air)}$ = .95 Rads$_{(soft\ tissue)}$

REM - A unit of radiation dose related to radiation protection.

- rem = Rad x Quality Factor
- The Quality Factor is related to the L.E.T. (Linear Energy Transfer) and the R.B.E. (Relative Biological Effectiveness).

Type of Radiation	Q.F.
X, B, gamma	1
thermal neutrons	2.3
fast neutrons	10
alpha particles	20

For X, B, and gamma: 1 R = 1 RAD = 1 rem for radiation protection purposes

RADIATION DOSIMETRY

FOR ^{60}Co AND ^{137}CS SOURCES

- Nominal Activity ^{60}Co Device 5000 Ci

- Gamma Constant

^{60}Co - 1.32 $\frac{R}{Ci\text{-}hr}$ at 1m _____ $\frac{R}{Ci\text{-}hr}$ at 1cm

^{137}Cs - 0.33 $\frac{R}{Ci\text{-}hr}$ at 1 m

Example: What is dose rate at 1 meter from a 4700 Ci ^{60}Co point source?

$$1.32 \frac{R}{Ci\text{-}hr} \times 4700 \text{ Ci} = 6204 \text{ R/hr}$$

If distance is decreased to 1/2 meter, what would the dose rate be?

6204 R/hr @ 1 m. (initial)

? @ 1/2 m. (final)

use:

$DR_{final} = DR_{initial} (r_i/r_f)^2$ where r is the distance from the source

$DR_{final} = 6204 \text{ R/hr} \times (1/.5)^2$

$= 6204 \text{ R/hr} \times (4)$

$= 24816 \text{ R/hr}$

SUMMARY OF AVERAGE ANNUAL PER CAPITA

DOSES TO WHOLE U.S. POPULATION

Source	Average per capita Dose (mrem/year)	
Natural background		
Cosmic	31	
Terrestrial	68	
Tech. Inhanced	4	
Sub-total		103
Man-made		
Medical	—	
X-ray	77	
Nuc. Med.	14	
Sub-total		91
Nuclear weapons	4-5	
Nuclear power	<1	
Consumer products	0.5-1.5	
Sub-total		-8
Total		-200

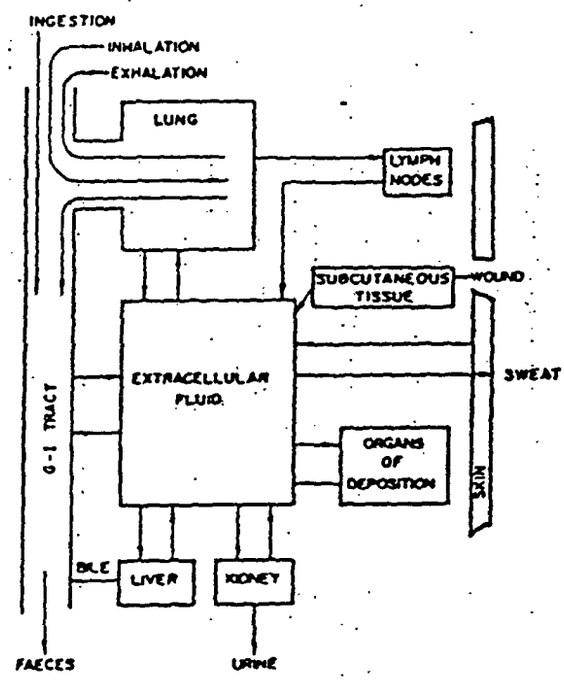
REF 3

U.S. AVERAGE ANNUAL DOSES

FROM RADIOACTIVE PRODUCTS

1.	Radium wrist watch	3 mrem
2.	Tritium wrist watch	0.6 mrem
3.	Radium dial alarm clocks	7 to 9 mrem
4.	Cigarettes, 1 1/2 pack per day, to lung	8,000 mrem
5.	Building materials, masonry	7 mrem
6.	Road construction materials	4 mrem
7.	Coal fired power plant, to lung	1 to 4 mrem
8.	Cooking with natural gas stove	6 to 9 mrem
9.	Residential ionization smoke detector	1 mrem
10.	Dental porcelain in false teeth, to gum	60,000 mrem
11.	Thorium rose tinted eyeglasses, to eye	4,000 mrem
12.	Phonograph record static eliminator	0.001 mrem
13.	Reading a book, 3 hrs/day	0.5 mrem
14.	Aircraft luminous instrument dial	1,000 to 5,000 mrem
15.	Radium pocket watch, GSD	6 mrem
16.	Radioactive lightning rods	0.05 mrem
17.	Uranium glaze in dinnerware, to skin	2,400 mrem
18.	Farmer using phosphate fertilizer, GSD	2 mrem
19.	Worker in fertilizer plant, to lung	5,000 mrem
20.	Gas lantern mantles for camping	0.1 to 0.4 mrem

REF 3



Principal Metabolic Pathways of Radionuclides in the body. (From ICRP 10)

BIOLOGICAL EFFECTS OF

EXPOSURE TO IONIZING RADIATION

Observed effects fall into two categories:

Stochastic Effects	Non-Stochastic Effects
1. occurs by chance	1. a minimum dose must be exceeded-threshold
2. probability of effect is proportional to dose	2. magnitude of effect is proportional to dose
3. no threshold, every increment of dose has a corresponding risk	3. Example: LD 50/30 = 600-800 RADS
4. Example: cancer or genetic effects	

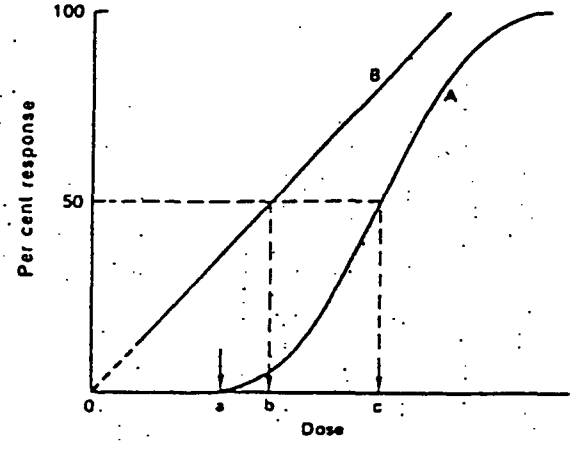


FIG. 7.1. Dose-response curves. Curve *A* is the characteristic shape for a biological effect that exhibits a threshold dose—point *a*. The spread of the curve, from the threshold at *a* until the 100% response is thought to be due to "biological variability" around the mean dose, point *c*, which is called the 50% dose. Curve *B* represents a zero-threshold, or linear response: point *b* represents the 50% dose for the zero-threshold biological effect.

CELL RADIOSENSITIVITY

Law of Bergonie and Tribondean (1906)

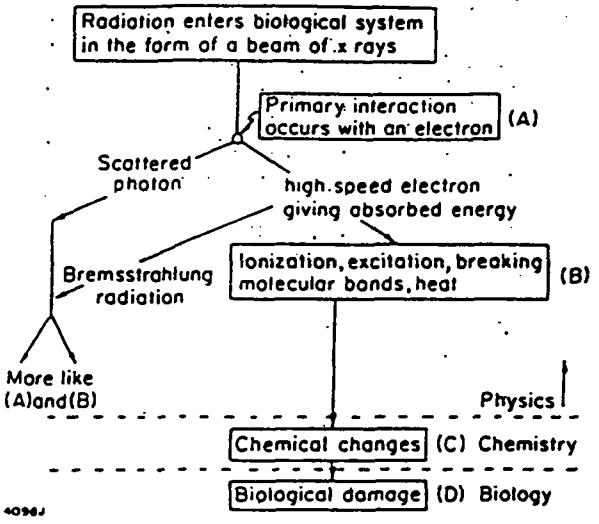
Cells that are most radiosensitive tend to have:

- a high division rate
- a long dividing future
- the capability to "specialize" at some future time into an "adult" cell type

"The generalization of the Law of Bergonie and Tribondeau is that tissues which are young and rapidly growing are most likely radiosensitive. A very practical application of the Law is given by NRC Regulatory Guide 8.13 which is titled "Instruction Concerning Prenatal Radiation Exposure". This Guide requires that women of reproductive age be informed of the increased risk of injury of the human fetus from radiation exposure because such a tissue meets all the criteria of the Law of Bergonie and Tribondeau. The human fetus is particularly sensitive in the first weeks of pregnancy when organs are forming. This is also a time period when the women may not be aware of her pregnancy. Most radiation protection standards recommend that the dose to a developing embryo and fetus be kept below 0.5 rem during the entire 9 months of gestation." (REF 3)

See also NCRP Report No. 54

Schematic Diagram Illustrating The Absorption Of Energy From Radiation Resulting In Biological Damage



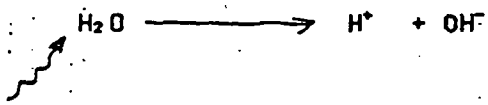
Effects of overexposure

Direct action

- direct insult on a molecule by ionization or excitation and subsequent dissociation

Example: dissociation of an atom on a DNA molecule

Indirect action (by dissociation of atoms in water molecules)



$$H_2O \longrightarrow H^+ + OH^-$$

can recombine a number of ways

$$H + H \longrightarrow H_2 \quad \text{(gas)}$$

$$H + OH \longrightarrow H_2O \quad \text{(water)}$$

$$OH + OH \longrightarrow H_2O_2 \quad \text{(H peroxide)}$$

Peroxides are highly toxic (chemically) to cells.

Exposure Types

Acute - high dose in a short time

Chronic - lose doses over a long time
(effects may take years to show up)

Clinical Effects

Acute Radiation Syndrome from acute whole body exposure.

1. Hemopoietic syndrome > 200 RADS
2. Gastrointestinal syndrome ≥ 1000 RADS
3. Central nervous system syndrome > 2000 RADS

Common to each are:

a. nausea and vomiting

b. malaise and fatigue

c. increased body temperature

* d. blood changes

*the most significant biological indicator of overexposure

Delayed Radiation Effects

- caused by acute large exposure or by a continuous low level exposure (internally or externally)
- effect occurs 5-20 years after exposure
- examples: Cancer (hemopoietic system, thyroid, bone and skin are the most common)

  Leukemia

  Lung cancer

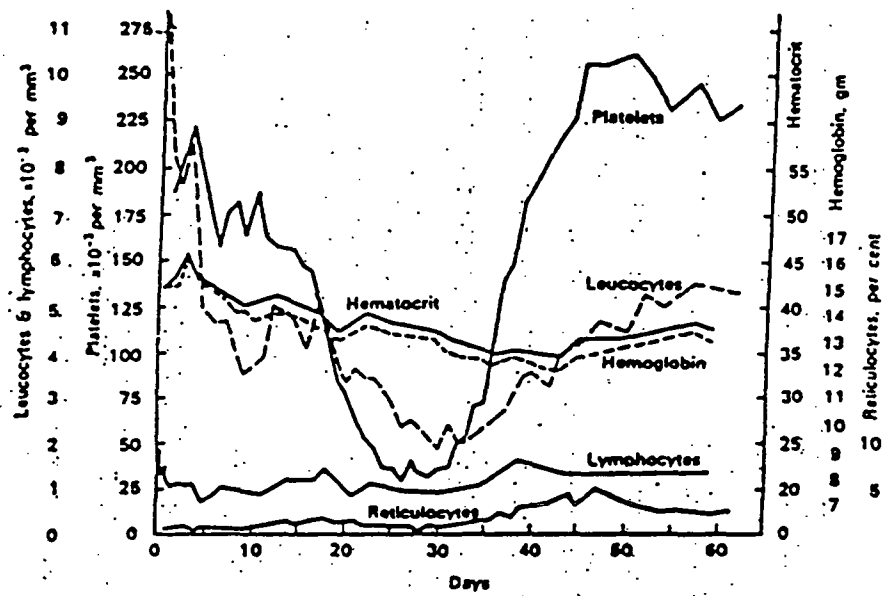
  Genetic effects

RADIOBIOLOGY

RANGE	Subclinical Range 0 to 100 rem	Therapeutic Range 100 to 1,000 rem			Lethal Range Over 1,000 rem	
		100 to 200 rem	200 to 600 rem	600 to 1,000 rem	1,000 to 5,000 rem	Over 5,000 r
INCIDENCE OF VOMITING	None	100 rem: 5% 200 rem: 50%	300 rem: 100%	100%	100%	
DELAY TIME	- - -	3 hr	2 hr	1 hr	30 min	
LEADING ORGAN	None	Bone Marrow			Gastrointestinal Tract	Central Nerv System
CHARACTERISTIC SIGNS	None	Moderate leukopenia	Severe leukopenia, hemorrhage, infection, purpura, epilation above 300 rem		Diarrhea, fever, electrolyte loss	Convulsions, tremor, stazi
THERAPY	Reassurance	Blood surveillance	Blood transfusion Antibiotics	Possible marrow transplant	Maintain electrolytes	Sedatives
PROGNOSIS	Excellent	Excellent	Good	Guarded	Hopeless	
INCIDENCE OF DEATH	None	None	0 to 80%	80 to 90%	90 to 100%	

REF 3

HEMATOLOGIC EFFECTS



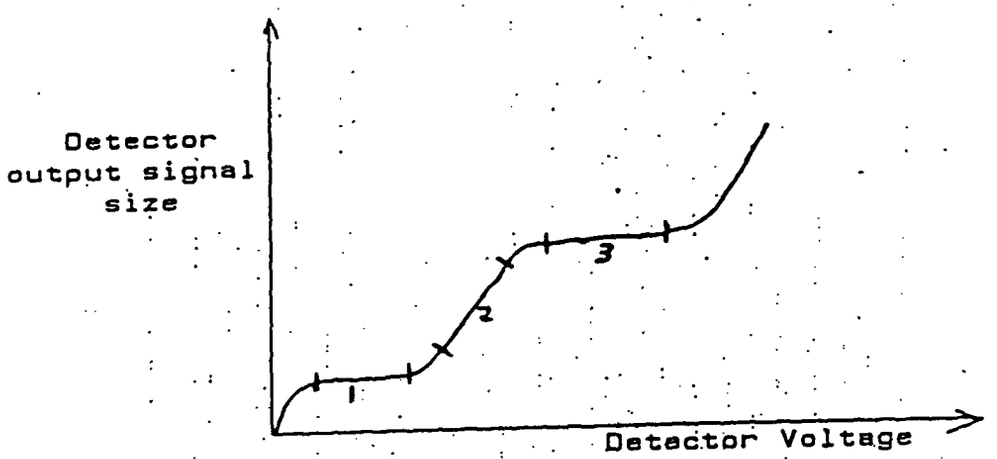
Hematologic effect of radiation overexposure. Average values for five patients who were exposed to 236–365 rad (estimated) during a criticality accident at the Y-12 plant in Oak Ridge on 16 June 1958. (G. H. Andrews, B. W. Sitterson, A. L. Kretchman and M. Brucer, Criticality accident at the Y-12 plant, *Diagnosis and Treatment of Acute Radiation Injury*, pp. 27–48, World Health Organization, Geneva, 1961.)

MECHANISMS FOR DETECTION OF RADIATION

1.	IONIZATION	-	Release of ion pairs by the incoming radiation.
2.	BIOLOGICAL	-	Changes produced in a living system exposed to radiation.
3.	CHEMICAL	-	Changes caused in a chemical solution due to free radical release.
4.	HEAT	-	Energy deposited by the radiation causes a temperature rise in absorber.
5.	SCINTILLATION	-	Production of a flash of visible light in certain phosphors.
6.	THERMOLUMINESCENCE	-	The release of visible light after heating an irradiated sample.

GAS-FILLED DETECTOR

CHARACTERISTIC CURVE



Region 1

- Ion chamber region
- 100% collection of primary ionizations only
- no gas amplification
- can measure only cumulative effects

Region 2

- proportional counter region
- gas amplification produces secondary and tertiary ionizations
- output signal is proportional to incident radiation
- can measure individual events

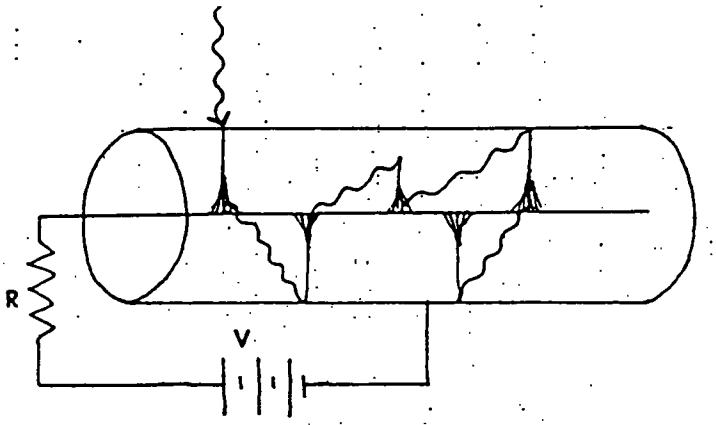
Region 3

- Geiger-Mueller region (G.M.)
- initial ion formation produces total avalanche of gas (complete discharge)
- output signal is the same for any energy of input radiation*

*may overrespond for low energy gamma rays

GM DETECTORS

SPECIAL CONSIDERATIONS



Tube saturation occurs when the tube is exposed to a very high exposure rate in a radiation field.

A conventional instrument will show a momentary upswing of the meter needle followed by a return of the needle to a point near zero, even though the instrument is still in the high field. In such a high field, the ionizing events are interacting with the counter tube with an average separation in time much closer together than the counter dead time. Most of these rays will be missed since the tube is "dead". The problem occurs near the end of the dead time while the last ions are being cleared. If a new event is detected then, the tube still has not fully recovered so the gas multiplication factor will still be depressed. This produces a must smaller pulse than normal. In fact, the pulses formed under these conditions are usually so small as to be at the same level as the background electronic noise. Since the noise pulses are discriminated against by the electronic circuit, this read count will be missed along with all the following counts that continue to trigger the tube before it can recover. Thus the instrument reads "background" while in fact the operator is in an extremely hazardous radiation field. This problem can be eliminated by using only the "non-saturating" type of geiger counters now commercially available. If in doubt, check the instrument specifications to make sure it will not saturate in fields which might be possible at your facility, even under worst case accident conditions.

REF 3

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LONG-TERM FOLLOW-UP AFTER ACCIDENTAL γ IRRADIATION FROM A ^{60}Co SOURCE

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Abstract—In December 1973 a technician was accidentally irradiated when attempting to bring under control a sealed ^{60}Co source (110 TBq) which had been lodged in the head of a medical irradiation unit during a replacement operation. In the early period after the accident, severe skin changes on the left hand, epilation in a small area of the left temporal region and minor deviations in peripheral blood developed. In the following years, repeated surgery due to secondary skin defects of the left hand resulted in the loss of the fingers 2–5. Since 1975, changes in the lens of the left eye began to appear leading gradually to the deterioration of visual acuity. Later, opacities of the lens of the right eye were found. The patient's psychological and emotional attitude about the accident changed in the course of time. The factors influencing the psychic state of the patient are identified.

EVALUATION of the impact and consequences of an accident after some longer time complements the information obtained immediately after recovery from acute radiation injury and offers another useful lesson. The overall health status of a worker was followed for 11 y after quite severe non-uniform γ irradiation from a ^{60}Co source.

In the first years after the accident, the most significant health disorder was local necrosis of the skin and deeper layers of the left hand, which stabilized after a series of surgeries. Repeated monitoring of the eye lenses permitted reconstruction of the time course of development of a cataract and a description of its morphological characteristics.

CIRCUMSTANCES OF THE ACCIDENT AND IMMEDIATE CLINICAL MANIFESTATIONS

On 17 December 1973 a 26-y-old technician (A), responsible for servicing medical irradiation units, installed, together with his co-worker (B) a 110-TBq ^{60}Co source into the head of a tele-

therapy unit at a hospital outside Czechoslovakia. After sliding the source from the transport container into the head of the teletherapy unit, some doubts arose as to whether the operation had been conducted properly because the orange-yellow control light indicated that the source had not reached the resting position in the head. The workers were equipped with personal film dosimeters and a simple portable indicator on the principle of a GM-tube, which showed no deviation on routine assessment of the radiation field. The fault was concluded to be in the light signal system, namely in a broken wire; therefore, they repaired it by soldering it to the microswitch. In the course of repairing the wire, they determined that the actual failure was blockage of the source on its track into the head. During further manipulation of the head, the source dropped to the floor of the room. Both workers quickly left the room and after considering the situation, they decided to bring the source under control by their own efforts using improvised tools.

The source was sealed in a cylindrical capsule of 5.2-cm height and 2.6-cm radius and weighed about 1200 g. This capsule lay on the floor in the irradiation room about 3 m from the entrance and about 2 m from the source container which was near the shielded door. The objective of the operation was to transfer the source to the container with available remote manipulator tools and mirrors, taking advantage of the shielding capacity of the door. After some unsuccessful attempts, they finally managed to place the source back into the container.

Further action by the technicians was unfavorably influenced by the fact that the accident occurred far from their workplace and that the biological response began to appear during the Christmas and New Year holidays. Technician (A) felt ill on 18 December (12–24 h following the accident). He felt general malaise without vomiting, his left eye watered, and his nose bled twice though he previously never suffered from a bleeding nose. Both technicians had a blood count conducted which showed no marked deviation. After his return to Czechoslovakia, technician (A) did not report the accident and returned for routine evaluation the film dosimeter which at the time of the accident was worn on the left side of the chest.

On 25 December (the eighth day after the accident) technician (A) experienced a reddening on the left palm above the metacarpophalangeal joint of the fourth digit accompanied by painful swelling. The inflammatory changes, characterized by erythema and bullae, spread within a few days to the other fingers with the exception of the thumb. At that time he saw a doctor who diagnosed, in view of the elevated temperature (38.5°C), erysipelas and placed the patient on antibiotics. On 4 January 1974, the film dosimeter was evaluated and indicated an exposure corresponding to 1.59 Gy† which prompted the patient's hospitalization at the Clinic for Occupational Diseases, Faculty of General Medicine in Prague.

For assessing the severity of the accident and the prognosis of further clinical manifestations, physical as well as medico-biological methods were used. On the basis of information from both victims of the accident, the time course and geometric conditions of the particular phases of manipulation with the source after its drop to the floor were reconstructed. Attention was wrongly focused solely on this period of the accident, omitting a critical evaluation of the information about the absence of response of the portable dosimetric apparatus at the time of soldering the electric conductor. Thus the result of initial calculations showed doses to the left hand which could hardly induce severe lesions of the skin and deeper layers of the hand with a relatively short latency period. Only later was the possibility of GM-tube saturation considered. The geometry of changes on the left hand during the relapse indicated that the critical operation might have been soldering of the electric conductors on the head of the irradiation unit. In retrospect, it was not possible to determine exactly the phase of the operation in which technician (A) was irradiated.

On the twenty-seventh day after the accident, a cytogenetic examination of peripheral blood lymphocytes was performed in both workers, using a standard micromethod. In technician (A), 13 dicentrics were found in 100 metaphases which, when using a calibration curve for radio-

† In worker (B), the data on the film dosimeter corresponded to 0.1 Gy.

cobalt, led to the estimate of whole-body dose equivalent of 1.2–1.6 Gy (KI79). In worker (B), no chromosome aberrations of the dicentric or ring type were found in 100 cells. In view of these results and the absence of clinical symptoms in worker (B), the remainder of this report will deal solely with worker (A).

During hospitalization, care was given to the evaluation and treatment of general as well as local symptoms. Between Days 18 and 25 after the accident, the patient developed irregular subfebrile temperatures despite continued treatment with antibiotics. This was attributed to developing local changes on the left hand. Deviations in the peripheral blood count were not marked and were conspicuous only in comparison with individual mean values obtained from 14 examinations of peripheral blood prior to the accident (Fig. 1). The horizontal continuous line in Fig. 1 denotes individual means and broken lines ±2 standard deviations. The total leukocyte count and count of neutrophils the first day after the accident exceeded the band ±2 s. Between the second and seventeenth days after the accident, hematologic data are missing. On the thirty-first and forty-ninth postaccident days, the total leukocyte values were the lowest, and in this period a drop in the number of neutrophils below the lower limit was recorded. Lymphocyte count the first day after the accident was normal, but decreased below the level of the lower limit between Days 19 and 23 and later on the forty-ninth day. Morphological deviations in white blood elements were observable, including neutrophils with coarse granulations and hypersegmentation of nuclei. A number of mononuclears showed the pattern of lymphomonocyte cells. Thrombocytes were near the bottom limit of normal values (data not shown), but hemocoagulation examinations revealed no deviations. Sternal puncture was refused by the patient. Even at small quantitative changes, the time course of changes and concomitant qualitative deviations in white blood elements, being distinct responses of the hemopoietic system to irradiation, permitted assessment of the situation.

The most conspicuous and most serious medical problem was local damage on the left hand at the time of admission to the clinic. On the palm above the metacarpophalangeal joints of

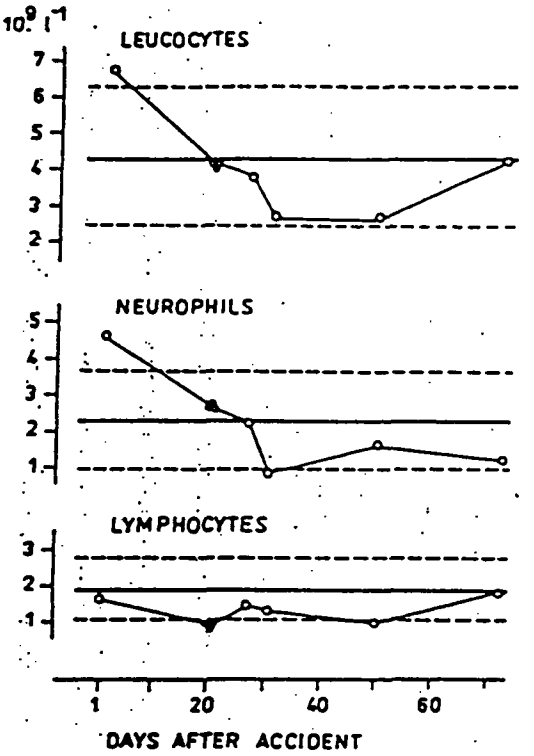

FIG. 1. The course in time of white blood cell count (total leucocytes, neutrophils, lymphocytes) in the exposed technician (A) 1–72 days after the accident. The mean (continuous line) and ±2 standard deviations (broken lines) calculated from 14 blood counts carried out during the last 6 y before the accident.

the third and fourth finger, an irregular oval defect 3 × 4 cm with whitish edges and bleeding bottom was observed. Palmar to the basal phalanges of the third and fourth finger were superficial skin lesions after removal of bullae. Localization of the changes is schematically illustrated in Fig. 2. Considerable spontaneous pain required administration of analgesics. The defects showed no tendency to heal, rather they spread to adjacent interdigital spaces. Therefore, between the thirty-fourth and fifty-third day after the accident, the patient was hospitalized in the Burn Unit of the Clinic of Plastic Surgery, Medical Faculty of Hygiene. No signs of necrosis developed during this period and the skin lesions healed.

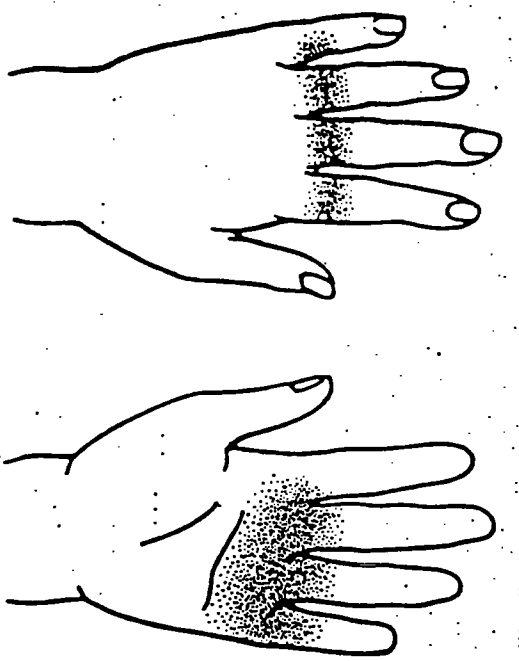

FIG. 2. Areas of the acute skin injury of the left hand in the exposed technician (A) 17 d after accident.

Local symptoms of lesser intensity appeared between Days 20 and 30 after the accident in the left temporal region with epilation of an area 4 × 6 cm; however, alopecia was incomplete. There was slight swelling of the left eyelid and slight reaction of the conjuctiva. Examination of the spermiogram on Days 31 and 42, and 6 mo after the accident showed no important deviations.

DEVELOPMENT OF LOCAL CHANGES ON THE LEFT HAND

Serious trophic changes persisted on the left hand, characterized by a smoothed discolored skin and disturbed local blood flow. The earlier defects were partly covered by a fine crust. Due to the hard swelling of deeper skin layers, motility of fingers 2–5 was greatly limited. Twelve months after the accident, a secondary defect developed on the palmar area of the basal phalange of the fifth finger. The patient was again admitted to the Burn Unit of the clinic for plastic surgery, when it was first attempted to cover the defect by tubular graft. Failure of this attempt necessitated within the next 4 mo successive amputations of fingers 5 through 2 and surgical interventions to improve function and cosmetic appearance of the remaining part of the left hand. The patient had been originally lefthanded and was trained to use the right hand. The state of the amputated hand in 1985 is shown in Fig. 3. The skin of the hand requires protection against cold, direct sunlight and chemical or mechanical irritation. Observing these principles, no relapse of skin defects has occurred since 1975, and the person in question continues to work as a testing technician at his original workplace; however, he does not work with radiation sources.

DEVELOPMENT OF CHANGES IN EYE LENSES

Early local manifestations in the left temporal region and in the anterior segment of the left eye

FIG. 3. Final outcome of the repeated surgery of the left hand (March 1985).

indicated a significant local dose in this region and prompted a systematic monitoring of the state of the eye lens.

The first changes in the form of fine radial opacities in the posterior cortex inferotemporally and of a flat posterior subcapsular cataract inferonasally were observed in May 1975 (17 mo after the accident). In 1977 (i.e. the fourth year after the accident and the patient's thirtieth year of age) vacuoles appeared under the anterior lens capsule, and the flat posterior subcapsular opacity became more strongly marked.

Vision in both eyes was 6/6 with −0.5 D sphere. In 1977 the patient started to read 6/6 to 6/8 with the left eye. Deterioration of visual acuity of the left eye progressed relatively rapidly. By October 1978 the patient's best corrected vision was 6/18. By April 1979 it was 6/60 uncorrected (6/24 with +1 D correction).

In 1980 changes appeared also in the right eye lens. At first, several vacuoles and powder-like opacities appeared under the anterior capsule. In the central area under the posterior capsule, there was a net-like opacity. Visual acuity of the right eye is normal; however, the refractive error changed as the opacities in the lens developed.

OPHTHALMOLOGIC FINDINGS IN MARCH 1985

External and intraocular findings up to the pupil were normal in both eyes.

Right eye. Under the central anterior capsule of the lens was a fine opacity with ray-like projections visible only with a slit lamp biomicroscope. Powder-like opacities were observed in both cortices. In the central posterior capsule, there was a nonhomogeneous, flat, ring-shaped, fairly dense opacity 2 mm in diameter with fine ray-like opacities. Vision was 6/6 uncorrected; 6/4 with +0.5 D sphere.

Left eye. Under the anterior capsule of the lens there was a similar spot as in the right eye, and powder-like opacities in both cortices were more frequent. Under the posterior capsule was a flat, nonhomogeneous, porous opacity 6 mm in diameter. The opacity had a wavy border and was denser at the periphery. From the opaque spot, fine ray-like opacities emerged to the equator. The opacity was granular and net-like. Around the posterior pole there was a dense, greyish, slightly oval opacity, denser at the periphery, about 1 mm in diameter, with no porous structure. Vision was 6/60 uncorrected; 6/24 with +1.5 D sphere.

Figure 4 shows the optical section of the cataract on the posterior pole of the lens of the right and the left eye. A substantially larger extent of the left eye opacity is apparent.

PSYCHOLOGICAL ASPECTS OF THE ACCIDENT

The patient's psychological and emotional attitude about the accident changed with the course of the illness. The day after the accident techni-

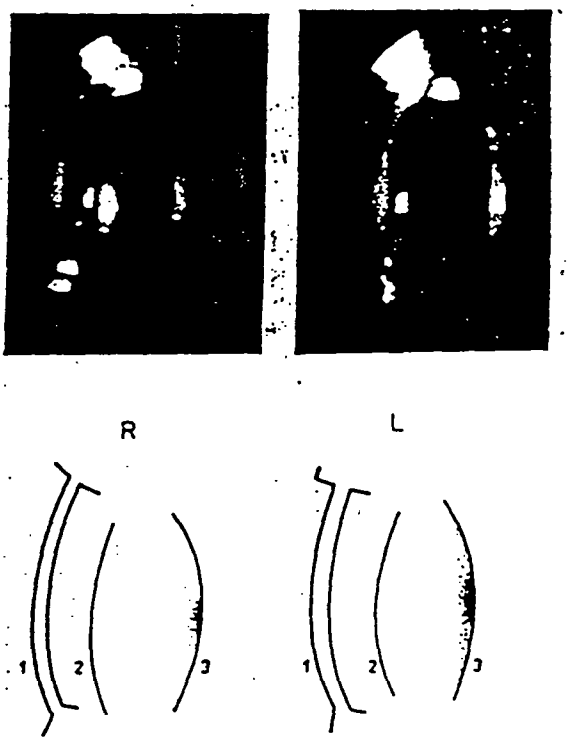

FIG. 4. Lateral optical sections of the lens of the right (R) and left (L) eye. The biconcave body of the lenses could be easily distinguished with the flat subcapsular opacity of the posterior pole clearly showing greater extent and density of the cataract of the left eye (March 1985).

cian (A) felt somehow uneasy and asked for his blood count to be made. The information that the values were within normal limits and the absence of skin response alleviated his anxiety. During his training, he had received basic information about the possible consequences of an accident. But at the moment the implications of the latency period escaped him, and he thought he was entirely out of danger. Five to six days after the accident, he painted and cleaned his apartment using no protection for his hands. During his first stay at hospital (Day 17 to Day 53 after the accident) he accepted the situation more or less rationally and felt reassured by the healing of the defects. After discharge from the hospital, painful swelling of the left-hand finger joints and their confined motility bothered him. Rehabilitation had, however, good results, and he expected further improvement.

The reappearance of the defect on the fifth finger of his left hand at the beginning of 1973 (13 mo after the accident) aroused considerable anxiety in worker (A). Repeated surgery during his long hospitalization and the successive amputation of fingers produced prolonged depression, accentuated by severe pain in the affected limb.

With the aim of gaining insight into the treatment of similar situations we have identified in retrospect the moments having a positive effect on the psychic state of the patient and those with an unfavorable effect. In the first days of hospitalization in January 1974 (at the time of determining the circumstances of the accident), the patient felt annoyed by the great number of questions pertaining to the accident. In this atmosphere the patient perceived that people had lost interest in his personal problems and his health, although objectively he received good medical care. He felt annoyed by the suspicion of some experts that during the handling of the accident he had touched the ^{60}Co source with his unprotected hand and that he concealed this fact. On the other hand, he recalls vividly the attitude of those doctors who showed a personal interest in his situation and who tried to influence actively his state of health. Throughout the whole period of treatment, he found great support among his family. The attitude of the employing organization and of his co-workers was one of understanding of his personal situation.

DISCUSSION

The retrospective evaluation of the consequences of the accident, which occurred 13 y ago, provides data on the development of some post-irradiation effects during a long period and a lesson about the management of persons affected in an accident.

Due to the long-term continual monitoring of the patient, it was possible to detect the development of a cataract from the very beginning. Initial changes in the lens of the more irradiated left eye appeared 18 mo after the accident and since then intensity of the opacity has been progressing. Forty-six months after the accident these changes have distinctly reduced visual acuity. Progressive changes in the right eye have been observed since 1980; however, visual acuity has thus far not been affected. The dose to the eye lens cannot be estimated from dosimetric data, but an estimate can be made from the presence of distinct incomplete epilation in the left temporal area early after the accident. A dose of 1–2 Gy will cause histological changes without clinical signs in hair follicles, 3–5 Gy will induce transient epilation, and doses greater than 7 Gy cause permanent epilation (Ru68; UNSCEAR82). Since hair follicles of the head may be more sensitive to irradiation than hair follicles of other parts of the body, the dose to the left temporal region was estimated to be 3–4 Gy. The dose to the left-eye lens may be comparable. The dose estimate to the right eye is more difficult. In view of the progressing changes on the right-eye lens and the presumed geometry at the time of irradiation, the dose to the right-eye lens may correspond to a significant fraction of the estimate for the left lens.

To prevent accidents during repair and maintenance of irradiation units, adequate technological and dosimetric equipment and clear-cut guidelines for their use are indispensable. Technical procedures for replacement of radiation sources must be devised to minimize the probability of technical problems during such operations. The procedures should provide for the use of high dose rate personal alarm monitors, as well as portable high dose rate radiation field monitors. Since a technical failure may occur and its correction may entail the possibility of higher dose rates, thorough plans should be prepared

for bringing the source under control and should include provision for the shielding of workers, use of remote manipulation, and monitoring of the operation.

Since the accident, there has been time to reconsider problems connected with the human factor and emotional reactions. In a radiation accident the victim is exposed to an extremely unusual situation. The great rush around him produces a sense of insecurity and even panic, which affects his cooperation with the medical team and can influence the outcome of medical care. The medical staff should endeavour to create conditions in which the patient will not feel like a mere subject of examinations but rather like a partner of the team providing medical help (Br83).

CONCLUSIONS

The analysis of the accident and the evaluation of the results of the long-term follow-up may be summarized as follows:

(1) Non-adherence to several safety precautions contributed to the cause of the accidental irradiation and inadequate response thereafter. All safety measures should be strictly observed in handling high-yield γ sources during mounting and maintenance work.

(2) The clinical signs in the injured worker were a guide for the medical approach, particularly when more detailed dosimetric data were lacking.

(3) The time course of the changes on the left hand confirmed the experience that the skin and subcutaneous injury after heavy local γ irradiation does not culminate in the early period but in the time of recurrence 1–2 y later. The overexposed skin should always be protected not only from ionizing radiation but from mechanical and chemical irritation as well.

(4) The time course of the changes in the lenses of both eyes contributed retrospectively to the assessment of the dose and its geometrical distribution on the head.

(5) Emotional problems preoccupied the mind of the overexposed individual a long time after the accident and deserved systematic support on the part of the physicians.

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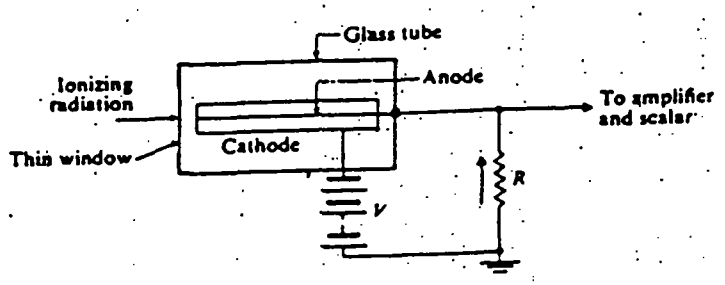
Ru68 Rubin P. and Casarett G. W., 1968, *Clinical Radiation Pathology*, p. 83 (Philadelphia, PA: W. B. Saunders Company).

UNSCEAR82 United Nations Scientific Committee on the Effects of Atomic Radiation, 1982, *Ionizing Radiation: Sources and Biological Effects, Report to the General Assembly*, p. 594 (New York: United Nations).

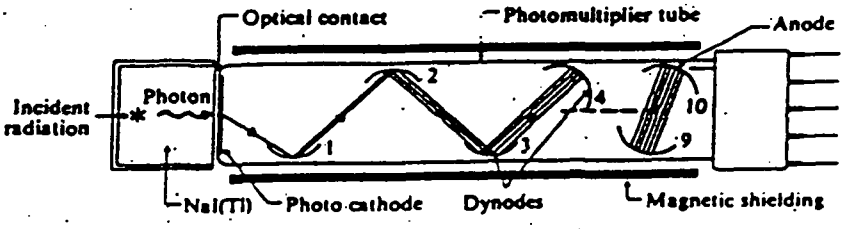
RADIATION DETECTION INSTRUMENTS

Gas Filled Detector



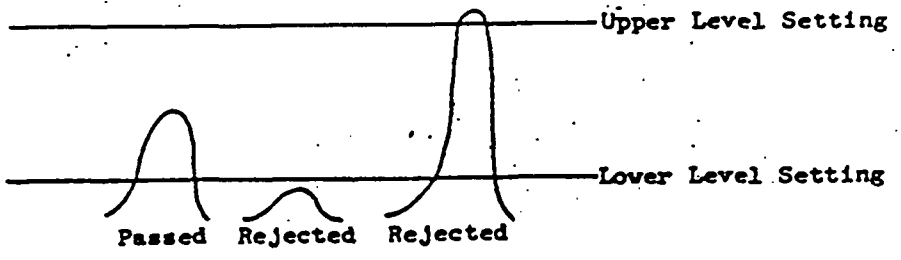
Typical gas-filled detector with a thin mica window so that or B particles may be counted. Depending on the gas pressure and the applied voltage, the detector may be operated as proportional counter or Geiger counter.

Scintillation Detector - not gas filled



Typical NaI(Tl) scintillation detector. The number of photoelectrons emitted is multiplied by successive dynodes, resulting in an electrical pulse at the anode. Output at the anode is proportional to incident radiation.

A Single Channel Analyzer Voltage Window



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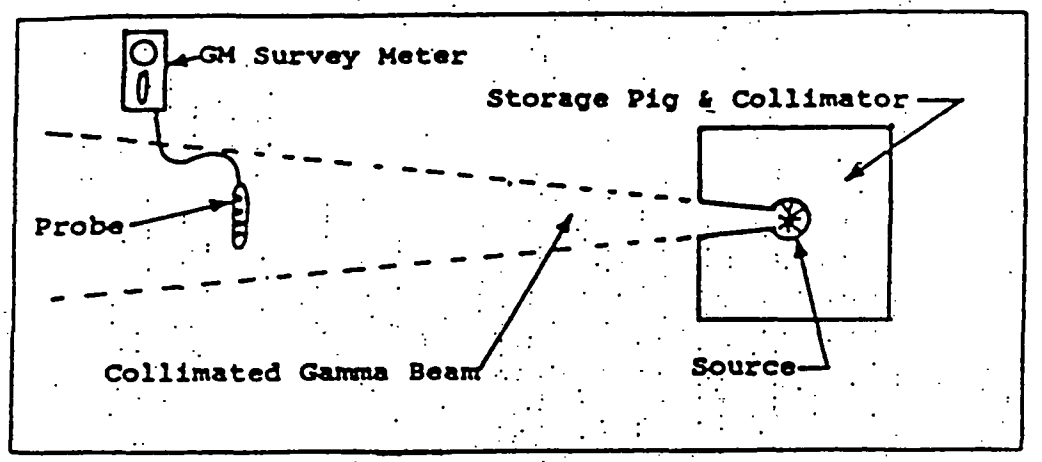
RADIATION SURVEY INSTRUMENT CALIBRATION



Each radiation survey instrument shall be calibrated:

(1) by a person licensed or registered by the Agency, another Agreement State, or the U.S. Nuclear Regulatory Commission to perform such service;

(2) at intervals not to exceed 12 months unless a more restrictive time interval is specified in another part of these rules;

(3) after each survey instrument repair;

(4) for the types of radiation used at energies appropriate for use; and

(5) at an accuracy within 20 percent of the true radiation level.

Records of survey instrument calibrations shall be maintained for inspection by the regulatory agency.

to relate biological insult to a common base.

Rem (See § 20.1004).

Respiratory protective device means an apparatus, such as a respirator, used to reduce the individual's intake of airborne radioactive materials.

Restricted area means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Sanitary sewerage means a system of public sewers for carrying off waste water and refuse, but excluding sewage treatment facilities, septic tanks, and leach fields owned or operated by the licensee.

Shallow-dose equivalent (H_S), which applies to the external exposure of the skin or an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm^2) averaged over an area of 1 square centimeter.

Sievert (See § 20.1004).

Site boundary means that line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee.

Source material means—

(1) Uranium or thorium or any combination of uranium and thorium in any physical or chemical form; or

(2) Ores that contain, by weight, one-twentieth of 1 percent (0.05 percent), or more, of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material.

Special nuclear material means—

(1) Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material that the Commission, pursuant to the provisions of section 51 of the Act, determines to be special nuclear material, but does not include source material; or

(2) Any material artificially enriched by any of the foregoing but does not include source material.

Stochastic effects means health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

Survey means an evalulation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

Total Effective Dose Equivalent (TEDE) means the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Unrestricted area means an area, access to which is neither limited nor controlled by the licensee.

Uranium fuel cycle means the operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel to the extent that these activities directly support the production of electrical power for public use. Uranium fuel cycle does not include mining operations, operations at waste disposal sites, transportation of radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and byproduct materials from the cycle.

Very high radiation area means an area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in 1 hour at 1 meter from a radiation source or from any surface that the radiation penetrates.

(NOTE: At very high doses received at high dose rates, units of absorbed dose (e.g., rads and grays) are appropriate, rather than units of dose equivalent (e.g., rems and sieverts).)

Week means 7 consecutive days starting on Sunday.

Weighting factor w_T, for an organ or tissue (T) is the proportion of the risk of stochastic effects resulting from ir

liation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values of w_T are:

ORGAN DOSE WEIGHTING FACTORS

Organ or tissue	w_T
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder	[1] 0.30
Whole Body	[2] 1.00

[1] 0.30 results from 0.06 for each of 5 "remainder" organs (excluding the skin and the lens of the eye) that receive the highest doses.

[2] For the purpose of weighting the external whole body dose (for adding it to the internal dose), a single weighting factor, w_T=1.0, has been specified. The use of other weighting factors for external exposure will be approved on a case-by-case basis until such time as specific guidance is issued.

Whole body means, for purposes of external exposure, head, trunk (including male gonads), arms above the elbow, or legs above the knee.

Working level (WL) is any combination of short-lived radon daughters (for radon-222: polonium-218, lead-214, bismuth-214, and polonium-214; and for radon-220: polonium-216, lead-212, bismuth-212, and polonium-212) in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha particle energy.

Working level month (WLM) means an exposure to 1 working level for 170 hours (2,000 working hours per year/12 months per year=approximately 170 hours per month).

Year means the period of time beginning in January used to determine compliance with the provisions of this part. The licensee may change the starting date of the year used to determine compliance by the licensee provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years.

[56 FR 23391, May 21, 1991, as amended at 57 FR 57878, Dec. 8, 1992; 58 FR 7736, Feb. 9, 1993]

§20.1004 Units of radiation dose.

(a) Definitions. As used in this part, the units of radiation dose are:

Gray (Gy) is the SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 Joule/kilogram (100 rads).

Rad is the special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 gray).

Rem is the special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem=0.01 sievert).

Sievert is the SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv=100 rems).

(b) As used in this part, the quality factors for converting absorbed dose to dose equivalent are shown in table 1004(b).1.

TABLE 1004(b).1—QUALITY FACTORS AND ABSORBED DOSE EQUIVALENCIES

Type of radiation	Quality factor (Q)	Absorbed dose equal to a unit dose equivalent [a]
X-, gamma, or beta radiation	1	1
Alpha particles, multiple-charged particles, fission fragments and heavy particles of unknown charge	20	0.05
Neutrons of unknown energy	10	0.1
High-energy protons	10	0.1

[a] Absorbed dose in rad equal to 1 rem or the absorbed dose in gray equal to 1 sievert.

(c) If it is more convenient to measure the neutron fluence rate than to determine the neutron dose equivalent rate in rems per hour or sieverts per hour, as provided in paragraph (b) of this section, 1 rem (0.01 Sv) of neutron radiation of unknown energies may, for purposes of the regulations in this part, be assumed to result from a total fluence of 25 million neutrons per square centimeter incident upon the body. If sufficient information exists to estimate the approximate energy distribution of the neutrons, the licensee may use the fluence rate per unit dose equivalent or the appropriate Q value from table 1004(b).2 to convert a measured tissue dose in rads to dose equivalent in rems.

TABLE 1004(b).2—MEAN QUALITY FACTORS, Q, AND FLUENCE PER UNIT DOSE EQUIVALENT FOR MONOENERGETIC NEUTRONS

	Neutron energy (MeV)	Quality factor[a] (Q)	Fluence per unit dose equivalent[b] (neutrons cm^{-2} rem^{-1})
(thermal)	2.5×10^{-8}	2	980×10^{6}
	1×10^{-7}	2	980×10^{6}
	1×10^{-6}	2	810×10^{6}
	1×10^{-5}	2	810×10^{6}
	1×10^{-4}	2	840×10^{6}
	1×10^{-3}	2	980×10^{6}
	1×10^{-2}	2.5	1010×10^{6}
	1×10^{-1}	7.5	170×10^{6}
	5×10^{-1}	11	39×10^{6}
	1	11	27×10^{6}
	2.5	9	29×10^{6}
	5	8	23×10^{6}
	7	7	24×10^{6}
	10	6.5	24×10^{6}
	14	7.5	17×10^{6}
	20	8	16×10^{6}
	40	7	14×10^{6}
	60	5.5	16×10^{6}
	1×10^{2}	4	20×10^{6}
	2×10^{2}	3.5	19×10^{6}
	3×10^{2}	3.5	16×10^{6}
	4×10^{2}	3.5	14×10^{6}

[a] Value of quality factor (Q) at the point where the dose equivalent is maximum in a 30-cm diameter cylinder tissue-equivalent phantom.

[b] Monoenergetic neutrons incident normally on a 30-cm diameter cylinder tissue-equivalent phantom.

§ 20.1005 Units of radioactivity.

For the purposes of this part, activity is expressed in the special unit of curies (Ci) or in the SI unit of becquerels (Bq), or their multiples, or disintegrations (transformations) per unit of time.

(a) One becquerel=1 disintegration per second (s^{-1}).

(b) One curie=3.7×10^{10} disintegrations per second=3.7×10^{10} becquerels=2.22×10^{12} disintegrations per minute.

[56 FR 23391, May 21, 1991; 56 FR 61352, Dec. 3, 1991]

§ 20.1006 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by an officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 20.1007 Communications.

Unless otherwise specified, communications or reports concerning the regulations in this part should be addressed to the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, DC 20555. A communication, report, or application may be delivered in person to the Office of the Executive Director for Operations, 11555 Rockville Pike, Rockville, MD 20852.

§ 20.1008—[Reserved]

§ 20.1009 Reporting, recording, and application requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 *et seq.*). OMB has approved the information collection requirements contained in this part under control number 3150–0014.

(b) The approved information collection requirements contained in this part appear in §§ 20.1101, 20.1202, 20.1204, 20.1206, 20.1301, 20.1501, 20.1601, 20.1703, 20.1901, 20.1902, 20.1904, 20.1906, 20.2002, 20.2004, 20.2006, 20.2102, 20.2103, 20.2104, 20.2105, 20.2106, 20.2107, 20.2108, 20.2110, 20.2201, 20.2202, 20.2203, 20.2204, 20.2206, and appendix F to 20.1001–20.2401.

(c) This part contains information collection requirements in addition to those approved under the control number specified in paragraph (a) of this section. These information collection requirements and the control numbers under which they are approved are as follows:

(1) In § 20.2104, NRC Form 4 is approved under control number 3150–0005

(2) In §§ 20.2106 and 20.2206, NRC Form 5 is approved under control number 3150–0006.

[57 FR 57878, Dec. 8, 1992]

Subpart B—Radiation Protection Programs

SOURCE: 56 FR 23396, May 21, 1991, unless otherwise noted.

§ 20.1101 Radiation protection programs.

(a) Each licensee shall develop, document, and implement a radiation protection program commensurate with the scope and extent of licensed activi

s and sufficient to ensure compli-ce with the provisions of this part. ee §20.2102 for recordkeeping require-ents relating to these programs.)

(b) The licensee shall use, to the extent practicable, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA).

(c) The licensee shall periodically (at least annually) review the radiation protection program content and implementation.

Subpart C—Occupational Dose Limits

SOURCE: 56 FR 23396, May 21, 1991, unless otherwise noted.

§ 20.1201 Occupational dose limits for adults.

(a) The licensee shall control the occupational dose to individual adults, except for planned special exposures under §20.1206, to the following dose limits.

(1) An annual limit, which is the more limiting of—

(i) The total effective dose equivalent being equal to 5 rems (0.05 Sv); or

(ii) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv).

(2) The annual limits to the lens of the eye, to the skin, and to the extremities, which are:

(i) An eye dose equivalent of 15 rems (0.15 Sv), and

(ii) A shallow-dose equivalent of 50 rems (0.50 Sv) to the skin or to any extremity.

(b) Doses received in excess of the annual limits, including doses received during accidents, emergencies, and planned special exposures, must be subtracted from the limits for planned special exposures that the individual may receive during the current year (see §20.1206(e)(1)) and during the individual's lifetime (see §20.1206(e)(2)).

(c) The assigned deep-dose equivalent and shallow-dose equivalent must be for the part of the body receiving the highest exposure. The deep-dose equivalent, eye dose equivalent and shallow-dose equivalent may be assessed from surveys or other radiation measurements for the purpose of demonstrating compliance with the occupational dose limits, if the individual monitoring device was not in the region of highest potential exposure, or the results of individual monitoring are unavailable.

(d) Derived air concentration (DAC) and annual limit on intake (ALI) values are presented in table 1 of appendix B to §§20.1001–20.2401 and may be used to determine the individual's dose (see §20.2106) and to demonstrate compliance with the occupational dose limits.

(e) In addition to the annual dose limits, the licensee shall limit the soluble uranium intake by an individual to 10 milligrams in a week in consideration of chemical toxicity (see footnote 3 of appendix B to §§20.1001–20.2401).

(f) The licensee shall reduce the dose that an individual may be allowed to receive in the current year by the amount of occupational dose received while employed by any other person (see §20.2104(e)).

§ 20.1202 Compliance with requirements for summation of external and internal doses.

(a) If the licensee is required to monitor under both §§20.1502(a) and (b), the licensee shall demonstrate compliance with the dose limits by summing external and internal doses. If the licensee is required to monitor only under §20.1502(a) or only under §20.1502(b), then summation is not required to demonstrate compliance with the dose limits. The licensee may demonstrate compliance with the requirements for summation of external and internal doses by meeting one of the conditions specified in paragraph (b) of this section and the conditions in paragraphs (c) and (d) of this section.

(NOTE: The dose equivalents for the lens of the eye, the skin, and the extremities are not included in the summation, but are subject to separate limits.)

(b) *Intake by inhalation.* If the only intake of radionuclides is by inhalation, the total effective dose equivalent limit is not exceeded if the sum of the deep-dose equivalent divided by the total effective dose equivalent limit,

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and one of the following, does not exceed unity:

(1) The sum of the fractions of the inhalation ALI for each radionuclide, or

(2) The total number of derived air concentration-hours (DAC-hours) for all radionuclides divided by 2,000, or

(3) The sum of the calculated committed effective dose equivalents to all significantly irradiated[1] organs or tissues (T) calculated from bioassay data using appropriate biological models and expressed as a fraction of the annual limit.

(c) *Intake by oral ingestion.* If the occupationally exposed individual also receives an intake of radionuclides by oral ingestion greater than 10 percent of the applicable oral ALI, the licensee shall account for this intake and include it in demonstrating compliance with the limits.

(d) *Intake through wounds or absorption through skin.* The licensee shall evaluate and, to the extent practical, account for intakes through wounds or skin absorption.

NOTE: The intake through intact skin has been included in the calculation of DAC for hydrogen-3 and does not need to be further evaluated.

[56 FR 23396, May 21, 1991, as amended at 57 FR 57878, Dec. 8, 1992]

§ 20.1203 Determination of external dose from airborne radioactive material.

Licensees shall, when determining the dose from airborne radioactive material, include the contribution to the deep-dose equivalent, eye dose equivalent, and shallow-dose equivalent from external exposure to the radioactive cloud (see appendix B to §§ 20.1001–20.2401, footnotes 1 and 2).

NOTE: Airborne radioactivity measurements and DAC values should not be used as the primary means to assess the deep-dose equivalent when the airborne radioactive material includes radionuclides other than noble gases or if the cloud of airborne radioactive material is not relatively uniform. The determination of the deep-dose equivalent to an individual should be based upon measurements using instruments or individual monitoring devices.

[1] An organ or tissue is deemed to be significantly irradiated if, for that organ or tissue, the product of the weighting factor, w_T, and the committed dose equivalent, $H_{T,50}$, per unit intake is greater than 10 percent of the maximum weighted value of $H_{T,50}$ (i.e., $w_T H_{T,50}$) per unit intake for any organ or tissue.

§ 20.1204 Determination of internal exposure.

(a) For purposes of assessing dose used to determine compliance with occupational dose equivalent limits, the licensee shall, when required under § 20.1502, take suitable and timel measurements of—

(1) Concentrations of radioactive materials in air in work areas; or

(2) Quantities of radionuclides in the body; or

(3) Quantities of radionuclides excreted from the body; or

(4) Combinations of these measurements.

(b) Unless respiratory protective equipment is used, as provided in § 20.1703, or the assessment of intake based on bioassays, the licensee shall assume that an individual inhales radioactive material at the airborne concentration in which the individual is present.

(c) When specific information on the physical and biochemical properties of the radionuclides taken into the body or the behavior or the material in an individual is known, the licensee may

(1) Use that information to calculate the committed effective dose equivalent, and, if used, the licensee shall document that information in the individual's record; and

(2) Upon prior approval of the Commission, adjust the DAC or ALI values to reflect the actual physical and chemical characteristics of airborne radioactive material (e.g., aerosol size distribution or density); and

(3) Separately assess the contribution of fractional intakes of Class D, W, or Y compounds of a given radionuclide (see appendix B to §§ 20.1001–20.2401) to the committed effective dose equivalent.

(d) If the licensee chooses to assess intakes of Class Y material using the measurements given in § 20.1204(a)(2) or (3), the licensee may delay the recording and reporting of the assessment for periods up to 7 months, unless otherwise required by §§ 20.2202 or 20.2203 in order to permit the licensee to ma

additional measurements basic to the assessments.

(e) If the identity and concentration of each radionuclide in a mixture are known, the fraction of the DAC applicable to the mixture for use in calculating DAC-hours must be either—

(1) The sum of the ratios of the concentration to the appropriate DAC value (e.g., D, W, Y) from appendix B to §§20.1001–20.2401 for each radio-nuclide in the mixture; or

(2) The ratio of the total concentration for all radionuclides in the mixture to the most restrictive DAC value for any radionuclide in the mixture.

(f) If the identity of each radionuclide in a mixture is known, but the concentration of one or more of the radionuclides in the mixture is not known, the DAC for the mixture must be the most restrictive DAC of any radionuclide in the mixture.

(g) When a mixture of radionuclides exists, licensees may disregard certain radionuclides in the mixture if—

(1) The licensee uses the total activity of the mixture in demonstrating compliance with the dose limits in §20.1201 and in complying with the monitoring requirements in §20.1502(b), and

(2) The concentration of any radionuclide disregarded is less than 10 percent of its DAC, and

(3) The sum of these percentages for all of the radionuclides disregarded in the mixture does not exceed 30 percent.

(h)(1) In order to calculate the committed effective dose equivalent, the licensee may assume that the inhalation of one ALI, or an exposure of 2,000 DAC-hours, results in a committed effective dose equivalent of 5 rems (0.05 Sv) for radionuclides that have their ALIs or DACs based on the committed effective dose equivalent.

(2) When the ALI (and the associated DAC) is determined by the nonstochastic organ dose limit of 50 rems (0.5 Sv), the intake of radionuclides that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) (the stochastic ALI) is listed in parentheses in table 1 of appendix B to §§20.1001–20.2401. In this case, the licensee may, as a simplifying assumption, use the stochastic ALIs to determine committed effective dose equivalent. However, if the licensee uses the stochastic ALIs, the licensee must also demonstrate that the limit in §20.1201(a)(1)(ii) is met.

§ 20.1205 [Reserved]

§ 20.1206 Planned special exposures.

A licensee may authorize an adult worker to receive doses in addition to and accounted for separately from the doses received under the limits specified in §20.1201 provided that each of the following conditions is satisfied—

(a) The licensee authorizes a planned special exposure only in an exceptional situation when alternatives that might avoid the higher exposure are unavailable or impractical.

(b) The licensee (and employer if the employer is not the licensee) specifically authorizes the planned special exposure, in writing, before the exposure occurs.

(c) Before a planned special exposure, the licensee ensures that the individuals involved are—

(1) Informed of the purpose of the planned operation;

(2) Informed of the estimated doses and associated potential risks and specific radiation levels or other conditions that might be involved in performing the task; and

(3) Instructed in the measures to be taken to keep the dose ALARA considering other risks that may be present.

(d) Prior to permitting an individual to participate in a planned special exposure, the licensee ascertains prior doses as required by §20.2104(b) during the lifetime of the individual for each individual involved.

(e) Subject to §20.1201(b), the licensee does not authorize a planned special exposure that would cause an individual to receive a dose from all planned special exposures and all doses in excess of the limits to exceed—

(1) The numerical values of any of the dose limits in §20.1201(a) in any year; and

(2) Five times the annual dose limits in §20.1201(a) during the individual's lifetime.

(f) The licensee maintains records of the conduct of a planned special exposure in accordance with §20.2105 and

submits a written report in accordance with § 20.2204.

(g) The licensee records the best estimate of the dose resulting from the planned special exposure in the individual's record and informs the individual, in writing, of the dose within 30 days from the date of the planned special exposure. The dose from planned special exposures is not to be considered in controlling future occupational dose of the individual under § 20.1201(a) but is to be included in evaluations required by § 20.1206 (d) and (e).

§ 20.1207 Occupational dose limits for minors.

The annual occupational dose limits for minors are 10 percent of the annual dose limits specified for adult workers in § 20.1201.

§ 20.1208 Dose to an embryo/fetus.

(a) The licensee shall ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv). (For recordkeeping requirements, see § 20.2106.)

(b) The licensee shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in paragraph (a) of this section.

(c) The dose to an embryo/fetus shall be taken as the sum of—

(1) The deep-dose equivalent to the declared pregnant woman; and

(2) The dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman.

(d) If the dose to the embryo/fetus is found to have exceeded 0.5 rem (5 mSv), or is within 0.05 rem (0.5 mSv) of this dose, by the time the woman declares the pregnancy to the licensee, the licensee shall be deemed to be in compliance with paragraph (a) of this section if the additional dose to the embryo/fetus does not exceed 0.05 rem (0.5 mSv) during the remainder of the pregnancy.

Subpart D—Radiation Dose Lim for Individual Members of t Public

SOURCE: 56 FR 23398, May 21, 1991, un otherwise noted.

§ 20.1301 Dose limits for individ members of the public.

(a) Each licensee shall conduct op ations so that—

(1) The total effective dose equi lent to individual members of the p lic from the licensed operation d not exceed 0.1 rem (1 mSv) in a ye exclusive of the dose contribution fr the licensee's disposal of radioact material into sanitary sewerage in cordance with § 20.2003, and

(2) The dose in any unrestricted a from external sources does not exc 0.002 rem (0.02 mSv) in any one hour.

(b) If the licensee permits memb of the public to have access to c trolled areas, the limits for member the public continue to apply to th individuals.

(c) A licensee or license applic may apply for prior NRC authorizat to operate up to an annual dose li for an individual member of the pul of 0.5 rem (5 mSv). The licensee or cense applicant shall include the lowing information in this applicati

(1) Demonstration of the need for the expected duration of operations excess of the limit in paragraph (a) this section;

(2) The licensee's program to ass and control dose within the 0.5 rem mSv) annual limit; and

(3) The procedures to be followed maintain the dose as low as is reas ably achievable.

(d) In addition to the requirement this part, a licensee subject to the p visions of EPA's generally applica environmental radiation standards 40 CFR part 190 shall comply w those standards.

(e) The Commission may impose ditional restrictions on radiation le in unrestricted areas and on the to quantity of radionuclides that a censee may release in effluents in or to restrict the collective dose.

§ 20.1302 Compliance with dose limits for individual members of the public.

(a) The licensee shall make or cause to be made, as appropriate, surveys of radiation levels in unrestricted and controlled areas and radioactive materials in effluents released to unrestricted and controlled areas to demonstrate compliance with the dose limits for individual members of the public in § 20.1301.

(b) A licensee shall show compliance with the annual dose limit in § 20.1301 by—

(1) Demonstrating by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the annual dose limit; or

(2) Demonstrating that—

(i) The annual average concentrations of radioactive material released in gaseous and liquid effluents at the boundary of the unrestricted area do not exceed the values specified in table 2 of appendix B to §§ 20.1001–20.2401; and

(ii) If an individual were continuously present in an unrestricted area, the dose from external sources would not exceed 0.002 rem (0.02 mSv) in an hour and 0.05 rem (0.5 mSv) in a year.

(c) Upon approval from the Commission, the licensee may adjust the effluent concentration values in appendix B to §§ 20.1001–20.2401, table 2, for members of the public, to take into account the actual physical and chemical characteristics of the effluents (e.g., aerosol size distribution, solubility, density, radioactive decay equilibrium, chemical form).

[56 FR 23398, May 21, 1991; 56 FR 61352, Dec. 3, 1991, as amended at 57 FR 57878, Dec. 8, 1992]

Subpart E—(Reserved)

Subpart F—Surveys and Monitoring

SOURCE: 56 FR 23398, May 21, 1991, unless otherwise noted.

§ 20.1501 General.

(a) Each licensee shall make or cause to be made, surveys that—

(1) May be necessary for the licensee to comply with the regulations in this part; and

(2) Are reasonable under the circumstances to evaluate—

(i) The extent of radiation levels; and

(ii) Concentrations or quantities of radioactive material; and

(iii) The potential radiological hazards that could be present.

(b) The licensee shall ensure that instruments and equipment used for quantitative radiation measurements (e.g., dose rate and effluent monitoring) are calibrated periodically for the radiation measured.

(c) All personnel dosimeters (except for direct and indirect reading pocket ionization chambers and those dosimeters used to measure the dose to the extremities) that require processing to determine the radiation dose and that are used by licensees to comply with § 20.1201, with other applicable provisions of this chapter, or with conditions specified in a license must be processed and evaluated by a dosimetry processor—

(1) Holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology; and

(2) Approved in this accreditation process for the type of radiation or radiations included in the NVLAP program that most closely approximates the type of radiation or radiations for which the individual wearing the dosimeter is monitored.

§ 20.1502 Conditions requiring individual monitoring of external and internal occupational dose.

Each licensee shall monitor exposures to radiation and radioactive material at levels sufficient to demonstrate compliance with the occupational dose limits of this part. As a minimum—

(a) Each licensee shall monitor occupational exposure to radiation and shall supply and require the use of individual monitoring devices by—

(1) Adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits in § 20.1201(a),

(2) Minors and declared pregnant women likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of any of the applicable limits in § 20.1207 or § 20.1208, and

(3) Individuals entering a high or very high radiation area.

(b) Each licensee shall monitor (see § 20.1204) the occupational intake of radioactive material by and assess the committed effective dose equivalent to—

(1) Adults likely to receive, in 1 year, an intake in excess of 10 percent of the applicable ALI(s) in table 1, Columns 1 and 2, of appendix B to §§ 20.1001–20.2401; and

(2) Minors and declared pregnant women likely to receive, in 1 year, a committed effective dose equivalent in excess of 0.05 rem (0.5 mSv).

Subpart G—Control of Exposure From External Sources in Restricted Areas

SOURCE: 56 FR 23398, May 21, 1991, unless otherwise noted.

§ 20.1601 Control of access to high radiation areas.

(a) The licensee shall ensure that each entrance or access point to a high radiation area has one or more of the following features—

(1) A control device that, upon entry into the area, causes the level of radiation to be reduced below that level at which an individual might receive a deep-dose equivalent of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates;

(2) A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry; or

(3) Entryways that are locked, except during periods when access to the areas is required, with positive control over each individual entry.

(b) In place of the controls required by paragraph (a) of this section for a high radiation area, the licensee may substitute continuous direct or electronic surveillance that is capable of preventing unauthorized entry.

(c) A licensee may apply to the Commission for approval of alternative methods for controlling access to high radiation areas.

(d) The licensee shall establish the controls required by paragraphs (a) and (c) of this section in a way that does not prevent individuals from leaving a high radiation area.

(e) Control is not required for each entrance or access point to a room or other area that is a high radiation area solely because of the presence of radioactive materials prepared for transport and packaged and labeled in accordance with the regulations of the Department of Transportation provided that—

(1) The packages do not remain in the area longer than 3 days; and

(2) The dose rate at 1 meter from the external surface of any package does not exceed 0.01 rem (0.1 mSv) per hour.

(f) Control of entrance or access to rooms or other areas in hospitals is not required solely because of the presence of patients containing radioactive material, provided that there are personnel in attendance who will take the necessary precautions to prevent the exposure of individuals to radiation or radioactive material in excess of the limits established in this part and to operate within the ALARA provisions of the licensee's radiation protection program.

§ 20.1602 Control of access to very high radiation areas.

In addition to the requirements in § 20.1601, the licensee shall institute additional measures to ensure that an individual is not able to gain unauthorized or inadvertent access to areas in which radiation levels could be encountered at 500 rads (5 grays) or more in 1 hour at 1 meter from a radiation source or any surface through which the radiation penetrates.

Subpart H—Respiratory Protection and Controls to Restrict Internal Exposure in Restricted Areas

SOURCE: 56 FR 23400, May 21, 1991, unless otherwise noted.

§ 20.1701 Use of process or other engineering controls.

e licensee shall use, to the extent ticable, process or other engineer- controls (e.g., containment or ven- tion) to control the concentrations radioactive material in air.

§ 20.1702 Use of other controls.

When it is not practicable to apply process or other engineering controls to control the concentrations of radioactive material in air to values below those that define an airborne radioactivity area, the licensee shall, consistent with maintaining the total effective dose equivalent ALARA, increase monitoring and limit intakes by one or more of the following means:

(a) Control of access;

(b) Limitation of exposure times;

(c) Use of respiratory protection equipment; or

(d) Other controls.

§ 20.1703 Use of individual respiratory protection equipment.

(a) If the licensee uses respiratory tion equipment to limit intakes ant to § 20.1702—

The licensee shall use only respiratory protection equipment that is tested and certified or had certification extended by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration H/MSHA).

If the licensee wishes to use equip- t that has not been tested or cer- d by NIOSH/MSHA, has not had ification extended by NIOSH/ MSHA, or for which there is no schedule for testing or certification, the licensee shall submit an application for authorized use of that equipment, including a demonstration by testing, or a demonstration on the basis of reliable test information, that the material and performance characteristics of uipment are capable of providing oposed degree of protection under anticipated conditions of use.

(3) The licensee shall implement and maintain a respiratory protection program that includes—

(i) Air sampling sufficient to identify the potential hazard, permit proper equipment selection, and estimate exposures;

(ii) Surveys and bioassays, as appropriate, to evaluate actual intakes;

(iii) Testing of respirators for operability immediately prior to each use;

(iv) Written procedures regarding selection, fitting, issuance, maintenance, and testing of respirators, including testing for operability immediately prior to each use; supervision and training of personnel; monitoring, including air sampling and bioassays; and recordkeeping; and

(v) Determination by a physician prior to initial fitting of respirators, and at least every 12 months thereafter, that the individual user is physically able to use the respiratory protection equipment.

(4) The licensee shall issue a written policy statement on respirator usage covering—

(i) The use of process or other engineering controls, instead of respirators;

(ii) The routine, nonroutine, and emergency use of respirators; and

(iii) The periods of respirator use and relief from respirator use.

(5) The licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other conditions that might require such relief.

(6) The licensee shall use equipment within limitations for type and mode of use and shall provide proper visual, communication, and other special capabilities (such as adequate skin protection) when needed.

(b) In estimating exposure of individuals to airborne radioactive materials, the licensee may make allowance for respiratory protection equipment used to limit intakes pursuant to § 20.1702, provided that the following conditions, in addition to those in § 20.1703(a), are satisfied:

(1) The licensee selects respiratory protection equipment that provides a protection factor (see appendix A to §§ 20.1001–20.2401) greater than the multiple by which peak concentrations of airborne radioactive materials in the working area are expected to exceed the values specified in appendix B to §§ 20.1001–20.2401, table 1, column 3. If

the selection of a respiratory protection device with a protection factor greater than the peak concentration is inconsistent with the goal specified in § 20.1702 of keeping the total effective dose equivalent ALARA, the licensee may select respiratory protection equipment with a lower protection factor only if such a selection would result in keeping the total effective dose equivalent ALARA. The concentration of radioactive material in the air that is inhaled when respirators are worn may be initially estimated by dividing the average concentration in air, during each period of uninterrupted use, by the protection factor. If the exposure is later found to be greater than estimated, the corrected value must be used; if the exposure is later found to be less than estimated, the corrected value may be used.

(2) The licensee shall obtain authorization from the Commission before assigning respiratory protection factors in excess of those specified in appendix A to §§ 20.1001–20.2401. The Commission may authorize a licensee to use higher protection factors on receipt of an application that—

(i) Describes the situation for which a need exists for higher protection factors, and

(ii) Demonstrates that the respiratory protection equipment provides these higher protection factors under the proposed conditions of use.

(c) The licensee shall use as emergency devices only respiratory protection equipment that has been specifically certified or had certification extended for emergency use by NIOSH/MSHA.

(d) The licensee shall notify, in writing, the Regional Administrator of the appropriate NRC Regional Office listed in appendix D to §§ 20.1001–20.2401 at least 30 days before the date that respiratory protection equipment is first used under the provisions of either § 20.1703 (a) or (b).

[56 FR 23400, May 21, 1991, as amended at 57 FR 57878, Dec. 8, 1992]

§ 20.1704 Further restrictions on the use of respiratory protection equipment.

The Commission may impose restrictions in addition to those in §§ 20.1702, 20.1703, and appendix A to §§ 20.1001–20.2401 to—

(a) Ensure that the respiratory protection program of the licensee is adequate to limit exposures of individuals to airborne radioactive materials; and

(b) Limit the extent to which a licensee may use respiratory protection equipment instead of process or other engineering controls.

Subpart I—Storage and Control of Licensed Material

SOURCE: 56 FR 23401, May 21, 1991, unless otherwise noted.

§ 20.1801 Security of stored material.

The licensee shall secure from unauthorized removal or access licensed materials that are stored in controlled or unrestricted areas.

§ 20.1802 Control of material not in storage.

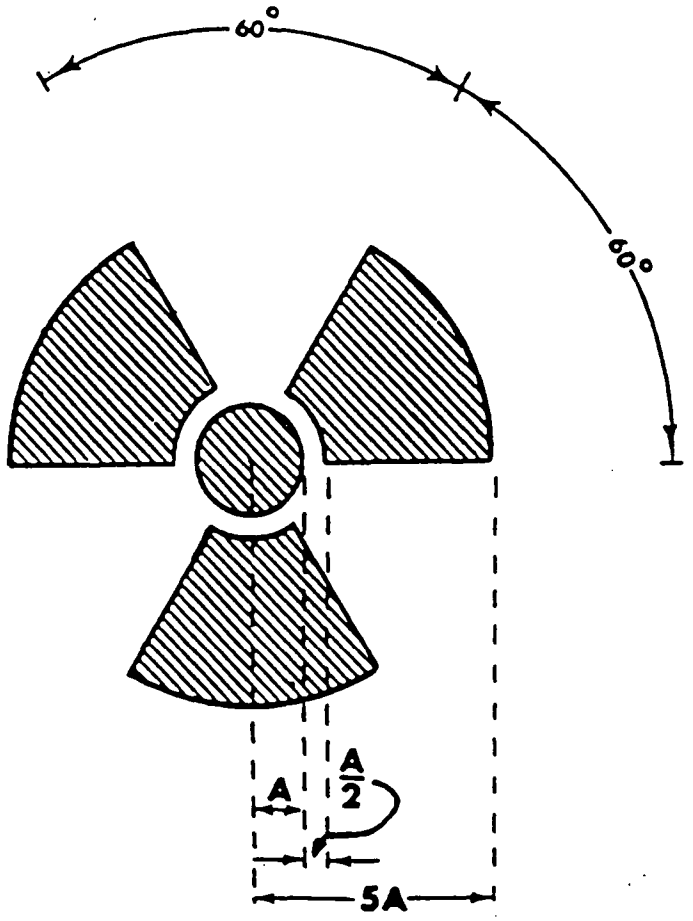
The licensee shall control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and that is not in storage.

Subpart J—Precautionary Procedures

SOURCE: 56 FR 23401, May 21, 1991, unless otherwise noted.

§ 20.1901 Caution signs.

(a) *Standard radiation symbol.* Unless otherwise authorized by the Commission, the symbol prescribed by this part shall use the colors magenta, or purple, or black on yellow background. The symbol prescribed by this part is the three-bladed design:



RADIATION SYMBOL

(1) Cross-hatched area is to be magenta, or purple, or black, and

(2) The background is to be yellow.

Exception to color requirements for standard radiation symbol. Notwithstanding the requirements of paragraph (a) of this section, licensees are authorized to label sources, source holders, or device components containing sources of licensed materials that are subjected to high temperatures, with conspicuously etched or stamped radiation caution symbols and without a color requirement.

(c) *Additional information on signs and labels.* In addition to the contents of signs and labels prescribed in this part, the licensee may provide, on or near the required signs and labels, additional information, as appropriate, to make individuals aware of potential radiation exposures and to minimize the exposures.

§ 20.1902 Posting requirements.

(a) *Posting of radiation areas.* The licensee shall post each radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA."

(b) *Posting of high radiation areas.* The licensee shall post each high radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, HIGH RADIATION AREA" or "DANGER, HIGH RADIATION AREA."

(c) *Posting of very high radiation areas.* The licensee shall post each very high radiation area with a conspicuous sign or signs bearing the radiation symbol and words "GRAVE DANGER, VERY HIGH RADIATION AREA."

(d) *Posting of airborne radioactivity areas.* The licensee shall post each airborne radioactivity area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, AIRBORNE RADIOACTIVITY AREA" or "DANGER, AIRBORNE RADIOACTIVITY AREA."

(e) *Posting of areas or rooms in which licensed material is used or stored.* The licensee shall post each area or room in which there is used or stored an amount of licensed material exceeding 10 times the quantity of such material specified in appendix C to §§20.1001–20.2401 with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL(S)" or "DANGER, RADIOACTIVE MATERIAL(S)."

§ 20.1903 Exceptions to posting requirements.

(a) A licensee is not required to post caution signs in areas or rooms containing radioactive materials for periods of less than 8 hours, if each of the following conditions is met:

(1) The materials are constantly attended during these periods by an individual who takes the precautions necessary to prevent the exposure of individuals to radiation or radioactive materials in excess of the limits established in this part; and

(2) The area or room is subject to the licensee's control.

(b) Rooms or other areas in hospitals that are occupied by patients are not required to be posted with caution signs pursuant to § 20.1902 provided tha the patient could be released from cor finement pursuant to § 35.75 of thi chapter.

(c) A room or area is not required t be posted with a caution sign becau of the presence of a sealed source pr vided the radiation level at 30 cent meters from the surface of the sour container or housing does not exce 0.005 rem (0.05 mSv) per hour.

[56 FR 23401, May 21, 1991, as amended at FR 39357, Aug. 31, 1992]

§ 20.1904 Labeling containers.

(a) The licensee shall ensure th each container of licensed materi bears a durable, clearly visible lat bearing the radiation symbol and t words "CAUTION, RADIOACTIVE M TERIAL" or "DANGER, RADI ACTIVE MATERIAL." The label m also provide sufficient informati (such as the radionuclide(s) present, estimate of the quantity of radioact ity, the date for which the activity estimated, radiation levels, kinds materials, and mass enrichment) permit individuals handling or us the containers, or working in the vic ity of the containers, to take p cautions to avoid or minimize ex sures.

(b) Each licensee shall, prior to moval or disposal of em uncontaminated containers to ur stricted areas, remove or deface the dioactive material label or otherw clearly indicate that the container longer contains radioactive materia

§ 20.1905 Exemptions to labeling quirements.

A licensee is not required to label-

(a) Containers holding licensed m rial in quantities less than the q tities listed in appendix C to §§20.1 20.2401; or

(b) Containers holding licensed m rial in concentrations less than t specified in table 3 of appendix I §§20.1001–20.2401; or

(c) Containers attended by an i vidual who takes the precautions essary to prevent the exposure of i viduals in excess of the limits es lished by this part; or

(d) Containers when they are transport and packaged and labele

accordance with the regulations of the Department of Transportation,[3] or

(e) Containers that are accessible only to individuals authorized to handle or use them, or to work in the vicinity of the containers, if the contents are identified to these individuals by a readily available written record (examples of containers of this type are containers in locations such as water-filled canals, storage vaults, or hot cells). The record must be retained as long as the containers are in use for the purpose indicated on the record; or

(f) Installed manufacturing or process equipment, such as reactor components, piping, and tanks.

§ 20.1906 Procedures for receiving and opening packages.

(a) Each licensee who expects to receive a package containing quantities of radioactive material in excess of a Type A quantity, as defined in §71.4 and appendix A to part 71 of this chapter, shall make arrangements to receive—

(1) The package when the carrier offers it for delivery; or

(2) Notification of the arrival of the package at the carrier's terminal and to take possession of the package expeditiously.

(b) Each licensee shall—

(1) Monitor the external surfaces of a labeled[3a] package for radioactive contamination unless the package contains only radioactive material in the form of a gas or in special form as defined in 10 CFR 71.4;

(2) Monitor the external surfaces of a labeled[3a] package for radiation levels unless the package contains quantities of radioactive material that are less than or equal to the Type A quantity, as defined in §71.4 and appendix A to part 71 of this chapter; and

(3) Monitor all packages known to contain radioactive material for radioactive contamination and radiation levels if there is evidence of degradation of package integrity, such as packages that are crushed, wet, or damaged.

(c) The licensee shall perform the monitoring required by paragraph (b) of this section as soon as practicable after receipt of the package, but not later than 3 hours after the package is received at the licensee's facility if it is received during the licensee's normal working hours, or not later than 3 hours from the beginning of the next working day if it is received after working hours.

(d) The licensee shall immediately notify the final delivery carrier and, by telephone and telegram, mailgram, or facsimile, the Administrator of the appropriate NRC Regional Office listed in appendix D to §§ 20.1001–20.2401 when—

(1) Removable radioactive surface contamination exceeds the limits of §71.87(i) of this chapter; or

(2) External radiation levels exceed the limits of §71.47 of this chapter.

(e) Each licensee shall—

(1) Establish, maintain, and retain written procedures for safely opening packages in which radioactive material is received; and

(2) Ensure that the procedures are followed and that due consideration is given to special instructions for the type of package being opened.

(f) Licensees transferring special form sources in licensee-owned or licensee-operated vehicles to and from a work site are exempt from the contamination monitoring requirements of paragraph (b) of this section, but are not exempt from the survey requirement in paragraph (b) of this section for measuring radiation levels that is required to ensure that the source is still properly lodged in its shield.

[56 FR 23401, May 21, 1991, as amended at 57 FR 39357, Aug. 31, 1992]

[3] Labeling of packages containing radioactive materials is required by the Department of Transportation (DOT) if the amount and type of radioactive material exceeds the limits for an excepted quantity or article as defined and limited by DOT regulations 49 CFR 173.403 (m) and (w) and 173.421–424.

[3a] Labeled with a Radioactive White I, Yellow II, or Yellow III label as specified in U.S. Department of Transportation regulations, 49 CFR 172.403 and 172.436–440.

Subpart K—Waste Disposal

SOURCE: 56 FR 23403, May 21, 1991, unless otherwise noted.

§ 20.2001 General requirements.

(a) A licensee shall dispose of licensed material only—

(1) By transfer to an authorized recipient as provided in § 20.2006 or in the regulations in parts 30, 40, 60, 61, 70, or 72 of this chapter; or

(2) By decay in storage; or

(3) By release in effluents within the limits in § 20.1301; or

(4) As authorized under §§ 20.2002, 20.2003, 20.2004, or § 20.2005.

(b) A person must be specifically licensed to receive waste containing licensed material from other persons for:

(1) Treatment prior to disposal; or

(2) Treatment or disposal by incineration; or

(3) Decay in storage; or

(4) Disposal at a land disposal facility licensed under part 61 of this chapter; or

(5) Disposal at a geologic repository under part 60 of this chapter.

§ 20.2002 Method for obtaining approval of proposed disposal procedures.

A licensee or applicant for a license may apply to the Commission for approval of proposed procedures, not otherwise authorized in the regulations in this chapter, to dispose of licensed material generated in the licensee's activities. Each application shall include:

(a) A description of the waste containing licensed material to be disposed of, including the physical and chemical properties important to risk evaluation, and the proposed manner and conditions of waste disposal; and

(b) An analysis and evaluation of pertinent information on the nature of the environment; and

(c) The nature and location of other potentially affected licensed and unlicensed facilities; and

(d) Analyses and procedures to ensure that doses are maintained ALARA and within the dose limits in this part.

§ 20.2003 Disposal by release into sanitary sewerage.

(a) A licensee may discharge licensed material into sanitary sewerage if each of the following conditions is satisfied:

(1) The material is readily soluble (or is readily dispersible biological material) in water; and

(2) The quantity of licensed or other radioactive material that the licensee releases into the sewer in 1 month divided by the average monthly volume of water released into the sewer by the licensee does not exceed the concentration listed in table 3 of appendix B to §§ 20.1001–20.2401; and

(3) If more than one radionuclide is released, the following conditions must also be satisfied:

(i) The licensee shall determine the fraction of the limit in table 3 of appendix B to §§ 20.1001–20.2401 represented by discharges into sanitary sewerage by dividing the actual monthly average concentration of each radionuclide released by the licensee into the sewer by the concentration of that radionuclide listed in table 3 of appendix B to §§ 20.1001–20.2401; and

(ii) The sum of the fractions for each radionuclide required by paragraph (a)(3)(i) of this section does not exceed unity; and

(4) The total quantity of licensed and other radioactive material that the licensee releases into the sanitary sewerage system in a year does not exceed 1 curies (185 GBq) of hydrogen-3, 1 curie (37 GBq) of carbon-14, and 1 curie (37 GBq) of all other radioactive material combined.

(b) Excreta from individuals undergoing medical diagnosis or therapy with radioactive material are not subject to the limitations contained in paragraph (a) of this section.

§ 20.2004 Treatment or disposal by incineration.

(a) A licensee may treat or dispose of licensed material by incineration only:

(1) As authorized by paragraph (b) of this section; or

(2) If the material is in a form and concentration specified in § 20.2005; or

(3) As specifically approved by the Commission pursuant to § 20.2002.

(b) (1) Waste oils (petroleum derived or synthetic oils used principally as lubricants, coolants, hydraulic or insulating fluids, or metalworking oils that have been radioactively contaminated in the course of the operation maintenance of a nuclear power reactor licensed under part 50 of this chapter may be incinerated on the site where generated provided that the

total radioactive effluents from the facility, including the effluents from [illegible] incineration, conform to the re[illegible]nents of appendix I to part 50 of [illegible]chapter and the effluent release [illegible] contained in applicable license conditions other than effluent limits specifically related to incineration of waste oil. The licensee shall report any changes or additions to the information supplied under §§ 50.34 and 50.34a of this chapter associated with this incineration pursuant to § 50.71 of this chapter, as appropriate. The licensee shall also follow the procedures of § 50.59 of this chapter with respect to such changes to the facility or procedures.

(2) Solid residues produced in the process of incinerating waste oils must be disposed of as provided by § 20.2001.

(3) The provisions of this section authorize onsite waste oil incineration under the terms of this section and supersede any provision in an individual plant license or technical specification that may be inconsistent.

[57 FR 57656, Dec. 7, 1992]

[illegible]05 Disposal of specific wastes.

(a) A licensee may dispose of the following licensed material as if it were not radioactive:

(1) 0.05 microcurie (1.85 kBq), or less, of hydrogen-3 or carbon-14 per gram of [illegible]edium used for liquid scintillation [illegible]ting; and

[illegible] 0.05 microcurie (1.85 kBq), or less, [illegible]ydrogen-3 or carbon-14 per gram of [illegible]al tissue, averaged over the [illegible]ght of the entire animal.

(b) A licensee may not dispose of tissue under paragraph (a)(2) of this section in a manner that would permit its use either as food for humans or as animal feed.

(c) The licensee shall maintain records in accordance with § 20.2108.

[illegible]06 Transfer for disposal and [illegible]nifests.

(a) The requirements of this section and appendix F to §§ 20.1001–20.2401 are designed to control transfers of low-level radioactive waste intended for disposal at a land disposal facility (as defined in part 61 of this chapter), establish a manifest tracking system, and supplement existing requirements concerning transfers and recordkeeping for those wastes.

(b) Each shipment of radioactive waste intended for disposal at a licensed land disposal facility must be accompanied by a shipment manifest as specified in section I of appendix F to §§ 20.1001–20.2401.

(c) Each shipment manifest must include a certification by the waste generator as specified in section II of appendix F to §§ 20.1001–20.2401.

(d) Each person involved in the transfer for disposal and disposal of waste, including the waste generator, waste collector, waste processor, and disposal facility operator, shall comply with the requirements specified in section III of appendix F to §§ 20.1001–20.2401.

§ 20.2007 Compliance with environmental and health protection regulations.

Nothing in this subpart relieves the licensee from complying with other applicable Federal, State, and local regulations governing any other toxic or hazardous properties of materials that may be disposed of under this subpart.

Subpart L—Records

SOURCE: 56 FR 23404, May 21, 1991, unless otherwise noted.

§ 20.2101 General provisions.

(a) Each licensee shall use the units: curie, rad, rem, including multiples and subdivisions, and shall clearly indicate the units of all quantities on records required by this part.

(b) The licensee shall make a clear distinction among the quantities entered on the records required by this part (e.g., total effective dose equivalent, shallow-dose equivalent, eye dose equivalent, deep-dose equivalent, committed effective dose equivalent).

§ 20.2102 Records of radiation protection programs.

(a) Each licensee shall maintain records of the radiation protection program, including:

(1) The provisions of the program; and

(2) Audits and other reviews of program content and implementation.

(b) The licensee shall retain the records required by paragraph (a)(1) of this section until the Commission terminates each pertinent license requiring the record. The licensee shall retain the records required by paragraph (a)(2) of this section for 3 years after the record is made.

§ 20.2103 Records of surveys.

(a) Each licensee shall maintain records showing the results of surveys and calibrations required by §§ 20.1501 and 20.1906(b). The licensee shall retain these records for 3 years after the record is made.

(b) The licensee shall retain each of the following records until the Commission terminates each pertinent license requiring the record:

(1) Records of the results of surveys to determine the dose from external sources and used, in the absence of or in combination with individual monitoring data, in the assessment of individual dose equivalents; and

(2) Records of the results of measurements and calculations used to determine individual intakes of radioactive material and used in the assessment of internal dose; and

(3) Records showing the results of air sampling, surveys, and bioassays required pursuant to § 20.1703(a)(3) (i) and (ii); and

(4) Records of the results of measurements and calculations used to evaluate the release of radioactive effluents to the environment.

§ 20.2104 Determination of prior occupational dose.

(a) For each individual who may enter the licensee's restricted or controlled area and is likely to receive, in a year, an occupational dose requiring monitoring pursuant to § 20.1502, the licensee shall—

(1) Determine the occupational radiation dose received during the current year; and

(2) Attempt to obtain the records of cumulative occupational radiation dose.

(b) Prior to permitting an individual to participate in a planned special exposure, the licensee shall determine—

(1) The internal and external doses from all previous planned special exposures; and

(2) All doses in excess of the limits (including doses received during accidents and emergencies) received during the lifetime of the individual.

(c) In complying with the requirements of paragraph (a) of this section, a licensee may—

(1) Accept, as a record of the occupational dose that the individual received during the current year, a written signed statement from the individual, or from the individual's most recent employer for work involving radiation exposure, that discloses the nature and the amount of any occupational dose that the individual may have received during the current year;

(2) Accept, as the record of cumulative radiation dose, an up-to-date NRC Form 4, or equivalent, signed by the individual and countersigned by an appropriate official of the most recent employer for work involving radiation exposure, or the individual's current employer (if the individual is not employed by the licensee); and

(3) Obtain reports of the individual's dose equivalent(s) from the most recent employer for work involving radiation exposure, or the individual's current employer (if the individual is not employed by the licensee) by telephone, telegram, electronic media, or letter. The licensee shall request a written verification of the dose data if the authenticity of the transmitted report cannot be established.

(d) The licensee shall record the exposure history of each individual, as required by paragraph (a) of this section, on NRC Form 4, or other clear and legible record, including all of the information required by NRC Form 4[4]. The form or record must show each period in which the individual received occupational exposure to radiation or radio-

[4] Licensees are not required to partition historical dose between external dose equivalent(s) and internal committed dose equivalent(s). Further, occupational exposure histories obtained and recorded on NRC Form 4 before January 1, 1994, might not have included effective dose equivalent, but may be used in the absence of specific information on the intake of radionuclides by the individual.

active material and must be signed by the individual who received the expo-

For each period for which the li- obtains reports, the licensee use the dose shown in the report eparing the NRC Form 4. For any od in which the licensee does not obtain a report, the licensee shall place a notation on the NRC Form 4 indicating the periods of time for which data are not available.

(e) If the licensee is unable to obtain a complete record of an individual's current and previously accumulated occupational dose, the licensee shall assume—

(1) In establishing administrative controls under §20.1201(f) for the current year, that the allowable dose limit for the individual is reduced by 1.25 rems (12.5 mSv) for each quarter for which records were unavailable and the individual was engaged in activities that could have resulted in occupational radiation exposure; and

(2) That the individual is not available for planned special exposures.

The licensee shall retain the on NRC Form 4 or equivalent he Commission terminates each pertinent license requiring this record. The licensee shall retain records used in preparing NRC Form 4 for 3 years after the record is made.

[56 FR 23404, May 21, 1991, as amended at 57 FR 58878, Dec. 8, 1992]

105 Records of planned special posures.

For each use of the provisions of §20.1206 for planned special exposures, the licensee shall maintain records that describe—

(1) The exceptional circumstances requiring the use of a planned special exposure; and

(2) The name of the management official who authorized the planned special re and a copy of the signed au- tion; and

hat actions were necessary; and

(4) Why the actions were necessary; and

(5) How doses were maintained ALARA; and

(6) What individual and collective doses were expected to result, and the doses actually received in the planned special exposure.

(b) The licensee shall retain the records until the Commission terminates each pertinent license requiring these records.

§ 20.2106 Records of individual monitoring results.

(a) *Recordkeeping requirement.* Each licensee shall maintain records of doses received by all individuals for whom monitoring was required pursuant to §20.1502, and records of doses received during planned special exposures, accidents, and emergency conditions. These records[5] must include, when applicable—

(1) The deep-dose equivalent to the whole body, eye dose equivalent, shallow-dose equivalent to the skin, and shallow-dose equivalent to the extremities; and

(2) The estimated intake or body burden of radionuclides (see §20.1202); and

(3) The committed effective dose equivalent assigned to the intake or body burden of radionuclides; and

(4) The specific information used to calculate the committed effective dose equivalent pursuant to §20.1204(c); and

(5) The total effective dose equivalent when required by §20.1202; and

(6) The total of the deep-dose equivalent and the committed dose to the organ receiving the highest total dose.

(b) *Recordkeeping frequency.* The licensee shall make entries of the records specified in paragraph (a) of this section at least annually.

(c) *Recordkeeping format.* The licensee shall maintain the records specified in paragraph (a) of this section on NRC Form 5, in accordance with the instructions for NRC Form 5, or in clear and legible records containing all the information required by NRC Form 5.

(d) *Privacy protection.* The records required under this section should be protected from public disclosure because of their personal privacy nature. These records are protected by most State privacy laws and, when transferred to the NRC, are protected by the Privacy Act of 1974, Public Law 93–579, 5 U.S.C. 552a, and the Commission's regulations in 10 CFR part 9.

[5] Assessments of dose equivalent and records made using units in effect before the licensee's adoption of this part need not be changed.

(e) The licensee shall maintain the records of dose to an embryo/fetus with the records of dose to the declared pregnant woman. The declaration of pregnancy shall also be kept on file, but may be maintained separately from the dose records.

(f) The licensee shall retain each required form or record until the Commission terminates each pertinent license requiring the record.

§ 20.2107 Records of dose to individual members of the public.

(a) Each licensee shall maintain records sufficient to demonstrate compliance with the dose limit for individual members of the public (see § 20.1301).

(b) The licensee shall retain the records required by paragraph (a) of this section until the Commission terminates each pertinent license requiring the record.

§ 20.2108 Records of waste disposal.

(a) Each licensee shall maintain records of the disposal of licensed materials made under §§ 20.2002, 20.2003, 20.2004, 20.2005, 10 CFR part 61 and disposal by burial in soil, including burials authorized before January 28, 1981.[6]

(b) The licensee shall retain the records required by paragraph (a) of this section until the Commission terminates each pertinent license requiring the record.

§ 20.2109 [Reserved]

§ 20.2110 Form of records.

Each record required by this part must be legible throughout the specified retention period. The record may be the original or a reproduced copy or a microform provided that the copy or microform is authenticated by authorized personnel and that the microform is capable of producing a clear copy throughout the required retention period. The record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records, such as letters, drawings, and specifications, must include all pertinent information, such as stamps, initials, and signatures. The licensee shall maintain adequate safeguards against tampering with and loss of records.

[6] A previous § 20.304 permitted burial of small quantities of licensed materials in soil before January 28, 1981, without specific Commission authorization.

Subpart M—Reports

SOURCE: 56 FR 23406, May 21, 1991, unless otherwise noted.

§ 20.2201 Reports of theft or loss of licensed material.

(a) Telephone reports. (1) Each licensee shall report by telephone as follows:

(i) Immediately after its occurrence becomes known to the licensee, any lost, stolen, or missing licensed material in an aggregate quantity equal to or greater than 1,000 times the quantity specified in appendix C to §§ 20.1001–20.2401 under such circumstances that it appears to the licensee that an exposure could result to persons in unrestricted areas; or

(ii) Within 30 days after the occurrence of any lost, stolen, or missing licensed material becomes known to the licensee, all licensed material in a quantity greater than 10 times the quantity specified in appendix C to §§ 20.1001–20.2401 that is still missing at this time.

(2) Reports must be made as follows

(i) Licensees having an installed Emergency Notification System shall make the reports to the NRC Operations Center in accordance with § 50.72 of this chapter, and

(ii) All other licensees shall make reports by telephone to the NRC Operations Center (301–951–0550).

(b) *Written reports.* (1) Each licensee required to make a report under paragraph (a) of this section shall, within 30 days after making the telephone report, make a written report setting forth the following information:

(i) A description of the licensed material involved, including kind, quantity, and chemical and physical form and

(ii) A description of the circumstances under which the loss or theft occurred; and

(iii) A statement of disposition, or probable disposition, of the licensed material involved; and

(iv) Exposures of individuals to radiation, circumstances under which the exposures occurred, and the possible total effective dose equivalent to persons in unrestricted areas; and

(v) Actions that have been taken, or will be taken, to recover the material; and

(vi) Procedures or measures that have been, or will be, adopted to ensure against a recurrence of the loss or theft of licensed material.

(2) Reports must be made as follows:

(i) For holders of an operating license for a nuclear power plant, the events included in paragraph (b) of this section must be reported in accordance with the procedures described in § 50.73(b), (c), (d), (e), and (g) of this chapter and must include the information required in paragraph (b)(1) of this section, and

(ii) All other licensees shall make reports to the Administrator of the appropriate NRC Regional Office listed in Appendix D to §§ 20.1001–20.2401.

(c) A duplicate report is not required under paragraph (b) of this section if the licensee is also required to submit a report pursuant to §§ 30.55(c), 40.64(c), 50.72, 50.73, 70.52, 73.27(b), 73.67(e)(3)(vi), 73.67(g)(3)(iii), 73.71, or § 150.19(c) of this chapter.

(d) Subsequent to filing the written report, the licensee shall also report any additional substantive information on the loss or theft within 30 days after the licensee learns of such information.

(e) The licensee shall prepare any report filed with the Commission pursuant to this section so that names of individuals who may have received exposure to radiation are stated in a separate and detachable part of the report.

[56 FR 23406, May 21, 1991, as amended at 58 FR 69220, Dec. 30, 1993]

20.2202 Notification of incidents.

(a) Immediate notification. Notwithstanding any other requirements for notification, each licensee shall immediately report any event involving byproduct, source, or special nuclear material possessed by the licensee that may have caused or threatens to cause any of the following conditions—

(1) An individual to receive—

(i) A total effective dose equivalent of 25 rems (0.25 Sv) or more; or

(ii) An eye dose equivalent of 75 rems (0.75 Sv) or more; or

(iii) A shallow-dose equivalent to the skin or extremities of 250 rads (2.5 Gy) or more; or

(2) The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake five times the annual limit on intake (the provisions of this paragraph do not apply to locations where personnel are not normally stationed during routine operations, such as hot-cells or process enclosures).

(b) Twenty-four hour notification. Each licensee shall, within 24 hours of discovery of the event, report any event involving loss of control of licensed material possessed by the licensee that may have caused, or threatens to cause, any of the following conditions:

(1) An individual to receive, in a period of 24 hours—

(i) A total effective dose equivalent exceeding 5 rems (0.05 Sv); or

(ii) An eye dose equivalent exceeding 15 rems (0.15 Sv); or

(iii) A shallow-dose equivalent to the skin or extremities exceeding 50 rems (0.5 Sv); or

(2) The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake in excess of one occupational annual limit on intake (the provisions of this paragraph do not apply to locations where personnel are not normally stationed during routine operations, such as hot-cells or process enclosures).

(c) The licensee shall prepare any report filed with the Commission pursuant to this section so that names of individuals who have received exposure to radiation or radioactive material are stated in a separate and detachable part of the report.

(d) Reports made by licensees in response to the requirements of this section must be made as follows:

(1) Licensees having an installed Emergency Notification System shall

make the reports required by paragraphs (a) and (b) of this section to the NRC Operations Center in accordance with 10 CFR 50.72; and

(2) All other licensees shall make the reports required by paragraphs (a) and (b) of this section by telephone to the NRC Operations Center (301–951–0550) and by telegram, mailgram, or facsimile to the Administrator of the appropriate NRC Regional Office listed in appendix D to this part.

(e) The provisions of this section do not include doses that result from planned special exposures, that are within the limits for planned special exposures, and that are reported under § 20.2204.

[56 FR 23406, May 21, 1991, as amended at 56 FR 40766, Aug. 16, 1991; 57 FR 57879, Dec. 8, 1992; 58 FR 69220, Dec. 30, 1993]

§ 20.2203 Reports of exposures, radiation levels, and concentrations of radioactive material exceeding the limits.

(a) Reportable events. In addition to the notification required by § 20.2202, each licensee shall submit a written report within 30 days after learning of any of the following occurrences:

(1) Any incident for which notification is required by § 20.2202; or

(2) Doses in excess of any of the following:

(i) The occupational dose limits for adults in § 20.1201; or

(ii) The occupational dose limits for a minor in § 20.1207; or

(iii) The limits for an embryo/fetus of a declared pregnant woman in § 20.1208; or

(iv) The limits for an individual member of the public in § 20.1301; or

(v) Any applicable limit in the license; or

(3) Levels of radiation or concentrations of radioactive material in—

(i) A restricted area in excess of any applicable limit in the license; or

(ii) An unrestricted area in excess of 10 times any applicable limit set forth in this part or in the license (whether or not involving exposure of any individual in excess of the limits in § 20.1301); or

(4) For licensees subject to the provisions of EPA's generally applicable environmental radiation standards in 40 CFR part 190, levels of radiation or releases of radioactive material in excess of those standards, or of license conditions related to those standards.

(b) Contents of reports. (1) Each report required by paragraph (a) of this section must describe the extent of exposure of individuals to radiation and radioactive material, including, as appropriate:

(i) Estimates of each individual's dose; and

(ii) The levels of radiation and concentrations of radioactive material involved; and

(iii) The cause of the elevated exposures, dose rates, or concentrations; and

(iv) Corrective steps taken or planned to ensure against a recurrence, including the schedule for achieving conformance with applicable limits, generally applicable environmental standards, and associated license conditions.

(2) Each report filed pursuant to paragraph (a) of this section must include for each individual[7] exposed: the name, Social Security account number, and date of birth. The report must be prepared so that this information is stated in a separate and detachable part of the report.

(c) For holders of an operating license for a nuclear power plant, the occurrences included in paragraph (a) of this section must be reported in accordance with the procedures described in § 50.73(b), (c), (d), (e), and (g) of this chapter and must also include the information required by paragraph (b) of this section. Occurrences reported in accordance with § 50.73 of this chapter need not be reported by a duplicate report under paragraph (a) of this section.

(d) All licensees, other than those holding an operating license for a nuclear power plant, who make reports under paragraph (a) of this section shall submit the report in writing to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, DC 20555, with a copy to the appropriate NRC Regional Office listed in appendix D to §§ 20.1001–20.2401.

[7] With respect to the limit for the embryo-fetus (§ 20.1208), the identifiers should be those of the declared pregnant woman.

§ 20.2204 Reports of planned special exposures.

The licensee shall submit a written report to the Administrator of the appropriate NRC Regional Office listed in Appendix D to §§ 20.1001–20.2401 within 30 days following any planned special exposure conducted in accordance with § 20.1206, informing the Commission that a planned special exposure was conducted and indicating the date the planned special exposure occurred and the information required by § 20.2105.

§ 20.2205 [Reserved]

§ 20.2206 Reports of individual monitoring.

(a) This section applies to each person licensed by the Commission to—

(1) Operate a nuclear reactor designed to produce electrical or heat energy pursuant to § 50.21(b) or § 50.22 of this chapter or a testing facility as defined in § 50.2 of this chapter; or

(2) Possess or use byproduct material for purposes of radiography pursuant to Parts 30 and 34 of this chapter; or

(3) Possess or use at any one time, for purposes of fuel processing, fabricating, or reprocessing, special nuclear material in a quantity exceeding 5,000 grams of contained uranium-235, uranium-233, or plutonium, or any combination thereof pursuant to part 70 of this chapter; or

(4) Possess high-level radioactive waste at a geologic repository operations area pursuant to part 60 of this chapter; or

(5) Possess spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to part 72 of this chapter; or

(6) Receive radioactive waste from other persons for disposal under part 61 of this chapter; or

(7) Possess or use at any time, for processing or manufacturing for distribution pursuant to parts 30, 32, 33 or 35 of this chapter, byproduct material in quantities exceeding any one of the following quantitites:

Radionuclide	Quantity of radionuclide [1] in curies
Cesium-137	1
Cobalt-60	1
Gold-198	100
Iodine-131	1
Iridium-192	10
Krypton-85	1,000
Promethium-147	10
Technetium-99m	1,000

[1] The Commission may require as a license condition, or by rule, regulation, or order pursuant to § 20.2302, reports from licensees who are licensed to use radionuclides not on this list, in quantities sufficient to cause comparable radiation levels.

(b) Each licensee in a category listed in paragraph (a) of this section shall submit an annual report of the results of individual monitoring carried out by the licensee for each individual for whom monitoring was required by § 20.1502 during that year. The licensee may include additional data for individuals for whom monitoring was provided but not required. The licensee shall use Form NRC 5 or electronic media containing all the information required by Form NRC 5.

(c) The licensee shall file the report required by § 20.2206(b), covering the preceding year, on or before April 30 of each year. The licensee shall submit the report to the REIRS Project Manager, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

[56 FR 23406, May 21, 1991, as amended at 56 FR 32072, July 15, 1991]

Subpart N—Exemptions and Additional Requirements

SOURCE: 56 FR 23408, May 21, 1991, unless otherwise noted.

§ 20.2301 Applications for exemptions.

The Commission may, upon application by a licensee or upon its own initiative, grant an exemption from the requirements of the regulations in this part if it determines the exemption is authorized by law and would not result in undue hazard to life or property.

§ 20.2302 Additional requirements.

The Commission may, by rule, regulation, or order, impose requirements on a licensee, in addition to those established in the regulations in this part, as it deems appropriate or necessary to protect health or to minimize danger to life or property.

Subpart O—Enforcement

§ 20.2401 Violations.

(a) The Commission may obtain an injunction or other court order to prevent a violation of the provisions of—

(1) The Atomic Energy Act of 1954, as amended;

(2) Title II of the Energy Reorganization Act of 1974, as amended; or

(3) A regulation or order issued pursuant to those Acts.

(b) The Commission may obtain a court order for the payment of a civil penalty imposed under section 234 of the Atomic Energy Act:

(1) For violations of—

(i) Sections 53, 57, 62, 63, 81, 82, 101, 103, 104, 107 or 109 of the Atomic Energy Act of 1954, as amended;

(ii) Section 206 of the Energy Reorganization Act;

(iii) Any rule, regulation, or order issued pursuant to the sections specified in paragraph (b)(1)(i) of this section; and

(iv) Any term, condition, or limitation of any license issued under the sections specified in paragraph (b)(1)(i) of this section.

(2) For any violation for which a license may be revoked under Section 186 of the Atomic Energy Act of 1954, as amended.

[56 FR 23408, May 21, 1991; 56 FR 61352, Dec. 3, 1991, as amended at 57 FR 55071, Nov. 24, 1992]

§ 20.2402 Criminal penalties.

(a) Section 223 of the Atomic Energy Act of 1954, as amended, provides for criminal sanctions for willful violation of, attempted violation of, or conspiracy to violate, any regulation issued under sections 161b, 161i, or 161o of the Act. For purposes of section 223, all the regulations in §§ 20.1001 through 20.2402 are issued under one or more of sections 161b, 161i, or 161o, except for the sections listed in paragraph (b) this section.

(b) The regulations in §§ 20.1001 through 20.2402 that are not issued under Sections 161b, 161i, or 161o for the purposes of Section 223 are as follows: §§ 20.1001, 20.1002, 20.1003, 20.1004, 20.1005, 20.1006, 20.1007, 20.1008, 20.1009, 20.1704, 20.1903, 20.1905, 20.2002, 20.2007, 20.2301, 20.2302, 20.2401, and 20.2402.

[57 FR 55071, Nov. 24, 1992]

APPENDIX A TO PART 20—PROTECTION FACTORS FOR RESPIRATORS[a]

Description[b]	Protection Factors[d]			Tested & Certified Equipment
	Modes[c]	Particulates only	Particulates, gases, & vapors[e]	National Institute for Occupational Safety and Health/Mine Safety and Health Administration tests for permissibility
I. Air-Purifying Respirators:[f]				
Facepiece, half-mask[g]	NP	10		30 CFR Part 11, Subpart K.
Facepiece, full	NP	50		
Facepiece, half-mask full, or hood.	PP	1000		
II. Atmosphere-Supplying Respirators:				
1. Air-line respirator:				
Facepiece, half-mask	CF		1000	30 CFR Part 11, Subpart J.
Facepiece, half-mask	D		5	
Facepiece, full	CF		2000	
Facepiece, full	D		5	
Facepiece, full	PD		2000	
Hood	CF		[h]	
Suit	CF		[i]	[i]
2. Self-contained breathing apparatus (SCBA):				
Facepiece, full	D		50	30 CFR Part 11, Subpart H.
Facepiece, full	PD		[k] 10,000	
Facepiece, full	RD		50	
Facepiece, full	RP		[l] 5,000	
III. Combination Respirators:				
Any combination of air-purifying and atmosphere-supplying respirators.	Protection factor for type and mode of operation as listed above.			30 CFR Part 11, § 11.63(b).

Footnotes

a. For use in the selection of respiratory protective devices to be used only where the contaminants have been identified and the concentrations (or possible concentrations) are known.
b. Only for shaven faces and where nothing interferes with the seal of tight-fitting facepieces against the skin. (Hoods and suits are excepted.)
c. The mode symbols are defined as follows:

CF=continuous flow
D=demand
NP=negative pressure (i.e., negative phase during inhalation)
PD=pressure demand (i.e., always positive pressure)
PP=positive pressure
RD=demand, recirculating (closed circuit)
RP=pressure demand, recirculating (closed circuit)

d.1. The protection factor is a measure of the degree of protection afforded by a respirator, defined as the ratio of the concentration of airborne radioactive material outside the respiratory protective equipment to that inside the equipment (usually inside the facepiece) under conditions of use. It is applied to the ambient airborne concentration to estimate the concentrations inhaled by the wearer according to the following formula:

$$\text{Concentration inhaled} = \frac{\text{Ambient airborne concentration}}{\text{Protection factor}}$$

2. The protection factors apply:

(a) Only for individuals trained in using respirators and wearing properly fitted respirators that are used and maintained under supervision in a well-planned respiratory protective program.

(b) For air-purifying respirators only when high efficiency particulate filters (above 99.97% removal efficiency by thermally generated 0.3 μm dioctyl phthalate (DOP) test or equivalent) are used in atmospheres not deficient in oxygen and not containing radioactive gas or vapor respiratory hazards.

(c) No adjustment is to be made for the use of sorbents against radioactive material in the form of gases or vapors.

(d) For atmosphere-supplying respirators only when supplied with adequate respirable air. Respirable air shall be provided of the quality and quantity required in accordance with NIOSH/MSHA certification (described in 30 CFR part 11). Oxygen and air shall not be used in the same apparatus.

(e) Excluding radioactive contaminants that present an absorption or submersion hazard. For tritium oxide, approximately one-third of the intake occurs by absorption through the skin so that an overall protection factor of less than 2 is appropriate when atmosphere-supplying respirators are used to protect against tritium oxide. If the protection factor for a device is 5 the effective protection factor for tritium is about 1.4; for devices with protection factors of 10 the effective factor for tritium oxide is about 1.7, and for devices with protection factors of 100 or more the effective factor for tritium oxide is about 1.9. Air-purifying respirators are not suitable for protection against tritium oxide. See also footnote 1 concerning supplied-air suits.

(f) Canisters and cartridges shall not be used beyond service-life limitations.

(g) Under-chin type only. This type of respirator is not satisfactory for use where it might be possible (e.g., if an accident or emergency were to occur) for the ambient airborne concentrations to reach instantaneous values greater than 10 times the pertinent values in table 1, column 3 of appendix B to §§ 20.1001—20.2401 of this part. This type of respirator is not suitable for protection against plutonium or other high-toxicity materials. The mask is to be tested for fit prior to use, each time it is donned.

(h)(1) Equipment shall be operated in a manner that ensures that proper air flowrates are maintained. A protection factor of no more than 1000 may be utilized for tested-and-certified supplied-air hoods when a minimum air flow of 6 cubic feet (0.17 cubic meters) per minute is maintained and calibrated air-line pressure gauges or flow measuring devices are used. A protection factor of up to 2000 may be used for tested and certified hoods only when the air flow is maintained at the manufacturer's recommended maximum rate for the equipment, this rate is greater than 6 cubic feet (0.17 cubic meters) per minute, and calibrated air-line pressure gauges or flow measuring devices are used.

(2) The design of the supplied-air hood or helmet (with a minimum flow of 6 cfm (0.17 m^3 per minute) of air) may determine its overall efficiency and the protection it provides. For example, some hoods aspirate contaminated air into the breathing zone when the wearer works with hands-over-head. This aspiration may be overcome if a short cape-like extension to the hood is worn under a coat or overalls. Other limitations specified by the approval agency shall be considered before using a hood in certain types of atmospheres (see footnote 1).

(i) Appropriate protection factors shall be determined, taking into account the design of the suit and its permeability to the contaminant under conditions of use. There shall be a standby rescue person equipped with a respirator or other apparatus appropriate for the potential hazards and commu-

nications equipment whenever supplied-air suits are used.

(j) No approval schedules are currently available for this equipment. Equipment is to be evaluated by testing or on the basis of reliable test information.

(k) This type of respirator may provide greater protection and be used as an emergency device in unknown concentrations for protection against inhalation hazards. External radiation hazards and other limitations to permitted exposure, such as skin absorption, must be taken into account in such circumstances.

(l) Quantitative fit testing shall be performed on each individual and no more than 0.02% leakage is allowed with this type of apparatus. Perceptible outward leakage of gas from this or any positive pressure self-contained breathing apparatus is unacceptable because service life will be reduced substantially. Special training in the use of this type of apparatus shall be provided to the wearer.

NOTE 1: Protection factors for respirators as may be approved by the U.S. Bureau of Mines/National Institute for Occupational Safety and Health (NIOSH), according to applicable approvals for respirators for type and mode of use to protect against airborne radionuclides, may be used to the extent that they do not exceed the protection factors listed in this table. The protection factors listed in this table may not be appropriate to circumstances where chemical or other respiratory hazards exist in addition to radioactive hazards. The selection and use of respirators for such circumstances should take into account applicable approvals of the U.S. Bureau of Mines/NIOSH.

NOTE 2: Radioactive contaminants for which the concentration values in Table 1, Column 3 of Appendix B to §§20.1001–20.2401 of this part are based on internal dose due to inhalation may, in addition, present external exposure hazards at higher concentrations. Under these circumstances, limitations on occupancy may have to be governed by external dose limits.

[56 FR 23408, May 21, 1991. Redesignated at 58 FR 67659, Dec. 22, 1993]

APPENDIX B TO PART 20—ANNUAL LIMITS ON INTAKE (ALIS) AND DERIVED AIR CONCENTRATIONS (DACS) OF RADIONUCLIDES FOR OCCUPATIONAL EXPOSURE; EFFLUENT CONCENTRATIONS; CONCENTRATIONS FOR RELEASE TO SEWERAGE

Introduction

For each radionuclide Table 1 indicates the chemical form which is to be used for selecting the appropriate ALI or DAC value. The ALIs and DACs for inhalation are given for an aerosol with an activity median aerodynamic diameter (AMAD) of 1 μm and for three classes (D,W,Y) of radioactive material, which refer to their retention (approximately days, weeks or years) in the pulmonary region of the lung. This classification applies to a range of clearance half-times of less than 10 days for D, for W from 10 to 100 days, and for Y greater than 100 days. The class (D, W, or Y) given in the column headed "Class" applies only to the inhalation ALIs and DACs given in Table 1, columns 2 and 3. Table 2 provides concentration limits for airborne and liquid effluents released to the general environment. Table 3 provides concentration limits for discharges to sanitary sewer systems.

Notation

The values in Tables 1, 2, and 3 are presented in the computer "E" notation. In this notation a value of 6E−02 represents a value of 6×10^{-2} or 0.06, 6E+2 represents 6×10^{2} or 600, and 6E+0 represents 6×10^{0} or 6.

Table 1 "Occupational"

Note that the columns in Table 1, of this appendix captioned "Oral Ingestion ALI," "Inhalation ALI," and "DAC," are applicable to occupational exposure to radioactive material.

The ALIs in this appendix are the annual intakes of a given radionuclide by "Reference Man" which would result in either (1) a committed effective dose equivalent of 5 rems (stochastic ALI) or (2) a committed dose equivalent of 50 rems to an organ or tissue (non-stochastic ALI). The stochastic ALIs were derived to result in a risk, due to irradiation of organs and tissues, comparable to the risk associated with deep dose equivalent to the whole body of 5 rems. The derivation includes multiplying the committed dose equivalent to an organ or tissue by a weighting factor, w_T. This weighting factor is the proportion of the risk of stochastic effects resulting from irradiation of the organ or tissue, T, to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of w_T are listed under the definition of weighting factor in §20.1003. The non-stochastic ALIs were derived to avoid non-stochastic effects, such as prompt damage to tissue or reduction in organ function.

A value of w_T=0.06 is applicable to each of the five organs or tissues in the "remainder" category receiving the highest dose equivalents, and the dose equivalents of all other remaining tissues may be disregarded. The following parts of the GI tract—stomach, small intestine, upper large intestine, and lower large intestine—are to be treated as four separate organs.

Note that the dose equivalents for extremities (hands and forearms, feet and lower

legs), skin, and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

When an ALI is defined by the stochastic dose limit, this value alone, is given. When an ALI is determined by the non-stochastic dose limit to an organ, the organ or tissue to which the limit applies is shown, and the ALI for the stochastic limit is shown in parentheses. (Abbreviated organ or tissue designations are used: LLI wall = lower large intestine wall; St. wall = stomach wall; Blad wall = bladder wall; and Bone surf = bone surface.)

The use of the ALIs listed first, the more limiting of the stochastic and non-stochastic ALIs, will ensure that non-stochastic effects are avoided and that the risk of stochastic effects is limited to an acceptably low value. If, in a particular situation involving a radionuclide for which the non-stochastic ALI is limiting, use of that non-stochastic ALI is considered unduly conservative, the licensee may use the stochastic ALI to determine the committed effective dose equivalent. However, the licensee shall also ensure that the 50-rem dose equivalent limit for any organ or tissue is not exceeded by the sum of the external deep dose equivalent plus the internal committed dose to that organ (not the effective dose). For the case where there is no external dose contribution, this would be demonstrated if the sum of the fractions of the nonstochastic ALIs (ALI_{ns}) that contribute to the committed dose equivalent to the organ receiving the highest dose does not exceed unity (i.e., Σ (intake (in μCi) of each radionuclide/ALI_{ns}) <1.0). If there is an external deep dose equivalent contribution of H_d then this sum must be less than $1-(H_d/50)$ instead of being <1.0.

The derived air concentration (DAC) values are derived limits intended to control chronic occupational exposures. The relationship between the DAC and the ALI is given by: DAC=ALI(in μCi)/(2000 hours per working year×60 minutes/hour×2×10^4 ml per minute)=[ALI/2.4×10^9] μCi/ml, where 2×10^4 ml is the volume of air breathed per minute at work by "Reference Man" under working conditions of "light work."

The DAC values relate to one of two modes of exposure: either external submersion or the internal committed dose equivalents resulting from inhalation of radioactive materials. Derived air concentrations based upon submersion are for immersion in a semi-infinite cloud of uniform concentration and apply to each radionuclide separately.

The ALI and DAC values relate to exposure to the single radionuclide named, but also include contributions from the in-growth of any daughter radionuclide produced in the body by the decay of the parent. However, intakes that include both the parent and daughter radionuclides should be treated by the general method appropriate for mixtures.

The value of ALI and DAC do not apply directly when the individual both ingests and inhales a radionuclide, when the individual is exposed to a mixture of radionuclides by either inhalation or ingestion or both, or when the individual is exposed to both internal and external radiation (see §20.1202). When an individual is exposed to radioactive materials which fall under several of the translocation classifications (i.e., Class D, Class W, or Class Y) of the same radionuclide, the exposure may be evaluated as if it were a mixture of different radionuclides.

It should be noted that the classification of a compound as Class D, W, or Y is based on the chemical form of the compound and does not take into account the radiological half-life of different radioisotopes. For this reason, values are given for Class D, W, and Y compounds, even for very short-lived radionuclides.

Table 2

The columns in Table 2 of this appendix captioned "Effluents," "Air," and "Water," are applicable to the assessment and control of dose to the public, particularly in the implementation of the provisions of §20.1302. The concentration values given in Columns 1 and 2 of Table 2 are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 0.05 rem (50 millirem or 0.5 millisieverts).

Consideration of non-stochastic limits has not been included in deriving the air and water effluent concentration limits because non-stochastic effects are presumed not to occur at the dose levels established for individual members of the public. For radionuclides, where the non-stochastic limit was governing in deriving the occupational DAC, the stochastic ALI was used in deriving the corresponding airborne effluent limit in Table 2. For this reason, the DAC and airborne effluent limits are not always proportional as was the case in appendix B to §§20.1–20.601.

The air concentration values listed in Table 2, Column 1, were derived by one of two methods. For those radionuclides for which the stochastic limit is governing, the occupational stochastic inhalation ALI was divided by 2.4×10^9 ml, relating the inhalation ALI to the DAC, as explained above, and then divided by a factor of 300. The factor of 300 includes the following components: a factor of 50 to relate the 5-rem annual occupational dose limit to the 0.1-rem limit for members of the public, a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker and that for members of the public; and a factor of 2 to adjust the occupational values (derived for

adults) so that they are applicable to other age groups.

For those radionuclides for which submersion (external dose) is limiting, the occupational DAC in Table 1, Column 3, was divided by 219. The factor of 219 is composed of a factor of 50, as described above, and a factor of 4.38 relating occupational exposure for 2,000 hours per year to full-time exposure (8,760 hours per year). Note that an additional factor of 2 for age considerations is not warranted in the submersion case.

The water concentrations were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^7. The factor of 7.3×10^7 (ml) includes the following components: the factors of 50 and 2 described above and a factor of 7.3×10^5 (ml) which is the annual water intake of "Reference Man."

Note 2 of this appendix provides groupings of radionuclides which are applicable to unknown mixtures of radionuclides. These groupings (including occupational inhalation ALIs and DACs, air and water effluent concentrations and sewerage) require demonstrating that the most limiting radionuclides in successive classes are absent. The limit for the unknown mixture is defined when the presence of one of the listed radionuclides cannot be definitely excluded either from knowledge of the radionuclide composition of the source or from actual measurements.

Table 3 "Sewer Disposal"

The monthly average concentrations for release to sanitary sewers are applicable to the provisions in §20.2003. The concentration values were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^6(ml). The factor of 7.3×10^6(ml) is composed of a factor of 7.3×10^5(ml), the annual water intake by "Reference Man," and a factor of 10, such that the concentrations, if the sewage released by the licensee were the only source of water ingested by a reference man during a year, would result in a committed effective dose equivalent of 0.5 rem.

LIST OF ELEMENTS

Name	Atomic Symbol	Atomic No.
Actinium	Ac	89
Aluminum	Al	13
Americium	Am	95
Antimony	Sb	51
Argon	Ar	18
Arsenic	As	33
Astatine	At	85
Barium	Ba	56
Berkelium	Bk	97
Beryllium	Be	4
Bismuth	Bi	83
Bromine	Br	35

LIST OF ELEMENTS—Continued

Name	Atomic Symbol	Atomic No.
Cadmium	Cd	48
Calcium	Ca	20
Californium	Cf	98
Carbon	C	6
Cerium	Ce	58
Cesium	Cs	55
Chlorine	Cl	17
Chromium	Cr	24
Cobalt	Co	27
Copper	Cu	29
Curium	Cm	96
Dysprosium	Dy	66
Einsteinium	Es	99
Erbium	Er	68
Europium	Eu	63
Fermium	Fm	100
Fluorine	F	9
Francium	Fr	87
Gadolinium	Gd	64
Gallium	Ga	31
Germanium	Ge	32
Gold	Au	79
Hafnium	Hf	72
Holmium	Ho	67
Hydrogen	H	1
Indium	In	49
Iodine	I	53
Iridium	Ir	77
Iron	Fe	26
Krypton	Kr	36
Lanthanum	La	57
Lead	Pb	82
Lutetium	Lu	71
Magnesium	Mg	12
Manganese	Mn	25
Mendelevium	Md	101
Mercury	Hg	80
Molybdenum	Mo	42
Neodymium	Nd	60
Neptunium	Np	93
Nickel	Ni	28
Niobium	Nb	41
Osmium	Os	76
Palladium	Pd	46
Phosphorus	P	15
Platinum	Pt	78
Plutonium	Pu	94
Polonium	Po	84
Potassium	K	19
Praseodymium	Pr	59
Promethium	Pm	61
Protactinium	Pa	91
Radium	Ra	88
Radon	Rn	86
Rhenium	Re	75
Rhodium	Rh	45
Rubidium	Rb	37
Ruthenium	Ru	44
Samarium	Sm	62
Scandium	Sc	21
Selenium	Se	34
Silicon	Si	14
Silver	Ag	47
Sodium	Na	11
Strontium	Sr	38
Sulfur	S	16
Tantalum	Ta	73
Technetium	Tc	43
Tellurium	Te	52
Terbium	Tb	65

LIST OF ELEMENTS—Continued

Name	Atomic Symbol	Atomic No.
[illegible]alium	Tl	81
[illegible]orium	Th	90
Thulium	Tm	69
Tin	Sn	50
Titanium	Ti	22
Tungsten	W	74
Uranium	U	92

LIST OF ELEMENTS—Continued

Name	Atomic Symbol	Atomic No.
Vanadium	V	23
Xenon	Xe	54
Ytterbium	Yb	70
Yttrium	Y	39
Zinc	Zn	30
Zirconium	Zr	40

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
1	Hydrogen-3	Water, DAC includes skin absorption	8E+4	8E+4	2E-5	1E-7	1E-3	1E-2
		Gas (HT or T_2)Submersion[1]: Use above values as HT and T_2 oxidize in air and in the body to HTO						
4	Beryllium-7	W, all compounds except those given for Y	4E+4	2E+4	9E-6	3E-8	6E-4	6E-3
		Y, oxides, halides, and nitrates	-	2E+4	8E-6	3E-8	-	-
4	Beryllium-10	W, see ^{7}Be	1E+3	2E+2	6E-8	2E-10	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{7}Be	-	1E+1	6E-9	2E-11	-	-
6	Carbon-11[2]	Monoxide	-	1E+6	5E-4	2E-6	-	-
		Dioxide	-	6E+5	3E-4	9E-7	-	-
		Compounds	4E+5	4E+5	2E-4	6E-7	6E-3	6E-2
6	Carbon-14	Monoxide	-	2E+6	7E-4	2E-6	-	-
		Dioxide	-	2E+5	9E-5	3E-7	-	-
		Compounds	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
9	Fluorine-18[2]	D, fluorides of W, Li, Na, K, Rb, Cs, and Fr	5E+4	7E+4	3E-5	1E-7	-	-
			St wall (5E+4)	-	-	-	7E-4	7E-3
		W, fluorides of Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, As, Sb, Bi, Fe, Ru, Os, Co, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, V, Nb, Ta, Mn, Tc, and Re	-	9E+4	4E-5	1E-7	-	-
		Y, lanthanum fluoride	-	8E+4	3E-5	1E-7	-	-
11	Sodium-22	D, all compounds	4E+2	6E+2	3E-7	9E-10	6E-6	6E-5
11	Sodium-24	D, all compounds	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
12	Magnesium-28	D, all compounds except those given for W	7E+2	2E+3	7E-7	2E-9	9E-6	9E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	1E+3	5E-7	2E-9	-	-
13	Aluminum-26	D, all compounds except those given for W	4E+2	6E+1	3E-8	9E-11	6E-6	6E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	9E+1	4E-8	1E-10	-	-

ic	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
14	Silicon-31	D, all compounds except those given for W and Y	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, oxides, hydroxides, carbides, and nitrates	-	3E+4	1E-5	5E-8	-	-
		Y, aluminosilicate glass	-	3E+4	1E-5	4E-8	-	-
14	Silicon-32	D, see ^{31}Si	2E+3	2E+2	1E-7	3E-10	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
		W, see ^{31}Si	-	1E+2	5E-8	2E-10	-	-
		Y, see ^{31}Si	-	5E+0	2E-9	7E-12	-	-
15	Phosphorus-32	D, all compounds except phosphates given for W	6E+2	9E+2	4E-7	1E-9	9E-6	9E-5
		W, phosphates of Zn^{2+}, S^{3+}, Mg^{2+}, Fe^{3+}, Bi^{3+}, and lanthanides	-	4E+2	2E-7	5E-10	-	-
15	Phosphorus-33	D, see ^{32}P	6E+3	8E+3	4E-6	1E-8	8E-5	8E-4
		W, see ^{32}P	-	3E+3	1E-6	4E-9	-	-
16	Sulfur-35	Vapor	-	1E+4	6E-6	2E-8	-	-
		D, sulfides and sulfates except those given for W	1E+4	2E+4	7E-6	2E-8	-	-
			LLI wall (8E+3)	-	-	-	1E-4	1E-3
		W, elemental sulfur, sulfides of Sr, Ba, Ge, Sn, Pb, As, Sb, Bi, Cu, Ag, Au, Zn, Cd, Hg, W, and Mo. Sulfates of Ca, Sr, Ba, Ra, As, Sb, and Bi	6E+3 -	2E+3	9E-7	3E-9	-	-
17	Chlorine-36	D, chlorides of H, Li, Na, K, Rb, Cs, and Fr	2E+3	2E+3	1E-6	3E-9	2E-5	2E-4
		W, chlorides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Tc, and Re	-	2E+2	1E-7	3E-10	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
17	Chlorine-38[2]	D, see ^{36}Cl	2E+4	4E+4	2E-5	6E-8	-	-
			St. wall (3E+4)	-	-	-	3E-4	3E-3
		W, see ^{36}Cl	-	5E+4	2E-5	6E-8	-	-
17	Chlorine-39[2]	D, see ^{36}Cl	2E+4	5E+4	2E-5	7E-8	-	-
			St. wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{36}Cl	-	6E+4	2E-5	8E-8	-	-
18	Argon-37	Submersion[1]	-	-	1E+0	6E-3	-	-
18	Argon-39	Submersion[1]	-	-	2E-4	8E-7	-	-
18	Argon-41	Submersion[1]	-	-	3E-6	1E-8	-	-
19	Potassium-40	D, all compounds	3E+2	4E+2	2E-7	6E-10	4E-6	4E-5
19	Potassium-42	D, all compounds	5E+3	5E+3	2E-6	7E-9	6E-5	6E-4
19	Potassium-43	D, all compounds	6E+3	9E+3	4E-6	1E-8	9E-5	9E-4
19	Potassium-44[2]	D, all compounds	2E+4	7E+4	3E-5	9E-8	-	-
			St. wall (4E+4)	-	-	-	5E-4	5E-3
19	Potassium-45[2]	D, all compounds	3E+4	1E+5	5E-5	2E-7	-	-
			St. wall (5E+4)	-	-	-	7E-4	7E-3
20	Calcium-41	W, all compounds	3E+3	4E+3	2E-6	-	-	-
			Bone surf (4E+3)	Bone surf (4E+3)	-	5E-9	6E-5	6E-4
20	Calcium-45	W, all compounds	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4
20	Calcium-47	W, all compounds	8E+2	9E+2	4E-7	1E-9	1E-5	1E-4
21	Scandium-43	Y, all compounds	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
21	Scandium-44m	Y, all compounds	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
21	Scandium-44	Y, all compounds	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
21	Scandium-46	Y, all compounds	9E+2	2E+2	1E-7	3E-10	1E-5	1E-4
21	Scandium-47	Y, all compounds	2E+3	3E+3	1E-6	4E-9	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
21	Scandium-48	Y, all compounds	8E+2	1E+3	6E-7	2E-9	1E-5	1E-4
21	Scandium-49[2]	Y, all compounds	2E+4	5E+4	2E-5	8E-8	3E-4	3E-3
22	Titanium-44	D, all compounds except those given for W and Y	3E+2	1E+1	5E-9	2E-11	4E-6	4E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	3E+1	1E-8	4E-11	-	-
		Y, $SrTiO_3$	-	6E+0	2E-9	8E-12	-	-

			Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				Monthly Average
Atomic No.	Radionuclide	Class	ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Concentration (μCi/ml)
22	Titanium-45	D, see ^{44}Ti	9E+3	3E+4	1E-5	5E-8	1E-4	1E-3
		W, see ^{44}Ti	-	4E+4	2E-5	5E-8	-	-
		Y, see ^{44}Ti	-	3E+4	1E-5	4E-8	-	-
23	Vanadium-47[2]	D, all compounds except those given for W	3E+4	8E+4	3E-5	1E-7	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		W, oxides, hydroxides, carbides, and halides	-	1E+5	4E-5	1E-7	-	-
23	Vanadium-48	D, see ^{47}V	6E+2	1E+3	5E-7	2E-9	9E-6	9E-5
		W, see ^{47}V	-	6E+2	3E-7	9E-10	-	-
23	Vanadium-49	D, see ^{47}V	7E+4	3E+4	1E-5	-	-	-
			LLI wall (9E+4)	Bone surf (3E+4)	-	5E-8	1E-3	1E-2
		W, see ^{47}V	-	2E+4	8E-6	2E-8	-	-
24	Chromium-48	D, all compounds except those given for W and Y	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, halides and nitrates	-	7E+3	3E-6	1E-8	-	-
		Y, oxides and hydroxides	-	7E+3	3E-6	1E-8	-	-
24	Chromium-49[2]	D, see ^{48}Cr	3E+4	8E+4	4E-5	1E-7	4E-4	4E-3
		W, see ^{48}Cr	-	1E+5	4E-5	1E-7	-	-
		Y, see ^{48}Cr	-	9E+4	4E-5	1E-7	-	-
24	Chromium-51	D, see ^{48}Cr	4E+4	5E+4	2E-5	6E-8	5E-4	5E-3
		W, see ^{48}Cr	-	2E+4	1E-5	3E-8	-	-
		Y, see ^{48}Cr	-	2E+4	8E-6	3E-8	-	-
25	Manganese-51[2]	D, all compounds except those given for W	2E+4	5E+4	2E-5	7E-8	3E-4	3E-3
		W, oxides, hydroxides, halides, and nitrates	-	6E+4	3E-5	8E-8	-	-
25	Manganese-52m[2]	D, see ^{51}Mn	3E+4	9E+4	4E-5	1E-7	-	-
			St. wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{51}Mn	-	1E+5	4E-5	1E-7	-	-
25	Manganese-52	D, see ^{51}Mn	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
		W, see ^{51}Mn	-	9E+2	4E-7	1E-9	-	-
25	Manganese-53	D, see ^{51}Mn	5E+4	1E+4	5E-6	-	7E-4	7E-3
			-	Bone surf (2E+4)	-	3E-8	-	-
		W, see ^{51}Mn	-	1E+4	5E-6	2E-8	-	-
25	Manganese-54	D, see ^{51}Mn	2E+3	9E+2	4E-7	1E-9	3E-5	3E-4
		W, see ^{51}Mn	-	8E+2	3E-7	1E-9	-	-
25	Manganese-56	D, see ^{51}Mn	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{51}Mn	-	2E+4	9E-6	3E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values: Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values: Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values: Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations: Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations: Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers: Monthly Average Concentration (μCi/ml)
26	Iron-52	D, all compounds except those given for W	9E+2	3E+3	1E-6	4E-9	1E-5	1E-4
		W, oxides, hydroxides, and halides	-	2E+3	1E-6	3E-9	-	-
26	Iron-55	D, see ^{52}Fe	9E+3	2E+3	8E-7	3E-9	1E-4	1E-3
		W, see ^{52}Fe	-	4E+3	2E-6	6E-9	-	-
26	Iron-59	D, see ^{52}Fe	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		W, see ^{52}Fe	-	5E+2	2E-7	7E-10	-	-
26	Iron-60	D, see ^{52}Fe	3E+1	6E+0	3E-9	9E-12	4E-7	4E-6
		W, see ^{52}Fe	-	2E+1	8E-9	3E-11	-	-
27	Cobalt-55	W, all compounds except those given for Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, oxides, hydroxides, halides, and nitrates	-	3E+3	1E-6	4E-9	-	-
27	Cobalt-56	W, see ^{55}Co	5E+2	3E+2	1E-7	4E-10	6E-6	6E-5
		Y, see ^{55}Co	4E+2	2E+2	8E-8	3E-10	-	-
27	Cobalt-57	W, see ^{55}Co	8E+3	3E+3	1E-6	4E-9	6E-5	6E-4
		Y, see ^{55}Co	4E+3	7E+2	3E-7	9E-10	-	-
27	Cobalt-58m	W, see ^{55}Co	6E+4	9E+4	4E-5	1E-7	8E-4	8E-3
		Y, see ^{55}Co	-	6E+4	3E-5	9E-8	-	-
27	Cobalt-58	W, see ^{55}Co	2E+3	1E+3	5E-7	2E-9	2E-5	2E-4
		Y, see ^{55}Co	1E+3	7E+2	3E-7	1E-9	-	-
27	Cobalt-60m[2]	W, see ^{55}Co	1E+6 St. wall (1E+6)	4E+6	2E-3	6E-6	-	-
		Y, see ^{55}Co	-	3E+6	1E-3	4E-6	2E-2	2E-1
27	Cobalt-60	W, see ^{55}Co	5E+2	2E+2	7E-8	2E-10	3E-6	3E-5
		Y, see ^{55}Co	2E+2	3E+1	1E-8	5E-11	-	-
27	Cobalt-61[2]	W, see ^{55}Co	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		Y, see ^{55}Co	2E+4	6E+4	2E-5	8E-8	-	-
27	Cobalt-62m[2]	W, see ^{55}Co	4E+4 St. wall (5E+4)	2E+5	7E-5	2E-7	-	-
		Y, see ^{55}Co	-	2E+5	6E-5	2E-7	7E-4	7E-3
28	Nickel-56	D, all compounds except those given for W	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4
		W, oxides, hydroxides, and carbides	-	1E+3	5E-7	2E-9	-	-
		Vapor	-	1E+3	5E-7	2E-9	-	-
28	Nickel-57	D, see ^{56}Ni	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see ^{56}Ni	-	3E+3	1E-6	4E-9	-	-
		Vapor	-	6E+3	3E-6	9E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values: Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values: Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values: Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations: Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations: Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers: Monthly Average Concentration (μCi/ml)
28	Nickel-59	D, see ^{56}Ni	2E+4	4E+3	2E-6	5E-9	3E-4	3E-3
		W, see ^{56}Ni	-	7E+3	3E-6	1E-8	-	-
		Vapor	-	2E+3	8E-7	3E-9	-	-
28	Nickel-63	D, see ^{56}Ni	9E+3	2E+3	7E-7	2E-9	1E-4	1E-3
		W, see ^{56}Ni	-	3E+3	1E-6	4E-9	-	-
		Vapor	-	8E+2	3E-7	1E-9	-	-
28	Nickel-65	D, see ^{56}Ni	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{56}Ni	-	3E+4	1E-5	4E-8	-	-
		Vapor	-	2E+4	7E-6	2E-8	-	-
28	Nickel-66	D, see ^{56}Ni	4E+2	2E+3	7E-7	2E-9	-	-
			LLI wall (5E+2)	-	-	-	6E-6	6E-5
		W, see ^{56}Ni	-	6E+2	3E-7	9E-10	-	-
		Vapor	-	3E+3	1E-6	4E-9	-	-
29	Copper-60[2]	D, all compounds except those given for W and Y	3E+4	9E+4	4E-5	1E-7	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		W, sulfides, halides, and nitrates	-	1E+5	5E-5	2E-7	-	-
		Y, oxides and hydroxides	-	1E+5	4E-5	1E-7	-	-
29	Copper-61	D, see ^{60}Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{60}Cu	-	4E+4	2E-5	6E-8	-	-
		Y, see ^{60}Cu	-	4E+4	1E-5	5E-8	-	-
	Copper-64	D, see ^{60}Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{60}Cu	-	2E+4	1E-5	3E-8	-	-
		Y, see ^{60}Cu	-	2E+4	9E-6	3E-8	-	-
	Copper-67	D, see ^{60}Cu	5E+3	8E+3	3E-6	1E-8	6E-5	6E-4
		W, see ^{60}Cu	-	5E+3	2E-6	7E-9	-	-
		Y, see ^{60}Cu	-	5E+3	2E-6	6E-9	-	-
30	Zinc-62	Y, all compounds	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
30	Zinc-63[2]	Y, all compounds	2E+4	7E+4	3E-5	9E-8	-	-
			St. wall (3E+4)	-	-	-	3E-4	3E-3
	Zinc-65	Y, all compounds	4E+2	3E+2	1E-7	4E-10	5E-6	5E-5
	Zinc-69m	Y, all compounds	4E+3	7E+3	3E-6	1E-8	6E-5	6E-4
	Zinc-69[2]	Y, all compounds	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
	Zinc-71m	Y, all compounds	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
30	Zinc-72	Y, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
31	Gallium-65[2]	D, all compounds except those given for W	5E+4	2E+5	7E-5	2E-7	-	-
			St. wall (6E+4)	-	-	-	9E-4	9E-3
		W, oxides, hydroxides, carbides, halides, and nitrates	-	2E+5	8E-5	3E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
31	Gallium-66	D, see ^{65}Ga	1E+3	4E+3	1E-6	5E-9	1E-5	1E-4
		W, see ^{65}Ga	-	3E+3	1E-6	4E-9	-	-
31	Gallium-67	D, see ^{65}Ga	7E+3	1E+4	6E-6	2E-8	1E-4	1E-3
		W, see ^{65}Ga	-	1E+4	4E-6	1E-8	-	-
31	Gallium-68[2]	D, see ^{65}Ga	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{65}Ga	-	5E+4	2E-5	7E-8	-	-
31	Gallium-70[2]	D, see ^{65}Ga	5E+4	2E+5	7E-5	2E-7	-	-
			St. wall (7E+4)	-	-	-	1E-3	1E-2
		W, see ^{65}Ga	-	2E+5	8E-5	3E-7	-	-
31	Gallium-72	D, see ^{65}Ga	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{65}Ga	-	3E+3	1E-6	4E-9	-	-
31	Gallium-73	D, see ^{65}Ga	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{65}Ga	-	2E+4	6E-6	2E-8	-	-
32	Germanium-66	D, all compounds except those given for W	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
		W, oxides, sulfides, and halides	-	2E+4	8E-6	3E-8	-	-
32	Germanium-67[2]	D, see ^{66}Ge	3E+4	9E+4	4E-5	1E-7	-	-
			St. wall (4E+4)	-	-	-	6E-4	6E-3
		W, see ^{66}Ge	-	1E+5	4E-5	1E-7	-	-
32	Germanium-68	D, see ^{66}Ge	5E+3	4E+3	2E-6	5E-9	6E-5	6E-4
		W, see ^{66}Ge	-	1E+2	4E-8	1E-10	-	-
32	Germanium-69	D, see ^{66}Ge	1E+4	2E+4	6E-6	2E-8	2E-4	2E-3
		W, see ^{66}Ge	-	8E+3	3E-6	1E-8	-	-
32	Germanium-71	D, see ^{66}Ge	5E+5	4E+5	2E-4	6E-7	7E-3	7E-2
		W, see ^{66}Ge	-	4E+4	2E-5	6E-8	-	-
32	Germanium-75[2]	D, see ^{66}Ge	4E+4	8E+4	3E-5	1E-7	-	-
			St. wall (7E+4)	-	-	-	9E-4	9E-3
		W, see ^{66}Ge	-	8E+4	4E-5	1E-7	-	-
32	Germanium-77	D, see ^{66}Ge	9E+3	1E+4	4E-6	1E-8	1E-4	1E-3
		W, see ^{66}Ge	-	6E+3	2E-6	8E-9	-	-
32	Germanium-78[2]	D, see ^{66}Ge	2E+4	2E+4	9E-6	3E-8	-	-
			St. wall (2E+4)	-	-	-	3E-4	3E-3
		W, see ^{66}Ge	-	2E+4	9E-6	3E-8	-	-

			Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				Monthly Average
c	Radionuclide	Class	ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Concentration (μCi/ml)
33	Arsenic-69[2]	W, all compounds	3E+4	1E+5	5E-5	2E-7	-	-
			St. wall (4E+4)	-	-	-	6E-4	6E-3
33	Arsenic-70[2]	W, all compounds	1E+4	5E+4	2E-5	7E-8	2E-4	2E-3
33	Arsenic-71	W, all compounds	4E+3	5E+3	2E-6	6E-9	5E-5	5E-4
33	Arsenic-72	W, all compounds	9E+2	1E+3	6E-7	2E-9	1E-5	1E-4
33	Arsenic-73	W, all compounds	8E+3	2E+3	7E-7	2E-9	1E-4	1E-3
33	Arsenic-74	W, all compounds	1E+3	8E+2	3E-7	1E-9	2E-5	2E-4
33	Arsenic-76	W, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4
33	Arsenic-77	W, all compounds	4E+3	5E+3	2E-6	7E-9	-	-
			LLI wall (5E+3)	-	-	-	6E-5	6E-4
33	Arsenic-78[2]	W, all compounds	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
34	Selenium-70[2]	D, all compounds except those given for W	2E+4	4E+4	2E-5	5E-8	1E-4	1E-3
		W, oxides, hydroxides, carbides, and elemental Se	1E+4-	4E+4	2E-5	6E-8	-	-
34	Selenium-73m[2]	D, see ^{70}Se	6E+4	2E+5	6E-5	2E-7	4E-4	4E-3
		W, see ^{70}Se	3E+4	1E+5	6E-5	2E-7	-	-
	Selenium-73	D, see ^{70}Se	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
		W, see ^{70}Se	-	2E+4	7E-6	2E-8	-	-
34	Selenium-75	D, see ^{70}Se	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
		W, see ^{70}Se	-	6E+2	3E-7	8E-10	-	-
34	Selenium-79	D, see ^{70}Se	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
		W, see ^{70}Se	-	6E+2	2E-7	8E-10	-	-
34	Selenium-81m[2]	D, see ^{70}Se	4E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		W, see ^{70}Se	2E+4	7E+4	3E-5	1E-7	-	-
	Selenium-81[2]	D, see ^{70}Se	6E+4	2E+5	9E-5	3E-7	-	-
			St. wall (8E+4)	-	-	-	1E-3	1E-2
		W, see ^{70}Se	-	2E+5	1E-4	3E-7	-	-
	Selenium-83[2]	D, see ^{70}Se	4E+4	1E+5	5E-5	2E-7	4E-4	4E-3
		W, see ^{70}Se	3E+4	1E+5	5E-5	2E-7	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentrat (μCi/ml)
35	Bromine-74m[2]	D, bromides of H, Li, Na, K, Rb, Cs, and Fr	1E+4	4E+4	2E-5	5E-8	-	-
			St. wall (2E+4)	-	-	-	3E-4	3E-3
		W, bromides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Mn, Tc, and Re	-	4E+4	2E-5	6E-8	-	-
35	Bromine-74[2]	D, see ^{74m}Br	2E+4	7E+4	3E-5	1E-7	-	-
			St. wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{74m}Br	-	8E+4	4E-5	1E-7	-	-
35	Bromine-75[2]	D, see ^{74m}Br	3E+4	5E+4	2E-5	7E-8	-	-
			St. wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{74m}Br	-	5E+4	2E-5	7E-8	-	-
35	Bromine-76	D, see ^{74m}Br	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
		W, see ^{74m}Br	-	4E+3	2E-6	6E-9	-	-
35	Bromine-77	D, see ^{74m}Br	2E+4	2E+4	1E-5	3E-8	2E-4	2E-3
		W, see ^{74m}Br	-	2E+4	8E-6	3E-8	-	-
35	Bromine-80m	D, see ^{74m}Br	2E+4	2E+4	7E-6	2E-8	3E-4	3E-3
		W, see ^{74m}Br	-	1E+4	6E-6	2E-8	-	-
35	Bromine-80[2]	D, see ^{74m}Br	5E+4	2E+5	8E-5	3E-7	-	-
			St. wall (9E+4)	-	-	-	1E-3	1E-2
		W, see ^{74m}Br	-	2E+5	9E-5	3E-7	-	-
35	Bromine-82	D, see ^{74m}Br	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see ^{74m}Br	-	4E+3	2E-6	5E-9	-	-
35	Bromine-83	D, see ^{74m}Br	5E+4	6E+4	3E-5	9E-8	-	-
			St. wall (7E+4)	-	-	-	9E-4	9E-3
		W, see ^{74m}Br	-	6E+4	3E-5	9E-8	-	-
35	Bromine-84[2]	D, see ^{74m}Br	2E+4	6E+4	2E-5	8E-8	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		W, see ^{74m}Br	-	6E+4	3E-5	9E-8	-	-
36	Krypton-74[2]	Submersion[1]	-	-	3E-6	1E-8	-	-
36	Krypton-76	Submersion[1]	-	-	9E-6	4E-8	-	-
36	Krypton-77[2]	Submersion[1]	-	-	4E-6	2E-8	-	-
36	Krypton-79	Submersion[1]	-	-	2E-5	7E-8	-	-
36	Krypton-81	Submersion[1]	-	-	7E-4	3E-6	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
36	Krypton-83m[2]	Submersion[1]			1E-2	5E-5	-	
36	Krypton-85m	Submersion[1]	-	-	2E-5	1E-7	-	
36	Krypton-85	Submersion[1]	-	-	1E-4	7E-7	-	-
36	Krypton-87[2]	Submersion[1]	-	-	5E-6	2E-8	-	-
36	Krypton-88	Submersion[1]	-	-	2E-6	9E-9	-	-
37	Rubidium-79[2]	D, all compounds	4E+4	1E+5	5E-5	2E-7	-	-
			St. wall (6E+4)	-	-	-	8E-4	8E-3
37	Rubidium-81m[2]	D, all compounds	2E+5	3E+5	1E-4	5E-7	-	-
			St. wall (3E+5)	-	-	-	4E-3	4E-2
37	Rubidium-81	D, all compounds	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
37	Rubidium-82m	D, all compounds	1E+4	2E+4	7E-6	2E-8	2E-4	2E-3
37	Rubidium-83	D, all compounds	6E+2	1E+3	4E-7	1E-9	9E-6	9E-5
37	Rubidium-84	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-86	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-87	D, all compounds	1E+3	2E+3	6E-7	2E-9	1E-5	1E-4
37	Rubidium-88[2]	D, all compounds	2E+4	6E+4	3E-5	9E-8	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
	Rubidium-89[2]	D, all compounds	4E+4	1E+5	6E-5	2E-7	-	-
			St. wall (6E+4)	-	-	-	9E-4	9E-3
38	Strontium-80[2]	D, all soluble compounds except $SrTiO_3$	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		Y, all insoluble compounds and $SrTiO_3$	-	1E+4	5E-6	2E-8	-	-
38	Strontium-81[2]	D, see ^{80}Sr	3E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see ^{80}Sr	2E+4	8E+4	3E-5	1E-7	-	-
38	Strontium-82	D, see ^{80}Sr	3E+2	4E+2	2E-7	6E-10	-	-
			LLI wall (2E+2)	-	-	-	3E-6	3E-5
		Y, see ^{80}Sr	2E+2	9E+1	4E-8	1E-10	-	-
38	Strontium-83	D, see ^{80}Sr	3E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, see ^{80}Sr	2E+3	4E+3	1E-6	5E-9	-	-
38	Strontium-85m[2]	D, see ^{80}Sr	2E+5	6E+5	3E-4	9E-7	3E-3	3E-2
		Y, see ^{80}Sr	-	8E+5	4E-4	1E-6	-	-
38	Strontium-85	D, see ^{80}Sr	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
		Y, see ^{80}Sr	-	2E+3	6E-7	2E-9	-	-
38	Strontium-87m	D, see ^{80}Sr	5E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see ^{80}Sr	4E+4	2E+5	6E-5	2E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values: Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values: Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values: Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations: Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations: Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers: Monthly Average Concentration (μCi/ml)
38	Strontium-89	D, see ^{80}Sr	6E+2	8E+2	4E-7	1E-9	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
		Y, see ^{80}Sr	5E+2	1E+2	6E-8	2E-10	-	-
38	Strontium-90	D, see ^{80}Sr	3E+1	2E+1	8E-9	-	-	-
			Bone surf (4E+1)	Bone surf (2E+1)	-	3E-11	5E-7	5E-6
		Y, see ^{80}Sr	-	4E+0	2E-9	6E-12	-	-
38	Strontium-91	D, see ^{80}Sr	2E+3	6E+3	2E-6	8E-9	2E-5	2E-4
		Y, see ^{80}Sr	-	4E+3	1E-6	5E-9	-	-
38	Strontium-92	D, see ^{80}Sr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{80}Sr	-	7E+3	3E-6	9E-9	-	-
39	Yttrium-86m[2]	W, all compounds except those given for Y	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		Y, oxides and hydroxides	-	5E+4	2E-5	8E-8	-	-
39	Yttrium-86	W, see ^{86m}Y	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4
		Y, see ^{86m}Y	-	3E+3	1E-6	5E-9	-	-
39	Yttrium-87	W, see ^{86m}Y	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		Y, see ^{86m}Y	-	3E+3	1E-6	5E-9	-	-
39	Yttrium-88	W, see ^{86m}Y	1E+3	3E+2	1E-7	3E-10	1E-5	1E-4
		Y, see ^{86m}Y	-	2E+2	1E-7	3E-10	-	-
39	Yttrium-90m	W, see ^{86m}Y	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
		Y, see ^{86m}Y	-	1E+4	5E-6	2E-8	-	-
39	Yttrium-90	W, see ^{86m}Y	4E+2	7E+2	3E-7	9E-10	-	-
			LLI wall (5E+2)	-	-	-	7E-6	7E-5
		Y, see ^{86m}Y	-	6E+2	3E-7	9E-10	-	-
39	Yttrium-91m[2]	W, see ^{86m}Y	1E+5	2E+5	1E-4	3E-7	2E-3	2E-2
		Y, see ^{86m}Y	-	2E+5	7E-5	2E-7	-	-
39	Yttrium-91	W, see ^{86m}Y	5E+2	2E+2	7E-8	2E-10	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
		Y, see ^{86m}Y	-	1E+2	5E-8	2E-10	-	-
39	Yttrium-92	W, see ^{86m}Y	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{86m}Y	-	8E+3	3E-6	1E-8	-	-
39	Yttrium-93	W, see ^{86m}Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, see ^{86m}Y	-	2E+3	1E-6	3E-9	-	-
39	Yttrium-94[2]	W, see ^{86m}Y	2E+4	8E+4	3E-5	1E-7	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		Y, see ^{86m}Y	-	8E+4	3E-5	1E-7	-	-
39	Yttrium-95[2]	W, see ^{86m}Y	4E+4	2E+5	6E-5	2E-7	-	-
			St. wall (5E+4)	-	-	-	7E-4	7E-3
		Y, see ^{86m}Y	-	1E+5	6E-5	2E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values: Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values: Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values: Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations: Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations: Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers: Monthly Average Concentration (μCi/ml)
40	Zirconium-86	D, all compounds except those given for W and Y	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, oxides, hydroxides, halides, and nitrates	-	3E+3	1E-6	4E-9	-	-
		Y, carbide	-	2E+3	1E-6	3E-9	-	-
40	Zirconium-88	D, see ^{86}Zr	4E+3	2E+2	9E-8	3E-10	5E-5	5E-4
		W, see ^{86}Zr	-	5E+2	2E-7	7E-10	-	-
		Y, see ^{86}Zr	-	3E+2	1E-7	4E-10	-	-
40	Zirconium-89	D, see ^{86}Zr	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{86}Zr	-	2E+3	1E-6	3E-9	-	-
		Y, see ^{86}Zr	-	2E+3	1E-6	3E-9	-	-
40	Zirconium-93	D, see ^{86}Zr	1E+3 Bone surf (3E+3)	6E+0 Bone surf (2E+1)	3E-9	-	-	-
		W, see ^{86}Zr	-	2E+1 Bone surf (6E+1)	1E-8	2E-11 -	4E-5 -	4E-4 -
		Y, see ^{86}Zr	-	6E+1 Bone surf (7E+1)	2E-8	9E-11 -	- -	- -
40	Zirconium-95	D, see ^{86}Zr	1E+3	1E+2 Bone surf (3E+2)	5E-8	-	2E-5	2E-4
		W, see ^{86}Zr	-	4E+2	2E-7	4E-10 5E-10	- -	- -
		Y, see ^{86}Zr	-	3E+2	1E-7	4E-10	-	-
	Zirconium-97	D, see ^{86}Zr	6E+2	2E+3	8E-7	3E-9	9E-6	9E-5
		W, see ^{86}Zr	-	1E+3	6E-7	2E-9	-	-
		Y, see ^{86}Zr	-	1E+3	5E-7	2E-9	-	-
	Niobium-88[2]	W, all compounds except those given for Y	5E+4 St. wall (7E+4)	2E+5 -	9E-5 -	3E-7 -	- 1E-3	- 1E-2
		Y, oxides and hydroxides	-	2E+5	9E-5	3E-7	-	-
41	Niobium-89a[2] (66 min)	W, see ^{88}Nb	1E+4	4E+4	2E-5	6E-8	1E-4	1E-3
		Y, see ^{88}Nb	-	4E+4	2E-5	5E-8	-	-
	Niobium-89 (122 min)	W, see ^{88}Nb	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see ^{88}Nb	-	2E+4	6E-6	2E-8	-	-
	Niobium-90	W, see ^{88}Nb	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		Y, see ^{88}Nb	-	2E+3	1E-6	3E-9	-	-
	Niobium-93m	W, see ^{88}Nb	9E+3 LLI wall (1E+4)	2E+3 -	8E-7 -	3E-9 -	- 2E-4	- 2E-3
		Y, see ^{88}Nb	-	2E+2	7E-8	2E-10	-	-
41	Niobium-94	W, see ^{88}Nb	9E+2	2E+2	8E-8	3E-10	1E-5	1E-4
		Y, see ^{88}Nb	-	2E+1	6E-9	2E-11	-	-
41	Niobium-95m	W, see ^{88}Nb	2E+3 LLI wall (2E+3)	3E+3 -	1E-6 -	4E-9 -	- 3E-5	- 3E-4
		Y, see ^{88}Nb	-	2E+3	9E-7	3E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
41	Niobium-95	W, see ^{88}Nb	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		Y, see ^{88}Nb	-	1E+3	5E-7	2E-9	-	-
41	Niobium-96	W, see ^{88}Nb	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, see ^{88}Nb	-	2E+3	1E-6	3E-9	-	-
41	Niobium-97[2]	W, see ^{88}Nb	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see ^{88}Nb	-	7E+4	3E-5	1E-7	-	-
41	Niobium-98[2]	W, see ^{88}Nb	1E+4	5E+4	2E-5	8E-8	2E-4	2E-3
		Y, see ^{88}Nb	-	5E+4	2E-5	7E-8	-	-
42	Molybdenum-90	D, all compounds except those given for Y	4E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, oxides, hydroxides, and MoS_2	2E+3	5E+3	2E-6	6E-9	-	-
42	Molybdenum-93m	D, see ^{90}Mo	9E+3	2E+4	7E-6	2E-8	6E-5	6E-4
		Y, see ^{90}Mo	4E+3	1E+4	6E-6	2E-8	-	-
42	Molybdenum-93	D, see ^{90}Mo	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
		Y, see ^{90}Mo	2E+4	2E+2	8E-8	2E-10	-	-
42	Molybdenum-99	D, see ^{90}Mo	2E+3	3E+3	1E-6	4E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{90}Mo	1E+3	1E+3	6E-7	2E-9	-	-
42	Molybdenum-101[2]	D, see ^{90}Mo	4E+4	1E+5	6E-5	2E-7	-	-
			St. wall (5E+4)	-	-	-	7E-4	7E-3
		Y, see ^{90}Mo	-	1E+5	6E-5	2E-7	-	-
43	Technetium-93m[2]	D, all compounds except those given for W	7E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, and nitrates	-	3E+5	1E-4	4E-7	-	-
43	Technetium-93	D, see ^{93m}Tc	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
		W, see ^{93m}Tc	-	1E+5	4E-5	1E-7	-	-
43	Technetium-94m[2]	D, see ^{93m}Tc	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
		W, see ^{93m}Tc	-	6E+4	2E-5	8E-8	-	-
43	Technetium-94	D, see ^{93m}Tc	9E+3	2E+4	8E-6	3E-8	1E-4	1E-3
		W, see ^{93m}Tc	-	2E+4	1E-5	3E-8	-	-
43	Technetium-95m	D, see ^{93m}Tc	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
		W, see ^{93m}Tc	-	2E+3	8E-7	3E-9	-	-
43	Technetium-95	D, see ^{93m}Tc	1E+4	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{93m}Tc	-	2E+4	8E-6	3E-8	-	-
43	Technetium-96m[2]	D, see ^{93m}Tc	2E+5	3E+5	1E-4	4E-7	2E-3	2E-2
		W, see ^{93m}Tc	-	2E+5	1E-4	3E-7	-	-
43	Technetium-96	D, see ^{93m}Tc	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		W, see ^{93m}Tc	-	2E+3	9E-7	3E-9	-	-
43	Technetium-97m	D, see ^{93m}Tc	5E+3	7E+3	3E-6	-	6E-5	6E-4
			-	St. wall (7E+3)	-	1E-8	-	-
		W, see ^{93m}Tc	-	1E+3	5E-7	2E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values: Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values: Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values: Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations: Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations: Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers: Monthly Average Concentration (μCi/ml)
43	Technetium-97	D, see ^{93m}Tc	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
		W, see ^{93m}Tc	-	6E+3	2E-6	8E-9	-	-
43	Technetium-98	D, see ^{93m}Tc	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see ^{93m}Tc	-	3E+2	1E-7	4E-10	-	-
43	Technetium-99m	D, see ^{93m}Tc	8E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, see ^{93m}Tc	-	2E+5	1E-4	3E-7	-	-
43	Technetium-99	D, see ^{93m}Tc	4E+3	5E+3	2E-6	-	6E-5	6E-4
			-	St. wall (6E+3)	-	8E-9	-	-
		W, see ^{93m}Tc	-	7E+2	3E-7	9E-10	-	-
43	Technetium-101[2]	D, see ^{93m}Tc	9E+4	3E+5	1E-4	5E-7	-	-
			St. wall (1E+5)	-	-	-	2E-3	2E-2
		W, see ^{93m}Tc	-	4E+5	2E-4	5E-7	-	-
43	Technetium-104[2]	D, see ^{93m}Tc	2E+4	7E+4	3E-5	1E-7	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		W, see ^{93m}Tc	-	9E+4	4E-5	1E-7	-	-
44	Ruthenium-94[2]	D, all compounds except those given for W and Y	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, halides	-	6E+4	3E-5	9E-8	-	-
		Y, oxides and hydroxides	-	6E+4	2E-5	8E-8	-	-
44	Ruthenium-97	D, see ^{94}Ru	8E+3	2E+4	8E-6	3E-8	1E-4	1E-3
		W, see ^{94}Ru	-	1E+4	5E-6	2E-8	-	-
		Y, see ^{94}Ru	-	1E+4	5E-6	2E-8	-	-
44	Ruthenium-103	D, see ^{94}Ru	2E+3	2E+3	7E-7	2E-9	3E-5	3E-4
		W, see ^{94}Ru	-	1E+3	4E-7	1E-9	-	-
		Y, see ^{94}Ru	-	6E+2	3E-7	9E-10	-	-
44	Ruthenium-105	D, see ^{94}Ru	5E+3	1E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{94}Ru	-	1E+4	6E-6	2E-8	-	-
		Y, see ^{94}Ru	-	1E+4	5E-6	2E-8	-	-
44	Ruthenium-106	D, see ^{94}Ru	2E+2	9E+1	4E-8	1E-10	-	-
			LLI wall (2E+2)	-	-	-	3E-6	3E-5
		W, see ^{94}Ru	-	5E+1	2E-8	8E-11	-	-
		Y, see ^{94}Ru	-	1E+1	5E-9	2E-11	-	-
45	Rhodium-99	D, all compounds except those given for W and Y	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3
		W, halides	-	8E+4	3E-5	1E-7	-	-
		Y, oxides and hydroxides	-	7E+4	3E-5	9E-8	-	-
45	Rhodium-99	D, see ^{99m}Rh	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{99m}Rh	-	2E+3	9E-7	3E-9	-	-
		Y, see ^{99m}Rh	-	2E+3	8E-7	3E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
45	Rhodium-100	D, see ^{99m}Rh	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see ^{99m}Rh	-	4E+3	2E-6	6E-9	-	-
		Y, see ^{99m}Rh	-	4E+3	2E-6	5E-9	-	-
45	Rhodium-101m	D, see ^{99m}Rh	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see ^{99m}Rh	-	8E+3	4E-6	1E-8	-	-
		Y, see ^{99m}Rh	-	8E+3	3E-6	1E-8	-	-
45	Rhodium-101	D, see ^{99m}Rh	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
		W, see ^{99m}Rh	-	8E+2	3E-7	1E-9	-	-
		Y, see ^{99m}Rh	-	2E+2	6E-8	2E-10	-	-
45	Rhodium-102m	D, see ^{99m}Rh	1E+3 LLI wall (3E+3)	5E+2	2E-7	7E-10	-	-
				-	-	-	2E-5	2E-4
		W, see ^{99m}Rh	-	4E+2	2E-7	5E-10	-	-
		Y, see ^{99m}Rh	-	1E+2	5E-8	2E-10	-	-
45	Rhodium-102	D, see ^{99m}Rh	6E+2	9E+1	4E-8	1E-10	8E-6	8E-5
		W, see ^{99m}Rh	-	2E+2	7E-8	2E-10	-	-
		Y, see ^{99m}Rh	-	6E+1	2E-8	8E-11	-	-
45	Rhodium-103m[2]	D, see ^{99m}Rh	4E+5	1E+6	5E-4	2E-6	6E-3	6E-2
		W, see ^{99m}Rh	-	1E+6	5E-4	2E-6	-	-
		Y, see ^{99m}Rh	-	1E+6	5E-4	2E-6	-	-
45	Rhodium-105	D, see ^{99m}Rh	4E+3 LLI wall (4E+3)	1E+4	5E-6	2E-8	-	-
				-	-	-	9E-9	9E-4
		W, see ^{99m}Rh	-	6E+3	3E-6	9E-9	-	-
		Y, see ^{99m}Rh	-	6E+3	2E-6	8E-9	-	-
45	Rhodium-106m	D, see ^{99m}Rh	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{99m}Rh	-	4E+4	2E-5	5E-8	-	-
		Y, see ^{99m}Rh	-	4E+4	1E-5	9E-8	-	-
45	Rhodium-107[2]	D, see ^{99m}Rh	7E+4 St. wall (9E+6)	2E+5	1E-4	3E-7	-	-
				-	-	-	1E-3	1E-2
		W, see ^{99m}Rh	-	3E+5	1E-4	4E-7	-	-
		Y, see ^{99m}Rh	-	3E+5	1E-4	3E-7	-	-
46	Palladium-100	D, all compounds except those given for W and Y	1E+3	1E+3	6E-7	2E-9	2E-5	2E-4
		W, nitrates	-	1E+3	5E-7	2E-9	-	-
		Y, oxides and hydroxides	-	1E+3	6E-7	2E-9	-	-
46	Palladium-101	D, see ^{100}Pd	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{100}Pd	-	3E+4	1E-5	9E-8	-	-
		Y, see ^{100}Pd	-	3E+4	1E-5	4E-8	-	-
46	Palladium-103	D, see ^{100}Pd	6E+3 LLI wall (7E+3)	6E+3	3E-6	9E-9	-	-
				-	-	-	1E-4	1E-3
		W, see ^{100}Pd	-	4E+3	2E-6	6E-9	-	-
		Y, see ^{100}Pd	-	4E+3	1E-6	5E-9	-	-
46	Palladium-107	D, see ^{100}Pd	3E+4 LLI wall (4E+4)	2E+4 Kidneys (2E+4)	9E-6	-	-	-
				-	-	3E-8	5E-4	5E-3
		W, see ^{100}Pd	-	7E+3	3E-6	1E-8	-	-
		Y, see ^{100}Pd	-	4E+2	2E-7	6E-10	-	-

c	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
46	Palladium-109	D, see ^{100}Pd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
		W, see ^{100}Pd	-	5E+3	2E-6	8E-9	-	-
		Y, see ^{100}Pd	-	5E+3	2E-6	6E-9	-	-
47	Silver-102[2]	D, all compounds except those given for W and Y	5E+4	2E+5	8E-6	2E-7	-	-
			St. wall (6E+4)	-	-	-	9E-4	9E-3
		W, nitrates and sulfides	-	2E+5	9E-5	3E-7	-	-
		Y, oxides and hydroxides	-	2E+5	8E-5	3E-7	-	-
47	Silver-103[2]	D, see ^{102}Ag	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see ^{102}Ag	-	1E+5	5E-5	2E-7	-	-
		Y, see ^{102}Ag	-	1E+5	5E-5	2E-7	-	-
47	Silver-104m[2]	D, see ^{102}Ag	3E+4	9E+4	4E-5	1E-7	4E-4	4E-3
		W, see ^{102}Ag	-	1E+5	5E-5	2E-7	-	-
		Y, see ^{102}Ag	-	1E+5	5E-5	2E-7	-	-
47	Silver-104[2]	D, see ^{102}Ag	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{102}Ag	-	1E+5	6E-5	2E-7	-	-
		Y, see ^{102}Ag	-	1E+5	6E-5	2E-7	-	-
47	Silver-105	D, see ^{102}Ag	3E+3	1E+3	4E-7	1E-9	4E-5	4E-4
		W, see ^{102}Ag	-	2E+3	7E-7	2E-9	-	-
		Y, see ^{102}Ag	-	2E+3	7E-7	2E-9	-	-
47	Silver-106m	D, see ^{102}Ag	8E+2	7E+2	3E-7	1E-9	1E-5	1E-4
		W, see ^{102}Ag	-	9E+2	4E-7	1E-9	-	-
		Y, see ^{102}Ag	-	9E+2	4E-7	1E-9	-	-
	Silver-106[2]	D, see ^{102}Ag	6E+4	2E+5	8E-5	3E-7	-	-
			St. wall (6E+4)	-	-	-	9E-4	9E-3
		W, see ^{102}Ag	-	2E+5	9E-5	3E-7	-	-
		Y, see ^{102}Ag	-	2E+5	8E-5	3E-7	-	-
47	Silver-108m	D, see ^{102}Ag	6E+2	2E+2	8E-8	3E-10	9E-6	9E-5
		W, see ^{102}Ag	-	3E+2	1E-7	4E-10	-	-
		Y, see ^{102}Ag	-	2E+1	1E-8	3E-11	-	-
	Silver-110m	D, see ^{102}Ag	5E+2	1E+2	5E-8	2E-10	6E-6	6E-5
		W, see ^{102}Ag	-	2E+2	8E-8	3E-10	-	-
		Y, see ^{102}Ag	-	9E+1	4E-8	1E-10	-	-
	Silver-111	D, see ^{102}Ag	9E+2	2E+3	6E-7	-	-	-
			LLI wall (1E+3)	Liver (2E+3)	-	2E-9	2E-5	2E-4
		W, see ^{102}Ag	-	9E+2	4E-7	1E-9	-	-
		Y, see ^{102}Ag	-	9E+2	4E-7	1E-9	-	-
47	Silver-112	D, see ^{102}Ag	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{102}Ag	-	1E+4	4E-6	1E-8	-	-
		Y, see ^{102}Ag	-	9E+3	4E-6	1E-8	-	-

Atomic No.	Radionuclide	Class	Table 2 Occupational Values: Col. 1 Oral Ingestion ALI (μCi)	Table 2 Occupational Values: Col. 2 Inhalation ALI (μCi)	Table 2 Occupational Values: Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations: Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations: Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers: Monthly Average Concentration (μCi/ml)
47	Silver-115[2]	D, see ^{102}Ag	3E+6 St. wall (3E+6)	9E+6	4E-5	1E-7	-	-
		W, see ^{102}Ag	-	-	-	-	4E-4	4E-3
		Y, see ^{102}Ag	-	9E+6	4E-5	1E-7	-	-
48	Cadmium-104[2]	D, all compounds except those given for W and Y	2E+4	8E+6	3E-5	1E-7	-	-
		W, sulfides, halides, and nitrates	-	7E+4	3E-5	9E-8	3E-4	3E-3
		Y, oxides and hydroxides	-	1E+5	5E-5	2E-7	-	-
48	Cadmium-107	D, see ^{104}Cd	2E+4	1E+5	5E-5	2E-7	-	-
		W, see ^{104}Cd	-	5E+4	2E-5	7E-8	-	-
		Y, see ^{104}Cd	-	6E+4	2E-5	8E-8	3E-4	3E-3
48	Cadmium-109	D, see ^{104}Cd	3E+2 Kidneys (4E+2)	4E+3 Kidneys (5E+1)	1E-8	-	-	-
		W, see ^{104}Cd	-	2E+2 Kidneys (1E+2)	-	7E-11	6E-6	6E-5
		Y, see ^{104}Cd	-	1E+2	5E-8	2E-10	-	-
48	Cadmium-113m	D, see ^{104}Cd	2E+1 Kidneys (4E+1)	2E+0 Kidneys (4E+0)	1E-9	-	-	-
		W, see ^{104}Cd	-	8E+0 Kidneys (1E+1)	4E-9	5E-12	5E-7	5E-6
		Y, see ^{104}Cd	-	1E+1	5E-9	2E-11	-	-
48	Cadmium-113	D, see ^{104}Cd	2E+1 Kidneys (3E+1)	2E+0 Kidneys (3E+0)	9E-10	-	-	-
		W, see ^{104}Cd	-	8E+0 Kidneys (1E+1)	3E-9	5E-12	4E-7	4E-6
		Y, see ^{104}Cd	-	1E+1	6E-9	2E-11	-	-
48	Cadmium-115m	D, see ^{104}Cd	3E+2	9E+1 Kidneys (8E+1)	2E-8	-	4E-6	4E-5
		W, see ^{104}Cd	-	1E+2	5E-8	1E-10	-	-
		Y, see ^{104}Cd	-	1E+2	6E-8	2E-10	-	-
48	Cadmium-115	D, see ^{104}Cd	9E+2 LLI wall (1E+3)	1E+3	6E-7	2E-9	-	-
		W, see ^{104}Cd	-	-	-	-	1E-5	1E-4
		Y, see ^{104}Cd	-	1E+3	5E-7	2E-9	-	-
48	Cadmium-117m	D, see ^{104}Cd	5E+3	1E+3	6E-7	2E-9	-	-
		W, see ^{104}Cd	-	1E+4	5E-6	2E-8	6E-5	6E-4
		Y, see ^{104}Cd	-	2E+4	7E-6	2E-8	-	-
			-	1E+4	6E-6	2E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values: Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values: Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values: Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations: Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations: Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers: Monthly Average Concentration (μCi/ml)
48	Cadmium-117	D, see ^{104}Cd	5E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		W, see ^{104}Cd	-	2E+4	7E-6	2E-8	-	-
		Y, see ^{104}Cd	-	1E+4	6E-6	2E-8	-	-
49	Indium-109	D, all compounds except those given for W	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
		W, oxides, hydroxides, halides, and nitrates	-	6E+4	3E-5	9E-8	-	-
49	Indium-110[2] (69.1 min)	D, see ^{109}In	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{109}In	-	6E+4	2E-5	8E-8	-	-
49	Indium-110 (4.9 h)	D, see ^{109}In	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4
		W, see ^{109}In	-	2E+4	8E-6	3E-8	-	-
49	Indium-111	D, see ^{109}In	4E+3	6E+3	3E-6	9E-9	6E-5	6E-4
		W, see ^{109}In	-	6E+3	3E-6	9E-9	-	-
49	Indium-112[2]	D, see ^{109}In	2E+5	6E+5	3E-4	9E-7	2E-3	2E-2
		W, see ^{109}In	-	7E+5	3E-4	1E-6	-	-
49	Indium-113m[2]	D, see ^{109}In	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
		W, see ^{109}In	-	2E+5	8E-5	3E-7	-	-
49	Indium-114m	D, see ^{109}In	3E+2 LLI wall (4E+2)	6E+1	3E-8	9E-11	-	-
		W, see ^{109}In	-	1E+2	4E-8	1E-10	5E-6 -	5E-5 -
	Indium-115m	D, see ^{109}In	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{109}In	-	5E+4	2E-5	7E-8	-	-
	Indium-115	D, see ^{109}In	4E+1	1E+0	6E-10	2E-12	5E-7	5E-6
		W, see ^{109}In	-	5E+0	2E-9	8E-12	-	-
49	Indium-116m[2]	D, see ^{109}In	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{109}In	-	1E+5	5E-5	2E-7	-	-
49	Indium-117m[2]	D, see ^{109}In	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{109}In	-	4E+4	2E-5	6E-8	-	-
49	Indium-117[2]	D, see ^{109}In	6E+4	2E+5	7E-5	2E-7	8E-4	8E-3
		W, see ^{109}In	-	2E+5	9E-5	3E-7	-	-
	Indium-119m[2]	D, see ^{109}In	4E+4 St. wall (5E+4)	1E+5	5E-5	2E-7	-	-
		W, see ^{109}In	-	1E+5	6E-5	2E-7	7E-4 -	7E-3 -
50	Tin-110	D, all compounds except those given for W	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
		W, sulfides, oxides, hydroxides, halides, nitrates, and stannic phosphate	-	1E+4	5E-6	2E-8	-	-
50	Tin-111[2]	D, see ^{110}Sn	7E+4	2E+5	9E-5	3E-7	1E-3	1E-2
		W, see ^{110}Sn	-	3E+5	1E-4	4E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
50	Tin-113	D, see ^{110}Sn	2E+3	1E+3	5E-7	2E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
		W, see ^{110}Sn	-	5E+2	2E-7	8E-10	-	-
50	Tin-117m	D, see ^{110}Sn	2E+3	1E+3	5E-7	-	-	-
			LLI wall (2E+3)	Bone surf (2E+3)	-	3E-9	3E-5	3E-4
		W, see ^{110}Sn	-	1E+3	6E-7	2E-9	-	-
50	Tin-119m	D, see ^{110}Sn	3E+3	2E+3	1E-6	3E-9	-	-
			LLI wall (4E+3)	-	-	-	6E-5	6E-4
		W, see ^{110}Sn	-	1E+3	4E-7	1E-9	-	-
50	Tin-121m	D, see ^{110}Sn	3E+3	9E+2	4E-7	1E-9	-	-
			LLI wall (4E+3)	-	-	-	5E-5	5E-4
		W, see ^{110}Sn	-	5E+2	2E-7	8E-10	-	-
50	Tin-121	D, see ^{110}Sn	6E+3	2E+4	6E-6	2E-8	-	-
			LLI wall (6E+3)	-	-	-	8E-5	8E-4
		W, see ^{110}Sn	-	1E+4	5E-6	2E-8	-	-
50	Tin-123m[2]	D, see ^{110}Sn	5E+4	1E+5	5E-5	2E-7	7E-4	7E-3
		W, see ^{110}Sn	-	1E+5	6E-5	2E-7	-	-
50	Tin-123	D, see ^{110}Sn	5E+2	6E+2	3E-7	9E-10	-	-
			LLI wall (6E+2)	-	-	-	9E-6	9E-5
		W, see ^{110}Sn	-	2E+2	7E-8	2E-10	-	-
50	Tin-125	D, see ^{110}Sn	4E+2	9E+2	4E-7	1E-9	-	-
			LLI wall (5E+2)	-	-	-	6E-6	6E-5
		W, see ^{110}Sn	-	4E+2	1E-7	5E-10	-	-
50	Tin-126	D, see ^{110}Sn	3E+2	6E+1	2E-8	8E-11	4E-6	4E-5
		W, see ^{110}Sn	-	7E+1	3E-8	9E-11	-	-
50	Tin-127	D, see ^{110}Sn	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		W, see ^{110}Sn	-	2E+4	8E-6	3E-8	-	-
50	Tin-128[2]	D, see ^{110}Sn	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{110}Sn	-	4E+4	1E-5	5E-8	-	-
51	Antimony-115[2]	D, all compounds except those given for W	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, sulfides, sulfates, and nitrates	-	3E+5	1E-4	4E-7	-	-
51	Antimony-116m[2]	D, see ^{115}Sb	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{115}Sb	-	1E+5	6E-5	2E-7	-	-
51	Antimony-116[2]	D, see ^{115}Sb	7E+4	3E+5	1E-4	4E-7	-	-
			St. wall (9E+4)	-	-	-	1E-3	1E-2
		W, see ^{115}Sb	-	3E+5	1E-4	5E-7	-	-
51	Antimony-117	D, see ^{115}Sb	7E+4	2E+5	9E-5	3E-7	9E-4	9E-3
		W, see ^{115}Sb	-	3E+5	1E-4	4E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
51	Antimony-118m	D, see ^{115}Sb	6E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		W, see ^{115}Sb	5E+3	2E+4	9E-6	3E-8	-	-
51	Antimony-119	D, see ^{115}Sb	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{115}Sb	2E+4	3E+4	1E-5	4E-8	-	-
51	Antimony-120[2] (16 min)	D, see ^{115}Sb	1E+5	4E+5	2E-4	6E-7	-	-
			St. wall (2E+5)	-	-	-	2E-3	2E-2
		W, see ^{115}Sb	-	5E+5	2E-4	7E-7	-	-
51	Antimony-120 (5.76 d)	D, see ^{115}Sb	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
		W, see ^{115}Sb	9E+2	1E+3	5E-7	2E-9	-	-
51	Antimony-122	D, see ^{115}Sb	8E+2	2E+3	1E-6	3E-9	-	-
			LLI wall (8E+2)	-	-	-	1E-5	1E-4
		W, see ^{115}Sb	7E+2	1E+3	4E-7	2E-9	-	-
51	Antimony-124a[2]	D, see ^{115}Sb	3E+5	8E+5	4E-4	1E-6	3E-3	3E-2
		W, see ^{115}Sb	2E+5	6E+5	2E-4	8E-7	-	-
51	Antimony-124	D, see ^{115}Sb	6E+2	9E+2	4E-7	1E-9	7E-6	7E-5
		W, see ^{115}Sb	5E+2	2E+2	1E-7	3E-10	-	-
51	Antimony-125	D, see ^{115}Sb	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
		W, see ^{115}Sb	-	5E+2	2E-7	7E-10	-	-
51	Antimony-126a[2]	D, see ^{115}Sb	5E+4	2E+5	8E-5	3E-7	-	-
			St. wall (7E+4)	-	-	-	9E-4	9E-3
		W, see ^{115}Sb	-	2E+5	8E-5	3E-7	-	-
	Antimony-126	D, see ^{115}Sb	6E+2	1E+3	5E-7	2E-9	7E-6	7E-5
		W, see ^{115}Sb	5E+2	5E+2	2E-7	7E-10	-	-
51	Antimony-127	D, see ^{115}Sb	8E+2	2E+3	9E-7	3E-9	-	-
			LLI wall (8E+2)	-	-	-	1E-5	1E-4
		W, see ^{115}Sb	7E+2	9E+2	4E-7	1E-9	-	-
51	Antimony-128[2] (10.4 min)	D, see ^{115}Sb	8E+4	4E+5	2E-4	5E-7	-	-
			St. wall (1E+5)	-	-	-	1E-3	1E-2
		W, see ^{115}Sb	-	4E+5	2E-4	6E-7	-	-
	Antimony-128 (9.01 h)	D, see ^{115}Sb	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, see ^{115}Sb	-	3E+3	1E-6	5E-9	-	-
	Antimony-129	D, see ^{115}Sb	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		W, see ^{115}Sb	-	9E+3	4E-6	1E-8	-	-
51	Antimony-130[2]	D, see ^{115}Sb	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		W, see ^{115}Sb	-	8E+4	3E-5	1E-7	-	-
51	Antimony-131[2]	D, see ^{115}Sb	1E+4	2E+4	1E-5	-	-	-
			Thyroid (2E+4)	Thyroid (4E+4)	-	6E-8	2E-4	2E-3
		W, see ^{115}Sb	-	2E+4	1E-5		-	-
			-	Thyroid (4E+4)	-	6E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
52	Tellurium-116	D, all compounds except those given for W	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, oxides, hydroxides, and nitrates	-	3E+4	1E-5	4E-8	-	-
52	Tellurium-121m	D, see ^{116}Te	5E+2 Bone surf (7E+2)	2E+2 Bone surf (4E+2)	8E-8 -	- 5E-10	- 1E-5	- 1E-4
		W, see ^{116}Te	-	4E+2	2E-7	6E-10	-	-
52	Tellurium-121	D, see ^{116}Te	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see ^{116}Te	-	3E+3	1E-6	4E-9	-	-
52	Tellurium-123m	D, see ^{116}Te	6E+2 Bone surf (1E+3)	2E+2 Bone surf (5E+2)	9E-8 -	- 8E-10	- 1E-5	- 1E-4
		W, see ^{116}Te	-	5E+2	2E-7	8E-10	-	-
52	Tellurium-123	D, see ^{116}Te	5E+2 Bone surf (1E+3)	2E+2 Bone surf (5E+2)	8E-8 -	- 7E-10	- 2E-5	- 2E-4
		W, see ^{116}Te	-	4E+2 Bone surf (1E+3)	2E-7 -	- 2E-9	- -	- -
52	Tellurium-125m	D, see ^{116}Te	1E+3 Bone surf (1E+3)	4E+2 Bone surf (1E+3)	2E-7 -	- 1E-9	- 2E-5	- 2E-4
		W, see ^{116}Te	-	7E+2	3E-7	1E-9	-	-
52	Tellurium-127m	D, see ^{116}Te	6E+2	3E+2 Bone surf (4E+2)	1E-7 -	- 6E-10	9E-6 -	9E-5 -
		W, see ^{116}Te	-	3E+2	1E-7	4E-10	-	-
52	Tellurium-127	D, see ^{116}Te	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{116}Te	-	2E+4	7E-6	2E-8	-	-
52	Tellurium-129m	D, see ^{116}Te	5E+2	6E+2	3E-7	9E-10	7E-6	7E-5
		W, see ^{116}Te	-	2E+2	1E-7	3E-10	-	-
52	Tellurium-129[2]	D, see ^{116}Te	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
		W, see ^{116}Te	-	7E+4	3E-5	1E-7	-	-
52	Tellurium-131m	D, see ^{116}Te	3E+2 Thyroid (6E+2)	4E+2 Thyroid (1E+3)	2E-7 -	- 2E-9	- 8E-6	- 8E-5
		W, see ^{116}Te	-	4E+2 Thyroid (9E+2)	2E-7 -	- 1E-9	- -	- -
52	Tellurium-131[2]	D, see ^{116}Te	3E+3 Thyroid (6E+3)	5E+3 Thyroid (1E+4)	2E-6 -	- 2E-8	- 8E-5	- 8E-4
		W, see ^{116}Te	-	5E+3 Thyroid (1E+4)	2E-6 -	- 2E-8	- -	- -

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
52	Tellurium-132	D, see ^{116}Te	2E+2 Thyroid (7E+2)	2E+2 Thyroid (8E+2)	9E-8	-	-	-
		W, see ^{116}Te	-	2E+2 Thyroid (6E+2)	9E-8 -	1E-9 -	9E-6 -	9E-5 -
52	Tellurium-133m[2]	D, see ^{116}Te	3E+3 Thyroid (6E+3)	5E+3 Thyroid (1E+4)	2E-6	-	-	-
		W, see ^{116}Te	-	5E+3 Thyroid (1E+4)	2E-6 -	2E-8 -	9E-5 -	9E-4 -
52	Tellurium-133[2]	D, see ^{116}Te	1E+4 Thyroid (3E+4)	2E+4 Thyroid (6E+4)	9E-6	-	-	-
		W, see ^{116}Te	-	2E+4 Thyroid (6E+4)	9E-6 -	8E-8 -	4E-4 -	4E-3 -
52	Tellurium-134[2]	D, see ^{116}Te	2E+4 Thyroid (2E+4)	2E+4 Thyroid (5E+4)	1E-5	-	-	-
		W, see ^{116}Te	-	2E+4 Thyroid (5E+4)	1E-5 -	7E-8 -	3E-4 -	3E-3 -
53	Iodine-120m[2]	D, all compounds	1E+4 Thyroid (1E+4)	2E+4 -	9E-6 -	3E-8 -	2E-4	2E-3
	Iodine-120[2]	D, all compounds	4E+3 Thyroid (8E+3)	9E+3 Thyroid (1E+4)	4E-6	-	-	-
53	Iodine-121	D, all compounds	1E+4 Thyroid (3E+4)	2E+4 Thyroid (5E+4)	8E-6 -	2E-8 -	1E-4 -	1E-3 -
53	Iodine-123	D, all compounds	3E+3 Thyroid (1E+4)	6E+3 Thyroid (2E+4)	3E-6	-	-	-
53	Iodine-124	D, all compounds	5E+1 Thyroid (2E+2)	8E+1 Thyroid (3E+2)	3E-8 -	2E-8 -	1E-4 -	1E-3 -
	Iodine-125	D, all compounds	4E+1 Thyroid (1E+2)	6E+1 Thyroid (2E+2)	3E-8 -	4E-10 -	2E-6 -	2E-5 -
53	Iodine-126	D, all compounds	2E+1 Thyroid (7E+1)	4E+1 Thyroid (1E+2)	1E-8 -	3E-10 -	2E-6 -	2E-5 -
53	Iodine-128[2]	D, all compounds	4E+4 St. wall (6E+4)	1E+5 -	5E-5 -	2E-10 -	1E-6 -	1E-5 -
53	Iodine-129	D, all compounds	5E+0 Thyroid (2E+1)	9E+0 Thyroid (3E+1)	4E-9 -	2E-7 -	8E-4 -	8E-3 -
						4E-11 -	2E-7 -	2E-6 -

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentrati (μCi/ml)
53	Iodine-130	D, all compounds	4E+2 Thyroid (1E+3)	7E+2 Thyroid (2E+3)	3E-7 -	- 3E-9	- 2E-5	- 2E-4
53	Iodine-131	D, all compounds	3E+1 Thyroid (9E+1)	5E+1 Thyroid (2E+2)	2E-8 -	- 2E-10	- 1E-6	- 1E-5
53	Iodine-132m[2]	D, all compounds	4E+3 Thyroid (1E+4)	8E+3 Thyroid (2E+4)	4E-6 -	- 3E-8	- 1E-4	- 1E-3
53	Iodine-132	D, all compounds	4E+3 Thyroid (9E+3)	8E+3 Thyroid (1E+4)	3E-6 -	- 2E-8	- 1E-4	- 1E-3
53	Iodine-133	D, all compounds	1E+2 Thyroid (5E+2)	3E+2 Thyroid (9E+2)	1E-7 -	- 1E-9	- 7E-6	- 7E-5
53	Iodine-134[2]	D, all compounds	2E+4 Thyroid (3E+4)	5E+4 -	2E-5 -	6E-8 -	- 4E-4	- 4E-3
53	Iodine-135	D, all compounds	8E+2 Thyroid (3E+3)	2E+3 Thyroid (4E+3)	7E-7 -	- 6E-9	- 3E-5	- 3E-4
54	Xenon-120[2]	Submersion[1]	-	-	1E-5	4E-8	-	-
54	Xenon-121[2]	Submersion[1]	-	-	2E-6	1E-8	-	-
54	Xenon-122	Submersion[1]	-	-	7E-5	3E-7	-	-
54	Xenon-123	Submersion[1]	-	-	6E-6	3E-8	-	-
54	Xenon-125	Submersion[1]	-	-	2E-5	7E-8	-	-
54	Xenon-127	Submersion[1]	-	-	1E-5	6E-8	-	-
54	Xenon-129m	Submersion[1]	-	-	2E-4	9E-7	-	-
54	Xenon-131m	Submersion[1]	-	-	4E-4	2E-6	-	-
54	Xenon-133m	Submersion[1]	-	-	1E-4	6E-7	-	-
54	Xenon-133	Submersion[1]	-	-	1E-4	5E-7	-	-
54	Xenon-135m[2]	Submersion[1]	-	-	9E-6	4E-8	-	-
54	Xenon-135	Submersion[1]	-	-	1E-5	7E-8	-	-
54	Xenon-138[2]	Submersion[1]	-	-	4E-6	2E-8	-	-
55	Cesium-125[2]	D, all compounds	5E+4 St. wall (9E+4)	1E+5 -	6E-5 -	2E-7 -	- 1E-3	- 1E-4
55	Cesium-127	D, all compounds	6E+4	9E+4	4E-5	1E-7	9E-4	9E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
55	Cesium-129	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
55	Cesium-130[2]	D, all compounds	6E+4	2E+5	8E-5	3E-7	-	-
			St. wall (1E+5)	-	-	-	1E-3	1E-2
55	Cesium-131	D, all compounds	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
55	Cesium-132	D, all compounds	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
55	Cesium-134m	D, all compounds	1E+5	1E+5	6E-5	2E-7	-	-
			St. wall (1E+5)	-	-	-	2E-3	2E-2
55	Cesium-134	D, all compounds	7E+1	1E+2	4E-8	2E-10	9E-7	9E-6
55	Cesium-135m[2]	D, all compounds	1E+5	2E+5	8E-5	3E-7	1E-3	1E-2
55	Cesium-135	D, all compounds	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
55	Cesium-136	D, all compounds	4E+2	7E+2	3E-7	9E-10	6E-6	6E-5
55	Cesium-137	D, all compounds	1E+2	2E+2	6E-8	2E-10	1E-6	1E-5
55	Cesium-138[2]	D, all compounds	2E+4	6E+4	2E-5	8E-8	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
[illegible]	Barium-126[2]	D, all compounds	6E+3	2E+4	6E-6	2E-8	8E-5	8E-4
[illegible]	Barium-128	D, all compounds	5E+2	2E+3	7E-7	2E-9	7E-6	7E-5
56	Barium-131m[2]	D, all compounds	4E+5	1E+6	6E-4	2E-6	-	-
			St. wall (5E+5)	-	-	-	7E-3	7E-2
56	Barium-131	D, all compounds	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
56	Barium-133m	D, all compounds	2E+3	9E+3	4E-6	1E-8	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
56	Barium-133	D, all compounds	2E+3	7E+2	3E-7	9E-10	2E-5	2E-4
56	Barium-135m	D, all compounds	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
56	Barium-139[2]	D, all compounds	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
56	Barium-140	D, all compounds	5E+2	1E+3	6E-7	2E-9	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
56	Barium-141[2]	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
56	Barium-142[2]	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
57	Lanthanum-131[2]	D, all compounds except those given for W	5E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		W, oxides and hydroxides	-	2E+5	7E-5	2E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
57	Lanthanum-132	D, see ^{131}La	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
		W, see ^{131}La	-	1E+4	5E-6	2E-8	-	-
57	Lanthanum-135	D, see ^{131}La	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see ^{131}La	-	9E+4	4E-5	1E-7	-	-
57	Lanthanum-137	D, see ^{131}La	1E+4	6E+1 Liver	3E-8	-	2E-4	2E-3
			-	(7E+1)	-	1E-10	-	-
		W, see ^{131}La	-	3E+2	1E-7	-	-	-
			-	Liver (3E+2)	-	4E-10	-	-
57	Lanthanum-138	D, see ^{131}La	9E+2	4E+0	1E-9	5E-12	1E-5	1E-4
		W, see ^{131}La	-	1E+1	6E-9	2E-11	-	-
57	Lanthanum-140	D, see ^{131}La	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see ^{131}La	-	1E+3	5E-7	2E-9	-	-
57	Lanthanum-141	D, see ^{131}La	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		W, see ^{131}La	-	1E+4	5E-6	2E-8	-	-
57	Lanthanum-142[2]	D, see ^{131}La	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{131}La	-	3E+4	1E-5	5E-8	-	-
57	Lanthanum-143[2]	D, see ^{131}La	4E+4	1E+5	4E-5	1E-7	-	-
			St. wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{131}La	-	9E+4	4E-5	1E-7	-	-
58	Cerium-134	W, all compounds except those given for Y	5E+2	7E+2	3E-7	1E-9	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
		Y, oxides, hydroxides, and fluorides	-	7E+2	3E-7	9E-10	-	-
58	Cerium-135	W, see ^{134}Ce	2E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		Y, see ^{134}Ce	-	4E+3	1E-6	5E-9	-	-
58	Cerium-137m	W, see ^{134}Ce	2E+3	4E+3	2E-6	6E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
		Y, see ^{134}Ce	-	4E+3	2E-6	5E-9	-	-
58	Cerium-137	W, see ^{134}Ce	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
		Y, see ^{134}Ce	-	1E+5	5E-5	2E-7	-	-
58	Cerium-139	W, see ^{134}Ce	5E+3	8E+2	3E-7	1E-9	7E-5	7E-4
		Y, see ^{134}Ce	-	7E+2	3E-7	9E-10	-	-
58	Cerium-141	W, see ^{134}Ce	2E+3	7E+2	3E-7	1E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
		Y, see ^{134}Ce	-	6E+2	2E-7	8E-10	-	-
58	Cerium-143	W, see ^{134}Ce	1E+3	2E+3	8E-7	3E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{134}Ce	-	2E+3	7E-7	2E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
58	Cerium-144	W, see ^{134}Ce	2E+2	3E+1	1E-8	4E-11	-	-
			LLI wall (3E+2)	-	-	-	3E-6	3E-5
		Y, see ^{134}Ce	-	1E+1	6E-9	2E-11	-	-
59	Praseodymium-136[2]	W, all compounds except those given for Y	5E+4	2E+5	1E-4	3E-7	-	-
			St. wall (7E+4)	-	-	-	1E-3	1E-2
		Y, oxides, hydroxides, carbides, and fluorides	-	2E+5	9E-5	3E-7	-	-
59	Praseodymium-137[2]	W, see ^{136}Pr	4E+4	2E+5	6E-5	2E-7	5E-4	5E-3
		Y, see ^{136}Pr	-	1E+5	6E-5	2E-7	-	-
59	Praseodymium-138m	W, see ^{136}Pr	1E+4	5E+4	2E-5	8E-8	1E-4	1E-3
		Y, see ^{136}Pr	-	4E+4	2E-5	6E-8	-	-
59	Praseodymium-139	W, see ^{136}Pr	4E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see ^{136}Pr	-	1E+5	5E-5	2E-7	-	-
59	Praseodymium-142m[2]	W, see ^{136}Pr	8E+4	2E+5	7E-5	2E-7	1E-3	1E-2
		Y, see ^{136}Pr	-	1E+5	6E-5	2E-7	-	-
59	Praseodymium-142	W, see ^{136}Pr	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
		Y, see ^{136}Pr	-	2E+3	8E-7	3E-9	-	-
59	Praseodymium-143	W, see ^{136}Pr	9E+2	8E+2	3E-7	1E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{136}Pr	-	7E+2	3E-7	9E-10	-	-
59	Praseodymium-144[2]	W, see ^{136}Pr	3E+4	1E+5	5E-5	2E-7	-	-
			St. wall (4E+4)	-	-	-	6E-4	6E-3
		Y, see ^{136}Pr	-	1E+5	5E-5	2E-7	-	-
59	Praseodymium-145	W, see ^{136}Pr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{136}Pr	-	8E+3	3E-6	1E-8	-	-
59	Praseodymium-147[2]	W, see ^{136}Pr	5E+4	2E+5	8E-5	3E-7	-	-
			St. wall (8E+4)	-	-	-	1E-3	1E-2
		Y, see ^{136}Pr	-	2E+5	8E-5	3E-7	-	-
60	Neodymium-136[2]	W, all compounds except those given for Y	1E+4	6E+4	2E-5	8E-8	2E-4	2E-3
		Y, oxides, hydroxides, carbides, and fluorides	-	5E+4	2E-5	8E-8	-	-
60	Neodymium-138	W, see ^{136}Nd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
		Y, see ^{136}Nd	-	5E+3	2E-6	7E-9	-	-
60	Neodymium-139m	W, see ^{136}Nd	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4
		Y, see ^{136}Nd	-	1E+4	6E-6	2E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
60	Neodymium-139[2]	W, see ^{136}Nd	9E+4	3E+5	1E-4	5E-7	1E-3	1E-2
		Y, see ^{136}Nd	-	3E+5	1E-4	4E-7	-	-
			-					
60	Neodymium-141	W, see ^{136}Nd	2E+5	7E+5	3E-4	1E-6	2E-3	2E-2
		Y, see ^{136}Nd	-	6E+5	3E-4	9E-7	-	-
60	Neodymium-147	W, see ^{136}Nd	1E+3	9E+2	4E-7	1E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{136}Nd	-	8E+2	4E-7	1E-9	-	-
60	Neodymium-149[2]	W, see ^{136}Nd	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
		Y, see ^{136}Nd	-	2E+4	1E-5	3E-8	-	-
60	Neodymium-151[2]	W, see ^{136}Nd	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		Y, see ^{136}Nd	-	2E+5	8E-5	3E-7	-	-
61	Promethium-141[2]	W, all compounds except those given for Y	5E+4	2E+5	8E-5	3E-7	-	-
			St. wall (6E+4)	-	-	-	8E-4	8E-3
		Y, oxides, hydroxides, carbides, and fluorides	-	2E+5	7E-5	2E-7	-	-
61	Promethium-143	W, see ^{141}Pm	5E+3	6E+2	2E-7	8E-10	7E-5	7E-4
		Y, see ^{141}Pm	-	7E+2	3E-7	1E-9	-	-
61	Promethium-144	W, see ^{141}Pm	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		Y, see ^{141}Pm	-	1E+2	5E-8	2E-10	-	-
61	Promethium-145	W, see ^{141}Pm	1E+4	2E+2	7E-8	-	1E-4	1E-3
			-	Bone surf (2E+2)	-	3E-10	-	-
		Y, see ^{141}Pm	-	2E+2	8E-8	3E-10	-	-
61	Promethium-146	W, see ^{141}Pm	2E+3	5E+1	2E-8	7E-11	2E-5	2E-4
		Y, see ^{141}Pm	-	4E+1	2E-8	6E-11	-	-
61	Promethium-147	W, see ^{141}Pm	4E+3	1E+2	5E-8	-	-	-
			LLI wall (5E+3)	Bone surf (2E+2)	-	3E-10	7E-5	7E-4
		Y, see ^{141}Pm	-	1E+2	6E-8	2E-10	-	-
61	Promethium-148m	W, see ^{141}Pm	7E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		Y, see ^{141}Pm	-	3E+2	1E-7	5E-10	-	-
61	Promethium-148	W, see ^{141}Pm	4E+2	5E+2	2E-7	8E-10	-	-
			LLI wall (5E+2)	-	-	-	7E-6	7E-5
		Y, see ^{141}Pm	-	5E+2	2E-7	7E-10	-	-
61	Promethium-149	W, see ^{141}Pm	1E+3	2E+3	8E-7	3E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{141}Pm	-	2E+3	8E-7	2E-9	-	-
61	Promethium-150	W, see ^{141}Pm	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see ^{141}Pm	-	2E+4	7E-6	2E-8	-	-
61	Promethium-151	W, see ^{141}Pm	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		Y, see ^{141}Pm	-	3E+3	1E-6	4E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
62	Samarium-141m[2]	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
62	Samarium-141[2]	W, all compounds	5E+4 St. wall (6E+4)	2E+5 -	8E-5	2E-7 -	- 8E-4	- 8E-3
62	Samarium-142[2]	W, all compounds	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
62	Samarium-145	W, all compounds	6E+3	5E+2	2E-7	7E-10	8E-5	8E-4
62	Samarium-146	W, all compounds	1E+1 Bone surf (3E+1)	4E-2 Bone surf (6E-2)	1E-11 -	- 9E-14	- 3E-7	- 3E-6
62	Samarium-147	W, all compounds	2E+1 Bone surf (3E+1)	4E-2 Bone surf (7E-2)	2E-11 -	- 1E-13	- 4E-7	- 4E-6
62	Samarium-151	W, all compounds	1E+4 LLI wall (1E+4)	1E+2 Bone surf (2E+2)	4E-8 -	- 2E-10	- 2E-4	- 2E-3
62	Samarium-153	W, all compounds	2E+3 LLI wall (2E+3)	3E+3 -	1E-6 -	4E-9 -	- 3E-5	- 3E-4
62	Samarium-155[2]	W, all compounds	6E+4 St. wall (8E+4)	2E+5 -	9E-5 -	3E-7 -	- 1E-3	- 1E-2
[illegible]	Samarium-156	W, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
[illegible]	Europium-145	W, all compounds	2E+3	2E+3	8E-7	3E-9	2E-5	2E-4
63	Europium-146	W, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
63	Europium-147	W, all compounds	3E+3	2E+3	7E-7	2E-9	4E-5	4E-4
63	Europium-148	W, all compounds	1E+3	4E+2	1E-7	5E-10	1E-5	1E-4
63	Europium-149	W, all compounds	1E+4	3E+3	1E-6	4E-9	2E-4	2E-3
63	Europium-150 (12.62 h)	W, all compounds	3E+3	8E+3	4E-6	1E-8	4E-5	4E-4
63	Europium-150 (34.2 y)	W, all compounds	8E+2	2E+1	8E-9	3E-11	1E-5	1E-4
63	Europium-152m	W, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
63	Europium-152	W, all compounds	8E+2	2E+1	1E-8	3E-11	1E-5	1E-4
63	Europium-154	W, all compounds	5E+2	2E+1	8E-9	3E-11	7E-6	7E-5
63	Europium-155	W, all compounds	4E+3 -	9E+1 Bone surf (1E+2)	4E-8 -	- 2E-10	5E-5 -	5E-4 -
63	Europium-156	W, all compounds	6E+2	5E+2	2E-7	6E-10	8E-6	8E-5

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentrati (μCi/ml)
63	Europium-157	W, all compounds	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
63	Europium-158[2]	W, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
64	Gadolinium-145[2]	D, all compounds except those given for W	5E+4	2E+5	6E-5	2E-7	-	-
			St. wall (5E+4)	-	-	-	6E-4	6E-3
		W, oxides, hydroxides, and fluorides	-	2E+5	7E-5	2E-7	-	-
64	Gadolinium-146	D, see ^{145}Gd	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		W, see ^{145}Gd	-	3E+2	1E-7	4E-10	-	-
64	Gadolinium-147	D, see ^{145}Gd	2E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		W, see ^{145}Gd	-	4E+3	1E-6	5E-9	-	-
64	Gadolinium-148	D, see ^{145}Gd	1E+1	8E-3	3E-12	-	-	-
			Bone surf (2E+1)	Bone surf (2E-2)	-	2E-14	3E-7	3E-6
		W, see ^{145}Gd	-	3E-2	1E-11	-	-	-
			-	Bone surf (6E-2)	-	8E-14	-	-
64	Gadolinium-149	D, see ^{145}Gd	3E+3	2E+3	9E-7	3E-9	4E-5	4E-4
		W, see ^{145}Gd	-	2E+3	1E-6	3E-9	-	-
64	Gadolinium-151	D, see ^{145}Gd	6E+3	4E+2	2E-7	-	9E-5	9E-4
			-	Bone surf (9E+2)	-	9E-10	-	-
		W, see ^{145}Gd	-	1E+3	5E-7	2E-9	-	-
64	Gadolinium-152	D, see ^{145}Gd	2E+1	1E-2	4E-12	-	-	-
			Bone surf (3E+1)	Bone surf (2E-2)	-	3E-14	4E-7	4E-6
		W, see ^{145}Gd	-	4E-2	2E-11	-	-	-
			-	Bone surf (8E-2)	-	1E-13	-	-
64	Gadolinium-153	D, see ^{145}Gd	9E+3	1E+2	6E-8	-	6E-5	6E-4
			-	Bone surf (2E+2)	-	3E-10	-	-
		W, see ^{145}Gd	-	6E+2	2E-7	8E-10	-	-
64	Gadolinium-159	D, see ^{145}Gd	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{145}Gd	-	6E+3	2E-6	8E-9	-	-
65	Terbium-147[2]	W, all compounds	9E+3	3E+4	1E-5	5E-8	1E-4	1E-3
65	Terbium-149	W, all compounds	5E+3	7E+2	3E-7	1E-9	2E-5	7E-4
65	Terbium-150	W, all compounds	5E+3	2E+4	9E-6	3E-8	7E-5	7E-4
65	Terbium-151	W, all compounds	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
65	Terbium-153	W, all compounds	5E+3	9E+3	3E-6	1E-8	7E-5	7E-4
65	Terbium-154	W, all compounds	2E+3	4E+3	2E-6	6E-9	2E-5	2E-4
65	Terbium-155	W, all compounds	6E+3	8E+3	3E-6	1E-8	8E-5	8E-4
65	Terbium-156m (5.0 h)	W, all compounds	2E+4	3E+4	1E-5	4E-8	2E-4	2E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
65	Terbium-156m (24.4 h)	W, all compounds	7E+3	8E+3	3E-6	1E-8	1E-4	1E-3
65	Terbium-156	W, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4
65	Terbium-157	W, all compounds	5E+4 LLI wall (5E+4)	3E+2 Bone surf (6E+2)	1E-7 -	- 8E-10	- 7E-4	- 7E-3
65	Terbium-158	W, all compounds	1E+3	2E+1	8E-9	3E-11	2E-5	2E-4
65	Terbium-160	W, all compounds	8E+2	2E+2	9E-8	3E-10	1E-5	1E-4
65	Terbium-161	W, all compounds	2E+3 LLI wall (2E+3)	2E+3 -	7E-7 -	2E-9 -	- 3E-5	- 3E-4
66	Dysprosium-155	W, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
66	Dysprosium-157	W, all compounds	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
66	Dysprosium-159	W, all compounds	1E+4	2E+3	1E-6	3E-9	2E-4	2E-3
66	Dysprosium-165	W, all compounds	1E+4	5E+4	2E-5	6E-8	2E-4	2E-3
66	Dysprosium-166	W, all compounds	6E+2 LLI wall (8E+2)	7E+2 -	3E-7 -	1E-9 -	- 1E-5	- 1E-4
67	Holmium-155[2]	W, all compounds	4E+4	2E+5	6E-5	2E-7	6E-4	6E-3
67	Holmium-157[2]	W, all compounds	3E+5	1E+6	6E-4	2E-6	4E-3	4E-2
67	Holmium-159[2]	W, all compounds	2E+5	1E+6	4E-4	1E-6	3E-3	3E-2
67	Holmium-161	W, all compounds	1E+5	4E+5	2E-4	6E-7	1E-3	1E-2
67	Holmium-162m[2]	W, all compounds	5E+4	3E+5	1E-4	4E-7	7E-4	7E-3
67	Holmium-162[2]	W, all compounds	5E+5 St. wall (8E+5)	2E+6 -	1E-3 -	3E-6 -	- 1E-2	- 1E-1
67	Holmium-164m[2]	W, all compounds	1E+5	3E+5	1E-4	4E-7	1E-3	1E-2
67	Holmium-164[2]	W, all compounds	2E+5 St. wall (2E+5)	6E+5 -	3E-4 -	9E-7 -	- 3E-3	- 3E-2
67	Holmium-166m	W, all compounds	6E+2	7E+0	3E-9	9E-12	9E-6	9E-5
67	Holmium-166	W, all compounds	9E+2 LLI wall (9E+2)	2E+3 -	7E-7 -	2E-9 -	- 1E-5	- 1E-4
67	Holmium-167	W, all compounds	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3
68	Erbium-161	W, all compounds	2E+4	6E+4	3E-5	9E-8	2E-4	2E-3
68	Erbium-165	W, all compounds	6E+4	2E+5	8E-5	3E-7	9E-4	9E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values: Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values: Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values: Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations: Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations: Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers: Monthly Average Concentration (μCi/ml)
68	Erbium-169	W, all compounds	3E+3 LLI wall (4E+3)	3E+3 -	1E-6 -	4E-9 -	- 5E-5	- 5E-4
68	Erbium-171	W, all compounds	4E+3	1E+4	4E-6	1E-8	5E-5	5E-4
68	Erbium-172	W, all compounds	1E+3 LLI wall (1E+3)	1E+3 -	6E-7 -	2E-9 -	- 2E-5	- 2E-4
69	Thulium-162[2]	W, all compounds	7E+4 St. wall (7E+4)	3E+5 -	1E-4 -	4E-7 -	- 1E-3	- 1E-2
69	Thulium-166	W, all compounds	4E+3	1E+4	6E-6	2E-8	6E-5	6E-4
69	Thulium-167	W, all compounds	2E+3 LLI wall (2E+3)	2E+3 -	8E-7 -	3E-9 -	- 3E-5	- 3E-4
69	Thulium-170	W, all compounds	8E+2 LLI wall (1E+3)	2E+2 -	9E-8 -	3E-10 -	- 1E-5	- 1E-4
69	Thulium-171	W, all compounds	1E+4 LLI wall (1E+4)	3E+2 Bone surf (6E+2)	1E-7 -	- 8E-10	- 2E-6	- 2E-3
69	Thulium-172	W, all compounds	7E+2 LLI wall (8E+2)	1E+3 -	5E-7 -	2E-9 -	- 1E-5	- 1E-4
69	Thulium-173	W, all compounds	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
69	Thulium-175[2]	W, all compounds	7E+4 St. wall (9E+4)	3E+5 -	1E-4 -	4E-7 -	- 1E-3	- 1E-2
70	Ytterbium-162[2]	W, all compounds except those given for Y	7E+4	3E+5	1E-4	4E-7	1E-3	1E-2
		Y, oxides, hydroxides, and fluorides	-	3E+5	1E-4	4E-7	-	-
70	Ytterbium-166	W, see ^{162}Yb Y, see ^{162}Yb	1E+3 -	2E+3 2E+3	8E-7 8E-7	3E-9 3E-9	2E-5 -	2E-4 -
70	Ytterbium-167[2]	W, see ^{162}Yb Y, see ^{162}Yb	3E+5 -	8E+5 7E+5	3E-4 3E-4	1E-6 1E-6	4E-3 -	4E-2 -
70	Ytterbium-169	W, see ^{162}Yb Y, see ^{162}Yb	2E+3 -	8E+2 7E+2	4E-7 3E-7	1E-9 1E-9	2E-5 -	2E-4 -
70	Ytterbium-175	W, see ^{162}Yb	3E+3 LLI wall (3E+3)	4E+3 -	1E-6 -	9E-9 -	- 4E-5	- 4E-4
		Y, see ^{162}Yb	-	3E+3	1E-6	5E-9	-	-
70	Ytterbium-177[2]	W, see ^{162}Yb Y, see ^{162}Yb	2E+4 -	5E+4 5E+4	2E-5 2E-5	7E-8 6E-8	2E-4 -	2E-3 -
70	Ytterbium-178[2]	W, see ^{162}Yb Y, see ^{162}Yb	1E+4 -	4E+4 4E+4	2E-5 2E-5	6E-8 5E-8	2E-4 -	2E-3 -

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
71	Lutetium-169	W, all compounds except those given for Y	3E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		Y, oxides, hydroxides, and fluorides	-	4E+3	2E-6	6E-9	-	-
71	Lutetium-170	W, see ^{169}Lu	1E+3	2E+3	9E-7	3E-9	2E-5	2E-4
		Y, see ^{169}Lu	-	2E+3	8E-7	3E-9	-	-
71	Lutetium-171	W, see ^{169}Lu	2E+3	2E+3	8E-7	3E-9	3E-5	3E-4
		Y, see ^{169}Lu	-	2E+3	8E-7	3E-9	-	-
71	Lutetium-172	W, see ^{169}Lu	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
		Y, see ^{169}Lu	-	1E+3	5E-7	2E-9	-	-
71	Lutetium-173	W, see ^{169}Lu	5E+3	3E+2 Bone surf (5E+2)	1E-7	-	7E-5	7E-4
			-	-	-	6E-10	-	-
		Y, see ^{169}Lu	-	3E+2	1E-7	4E-10	-	-
71	Lutetium-174m	W, see ^{169}Lu	2E+3 LLI wall (3E+3)	2E+2 Bone surf (3E+2)	1E-7	-	-	-
			-	2E+2	-	5E-10	4E-5	4E-4
		Y, see ^{169}Lu	-	2E+2	9E-8	3E-10	-	-
71	Lutetium-174	W, see ^{169}Lu	5E+3	1E+2 Bone surf (2E+2)	5E-8	-	7E-5	7E-4
			-	-	-	3E-10	-	-
		Y, see ^{169}Lu	-	2E+2	6E-8	2E-10	-	-
	Lutetium-176m	W, see ^{169}Lu	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		Y, see ^{169}Lu	-	2E+4	9E-6	3E-8	-	-
71	Lutetium-176	W, see ^{169}Lu	7E+2	5E+0 Bone surf (1E+1)	2E-9	-	1E-5	1E-4
			-	-	-	2E-11	-	-
		Y, see ^{169}Lu	-	8E+0	3E-9	1E-11	-	-
71	Lutetium-177m	W, see ^{169}Lu	7E+2	1E+2 Bone surf (1E+2)	5E-8	-	1E-5	1E-4
			-	-	-	2E-10	-	-
		Y, see ^{169}Lu	-	8E+1	3E-8	1E-10	-	-
	Lutetium-177	W, see ^{169}Lu	2E+3 LLI wall (3E+3)	2E+3	9E-7	3E-9	-	-
			-	-	-	-	4E-5	4E-4
		Y, see ^{169}Lu	-	2E+3	9E-7	3E-9	-	-
	Lutetium-179m[2]	W, see ^{169}Lu	5E+4 St. wall (6E+4)	2E+5	8E-5	3E-7	-	-
			-	-	-	-	8E-4	8E-3
		Y, see ^{169}Lu	-	2E+5	7E-5	2E-7	-	-
71	Lutetium-178[2]	W, see ^{169}Lu	4E+4 St. wall (4E+4)	1E+5	5E-5	2E-7	-	-
			-	-	-	-	6E-4	6E-3
		Y, see ^{169}Lu	-	1E+5	5E-5	2E-7	-	-
71	Lutetium-179	W, see ^{169}Lu	6E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see ^{169}Lu	-	2E+4	6E-6	3E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values: Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values: Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values: Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations: Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations: Col. 2 Water (μCi/ml)	Table Release Sewer Monthl Averag Concent (μCi/ml
72	Hafnium-170	D, all compounds except those given for W	3E+3	6E+3	2E-6	8E-9	4E-5	4E-4
		W, oxides, hydroxides, carbides, and nitrates	-	5E+3	2E-6	6E-9	-	-
72	Hafnium-172	D, see ^{170}Hf	1E+3	9E+0	4E-9	-	2E-5	2E-4
			-	Bone surf (2E+1)	-	3E-11	-	-
		W, see ^{170}Hf	-	4E+1	2E-8	-	-	-
			-	Bone surf (6E+1)	-	8E-11	-	-
72	Hafnium-173	D, see ^{170}Hf	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{170}Hf	-	1E+4	5E-6	2E-8	-	-
72	Hafnium-175	D, see ^{170}Hf	3E+3	9E+2	4E-7	-	4E-5	4E-4
			-	Bone surf (1E+3)	-	1E-9	-	-
		W, see ^{170}Hf	-	1E+3	5E-7	2E-9	-	-
72	Hafnium-177m[2]	D, see ^{170}Hf	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		W, see ^{170}Hf	-	9E+4	4E-5	1E-7	-	-
72	Hafnium-178m	D, see ^{170}Hf	3E+2	1E+0	5E-10	-	3E-6	3E-5
			-	Bone surf (2E+0)	-	3E-12	-	-
		W, see ^{170}Hf	-	5E+0	2E-9	-	-	-
			-	Bone surf (9E+0)	-	1E-11	-	-
72	Hafnium-179m	D, see ^{170}Hf	1E+3	3E+2	1E-7	-	1E-5	1E-4
			-	Bone surf (6E+2)	-	8E-10	-	-
		W, see ^{170}Hf	-	6E+2	3E-7	8E-10	-	-
72	Hafnium-180m	D, see ^{170}Hf	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{170}Hf	-	3E+4	1E-5	4E-8	-	-
72	Hafnium-181	D, see ^{170}Hf	1E+3	2E+2	7E-8	-	2E-5	2E-4
			-	Bone surf (4E+2)	-	6E-10	-	-
		W, see ^{170}Hf	-	4E+2	2E-7	6E-10	-	-
72	Hafnium-182m[2]	D, see ^{170}Hf	4E+4	9E+4	4E-5	1E-7	5E-4	5E-3
		W, see ^{170}Hf	-	1E+5	6E-5	2E-7	-	-
72	Hafnium-182	D, see ^{170}Hf	2E+2	8E-1	3E-10	-	-	-
			Bone surf (4E+2)	Bone surf (2E+0)	-	2E-12	5E-6	5E-5
		W, see ^{170}Hf	-	3E+0	1E-9	-	-	-
			-	Bone surf (7E+0)	-	1E-11	-	-
72	Hafnium-183[2]	D, see ^{170}Hf	2E+4	5E+4	2E-5	6E-8	3E-4	3E-3
		W, see ^{170}Hf	-	6E+4	2E-5	8E-8	-	-
72	Hafnium-184	D, see ^{170}Hf	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		W, see ^{170}Hf	-	6E+3	3E-6	9E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
73	Tantalum-172[2]	W, all compounds except those given for Y	4E+4	1E+5	5E-5	2E-7	5E-4	5E-3
		Y, elemental Ta, oxides, hydroxides, halides, carbides, nitrates, and nitrides	-	1E+5	4E-5	1E-7	-	-
73	Tantalum-173	W, see ^{172}Ta	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see ^{172}Ta	-	2E+4	7E-6	2E-8	-	-
73	Tantalum-174[2]	W, see ^{172}Ta	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
		Y, see ^{172}Ta	-	9E+4	4E-5	1E-7	-	-
73	Tantalum-175	W, see ^{172}Ta	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
		Y, see ^{172}Ta	-	1E+4	6E-6	2E-8	-	-
73	Tantalum-176	W, see ^{172}Ta	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
		Y, see ^{172}Ta	-	1E+4	5E-6	2E-8	-	-
73	Tantalum-177	W, see ^{172}Ta	1E+4	2E+4	8E-6	3E-8	2E-4	2E-3
		Y, see ^{172}Ta	-	2E+4	7E-6	2E-8	-	-
73	Tantalum-178	W, see ^{172}Ta	2E+4	9E+4	4E-5	1E-7	2E-4	2E-3
		Y, see ^{172}Ta	-	7E+4	3E-5	1E-7	-	-
73	Tantalum-179	W, see ^{172}Ta	2E+4	5E+3	2E-6	8E-9	3E-4	3E-3
		Y, see ^{172}Ta	-	9E+2	4E-7	1E-9	-	-
73	Tantalum-180m	W, see ^{172}Ta	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		Y, see ^{172}Ta	-	6E+4	2E-5	8E-8	-	-
73	Tantalum-180	W, see ^{172}Ta	1E+3	4E+2	2E-7	6E-10	2E-5	2E-4
		Y, see ^{172}Ta	-	2E+1	1E-8	3E-11	-	-
73	Tantalum-182m[2]	W, see ^{172}Ta	2E+5 St. wall (2E+5)	5E+5	2E-4	8E-7	-	-
		Y, see ^{172}Ta	-	4E+5	2E-4	6E-7	3E-3	3E-2
73	Tantalum-182	W, see ^{172}Ta	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		Y, see ^{172}Ta	-	1E+2	6E-8	2E-10	-	-
	Tantalum-183	W, see ^{172}Ta	9E+2 LLI wall (1E+3)	1E+3	5E-7	2E-9	-	-
		Y, see ^{172}Ta	-	1E+3	4E-7	1E-9	2E-5	2E-4
	Tantalum-184	W, see ^{172}Ta	2E+3	5E+3	2E-6	8E-9	3E-5	3E-4
		Y, see ^{172}Ta	-	5E+3	2E-6	7E-9	-	-
73	Tantalum-185[2]	W, see ^{172}Ta	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
		Y, see ^{172}Ta	-	6E+4	3E-5	9E-8	-	-
73	Tantalum-186[2]	W, see ^{172}Ta	5E+4 St. wall (7E+4)	2E+5	1E-4	3E-7	-	
		Y, see ^{172}Ta	-	2E+5	9E-5	3E-7	1E-3	1E-2
74	Tungsten-176	D, all compounds	1E+4	5E+4	2E-5	7E-8	1E-4	1E-3
74	Tungsten-177	D, all compounds	2E+4	9E+4	4E-5	1E-7	3E-4	3E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
74	Tungsten-178	D, all compounds	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
74	Tungsten-179[2]	D, all compounds	5E+6	2E+6	7E-4	2E-6	7E-3	7E-2
74	Tungsten-181	D, all compounds	2E+4	3E+4	1E-5	5E-8	2E-4	2E-3
74	Tungsten-185	D, all compounds	2E+3	2E+3	3E-6	9E-9	-	-
			St. wall (3E+3)	-	-	-	4E-5	4E-4
74	Tungsten-187	D, all compounds	2E+3	9E+3	4E-6	1E-8	3E-5	3E-4
74	Tungsten-188	D, all compounds	4E+2	1E+3	5E-7	2E-9	-	-
			St. wall (5E+2)	-	-	-	7E-6	7E-5
75	Rhenium-177[2]	D, all compounds except those given for W	9E+4	3E+5	1E-4	4E-7	-	-
			St. wall (1E+5)	-	-	-	2E-3	2E-2
		W, oxides, hydroxides, and nitrates	-	4E+5	1E-4	5E-7	-	-
75	Rhenium-178[2]	D, see ^{177}Re	7E+4	3E+5	1E-4	4E-7	-	-
			St. wall (1E+5)	-	-	-	1E-3	1E-2
		W, see ^{177}Re	-	3E+5	1E-4	4E-7	-	-
75	Rhenium-181	D, see ^{177}Re	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
		W, see ^{177}Re	-	8E+3	4E-6	1E-8	-	-
75	Rhenium-182 (12.7 h)	D, see ^{177}Re	7E+3	1E+4	5E-6	2E-8	9E-5	9E-4
		W, see ^{177}Re	-	2E+4	6E-6	2E-8	-	-
75	Rhenium-182 (64.0 h)	D, see ^{177}Re	1E+3	7E+3	1E-6	3E-9	2E-5	2E-4
		W, see ^{177}Re	-	2E+3	9E-7	2E-9	-	-
75	Rhenium-184m	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{177}Re	-	4E+2	2E-7	6E-10	-	-
75	Rhenium-184	D, see ^{177}Re	2E+3	4E+3	1E-6	5E-9	3E-5	3E-4
		W, see ^{177}Re	-	1E+3	6E-7	2E-9	-	-
75	Rhenium-186m	D, see ^{177}Re	1E+3	2E+3	7E-7	-	-	-
			St. wall (2E+3)	St. wall (2E+3)	-	3E-9	2E-5	2E-4
		W, see ^{177}Re	-	2E+2	6E-8	2E-10	-	-
75	Rhenium-186	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{177}Re	-	2E+3	7E-7	2E-9	-	-
75	Rhenium-187	D, see ^{177}Re	6E+5	8E+5	4E-4	-	8E-3	8E-2
			-	St. wall (9E+5)	-	1E-6	-	-
		W, see ^{177}Re	-	1E+5	4E-5	1E-7	-	-
75	Rhenium-188m[2]	D, see ^{177}Re	8E+4	1E+5	6E-5	2E-7	1E-3	1E-2
		W, see ^{177}Re	-	1E+5	6E-5	2E-7	-	-
75	Rhenium-188	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		W, see ^{177}Re	-	3E+3	1E-6	4E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
75	Rhenium-189	D, see ^{177}Re	3E+3	5E+3	2E-6	7E-9	4E-5	4E-4
		W, see ^{177}Re	-	4E+3	2E-6	6E-9	-	-
76	Osmium-180[2]	D; all compounds except these given for W and Y	1E+5	4E+5	2E-4	5E-7	1E-3	1E-2
		W, halides and nitrates	-	5E+5	2E-4	7E-7	-	-
		Y, oxides and hydroxides	-	5E+5	2E-4	6E-7	-	-
76	Osmium-181[2]	D, see ^{180}Os	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{180}Os	-	5E+4	2E-5	6E-8	-	-
		Y, see ^{180}Os	-	4E+4	2E-5	6E-8	-	-
76	Osmium-182	D, see ^{180}Os	2E+3	6E+3	2E-6	8E-9	3E-5	3E-4
		W, see ^{180}Os	-	4E+3	2E-6	6E-9	-	-
		Y, see ^{180}Os	-	4E+3	2E-6	6E-9	-	-
76	Osmium-185	D, see ^{180}Os	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
		W, see ^{180}Os	-	8E+2	3E-7	1E-9	-	-
		Y, see ^{180}Os	-	8E+2	3E-7	1E-9	-	-
76	Osmium-189m	D, see ^{180}Os	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, see ^{180}Os	-	2E+5	9E-5	3E-7	-	-
		Y, see ^{180}Os	-	2E+5	7E-5	2E-7	-	-
76	Osmium-191m	D, see ^{180}Os	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{180}Os	-	2E+4	8E-6	3E-8	-	-
		Y, see ^{180}Os	-	2E+4	7E-6	2E-8	-	-
	Osmium-191	D, see ^{180}Os	2E+3 LLI wall (3E+3)	2E+3	9E-7	3E-9	-	-
			-	-	-	-	3E-5	3E-4
		W, see ^{180}Os	-	2E+3	7E-7	2E-9	-	-
		Y, see ^{180}Os	-	1E+3	6E-7	2E-9	-	-
76	Osmium-193	D, see ^{180}Os	2E+3 LLI wall (2E+3)	5E+3	2E-6	6E-9	-	-
			-	-	-	-	2E-5	2E-4
		W, see ^{180}Os	-	9E+3	1E-6	4E-9	-	-
		Y, see ^{180}Os	-	3E+3	3E-6	4E-9	-	-
	Osmium-194	D, see ^{180}Os	4E+2 LLI wall (6E+2)	4E+1	2E-8	6E-11	-	-
			-	-	-	-	8E-6	8E-5
		W, see ^{180}Os	-	6E+1	2E-8	8E-11	-	-
		Y, see ^{180}Os	-	8E+0	3E-9	1E-11	-	-
	Iridium-182[2]	D; all compounds except these given for W and Y	4E+4 St. wall (4E+4)	1E+5	6E-5	2E-7	-	-
			-	-	-	-	6E-4	6E-3
		W, halides, nitrates, and metallic iridium	-	2E+5	6E-5	2E-7	-	-
		Y, oxides and hydroxides	-	1E+5	5E-5	2E-7	-	-
77	Iridium-184	D, see ^{182}Ir	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{182}Ir	-	3E+4	1E-5	5E-8	-	-
		Y, see ^{182}Ir	-	3E+4	1E-5	4E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentrati (μCi/ml)
77	Iridium-185	D, see ^{182}Ir	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{182}Ir	-	1E+4	5E-6	2E-8	-	-
		Y, see ^{182}Ir	-	1E+4	4E-6	1E-8	-	-
77	Iridium-186	D, see ^{182}Ir	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		W, see ^{182}Ir	-	6E+3	3E-6	9E-9	-	-
		Y, see ^{182}Ir	-	6E+3	2E-6	8E-9	-	-
77	Iridium-187	D, see ^{182}Ir	1E+4	2E+4	1E-5	5E-8	1E-4	1E-3
		W, see ^{182}Ir	-	3E+4	1E-5	4E-8	-	-
		Y, see ^{182}Ir	-	2E+4	1E-5	4E-8	-	-
77	Iridium-188	D, see ^{182}Ir	2E+3	5E+3	2E-6	6E-8	3E-5	3E-4
		W, see ^{182}Ir	-	4E+3	1E-6	5E-9	-	-
		Y, see ^{182}Ir	-	3E+3	1E-6	5E-9	-	-
77	Iridium-189	D, see ^{182}Ir	9E+3 LLI wall (5E+3)	5E+3	2E-6	7E-9	-	-
		W, see ^{182}Ir	-	-	-	-	7E-5	7E-4
		Y, see ^{182}Ir	-	4E+3	2E-6	9E-9	-	-
			-	4E+3	1E-6	5E-9	-	-
77	Iridium-190m[2]	D, see ^{182}Ir	2E+5	2E+5	8E-5	3E-7	2E-3	2E-2
		W, see ^{182}Ir	-	2E+5	9E-5	3E-7	-	-
		Y, see ^{182}Ir	-	2E+5	8E-5	3E-7	-	-
77	Iridium-190	D, see ^{182}Ir	1E+3	9E+2	4E-7	1E-9	1E-5	1E-4
		W, see ^{182}Ir	-	1E+3	4E-7	1E-9	-	-
		Y, see ^{182}Ir	-	9E+2	4E-7	1E-9	-	-
77	Iridium-192m	D, see ^{182}Ir	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
		W, see ^{182}Ir	-	2E+2	9E-8	3E-10	-	-
		Y, see ^{182}Ir	-	2E+1	6E-9	2E-11	-	-
77	Iridium-192	D, see ^{182}Ir	9E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		W, see ^{182}Ir	-	4E+2	2E-7	6E-10	-	-
		Y, see ^{182}Ir	-	2E+2	8E-8	3E-10	-	-
77	Iridium-194m	D, see ^{182}Ir	6E+2	9E+1	4E-8	1E-10	9E-6	9E-5
		W, see ^{182}Ir	-	2E+2	7E-8	2E-10	-	-
		Y, see ^{182}Ir	-	1E+2	4E-8	1E-10	-	-
77	Iridium-194	D, see ^{182}Ir	3E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		W, see ^{182}Ir	-	2E+3	9E-7	3E-9	-	-
		Y, see ^{182}Ir	-	2E+3	8E-7	3E-9	-	-
77	Iridium-195m	D, see ^{182}Ir	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{182}Ir	-	3E+4	1E-5	4E-8	-	-
		Y, see ^{182}Ir	-	2E+4	9E-6	3E-8	-	-
77	Iridium-195	D, see ^{182}Ir	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{182}Ir	-	5E+4	2E-5	7E-8	-	-
		Y, see ^{182}Ir	-	4E+4	2E-5	6E-8	-	-
78	Platinum-186	D, all compounds	1E+4	4E+4	2E-5	5E-8	2E-4	2E-3
78	Platinum-188	D, all compounds	2E+3	2E+3	7E-7	2E-9	2E-5	2E-4
78	Platinum-189	D, all compounds	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
78	Platinum-191	D, all compounds	4E+3	6E+3	4E-6	1E-8	5E-5	5E-4

Atomic No.	Radionuclide	Class	Table 1 Occupational Values: Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values: Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values: Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations: Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations: Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers: Monthly Average Concentration (μCi/ml)
78	Platinum-193m	D, all compounds	3E+3	6E+3	3E-6	8E-9	-	-
			LLI wall (3E+4)	-	-	-	4E-5	4E-4
78	Platinum-193	D, all compounds	4E+4	2E+4	1E-5	3E-8	-	-
			LLI wall (5E+4)	-	-	-	6E-4	6E-3
78	Platinum-195m	D, all compounds	2E+3	4E+3	2E-6	6E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
78	Platinum-197m[2]	D, all compounds	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
78	Platinum-197	D, all compounds	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
78	Platinum-199[2]	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
78	Platinum-200	D, all compounds	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4
79	Gold-193	D, all compounds except those given for W and Y	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, halides and nitrates	-	2E+4	9E-6	3E-8	-	-
		Y, oxides and hydroxides	-	2E+4	8E-6	3E-8	-	-
79	Gold-194	D, see ^{193}Au	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{193}Au	-	5E+3	2E-6	8E-9	-	-
		Y, see ^{193}Au	-	5E+3	2E-6	7E-9	-	-
	Gold-195	D, see ^{193}Au	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{193}Au	-	1E+3	6E-7	2E-9	-	-
		Y, see ^{193}Au	-	4E+2	2E-7	6E-10	-	-
79	Gold-198m	D, see ^{193}Au	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		W, see ^{193}Au	-	1E+3	5E-7	2E-9	-	-
		Y, see ^{193}Au	-	1E+3	5E-7	2E-9	-	-
79	Gold-198	D, see ^{193}Au	1E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		W, see ^{193}Au	-	2E+3	8E-7	3E-9	-	-
		Y, see ^{193}Au	-	2E+3	7E-7	2E-9	-	-
	Gold-199	D, see ^{193}Au	3E+3	9E+3	4E-6	1E-8	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
		W, see ^{193}Au	-	4E+3	2E-6	6E-9	-	-
		Y, see ^{193}Au	-	4E+3	2E-6	5E-9	-	-
79	Gold-200m	D, see ^{193}Au	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{193}Au	-	3E+3	1E-6	4E-9	-	-
		Y, see ^{193}Au	-	2E+4	1E-6	3E-9	-	-
79	Gold-200[2]	D, see ^{193}Au	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
		W, see ^{193}Au	-	8E+4	3E-5	1E-7	-	-
		Y, see ^{193}Au	-	7E+4	3E-5	1E-7	-	-
79	Gold-201[2]	D, see ^{193}Au	7E+4	2E+5	9E-5	3E-7	-	-
			St. wall (9E+4)	-	-	-	1E-3	1E-2
		W, see ^{193}Au	-	2E+5	1E-4	3E-7	-	-
		Y, see ^{193}Au	-	2E+5	9E-5	3E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
80	Mercury-193m	Vapor	-	8E+3	4E-6	1E-8	-	-
		Organic D	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		D, sulfates	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		W, oxides, hydroxides, halides, nitrates, and sulfides	-	8E+3	3E-6	1E-8	-	-
80	Mercury-193	Vapor	-	3E+4	1E-5	4E-8	-	-
		Organic D	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		D, see ^{193m}Hg	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{193m}Hg	-	4E+4	2E-5	6E-8	-	-
80	Mercury-194	Vapor	-	3E+1	1E-8	4E-11	-	-
		Organic D	2E+1	3E+1	1E-8	4E-11	2E-7	2E-6
		D, see ^{193m}Hg	8E+2	4E+1	2E-8	6E-11	1E-5	1E-4
		W, see ^{193m}Hg	-	1E+2	5E-8	2E-10	-	-
80	Mercury-195m	Vapor	-	4E+3	2E-6	6E-9	-	-
		Organic D	3E+3	6E+3	3E-6	8E-9	4E-5	4E-4
		D, see ^{193m}Hg	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
		W, see ^{193m}Hg	-	4E+3	2E-6	5E-9	-	-
80	Mercury-195	Vapor	-	3E+4	1E-5	4E-8	-	-
		Organic D	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		D, see ^{193m}Hg	1E+4	4E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{193m}Hg	-	3E+4	1E-5	5E-8	-	-
80	Mercury-197m	Vapor	-	5E+3	2E-6	7E-9	-	-
		Organic D	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		D, see ^{193m}Hg	3E+3	7E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{193m}Hg	-	5E+3	2E-6	7E-9	-	-
80	Mercury-197	Vapor	-	8E+3	4E-6	1E-8	-	-
		Organic D	7E+3	1E+4	6E-6	2E-8	9E-5	9E-4
		D, see ^{193m}Hg	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see ^{193m}Hg	-	9E+3	4E-6	1E-8	-	-
80	Mercury-199m[2]	Vapor	-	8E+4	3E-5	1E-7	-	-
		Organic D	6E+4	2E+5	7E-5	2E-7	-	-
			St. wall (1E+5)	-	-	-	1E-3	1E-2
		D, see ^{193m}Hg	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
		W, see ^{193m}Hg	-	2E+5	7E-5	2E-7	-	-
80	Mercury-203	Vapor	-	8E+2	4E-7	1E-9	-	-
		Organic D	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
		D, see ^{193m}Hg	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		W, see ^{193m}Hg	-	1E+3	5E-7	2E-9	-	-
81	Thallium-194m[2]	D, all compounds	5E+4	2E+5	6E-5	2E-7	-	-
			St. wall (7E+4)	-	-	-	1E-3	1E-2

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
81	Thallium-194[2]	D, all compounds	3E+5	6E+5	2E-4	8E-7	-	-
		St. wall	(3E+5)	-	-	-	4E-3	4E-2
81	Thallium-195[2]	D, all compounds	6E+4	1E+5	5E-5	2E-7	9E-4	9E-3
81	Thallium-197	D, all compounds	7E+4	1E+5	5E-5	2E-7	1E-3	1E-2
81	Thallium-198m[2]	D, all compounds	3E+4	5E+4	2E-5	8E-8	4E-4	4E-3
81	Thallium-198	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
81	Thallium-199	D, all compounds	6E+4	8E+4	4E-5	1E-7	9E-4	9E-3
81	Thallium-200	D, all compounds	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
81	Thallium-201	D, all compounds	2E+4	2E+4	9E-6	3E-8	2E-4	2E-3
81	Thallium-202	D, all compounds	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
81	Thallium-204	D, all compounds	2E+3	2E+3	9E-7	3E-9	2E-5	2E-4
82	Lead-195m[2]	D, all compounds	6E+4	2E+5	8E-5	3E-7	8E-4	8E-3
82	Lead-198	D, all compounds	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
82	Lead-199[2]	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
	Lead-200	D, all compounds	9E+3	6E+3	3E-6	9E-9	4E-5	4E-4
	Lead-201	D, all compounds	7E+3	2E+4	8E-6	3E-8	1E-4	1E-3
82	Lead-202m	D, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
82	Lead-202	D, all compounds	1E+2	5E+1	2E-8	7E-11	2E-6	2E-5
82	Lead-203	D, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
82	Lead-205	D, all compounds	4E+3	1E+3	6E-7	2E-9	5E-5	5E-4
	Lead-209	D, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
	Lead-210	D, all compounds	6E-1	2E-1	1E-10	-	-	-
			Bone surf (1E+0)	Bone surf (4E-1)	-	6E-13	1E-8	1E-7
	Lead-211[2]	D, all compounds	1E+4	6E+2	3E-7	9E-10	2E-4	2E-3
82	Lead-212	D, all compounds	8E+1	3E+1	1E-8	5E-11	-	-
			Bone surf (1E+2)	-	-	-	2E-6	2E-5
82	Lead-214[2]	D, all compounds	9E+3	8E+2	3E-7	1E-9	1E-4	1E-3
83	Bismuth-200[2]	D, nitrates	3E+4	8E+4	4E-5	1E-7	4E-4	4E-3
		W, all other compounds	-	1E+5	4E-5	1E-7	-	-
83	Bismuth-201[2]	D, see ^{200}Bi	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{200}Bi	-	4E+4	2E-5	5E-8	-	-
	Bismuth-202[2]	D, see ^{200}Bi	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{200}Bi	-	8E+4	3E-5	1E-7	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Table 3 Releases Sewers Monthly Average Concentr (μCi/ml)
83	Bismuth-203	D, see ^{200}Bi	2E+3	7E+3	3E-6	9E-9	3E-5	3E-4
		W, see ^{200}Bi	-	6E+3	3E-6	9E-9	-	-
83	Bismuth-205	D, see ^{200}Bi	1E+3	3E+3	1E-6	3E-9	2E-5	2E-4
		W, see ^{200}Bi	-	1E+3	5E-7	2E-9	-	-
83	Bismuth-206	D, see ^{200}Bi	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see ^{200}Bi	-	9E+2	4E-7	1E-9	-	-
83	Bismuth-207	D, see ^{200}Bi	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see ^{200}Bi	-	4E+2	1E-7	5E-10	-	-
83	Bismuth-210m	D, see ^{200}Bi	4E+1 Kidneys (6E+1)	5E+0 Kidneys (6E+0)	2E-9	-	-	-
		W, see ^{200}Bi	-	7E-1	3E-10	9E-12 9E-13	8E-7 -	8E-6 -
83	Bismuth-210	D, see ^{200}Bi	8E+2	2E+2 Kidneys (4E+2)	1E-7	-	1E-5	1E-4
		W, see ^{200}Bi	- -	- 3E+1	- 1E-8	5E-10 4E-11	- -	- -
83	Bismuth-212[2]	D, see ^{200}Bi	5E+3	2E+2	1E-7	3E-10	7E-5	7E-4
		W, see ^{200}Bi	-	3E+2	1E-7	4E-10	-	-
83	Bismuth-213[2]	D, see ^{200}Bi	7E+3	3E+2	1E-7	4E-10	1E-4	1E-3
		W, see ^{200}Bi	-	4E+2	1E-7	5E-10	-	-
83	Bismuth-214[2]	D, see ^{200}Bi	2E+4 St. wall (2E+4)	8E+2	3E-7	1E-9	-	-
		W, see ^{200}Bi	-	9E-2	4E-7	1E-9	3E-4 -	3E-3 -
84	Polonium-203[2]	D, all compounds except those given for W	3E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		W, oxides, hydroxides, and nitrates	-	9E+4	4E-5	1E-7	-	-
84	Polonium-205[2]	D, see ^{203}Po	2E+4	4E+4	2E-5	5E-8	3E-4	3E-3
		W, see ^{203}Po	-	7E+4	3E-5	1E-7	-	-
84	Polonium-207	D, see ^{203}Po	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{203}Po	-	3E+4	1E-5	4E-8	-	-
84	Polonium-210	D, see ^{203}Po	3E+0	6E-1	3E-10	9E-13	4E-8	4E-7
		W, see ^{203}Po	-	6E-1	3E-10	9E-13	-	-
85	Astatine-207[2]	D, halides	6E+3	3E+3	1E-6	4E-9	8E-5	8E-4
		W	-	2E+3	9E-7	3E-9	-	-
85	Astatine-211	D, halides	1E+2	8E+1	3E-8	1E-10	2E-6	2E-5
		W	-	5E+1	2E-8	8E-11	-	-
86	Radon-220	With daughters removed	-	2E+4	7E-6	2E-8	-	-
		With daughters present	-	2E+1 (or 12 working level months)	9E-9 (or 1.0 working level)	3E-11	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
86	Radon-222	With daughters removed	-	1E+4	4E-6	1E-8	-	-
		With daughters present	-	1E+2 (or 4 working level months)	3E-8 (or 0.33 working level)	1E-10	-	-
87	Francium-222[2]	D, all compounds	2E+3	5E+2	2E-7	6E-10	3E-5	3E-4
87	Francium-223[2]	D, all compounds	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
88	Radium-223	W, all compounds	5E+0 Bone surf (9E+0)	7E-1 -	3E-10 -	9E-13 -	- 1E-7	- 1E-6
88	Radium-224	W, all compounds	8E+0 Bone surf (2E+1)	2E+0 -	7E-10 -	2E-12 -	- 2E-7	- 2E-6
88	Radium-225	W, all compounds	8E+0 Bone surf (2E+1)	7E-1 -	3E-10 -	9E-13 -	- 2E-7	- 2E-6
88	Radium-226	W, all compounds	2E+0 Bone surf (5E+0)	6E-1 -	3E-10 -	9E-13 -	- 6E-8	- 6E-7
	Radium-227[2]	W, all compounds	2E+4 Bone surf (2E+4)	1E+4 Bone surf (2E+4)	6E-6 -	- 3E-8	- 3E-4	- 3E-3
88	Radium-228	W, all compounds	2E+0 Bone surf (4E+0)	1E+0 -	5E-10 -	2E-12 -	- 6E-8	- 6E-7
89	Actinium-224	D, all compounds except those given for W and Y	2E+3 LLI wall (2E+3)	3E+1 Bone surf (4E+1)	1E-8 -	- 5E-11	- 3E-5	- 3E-4
		W, halides and nitrates	-	5E+1	2E-8	7E-11	-	-
		Y, oxides and hydroxides	-	5E+1	2E-8	6E-11	-	-
	Actinium-225	D, see ^{224}Ac	5E+1 LLI wall (5E+1)	3E-1 Bone surf (5E-1)	1E-10 -	- 7E-13	- 7E-7	- 7E-6
		W, see ^{224}Ac	-	6E-1	3E-10	9E-13	-	-
		Y, see ^{224}Ac	-	6E-1	3E-10	9E-13	-	-
89	Actinium-226	D, see ^{224}Ac	1E+2 LLI wall (1E+2)	3E+0 Bone surf (4E+0)	1E-9 -	- 5E-12	- 2E-6	- 2E-5
		W, see ^{224}Ac	-	5E+0	2E-9	7E-12	-	-
		Y, see ^{224}Ac	-	5E+0	2E-9	6E-12	-	-
89	Actinium-227	D, see ^{224}Ac	2E-1 Bone surf (4E-1)	4E-4 Bone surf (8E-4)	2E-13 -	- 1E-15	- 5E-9	- 5E-8
		W, see ^{224}Ac	-	2E-3 Bone surf (3E-3)	7E-13 -	- 4E-15	- -	- -
		Y, see ^{224}Ac	-	4E-3	2E-12	6E-15	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentratio (μCi/ml)
89	Actinium-228	D, see ^{224}Ac	2E+3	9E+0	4E-9	-	3E-5	3E-4
				Bone surf				
			-	(2E+1)	-	2E-11	-	-
		W, see ^{224}Ac	-	4E+1	2E-8	-	-	-
				Bone surf				
			-	(6E+1)	-	8E-11	-	-
		Y, see ^{224}Ac	-	4E+1	2E-8	6E-11	-	-
90	Thorium-226[2]	W, all compounds except those given for Y	5E+3	2E+2	6E-8	2E-10	-	-
			St. wall					
			(5E+3)	-	-	-	7E-5	7E-4
		Y, oxides and hydroxides	-	1E+2	6E-8	2E-10	-	-
90	Thorium-227	W, see ^{226}Th	1E+2	3E-1	1E-10	5E-13	2E-6	2E-5
		Y, see ^{226}Th	-	3E-1	1E-10	5E-13	-	-
90	Thorium-228	W, see ^{226}Th	6E+0	1E-2	4E-12	-	-	-
			Bone surf	Bone surf				
			(1E+1)	(2E-2)	-	3E-14	2E-7	2E-6
		Y, see ^{226}Th	-	2E-2	7E-12	2E-14	-	-
90	Thorium-229	W, see ^{226}Th	6E-1	9E-4	4E-13	-	-	-
			Bone surf	Bone surf				
			(1E+0)	(2E-3)	-	3E-15	2E-8	2E-7
		Y, see ^{226}Th	-	2E-3	1E-12	-	-	-
				Bone surf				
			-	(3E-3)	-	4E-15	-	-
90	Thorium-230	W, see ^{226}Th	4E+0	6E-3	3E-12	-	-	-
			Bone surf	Bone surf				
			(9E+0)	(2E-2)	-	2E-14	1E-7	1E-6
		Y, see ^{226}Th	-	2E-2	6E-12	-	-	-
				Bone surf				
			-	(2E-2)	-	3E-14	-	-
90	Thorium-231	W, see ^{226}Th	4E+3	6E+3	3E-6	9E-9	5E-5	5E-4
		Y, see ^{226}Th	-	6E+3	3E-6	9E-9	-	-
90	Thorium-232	W, see ^{226}Th	7E-1	1E-3	5E-13	-	-	-
			Bone surf	Bone surf				
			(2E+0)	(3E-3)	-	4E-15	3E-8	3E-7
		Y, see ^{226}Th	-	3E-3	1E-12	-	-	-
				Bone surf				
			-	(4E-3)	-	6E-15	-	-
90	Thorium-234	W, see ^{226}Th	3E+2	2E+2	8E-8	3E-10	-	-
			LLI wall					
			(4E+2)	-	-	-	5E-6	5E-5
		Y, see ^{226}Th	-	2E+2	6E-8	2E-10	-	-
91	Protactinium-227[2]	W, all compounds except those given for Y	4E+3	1E+2	5E-8	2E-10	5E-5	5E-4
		Y, oxides and hydroxides	-	1E+2	4E-8	1E-10	-	-
91	Protactinium-228	W, see ^{227}Pa	1E+3	1E+1	5E-9	-	2E-5	2E-4
				Bone surf				
			-	(2E+1)	-	3E-11	-	-
		Y, see ^{226}Pa	-	1E+1	5E-9	2E-11	-	-

			Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				Monthly Average
c	Radionuclide	Class	ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Concentration (μCi/ml)
91	Protactinium-230	W, see ^{227}Pa	6E+2 Bone surf (9E+2)	5E+0	2E-9	7E-12	-	-
		Y, see ^{227}Pa	-	4E+0	1E-9	5E-12	1E-5 -	1E-4 -
91	Protactinium-231	W, see ^{227}Pa	2E-1 Bone surf (5E-1)	2E-3 Bone surf (4E-3)	6E-13 -	-	-	-
		Y, see ^{226}Pa	-	4E-3 Bone surf (6E-3)	2E-12 -	6E-15 -	6E-9 -	6E-8 -
91	Protactinium-232	W, see ^{227}Pa	1E+3	2E+1 Bone surf (6E+1)	9E-9 -	-	2E-5 -	2E-4 -
		Y, see ^{227}Pa	-	6E+1 Bone surf (7E+1)	2E-8 -	8E-11 -	-	-
91	Protactinium-233	W, see ^{227}Pa	1E+3 LLI wall (2E+3)	7E+2	3E-7 -	1E-9 -	-	-
		Y, see ^{227}Pa	-	6E+2	2E-7	8E-10	2E-5 -	2E-4 -
91	Protactinium-234	W, see ^{227}Pa	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		Y, see ^{227}Pa	-	7E+3	3E-6	9E-9	-	-
92	Uranium-230	D, UF_6, UO_2F_2, $UO_2(NO_3)_2$	4E+0 Bone surf (6E+0)	4E-1 Bone surf (6E-1)	2E-10 -	-	-	-
		W, UO_3, UF_4, UCl_4	-	4E-1	1E-10	5E-13	8E-13 -	8E-8 -	8E-7 -
		Y, UO_2, U_3O_8	-	3E-1	1E-10	4E-13	-	-
	Uranium-231	D, see ^{230}U	5E+3 LLI wall (4E+3)	8E+3	3E-6	1E-8	-	-
		W, see ^{230}U	-	6E+3	2E-6	8E-9	6E-5 -	6E-4 -
		Y, see ^{230}U	-	5E+3	2E-6	6E-9	-	-
92	Uranium-232	D, see ^{230}U	2E+0 Bone surf (4E+0)	2E-1 Bone surf (4E-1)	9E-11 -	-	-	-
		W, see ^{230}U	-	4E-1	2E-10	5E-13	6E-13 -	6E-8 -	6E-7 -
		Y, see ^{230}U	-	8E-3	3E-12	1E-14	-	-
	Uranium-233	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 -	-	-	-
		W, see ^{230}U	-	7E-1	3E-10	1E-12	3E-12 -	3E-7 -	3E-6 -
		Y, see ^{230}U	-	4E-2	2E-11	5E-14	-	-
92	Uranium-234[3]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 -	-	-	-
		W, see ^{230}U	-	7E-1	3E-10	1E-12	3E-12 -	3E-7 -	3E-6 -
		Y, see ^{230}U	-	4E-2	2E-11	5E-14	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table Releases Sewer
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
92	Uranium-235[3]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10 -	- 3E-12	- 3E-7	- 3E-6
		W, see ^{230}U	-	8E-1	3E-10	1E-12	-	-
		Y, see ^{230}U	-	4E-2	2E-11	6E-14	-	-
92	Uranium-236	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 -	- 3E-12	- 3E-7	- 3E-6
		W, see ^{230}U	-	8E-1	3E-10	1E-12	-	-
		Y, see ^{230}U	-	4E-2	2E-11	6E-14	-	-
92	Uranium-237	D, see ^{230}U	2E+3 LLI wall (2E+3)	3E+3 -	1E-6 -	4E-9 -	- 3E-5	- 3E-4
		W, see ^{230}U	-	2E+3	7E-7	2E-9	-	-
		Y, see ^{230}U	-	2E+3	6E-7	2E-9	-	-
92	Uranium-238[3]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10 -	- 3E-12	- 3E-7	- 3E-6
		W, see ^{230}U	-	8E-1	3E-10	1E-12	-	-
		Y, see ^{230}U	-	4E-2	2E-11	6E-14	-	-
92	Uranium-239[2]	D, see ^{230}U	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		W, see ^{230}U	-	2E+5	7E-5	2E-7	-	-
		Y, see ^{230}U	-	2E+5	6E-5	2E-7	-	-
92	Uranium-240	D, see ^{230}U	1E+3	4E+3	2E-6	5E-9	2E-6	2E-4
		W, see ^{230}U	-	3E+3	1E-6	4E-9	-	-
		Y, see ^{230}U	-	2E+3	1E-6	3E-9	-	-
92	Uranium-natural[3]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 -	- 3E-12	- 3E-7	- 3E-6
		W, see ^{230}U	-	8E-1	3E-10	9E-13	-	-
		Y, see ^{230}U	-	5E-2	2E-11	9E-14	-	-
9	Neptunium-232[2]	W, all compounds	1E+5 -	2E+3 Bone surf (5E+2)	7E-7 -	- 6E-9	2E-3 -	2E-2 -
93	Neptunium-233[2]	W, all compounds	8E+5	3E+6	1E-3	4E-6	1E-2	1E-1
93	Neptunium-234	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
93	Neptunium-235	W, all compounds	2E+4 LLI wall (2E+4)	8E+2 Bone surf (1E+3)	3E-7 -	- 2E-9	- 3E-4	- 3E-3
93	Neptunium-236 (1.15E+5 y)	W, all compounds	3E+0 Bone surf (6E+0)	2E-2 Bone surf (5E-2)	9E-12 -	- 8E-14	- 9E-8	- 9E-7
93	Neptunium-236m (22.5 h)	W, all compounds	3E+3 Bone surf (4E+3)	3E+1 Bone surf (7E+1)	1E-8 -	- 1E-10	- 5E-5	- 5E-4
93	Neptunium-237	W, all compounds	5E-1 Bone surf (1E+0)	4E-3 Bone surf (1E-2)	2E-12 -	- 1E-14	- 2E-8	- 2E-7

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
93	Neptunium-238	W, all compounds	1E+3	6E+1	3E-8	-	2E-5	2E-4
			-	Bone surf (2E+2)	-	2E-10	-	-
93	Neptunium-239	W, all compounds	2E+3	2E+3	9E-7	3E-9	-	-
			LLI wall (2E+3)	-	-	-	2E-5	2E-4
93	Neptunium-240[2]	W, all compounds	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
94	Plutonium-234	W, all compounds except PuO_2	8E+3	2E+2	9E-8	3E-10	1E-4	1E-3
		Y, PuO_2	-	2E+2	8E-8	3E-10	-	-
94	Plutonium-235[2]	W, see ^{234}Pu	9E+5	3E+6	1E-3	4E-6	1E-2	1E-1
		Y, see ^{234}Pu	-	3E+6	1E-3	3E-6	-	-
94	Plutonium-236	W, see ^{234}Pu	2E+0	2E-2	8E-12	-	-	-
			Bone surf (4E+0)	Bone surf (4E-2)	-	5E-14	6E-8	6E-7
		Y, see ^{234}Pu	-	4E-2	2E-11	6E-14	-	-
94	Plutonium-237	W, see ^{234}Pu	1E+4	3E+3	1E-6	5E-9	2E-4	2E-3
		Y, see ^{234}Pu	-	3E+3	1E-6	4E-9	-	-
94	Plutonium-238	W, see ^{234}Pu	9E-1	7E-3	3E-12	-	-	-
			Bone surf (2E+0)	Bone surf (1E-2)	-	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	-	2E-2	8E-12	2E-14	-	-
	Plutonium-239	W, see ^{234}Pu	8E-1	6E-3	3E-12	-	-	-
			Bone surf (1E+0)	Bone surf (1E-2)	-	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	-	2E-2	7E-12	-	-	-
			-	Bone surf (2E-2)	-	2E-14	-	-
94	Plutonium-240	W, see ^{234}Pu	8E-1	6E-3	3E-12	-	-	-
			Bone surf (1E+0)	Bone surf (1E-2)	-	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	-	2E-2	7E-12	-	-	-
			-	Bone surf (2E-2)	-	2E-14	-	-
	Plutonium-241	W, see ^{234}Pu	4E+1	3E-1	1E-10	-	-	-
			Bone surf (7E+1)	Bone surf (6E-1)	-	8E-13	1E-6	1E-5
		Y, see ^{234}Pu	-	8E-1	3E-10	-	-	-
			-	Bone surf (1E+0)	-	1E-12	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
94	Plutonium-242	W, see ^{234}Pu	8E-1 Bone surf (1E+0)	7E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
		Y, see ^{234}Pu	- -	2E-2 Bone surf (2E-2)	7E-12 -	- 2E-14	- -	- -
94	Plutonium-243	W, see ^{234}Pu	2E+4	4E+4	2E-5	5E-8	2E-4	2E-3
		Y, see ^{234}Pu	-	4E+4	2E-5	5E-8	-	-
94	Plutonium-244	W, see ^{234}Pu	8E-1 Bone surf (2E+0)	7E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
		Y, see ^{234}Pu	- -	2E-2 Bone surf (2E-2)	7E-12 -	- 2E-14	- -	- -
94	Plutonium-245	W, see ^{234}Pu	2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
		Y, see ^{234}Pu	-	4E+3	2E-6	6E-9	-	-
94	Plutonium-246	W, see ^{234}Pu	4E+2 LLI wall (4E+2)	3E+2 -	1E-7 -	4E-10 -	- 6E-6	- 6E-5
		Y, see ^{234}Pu	-	3E+2	1E-7	4E-10	-	-
95	Americium-237[2]	W, all compounds	8E+4	3E+5	1E-4	4E-7	1E-3	1E-2
95	Americium-238[2]	W, all compounds	4E+4 -	3E+3 Bone surf (6E+3)	1E-6 -	- 9E-9	5E-4 -	5E-3 -
95	Americium-239	W, all compounds	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
95	Americium-240	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
95	Americium-241	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
95	Americium-242m	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
95	Americium-242	W, all compounds	4E+3 -	8E+1 Bone surf (9E+1)	4E-8 -	- 1E-10	5E-5 -	5E-4 -
95	Americium-243	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
95	Americium-244m[2]	W, all compounds	6E+4 St. wall (8E+4)	4E+3 Bone surf (7E+3)	2E-6 -	- 1E-8	- 1E-3	- 1E-2
95	Americium-244	W, all compounds	3E+3 -	2E+2 Bone surf (3E+2)	8E-8 -	- 4E-10	4E-5 -	4E-4 -
95	Americium-245	W, all compounds	3E+4	8E+4	3E-5	1E-7	4E-4	4E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
95	Americium-246m[2]	W, all compounds	5E+4 St. wall (6E+4)	2E+5 -	8E-5 -	3E-7 -	- 8E-4	- 8E-3
95	Americium-246[2]	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
96	Curium-238	W, all compounds	2E+4	1E+3	5E-7	2E-9	2E-4	2E-3
96	Curium-240	W, all compounds	6E+1 Bone surf (8E+1)	6E-1 Bone surf (6E-1)	2E-10 -	- 9E-13	- 1E-6	- 1E-5
96	Curium-241	W, all compounds	1E+3 - -	3E+1 Bone surf (4E+1)	1E-8 -	- 5E-11	2E-5 -	2E-4 -
96	Curium-242	W, all compounds	3E+1 Bone surf (5E+1)	3E-1 Bone surf (3E-1)	1E-10 -	- 4E-13	- 7E-7	- 7E-6
96	Curium-243	W, all compounds	1E+0 Bone surf (2E+0)	9E-3 Bone surf (2E-2)	4E-12 -	- 2E-14	- 3E-8	- 3E-7
96	Curium-244	W, all compounds	1E+0 Bone surf (3E+0)	1E-2 Bone surf (2E-2)	5E-12 -	- 3E-14	- 3E-8	- 3E-7
	Curium-245	W, all compounds	7E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
96	Curium-246	W, all compounds	7E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
96	Curium-247	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
	Curium-248	W, all compounds	2E-1 Bone surf (4E-1)	2E-3 Bone surf (3E-3)	7E-13 -	- 4E-15	- 5E-9	- 5E-8
	Curium-249[2]	W, all compounds	5E+4 - -	2E+4 Bone surf (3E+4)	7E-6 -	- 4E-8	7E-4 -	7E-3 -
96	Curium-250	W, all compounds	4E-2 Bone surf (6E-2)	3E-4 Bone surf (5E-4)	1E-13 -	- 8E-16	- 9E-10	- 9E-9
97	Berkelium-245	W, all compounds	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
97	Berkelium-246	W, all compounds	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
97	Berkelium-247	W, all compounds	5E-1 Bone surf (1E+0)	4E-3 Bone surf (9E-3)	2E-12 -	- 1E-14	- 2E-8	- 2E-7
	Berkelium-249	W, all compounds	2E+2 Bone surf (5E+2)	2E+0 Bone surf (4E+0)	7E-10 -	- 5E-12	- 6E-6	- 6E-5

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Table Release Sewer Monthl Averag Concent (μCi/ml
97	Berkelium-250	W, all compounds	9E+3	3E+2	1E-7	-	1E-4	1E-3
			-	Bone surf (7E+2)	-	1E-9	-	-
98	Californium-244[2]	W, all compounds except those given for Y	3E+4	6E+2	2E-7	8E-10	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		Y, oxides and hydroxides	- -	6E+2	2E-7	8E-10	-	-
98	Californium-246	W, see ^{244}Cf	4E+2	9E+0	4E-9	1E-11	5E-6	5E-5
		Y, see ^{244}Cf	-	9E+0	4E-9	1E-11	-	-
98	Californium-248	W, see ^{244}Cf	8E+0	6E-2	3E-11	-	-	-
			Bone surf (2E+1)	Bone surf (1E-1)	-	2E-13	2E-7	2E-6
		Y, see ^{244}Cf	-	1E-1	4E-11	1E-13	-	-
98	Californium-249	W, see ^{244}Cf	5E-1	4E-3	2E-12	-	-	-
			Bone surf (1E+0)	Bone surf (9E-3)	-	1E-14	2E-8	2E-7
		Y, see ^{244}Cf	-	1E-2	4E-12	-	-	-
			-	Bone surf (1E-2)	-	2E-14	-	-
98	Californium-250	W, see ^{244}Cf	1E+0	9E-3	4E-12	-	-	-
			Bone surf (2E+0)	Bone surf (2E-2)	-	3E-14	3E-8	3E-7
		Y, see ^{244}Cf	-	3E-2	1E-11	4E-14	-	-
98	Californium-251	W, see ^{244}Cf	5E-1	4E-3	2E-12	-	-	-
			Bone surf (1E+0)	Bone surf (9E-3)	-	1E-14	2E-8	2E-7
		Y, see ^{244}Cf	-	1E-2	4E-12	-	-	-
			-	Bone surf (1E-2)	-	2E-14	-	-
98	Californium-252	W, see ^{244}Cf	2E+0	2E-2	8E-12	-	-	-
			Bone surf (5E+0)	Bone surf (4E-2)	-	5E-14	7E-8	7E-7
		Y, see ^{244}Cf	-	3E-2	1E-11	5E-14	-	-
98	Californium-253	W, see ^{244}Cf	2E+2	2E+0	8E-10	3E-12	-	-
			Bone surf (4E+2)	-	-	-	5E-6	5E-5
		Y, see ^{244}Cf	-	2E+0	7E-10	2E-12	-	-
98	Californium-254	W, see ^{244}Cf	2E+0	2E-2	9E-12	3E-14	3E-8	3E-7
		Y, see ^{244}Cf	-	2E-2	7E-12	2E-14	-	-
99	Einsteinium-250	W, all compounds	4E+4	5E+2	2E-7	-	6E-4	6E-3
			-	Bone surf (1E+3)	-	2E-9	-	-
99	Einsteinium-251	W, all compounds	7E+3	9E+2	4E-7	-	1E-4	1E-3
			-	Bone surf (1E+3)	-	2E-9	-	-
99	Einsteinium-253	W, all compounds	2E+2	1E+0	6E-10	2E-12	2E-6	2E-5

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (pCi/ml)	Table 2 Effluent Concentrations Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
99	Einsteinium-254m	W, all compounds	3E+2 [LI wall (3E+2)	1E+1 -	4E-9 -	1E-11 -	- 4E-6	- 4E-5
99	Einsteinium-254	W, all compounds	8E+0 Bone surf (2E+1)	7E-2 Bone surf (1E-1)	3E-11 -	- 2E-13	- 2E-7	- 2E-6
100	Fermium-252	W, all compounds	5E+2	1E+1	5E-9	2E-11	6E-6	6E-5
100	Fermium-253	W, all compounds	1E+3	1E+1	4E-9	1E-11	1E-5	1E-4
100	Fermium-254	W, all compounds	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
100	Fermium-255	W, all compounds	5E+2	2E+1	9E-9	3E-11	7E-6	7E-5
100	Fermium-257	W, all compounds	2E+1 Bone surf (4E+1)	2E-1 Bone surf (2E-1)	7E-11 -	- 3E-13	- 5E-7	- 5E-6
101	Mendelevium-257	W, all compounds	7E+3 -	8E+1 Bone surf (9E+1)	4E-8 -	- 1E-10	1E-4 -	1E-3 -
101	Mendelevium-258	W, all compounds	3E+1 Bone surf (5E+1)	2E-1 Bone surf (3E-1)	1E-10 -	- 5E-13	- 6E-7	- 6E-6
-	Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours	Submersion[1]	-	2E+2	1E-7	1E-9	-	-
-	Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours		-	2E-1	1E-10	1E-12	1E-8	1E-7
-	Any single radionuclide not listed above that decays by alpha emission or spontaneous fission, or any mixture for which either the identity or the concentration of any radionuclide in the mixture is not known		-	4E-4	2E-13	1E-15	2E-9	2E-8

FOOTNOTES:

[1]"Submersion" means that values given are for submersion in a hemispherical semi-infinite cloud of airborne material.

[2]These radionuclides have radiological half-lives of less than 2 hours. The total effective dose equivalent received during operations with these radionuclides might include a significant contribution from external exposure. The DAC values for all radionuclides, other than those designated Class "Submersion," are based upon the committed effective dose equivalent due to the intake of the radionuclide into the body and do NOT include potentially significant contributions to dose equivalent from external exposures. The licensee may substitute 1E-7 μCi/ml for the listed DAC to account for the submersion dose prospectively, but should use individual monitoring devices or other radiation measuring instruments that measure external exposure to demonstrate compliance with the limits. (See § 20.1203.)

[3]For soluble mixtures of U-238, U-234, and U-235 in air, chemical toxicity may be the limiting factor (see § 20.1201(e)). If the percent by weight (enrichment) of U-235 is not greater than 5, the concentration value for a 40-hour workweek is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8E-3 (SA) μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The specific activity for natural uranium is 6.77E-7 curies per gram U. The specific activity for other mixtures of U-238, U-235, and U-234, if not known, shall be:

SA = 3.6E-7 curies/gram U U-depleted

SA = [0.4 + 0.38 (enrichment) + 0.0034 (enrichment)^2] E-6 , enrichment $\geq$ 0.72

where enrichment is the percentage by weight of U-235, expressed as percent.

NOTE:

1. If the identity of each radionuclide in a mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the DAC for the mixture shall be the most restrictive DAC of any radionuclide in the mixture.

2. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in this appendix are not present in the mixture, the inhalation ALI, DAC, and effluent and sewage concentrations for the mixture are the lowest values specified in this appendix for any radionuclide that is not known to be absent from the mixture; or

	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table Releas Sewer
	Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
	Oral Ingestion	Inhalation				Month Avera
Radionuclide	ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Conce (μCi/
If it is known that Ac-227-D and Cm-250-W are not present	-	7E-4	3E-13	-	-	-
If, in addition, it is known that Ac-227-W,Y, Th-229-W,Y, Th-230-W, Th-232-W,Y, Pa-231-W,Y, Np-237-W, Pu-239-W, Pu-240-W, Pu-242-W, Am-241-W, Am-242m-W, Am-243-W, Cm-245-W, Cm-246-W, Cm-247-W, Cm-248-W, Bk-247-W, Cf-249-W, and Cf-251-W are not present	-	7E-3	3E-12	-	-	-
If, in addition, it is known that Sm-146-W, Sm-147-W, Gd-148-D,W, Gd-152-D,W, Th-228-W,Y, Th-230-Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, Np-236-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-Y, Pu-240-Y, Pu-242-Y, Pu-244-W,Y, Cm-243-W, Cm-244-W, Cf-248-W, Cf-249-Y, Cf-250-W,Y, Cf-251-Y, Cf-252-W,Y, and Cf-254-W,Y are not present	-	7E-2	3E-11	-	-	-
If, in addition, it is known that Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-Y, Es-254-W, Fm-257-W, and Md-258-W are not present	-	7E-1	3E-10	-	-	-

Radionuclide	Table 1 Occupational Values: Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values: Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values: Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations: Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations: Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers: Monthly Average Concentration (μCi/ml)
If, in addition, it is known that Si-32-Y, Ti-44-Y, Fe-60-D, Sr-90-Y, Zr-93-D, Cd-113m-D, Cd-113-D, In-115-D,W, La-138-D, Lu-176-W, Hf-178m-D,W, Hf-182-D,W, Bi-210m-D, Ra-224-W, Ra-228-W, Ac-226-D,W,Y, Pa-230-W,Y, U-233-D,W, U-234-D,W, U-235-D,W, U-236-D,W, U-238-D,W, Pu-241-Y, Bk-249-W, Cf-253-W,Y, and Es-253-W are not present	-	7E+0	3E-9	-	-	-
If it is known that Ac-227-D,W,Y, Th-229-W,Y, Th-232-W,Y, Pa-231-W,Y, Cm-248-W, and Cm-250-W are not present	-	-		1E-14	-	-
If, in addition, it is known that Sm-146-W, Gd-148-D,W, Gd-152-D, Th-228-W,Y, Th-230-W,Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, U-Nat-Y, Np-236-W, Np-237-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-W,Y, Pu-240-W,Y, Pu-242-W,Y, Pu-244-W,Y, Am-241-W, Am-242m-W, Am-243-W, Cm-243-W, Cm-244-W, Cm-245-W, Cm-246-W, Cm-247-W, Bk-247-W, Cf-249-W,Y, Cf-250-W,Y, Cf-251-W,Y, Cf-252-W,Y, and Cf-254-W,Y are not present			-	1E-13	-	-
If, in addition, it is known that Sm-147-W, Gd-152-W, Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, U-Nat-W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-W,Y, Es-254-W, Fm-257-W, and Md-258-W are not present			-	1E-12	-	-
In addition it is known that Fe-60, Co-60, Cd-113m, Cd-113, In-115, I-129, Cs-134, Sm-145, Sm-147, Gd-148, Gd-152, Hg-194 (organic), Bi-210m, Ra-223, Ra-224, Ra-225, Ac-225, Th-228, Th-230, U-233, U-234, U-235, U-236, U-238, U-Nat, Cm-242, Cf-248, Es-254, Fm-257, and Md-258 are not present	-	-	-	-	1E-6	1E-5

[3] If a mixture of radionuclides consists of uranium and its daughters in ore dust (10 μm AMAD particle distribution assumed) prior to chemical separation of the uranium from the ore, the following values may be used for the DAC of the mixture: 6E-11 μCi of gross alpha activity from uranium-238, uranium-234, thorium-230, and radium-226 per milliliter of air; 3E-11 μCi of natural uranium per milliliter of air; or 45 micrograms of natural uranium per cubic meter of air.

[4] If the identity and concentration of each radionuclide in a mixture are known, the limiting values should be derived as follows: determine, for each radionuclide in the mixture, the ratio between the concentration present in the mixture and the concentration otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all of the radionuclides in the mixture may not exceed "1" (i.e., "unity")

Example: If radionuclides "A," "B," and "C" are present in concentrations C_A, C_B, and C_C, and if the applicable DACs are DAC_A, DAC_B, and DAC_C, respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{DAC_A} + \frac{C_B}{DAC_B} + \frac{C_C}{DAC_C} < 1$$

[56 FR 23409, May 21, 1991; 56 FR 61352, Dec. 3, 1991, as amended at 57 FR 57879, Dec. 8, 1 Redesignated at 58 FR 67659, Dec. 22, 1993]

APPENDIX C TO PART 20—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING

Radionuclide	Quantity (μCi)
Hydrogen-3	1,000
Beryllium-7	1,000
Beryllium-10	1
Carbon-11	1,000
Carbon-14	1,000
Fluorine-18	1,000
Sodium-22	10
Sodium-24	100
Magnesium-28	100
Aluminum-26	10
Silicon-31	1,000
Silicon-32	1
Phosphorus-32	10
Phosphorus-33	100
Sulfur-35	100
Chlorine-36	10
Chlorine-38	1,000
Chlorine-39	1,000
Argon-39	1,000
Argon-41	1,000
Potassium-40	100
Potassium-42	1,000
Potassium-43	1,000
Potassium-44	1,000
Potassium-45	1,000
Calcium-41	100
Calcium-45	100
Calcium-47	100
Scandium-43	1,000
Scandium-44m	100
Scandium-44	100
Scandium-46	10
Scandium-47	100
Scandium-48	100
Scandium-49	1,000
Titanium-44	1
Titanium-45	1,000
Vanadium-47	1,000
Vanadium-48	100
Vanadium-49	1,000
Chromium-48	1,000
Chromium-49	1,000
Chromium-51	1,000
Manganese-51	1,000
Manganese-52m	1,000
Manganese-52	100
Manganese-53	1,000
Manganese-54	100
Manganese-56	1,000
Iron-52	100
Iron-55	100
Iron-59	10
Iron-60	1
Cobalt-55	100
Cobalt-56	10
Cobalt-57	100
Cobalt-58m	1,000
Cobalt-58	100
Cobalt-60m	1,000
Cobalt-60	1
Cobalt-61	1,000
Cobalt-62m	1,000
Nickel-56	100
Nickel-57	100
Nickel-59	100
Nickel-63	100
Nickel-65	1,000
Nickel-66	10
Copper-60	1,000
Copper-61	1,000

APPENDIX C TO PART 20—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Copper-64	1,000
Copper-67	1,000
Zinc-62	100
Zinc-63	1,000
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zinc-71m	1,000
Zinc-72	100
Gallium-65	1,000
Gallium-66	100
Gallium-67	1,000
Gallium-68	1,000
Gallium-70	1,000
Gallium-72	100
Gallium-73	1,000
Germanium-66	1,000
Germanium-67	1,000
Germanium-68	10
Germanium-69	1,000
Germanium-71	1,000
Germanium-75	1,000
Germanium-77	1,000
Germanium-78	1,000
Arsenic-69	1,000
Arsenic-70	1,000
Arsenic-71	100
Arsenic-72	100
Arsenic-73	100
Arsenic-74	100
Arsenic-76	100
Arsenic-77	100
Arsenic-78	1,000
Selenium-70	1,000
Selenium-73m	1,000
Selenium-73	100
Selenium-75	100
Selenium-79	100
Selenium-81m	1,000
Selenium-81	1,000
Selenium-83	1,000
Bromine-74m	1,000
Bromine-74	1,000
Bromine-75	1,000
Bromine-76	100
Bromine-77	1,000
Bromine-80m	1,000
Bromine-80	1,000
Bromine-82	100
Bromine-83	1,000
Bromine-84	1,000
Krypton-74	1,000
Krypton-76	1,000
Krypton-77	1,000
Krypton-79	1,000
Krypton-81	1,000
Krypton-83m	1,000
Krypton-85m	1,000
Krypton-85	1,000
Krypton-87	1,000
Krypton-88	1,000
Rubidium-79	1,000
Rubidium-81m	1,000
Rubidium-81	1,000
Rubidium-82m	1,000
Rubidium-83	100
Rubidium-84	100
Rubidium-86	100
Rubidium-87	100

APPENDIX C TO PART 20—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Rubidium-88	1,000
Rubidium-89	1,000
Strontium-80	100
Strontium-81	1,000
Strontium-83	100
Strontium-85m	1,000
Strontium-85	100
Strontium-87m	1,000
Strontium-89	10
Strontium-90	0.1
Strontium-91	100
Strontium-92	100
Yttrium-86m	1,000
Yttrium-86	100
Yttrium-87	100
Yttrium-88	10
Yttrium-90m	1,000
Yttrium-90	10
Yttrium-91m	1,000
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Yttrium-94	1,000
Yttrium-95	1,000
Zirconium-86	100
Zirconium-88	10
Zirconium-89	100
Zirconium-93	1
Zirconium-95	10
Zirconium-97	100
Niobium-88	1,000
Niobium-89m (66 min)	1,000
Niobium-89 (122 min)	1,000
Niobium-90	100
Niobium-93m	10
Niobium-94	1
Niobium-95m	100
Niobium-95	100
Niobium-96	100
Niobium-97	1,000
Niobium-98	1,000
Molybdenum-90	100
Molybdenum-93m	100
Molybdenum-93	10
Molybdenum-99	100
Molybdenum-101	1,000
Technetium-93m	1,000
Technetium-93	1,000
Technetium-94m	1,000
Technetium-94	1,000
Technetium-96m	1,000
Technetium-96	100
Technetium-97m	100
Technetium-97	1,000
Technetium-98	10
Technetium-99m	1,000
Technetium-99	100
Technetium-101	1,000
Technetium-104	1,000
Ruthenium-94	1,000
Ruthenium-97	1,000
Ruthenium-103	100
Ruthenium-105	1,000
Ruthenium-106	1
Rhodium-99m	1,000
Rhodium-99	100
Rhodium-100	100
Rhodium-101m	1,000
Rhodium-101	10

APPENDIX C TO PART 20—QUANTITIES[1] O CENSED MATERIAL REQUIRING LABELI Continued

Radionuclide	Qua (μ
Rhodium-102m	
Rhodium-102	
Rhodium-103m	1,0
Rhodium-105	1
Rhodium-106m	1,0
Rhodium-107	1,0
Palladium-100	1
Palladium-101	1,0
Palladium-103	1
Palladium-107	
Palladium-109	1
Silver-102	1,0
Silver-103	1,0
Silver-104m	1,0
Silver-104	1,0
Silver-105	1
Silver-106m	1
Silver-106	1,0
Silver-108m	
Silver-110m	
Silver-111	1
Silver-112	1
Silver-115	1,0
Cadmium-104	1,0
Cadmium-107	1,0
Cadmium-109	
Cadmium-113m	
Cadmium-113	1
Cadmium-115m	
Cadmium-115	1
Cadmium-117m	1,0
Cadmium-117	1,0
Indium-109	1,0
Indium-110 (69.1min.)	1,0
Indium-110	
(4.9h)	1,0
Indium-111	
Indium-112	1,0
Indium-113m	1,0
Indium-114m	
Indium-115m	1,0
Indium-115	
Indium-116m	1,0
Indium-117m	1,0
Indium-117	1,0
Indium-119m	1,0
Tin-110	
Tin-111	1,
Tin-113	
Tin-117m	
Tin-119m	
Tin-121m	
Tin-121	1,
Tin-123m	1,
Tin-123	
Tin-125	
Tin-126	
Tin-127	1.
Tin-128	1.
Antimony-115	1
Antimony-116m	1
Antimony-116	1
Antimony-117	1
Antimony-118m	1
Antimony-119	1
Antimony-120 (16min.)	1
Antimony-120 (5.76d)	
Antimony-122	
Antimony-124m	1

APPENDIX C TO PART 20—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Antimony-124	10
Antimony-125	100
Antimony-126m	1,000
Antimony-126	100
Antimony-127	100
Antimony-128 (10.4min.)	1,000
Antimony-128 (9.01h)	100
Antimony-129	100
Antimony-130	1,000
Antimony-131	1,000
Tellurium-116	1,000
Tellurium-121m	10
Tellurium-121	100
Tellurium-123m	10
Tellurium-123	100
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	1,000
Tellurium-129m	10
Tellurium-129	1,000
Tellurium-131m	10
Tellurium-131	100
Tellurium-132	10
Tellurium-133m	100
Tellurium-133	1,000
Tellurium-134	1,000
Iodine-120m	1,000
Iodine-120	100
Iodine-121	1,000
Iodine-123	100
Iodine-124	10
Iodine-125	1
Iodine-126	1
Iodine-128	1,000
Iodine-129	1
Iodine-130	10
Iodine-131	1
Iodine-132m	100
Iodine-132	100
Iodine-133	10
Iodine-134	1,000
Iodine-135	100
Xenon-120	1,000
Xenon-121	1,000
Xenon-122	1,000
Xenon-123	1,000
Xenon-125	1,000
Xenon-127	1,000
Xenon-129m	1,000
Xenon-131m	1,000
Xenon-133m	1,000
Xenon-133	1,000
Xenon-135m	1,000
Xenon-135	1,000
Xenon-138	1,000
Cesium-125	1,000
Cesium-127	1,000
Cesium-129	1,000
Cesium-130	1,000
Cesium-131	1,000
Cesium-132	100
Cesium-134m	1,000
Cesium-134	10
Cesium-135m	1,000
Cesium-135	100
Cesium-136	10
Cesium-137	10
Cesium-138	1,000
Barium-126	1,000

APPENDIX C TO PART 20—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Barium-128	100
Barium-131m	1,000
Barium-131	100
Barium-133m	100
Barium-133	100
Barium-135m	100
Barium-139	1,000
Barium-140	100
Barium-141	1,000
Barium-142	1,000
Lanthanum-131	1,000
Lanthanum-132	100
Lanthanum-135	1,000
Lanthanum-137	10
Lanthanum-138	100
Lanthanum-140	100
Lanthanum-141	100
Lanthanum-142	1,000
Lanthanum-143	1,000
Cerium-134	100
Cerium-135	100
Cerium-137m	100
Cerium-137	1,000
Cerium-139	100
Cerium-141	100
Cerium-143	100
Cerium-144	1
Praseodymium-136	1,000
Praseodymium-137	1,000
Praseodymium-138m	1,000
Praseodymium-139	1,000
Praseodymium-142m	1,000
Praseodymium-142	100
Praseodymium-143	100
Praseodymium-144	1,000
Praseodymium-145	100
Praseodymium-147	1,000
Neodymium-136	1,000
Neodymium-138	100
Neodymium-139m	1,000
Neodymium-139	1,000
Neodymium-141	1,000
Neodymium-147	100
Neodymium-149	1,000
Neodymium-151	1,000
Promethium-141	1,000
Promethium-143	100
Promethium-144	10
Promethium-145	10
Promethium-146	1
Promethium-147	10
Promethium-148m	10
Promethium-148	10
Promethium-149	100
Promethium-150	1,000
Promethium-151	100
Samarium-141m	1,000
Samarium-141	1,000
Samarium-142	1,000
Samarium-145	100
Samarium-146	1
Samarium-147	100
Samarium-151	10
Samarium-153	100
Samarium-155	1,000
Samarium-156	1,000
Europium-145	100
Europium-146	100
Europium-147	100

APPENDIX C TO PART 20—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Europium-148	10
Europium-149	100
Europium-150 (12.62h)	100
Europium-150 (34.2y)	1
Europium-152m	100
Europium-152	1
Europium-154	1
Europium-155	10
Europium-156	100
Europium-157	100
Europium-158	1,000
Gadolinium-145	1,000
Gadolinium-146	10
Gadolinium-147	100
Gadolinium-148	0.001
Gadolinium-149	100
Gadolinium-151	10
Gadolinium-152	100
Gadolinium-153	10
Gadolinium-159	100
Terbium-147	1,000
Terbium-149	100
Terbium-150	1,000
Terbium-151	100
Terbium-153	1,000
Terbium-154	100
Terbium-155	1,000
Terbium-156m (5.0h)	1,000
Terbium-156m (24.4h)	1,000
Terbium-156	100
Terbium-157	10
Terbium-158	1
Terbium-160	10
Terbium-161	100
Dysprosium-155	1,000
Dysprosium-157	1,000
Dysprosium-159	100
Dysprosium-165	1,000
Dysprosium-166	100
Holmium-155	1,000
Holmium-157	1,000
Holmium-159	1,000
Holmium-161	1,000
Holmium-162m	1,000
Holmium-162	1,000
Holmium-164m	1,000
Holmium-164	1,000
Holmium-166m	1
Holmium-166	100
Holmium-167	1,000
Erbium-161	1,000
Erbium-165	1,000
Erbium-169	100
Erbium-171	100
Erbium-172	100
Thulium-162	1,000
Thulium-166	100
Thulium-167	100
Thulium-170	10
Thulium-171	10
Thulium-172	100
Thulium-173	100
Thulium-175	1,000
Ytterbium-162	1,000
Ytterbium-166	100
Ytterbium-167	1,000
Ytterbium-169	100
Ytterbium-175	100
Ytterbium-177	1,000

APPENDIX C TO PART 20—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Ytterbium-178	1,000
Lutetium-169	100
Lutetium-170	100
Lutetium-171	100
Lutetium-172	100
Lutetium-173	10
Lutetium-174m	10
Lutetium-174	10
Lutetium-176m	1,000
Lutetium-176	100
Lutetium-177m	10
Lutetium-177	100
Lutetium-178m	1,000
Lutetium-178	1,000
Lutetium-179	1,000
Hafnium-170	100
Hafnium-172	1
Hafnium-173	1,000
Hafnium-175	100
Hafnium-177m	1,000
Hafnium-178m	0.1
Hafnium-179m	10
Hafnium-180m	1,000
Hafnium-181	10
Hafnium-182m	1,000
Hafnium-182	0.1
Hafnium-183	1,000
Hafnium-184	100
Tantalum-172	1,000
Tantalum-173	1,000
Tantalum-174	1,000
Tantalum-175	1,000
Tantalum-176	100
Tantalum-177	1,000
Tantalum-178	1,000
Tantalum-179	100
Tantalum-180m	1,000
Tantalum-180	100
Tantalum-182m	1,000
Tantalum-182	10
Tantalum-183	100
Tantalum-184	100
Tantalum-185	1,000
Tantalum-186	1,000
Tungsten-176	1,000
Tungsten-177	1,000
Tungsten-178	1,000
Tungsten-179	1,000
Tungsten-181	1,000
Tungsten-185	100
Tungsten-187	100
Tungsten-188	10
Rhenium-177	1,000
Rhenium-178	1,000
Rhenium-181	1,000
Rhenium-182 (12.7h)	1,000
Rhenium-182 (64.0h)	100
Rhenium-184m	10
Rhenium-184	100
Rhenium-186m	10
Rhenium-186	100
Rhenium-187	1,000
Rhenium-188m	1,000
Rhenium-188	100
Rhenium-189	100
Osmium-180	1,000
Osmium-181	1,000
Osmium-182	100
Osmium-185	100

APPENDIX C TO PART 20—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Osmium-189m	1,000
Osmium-191m	1,000
Osmium-191	100
Osmium-193	100
Osmium-194	1
Iridium-182	1,000
Iridium-184	1,000
Iridium-185	1,000
Iridium-186	100
Iridium-187	1,000
Iridium-188	100
Iridium-189	100
Iridium-190m	1,000
Iridium-190	100
Iridium-192 (73.8d)	1
Iridium-192m (1.4min.)	10
Iridium-194m	10
Iridium-194	100
Iridium-195m	1,000
Iridium-195	1,000
Platinum-186	1,000
Platinum-188	100
Platinum-189	1,000
Platinum-191	100
Platinum-193m	100
Platinum-193	1,000
Platinum-195m	100
Platinum-197m	1,000
Platinum-197	100
Platinum-199	1,000
Platinum-200	100
Gold-193	1,000
Gold-194	100
Gold-195	10
Gold-198m	100
Gold-198	100
Gold-199	100
Gold-200m	100
Gold-200	1,000
Gold-201	1,000
Mercury-193m	100
Mercury-193	1,000
Mercury-194	1
Mercury-195m	100
Mercury-195	1,000
Mercury-197m	100
Mercury-197	1,000
Mercury-199m	1,000
Mercury-203	100
Thallium-194m	1,000
Thallium-194	1,000
Thallium-195	1,000
Thallium-197	1,000
Thallium-198m	1,000
Thallium-198	1,000
Thallium-199	1,000
Thallium-200	1,000
Thallium-201	1,000
Thallium-202	100
Thallium-204	100
Lead-195m	1,000
Lead-198	1,000
Lead-199	1,000
Lead-200	100
Lead-201	1,000
Lead-202m	1,000
Lead-202	10
Lead-203	1,000
Lead-205	100

APPENDIX C TO PART 20—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Lead-209	1,000
Lead-210	0.01
Lead-211	100
Lead-212	1
Lead-214	100
Bismuth-200	1,000
Bismuth-201	1,000
Bismuth-202	1,000
Bismuth-203	100
Bismuth-205	100
Bismuth-206	100
Bismuth-207	10
Bismuth-210m	0.1
Bismuth-210	1
Bismuth-212	10
Bismuth-213	10
Bismuth-214	100
Polonium-203	1,000
Polonium-205	1,000
Polonium-207	1,000
Polonium-210	0.1
Astatine-207	100
Astatine-211	10
Radon-220	1
Radon-222	1
Francium-222	100
Francium-223	100
Radium-223	0.1
Radium-224	0.1
Radium-225	0.1
Radium-226	0.1
Radium-227	1,000
Radium-228	0.1
Actinium-224	1
Actinium-225	0.01
Actinium-226	0.1
Actinium-227	0.001
Actinium-228	1
Thorium-226	10
Thorium-227	0.01
Thorium-228	0.001
Thorium-229	0.001
Thorium-230	0.001
Thorium-231	100
Thorium-232	100
Thorium-234	10
Thorium-natural	100
Protactinium-227	10
Protactinium-228	1
Protactinium-230	0.1
Protactinium-231	0.001
Protactinium-232	1
Protactinium-233	100
Protactinium-234	100
Uranium-230	0.01
Uranium-231	100
Uranium-232	0.001
Uranium-233	0.001
Uranium-234	0.001
Uranium-235	0.001
Uranium-236	0.001
Uranium-237	100
Uranium-238	100
Uranium-239	1,000
Uranium-240	100
Uranium-natural	100
Neptunium-232	100
Neptunium-233	1,000
Neptunium-234	100

APPENDIX C TO PART 20—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Neptunium-235	100
Neptunium-236 (1.15x10³y)	0.001
Neptunium-236 (22.5h)	1
Neptunium-237	0.001
Neptunium-238	10
Neptunium-239	100
Neptunium-240	1,000
Plutonium-234	10
Plutonium-235	1,000
Plutonium-236	0.001
Plutonium-237	100
Plutonium-238	0.001
Plutonium-239	0.001
Plutonium-240	0.001
Plutonium-241	0.01
Plutonium-242	0.001
Plutonium-243	1,000
Plutonium-244	0.001
Plutonium-245	100
Americium-237	1,000
Americium-238	100
Americium-239	1,000
Americium-240	100
Americium-241	0.001
Americium-242m	0.001
Americium-242	10
Americium-243	0.001
Americium-244m	100
Americium-244	10
Americium-245	1,000
Americium-246m	1,000
Americium-246	1,000
Curium-238	100
Curium-240	0.1
Curium-241	1
Curium-242	0.01
Curium-243	0.001
Curium-244	0.001
Curium-245	0.001
Curium-246	0.001
Curium-247	0.001
Curium-248	0.001
Curium-249	1,000
Berkelium-245	100
Berkelium-246	100
Berkelium-247	0.001
Berkelium-249	0.1
Berkelium-250	10

APPENDIX C TO PART 20—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Californium-244	100
Californium-246	1
Californium-248	0.01
Californium-249	0.001
Californium-250	0.001
Californium-251	0.001
Californium-252	0.001
Californium-253	0.1
Californium-254	0.001
Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.001
Einsteinium-250	100
Einsteinium-251	100
Einsteinium-253	0.1
Einsteinium-254m	1
Einsteinium-254	0.01
Fermium-252	1
Fermium-253	1
Fermium-254	10
Fermium-255	1
Fermium-257	0.01
Mendelevium-257	10
Mendelevium-258	0.01
Any radionuclide other than alpha emitting radionuclides not listed above, or mixtures of beta emitters of unknown composition	0.01

[1] The quantities listed above were derived by taking 1/10th the most restrictive *ALI* listed in table 1, columns 1 and 2, appendix B to §§ 20.1001–20.2401 of this part, rounding the nearest factor of 10, and arbitrarily constraining the valu listed between 0.001 and 1,000 μCi. Values of 100 μCi ha been assigned for radionuclides having a radioactive half-li in excess of 10⁹ years (except rhenium, 1000 μCi) to take in account their low specific activity.

NOTE: For purposes of §§ 20.1902(e), 20.1905(a), a 20.2201(a) where there is involved a combination of rad nuclides in known amounts, the limit for the combinati should be derived as follows: determine, for each radionucli in the combination, the ratio between the quantity present the combination and the limit otherwise established for t specific radionuclide when not in combination. The sum such ratios for all radionuclides in the combination may exceed "1" (i.e., "unity").

[56 FR 23465, May 21, 1991; 56 FR 61352, Dec. 1991. Redesignated and amended at 58 1 67659, Dec. 22, 1993]

Appendix D to Part 20—UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICE

	Address	Telephone (24 hour)
Region I: Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.	USNRC, Region I, 475 Allendale Road, King of Prussia, PA 19406.	(215) 337–5000, (FTS) 346–5000.
Region II: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee, Virginia, Virgin Islands, and West Virginia.	USNRC, Region II, 101 Marietta Street, NW., Suite 2900, Atlanta, GA 30323.	(404) 331–4503, (FTS) 841–4503.
Region III: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.	USNRC, Region III, 801 Warrenville Road, Lisle, IL 60532-4351.	(708) 829–9500, (FTS) 829–9500.
Region IV: Arkansas, Colorado, Idaho, Kansas, Louisiana, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming.	USNRC, Region IV, 611 Ryan Plaza Drive, Suite 1000, Arlington, TX 76011.	(817) 860–8100, (FTS) 728–8100.

Appendix D to Part 20—UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICES—Continued

	Address	Telephone (24 hour)
Region IV: Field Office	USNRC, Region IV, Uranium Recovery Field Office, 730 Simms Street, Suite 100a, Golden, CO 80401, Mail: P.O. Box 25325, Denver, CO 80225.	(303) 231-5800, (FTS) 554-2805.
Region V: Alaska, Arizona, California, Hawaii, Nevada, Oregon, Washington, and U.S. territories and possessions in the Pacific.	USNRC, Region V, 1450 Maria Lane, Suite 210, Walnut Creek, CA 94596.	(510) 975-0200.

[56 FR 23468, May 21, 1991, as amended at 56 FR 41449, Aug. 21, 1991; 58 FR 64111, Dec. 6, 1993]

APPENDIX E TO PART 20—[RESERVED]

APPENDIX F TO PART 20— REQUIREMENTS FOR LOW-LEVEL-WASTE TRANSFER FOR DISPOSAL AT LAND DISPOSAL FACILITIES AND MANIFESTS

I. Manifest

The shipment manifest shall contain the name, address, and telephone number of the person generating the waste. The manifest shall also include the name, address, and telephone number or the name and EPA hazardous waste identification number of the person transporting the waste to the land disposal facility. The manifest must also indicate as completely as practicable: a physical description of the waste, the volume, radionuclide identity and quantity, the total radioactivity, and the principal chemical form. The solidification agent must be specified. Waste containing more than 0.1% chelating agents by weight must be identified and the weight percentage of the chelating agent estimated. Wastes classified as Class A, Class B, or Class C in §61.55 of this chapter must be clearly identified as such in the manifest. The total quantity of the radionuclides ^{3}H, ^{14}C, ^{99}Tc, and ^{129}I must be shown. The manifest required by this paragraph may be shipping papers used to meet Department of Transportation or Environmental Protection Agency regulations or requirements of the receiver, provided all the required information is included. Copies of manifests required by this section may be legible carbon copies or legible photocopies.

II. Certification

The waste generator shall include in the shipment manifest a certification that the transported materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the Commission. An authorized representative of the waste generator shall sign and date the manifest.

III. Control and Tracking

A. Any generating licensee who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in paragraphs A.1 through 8 of this section. Any generating licensee who transfers waste to a licensed waste processor who treats or repackages waste shall comply with the requirements of paragraphs A.4 through 8 of this section. A licensee shall:

1. Prepare all wastes so that the waste is classified according to §61.55 of this chapter and meets the waste characteristics requirements in §61.56 of this chapter;

2. Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §61.55 of this chapter;

3. Conduct a quality control program to ensure compliance with §§61.55 and 61.56 of this chapter; the program must include management evaluation of audits;

4. Prepare shipping manifests to meet the requirements of sections I and II of this appendix;

5. Forward a copy of the manifest to the intended recipient, at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgment of receipt in the form of a signed copy of the manifest or equivalent documentation from the collector;

6. Include one copy of the manifest with the shipment;

7. Retain a copy of the manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by parts 30, 40, and 70 of this chapter; and

8. For any shipments or any part of a shipment for which acknowledgment of receipt has not been received within the times set forth in this section, conduct an investigation in accordance with paragraph E of this appendix.

B. Any waste collector licensee who handles only prepackaged waste shall:

1. Acknowledge receipt of the waste from the generator within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation;

2. Prepare a new manifest to reflect consolidated shipments; the new manifest shall serve as a listing or index for the detailed generator manifests. Copies of the generator manifests shall be a part of the new manifest. The waste collector may prepare a new manifest without attaching the generator manifests, provided the new manifest contains for each package the information specified in section I of this appendix. The collector licensee shall certify that nothing has been done to the waste that would invalidate the generator's certification;

3. Forward a copy of the new manifest to the land disposal facility operator at the time of shipment;

4. Include the new manifest with the shipment to the disposal site;

5. Retain a copy of the manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by parts 30, 40, and 70 of this chapter, and retain information from generator manifest until the license is terminated; and

6. For any shipments or any part of a shipment for which acknowledgment of receipt is not received within the times set forth in this section, conduct an investigation in accordance with section III, E of this appendix.

C. Any licensed waste processor who treats or repackages wastes shall:

1. Acknowledge receipt of the waste from the generator within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation;

2. Prepare a new manifest that meets the requirements of sections I and II of this appendix. Preparation of the new manifest reflects that the processor is responsible for the waste;

3. Prepare all wastes so that the waste is classified according to §61.55 of this chapter and meets the waste characteristics requirements in §61.56 of this chapter;

4. Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §§61.55 and 61.57 of this chapter;

5. Conduct a quality control program to ensure compliance with §§61.55 and 61.56 of this chapter. The program shall include management evaluation of audits;

6. Forward a copy of the new manifest to the disposal site operator or waste collector at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgment of receipt in the form of a signed copy of the manifest or equivalent documentation by the collector;

7. Include the new manifest with the shipment;

8. Retain copies of original manifests and new manifests and documentation of acknowledgment of receipt as the record of transfer of licensed material required by parts 30, 40, and 70 of this chapter; and

9. For any shipment or part of a shipment for which acknowledgment is not received within the times set forth in this section, conduct an investigation in accordance with section III. E of this appendix.

D. The land disposal facility operator shall:

1. Acknowledge receipt of the waste within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. The returned copy of the manifest or equivalent documentation shall indicate any discrepancies between materials listed on the manifest and materials received;

2. Maintain copies of all completed manifests or equivalent documentation until the license is terminated; and

3. Notify the shipper (i.e., the generator, the collector, or processor) and the Administrator of the nearest Commission Regional Office listed in appendix D to this part when any shipment or part of a shipment has not arrived within 60 days after the advance manifest was received.

E. Any shipment or part of a shipment for which acknowledgment is not received within the times set forth in this section must:

1. Be investigated by the shipper if the shipper has not received notification or receipt within 20 days after transfer; and

2. Be traced and reported. The investigation shall include tracing the shipment and filing a report with the nearest Commission Regional Office listed in appendix D to this part. Each licensee who conducts a trace investigation shall file a written report with the appropriate NRC Regional Office within 2 weeks of completion of the investigation.

[56 FR 23468, May 21, 1991, as amended at 57 FR 57879, Dec. 8, 1992. Redesignated at 58 FR 67659, Dec. 22, 1993.]

PART 21—REPORTING OF DEFECTS AND NONCOMPLIANCE

General Provisions

Sec.

EXPOSURE GUIDELINES

External Exposure — 100 mR/week

(based on 40 hr work week)

Internal Exposure — 40 mpc-hrs in any 7 consecutive days

(based on not exceeding 520 mpc-hrs in a calendard quarter)

Stay-time

The maximum time allowed in a restricted area such that neither of the exposure guidelines are exceeded.

Calculations

Stay-time (external exposure)

$$\frac{\text{100 mR - accumulative exposure for the week}}{\text{work area exposure rate}}$$

Example:

Accumulative exposure for the week = 25 mR
Work area exposure rate = 50 mR/hr

$$ST_{(EE)} = \frac{\text{100 mR - 25 mR}}{\text{50 mR/hr}}$$

$$= \frac{\text{75 mR}}{\text{50 mR/hr}}$$

$$= 1.5 \text{ hr}$$

Stay-time* (internal exposure)

*Assuming start of day 7

$$\frac{\text{40 mpc-hrs - total mpc-hrs during last 6 consecutive days}}{\text{measured number of mpc's in work area}}$$

Example:

Total mpc-hrs during last 6 days = 20 mpc-hrs
Airborne activity in work area = 1.8×10^{-8} uC/ml

$$ST_{(IE)} = \frac{\text{40 mpc-hrs - 20 mpc-hrs}}{\frac{1.8 \times 10^{-8} \text{ uC/ml}}{9 \times 10^{-9} \text{ uC/ml/mpc}}}$$

$$= \frac{\text{20 mpc-hrs}}{\text{2 mpc's}}$$

$$= 10 \text{ hrs}$$

AMS BIOASSAY PROGRAM

A. Purpose

The bioassay program at the London Road Facility of Advanced Medical Systems provides internal monitoring dosimetry for individuals frequenting areas where there may exist a potential for internal contamination. This program also provides information to the Radiation Safety Officer in determining the adequacy of current procedural and engineering controls used in limiting internal contamination and in assessing the magnitude and significance of an intake of radioactivity.

B. References

10 CFR 20	"Standards for Protection Against Radiation"
U.S. NRC Regulatory Guide 8.11	"Applications of Bioassay for Uranium"
U.S. NRC Regulatory Guide 8.26	"Application of Bioassay for Fission and Activation Products"
ANSI N343-1978	"American National Standard for Internal Dosimetry for Mixed Fission and Activation Products"

C. Source of Internal Contamination

The primary source of potential internal contamination of individuals frequenting designated bioassay areas at the London Road Facility is a non-transportable (insoluble) form of cobalt-60. This form of loose contamination is generated by the oxidation of metallic ^{60}Co used in the fabrication of sealed sources.

D. Bioassay Areas

The following areas are designated BIOASSAY AREAS at the London Road facility of Advanced Medical Systems, Inc.

1. Hot Cell

2. Decontamination Room

3. Isotope Shop Area

4. Waste Storage and Packaging Area

5. Equipment Room

6. Any other area where respiratory protection is required or where the operation performed therein creates the potential for internal contamination of personnel as defined by the Radiation Safety Officer, i.e., waste packaging, a changing of air filters.

E. Internal Exposure Controls

The primary method used for control of internal exposures are the air monitoring and respiratory protection programs. These programs are designed to ensure that individuals are not exposed to concentrations in excess of the limits specified in 10 CFR 20.103. Accordingly, the basic criteria for limiting internal depositions is for any individual not to exceed a weekly exposure of 40 MPC-Hours.

The bioassay monitoring program is used in conjunction with the internal exposure control program. Data from bioassay monitoring is used as follows:

1. To verify that the air monitoring and respiratory protection programs are sufficiently effective in limiting internal exposure to less than 40 MPC-Hr/week and less than 520 MPC-Hr/quarter.

2. To determine the location and amount of internal deposition.

3. To provide information, if necessary, for determining the dose received to the critical organ.

4. To determine the applicability of work restrictions.

F. Body Burden and Critical Organ Assumptions

The air concentration limits given for insoluble ^{60}Co in Appendix B, Table I, Column 1 of 10 CFR 20 are based upon limiting the total dose to the critical organ to less than 15 rem in a year. Due to the avid retention of oxides of ^{60}Co in the lungs, the lungs are considered the critical organ for the body burden limit.

The correlation between the inhalation limits of 10 CFR 20.103 and the Maximum Permissible Body Burden by bioassay monitoring is given by the following:

Assumptions:

Maximum Permissible Concentration in Air (MPC_a) for insoluble $^{60}Co = 9 \times 10^{-9}$ uCi/ml

Quarterly Quantity Limit = 9×10^{-9} uCi/ml $\times 6.3 \times 10^{8} = 5.67$ uCi

The fraction of the Quarterly Quantity Limit retained in the lungs is .12 or in units of radioactivity , .68 uCi.

Based on these assumptions, the relationship between bioassay results and MPC-Hr is that an exposure of 40 MPC-Hr will result in a body burden with the lung as the critical organ of 52 nCi (nanocuries).

Internal exposures by ingestion or injection shall be evaluated on a case by case basis and included in determining whether the limitation of 10 CFR 20.103 has been exceeded.

G. Work Restrictions

Work restrictions shall be implemented by the Radiation Safety Officer in accordance with the following:

1. Access to bioassay areas for individuals with an apparent body burden $\geq$52 nCi is forbidden.

2. Access to bioassay areas for individuals required to have SPECIAL bioassay monitoring is forbidden, pending the results of the monitoring and evaluation by the Radiation Safety Officer.

These restrictions are necessary to minimize the potential for any individual to exceed the applicable exposure limits.

The Radiation Safety Officer shall also enforce such restrictions as necessary on individuals and operations to ensure that internal exposure and dose are limited in accordance with the principles of ALARA.

H. Bioassay Frequency

The bioassay program at Advanced Medical Systems incorporates the following monitoring frequencies:

MINIMUM

All facility personnel who routinely enter bioassay areas for routine operation or maintenance are to be bioassayed according to the following schedule:

1. A "baseline" analysis at the time of assignment to the London Road facility. A review of this analysis and the individuals previous occupational exposure shall be made by the Radiation Safety Officer prior to initial entry into any bioassay area;

2. Annually for extended employment at the London Road Facility;

3. Prior to employment termination; or

4. Post-operational (within one month of last assignment in bioassay area).

SPECIAL

Special bioassays shall be performed when the Radiation Safety Officer determines that conditions exist such that significant internal exposure may have occurred. Such conditions include:

1. Nasal-swab results exceeding 10,000 dpm.

   NOTE: Although positive results from a nasal swab are a good indication of possible internal contamination; negative results should never be used as the only criteria for not performing in-vivo bioassays.

2. An internal exposure in excess of 40 MPC-Hr in seven consecutive days. MPC-Hr shall be determined by using air sampling data in accordance with the applicable procedures in the Isotope Facility Safety Procedures Manual.

3. Any accidental exposure whether real or suspected.

Should special bioassays be required, an operational and procedural review of the incident shall be conducted by the Radiation Safety Officer to assure against recurrence.

ROUTINE

Routine bioassay evaluations shall be performed to ensure that the air monitoring and respiratory protection programs at the London Road Facility are sufficiently effective in controlling internal exposures.

The following schedule shall be used for routine bioassay monitoring of individuals frequenting the designated bioassay areas.

FREQUENCY FOR ROUTINE BIOASSAYS BASED ON AIRBORNE CONCENTRATIONS

AIR SAMPLE RESULTS IN DESIGNATED BIOASSAY AREAS (uCi/ml)	BIOASSAY FREQUENCY (BIOASSAYS/YR EQUALLY SPACED)
0 < QA < $^1/_{10}$ MPC and 0 < M < $^1/_4$ MPC	Minimum
0 < QA < $^1/_{10}$ MPC	
$^1/_4$ MPC < M < 1 MPC	2
1 MPC < M < 10 MPC	2
M > 10 MPC	4
$^1/_{10}$ MPC < QA < $^1/_4$ MPC	
0 < M < 1 MPC	2
1 MPC < M < 10 MPC	4
M > 10 MPC	4
$^1/_4$ MPC < QA < $^1/_2$ MPC	
0 < M < 1 MPC	4
1 MPC < M < 10 MPC	4
M > 10 MPC	12
$^1/_2$ MPC < QA < 1 MPC	
0 < M < 10 MPC	12
M > 10 MPC	12

MPC = 9×10^{-9} uCi/ml

Where:

QA = Most Recent Quarterly average of air concentration in a designated bioassay area

M = Maximum concentration used in the calculation of the quarterly average

The action based upon routine bioassay includes the following:

Individual Bioassay Results	Action
≤ 5.2 nCi	None
> 5.2 nCi and < 52 nCi	If the results of the bioassay are unexpected for the established exposure controls and exposure period, perform the following: 1. Compare MPC-Hr estimation from air monitoring data to confirm results. 2. Identify the probable cause and correct or initiate additional control measures. 3. Determine whether others could have been exposed and perform bioassay measurements if indicated.
≥ 52 nCi and ≤ 535 nCi	Perform 1, 2, and 3 above and 4. Apply applicable work restrictions 5. Determine whether the 40 MPC-Hr/week control measure has been exceeded for the exposure period. If the 40 MPC-Hr/week control measure has been exceeded review the air monitoring program to determine why air samples are not representative and make necessary corrections. 6. Take corrective actions necessary to prevent recurrence and to ensure the 520 MPC-Hr quarterly exposure limit is not exceeded (712 nCi).

FOLLOW-UP

If the bioassay results indicate an apparent body burden in excess of 100 nCi in an exposure period of 13 weeks, follow-up bioassays shall be performed on a biweekly basis until the body burden is less than 5.2 nCi or until the effective half-life has been determined. Data from follow-up bioassays shall be used by the Radiation Safety Officer for the following:

1. To verify the location and amount of the deposition.

2. To determine whether the deposition was from other than inhalation

3. To estimate the internal dose resulting from the internal deposition.

I. Type and Source of Bioassay Monitoring

Advanced Medical System's London Road Facility shall use in-vivo monitoring for its bioassay program. Whole body counting shall be obtained through the services of a private or commercial whole body counting facility.

Subpart C—Employee Protection

3.1 Protection of Employee Records

Licensee contracts with HHS certified laboratories and procedures for the licensee's testing facility shall require that test records be maintained in confidence, as provided in 10 CFR 26.29. Records shall be maintained and used with the highest regard for individual privacy.

3.2 Individual Access to Test and Laboratory Certification Results

Any individual who is the subject of a drug or alcohol test under this part shall, upon written request, have access to any records relating to his or her tests and any records relating to the results of any relevant laboratory certification, review, or revocation-of-certification proceedings.

Subpart D—Certification of Laboratories Engaged in Chemical Testing

4.1 Use of DHHS-certified laboratories

(a) Licensees subject to this part and their contractors shall use only laboratories certified under the DHHS "Mandatory Guidelines for Federal Workplace Drug Testing Programs", Subpart C—"Certification of Laboratories Engaged in Urine Drug Testing for Federal Agencies," (53 FR 11970, 11986–11989) dated April 11, 1988, and subsequent amendments thereto for screening and confirmatory testing except for initial screening tests at a licensee's testing facility conducted in accordance with 10 CFR 26.24(d). Information concerning the current certification status of laboratories is available from: The Office of Workplace Initiatives, National Institute on Drug Abuse, 5600 Fishers Lane, Rockville, Maryland 20857.

(b) Licensees or their contractors may use only HHS-certified laboratories that agree to follow the same rigorous chemical testing, quality control, and chain-of-custody procedures when testing for more stringent cut-off levels as may be specified by licensees for the classes of drugs identified in this Part, for analysis of blood specimens for alcohol, and for any other substances included in licensees' drug panels.

[54 FR 24494, June 7, 1989, as amended at 56 FR 41927, Aug. 26, 1991; 58 FR 31470, June 3, 1993]

PART 30—RULES OF GENERAL APPLICABILITY TO DOMESTIC LICENSING OF BYPRODUCT MATERIAL

GENERAL PROVISIONS

Sec.

AUTHORITY: Secs. 81, 82, 161, 182, 183, 186, 68 Stat. 935, 948, 953, 954, 955, as amended, sec. 234, 83, Stat. 444, as amended (42 U.S.C. 2111, 2112, 2201, 2232, 2233, 2236, 2282); secs. 201 as amended, 202, 206, 88 Stat. 1242, as amended, 1244, 1246 (42 U.S.C. 5841, 5842, 5846).

Section 30.7 also issued under Pub. L. 95-601, sec. 10, 92 Stat. 2951 as amended by Pub. L. 102-486, sec. 2902, 106 Stat. 3123, (42 U.S.C. 5851). Section 30.34(b) also issued under sec. 184, 68 Stat. 954, as amended (42 U.S.C. 2234). Section 30.61 also issued under sec. 187, 68 Stat. 955 (42 U.S.C. 2237).

GENERAL PROVISIONS

§30.1 Scope.

This part prescribes rules applicable to all persons in the United States governing domestic licensing of byproduct material under the Atomic Energy Act of 1954, as amended (68 Stat. 919), and under title II of the Energy Reorganization Act of 1974 (88 Stat. 1242), and exemptions from the domestic licensing requirements permitted by section 81 of the Act. This part also gives notice to all persons who knowingly provide to any licensee, contractor, or subcontractor, components, equipment, materials, or other goods or services, that relate to a licensee's activities subject to this part, that they may be individually subject to NRC enforcement action for violation of §30.10.

[56 FR 40689, Aug. 15, 1991]

§30.2 Resolution of conflict.

The requirements of this part are in addition to, and not in substitution for, other requirements of this chapter. In any conflict between the requirements in this part and a specific requirement in another part of the regulations in this chapter, the specific requirement governs.

[30 FR 8185, June 26, 1965]

§30.3 Activities requiring license.

Except for persons exempt as provided in this part and part 150 of this chapter, no person shall manufacture, produce, transfer, receive, acquire, own, possess, or use byproduct material except as authorized in a specific or general license issued pursuant to the regulations in this chapter.

[30 FR 8185, June 26, 1965, as amended at 43 FR 6921, Feb. 17, 1978]

§30.4 Definitions.

Act means the Atomic Energy Act of 1954 (68 Stat. 919), including any amendments thereto;

Agreement State means any state with which the Atomic Energy Commission or the Nuclear Regulatory Commission has entered into an effective agreement under subsection 274b. of the Act. *Non-agreement State* means any other State;

Alert means events may occur, are in progress, or have occurred that could lead to a release of radioactive material but that the release is not expected to require a response by offsite response organizations to protect persons offsite.

Byproduct material means any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material;

Commencement of construction means any clearing of land, excavation, or other substantial action that would adversely affect the natural environment of a site but does not include changes desirable for the temporary use of the land for public recreational uses, necessary borings to determine site characteristics or other preconstruction monitoring to establish background information related to the suitability of a site or to the protection of environmental values.

Commission means the Nuclear Regulatory Commission and its duly authorized representatives;

Curie means that amount of radioactive material which disintegrates at the rate of 37 billion atoms per second;

Decommission means to remove (as a facility) safely from service and reduce residual radioactivity to a level that permits release of the property for unrestricted use and termination of license.

Dentist means an individual licensed by a State or Territory of the United States, the District of Columbia, or the Commonwealth of Puerto Rico to practice dentistry.

Department and *Department of Energy* means the Department of Energy established by the Department of Energy Organization Act (Pub. L. 95–91, 91 Stat. 565, 42 U.S.C. 7101 *et seq.*) to the extent that the Department, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104 (b), (c) and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93–438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section 301(a) of the Department of Energy Organization Act (Pub. L. 95–91, 91 Stat. 565 at 577–578, 42 U.S.C. 7151).

Effective dose equivalent means the sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated. Weighting factors are: 0.25 for gonads, 0.15 for breast, 0.12 for red bone marrow, 0.12 for lungs, 0.03 for thyroid, 0.03 for bone surface, and 0.06 for each of the other five organs receiving the highest dose equivalent.

Government agency means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government;

License, except where otherwise specified means a license for by-product material issued pursuant to the regulations in this part and parts 31 thro 36 and 39 of this chapter;

Medical use means the intentiona ternal or external administratio byproduct material, or the radia therefrom, to human beings in practice of medicine in accord with a license issued by a State or ritory of the United States, the trict of Columbia, or the Comm wealth of Puerto Rico.

Microcurie means that amount o dioactive material which disintegr at the rate of 37 thousand atoms second;

Millicurie means that amount o dioactive material which disinteg at the rate of 37 million atoms per ond;

Person means: (1) Any individual, poration, partnership, firm, ass tion, trust, estate, public or privat stitution, group, Government ag other than the Commission or th partment, except that the Depart shall be considered a person withi meaning of the regulations in this to the extent that its facilities ar tivities are subject to the licensin related regulatory authority o Commission pursuant to section the Energy Reorganization Act o (88 Stat. 1244),[1] any State or any cal subdivision of or any politic tity within a State, any foreign

[1] The Department facilities and act identified in section 202 are:

(1) Demonstration Liquid Metal Breeder reactors when operated as the power generation facilities of an utility system, or when operated other manner for the purpose of demo ing the suitability for commercial tion of such a reactor.

(2) Other demonstration nuclear r except those in existence on January when operated as part of the power tion facilities of an electric utility or when operated in any other mar the purpose of demonstrating the sui for commercial application of such a

(3) Facilities used primarily for the and storage of high-level radioactive resulting from licensed activities.

(4) Retrievable Surface Storage F and other facilities authorized for press purpose of subsequent long-te age of high-level radioactive waste g by the Department, which are not or are part of, research and develop tivities.

ernment or nation or any political subdivision of any such government or na- or other entity; and (2) any legal ssor, representative, agent, or ncy of the foregoing;

ysician means a medical doctor or ctor of osteopathy licensed by a State or Territory of the United States, the District of Columbia, or the Commonwealth of Puerto Rico to prescribe drugs in the practice of medicine;

Podiatrist means an individual licensed by a State or Territory of the United States, the District of Columbia, or the Commonwealth of Puerto Rico to practice podiatry.

Production facility means production facility as defined in the regulations contained in Part 50 of this chapter;

Radiographer means any individual who performs or who, in attendance at the site where the sealed source or sources are being used, personally supervises radiographic operations and who is responsible to the licensee for assuring compliance with the requirements of the Commission's regulations he conditions of the license;

diographer's assistant means any individual who, under the personal supervision of a radiographer, uses radiographic exposure devices, sealed sources or related handling tools, or radiation survey instruments in radiography;

diography means the examination ne structure of materials by nontructive methods, utilizing sealed rces of byproduct materials;

Research and development means: (1) Theoretical analysis, exploration, or experimentation; or (2) the extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials and processes. "Research and development" as used in this part and parts 31 through 35 does not include the internal or external administration of byproduct material, or the radiation therefrom, to human beings;

Sealed source means any byproduct material that is encased in a capsule designed to prevent leakage or escape of the byproduct material;

Site area emergency means events may occur, are in progress, or have occurred that could lead to a significant release of radioactive material and that could require a response by offsite response organizations to protect persons offsite.

Source material means source material as defined in the regulations contained in part 40 of this chapter;

Special nuclear material means special nuclear material as defined in the regulations contained in part 70 of this chapter;

United States, when used in a geographical sense, includes Puerto Rico and all territories and possessions of the United States;

Utilization facility means a utilization facility as defined in the regulations contained in part 50 of this chapter;

[30 FR 8185, June 26, 1965, as amended at 36 FR 1466, Jan. 30, 1971; 37 FR 5746, Mar. 21, 1972; 38 FR 29314, Oct. 24, 1973; 40 FR 8784, Mar. 3, 1975; 43 FR 6921, Feb. 17, 1978; 45 FR 14200, Mar. 5, 1980; 45 FR 18905, Mar. 24, 1980; 48 FR 39037, Aug. 29, 1983; 51 FR 36967, Oct. 16, 1986; 52 FR 8241, Mar. 17, 1987; 53 FR 24044, June 27, 1988; 54 FR 14059, Apr. 7, 1989; 58 FR 7736, Feb. 9, 1993]

§30.5 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part and parts 31 through 36 and 39 by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

[30 FR 8185, June 26, 1965, as amended at 43 FR 6921, Feb. 17, 1978; 52 FR 8241, Mar. 17, 1987; 58 FR 7736, Feb. 9, 1993]

§30.6 Communications.

(a) Unless otherwise specified or covered under the regional licensing program as provided in paragraph (b) of this section, any communication or report concerning the regulations in parts 30 through 36 and 39 of this chapter and any application filed under these regulations may be submitted to the Commission as follows:

(1) By mail addressed to: Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

(2) By delivery in person to the Commission's offices to the Director, Office of Nuclear Material Safety and Safeguards at:

(i) 2120 L Street, NW., Washington, DC; or

(ii) 11555 Rockville Pike, One White Flint North, Rockville, Maryland.

(b) The Commission has delegated to the five Regional Administrators licensing authority for selected parts of its decentralized licensing program for nuclear materials as described in paragraph (b)(1) of this section. Any communication, report, or application covered under this licensing program must be submitted as specified in paragraph (b)(2) of this section.

(1) The delegated licensing program includes authority to issue, renew, amend, cancel, modify, suspend, or revoke licenses for nuclear materials issued pursuant to 10 CFR parts 30 through 36, 39, 40, and 70 to all persons for academic, medical, and industrial uses, with the following exceptions:

(i) Activities in the fuel cycle and special nuclear material in quantities sufficient to constitute a critical mass in any room or area. This exception does not apply to license modifications relating to termination of special nuclear material licenses that authorize possession of larger quantities when the case is referred for action from NRC's Headquarters to the Regional Administrators.

(ii) Health and safety design review of sealed sources and devices and approval, for licensing purposes, of sealed sources and devices.

(iii) Processing of source material for extracting of metallic compounds (including Zirconium, Hafnium, Tantalum, Titanium, Niobium, etc.).

(iv) Distribution of products containing radioactive material to persons exempt pursuant 10 CFR 32.11 through 32.26.

(v) New uses or techniques for use of byproducts, source, or special nuclear material.

(2) *Submissions*—(i) *Region I.* The regional licensing program involves all Federal facilities in the region and non-Federal licensees in the following Region I non-Agreement States and the District of Columbia: Connecticut, Delaware, Maine, Massachusetts, New Jersey, Pennsylvania, and Verm All inquiries, communications, and plication for a new license or amendment or renewal of an exis license specified in paragraph (b)(this section must be sent to: U.S. clear Regulatory Commission, Re I, Nuclear Material Section B, Allendale Road, King of Prussia, P sylvania 19406.

(ii) *Region II.* The regional lice program involves all Federal faci in the region and non-Federal lice in the following Region II non-A ment States and territories: Vir West Virginia, Puerto Rico, an Virgin Islands. All inquiries, co nications, and applications for a n cense or an amendment or renev an existing license specified in graph (b)(1) of this section must b to U.S. Nuclear Regulatory Co sion, Region II, Material Rad Protection Section, 101 Ma Street, NW., Suite 2900, Atlanta, gia 30323.

(iii) *Region III.* The regional lic program involves all Federal fac in the region and non-Federal lic in the following Region III non- ment States: Indiana, Michigan nesota, Missouri, Ohio, and Wisc All inquiries, communications, a plications for a new license amendment or renewal of an e license specified in paragraph (t this section must be sent to: U. clear Regulatory Commission, III, Material Licensing Sectio Warrenville Road, Lisle, Illinois 4351.

(iv) *Region IV.* The regional lic program involves all Federal fa in the region and non-Federal li in the following Region IV non ment States: Montana, Okl South Dakota, and Wyoming. quiries, communications, and tions for a new license or an ment or renewal of an existing specified in paragraph (b)(1) of t tion must be sent to: U.S. Nucle ulatory Commission, Region IV rial Radiation Protection Sect Ryan Plaza Drive, Suite 1000, ton, Texas 76011.

(v) *Region V.* The regional li program involves all Federal f in the region and non-Federal l

in the following Region V non-Agreement States and a territory: Alaska, Hawaii, and Guam. All inquiries, communications, and applications for a new license or an amendment or renewal of an existing license specified in paragraph (b)(1) of this section must be sent to: U.S. Nuclear Regulatory Commission, Region V, Material Radiation Protection Section, 1450 Maria Lane, Suite 210, Walnut Creek, California 94596.

[48 FR 16031, Apr. 14, 1983, as amended at 49 FR 19630, May 9, 1984; 49 FR 47824, Dec. 7, 1984; 50 FR 14693, Apr. 11, 1985; 51 FR 36000, Oct. 8, 1986; 52 FR 8241, Mar. 17, 1987; 52 FR 38392, Oct. 16, 1987; 52 FR 48093, Dec. 18, 1987; 53 FR 3862, Feb. 10, 1988; 53 FR 4110, Feb. 12, 1988; 53 FR 43420, Oct. 27, 1988; 58 FR 7736, Feb. 9, 1993; 58 FR 64111, Dec. 6, 1993]

§ 30.7 Employee protection.

(a) Discrimination by a Commission licensee, an applicant for a Commission license, or a contractor or subcontractor of a Commission licensee or applicant against an employee for engaging in certain protected activities is prohibited. Discrimination includes discharge and other actions that relate to compensation, terms, conditions, or privileges of employment. The protected activities are established in section 211 of the Energy Reorganization Act of 1974, as amended, and in general are related to the administration or enforcement of a requirement imposed under the Atomic Energy Act or the Energy Reorganization Act.

(1) The protected activities include but are not limited to:

(i) Providing the Commission or his or her employer information about alleged violations of either of the statutes named in paragraph (a) introductory text of this section or possible violations of requirements imposed under either of those statutes;

(ii) Refusing to engage in any practice made unlawful under either of the statutes named in paragraph (a) introductory text or under these requirements if the employee has identified the alleged illegality to the employer;

(iii) Requesting the Commission to institute action against his or her employer for the administration or enforcement of these requirements;

(iv) Testifying in any Commission proceeding, or before Congress, or at any Federal or State proceeding regarding any provision (or proposed provision) of either of the statutes named in paragraph (a) introductory text.

(v) Assisting or participating in, or is about to assist or participate in, these activities.

(2) These activities are protected even if no formal proceeding is actually initiated as a result of the employee assistance or participation.

(3) This section has no application to any employee alleging discrimination prohibited by this section who, acting without direction from his or her employer (or the employer's agent), deliberately causes a violation of any requirement of the Energy Reorganization Act of 1974, as amended, or the Atomic Energy Act of 1954, as amended.

(b) Any employee who believes that he or she has been discharged or otherwise discriminated against by any person for engaging in protected activities specified in paragraph (a)(1) of this section may seek a remedy for the discharge or discrimination through an administrative proceeding in the Department of Labor. The administrative proceeding must be initiated within 180 days after an alleged violation occurs. The employee may do this by filing a complaint alleging the violation with the Department of Labor, Employment Standards Administration, Wage and Hour Division. The Department of Labor may order reinstatement, back pay, and compensatory damages.

(c) A violation of paragraphs (a), (e), or (f) of this section by a Commission licensee, an applicant for a Commission license, or a contractor or subcontractor of a Commission licensee or applicant may be grounds for—

(1) Denial, revocation, or suspension of the license.

(2) Imposition of a civil penalty on the licensee or applicant.

(3) Other enforcement action.

(d) Actions taken by an employer, or others, which adversely affect an employee may be predicated upon nondiscriminatory grounds. The prohibition applies when the adverse action occurs because the employee has engaged in protected activities. An em-

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ployee's engagement in protected activities does not automatically render him or her immune from discharge or discipline for legitimate reasons or from adverse action dictated by nonprohibited considerations.

(e)(1) Each specific licensee, each applicant for a specific license, and each general licensee subject to part 19 shall prominently post the revision of NRC Form 3, "Notice to Employees," referenced in 10 CFR 19.11(c).

(2) The posting of NRC Form 3 must be at locations sufficient to permit employees protected by this section to observe a copy on the way to or from their place of work. Premises must be posted not later than 30 days after an application is docketed and remain posted while the application is pending before the Commission, during the term of the license, and for 30 days following license termination.

NOTE: Copies of NRC Form 3 may be obtained by writing to the Regional Administrator of the appropriate U.S. Nuclear Regulatory Commission Regional Office listed in appendix D to part 20 of this chapter or by contacting the NRC Information and Records Management Branch (telephone no. 301–492–8138).

(f) No agreement affecting the compensation, terms, conditions, or privileges of employment, including an agreement to settle a complaint filed by an employee with the Department of Labor pursuant to section 211 of the Energy Reorganization Act of 1974, as amended, may contain any provision which would prohibit, restrict, or otherwise discourage an employee from participating in protected activity as defined in paragraph (a)(1) of this section including, but not limited to, providing information to the NRC or to his or her employer on potential violations or other matters within NRC's regulatory responsibilities.

[58 FR 52408, Oct. 8, 1993]

§ 30.8 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 (U.S.C. 3501 *et seq*). OM has approved the information colle tion requirements contained in th part under control number 3150–0017.

(b) The approved information colle tion requirements contained in th part appear in §§ 30.9, 30.11, 30.15, 30.1 30.20, 30.32, 30.34, 30.35, 30.36, 30.37, 30.3 30.50, 30.51, 30.55, 30.56, and appendix and C to this part.

(c) This part contains informati collection requirements in addition those approved under the control nu ber specified in paragraph (a) of th section. These information collecti requirements and the control numbe under which they are approved are follows:

(1) In §§ 30.32, 30.37, and 30.38, Fo NRC–313I is approved under cont number 3150–0042.

(2) In §§ 30.32, 30.37, and 30.38, Fo NRC–313T is approved under cont number 3150–0081.

(3) In § 30.36, Form NRC–314 is proved under control number 3150–0

(4) In §§ 30.37 and 30.38, Form NR 313M is approved under control num 3150–0041.

(5) In §§30.37 and 30.38, Form NR 313R is approved under control num 3150–0023.

[49 FR 19625, May 9, 1984, as amended a FR 68730, Dec. 29, 1993; 59 FR 1618, Jan. 1994]

EFFECTIVE DATE NOTE: At 58 FR 39633, J 26, 1993 in § 30.8, paragraph (b) was revised 58 FR 68730, Dec. 29, 1993 paragraph (b) further revised, and at 59 FR 1618, Jan. 1994, paragraph (b) was corrected, effec January 28, 1994. For the convenience of reader, the superseded text is set f below.

§ 30.8 Information collection requirem OMB approval.

* * * * *

(b) The approved information collectio quirements contained in this part appe §§ 30.9, 30.11, 30.15, 30.19, 30.20, 30.32, 3 30.35, 30.36, 30.37, 30.38, 30.41, 30.50, 30.51, 3 and appendix A.

* * * * *

§ 30.9 Completeness and accurac information.

(a) Information provided to the C mission by an applicant for a licen

by a licensee or information required by statute or by the Commission's regulations, orders, or license conditions to be maintained by the applicant or the licensee shall be complete and accurate in all material respects.

(b) Each applicant or licensee shall notify the Commission of information identified by the applicant or licensee as having for the regulated activity a significant implication for public health and safety or common defense and security. An applicant or licensee violates this paragraph only if the applicant or licensee fails to notify the Commission of information that the applicant or licensee has identified as having a significant implication for public health and safety or common defense and security. Notification shall be provided to the Administrator of the appropriate Regional Office within two working days of identifying the information. This requirement is not applicable to information which is already required to be provided to the Commission by other reporting or updating requirements.

[52 FR 49371, Dec. 31, 1987]

§ 30.10 Deliberate misconduct.

(a) Any licensee or any employee of a licensee; and any contractor (including a supplier or consultant), subcontractor, or any employee of a contractor or subcontractor, of any licensee, who knowingly provides to any licensee, contractor, or subcontractor, components, equipment, materials, or other goods or services, that relate to a licensee's activities subject to this part; may not:

(1) Engage in deliberate misconduct that causes or, but for detection, would have caused, a licensee to be in violation of any rule, regulation, or order, or any term, condition, or limitation of any license, issued by the Commission,

(2) Deliberately submit to the NRC, a licensee, or a licensee's contractor or subcontractor, information that the person submitting the information knows to be incomplete or inaccurate in some respect material to the NRC.

(b) A person who violates paragraph (a)(1) or (a)(2) of this section may be subject to enforcement action in accordance with the procedures in 10 CFR part 2, subpart B.

(c) For purposes of paragraph (a)(1) of this section, deliberate misconduct by a person means an intentional act or omission that the person knows:

(1) Would cause a licensee to be in violation of any rule, regulation, or order, or any term, condition, or limitation, of any license issued by the Commission, or

(2) Constitutes a violation of a requirement, procedure, instruction, contract, purchase order or policy of a licensee, contractor, or subcontractor.

[56 FR 40689, Aug. 15, 1991]

EXEMPTIONS

§ 30.11 Specific exemptions.

(a) The Commission may, upon application of any interested person or upon its own initiative, grant such exemptions from the requirements of the regulations in this part and parts 31 through 36 and 39 of this chapter as it determines are authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest.

(b) [Reserved]

(c) The DOE is exempt from the requirements of this part to the extent that its activities are subject to the requirements of part 60 of this chapter.

(d) Except as specifically provided in part 61 of this chapter, any licensee is exempt from the requirements of this part to the extent that its activities are subject to the requirements of part 61 of this chapter.

[37 FR 5746, Mar. 21, 1972, as amended at 39 FR 26279, July 18, 1974; 40 FR 8784, Mar. 3, 1975; 43 FR 6921, Feb. 21, 1978; 45 FR 65530, Oct. 3, 1980; 46 FR 13979, Feb. 25, 1981; 47 FR 57480, Dec. 27, 1982; 52 FR 8241, Mar. 17, 1987; 58 FR 7736, Feb. 9, 1993]

§ 30.12 Persons using byproduct material under certain Department of Energy and Nuclear Regulatory Commission contracts.

Except to the extent that Department facilities or activities of the types subject to licensing pursuant to section 202 of the Energy Reorganization Act of 1974 are involved, any prime contractor of the Department is exempt from the requirements for a li-

cense set forth in sections 81 and 82 of the Act and from the regulations in this part to the extent that such contractor, under his prime contract with the Department manufactures, produces, transfers, receives, acquires, owns, possesses, or uses byproduct material for:

(a) The performance of work for the Department at a United States Government-owned or controlled site, including the transportation of byproduct material to or from such site and the performance of contract services during temporary interruptions of such transportation;

(b) Research in, or development, manufacture, storage, testing or transportation of, atomic weapons or components thereof; or

(c) The use or operation of nuclear reactors or other nuclear devices in a United States Government-owned vehicle or vessel.

In addition to the foregoing exemptions and subject to the requirement for licensing of Department facilities and activities pursuant to section 202 of the Energy Reorganization Act of 1974, any prime contractor or subcontractor of the Department or the Commission is exempt from the requirements for a license set forth in sections 81 and 82 of the Act and from the regulations in this part to the extent that such prime contractor or subcontractor manufacturers, produces, transfers, receives, acquires, owns, possesses, or uses byproduct material under his prime contract or subcontract when the Commission determines that the exemption of the prime contractor or subcontractor is authorized by law; and that, under the terms of the contract or subcontract, there is adequate assurance that the work thereunder can be accomplished without undue risk to the public health and safety.

[40 FR 8784, Mar. 3, 1975, as amended at 43 FR 6921, Feb. 17, 1978]

§ 30.13 Carriers.

Common and contract carriers, freight forwarders, warehousemen, and the U.S. Postal Service are exempt from the regulations in this part and parts 31 through 36 and 39 of this chapter and the requirements for a license set forth in section 81 of the Act to t extent that they transport or store t product material in the regular cou of carriage for another or storage in dent thereto.

[37 FR 3985, Feb. 25, 1972, as amended at FR 6921, Feb. 17, 1978; 52 FR 8241, Mar. 1987; 58 FR 7736, Feb. 9, 1993]

§ 30.14 Exempt concentrations.

(a) Except as provided in paragra (c) and (d) of this section, any person exempt from the requirements for a cense set forth in section 81 of the A and from the regulations in this p and parts 31 through 36 and 39 of t chapter to the extent that such per receives, possesses, uses, transfe owns or acquires products or materi containing byproduct material in c centrations not in excess of those li ed in § 30.70.

(b) This section shall not be deem to authorize the import of byprod material or products containing product material.

(c) A manufacturer, processor, or p ducer of a product or material in agreement State is exempt from the quirements for a license set forth section 81 of the Act and from the re lations in this part and parts 31, 32, 34, 36 and 39 of this chapter to the tent that he transfers byproduct ma rial contained in a product or mate in concentrations not in excess of th specified in § 30.70 and introduced i the product or material by a licen holding a specific license issued by agreement State, the Commission, the Atomic Energy Commission pressly authorizing such introducti This exemption does not apply to transfer of byproduct material c tained in any food, beverage, cosme drug, or other commodity or prod designed for ingestion or inhalation or application to, a human being.

(d) No person may introduce bypr uct material into a product or mate knowing or having reason to beli that it will be transferred to pers exempt under this section or equi lent regulations of an Agreem State, except in accordance with a cense issued pursuant to § 32.11 of t chapter or the general license provi in § 150.20 of this chapter.

[30 FR 8185, June 26, 1965, as amended at 40 FR 8785, Mar. 3, 1975; 43 FR 6921, Feb. 17, 1978; 52 FR 8241, Mar. 17, 1987; 58 FR 7736, Feb. 9, 1993]

§ 30.15 Certain items containing byproduct material.

(a) Except for persons who apply byproduct material to, or persons who incorporate byproduct material into, the following products, or persons who initially transfer for sale or distribution the following products containing byproduct material, any person is exempt from the requirements for a license set forth in section 81 of the Act and from the regulations in parts 20 and 30 through 36 and 39 of this chapter to the extent that such person receives, possesses, uses, transfers, owns, or acquires the following products:

(1) Timepieces or hands or dials containing not more than the following specified quantities of byproduct material and not exceeding the following specified levels of radiation:

(i) 25 millicuries of tritium per timepiece,

(ii) 5 millicuries of tritium per hand,

(iii) 15 millicuries of tritium per dial (bezels when used shall be considered as part of the dial),

(iv) 100 microcuries of promethium 147 per watch or 200 microcuries of promethium 147 per any other timepiece,

(v) 20 microcuries of promethium 147 per watch hand or 40 microcuries of promethium 147 per other timepiece hand,

(vi) 60 microcuries of promethium 147 per watch dial or 120 microcuries of promethium 147 per other timepiece dial (bezels when used shall be considered as part of the dial),

(vii) The levels of radiation from hands and dials containing promethium 147 will not exceed, when measured through 50 milligrams per square centimeter of absorber:

(*a*) For wrist watches, 0.1 millirad per hour at 10 centimeters from any surface,

(*b*) For pocket watches, 0.1 millirad per hour at 1 centimeter from any surface,

(*c*) For any other timepiece, 0.2 millirad per hour at 10 centimeters from any surface.

(2) Lock illuminators containing not more than 15 millicuries of tritium or not more than 2 millicuries of promethium 147 installed in automobile locks. The levels of radiation from each lock illuminator containing promethium 147 will not exceed 1 millirad per hour at 1 centimeter from any surface when measured through 50 milligrams per square centimeter of absorber.

(3) Balances of precision containing not more than 1 millicurie of tritium per balance or not more than 0.5 millicurie of tritium per balance part.

(4) Automobile shift quadrants containing not more than 25 millicuries of tritium.

(5) Marine compasses containing not more than 750 millicuries of tritium gas and other marine navigational instruments containing not more than 250 millicuries of tritium gas.

(6) Thermostat dials and pointers containing not more than 25 millicuries of tritium per thermostat.

(7) [Reserved]

(8) Electron tubes: *Provided*, That each tube does not contain more than one of the following specified quantities of byproduct material:

(i) 150 millicuries of tritium per microwave receiver protector tube or 10 millicuries of tritium per any other electron tube;

(ii) 1 microcurie of cobalt-60;

(iii) 5 microcuries of nickel-63;

(iv) 30 microcuries of krypton-85;

(v) 5 microcuries of cesium-137;

(vi) 30 microcuries of promethium-147;

And provided further, That the levels of radiation from each electron tube containing byproduct material do not exceed 1 millirad per hour at 1 centimeter from any surface when measured through 7 milligrams per square centimeter of absorber.[1]

(9) Ionizing radiation measuring instruments containing, for purposes of internal calibration or standardization, one or more sources of byproduct material: *Provided*, That;

[1] For purposes of this paragraph "electron tubes" include spark gap tubes, power tubes, gas tubes including glow lamps, receiving tubes, microwave tubes, indicator tubes, pickup tubes, radiation detection tubes, and any other completely sealed tube that is designed to conduct or control electrical currents.

(i) Each source contains no more than one exempt quantity set forth in § 30.71, Schedule B, and

(ii) Each instrument contains no more than 10 exempt quantities. For purposes of this paragraph (a)(9), an instrument's source(s) may contain either one type or different types of radionuclides and an individual exempt quantity may be composed of fractional parts of one or more of the exempt quantities in § 30.71, Schedule B, provided that the sum of such fractions shall not exceed unity.

(iii) For purposes of this paragraph (a)(9), 0.05 microcurie of americium-241 is considered an exempt quantity under § 30.71, Schedule B.

(10) Spark gap irradiators containing not more than 1 microcurie of cobalt-60 per spark gap irradiator for use in electrically ignited fuel oil burners having a firing rate of at least 3 gallons per hour (11.4 liters per hour).

(b) Any person who desires to apply byproduct material to, or to incorporate byproduct material into, the products exempted in paragraph (a) of this section, or who desires to initially transfer for sale or distribution such products containing byproduct material, should apply for a specific license pursuant to § 32.14 of this chapter, which license states that the product may be distributed by the licensee to persons exempt from the regulations pursuant to paragraph (a) of this section.

[31 FR 5316, Apr. 2, 1966, as amended at 31 FR 14349, Nov. 8, 1966; 32 FR 785, Jan. 24, 1967; 32 FR 6434, Apr. 26, 1967; 32 FR 13921, Oct. 6, 1967; 34 FR 6651, Apr. 18, 1969; 34 FR 19546, Dec. 11, 1969; 35 FR 6427, Apr. 22, 1970; 35 FR 8820, June 6, 1970; 43 FR 2387, Jan. 17, 1978; 43 FR 6921, Feb. 17, 1978; 46 FR 26471, May 13, 1981; 46 FR 46876, Sept. 23, 1981; 52 FR 8241, Mar. 17, 1987; 58 FR 7736, Feb. 9, 1993]

§ 30.16 Resins containing scandium-46 and designed for sand-consolidation in oil wells.

Any person is exempt from the requirements for a license set forth in section 81 of the Act and from the regulations in Parts 20 and 30 through 36 and 39 of this chapter to the extent that such person receives, possesses, uses, transfers, owns, or acquires synthetic plastic resins containing scandium-46 which are designed for sand-consolidation in oil wells, and wh have been manufactured or initia transferred for sale or distribution, accordance with a specific license sued pursuant to § 32.17 of this chap or equivalent regulations of an agr ment State. The exemption in this s tion does not authorize the manuf ture or initial transfer for sale or tribution of any resins contain scandium-46.

[32 FR 4241, Mar. 18, 1967, as amended a FR 6921, Feb. 17, 1978; 52 FR 8241, Mar. 1987; 58 FR 7736, Feb. 9, 1993]

§ 30.18 Exempt quantities.

(a) Except as provided in paragra (c) and (d) of this section, any perso exempt from the requirements for a cense set forth in section 81 of the and from the regulations in parts through 34, 36 and 39 of this chapte the extent that such person recei possesses, uses, transfers, owns, or quires byproduct material in indivi quantities each of which does not ceed the applicable quantity set f in § 30.71, Schedule B.

(b) Any person who possesses byp uct material received or acquired p to September 25, 1971 under the ger license then provided in § 31.4 of chapter is exempt from the req ments for a license set forth in sec 81 of the Act and from the regulat in parts 30 through 34 of this chapt the extent that such person posse uses, transfers, or owns such bypro material.

(c) This section does not auth for purposes of commercial dist tion the production, packaging, packaging, or transfer of bypro material or the incorporation o product material into products tended for commercial distributio

(d) No person may, for purpos commercial distribution, transfe product material in the indiv quantities set forth in § 30.71 Sch B, knowing or having reason to be that such quantities of byproduct terial will be transferred to perso empt under this section or equiv regulations of an Agreement Stat cept in accordance with a licen sued under § 32.18 of this chapter, license states that the byproduct rial may be transferred by the lic

to persons exempt under this section or the equivalent regulations of an Agreement State.

[35 FR 6427, Apr. 22, 1970, as amended at 36 FR 16898, Aug. 26, 1971; 43 FR 6921, Feb. 17, 1978; 52 FR 8241, Mar. 17, 1987; 58 FR 7736, Feb. 9, 1993]

§30.19 Self-luminous products containing tritium, krypton-85, or promethium-147.

(a) Except for persons who manufacture, process, produce, or initially transfer for sale or distribution self-luminous products containing tritium, krypton-85, or promethium-147, and except as provided in paragraph (c) of this section, any person is exempt from the requirements for a license set forth in section 81 of the Act and from the regulations in parts 20 and 30 through 36 and 39 of this chapter to the extent that such person receives, possesses, uses, transfers, owns, or acquires tritium, krypton-85, or promethium-147 in self-luminous products manufactured, processed, produced, or initially transferred in accordance with a specific license issued pursuant to §32.22 of this chapter, which license authorizes the initial transfer of the product for use under this section.

(b) Any person who desires to manufacture, process, or produce self-luminous products containing tritium, krypton-85, or promethium-147, or to transfer such products for use pursuant to paragraph (a) of this section, should apply for a license pursuant to §32.22 of this chapter, which license states that the product may be transferred by the licensee to persons exempt from the regulations pursuant to paragraph (a) of this section or equivalent regulations of an Agreement State.

(c) The exemption in paragraph (a) of this section does not apply to tritium, krypton-85, or promethium-147 used in products primarily for frivolous purposes or in toys or adornments.

[34 FR 9026, June 6, 1969, as amended at 40 FR 8785, Mar. 3, 1975; 43 FR 6921, Feb. 17, 1978; 52 FR 8241, Mar. 17, 1987; 58 FR 7736, Feb. 9, 1993]

§30.20 Gas and aerosol detectors containing byproduct material.

(a) Except for persons who manufacture, process, produce, or initially transfer for sale or distribution gas and aerosol detectors containing byproduct material, any person is exempt from the requirements for a license set forth in section 81 of the Act and from the regulations in parts 20 and 30 through 36 and 39 of this chapter to the extent that such person receives, possesses, uses, transfers, owns, or acquires byproduct material, in gas and aerosol detectors designed to protect life or property from fires and airborne hazards, and manufactured, processed, produced, or initially transferred in accordance with a specific license issued pursuant to §32.26 of this chapter, which license authorizes the initial transfer of the product for use under this section.

(b) Any person who desires to manufacture, process, or produce gas and aerosol detectors containing byproduct material, or to initially transfer such products for use pursuant to paragraph (a) of this section, should apply for a license pursuant to §32.26 of this chapter, which license states that the product may be initially transferred by the licensee to persons exempt from the regulations pursuant to paragraph (a) of this section or equivalent regulations of an Agreement State.

[34 FR 6653, Apr. 18, 1969, as amended at 40 FR 8785, Mar. 3, 1975; 43 FR 6921, Feb. 17, 1978; 52 FR 8241, Mar. 17, 1987; 58 FR 7736, Feb. 9, 1993]

LICENSES

§30.31 Types of licenses.

Licenses for byproduct material are of two types: General and specific. Specific licenses are issued to named persons upon applications filed pursuant to the regulations in this part and parts 32 through 36 and 39 of this chapter. General licenses are effective without the filing of applications with the Commission or the issuance of licensing documents to particular persons.

[30 FR 8185, June 26, 1965, as amended at 43 FR 6922, Feb. 17, 1978; 52 FR 8241, Mar. 17, 1987; 58 FR 7736, Feb. 9, 1993]

§30.32 Application for specific licenses.

(a) A person may file an application in duplicate on NRC Form 313, "Application for Material License," in accordance with the instructions in §30.6

of this chapter. Information contained in previous applications, statements or reports filed with the Commission or the Atomic Energy Commission may be incorporated by reference, provided that the reference is clear and specific.

(b) The Commission may at any time after the filing of the original application, and before the expiration of the license, require further statements in order to enable the Commission to determine whether the application should be granted or denied or whether a license should be modified or revoked.

(c) Each application shall be signed by the applicant or licensee or a person duly authorized to act for and on his behalf.

(d) An application for license filed pursuant to the regulations in this part and parts 32 through 35 of this chapter will be considered also as an application for licenses authorizing other activities for which licenses are required by the Act, provided that the application specifies the additional activities for which licenses are requested and complies with regulations of the Commission as to applications for such licenses.

(e) Each application for a byproduct material license, other than a license exempted from part 170 of this chapter, shall be accompanied by the fee prescribed in §170.31 of this chapter. No fee will be required to accompany an application for renewal or amendment of a license, except as provided in §170.31 of this chapter.

(f) An application for a license to receive and possess byproduct material for the conduct of any activity which the Commission has determined pursuant to subpart A of part 51 of this chapter will significantly affect the quality of the environment shall be filed at least 9 months prior to commencement of construction of the plant or facility in which the activity will be conducted and shall be accompanied by any Environmental Report required pursuant to subpart A of part 51 of this chapter.

(g) An application for a specific license to use byproduct material in the form of a sealed source or in a device that contains the sealed source must either—

(1) Identify the source or device by manufacturer and model number as registered with the Commission u §32.210 of this chapter or with Agreement State; or

(2) Contain the information ide fied in §32.210(c).

(h) As provided by §30.35, certain plications for specific licenses under this part and parts 32 throug of this chapter must contain a posed decommissioning funding pla a certification of financial assur for decommissioning. In the case o newal applications submitted b July 27, 1990, this submittal may f the renewal application but mus submitted on or before July 27, 199

(i)(1) Each application to posse dioactive materials in unsealed on foils or plated sources, or seal glass in excess of the quantiti §30.72, "Schedule C—Quantities o dioactive Materials Requiring C eration of the Need for an Emer Plan for Responding to a Rele must contain either:

(i) An evaluation showing tha maximum dose to a person offsit to a release of radioactive mat would not exceed 1 rem effectiv equivalent or 5 rems to the thyr

(ii) An emergency plan for respo to a release of radioactive materi

(2) One or more of the followi tors may be used to support an e tion submitted under paragraph (of this section:

(i) The radioactive material is ically separated so that only a p could be involved in an accident;

(ii) All or part of the radioacti terial is not subject to release an accident because of the wa stored or packaged;

(iii) The release fraction in t pirable size range would be low the release fraction shown §30.72 the chemical or physical form material;

(iv) The solubility of the radi material would reduce the d ceived;

(v) Facility design or eng safety features in the facility cause the release fraction to b than shown in §30.72;

(vi) Operating restrictions o dures would prevent a release as large as that shown in §30.72;

(vii) Other factors appropriate for the specific facility.

(3) An emergency plan for responding to a release of radioactive material submitted under paragraph (i)(1)(ii) of this section must include the following information:

(i) Facility description. A brief description of the licensee's facility and area near the site.

(ii) Types of accidents. An identification of each type of radio-active materials accident for which protective actions may be needed.

(iii) Classification of accidents. A classification system for classifying accidents as alerts or site area emergencies.

(iv) Detection of accidents. Identification of the means of detecting each type of accident in a timely manner.

(v) Mitigation of consequences. A brief description of the means and equipment for mitigating the consequences of each type of accident, including those provided to protect workers onsite, and a description of the program for maintaining the equipment.

(vi) Assessment of releases. A brief description of the methods and equipment to assess releases of radioactive materials.

(vii) Responsibilities. A brief description of the responsibilities of licensee personnel should an accident occur, including identification of personnel responsible for promptly notifying offsite response organizations and the NRC; also responsibilities for developing, maintaining, and updating the plan.

(viii) Notification and coordination. A commitment to and a brief description of the means to promptly notify offsite response organizations and request offsite assistance, including medical assistance for the treatment of contaminated injured onsite workers when appropriate. A control point must be established. The notification and coordination must be planned so that unavailability of some personnel, parts of the facility, and some equipment will not prevent the notification and coordination. The licensee shall also commit to notify the NRC operations center immediately after notification of the appropriate offsite response organizations and not later than one hour after the licensee declares an emergency.[1]

(ix) Information to be communicated. A brief description of the types of information on facility status, radioactive releases, and recommended protective actions, if necessary, to be given to offsite response organizations and to the NRC.

(x) Training. A brief description of the frequency, performance objectives and plans for the training that the licensee will provide workers on how to respond to an emergency including any special instructions and orientation tours the licensee would offer to fire, police, medical and other emergency personnel. The training shall familiarize personnel with site-specific emergency procedures. Also, the training shall thoroughly prepare site personnel for their responsibilities in the event of accident scenarios postulated as most probable for the specific site, including the use of team training for such scenarios.

(xi) Safe shutdown. A brief description of the means of restoring the facility to a safe condition after an accident.

(xii) Exercises. Provisions for conducting quarterly communications checks with offsite response organizations and biennial onsite exercises to test response to simulated emergencies. Quarterly communications checks with offsite response organizations must include the check and update of all necessary telephone numbers. The licensee shall invite offsite response organizations to participate in the biennial exercises. Participation of offsite response organizations in biennial exercises although recommended is not required. Exercises must use accident scenarios postulated as most probable for the specific site and the scenarios shall not be known to most exercise participants. The licensee shall critique each exercise using individuals not having direct implementation responsibility for the plan. Critiques of exercises must evalu-

[1] These reporting requirements do not superceed or release licensees of complying with the requirements under the Emergency Planning and Community Right-to-Know Act of 1986, Title III, Pub. L. 99-499 or other state or federal reporting requirements.

ate the appropriateness of the plan, emergency procedures, facilities, equipment, training of personnel, and overall effectiveness of the response. Deficiencies found by the critiques must be corrected.

(xiii) Hazardous chemicals. A certification that the applicant has met its responsibilities under the Emergency Planning and Community Right-to-Know Act of 1986, title III, Pub. L. 99-499, if applicable to the applicant's activities at the proposed place of use of the byproduct material.

(4) The licensee shall allow the offsite response organizations expected to respond in case of an accident 60 days to comment on the licensee's emergency plan before submitting it to NRC. The licensee shall provide any comments received within the 60 days to the NRC with the emergency plan.

[30 FR 8185, June 26, 1965, as amended at 36 FR 145, Jan. 6, 1971; 37 FR 5747, Mar. 21, 1972; 43 FR 6922, Feb. 17, 1978; 49 FR 9403, Mar. 12, 1984; 49 FR 27924, July 9, 1984; 52 FR 27786, July 24, 1987; 53 FR 24044, June 27, 1988; 54 FR 14060, Apr. 7, 1989]

§ 30.33 General requirements for issuance of specific licenses.

(a) An application for a specific license will be approved if:

(1) The application is for a purpose authorized by the Act;

(2) The applicant's proposed equipment and facilities are adequate to protect health and minimize danger to life or property;

(3) The applicant is qualified by training and experience to use the material for the purpose requested in such manner as to protect health and minimize danger to life or property;

(4) The applicant satisfies any special requirements contained in parts 32 through 36 and 39; and

(5) In the case of an application for a license to receive and possess byproduct material for the conduct of any activity which the Commission determines will significantly affect the quality of the environment, the Director of Nuclear Material Safety and Safeguards or his designee, before commencement of construction of the plant or facility in which the activity will be conducted, on the basis of information filed and evaluations made pursuant to subpart A of part 51 of th chapter, has concluded, after weighi the environmental, economic, tec nical, and other benefits against en ronmental costs and considering ava able alternatives, that the acti called for is the issuance of the pr posed license, with any appropria conditions to protect environmen values. Commencement of constructi prior to such conclusion shall grounds for denial of a license to ceive and possess byproduct mater in such plant or facility. As used this paragraph the term "commen ment of construction" means a clearing of land, excavation, or oth substantial action that would versely affect the environment of site. The term does not mean site ploration, necessary roads for site ploration, borings to determine foun tion conditions, or ot preconstruction monitoring or test to establish background informat related to the suitability of the site the protection of environmental ues.

(b) Upon a determination that an plication meets the requirements the Act, and the regulations of Commission, the Commission will is a specific license authorizing the session and use of byproduct mate (Form NRC 374, "Byproduct Mate License").

[30 FR 8185, June 26, 1965, as amended a FR 12731, July 7, 1971; 37 FR 5747, Mar 1972; 39 FR 26279, July 18, 1974; 43 FR Feb. 17, 1978; 49 FR 9403, Mar. 12, 1984; 5 8241, Mar. 17, 1987; 58 FR 7736, Feb. 9, 1993

§ 30.34 Terms and conditions of censes.

(a) Each license issued pursuan the regulations in this part and regulations in parts 31 through 36 39 of this chapter shall be subject t the provisions of the Act, now or h after in effect, and to all valid r regulations and orders of the Com sion.

(b) No license issued or granted suant to the regulations in this and parts 31 through 36, and 39 nor right under a license shall be tr ferred, assigned or in any manner posed of, either voluntarily or inv tarily, directly or indirectly, thr

transfer of control of any license to any person, unless the Commission shall, after securing full information, find that the transfer is in accordance with the provisions of the Act and shall give its consent in writing.

(c) Each person licensed by the Commission pursuant to the regulations in this part and parts 31 through 36 and 39 shall confine his possession and use of the byproduct material to the locations and purposes authorized in the license. Except as otherwise provided in the license, a license issued pursuant to the regulations in this part and parts 31 through 36 and 39 of this chapter shall carry with it the right to receive, acquire, own, and possess byproduct material. Preparation for shipment and transport of byproduct material shall be in accordance with the provisions of part 71 of this chapter.

(d) Each license issued pursuant to the regulations in this part and parts 31 through 36 and 39 shall be deemed to contain the provisions set forth in section 183b.–d., inclusive, of the Act, whether or not these provisions are expressly set forth in the license.

(e) The Commission may incorporate, in any license issued pursuant to the regulations in this part and parts 31 through 36 and 39, at the time of issuance, or thereafter by appropriate rule, regulation or order, such additional requirements and conditions with respect to the licensee's receipt, possession, use and transfer of byproduct material as it deems appropriate or necessary in order to:

(1) Promote the common defense and security;

(2) Protect health or to minimize danger to life or property;

(3) Protect restricted data;

(4) Require such reports and the keeping of such records, and to provide for such inspections of activities under the license as may be necessary or appropriate to effectuate the purposes of the Act and regulations thereunder.

(f) Licensees required to submit emergency plans by §30.32(i) shall follow the emergency plan approved by the Commission. The licensee may change the approved without Commission approval only if the changes do not decrease the effectiveness of the plan. The licensee shall furnish the change to the appropriate NRC Regional Office specified in §30.6 and to affected offsite response organizations within six months after the change is made. Proposed changes that decrease, or potentially decrease, the effectiveness of the approved emergency plan may not be implemented without prior application to and prior approval by the Commission.

(g) Each licensee preparing technetium-99m radiopharmaceuticals from molybdenum-99/technetium-99m generators shall test the generator eluates for molybdenum-99 breakthrough in accordance with §35.204 of this chapter. The licensee shall record the results of each test and retain each record for three years after the record is made.

(h)(1) Each licensee shall notify the appropriate NRC Regional Administrator, in writing, immediately following the filing of a voluntary or involuntary petition for bankruptcy under any chapter of title 11 (Bankruptcy) of the United States Code by or against:

(i) The licensee;

(ii) An entity (as that term is defined in 11 U.S.C. 101(14)) controlling the licensee or listing the license or licensee as property of the estate; or

(iii) An affiliate (as that term is defined in 11 U.S.C. 101(2)) of the licensee.

(2) This notification must indicate:

(i) The bankruptcy court in which the petition for bankruptcy was filed; and

(ii) The date of the filing of the petition.

(i)(1) From August 23, 1990, to December 31, 1994, each licensee eluting generators and processing radioactive material with diagnostic reagent kits for which the Food and Drug Administration (FDA) has approved a "New Drug Application" (NDA), may depart from the manufacturer's elution and preparation instructions (for radiopharmaceuticals authorized for use pursuant to 10 CFR 35.200), provided that the licensee follows the directions of an authorized user physician.

(2) The actions authorized in paragraph (i)(1) of this section are permitted in spite of more restrictive language in license conditions.

(3) Nothing in this section relieves the licensee from complying with other

applicable NRC, FDA, and other Federal or State regulations.

[30 FR 8185, June 26, 1965, as amended at 38 FR 33969, Dec. 10, 1973; 43 FR 6922, Feb. 17, 1978; 48 FR 32328, July 15, 1983; 52 FR 1295, Jan. 12, 1987; 52 FR 8241, Mar. 17, 1987; 53 FR 19245, May 27, 1988; 53 FR 23383, June 22, 1988; 54 FR 14061, Apr. 7, 1989; 57 FR 45568, Oct. 2, 1992; 58 FR 7736, Feb. 9, 1993; 58 FR 39132, July 22, 1993]

§ 30.35 Financial assurance and recordkeeping for decommissioning.

(a) Each applicant for a specific license authorizing the possession and use of unsealed byproduct material of half-life greater than 120 days and in quantities exceeding 10^5 times the applicable quantities set forth in appendix B to part 30 shall submit a decommissioning funding plan as described in paragraph (e) of this section. The decommissioning funding plan must also be submitted when a combination of isotopes is involved if R divided by 10^5 is greater than 1 (unity rule), where R is defined here as the sum of the ratios of the quantity of each isotope to the applicable value in appendix B to part 30.

(b) Each applicant for a specific license authorizing possession and use of byproduct material of half-life greater than 120 days and in quantities specified in paragraph (d) of this section shall either—

(1) Submit a decommissioning funding plan as described in paragraph (e) of this section; or

(2) Submit a certification that financial assurance for decommissioning has been provided in the amount prescribed by paragraph (d) of this section using one of the methods described in paragraph (f) of this section. For an applicant, this certification may state that the appropriate assurance will be obtained after the application has been approved and the license issued but prior to the receipt of licensed material. As part of the certification, a copy of the financial instrument obtained to satisfy the requirements of paragraph (f) of this section is to be submitted to NRC.

(c)(1) Each holder of a specific license issued on or after July 27, 1990, which is of a type described in paragraph (a) or (b) of this section, shall provide financial assurance for decommissioning in accordance with the criteria set for in this section.

(2) Each holder of a specific licen issued before July 27, 1990, and of type described in paragraph (a) of th section shall submit, on or before Ju 27, 1990, a decommissioning fundi plan or a certification of financial a surance for decommissioning in amount at least equal to $750,000 in a cordance with the criteria set forth this section. If the licensee submits t certification of financial assuran rather than a decommissioning fundi plan at this time, the licensee shall clude a decommissioning funding pl in any application for license renew

(3) Each holder of a specific licen issued before July 27, 1990, and o type described in paragraph (b) of t section shall submit, on or before J 27, 1990, a certification of financial surance for decommissioning or a commissioning funding plan in acco ance with the criteria set forth in t section.

(d) Table of required amounts of nancial assurance for decommission by quantity of material.

greater than 10^4 but less than or equal to 10^5 times the applicable quantities of appendix B to part 30 in unsealed form. (For a combination of isotopes, if R, as defined in §30.35(a), divided by 10^4 is greater than 1 but R divided by 10^5 is less than or equal to 1.)	$75
greater than 10^3 but less than or equal to 10^4 times the applicable quantities of appendix B to part 30 in unsealed form. (For a combination of isotopes, if R, as defined in §30.35(a), divided by 10^3 is greater than 1 but R divided by 10^4 is less than or equal to 1.)	$15
greater than 10^{10} times the applicable quantities of appendix B to part 30 in sealed sources or plated foils. (For a combination of isotopes, if R, as defined in §30.35(a), divided by 10^{10} is greater than 1).	$

(e) Each decommissioning fun plan must contain a cost estimat decommissioning and a descriptio the method of assuring funds fo commissioning from paragraph (this section, including means of ad ing cost estimates and associated ing levels periodically over the li the facility.

(f) Financial assurance for decommissioning must be provided by one or more of the following methods:

(1) Prepayment. Prepayment is the deposit prior to the start of operation into an account segregated from licensee assets and outside the licensee's administrative control of cash or liquid assets such that the amount of funds would be sufficient to pay decommissioning costs. Prepayment may be in the form of a trust, escrow account, government fund, certificate of deposit, or deposit of government securities.

(2) A surety method, insurance, or other guarantee method. These methods guarantee that decommissioning costs will be paid. A surety method may be in the form of a surety bond, letter of credit, or line of credit. A parent company guarantee of funds for decommissioning costs based on a financial test may be used if the guarantee and test are as contained in appendix A of this part. A parent company guarantee may not be used in combination with other financial methods to satisfy the requirements of this section. A guarantee of funds by the applicant or licensee for decommissioning costs based on a financial test may be used if the guarantee and test are as contained in appendix C of this part. A guarantee by the applicant or licensee may not be used in combination with any other financial methods to satisfy the requirements of this section or in any situation where the applicant or licensee has a parent company holding majority control of the voting stock of the company. Any surety method or insurance used to provide financial assurance for decommissioning must contain the following conditions:

(i) The surety method or insurance must be open-ended or, if written for a specified term, such as five years, must be renewed automatically unless 90 days or more prior to the renewal date, the issuer notifies the Commission, the beneficiary, and the licensee of its intention not to renew. The surety method or insurance must also provide that the full face amount be paid to the beneficiary automatically prior to the expiration without proof of forfeiture if the licensee fails to provide a replacement acceptable to the Commission within 30 days after receipt of notification of cancellation.

(ii) The surety method or insurance must be payable to a trust established for decommissioning costs. The trustee and trust must be acceptable to the Commission. An acceptable trustee includes an appropriate State or Federal government agency or an entity which has the authority to act as a trustee and whose trust operations are regulated and examined by a Federal or State agency.

(iii) The surety method or insurance must remain in effect until the Commission has terminated the license.

(3) An external sinking fund in which deposits are made at least annually, coupled with a surety method or insurance, the value of which may decrease by the amount being accumulated in the sinking fund. An external sinking fund is a fund established and maintained by setting aside funds periodically in an account segregated from licensee assets and outside the licensee's administrative control in which the total amount of funds would be sufficient to pay decommissioning costs at the time termination of operation is expected. An external sinking fund may be in the form of a trust, escrow account, government fund, certificate of deposit, or deposit of government securities. The surety or insurance provisions must be as stated in paragraph (f)(2) of this section.

(4) In the case of Federal, State, or local government licensees, a statement of intent containing a cost estimate for decommissioning or an amount based on the Table in paragraph (d) of this section, and indicating that funds for decommissioning will be obtained when necessary.

(g) Each person licensed under this part or parts 32 through 35 of this chapter shall keep records of information important to the safe and effective decommissioning of the facility in an indentified location until the license is terminated by the Commission. If records of relevant information are kept for other purposes, reference to these records and their locations may be used. Information the Commission considers important to decommissioning consists of—

(1) Records of spills or other unusual occurrences involving the spread of contamination in and around the facility, equipment, or site. These records may be limited to instances when contamination remains after any cleanup procedures or when there is reasonable likelihood that contaminants may have spread to inaccessible areas as in the case of possible seepage into porous materials such as concrete. These records must include any known information on identification of involved nuclides, quantities, forms, and concentrations.

(2) As-built drawings and modifications of structures and equipment in restricted areas where radioactive materials are used and/or stored, and of locations of possible inaccessible contamination such as buried pipes which may be subject to contamination. If required drawings are referenced, each relevant document need not be indexed individually. If drawings are not available, the licensee shall substitute appropriate records of available information concerning these areas and locations.

(3) Except for areas containing only sealed sources (provided the sources have not leaked or no contamination remains after any leak) or byproduct materials having only half-lives of less than 65 days, a list contained in a single document and updated every 2 years, of the following:

(i) All areas designated and formerly designated restricted areas as defined in 10 CFR 20.1003 (For requirements prior to January 1, 1994, see 10 CFR 20.3 as contained in the CFR edition revised as of January 1, 1993.);

(ii) All areas outside of restricted areas that require documentation under § 30.35(g)(1).

(iii) All areas outside of restricted areas where current and previous wastes have been buried as documented under 10 CFR 20.2108; and

(iv) All areas outside of restricted areas which contain material such that, if the license expired, the licensee would be required to either decontaminate the area to unrestricted release levels or apply for approval for disposal under 10 CFR 20.2002.

(4) Records of the cost estimate performed for the decommissioning funding plan or of the amount certified decommissioning, and records of funding method used for assuring fu if either a funding plan or certificat is used.

[53 FR 24044, June 27, 1988, as amended FR 23471, May 21, 1991; 58 FR 39633, Jul 1993; 58 FR 67659, Dec. 22, 1993; 58 FR 6 Dec. 29, 1993; 59 FR 1618, Jan. 12, 1994]

EFFECTIVE DATE NOTE: At 58 FR 68730, 29, 1993 in § 30.35, the introductory te paragraph (f)(2) was revised, and at 5 1618, Jan. 12, 1994, (f)(2) was corrected, e tive January 28, 1994. For the convenien the reader, the superseded text ap below.

§ 30.35 Financial assurance and re keeping for decommissioning.

* * * * *

(f) * * *

(2) A surety method, insurance, or guarantee method. These methods guar that decommissioning costs will be should the licensee default. A surety m may be in the form of a surety bond, of credit, or line of credit. A parent com guarantee of funds for decommissi costs based on a financial test may be if the guarantee and test are as contain appendix A to this part. A parent com guarantee may not be used in combin with other financial methods to satisf requirements of this section. Any s method or insurance used to provide cial assurance for decommissioning contain the following conditions:

* * * * *

§ 30.36 Expiration and terminati licenses.

(a) Except as provided in § 30.37(b paragraph (e) of this section, each cific license expires at the end o day, in the month and year stat the license.

(b) Each licensee shall notify Commission promptly, in writing § 30.6, and request termination of t cense when the licensee decides t minate all activities involving rials authorized under the license. notification and request for t nation of the license must includ reports and information specifi paragraphs (c)(1) (iv) and (v) o section and a plan for completion commissioning if required by

graph (c)(2) of this section or by license condition.

(c)(1) If a licensee does not submit an application for license renewal under §30.37, the licensee shall on or before the expiration date specified in the license—

(i) Terminate use of byproduct material;

(ii) Remove radioactive contamination to the extent practicable except for those procedures covered by paragraph (c)(2)(i) of this section;

(iii) Properly dispose of byproduct material;

(iv) Submit a completed form NRC–314, which certifies information concerning the disposition of materials; and

(v) Conduct a radiation survey of the premises where the licensed activities were carried out and submit a report of the results of this survey, unless the licensee demonstrates that the premises are suitable for release for unrestricted use in some other manner. The licensee shall, as appropriate—

(A) Report levels of radiation in units of microrads per hour of beta and gamma radiation at one centimeter and gamma radiation at one meter from surfaces, and report levels of radioactivity, including alpha, in units of disintegrations per minute (or microcuries) per 100 square centimeters removable and fixed for surfaces, microcuries per milliliter for water, and picocuries per gram for solids such as soils or concrete; and

(B) Specify the survey instrument(s) used and certify that each instrument is properly calibrated and tested.

(2)(i) In addition to the information required under paragraphs (c)(1)(iv) and (v) of this section, the licensee shall submit a plan for completion of decommissioning if the procedures necessary to carry out decommissioning have not been previously approved by the NRC and could increase potential health and safety impacts to workers or to the public such as in any of the following cases:

(A) Procedures would involve techniques not applied routinely during cleanup or maintenance operations; or

(B) Workers would be entering areas not normally occupied where surface contamination and radiation levels are significantly higher than routinely encountered during operation; or

(C) Procedures could result in significantly greater airborne concentrations of radioactive materials than are present during operation; or

(D) Procedures could result in significantly greater releases of radioactive material to the environment than those associated with operation.

(ii) Procedures with potential health and safety impacts may not be carried out prior to approval of the decommissioning plan.

(iii) The proposed decommissioning plan, if required by paragraph (c)(2)(i) of this section or by license condition, must include—

(A) Description of planned decommissioning activities;

(B) Description of methods used to assure protection of workers and the environment against radiation hazards during decommissioning;

(C) A description of the planned final radiation survey; and

(D) The information required in §30.35(g)(3) and any other information required by §30.35(g) that is considered necessary to support the adequacy of the decommissioning plan for approval;

(E) An updated detailed cost estimate for decommissioning, comparison of that estimate with present funds set aside for decommissioning, and plan for assuring the availability of adequate funds for completion of decommissioning.

(iv) The proposed decommissioning plan will be approved by the Commission if the information therein demonstrates that the decommissioning will be completed as soon as is reasonable and that the health and safety of workers and the public will be adequately protected.

(3) Upon approval of the decommissioning plan by the Commission, the licensee shall complete decommissioning in accordance with the approved plan. As a final step in decommissioning, the licensee shall again submit the information required in paragraph (c)(1)(v) of this section, shall certify the disposition of accumulated wastes from decommissioning, and shall include a list containing the location and description of all equipment to remain onsite after license termination that

was contaminated when final decommissioning was initiated.

(d) If the information submitted under paragraph (c)(1)(v) or (c)(3) of this section does not adequately demonstrate that the premises are suitable for release for unrestricted use, the Commission will inform the licensee of the appropriate further actions required for termination of license.

(e) Each specific license continues in effect, beyond the expiration date if necessary, with respect to possession of residual byproduct material present as contamination until the Commission notifies the licensee in writing that the license is terminated. During this time, the licensee shall—

(1) Limit actions involving byproduct material to those related to decommissioning; and

(2) Continue to control entry to restricted areas until they are suitable for release for unrestricted use and the Commission notifies the licensee in writing that the license is terminated.

(f) Specific licenses will be terminated by written notice to the licensee when the Commission determines that—

(1) Byproduct material has been properly disposed;

(2) Reasonable effort has been made to eliminate residual radioactive contamination, if present; and

(3)(i) A radiation survey has been performed which demonstrates that the premises are suitable for release for unrestricted use; or

(ii) Other information submitted by the licensee is sufficient to demonstrate that the premises are suitable for release for unrestricted use.

[53 FR 24045, June 27, 1988, as amended at 58 FR 36933, July 26, 1993]

§ 30.37 Application for renewal of licenses.

(a) Application for renewal of a specific license shall be filed on Form NRC–313 in accordance with § 30.32.

(b) In any case in which a licensee, not less than thirty (30) days prior to the expiration of his existing license, has filed an application in proper form for renewal or for a new license, such existing license shall not expire until the application has been finally determined by the Commission.

[30 FR 8185, June 26, 1965, as amended at FR 19625, May 9, 1984; 49 FR 21699, May 1984]

§ 30.38 Application for amendment licenses.

Applications for amendment of a cense shall be filed on Form NRC–313 accordance with § 30.32 and shall spec fy the respects in which the licens desires its license to be amended a the grounds for the amendment.

[49 FR 19625, May 9, 1984]

§ 30.39 Commission action on applic tions to renew or amend.

In considering an application by a censee to renew or amend his licen the Commission will apply the applic ble criteria set forth in § 30.33 and pa 32 through 36 and 39 of this chapter.

[30 FR 8185, June 26, 1965, as amended at FR 6922, Feb. 17, 1978; 52 FR 8241, Mar. 1987; 58 FR 7736, Feb. 9, 1993]

§ 30.41 Transfer of byproduct materi

(a) No licensee shall transfer bypr uct material except as authorized p suant to this section.

(b) Except as otherwise provided his license and subject to the pro sions of paragraphs (c) and (d) of t section, any licensee may transfer product material:

(1) To the Department;

(2) To the agency in any Agreem State which regulates radioactive m terial pursuant to an agreement un section 274 of the Act;

(3) To any person exempt from the censing requirements of the Act regulations in this part, to the ext permitted under such exemption;

(4) To any person in an Agreem State, subject to the jurisdiction that State, who has been exemp from the licensing requirements regulations of that State, to the ext permitted under such exemption;

(5) To any person authorized to ceive such byproduct material un terms of a specific license or a gen license or their equivalents issued the Atomic Energy Commission, Commission, or an Agreement State

(6) To a person abroad pursuant t export license issued under part 11 this chapter; or

(7) As otherwise authorized by the Commission in writing.

(c) Before transferring byproduct material to a specific licensee of the Commission or an Agreement State or to a general licensee who is required to register with the Commission or with an Agreement State prior to receipt of the byproduct material, the licensee transferring the material shall verify that the transferee's license authorizes the receipt of the type, form, and quantity of byproduct material to be transferred.

(d) The following methods for the verification required by paragraph (c) of this section are acceptable:

(1) The transferor may have in his possession, and read, a current copy of the transferee's specific license or registration certificate;

(2) The transferor may have in his possession a written certification by the transferee that he is authorized by license or registration certificate to receive the type, form, and quantity of byproduct material to be transferred, specifying the license or registration certificate number, issuing agency and expiration date;

(3) For emergency shipments the transferor may accept oral certification by the transferee that he is authorized by license or registration certificate to receive the type, form, and quantity of byproduct material to be transferred, specifying the license or registration certificate number, issuing agency and expiration date: *Provided*, That the oral certification is confirmed in writing within 10 days;

(4) The transferor may obtain other sources of information compiled by a reporting service from official records of the Commission or the licensing agency of an Agreement State as to the identity of licensees and the scope and expiration dates of licenses and registration; or

(5) When none of the methods of verification described in paragraphs (d)(1) to (4) of this section are readily available or when a transferor desires to verify that information received by one of such methods is correct or up-to-date, the transferor may obtain and record confirmation from the Commission or the licensing agency of an Agreement State that the transferee is licensed to receive the byproduct material.

[38 FR 33969, Dec. 10, 1973, as amended at 40 FR 8785, Mar. 3, 1975; 43 FR 6922, Feb. 17, 1978]

RECORDS, INSPECTIONS, TESTS, AND REPORTS

§ 30.50 Reporting requirements.

(a) *Immediate report.* Each licensee shall notify the NRC as soon as possible but not later than 4 hours after the discovery of an event that prevents immediate protective actions necessary to avoid exposures to radiation or radioactive materials that could exceed regulatory limits or releases of licensed material that could exceed regulatory limits (events may include fires, explosions, toxic gas releases, etc.).

(b) *Twenty-four hour report.* Each licensee shall notify the NRC within 24 hours after the discovery of any of the following events involving licensed material:

(1) An unplanned contamination event that:

(i) Requires access to the contaminated area, by workers or the public, to be restricted for more than 24 hours by imposing additional radiological controls or by prohibiting entry into the area;

(ii) Involves a quantity of material greater than five times the lowest annual limit on intake specified in appendix B of §§ 20.1001–20.2401 of 10 CFR part 20 for the material; and

(iii) Has access to the area restricted for a reason other than to allow isotopes with a half-life of less than 24 hours to decay prior to decontamination.

(2) An event in which equipment is disabled or fails to function as designed when:

(i) The equipment is required by regulation or license condition to prevent releases exceeding regulatory limits, to prevent exposures to radiation and radioactive materials exceeding regulatory limits, or to mitigate the consequences of an accident;

(ii) The equipment is required to be available and operable when it is disabled or fails to function; and

(iii) No redundant equipment is available and operable to perform the required safety function.

(3) An event that requires unplanned medical treatment at a medical facility of an individual with spreadable radioactive contamination on the individual's clothing or body.

(4) An unplanned fire or explosion damaging any licensed material or any device, container, or equipment containing licensed material when:

(i) The quantity of material involved is greater than five times the lowest annual limit on intake specified in appendix B of §§ 20.1001–20.2401 of 10 CFR part 20 for the material; and

(ii) The damage affects the integrity of the licensed material or its container.

(c) Preparation and submission of reports. Reports made by licensees in response to the requirements of this section must be made as follows:

(1) Licensees shall make reports required by paragraphs (a) and (b) of this section by telephone to the NRC Operations Center.[1] To the extent that the information is available at the time of notification, the information provided in these reports must include:

(i) The caller's name and call back telephone number;

(ii) A description of the event, including date and time;

(iii) The exact location of the event;

(iv) The isotopes, quantities, and chemical and physical form of the licensed material involved; and

(v) Any personnel radiation exposure data available.

(2) Written report. Each licensee who makes a report required by paragraph (a) or (b) of this section shall submit a written follow-up report within 30 days of the initial report. Written reports prepared pursuant to other regulations may be submitted to fulfill this requirement if the reports contain all of the necessary information and the appropriate distribution is made. These written reports must be sent to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, DC 20555, with a copy to the appropriate NRC Regional office listed in appendix D of 10 CFR part 20. The repo must include the following:

(i) A description of the event, incl ing the probable cause and the ma facturer and model number (if appli ble) of any equipment that failed malfunctioned;

(ii) The exact location of the event

(iii) The isotopes, quantities, chemical and physical form of the censed material involved;

(iv) Date and time of the event;

(v) Corrective actions taken planned and the results of any eval tions or assessments; and

(vi) The extent of exposure of indi uals to radiation or to radioactive terials without identification of i viduals by name.

(3) The provisions of § 30.50 do apply to licensees subject to the no cation requirements in § 50.72. The apply to those part 50 licensees poss ing material licensed under part who are not subject to the notifica requirements in § 50.72.

[56 FR 40767, Aug. 16, 1991]

§ 30.51 Records.

(a) Each person who receives byp uct material pursuant to a licens sued pursuant to the regulation this part and parts 31 through 36 of chapter shall keep records showing receipt, transfer, and disposal of byproduct material as follows:

(1) The licensee shall retain record of receipt of byproduct mat as long as the material is possessed for three years following transfe disposal of the material.

(2) The licensee who transferred material shall retain each recor transfer for three years after transfer unless a specific require in another part of the regulatio this chapter dictates otherwise.

(3) The licensee who disposed o material shall retain each reco disposal of byproduct material the Commission terminates eac cense that authorizes disposal o material.

(b) The licensee shall retain record that is required by the re tions in this part and parts 31 th 36 of this chapter or by license c tion for the period specified by t propriate regulation or license c

[1] The commercial telephone number for the NRC Operations Center is (301) 951–0550.

tion. If a retention period is not otherwise specified by regulation or license condition, the record must be retained until the Commission terminates each license that authorizes the activity that is subject to the recordkeeping requirement.

(c)(1) Records which must be maintained pursuant to this part and parts 31 through 36 of this chapter may be the original or a reproduced copy or microform if such reproduced copy or microform is duly authenticated by authorized personnel and the microform is capable of producing a clear and legible copy after storage for the period specified by Commission regulations. The record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records such as letters, drawings, specifications, must include all pertinent information such as stamps, initials, and signatures. The licensee shall maintain adequate safeguards against tampering with and loss of records.

(2) If there is a conflict between the Commission's regulations in this part and parts 31 through 36 and 39 of this chapter, license condition, or other written Commission approval or authorization pertaining to the retention period for the same type of record, the retention period specified in the regulations in this part and parts 31 through 36 and 39 of this chapter for such records shall apply unless the Commission, pursuant to §30.11, has granted a specific exemption from the record retention requirements specified in the regulations in this part or parts 31 through 36 and 39 of this chapter.

[41 FR 18301, May 5, 1976, as amended at 43 FR 6922, Feb. 17, 1978; 52 FR 8241, Mar. 17, 1987; 53 FR 19245, May 27, 1988; 58 FR 7736, Feb. 9, 1993]

§30.52 Inspections.

(a) Each licensee shall afford to the Commission at all reasonable times opportunity to inspect byproduct material and the premises and facilities wherein byproduct material is used or stored.

(b) Each licensee shall make available to the Commission for inspection, upon reasonable notice, records kept by him pursuant to the regulations in this chapter.

[30 FR 8185, June 26, 1965]

§30.53 Tests.

Each licensee shall perform, or permit the Commission to perform, such tests as the Commission deems appropriate or necessary for the administration of the regulations in this part and parts 31 through 36 and 39 of this chapter, including tests of:

(a) Byproduct material;

(b) Facilities wherein byproduct material is utilized or stored;

(c) Radiation detection and monitoring instruments; and

(d) Other equipment and devices used in connection with the utilization or storage of byproduct material.

[30 FR 8185, June 26, 1965, as amended by 43 FR 6922, Feb. 17, 1978; 52 FR 8241, Mar. 17, 1987; 58 FR 7736, Feb. 9, 1993]

§30.55 Tritium reports.

(a)–(b) [Reserved]

(c) Except as specified in paragraph (d) of this section, each licensee who is authorized to possess tritium shall report promptly to the appropriate NRC Regional Office listed in appendix D of part 20 of this chapter by telephone and telegraph, mailgram, or facsimile any incident in which an attempt has been made or is believed to have been made to commit a theft or unlawful diversion of more than 10 curies of such material at any one time or more than 100 curies of such material in any one calendar year. The initial report shall be followed within a period of fifteen (15) days by a written report submitted to the appropriate NRC Regional Office which sets forth the details of the incident and its consequences. Copies of such written report shall be sent to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Subsequent to the submission of the written report required by this paragraph, the licensee shall promptly inform the Office of Nuclear Material Safety and Safeguards by means of a written report of any substantive additional information, which becomes available to the licensee, concerning an

attempted or apparent theft or unlawful diversion of tritium.

(d) The reports described in this section are not required for tritium possessed pursuant to a general license provided in part 31 of this chapter or for tritium contained in spent fuel.

[37 FR 9208, May 6, 1972, as amended at 38 FR 1271, Jan. 11, 1973; 38 FR 2330, Jan. 24, 1973; 41 FR 16446, Apr. 19, 1976; 43 FR 6922, Feb. 17, 1978; 46 FR 55085, Nov. 6, 1981; 49 FR 24707, June 15, 1984; 52 FR 31611, Aug. 21, 1987]

ENFORCEMENT

§ 30.61 Modification and revocation of licenses.

(a) The terms and conditions of each license issued pursuant to the regulations in this part and parts 31 through 35 of this chapter shall be subject to amendment, revision or modification by reason of amendments to the Act, or by reason of rules, regulations and orders issued in accordance with the terms of the Act.

(b) Any license may be revoked, suspended or modified, in whole or in part, for any material false statement in the application or any statement of fact required under section 182 of the Act, or because of conditions revealed by such application or statement of fact or any report, record or inspection or other means which would warrant the Commission to refuse to grant a license on an original application, or for violation of, or failure to observe any of the terms and provisions of the Act or of any rule, regulation or order of the Commission.

(c) Except in cases of willfulness or those in which the public health, interest or safety requires otherwise, no license shall be modified, suspended or revoked unless, prior to the institution of proceedings therefor, facts or conduct which may warrant such action shall have been called to the attention of the licensee in writing and the licensee shall have been accorded an opportunity to demonstrate or achieve compliance with all lawful requirements.

[30 FR 8185, June 26, 1965, as amended at 35 FR 11460, July 17, 1970; 43 FR 6922, Feb. 17, 1978]

§ 30.62 Right to cause the withhol or recall of byproduct material.

The Commission may cause the w holding or recall of byproduct mat from any licensee who is not equi to observe or fails to observe such ty standards to protect health as be established by the Commissio who uses such materials in violati law or regulation of the Commis or in a manner other than as disc in the application therefor or appr by the Commission.

[30 FR 8185, June 26, 1965, as amended FR 8785, Mar. 3, 1975]

§ 30.63 Violations.

(a) The Commission may obtai injunction or other court order to vent a violation of the provisions c

(1) The Atomic Energy Act of 19 amended;

(2) Title II of the Energy Reorga tion Act of 1974, as amended; or

(3) A regulation or order issued suant to those Acts.

(b) The Commission may obt court order for the payment of a penalty imposed under section 2 the Atomic Energy Act:

(1) For violations of—

(i) Sections 53, 57, 62, 63, 81, 8 103, 104, 107, or 109 of the Atomi ergy Act of 1954, as amended;

(ii) Section 206 of the Energy R nization Act;

(iii) Any rule, regulation, or or sued pursuant to the sections spe in paragraph (b)(1)(i) of this secti

(iv) Any term, condition, or li tion of any license issued unde sections specified in paragraph (1 of this section.

(2) For any violation for whic cense may be revoked under secti of the Atomic Energy Act of 1 amended.

[57 FR 55072, Nov. 24, 1992]

§ 30.64 Criminal penalties.

(a) Section 223 of the Atomic E Act of 1954, as amended, provi criminal sanctions for willful vi of, attempted violation of, or c acy to violate, any regulation under sections 161b, 161i, or 161o Act. For purposes of section 223, regulations in part 30 are issued

one or more of sections 161b, 161i, or 161o, except for the sections listed in paragraph (b) of this section.

(b) The regulations in part 30 that are not issued under sections 161b, 161i, or 161o for the purposes of section 223 are as follows: §§ 30.1, 30.2, 30.4, 30.5, 30.6, 30.8, 30.11, 30.12, 30.13, 30.15, 30.16, 30.31, 30.32, 30.33, 30.37, 30.38, 30.39, 30.61, 30.62, 30.63, 30.64, 30.70, 30.71, and 30.72.

[57 FR 55072, Nov. 24, 1992]

SCHEDULES

§ 30.70 Schedule A—exempt concentrations.

[See footnotes at end of this table]

Element (atomic number)	Isotope	Col. I	Col. II
		Gas concentration μCi/ml [1]	Liquid and solid concentration μCi/ml [2]
Antimony (51)	Sb 122		3×10^{-4}
	Sb 124		2×10^{-4}
	Sb 125		1×10^{-3}
Argon (18)	A 37	1×10^{-3}	
	A 41	4×10^{-7}	
Arsenic (33)	As 73		5×10^{-3}
	As 74		5×10^{-4}
	As 76		2×10^{-4}
	As 77		8×10^{-4}
Barium (56)	Ba 131		2×10^{-3}
	Ba 140		3×10^{-4}
Beryllium (4)	Be 7		2×10^{-2}
Bismuth (83)	Bi 206		4×10^{-4}
Bromine (35)	Br 82	4×10^{-7}	3×10^{-3}
Cadmium (48)	Cd 109		2×10^{-3}
	Cd 115m		3×10^{-4}
	Cd 115		3×10^{-4}
Calcium (20)	Ca 45		9×10^{-5}
	Ca 47		5×10^{-4}
Carbon (6)	C 14	1×10^{-6}	8×10^{-3}
Cerium (58)	Ce 141		9×10^{-4}
	Ce 143		4×10^{-4}
	Ce 144		1×10^{-4}
Cesium (55)	Cs 131		2×10^{-2}
	Cs 134m		6×10^{-2}
	Cs 134		9×10^{-5}
Chlorine (17)	Cl 38	9×10^{-7}	4×10^{-3}
Chromium (24)	Cr 51		2×10^{-2}
Cobalt (27)	Co 57		5×10^{-3}
	Co 58		1×10^{-3}
	Co 60		5×10^{-4}
Copper (29)	Cu 64		3×10^{-3}
Dysprosium (66)	Dy 165		4×10^{-3}
	Dy 166		4×10^{-4}
Erbium (68)	Er 169		9×10^{-4}
	Er 171		1×10^{-3}
Europium (63)	Eu 152 (T/2=9.2 Hrs).		6×10^{-4}
	Eu 155		2×10^{-3}
Fluorine (9)	F 18	2×10^{-6}	8×10^{-3}
Gadolinium (64)	Gd 153		2×10^{-3}
	Gd 159		8×10^{-4}
Gallium (31)	Ga 72		4×10^{-4}
Germanium (32)	Ge 71		2×10^{-2}
Gold (79)	Au 196		2×10^{-3}
	Au 198		5×10^{-4}
	Au 199		2×10^{-3}
Hafnium (72)	Hf 181		7×10^{-4}
Hydrogen (1)	H 3	5×10^{-6}	3×10^{-2}
Indium (49)	In 113m		1×10^{-2}
	In 114m		2×10^{-4}
Iodine (53)	I 126	3×10^{-9}	2×10^{-5}
	I 131	3×10^{-9}	2×10^{-5}
	I 132	8×10^{-8}	6×10^{-4}
	I 133	1×10^{-8}	7×10^{-5}

[See footnotes at end of this table]

Element (atomic number)	Isotope	Col. I	Col. II
		Gas concentration μCi/ml [1]	Liquid and s concentration ml [2]
Iridium (77)	I 134	2x10⁻⁷	1x10⁻³
	Ir 190		2x10⁻⁵
	Ir 192		4x10⁻⁴
	Ir 194		3x10⁻⁴
Iron (26)	Fe 55		8x10⁻³
	Fe 59		6x10⁻⁴
Krypton (36)	Kr 85m	1x10⁻⁶	
	Kr 85	3x10⁻⁶	
Lanthanum (57)	La 140		2x10⁻⁴
Lead (82)	Pb 203		4x10⁻³
Lutetium (71)	Lu 177		1x10⁻³
Manganese (25)	Mn 52		3x10⁻⁴
	Mn 54		1x10⁻³
	Mn 56		1x10⁻³
Mercury (80)	Hg 197m		2x10⁻³
	Hg 197		3x10⁻³
	Hg 203		2x10⁻⁴
Molybdenum (42)	Mo 99		2x10⁻³
Neodymium (60)	Nd 147		6x10⁻⁴
	Nd 149		3x10⁻³
Nickel (28)	Ni 65		1x10⁻³
Niobium (Columbium) (41)	Nb 95		1x10⁻³
	Nb 97		9x10⁻³
Osmium (76)	Os 185		7x10⁻⁴
	Os 191m		3x10⁻²
	Os 191		2x10⁻³
	Os 193		6x10⁻⁴
Palladium (46)	Pd 103		3x10⁻³
	Pd 109		9x10⁻⁴
Phosphorus (15)	P 32		2x10⁻⁴
Platinum (78)	Pt 191		1x10⁻³
	Pt 193m		1x10⁻²
	Pt 197m		1x10⁻³
	Pt 197		1x10⁻³
Potassium (19)	K 42		3x10⁻³
Praseodymium (59)	Pr 142		3x10⁻⁴
	Pr 143		5x10⁻⁴
Promethium (61)	Pm 147		2x10⁻⁴
	Pm 149		4x10⁻³
Rhenium (75)	Re 183		6x10⁻⁴
	Re 186		9x10⁻³
	Re 188		6x10⁻⁴
Rhodium (45)	Rh 103m		1x10⁻¹
	Rh 105		1x10⁻³
Rubidium (37)	Rb 86		7x10⁻⁴
Ruthenium (44)	Ru 97		4x10⁻⁴
	Ru 103		8x10⁻⁴
	Ru 105		1x10⁻³
	Ru 106		1x10⁻⁴
Samarium (62)	Sm 153		8x10⁻⁴
Scandium (21)	Sc 46		4x10⁻⁴
	Sc 47		9x10⁻⁴
	Sc 48		3x10⁻⁴
Selenium (34)	Se 75		3x10⁻³
Silicon (14)	Si 31		9x10⁻³
Silver (47)	Ag 105		1x10⁻³
	Ag 110m		3x10⁻⁴
	Ag 111		4x10⁻⁴
Sodium (11)	Na 24		2x10⁻³
Strontium (38)	Sr 85		1x10⁻⁴
	Sr 89		1x10⁻⁴
	Sr 91		7x10⁻⁴
	Sr 92		7x10⁻⁴
Sulfur (16)	S 35	9x10⁻⁸	6x10⁻⁴
Tantalum (73)	Ta 182		4x10⁻⁴
Technetium (43)	Tc 96m		1x10⁻¹
	Tc 96		1x10⁻³
Tellurium (52)	Te 125m		2x10⁻³
	Te 127m		6x10⁻⁴

[See footnotes at end of this table]

Element (atomic number)	Isotope	Col. I	Col. II
		Gas concentration μCi/ml [1]	Liquid and solid concentration μCi/ml [2]
	Te 127		3×10^{-3}
	Te 129m		3×10^{-4}
	Te 131m		6×10^{-4}
	Te 132		3×10^{-4}
Terbium (65)	Tb 160		4×10^{-4}
Thallium (81)	Tl 200		4×10^{-3}
	Tl 201		3×10^{-3}
	Tl 202		1×10^{-3}
	Tl 204		1×10^{-3}
Thulium (69)	Tm 170		5×10^{-4}
	Tm 171		5×10^{-3}
Tin (50)	Sn 113		9×10^{-4}
	Sn 125		2×10^{-4}
Tungsten (Wolfram) (74)	W 181		4×10^{-3}
	W 187		7×10^{-4}
Vanadium (23)	V 48		3×10^{-4}
Xenon (54)	Xe 131m	4×10^{-6}	
	Xe 133	3×10^{-6}	
	Xe 135	1×10^{-6}	
Ytterbium (70)	Yb 175		1×10^{-3}
Yttrium (39)	Y 90		2×10^{-4}
	Y 91m		3×10^{-2}
	Y 91		3×10^{-4}
	Y 92		6×10^{-4}
	Y 93		3×10^{-4}
Zinc (30)	Zn 65		1×10^{-3}
	Zn 69m		7×10^{-4}
	Zn 69		2×10^{-2}
conium (40)	Zr 95		6×10^{-4}
	Zr 97		2×10^{-4}
a and/or gamma emitting byproduct material not listed above with half-life less than 3 years.		1×10^{-10}	1×10^{-6}

Footnotes to Schedule A:
[1] Values are given only for those materials normally used as gases.
[2] μCi/gm for solids.

NOTE 1: Many radioisotopes disintegrate into isotopes which are also radioactive. In expressing the concentrations in Schedule A, the activity stated is that of the parent isotope and takes into account the daughters.

NOTE 2: For purposes of §30.14 where there is involved a combination of isotopes, the limit for the combination should be derived as follows:

Determine for each isotope in the product the ratio between the concentration present in the product and the exempt concentration established in Schedule A for the specific isotope when not in combination. The sum of such ratios may not exceed "1" (i.e., unity).

Example:

$$\frac{\text{Concentration of Isotope A in Product}}{\text{Exempt concentration of Isotope A}} + \frac{\text{Concentration of Isotope B in Product}}{\text{Exempt concentration of Isotope B}} \leq 1$$

[30 FR 8185, June 26, 1965, as amended at 35 FR 3982, Mar. 3, 1970; 38 FR 29314, Oct. 24, 1973]

30.71 Schedule B.

Byproduct material	Microcuries
Antimony 122 (Sb 122)	100
Antimony 124 (Sb 124)	10
Antimony 125 (Sb 125)	10
Arsenic 73 (As 73)	100
Arsenic 74 (As 74)	10
Arsenic 76 (As 76)	10
Arsenic 77 (As 77)	100
Barium 131 (Ba 131)	10
Barium 133 (Ba 133)	10
Barium 140 (Ba 140)	10
Bismuth 210 (Bi 210)	1
Bromine 82 (Br 82)	10
Cadmium 109 (Cd 109)	10
Cadmium 115m (Cd 115m)	10
Cadmium 115 (Cd 115)	100
Calcium 45 (Ca 45)	10
Calcium 47 (Ca 47)	10
Carbon 14 (C 14)	100
Cerium 141 (Ce 141)	100
Cerium 143 (Ce 143)	100

Byproduct material	Microcuries
Cerium 144 (Ce 144)	1
Cesium 131 (Cs 131)	1,000
Cesium 134m (Cs 134m)	100
Cesium 134 (Cs 134)	1
Cesium 135 (Cs 135)	10
Cesium 136 (Cs 136)	10
Cesium 137 (Cs 137)	10
Chlorine 36 (Cl 36)	10
Chlorine 38 (Cl 38)	10
Chromium 51 (Cr 51)	1,000
Cobalt 58m (Co 58m)	10
Cobalt 58 (Co 58)	10
Cobalt 60 (Co 60)	1
Copper 64 (Cu 64)	100
Dysprosium 165 (Dy 165)	10
Dysprosium 166 (Dy 166)	100
Erbium 169 (Er 169)	100
Erbium 171 (Er 171)	100
Europium 152 9.2 h (Eu 152 9.2 h)	100
Europium 152 13 yr (Eu 152 13 yr)	1
Europium 154 (Eu 154)	1
Europium 155 (Eu 155)	10
Fluorine 18 (F 18)	1,000
Gadolinium 153 (Gd 153)	10
Gadolinium 159 (Gd 159)	100
Gallium 72 (Ga 72)	10
Germanium 71 (Ge 71)	100
Gold 198 (Au 198)	100
Gold 199 (Au 199)	100
Hafnium 181 (Hf 181)	10
Holmium 166 (Ho 166)	100
Hydrogen 3 (H 3)	1,000
Indium 113m (In 113m)	100
Indium 114m (In 114m)	10
Indium 115m (In 115m)	100
Indium 115 (In 115)	10
Iodine 125 (I 125)	1
Iodine 126 (I 126)	1
Iodine 129 (I 129)	0.1
Iodine 131 (I 131)	1
Iodine 132 (I 132)	10
Iodine 133 (I 133)	1
Iodine 134 (I 134)	10
Iodine 135 (I 135)	10
Iridium 192 (Ir 192)	10
Iridium 194 (Ir 194)	100
Iron 55 (Fe 55)	100
Iron 59 (Fe 59)	10
Krypton 85 (Kr 85)	100
Krypton 87 (Kr 87)	10
Lanthanum 140 (La 140)	10
Lutetium 177 (Lu 177)	100
Manganese 52 (Mn 52)	10
Manganese 54 (Mn 54)	10
Manganese 56 (Mn 56)	10
Mercury 197m (Hg 197m)	100
Mercury 197 (Hg 197)	100
Mercury 203 (Hg 203)	10
Molybdenum 99 (Mo 99)	100
Neodymium 147 (Nd 147)	100
Neodymium 149 (Nd 149)	100
Nickel 59 (Ni 59)	100
Nickel 63 (Ni 63)	10
Nickel 65 (Ni 65)	100
Niobium 93m (Nb 93m)	10
Niobium 95 (Nb 95)	10
Niobium 97 (Nb 97)	10
Osmium 185 (Os 185)	10
Osmium 191m (Os 191m)	100
Osmium 191 (Os 191)	100
Osmium 193 (Os 193)	100
Palladium 103 (Pd 103)	100
Palladium 109 (Pd 109)	100
Phosphorus 32 (P 32)	10

Byproduct material	Micro
Platinum 191 (Pt 191)	
Platinum 193m (Pt 193m)	
Platinum 193 (Pt 193)	
Platinum 197m (Pt 197m)	
Platinum 197 (Pt 197)	
Polonium 210 (Po 210)	
Potassium 42 (K 42)	
Praseodymium 142 (Pr 142)	
Praseodymium 143 (Pr 143)	
Promethium 147 (Pm 147)	
Promethium 149 (Pm 149)	
Rhenium 186 (Re 186)	
Rhenium 188 (Re 188)	
Rhodium 103m (Rh 103m)	
Rhodium 105 (Rh 105)	
Rubidium 86 (Rb 86)	
Rubidium 87 (Rb 87)	
Ruthenium 97 (Ru 97)	
Ruthenium 103 (Ru 103)	
Ruthenium 105 (Ru 105)	
Ruthenium 106 (Ru 106)	
Samarium 151 (Sm 151)	
Samarium 153 (Sm 153)	
Scandium 46 (Sc 46)	
Scandium 47 (Sc 47)	
Scandium 48 (Sc 48)	
Selenium 75 (Se 75)	
Silicon 31 (Si 31)	
Silver 105 (Ag 105)	
Silver 110m (Ag 110m)	
Silver 111 (Ag 111)	
Sodium 24 (Na 24)	
Strontium 85 (Sr 85)	
Strontium 89 (Sr 89)	
Strontium 90 (Sr 90)	
Strontium 91 (Sr 91)	
Strontium 92 (Sr 92)	
Sulphur 35 (S 35)	
Tantalum 182 (Ta 182)	
Technetium 96 (Tc 96)	
Technetium 97m (Tc 97m)	
Technetium 97 (Tc 97)	
Technetium 99m (Tc 99m)	
Technetium 99 (Tc 99)	
Tellurium 125m (Te 125m)	
Tellurium 127m (Te 127m)	
Tellurium 127 (Te 127)	
Tellurium 129m (Te 129m)	
Tellurium 129 (Te 129)	
Tellurium 131m (Te 131m)	
Tellurium 132 (Te 132)	
Terbium 160 (Tb 160)	
Thallium 200 (Tl 200)	
Thallium 201 (Tl 201)	
Thallium 202 (Tl 202)	
Thallium 204 (Tl 204)	
Thulium 170 (Tm 170)	
Thulium 171 (Tm 171)	
Tin 113 (Sn 113)	
Tin 125 (Sn 125)	
Tungsten 181 (W 181)	
Tungsten 185 (W 185)	
Tungsten 187 (W 187)	
Vanadium 48 (V 48)	
Xenon 131m (Xe 131m)	
Xenon 133 (Xe 133)	
Xenon 135 (Xe 135)	
Ytterbium 175 (Yb 175)	
Yttrium 90 (Y 90)	
Yttrium 91 (Y 91)	
Yttrium 92 (Y 92)	
Yttrium 93 (Y 93)	
Zinc 65 (Zn 65)	
Zinc 69m (Zn 69m)	

Byproduct material	Microcuries
Zinc 69 (Zn 69)	1,000
Zirconium 93 (Zr 93)	10
Zirconium 95 (Zr 95)	10
Zirconium 97 (Zr 97)	10
Any byproduct material not listed above other than alpha emitting byproduct material	0.1

[35 FR 6427, Apr. 22, 1970, as amended at 36 FR 16898, Aug. 26, 1971]

§ 30.72 Schedule C—Quantities of radioactive materials requiring consideration of the need for an emergency plan for responding to a release.

Radioactive material [1]	Release fraction	Quantity (curies)
Actinium-228	0.001	4,000
Americium-241	.001	2
Americium-242	.001	2
Americium-243	.001	2
Antimony-124	.01	4,000
Antimony-126	.01	6,000
Barium-133	.01	10,000
Barium-140	.01	30,000
Bismuth-207	.01	5,000
Bismuth-210	.01	600
Cadmium-109	.01	1,000
Cadmium-113	.01	80
Calcium-45	.01	20,000
Californium-252	.001	9 (20 mg)
Carbon-14	.01	50,000
Cerium-141	.01	10,000
Cerium-144	.01	300
Cesium-134	.01	2,000
Cesium-137	.01	3,000
Chlorine-36	.5	100
Chromium-51	.01	300,000
Cobalt-60	.001	5,000
Copper-64	.01	200,000
Curium-242	.001	60
Curium-243	.001	3
Curium-244	.001	4
Curium-245	.001	2
Europium-152	.01	500
Europium-154	.01	400
Europium-155	.01	3,000
Germanium-68	.01	2,000
Gadolinium-153	.01	5,000
Gold-198	.01	30,000
Hafnium-172	.01	400
Hafnium-181	.01	7,000
Holmium-166m	.01	100
Hydrogen-3	.5	20,000
Iodine-125	.5	10
Iodine-131	.5	10
Indium-114m	.01	1,000
Iridium-192	.001	40,000
Iron-55	.01	40,000
Iron-59	.01	7,000
Krypton-85	1.0	6,000,000
Lead-210	.01	8
Manganese-56	.01	60,000
Mercury-203	.01	10,000
Molybdenum-99	.01	30,000
Neptunium-237	.001	2
Nickel-63	.01	20,000
Niobium-94	.01	300
Phosphorus-32	.5	100
Phosphorus-33	.5	1,000
Polonium-210	.01	10
Potassium-42	.01	9,000
Promethium-145	.01	4,000
Promethium-147	.01	4,000
Ruthenium-106	.01	200
Samarium-151	.01	4,000
Scandium-46	.01	3,000
Selenium-75	.01	10,000
Silver-110m	.01	1,000
Sodium-22	.01	9,000
Sodium-24	.01	10,000
Strontium-89	.01	3,000
Strontium-90	.01	90
Sulfur-35	.5	900
Technitium-99	.01	10,000
Technitium-99m	.01	400,000
Tellurium-127m	.01	5,000
Tellurium-129m	.01	5,000
Terbium-160	.01	4,000
Thulium-170	.01	4,000
Tin-113	.01	10,000
Tin-123	.01	3,000
Tin-126	.01	1,000
Titanium-44	.01	100
Vanadium-48	.01	7,000
Xenon-133	1.0	900,000
Yttrium-91	.01	2,000
Zinc-65	.01	5,000
Zirconium-93	.01	400
Zirconium-95	.01	5,000
Any other beta-gamma emitter	.01	10,000
Mixed fission products	.01	1,000
Mixed corrosion products	.01	10,000
Contaminated equipment beta-gamma	.001	10,000
Irradiated material, any form other than solid noncombustible	.01	1,000
Irradiated material, solid noncombustible	.001	10,000
Mixed radioactive waste, beta-gamma	.01	1,000
Packaged mixed waste, beta-gamma [4]	.001	10,000
Any other alpha emitter	.001	2
Contaminated equipment, alpha	.0001	20
Packaged waste, alpha [4]	.0001	20
Combinations of radioactive materials listed above [1]		

[1] For combinations of radioactive materials, consideration of the need for an emergency plan is required if the sum of the ratios of the quantity of each radioactive material authorized to the quantity listed for that material in Schedule C exceeds one.

[2] Waste packaged in Type B containers does not require an emergency plan.

[54 FR 14061, Apr. 7, 1989]

Appendix A to Part 30—Criteria Relating to Use of Financial Tests and Parent Company Guarantees for Providing Reasonable Assurance of Funds for Decommissioning

I. Introduction

An applicant or licensee may provide reasonable assurance of the availability of funds for decommissioning based on obtaining a parent company guarantee that funds will be available for decommissioning costs and on a demonstration that the parent company passes a financial test. This appendix establishes criteria for passing the financial test

and for obtaining the parent company guarantee.

II. Financial Test

A. To pass the financial test, the parent company must meet the criteria of either paragraph A.1 or A.2 of this section:

1. The parent company must have:

(i) Two of the following three ratios: A ratio of total liabilities to net worth less than 2.0; a ratio of the sum of net income plus depreciation, depletion, and amortization to total liabilities greater than 0.1; and a ratio of current assets to current liabilities greater than 1.5; and

(ii) Net working capital and tangible net worth each at least six times the current decommissioning cost estimates (or prescribed amount if a certification is used); and

(iii) Tangible net worth of at least $10 million; and

(iv) Assets located in the United States amounting to at least 90 percent of total assets or at least six times the current decommissioning cost estimates (or prescribed amount if a certification is used).

2. The parent company must have:

(i) A current rating for its most recent bond issuance of AAA, AA, A, or BBB as issued by Standard and Poor's or Aaa, Aa, A, or Baa as issued by Moody's; and

(ii) Tangible net worth at least six times the current decommissioning cost estimate (or prescribed amount if a certification is used); and

(iii) Tangible net worth of at least $10 million; and

(iv) Assets located in the United States amounting to at least 90 percent of total assets or at least six times the current decommissioning cost estimates (or prescribed amount if certification is used).

B. The parent company's independent certified public accountant must have compared the data used by the parent company in the financial test, which is derived from the independently audited, year end financial statements for the latest fiscal year, with the amounts in such financial statement. In connection with that procedure the licensee shall inform NRC within 90 days of any matters coming to the auditor's attention which cause the auditor to believe that the data specified in the financial test should be adjusted and that the company no longer passes the test.

C. 1. After the initial financial test, the parent company must repeat the passage of the test within 90 days after the close of each succeeding fiscal year.

2. If the parent company no longer meets the requirements of paragraph A of this section, the licensee must send notice to the Commission of intent to establish alternate financial assurance as specified in the Commission's regulations. The notice must be sent by certified mail within 90 days after the end of the fiscal year for which the end financial data show that the parent pany no longer meets the financial te quirements. The licensee must provide nate financial assurance within 120 after the end of such fiscal year.

III. Parent Company Guarantee

The terms of a parent company guar which an applicant or licensee obtains provide that:

A. The parent company guarantee w main in force unless the guarantor sen tice of cancellation by certified mail licensee and the Commission. Cancel may not occur, however, during the 12 beginning on the date of receipt of the of cancellation by both the licensee a Commission, as evidenced by the retu ceipts.

B. If the licensee fails to provide alt financial assurance as specified in the mission's regulations within 90 days af ceipt by the licensee and Commissio notice of cancellation of the parent co guarantee from the guarantor, the gua will provide such alternative financial ance in the name of the licensee.

C. The parent company guarantee nancial test provisions must remain in until the Commission has terminated cense.

D. If a trust is established for dec sioning costs, the trustee and trust m acceptable to the Commission. An acc trustee includes an appropriate State eral Government agency or an entity has the authority to act as a trust whose trust operations are regulated amined by a Federal or State agency.

[53 FR 24046, June 27, 1988]

APPENDIX B TO PART 30—QUANTITIES LICENSED MATERIAL REQUIRING LABEL

Material	M
Americium-241	
Antimony-122	
Antimony-124	
Antimony-125	
Arsenic-73	
Arsenic-74	
Arsenic-76	
Arsenic-77	
Barium-131	
Barium-133	
Barium-140	
Bismuth-210	
Bromine-82	
Cadmium-109	
Cadmium-115m	
Cadmium-115	
Calcium-45	
Calcium-47	
Carbon-14	
Cerium-141	
Cerium-143	
Cerium-144	

APPENDIX B TO PART 30—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING—Continued

Material	Microcuries
Cesium-131	1,000
Cesium-134m	100
Cesium-134	1
Cesium-135	10
Cesium-136	10
Cesium-137	10
Chlorine-36	10
Chlorine-38	10
Chromium-51	1,000
Cobalt-58m	10
Cobalt-58	10
Cobalt-60	1
Copper-64	100
Dysprosium-165	10
Dysprosium-166	100
Erbium-169	100
Erbium-171	100
Europium-152 9.2 h	100
Europium-152 13 yr	1
Europium-154	1
Europium-155	10
Fluorine-18	1,000
Gadolinium-153	10
Gadolinium-159	100
Gallium-72	10
Germanium-71	100
Gold-198	100
Gold-199	100
Hafnium-181	10
Holmium-166	100
Hydrogen-3	1,000
Indium-113m	100
Indium-114m	10
Indium-115m	100
Indium-115	10
Iodine-125	1
Iodine-126	1
Iodine-129	0.1
Iodine-131	1
Iodine-132	10
Iodine-133	1
Iodine-134	10
Iodine-135	10
Iridium-192	10
Iridium-194	100
Iron-55	100
Iron-59	10
Krypton-85	100
Krypton-87	10
Lanthanum-140	10
Lutetium-177	100
Manganese-52	10
Manganese-54	10
Manganese-56	10
Mercury-197m	100
Mercury-197	100
Mercury-203	10
Molybdenum-99	100
Neodymium-147	100
Neodymium-149	100
Nickel-59	100
Nickel-63	10
Nickel-65	100
Niobium-93m	10
Niobium-95	10
Niobium-97	10
Osmium-185	10
Osmium-191m	100
Osmium-191	100
Osmium-193	100
Palladium-103	100
Palladium-109	100
Phosphorus-32	10
Platinum-191	100
Platinum-193m	100
Platinum-193	100
Platinum-197m	100
Platinum-197	100
Plutonium-239	.01
Polonium-210	0.1
Potassium-42	10
Praseodymium-142	100
Praseodymium-143	100
Promethium-147	10
Promethium-149	10
Radium-226	.01
Rhenium-186	100
Rhenium-188	100
Rhodium-103m	100
Rhodium-105	100
Rubidium-86	10
Rubidium-87	10
Ruthenium-97	100
Ruthenium-103	10
Ruthenium-105	10
Ruthenium-106	1
Samarium-151	10
Samarium-153	100
Scandium-46	10
Scandium-47	100
Scandium-48	10
Selenium-75	10
Silicon-31	100
Silver-105	10
Silver-110m	1
Silver-111	100
Sodium-24	10
Strontium-85	10
Strontium-89	1
Strontium-90	0.1
Strontium-91	10
Strontium-92	10
Sulphur-35	100
Tantalum-182	10
Technetium-96	10
Technetium-97m	100
Technetium-97	100
Technetium-99m	100
Technetium-99	10
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	100
Tellurium-129m	10
Tellurium-129	100
Tellurium-131m	10
Tellurium-132	10
Terbium-160	10
Thallium-200	100
Thallium-201	100
Thallium-202	100
Thallium-204	10
Thorium (natural)[1]	100
Thulium-170	10
Thulium-171	10
Tin-113	10
Tin-125	10
Tungsten-181	10
Tungsten-185	10
Tungsten-187	100
Uranium (natural)[2]	100

APPENDIX B TO PART 30—QUANTITIES[1] OF LICENSED MATERIAL REQUIRING LABELING—Continued

Material	Microcuries
Uranium-233	.01
Uranium-234—Uranium-235	.01
Vanadium-48	10
Xenon-131m	1,000
Xenon-133	100
Xenon-135	100
Ytterbium-175	100
Yttrium-90	10
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zirconium-93	10
Zirconium-95	10
Zirconium-97	10
Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	.01
Any radionuclide other than alpha emitting radionuclides, not listed above or mixtures of beta emitters of unknown composition	.1

[1] Based on alpha disintegration rate of Th-232, Th-230 and their daughter products.
[2] Based on alpha disintegration rate of U-238, U-234, and U-235.

NOTE: For purposes of §20.303, where there is involved a combination of isotopes in known amounts, the limit for the combination should be derived as follows: Determine, for each isotope in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1" (i.e., "unity").

[35 FR 6425, Apr. 22, 1970, as amended at 36 FR 16898, Aug. 26, 1971; 38 FR 29314, Oct. 24, 1973; 39 FR 23991, June 28, 1974; 45 FR 71763, Oct. 30, 1980. Redesignated at 56 FR 23391, May 21, 1991, and further redesignated at 58 FR 67659, Dec. 22, 1993]

APPENDIX C TO PART 30—CRITERIA RELATING TO USE OF FINANCIAL TESTS AND SELF GUARANTEES FOR PROVIDING REASONABLE ASSURANCE OF FUNDS FOR DECOMMISSIONING

I. Introduction

An applicant or licensee may provide reasonable assurance of the availability of funds for decommissioning based on furnishing its own guarantee that funds will be available for decommissioning costs and on a demonstration that the company passes the financial test of Section II of this appendix. The terms of the self-guarantee are in Section III of this appendix. This appendix establishes criteria for passing the financial test for the self guarantee and estal the terms for a self-guarantee.

II. Financial Test

A. To pass the financial test, a co must meet all of the following criteria:

(1) Tangible net worth at least 10 tim total current decommissioning cost es (or the current amount required if cation is used) for all decommissioni tivities for which the company is resp as self-guaranteeing licensee and as guarantor.

(2) Assets located in the United amounting to at least 90 percent of tc sets or at least 10 times the total curr commissioning cost estimate (or the amount required if certification is us all decommissioning activities for wh company is responsible as self-guara licensee and as parent-guarantor.

(3) A current rating for its most bond issuance of AAA, AA, or A as iss Standard and Poors (S&P), or Aaa, A as issued by Moodys.

B. To pass the financial test, a cc must meet all of the following additic quirements:

(1) The company must have at le class of equity securities registered the Securities Exchange Act of 1934.

(2) The company's independent c public accountant must have compa data used by the company in the fi test which is derived from the indepe audited, yearend financial statements latest fiscal year, with the amounts financial statement. In connection wi procedure, the licensee shall infor within 90 days of any matters comin attention of the auditor that cause t tor to believe that the data specifiec financial test should be adjusted a the company no longer passes the test

(3) After the initial financial test, t pany must repeat passage of the test 90 days after the close of each succee cal year.

C. If the licensee no longer meets quirements of Section II.A. of this a the licensee must send immediate n the Commission of its intent to estal ternate financial assurance as spec the Commission's regulations wit days of such notice.

III. Company Self-Guarantee

The terms of a self-guarantee whic plicant or licensee furnishes must that:

A. The guarantee will remain in f less the licensee sends notice of canc by certified mail to the Commissic cellation may not occur, however, du 120 days beginning on the date of re

the notice of cancellation by the Commission, as evidenced by the return receipt.

B. The licensee shall provide alternative financial assurance as specified in the Commission's regulations within 90 days following receipt by the Commission of a notice of cancellation of the guarantee.

C. The guarantee and financial test provisions must remain in effect until the Commission has terminated the license or until another financial assurance method acceptable to the Commission has been put in effect by the licensee.

D. The licensee will promptly forward to the Commission and the licensee's independent auditor all reports covering the latest fiscal year filed by the licensee with the Securities and Exchange Commission pursuant to the requirements of section 13 of the Securities and Exchange Act of 1934.

E. If, at any time, the licensee's most recent bond issuance ceases to be rated in any category of "A" or above by either Standard and Poors or Moodys, the licensee will provide notice in writing of such fact to the Commission within 20 days after publication of the change by the rating service. If the licensee's most recent bond issuance ceases to be rated in any category of A or above by both Standard and Poors and Moodys, the licensee no longer meets the requirements of Section II.A. of this appendix.

F. The applicant or licensee must provide to the Commission a written guarantee (a written commitment by a corporate officer) which states that the licensee will fund and carry out the required decommissioning activities or, upon issuance of an order by the Commission, the licensee will set up and fund a trust in the amount of the current cost estimates for decommissioning.

[58 FR 68730, Dec. 29, 1993; 59 FR 1618, Jan. 12, 1994]

EFFECTIVE DATE NOTE: At 58 FR 68730, Dec. 29, 1993, appendix C to part 30 was added, and at 59 FR 1618, Jan. 12, 1994 appendix C was correctly designated, effective January 28, 1994.

PART 31—GENERAL DOMESTIC LICENSES FOR BYPRODUCT MATERIAL

AUTHORITY: Secs. 81, 161, 183, 68 Stat. 935, 948, 954, as amended (42 U.S.C. 2111, 2201, 2233); secs. 201, as amended, 202, 88 Stat. 1242, as amended, 1244 (42 U.S.C. 5841, 5842).

Section 31.6 also issued under sec. 274, 73 Stat. 688 (42 U.S.C. 2021).

§31.1 Purpose and scope.

This part establishes general licenses for the possession and use of byproduct material contained in certain items and a general license for ownership of byproduct material. Part 30 of this chapter also contains provisions applicable to the subject matter of this part.

[35 FR 6428, Apr. 22, 1970]

§31.2 Terms and conditions.

(a) The general licenses provided in this part are subject to the provisions of §§30.14(d), 30.34(a) to (e), 30.41, 30.50 to 30.63 and parts 19, 20, and 21 of this chapter[1] unless indicated otherwise in the language of the general license.

[38 FR 22220, Aug. 17, 1973, as amended at 38 FR 33969, Dec. 10, 1973; 42 FR 28896, June 6, 1977; 43 FR 6922, Feb. 17, 1978; 56 FR 40767, Aug. 16, 1991]

§31.3 Certain devices and equipment.

A general license is hereby issued to transfer, receive, acquire, own, possess and use byproduct material incorporated in the following devices or equipment which have been manufactured, tested and labeled by the manufacturer in accordance with the specifications contained in a specific license issued to him by the Commission.

(a) *Static elimination device.* Devices designed for use as static eliminators which contain, as a sealed source or

[1] Attention is directed particularly to the provisions of the regulations in Part 20 of this chapter which relate to the labeling of containers.

PERSONAL EXPOSURE REDUCTION METHODS

Time Distance Shielding

Time - less time spent near source, less radiation exposure received

The radiation dose is directly proportional to time in radiation field.

Distance - the further from source, the less exposure received

The radiation dose is inversely proportional to the square of the distance from the source.

Shielding - use of shielding reduces radiation exposure

half-value layer (HVL) - The amount of shielding required to reduce the beam intensity by 1/2.

Half Value Layers

Shield Material	Co-60 HVL (Inches)	Cs-137 HVL (Inches)
Concrete	2.7	1.9
Lead	0.49	0.26
Uranium	0.26	-

$$DR_{FINAL} = DR_{INITIAL} \times \frac{1}{2^n}$$

Where:

n = the number of HVL's

ADVANCED MEDICAL SYSTEMS OPERATING PROCEDURE

RADIATION WORK PERMITS

ISP-29 Rev. 01/95

1.0 PURPOSE: To provide instructions to personnel needed to prepare and use Radiation Work Permits (RWP). Radiation Work Permits are an integral part of AMS ALARA Program.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Radiation Work Permits are written to inform workers of the radiological conditions and controls associated with work within Restricted Areas.

2.2 Each individual is responsible for following the RWP and keeping track of thier dose.

2.3 The RSO or designee is resposible for ensuring that all Radiation Work Permits are prepared in accordance with this procedure.

3.0 INSTRUCTIONS:

3.1 Types of RWPs

3.1.1 Job Specific RWP - This type RWP is to be used for all entries into Radiation Areas, Contamination Areas and for all work in Controlled Areas that involves radioactive materials. These RWPs will be prepared for each job and will be terminated immediately following the completion of the work.

Prepared by: Robert Meschter Approved by: R Meschter

Date: 1-24-95

3.1.2 Extended RWP - This type RWP is to be used for all entries into Restricted Areas that do not require a job specific RWP. This type RWP may also be used for repetitive jobs such as routine surveys, training, etc. These RWPs will be terminated at one (1) year intervals or sooner if radiological conditions change such that additional controls are needed.

3.2 Initiating a Radiation Work Permit

3.2.1 Any employee wishing to enter a Restricted Area of the facility should ensure that the entry is covered by a current RWP. If not, the employee can initiate an RWP by completing the Description and Location of Work section of the RWP, Form ISP-29B, and submit the RWP to the RSO or designee for completion and possible approval.

3.2.2 The RSO or designee will complete the RWP, including the ALARA review, and activate the permit by signing and dating the form. Each RWP will be consecutively numbered and entered in the RWP Tracking Log, Form ISP-29A.

3.2.3 Each person who enters an area under an RWP must read and sign the RWP Sign In Sheet, Form ISP-29C. Each person signing this sheet acknowledges that they have read and understand the RWP requirements and precautions.

3.3 Use of a Radiation Work Permit

3.3.1 Prior to entering the area, workers shall:

a. Read and understand the RWP.

b. When appropriate, receive a prejob briefing from the RSO or designee.

c. Obtain radiation safety job coverage, if required.

d. Ensure sufficient exposure is available for the job.

e. Ensure they have met all the necessary precautions and have obtained the needed protective clothing and devices for the job.

3.3.2 During work, workers should:

a. Periodically read their self reading pocket dosimeter unless exposure is being tracked by timekeeping methods.

b. Wear protective clothing and devices properly.

c. Maintain exposures ALARA.

d. Stop work and exit the area if radiological conditions change significantly from those outlined in the RWP.

3.3.3 When exiting the area/job site, workers should:

a. Leave the area in a clean and unlittered condition by removing all tools and materials from the job site.

b. Use proper techniques to minimize the spread of contamination, including proper removal of protective clothing and proper use of step-off pads.

c. Perform a whole body frisk for personal contamination, paying particular attention to those areas of the body that could most likely become contaminated (hands, feet, face, knees, etc.).

d. Report any personal contamination or unusual exposures to the RSO or designee.

3.4 RWP Termination

3.4.1 RWPs will be terminated by the RSO or designee:

a. Upon completion of work.

b. Upon expiration of the RWP.

c. If the scope of work has significantly changed.

d. If the radiological conditions have significantly changed.

RADIATION WORK PERMIT TRACKING LOG

ISP-29A

RWP NO.	DESCRIPTION OF WORK	AUTH DATE	TERM DATE

REVIEWED BY RSO: _____ DATE: _____

RADIATION WORK PERMIT

ISP-29B

PERMIT NO.: _____
EXPIRATION DATE: _____ JOB SPECIFIC - EXTENDED (CIRCLE)

DESCRIPTION AND LOCATION OF WORK: _____
_____
_____
_____
_____

SURVEY INFORMATION

GENERAL AREA DOSE RATES (MR/HR): _____
MAXIMUM ACCESSIBLE DOSE RATES (MR/HR): _____
REMOVABLE CONTAMINATION LEVELS (DPM/100CM^2): _____

ALARA REVIEW

ESTIMATED TOTAL DOSE: _____ ACTUAL TOTAL DOSE: _____
___PREJOB BRIEFING ___POSTJOB BRIEFING PERFORMED BY: _____
DOSE REDUCTION TECHNIQUES TO BE EMPLOYED: _____
_____
_____
_____

DOSIMETRY REQUIREMENTS

___TLD/FILM BADGE ___FINGER RING ___SRPD(200MR) ___SRPD(1R) ___SRPD(5R)
___OTHER-SPECIFY: _____

PROTECTIVE EQUIPMENT

___COVERALLS ___LABCOAT ___HOOD ___RUBBER GLOVES ___BOOTIES ___RUBBERS
___RESPIRATOR ___TAPED SEAMS ___RADIATION SAFETY COVERAGE ___AIR SAMPLE
OTHER PRECAUTIONS AND SPECIAL INSTRUCTIONS: _____
_____
_____
_____
_____
_____

AUTHORIZED BY: _____

TERMINATED BY: _____

RWP SIGN IN SHEET

ISP-29C

RWP NUMBER: _____

Signing this document means that the worker has read and understands this Radiation Work Permit.

PRINTED NAME	SIGNATURE	REQ. DOS.	VER. BY	DOSE IN	DOSE OUT	DOSE
TOTAL DOSE THIS RWP SIGN-IN SHEET						

REVIEWED BY RSO: _____ DATE: _____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

AREA SURVEY PROCEDURE

ISP-2 Rev. 01/95

1.0 PURPOSE: To standardize the method used for performing radiation and contamination surveys.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Observe all posted requirements for Restricted Areas.

2.2 Ensure survey instruments are in calibration and good working order prior to use.

2.3 Care must be used when handling smear samples to prevent spreading contamination or cross-contaminating samples.

2.4 The following information should be recorded for each survey performed:

ALL SURVEYS	CONTAMINATION SURVEYS
Date	Background cpm
Time	Counter Efficiency
Performed by	Counting time
Reason for survey	
Area surveyed	
Instrument(s) used (Serial #, Calibration due date)	

2.5 All surveys are Legal Records, therefore, it is of the utmost importance that all information is neatly and accurately recorded.

2.6 Do not hesitate to add additional information onto survey forms (i.e. oil on floor, lights burnt out, etc.).

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Radiation Surveys.

3.1.1 For general area dose rates, walk slowly around the area being surveyed while holding the probe at waist level. Record the highest dose rate in the appropriate units (normally mR/hr).

3.1.2 For contact readings, hold the probe within one (1) inch of the surface and record the dose rate, noting that it is a contact reading.

3.1.3 All readings less than 0.1 millirem per hour should be recorded as <0.1mR/hr.

3.1.4 For Hot Spot surveys, walk slowly around the area to be surveyed, determine the area of highest radiation, obtain a contact reading and record the location and dose rate.

3.2 Contamination Surveys.

3.2.1 Using moderate pressure, wipe a dry smear over a 100 cm^2 area (100 cm^2 = 4" x 4" area or a 16" long S-shape of that area).

3.2.2 Record the smear locations using one of the following methods:

a. List: Accurately record the location on a list of smear locations for the survey being performed.

b. Map: Use a number to indicate the smear location on a map of the area being surveyed. Smears should be noted on maps in the following manner:

Circle - horizontal surfaces
Square - vertical surfaces

3.3 Action Levels.

3.3.1 Loose Surface Contamination:

a. Restricted Areas - 40,000 dpm/100 cm^2.

b. Controlled Areas - 1,000 dpm/100 cm^2.

c. Unrestricted Areas - 1,000 dpm/100 cm^2.

3.3.2 Radiation Levels:

a. Controlled Areas - 0.5mR/hr general area.

b. Unrestricted Areas - Not to exceed one hundred (100) mrem exposure to the general public in one (1) year.

3.3.3 Actions required if limits are exceeded.

a. Restrict access to the area.

b. Notify the RSO.

c. Determine the cause of the excess radiation or contamination levels.

d. Decontaminate and resurvey.

e. Shield or remove the source of radiation and resurvey.

f. If the above actions cannot be accomplished before the end of the day, the area should be posted and secured according to the degree of the hazard.

NOTE: In the event that levels cannot be immediately reduced, all actions taken should be recorded and forwarded to the RSO for review. The RSO shall conduct and document an investigation of the conditions and circumstances involved.

3.3.4 Frequency of Surveys.

a. Controlled Areas should be surveyed semi-monthly.

b. Restricted Areas should be surveyed at least monthly.

c. Any area in which radioactive material is in use should be surveyed at least weekly.

3.3.5 Areas to be Surveyed.

a. The attached data sheets list the minimum areas to be surveyed. These surveys should be completed in their entirety at the specified frequency regardless of other surveys performed.

b. Surveys performed in addition to the minimum areas and frequencies should be recorded on separate data sheets.

c. All surveys should be forwarded to the RSO for review and filing.

CONTROLLED AREA SURVEY DATA SHEET

ISP-2A

LOCATION	RAD LEVEL	GCPM	CCPM	DPM
FIRST FLOOR				
1. Top Landing of Front Stairwell	_____	____	____	____
2. Entrance Level of Stairwell	_____	____	____	____
3. Basement Level of Stairwell	_____	____	____	____
4. Outside Change Room Interlock Door	_____	____	____	____
5. Manipulator Control Station	_____	____	____	____
6. Cell Control Office	_____	____	____	____
7. Hall in Front of Office	_____	____	____	____
8. Doorway Outside Shielded Work Room	_____	____	____	____
9. Conference Room - East	_____	____	____	____
10. Conference Room - West	_____	____	____	____
11. Hallway to Cage Area	_____	____	____	____
12. Outside Airlock Doors	_____	____	____	____
13. Outside Counting Room	_____	____	____	____
14. South of Counting Station	_____	____	____	____
15. Counting Station	_____	____	____	____
16. West Doorway Inside Counting Room	_____	____	____	____
17. Outside Isotope Warehouse Overhead Door	_____	____	____	____
18. Loading Dock Area	_____	____	____	____
19. Scale Area	_____	____	____	____
20. Fire Door to Warehouse	_____	____	____	____
21. North Side of LLWS Area (When in Use)	_____	____	____	____
22. East of LLWS Area (When in Use)	_____	____	____	____
23. South Side of LLWS Area (When in Use)	_____	____	____	____

Performed by: _____ Date: _____

SURVEY METER: _____ S/N: _____ CAL DUE: _____

COUNTING INST.: _____ S/N: _____ CAL DUE: _____

COUNTING EFFICIENCY: _____% BACKGROUND: _____CPM

ACTION LEVELS: 1000 DPM/100CM^2
0.5MR/HR

Reviewed by RSO: _____ Date: _____

CONTROLLED AREA SURVEY DATA SHEET

ISP-2B

LOCATION	RAD LEVEL	GCPM	CCPM	DPM
FIRST FLOOR				
1. Change Room Near Lockers	_____	____	____	____
2. Change Room Near Showers	_____	____	____	____
3. Change Room Near Sinks	_____	____	____	____
4. Change Room Entrance to ISA	_____	____	____	____
5. Warehouse Office - East	_____	____	____	____
6. Warehouse Office - Center	_____	____	____	____
7. Warehouse Office - West	_____	____	____	____
8. Cage Area - East	_____	____	____	____
9. Cage Area - Center	_____	____	____	____
10. Cage Area - West	_____	____	____	____
11. Outside Isotope Warehouse	_____	____	____	____
SECOND FLOOR				
1. Outside Washroom Door	_____	____	____	____
2. Office at Southeast Corner	_____	____	____	____
3. East Wall Near Stairwell	_____	____	____	____
4. Center of Office Area	_____	____	____	____
5. Northwest Corner of Office	_____	____	____	____
6. Outside Clean Equipment Room	_____	____	____	____

Performed by: _____ Date: _____

SURVEY METER: _____ S/N: _____ CAL DUE: _____

COUNTING INST.: _____ S/N: _____ CAL DUE: _____

COUNTING EFFICIENCY: _____% BACKGROUND: _____CPM

ACTION LEVELS: 1000 DPM/100CM^2
0.5MR/HR

Reviewed by RSO: _____ Date: _____

RESTRICTED AREA SURVEY DATA SHEET

ISP-2C

LOCATION	HOT SPOT	RAD LEVEL	GCPM	CCPM	DPM
1. HEPA Room North					
2. HEPA Room Middle					
3. HEPA Room South					
4. Stairs to HEPA Room					
5. Doorway to Washroom					
6. Doorway to Frisking Station					
7. Middle of Large Office					
8. Inside Doorway to Stairwell					
9. Inside Doorway of CER					
10. West of Boiler in CER					
11. Inside Doorway to Roof of CER					
12. Outside ISA Door					
13. ISA/Cell Wall					
14. ISA/Decon Room Wall					
15. West Wall Near SEC					
16. Source Garden					
17. Top Landing to Basement					
18. ISA/Landing to Basement					
19. Outside Basement Door					
20. Hallway Outside WHUT Room					
21. By WHUT Room Entrance					
22. North Side of Back Basement					
23. West Side of Back Basement					
24. Outside Decon Room Doors					
25. By Hot Cell Door in Decon Rm.					
26. Outside Airlock Doors					
27. Dirty Side of Airlock					
28. Clean Side of Airlock					
29. Inside Airlock Doors to Cage					
30. By Airlock Doors in Isotope Warehouse					
31. East of Isotope Warehouse					
32. Middle of Isotope Warehouse					
33. West of Isotope Warehouse					
34. Tank Room Front Basement					
35. Entrance Hall of Front Bsmt.					
36. Chart Room in Front Basement					
37. Back Entrance to Front Bsmt.					

Performed by:_____ Date:_____

SURVEY METER: _____ S/N: _____ CAL DUE: _____
COUNTING INST.: _____ S/N: _____ CAL DUE: _____
COUNTING EFFICIENCY: _____% BACKGROUND: _____cpm

ACTION LEVELS: 40,000 dpm/100cm^2
Areas >100MR/HR must be locked and posted as a High Radiation Area.

Reviewed by RSO: _____ Date: _____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

AIR MONITOR SYSTEM CHECK

ISP-7 Rev. 01/95

1.0 PURPOSE: To ensure that the air monitor system is functioning properly.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure is a routine safety check. It is to be performed monthly or any time there is an abnormal increase on the monitor.

2.2 The filter paper removed is to be considered a contaminated item. Proper handling procedures must be followed to limit personnel exposure and to prevent the spread of contamination.

2.3 The RSO is to be promptly notified of any system malfunctions.

3.0 INSTRUCTIONS:

3.1 Shut down the air sample vacuum pump.

3.2 Advance the filter paper and remove the old filter. Record the date and time on Form ISP-8A.

3.3 Restart the air vacuum pump.

3.4 Determine the total elapsed time (in minutes) since the last check was performed.

3.5 Calculate the total volume of air in milliliters.

Volume of air = Flowrate x Elapsed time.

Flowrate = 4 cfm or 1.133×10^5 ml/min.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.6 Count the old filter in a well counter and record the activity in cpm on Form ISP-8A.

3.7 Calculate activity per ISP-4.

3.8 Calculate the average concentration of activity in the discharged air as follows:

$$uCi/ml = \frac{\text{filter cpm - bkg cpm}}{(\text{total volume})(2.22 \times 10^{6})(C_{eff})}$$

3.9 The average concentration of discharged air should not exceed 5×10^{-11} uCi/ml.

3.10 Record all information of Form ISP-8A and submit the form to the RSO for review.

AIR MONITOR SYSTEM CHECK

ISP-7A

SAMPLE DATA

DATE:_____ TIME:_____

DATE LAST CHECK:_____ TIME:_____

TOTAL ELAPSED TIME:_____minutes

TOTAL VOLUME:_____milliliters

COUNTING DATA

COUNTER:_____ SER #:_____ CAL DUE:_____

EFF:_____ BKG:_____ MDC:_____*

COUNTED BY:_____DATE/TIME:_____

GCPM:_____ CCPM:_____ ACTIVITY:_____uCi/ml

$$\text{ACTIVITY} = \frac{\text{CCPM}}{(2.22 \times 10^{6})(C_{eff})(\text{volume})}$$

COMMENTS:_____

_____

_____

_____

_____

_____

_____

*Ref: ISP-4

Performed by: _____ Date: _____

Reviewed by RSO: _____ Date: _____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

PORTABLE AIR SAMPLES

ISP-9 Rev. 01/95

1.0 PURPOSE: To provide a standardized method of monitoring airborne contamination levels under various working conditions.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Air samples shall be performed during, but not limited to, the following:

a. Hot Cell opening.

b. Work performed in areas having >40,000 dpm/100cm^2 loose surface contamination.

c. Work in areas where the potential exists to exceed 1.0×10^{-8} uCi/ml airborne activity.

d. As directed by the RSO.

2.2 Use care when handling air samples to prevent the spread of contamination or cross-contaminating samples.

3.0 INSTRUCTIONS:

3.1 All portable air samplers should be operated in accordance with the manufacturers instructions.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.2 The air sample should be taken as close as practicable to the breathing zone for the area where the work is being performed. All steps possible shall be taken to ensure the most representative sample is obtained. If an air sample in the breathing zone is impractical, place the air sampler down wind of the work area, but as close as possible to the work area without interfering with personnel.

3.3 Complete the appropriate section of the Internal Exposure Tracking Form, Form ISP-9A for each individual that the air sample was taken for.

3.4 Calculate activity per ISP-3.

3.5 Calculate air sample concentration as follows:

$$uCi/ml = \frac{\text{sample cpm - bkg cpm}}{(\text{sample volume})(2.22 \times 10^{6})(C_{eff})}$$

3.6 In twenty four (24) hours, calculate the activity of the sample again and record the results.

3.7 Complete Form ISP-9A, for BZAs, or Form ISP-9B, for general area air samples, as appropriate.

3.8 Submit Form ISP-9A or 9B to the RSO for review.

INTERNAL EXPOSURE TRACKING

ISP-9A

NAME:_____ SSN:_____

SAMPLE DATE:_____ RWP:_____

SAMPLER DATA

SAMPLER:_____ SER #:_____ CAL DUE:_____

FLOW RATE:_____ VERIFIED BY:_____ DATE/TIME:_____

TIME ON:_____ TIME OFF:_____ TOTAL TIME:_____

TOTAL VOLUME:_____milliliters

COUNTING DATA

COUNTER:_____ SER #:_____ CAL DUE:_____

EFF:_____ BKG:_____ MDC:_____*

COUNTED BY:_____DATE/TIME:_____

GCPM:_____ CCPM:_____ ACTIVITY:_____uCi/ml

$$\text{ACTIVITY} = \frac{\text{CCPM}}{(2.22 \times 10^{6})(C_{eff})(\text{volume})}$$

24 HOUR DECAY:_____uCi/ml

DAC-HR CALCULATION

Performed by:_____ DATE/TIME:_____

DAC-HR:_____ INTAKE:_____uCi

$$\text{DAC-HR} = \frac{\text{Activity} \times \text{Time (hrs)}}{1.0 \times 10^{-8}}$$

INTAKE = (Time min.) X (2.0×10^{4} ml/min) X (Activity)

* Ref: ISP-4

Reviewed by RSO:_____ Date:_____

AIR SAMPLE CALCULATION

ISP-9B

LOCATION:_____

SAMPLE DATE:_____ RWP:_____

SAMPLER DATA

SAMPLER:_____ SER #:_____ CAL DUE:_____

FLOW RATE:_____ VERIFIED BY:_____ DATE/TIME:_____

TIME ON:_____ TIME OFF:_____ TOTAL TIME:_____

TOTAL VOLUME:_____milliliters

COUNTING DATA

COUNTER:_____ SER #:_____ CAL DUE:_____

EFF:_____ BKG:_____ MDC:_____*

COUNTED BY:_____DATE/TIME:_____

GCPM:_____ CCPM:_____ ACTIVITY:_____uCi/ml

$$\text{ACTIVITY} = \frac{\text{CCPM}}{(2.22 \times 10^6)(C_{eff})(\text{volume})}$$

24 HOUR DECAY:_____uCi/ml

COMMENTS:_____

_____

_____

_____

_____

*Ref: ISP-3

Performed by: _____ Date:_____

Reviewed by RSO: _____ Date:_____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

CALIBRATION OF PORTABLE RADIATION DETECTION INSTRUMENTS

ISP-23 Rev. 1/95

1.0 PURPOSE: The purpose of the procedure is to provide uniform and documented proof of calibration of the survey instruments and dosimeters used.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure applies to all survey meters and dosimeters in active use.

2.2 Calibration sources are to be stored only in Controlled Areas of the Isotope Facility.

2.3 Film badges and pocket dosimeters should be worn when calibrating equipment.

2.4 Keep as much distance from the calibration source as possible.

3.0 INSTRUCTIONS:

3.1 Calibration of Portable Survey Meters

3.1.1 Ensure meter is free of removable contamination and <1mR/hr fixed contamination.

3.1.2 Package the meter for shipment.

3.1.3 Ship the meter to a vendor for calibration.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.2 Calibration of Pocket Dosimeters.

3.2.1 Dosimeters may be calibrated in two ways:

a. Use of an outside calibration service.

b. Use of a commercially available dosimeter calibrator.

3.2.2 Set the dosimeter to zero and record the serial number on Form ISP-23A, Dosimeter Calibration Form.

3.2.3 Calculate the exposure rate of the calibrator and record on ISP-23A.

3.2.4 Calculate the exposure time by the following formula:

$$\text{Exposure time} = \frac{\text{3/4 dosimeter scale, mrem}}{\text{exposure rate, mrem/hr}}$$

3.2.5 Calculate the exposure by multiplying the exposure rate times the exposure time.

3.2.6 Place the dosimeter in one of the holes of the calibrator.

3.2.7 Expose the dosimeter to the calibration source for the calculated exposure time.

3.2.8 At the end of the exposure time, read and record the actual dosimeter reading on Form ISP-23A.

3.2.9 Calculate the accuracy of the dosimeter by the following formula:

$$\% \text{ accuracy} = \frac{\text{calc. exposure-dosimeter reading}}{\text{calculated exposure}} \times 100$$

3.2.10 Any dosimeter with an accuracy greater than $\pm$15% shall be replaced.

3.2.11 Record all applicable information on Form ISP-23A.

3.2.12 Perform a Drift Check as follows:

a. Zero the pocket dosimeter.

b. Store the dosimeter in a low dose area.

c. After at least twenty four (24) hours, read the dosimeter.

d. Calculate the Drift by the following:

$$\% \text{ Drift} = \frac{\text{dosimeter reading}}{\text{dosimeter scale}} \times 100$$

e. The dosimeter passes the Drift Check if the % Drift is less than 2%.

3.2.13 Apply a dated calibration label to the dosimeter which indicates the next calibration due date.

DOSIMETER CALIBRATION FORM

ISP-23A

Calibration Source:_____ Exposure Rate:_____

Serial Number	Calc. Reading	Act. Reading	%Acc.	%Drift

Performed by:_____ Date:_____

Reviewed by RSO:_____ Date:_____

CHAPTER 4 - PROCEDURES FOR HANDLING RADIOISOTOPES

4.1 Hazardous Qualities of Isotopes

All use of isotopes is to be considered hazardous and requires approval by the Radiation Safety Officer. Special care must be exercised in handling isotopes.

The use of Cobalt 60 and Cesium 137 requires careful planning of operations since both are penetrating gamma radiation emitters.

The Cesium 137 used will always be in the form of sealed sources.

Depleted uranium is used as shielding material in source head construction. This material is purchased in the final form. This material is nickel plated. No machining is done after receipt; therefore, a low hazard is presented.

The Cobalt 60 will be in the form of solid metal. This metal, even though plated, can oxidize and, therefore, a greater possibility of airborne contamination exists. Once this solid metal is encapsulated into sealed sources, this problem is almost eliminated.

The sealed sources are used or handled with loading equipment only in the controlled Isotope Shop Area or the Shielded Work Room.

4.2 External Hazards

4.2.1 General Operating Procedures

When working with sources of penetrating radiation, the following steps will help maintain levels of exposure ALARA: See ISP-14.

a. Plan each step of the operation thoroughly in advance to keep exposure at a minimum.
b. Keep as far away from the source as practical at all times.
c. Avoid getting radioactive isotopes on the hands. Hands should be kept at a safe distance from the source, as even small sources will cause burns if the distance is close enough.
d. Interpose a proper shield between you and the sources whenever practical.
e. Obtain actual exposure data with the proper monitoring instruments.
f. Know the properties of the material you are going to work with.
g. Attempt to positively identify the radioactive material and determine the activity.
h. Consult frequently with the Radiation Safety Officer.

4.2.2 Specific Procedures:

a. Source Transfer Operations - In any operation involving movement of a source from one container to another, there is a "flash" of higher radiation intensity as a source crosses the fine gap between the containers. For this reason, the area around any transfer operation must be cleared of all personnel not required for the transfer and the operating personnel must observe appropriate procedures. Transfer operation procedures are presented in the source exchange manuals.

b. Entering the Cell - See ISP-11 in Appendix A.

c. Entering the Equipment Room - This room is located directly above the Shielded Work Room and has adequate floor shielding for our operations. A Gammalarm in the Equipment Room gives a red signal if the radiation level exceeds 2 mR/hr and remotely indicates the signal above the entrance to the room. WHEN THERE IS NO SIGNAL LIGHT OR THERE IS A RED LIGHT, PERSONNEL ARE NOT PERMITTED IN THIS ROOM UNTIL CLEARED BY THE RADIATION SAFETY OFFICER.

4.3 Internal Hazards

Deposition of radioactive materials in the body may constitute one of the more serious hazards likely to be encountered. This may result from ingestion, inhalation and absorption or entry through the skin. It must be remembered that, apart from the accidental swallowing of a radioactive solid or solution, ingestion may take place quite unnoticed over long periods of time through contaminated food, cigarettes or other articles brought to the mouth. The presence of radioactive dust or spray in a laboratory may lead to similar chronic intake through inhalation. The following procedures are designed to prevent this internal hazard:

4.3.1 General Operating Procedures

a. Do not eat, drink or smoke in any controlled area or when handling any radioactive source.

b. Personnel with open cuts or lesions on hands shall refrain from working in potentially contaminated areas.

c. Never handle radioactive isotopes with bare hands. Forceps, rubber gloves or some other interposing device should always be used.

4.3.1 General Operating Procedures (Continued)

d. The pipetting of solutions by mouth is forbidden. Proper precautions should be taken during glass-blowing involving radioactive materials against the inhalation of fumes that might be generated.

e. General air ventilation shall be maintained.

f. Local exhaust ventilation is mandatory.

g. All effluents from local exhaust systems and from controlled areas must be properly filtered before being discharged to the outside. The "Cambridge" Absolute Filer or the "Mine Safety Appliance" Ultra-Air Filters have been found satisfactory.

h. Know the properties of the material with which you are to work and attempt to identify and determine its activity.

i. Plan ahead each step of the operation prior to entry into the controlled area. This should include action to be taken in the even of emergencies.

j. Frequent house - cleaning and good personal hygiene practices are essential.

k. Isotope shop surfaces are designed to prevent the accumulation of dust and must be kept clean.

l. Consult frequently with the Radiation Safety Officer.

4.3.2 Specific Operating Procedures

a. Cell and Decontamination Room - Respirators and rubber gloves must be worn in this area.

4.3.3 Accidents and Emergency Techniques

Refer to the AMS Radiological Contingency Plan.

4.4 Protective Clothing

The company furnishes a complete change of clothing which must be worn by any person performing work in any controlled area where radioactive contamination is known to exist or is suspected.

ADVANCED MEDICAL SYSTEMS OPERATING PROCEDURE

INSPECTION AND PROCEDURE FOR CONTAINERS WITH OVERPACKS AUTHORIZED FOR THE SHIPMENT OF RADIOACTIVE MATERIAL

ISP-33 Rev. 01/95

1.0 REQUIREMENTS AND DESCRIPTION:

1.1 In order to comply with NRC/DOT regulations concerning shipment of radioactive materials, this inspection procedure must be completed for each shipment of radioactive materials prior to movement of the material to the carrier for transportation. Defects found during inspections must be corrected prior to material movement.

1.2 The requirements are applicable when moving radioactive material in authorized containers from one customer location to another, from the field back to the Isotope facility, to the field from the Isotope Facility.

1.3 Authorized Shipping Containers

1.3.1 Cobalt 60 Shipments

1.3.1.1 590C, D, E, F and G Head in Overpack No. 181375.

1.3.1.2 C-12 Head in Overpack No. D-MEH-00-00004.

1.3.1.3 3320 AR Exchange Container in Overpack No. 181361.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

1.3.2 Cesium 137 shipments - 3320B Exchange Container in Overpack No. 181361.

1.4 Audit

In accordance with 10CFR 71.137, the Radiation Safety Officer will make an audit of the maintenance of the containers and overpacks according to the checklist. The audit shall be on an unannounced basis at intervals not to exceed one (1) year.

2.0 INSPECTIONS

2.1 The Inspection Data Sheet for Radioactive Material Containers and Overpacks (QA1014A) must be completed and forwarded to the Radiation Safety Officer and Isotope Facility for audit and record retention. Field operations are to return the Inspection Data Sheet in the pre-stamped, self-addressed envelope along with the waybill copy of the return shipment.

2.2 The only personnel permitted to perform the inspection and maintenance are those individuals qualified under the conditions of the license. Repairs may be permitted by an outside contractor; however, these repairs must be inspected before use.

3.0 HEAD OR SOURCE EXCHANGE CONTAINER PROCEDURE

Perform each inspection step as indicated. Defects found during inspection must be corrected and reinspected. Repairs must be listed on the Data Sheet along with the signature of the inspector. A check mark (✓) is to be placed on the Stat Sheet after each step.

3.1 Make a wife survey of the external surface of the container. Field operations are to use a Victoreen 491 or equal to evaluate the wipe. The meter must read less than 220 DPM/100cm^2 when the wipe is held 1/4" from the Geiger Tube (Beta shield open). Factory operations are to use a well counter to determine wipe activity. Results must indicate 220 DPM/100cm^2 or less of removable contamination.

3.2 Perform a preliminary radiation survey of the container. Results should be 200mR/hour or less on the surface and 10mR/hour or less at 1 meter from the surface.

3.3 Verify that the shutter or drawer is locked.

3.4 Verify that the gaskets on 3320 AR are in good condition.

3.5 Inspect the lifting loops on 3320 AR. Loops must be in good condition, not bent, and welds must not exhibit cracks.

3.6 Inspect the container to insure there is no mechanical damage which will affect the radiation integrity of the unit.

4.0 OVERPACK PROCEDURE

Perform each inspection step as indicated. Defects found during inspection must be corrected and reinspected. Repairs must be listed on the Data Sheet along with signature of the inspector. A check mark (✓) is to be placed on the Data Sheet after each step.

4.1 Inspect the overpack for the following mechanical characteristics:

4.1.1 All wood joints inside the overpack must be tight. Tighten reinforcing bars if necessary.

4.1.2 The wood joints inside the overpack should be free of holes and voids. Holes can be filled with wood plugs.

4.1.3 Lifting loops should be free of damage.

4.1.4 Welds on the framework must be free of cracks and damage.

4.1.5 Inspect the skid runners for damage.

4.2 Inspect the container hold-down system to insure it is properly secure.

4.3 Inspect that the bolts securing the overpack cover to the skid are tight, but not stripped.

4.4 Inspect the package and insure it is seal wired.

4.5 Survey the package with container inside. The radiation level must be less than 10mR/hour at any point 1 meter from the surface of the container and 200mR/hour or less at the surface.

4.6 Inspect the outside package for the following labels:

4.6.1 Two yellow Radioactive III diamond labels filled out indicating the radioactive material, number of curies and transport index (maximum radiation units at 1 meter) as measured in 4.5. These labels must be on opposite sides of the package.

4.6.2 Verify that the overpack bears an 11" x 18" yellow sign with magenta lettering listing AMS, Cleveland, Ohio, U.S.A., part number of the overpack, Package I.D. Number, gross and empty weights, Made in U.S.A. and Radiation Symbols. All markings must be clear and legible.

4.6.3 Verify that the opening instructions have been included with the package.

AMS MODEL 181375 SHIPPING PACKAGE

USNRC CERTIFICATE OF COMPLIANCE NO. 5

COBALT HEAD SHIPPING CONTAINER

PACKING/UNPACKING

INSTRUCTIONS

IMPORTANT - READ CAREFULLY

Revised ./20/91

Revisic B - 8/1992

1.0 Preparing a source loaded head container (Model 1[illegible]75) for shipment.

Only properly qualified service engineers may remo[illegible] a loaded teletherapy head from a machine. Once the head is [illegible]moved and properly secured to the container base, the follow[illegible]g procedure applies.

NOTE: QA Procedure 1014 and 1014A must be compl[illegible]d prior to shipment.

A. Position the tie down head assembly around t[illegible] machine head. Align the trunnion bolt holes with th[illegible] tie down bracket slots such that the tie down strap i[illegible] resting firmly against the machine head. (Use shims [illegible]nderneath the tie down bracket and/or head in order t[illegible] achieve proper alignment.)

B. Secure the tie down head assembly by first t[illegible]ightening the bracket-to-pallet base bolts, then tigh[illegible]ing the bracket-to-head trunnion bolts. Verify tha[illegible] he strap is tight against the head.

C. Attach the wooden support pads into place a[illegible]nd the machine head.

D. With a lifting device capable of lifting 100[illegible] lbs., place the overpack in position over the head[illegible]n the pallet base.

E. Secure the overpack to the pallet base with[illegible]e four one inch bolts and eight 1/2 inch bolts.

F. Attach an appropriate shipping seal to one [illegible] the side lugs.

G. Perform a radiation survey of the package a[illegible]he surface (maximum reading 200 mR/hr). If the radiati[illegible]n levels exceed these limits, the package shall not b[illegible] released for shipment. Notify the Radiation Safety O[illegible]ficer for further instructions.

H. Apply the proper labels to the container. V[illegible]ify that the package content description and caution [illegible]rkings are visible.

I. Complete the shipping papers.
Copies of QA 1014 and 1014A, shipping paper[illegible]d other documentation should be returned to Advanced[illegible]edical Systems for record-keeping purposes.

J. All shipments of radioactive material destined for Advanced Medical Systems should be shipped to:

Advanced Medical Systems, Inc.
1020 London Road
Cleveland, OH 44110

2.0 Unpacking a source loaded head container (Model 181375)

A. The package must be removed from the transport vehicle with material handling equipment of a capacity equal to or greater than the gross package weight of 4000 lbs.

B. Perform a radiation survey of the container to insure that the external radiation level does not exceed 200 mR/hr at the surface and 10 mR/hr at a distance of 1 meter from the surface. [If the level does exceed these limits, the appropriate NRC Regional Office and the final delivery carrier must be notified.]

C. Verify that the shipping seal is intact. The shipping seal may be removed only by a person qualified to install the equipment. Until such a person is present, the container should be stored in accordance with 10CFR20.

D. Upon the authorization of removal of the shipping seal, the overpack may be removed. Remove the four one-inch and eight 1-2-inch bolts securing the overpack to the pallet base (save hardware for reuse).

E. With a lifting device capable of lifting 1000 lbs., lift the overpack off the machine head and pallet base.

CAUTION: The machine head may not be removed from the pallet base until it has been moved into the room in which it is to be installed. This is to insure that the skid shield remains in place under the head.

F. Move the pallet base with head attached into the therapy room.

G. Remove the twelve bolts securing the tie down head bracket to the machine head and pallet bases (save hardware for reuse).

H. Remove the wooden support pads and slide the tie down head assembly forward, away from the machine head. The head installation including the removal of the machine head from the pallet base, may only be performed by a qualified service engineer.

3.0 Preparing an empty head container (Model 1813754) for shipment.

NOTE: QA Procedure 1014 and 1014A must be completed prior to shipment.

A. Bolt the skid shield into place on the pallet base

B. Bolt the tie down head bracket with attached wooden support pads, to the pallet base.

C. Place the overpack into position on the pallet base and secure it with the twelve bolts.

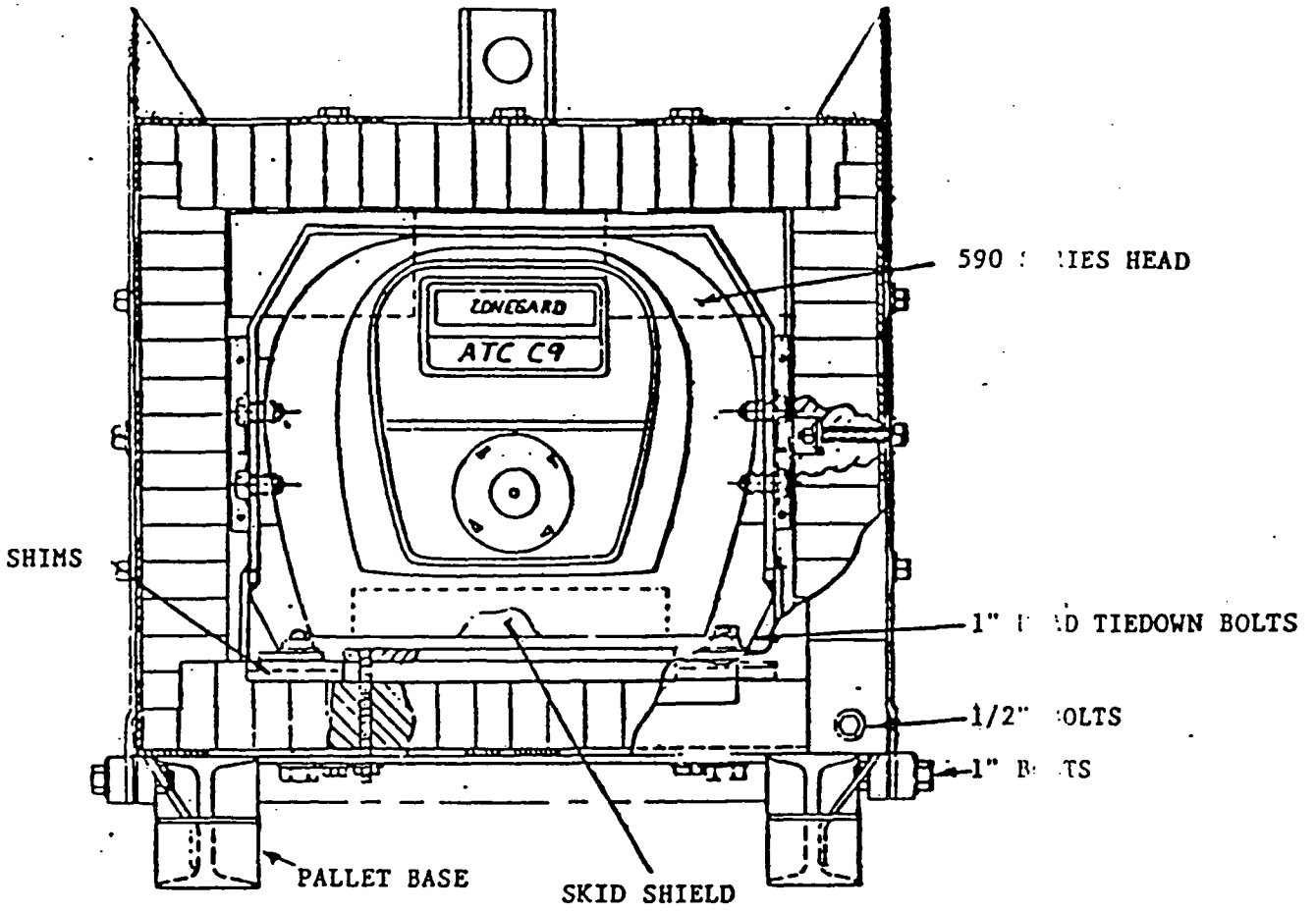
D. Mask out any "Radioactive Material" labels and marks (tape may be used).

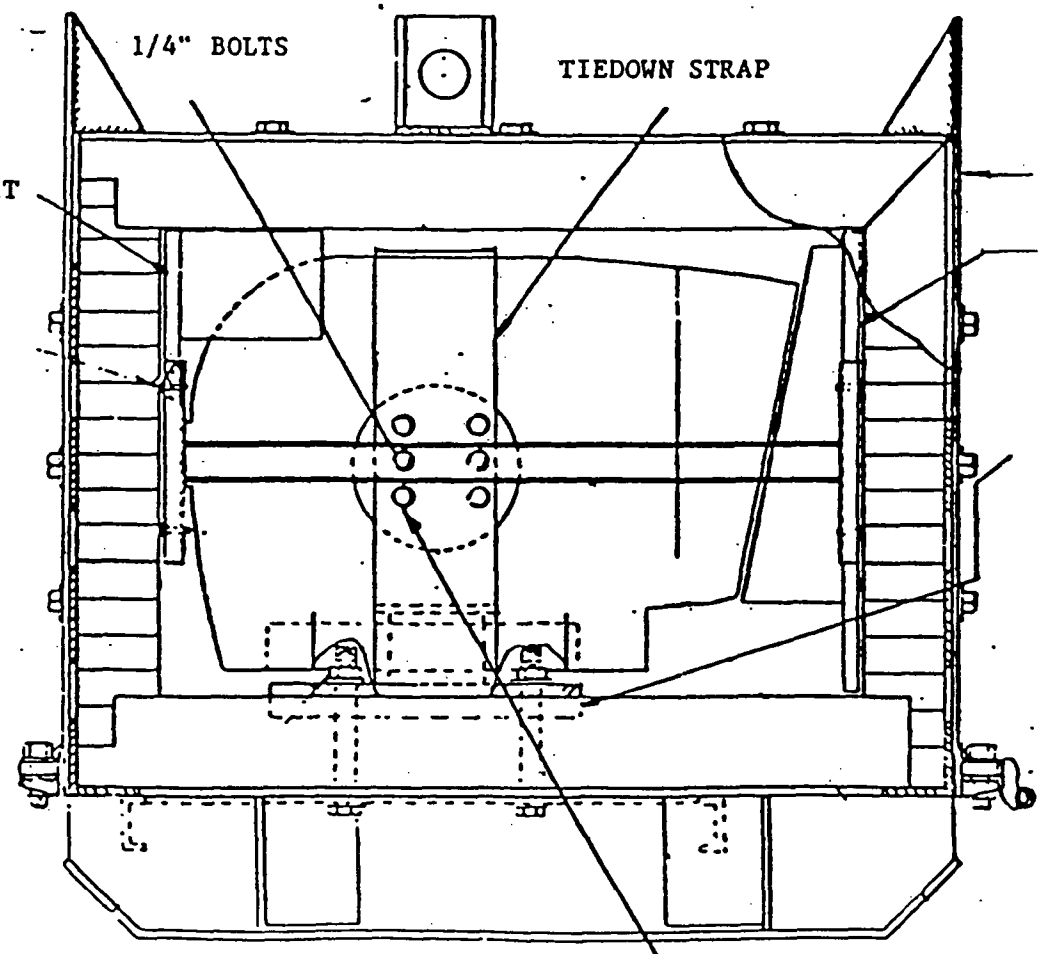
E. Remove the Radioactive Yellow III labels and apply "Empty" labels to the container.

F. Apply proper shipping labels.

All return shipments destined for Advanced Medical Systems should be shipped to:

Advanced Medical Systems, Inc.
1020 London Road
Cleveland, Ohio 44110





NOTE:
SHIM AS REQ'D.
AT PACKING TOTAL SHIM HEIGHT NOT TO EXCEED 1/2"
P/N 200742 1 thru 5
P/N 200743 1 thru 5

SHIPPING SEAL

Control No_____

Source S/N_____

Source Shipment Documentation Checklist

for 181375 (head) Container

A. Pre-shipment Documents

1. Container inspection report (QA1014A) _____
2. Head survey sheet _____
3. Shipping tags or stencils _____
4. Work sheet _____

B. Service Engineer Package

1. Presentation folder with:
   a) Calibration certificate _____
   b) Decay Tables (2) _____
   c) Certificate of Wipe _____
   d) Source Warranty _____

2. Return documents

		returned
a) Five year inspection report	_____	_____
b) Head survey sheets (2)	_____	_____
c) Service ticket	_____	_____
d) Return Bill of Lading	_____	_____
e) Container Inspection Report (QA1014)	_____	_____
f) Diamond labels (2)	_____	NA
g) State Notification Letters	_____	NA

C. Customer file

The following should be in file before shipment:

1. AMS work order _____
2. Customer license _____
3. Calibration data sheets _____
4. Calibration certificate _____
5. Wipe data sheets _____
6. Wipe certificate _____
7. Source work sheet _____
8. Source shipment checklist _____
9. Consignee notification letter _____

The following should be placed in file once returned shipment is received:

10. Head survey sheet _____
11. Five year inspection report _____
12. Bills of Lading _____

D. Shipping Documents

1) Bill of Lading _____
2) Instructions to Driver (ISP-30) _____
3) Placards _____
4) Export only - Container Loading/Unloading Instructions _____
5) Export only - IAEA Certificate of Competent Authority _____

LOOSE SURFACE CONTAMINATION SURVEY

page _____ of _____

ATE: _____ INST.: _____ S/N: _____ BKG. _____ CPM

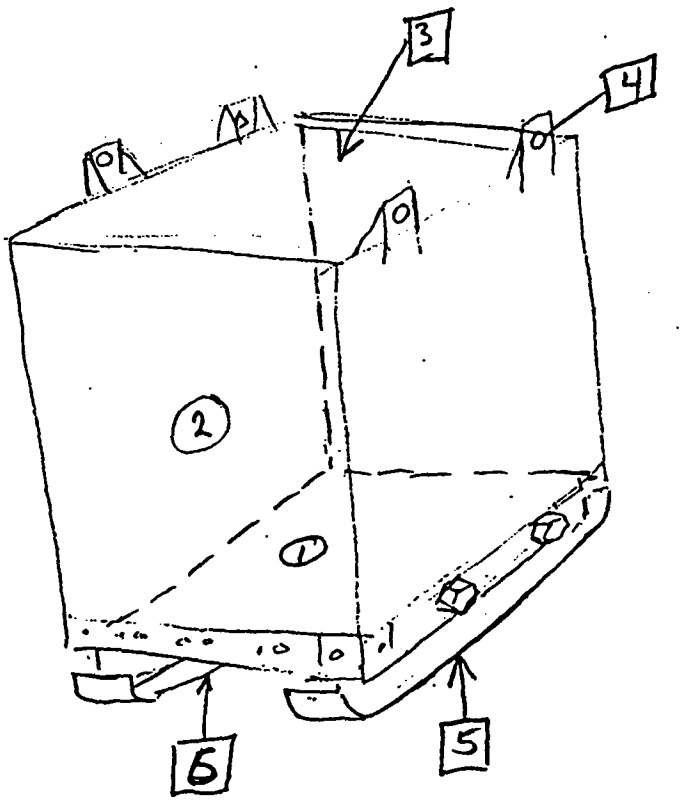
ME: _____ CAL. DATE: _____ C_{eff} _____ %

AME: _____ AREA / ITEM SURVEYED _____

Avg. smear area _____ cm^2

No.	G_{cpm}	C_{cpm}	DPM

DRAWING



○ INTERNAL SMEAR

□ EXTERNAL SMEAR

Comments #7 GROSS MASSLIN OVER ALL

Reviewed by _____

MODEL 181361 SHIPPING PACKAGE
USNRC CERTIFICATE OF COMPLIANCE NO. 5796
FOR
3320 SERIES
COBALT SOURCE EXCHANGE CONTAINER

PACKING/UNPACKING INSTRUCTION

IMPORTANT - READ CAREFULLY

ADVANCED MEDICAL SYSTEMS, INC.
ISOTOPE FACILITY
1020 LONDON RD.
CLEVELAND, OHIO 44110

Revised 1/87

INTRODUCTION

This procedure is intended to provide enough information to allow the handler of a radioactive source container to safely pack, unpack, load, or unload a 3320AR Source Transport Container.

WARNING

THE FOLLOWING PROCEDURES MUST BE CAREFULLY AND THOROUGHLY ADHERED TO AS TO AVOID EXPOSURE TO HARMFUL RADIATION AND/OR SERIOUS BODILY INJURY.

1.0 Unpacking a loaded source exchange container (Model 181361)

Upon receipt of the container at the destination the following general procedure applies:

A. The package must be removed from the transport vehicle with material handling equipment of a capacity equal to or greater than the gross package weight of 4000 lbs.

B. Perform a radiation survey of the container to insure that the external radiation level does not exceed 200 mR/hr at the surface and 10 mR/hr at a distance of 1 meter from the surface. [If the level does exceed these limits, the appropriate NRC Regional Office and the final delivery carrier must be notified.]

C. Verify that the shipping seal is intact. The shipping seal may be removed only by a person qualified to install the equipment. Until such a person is present, the container should be stored in accordance with 10CFR20.

D. Upon the authorized removal of the shipping seal, the overpack may be removed.
Remove the four 1 inch and twenty 1/2 inch bolts securing the overpack to the pallet base (save the hardware for reuse).

E. Remove the hex nuts from the thru rods, and the thru rods from the package.

F. With a device capable of lifting 1000 lbs., lift the overpack from the pallet base.

NOTE: The overpack fits very close to the inner package.

G. Remove the wooden jacket from the source exchange container. Do not allow the jacket to become wet or allow it to become misaligned due to rough handling (save the hardware for reuse).

H. Remove the four bolts securing the source exchange container to the pallet base.

I. With a lifting device capable of lifting 3000 lbs., lift the source exchange container off the pallet base.

J. Install the casters (shipped in a separate box) to the base of the source exchange container. Using the elevating wrench (shipped attached to the inside of the skid rail), adjust the casters so that the distance between the floor and the bottom of the skid rails is 11 3/4 ± 1/4 inches.

K. Move the source exchange container, still sealed, into the therapy room.

WARNING

THE CONCENTRATED WEIGHT ON THESE CASTERS WILL CRUMBLE MOST FLOOR SURFACES. SHEETS OF MASONITE SHOULD BE PLACED ON THE FLOOR FOR SURFACE PROTECTION (PLYWOOD WILL NOT SUFFICE, AS THE CASTERS WILL SINK IN AND MAKE MOVEMENT VERY DIFFICULT.) MASONITE SHOULD ALSO BE PLACED OVER DOOR SILLS TO FACILITATE CONTAINER MOVEMENT. DO NOT ATTEMPT TO USE THE MOMENTUM OF THE CONTAINER TO JUMP OVER DOOR SILLS OR OTHER SURFACE IRREGULARITIES. THE CASTERS WILL BE DAMAGED AND THE CONTAINER MAY TOPPLE OVER.

All further unpacking shall be performed by a properly qualified service engineer.

2.0 Preparing a loaded source exchange container (Model 181361) for shipment.

The following procedure applies once the source has been loaded into the 3320 source exchange container by a qualified service engineer.

NOTE: QA Procedure 1014 must be completed prior to shipment.

A. Inspect the source exchange container to insure that all components and covers are in place, bolted and seal wired.

B. Make a wipe survey of the external surfaces of the container.

C. Apply two Radioactive Yellow III labels to the container.

D. With a lifting device capable of lifting 1000 lbs., lift the container, remove the casters, and place the container on the pallet base, using orientation marks as a guide.

E. Carefully secure the wooden jacket around the container. Take care that the jacket is properly aligned with the container.

F. Insert the thru rods as a check for proper alignment. Secure the container to the pallet base with the four 1 inch bolts.

G. Remove the thru rods. Lower the overpack onto the pallet base, using the colored index markings for alignment. NOTE: There is only 1/4 inch clearance between the overpack and the jacket.

H. Insert the thru rods, seating the square ends to prevent rotation. Secure the thru rods with the hex nuts.

I. Attach the seal wire to the pallet base.

J. Perform a radiation survey of the package at the surface (maximum reading 200 mR/hr), and at 1 meter from the surface (maximum reading 10 mR/hr). If the radiation levels exceed these limits, the package shall not be released for shipment. Notify the Radiation Safety Officer for further instructions.

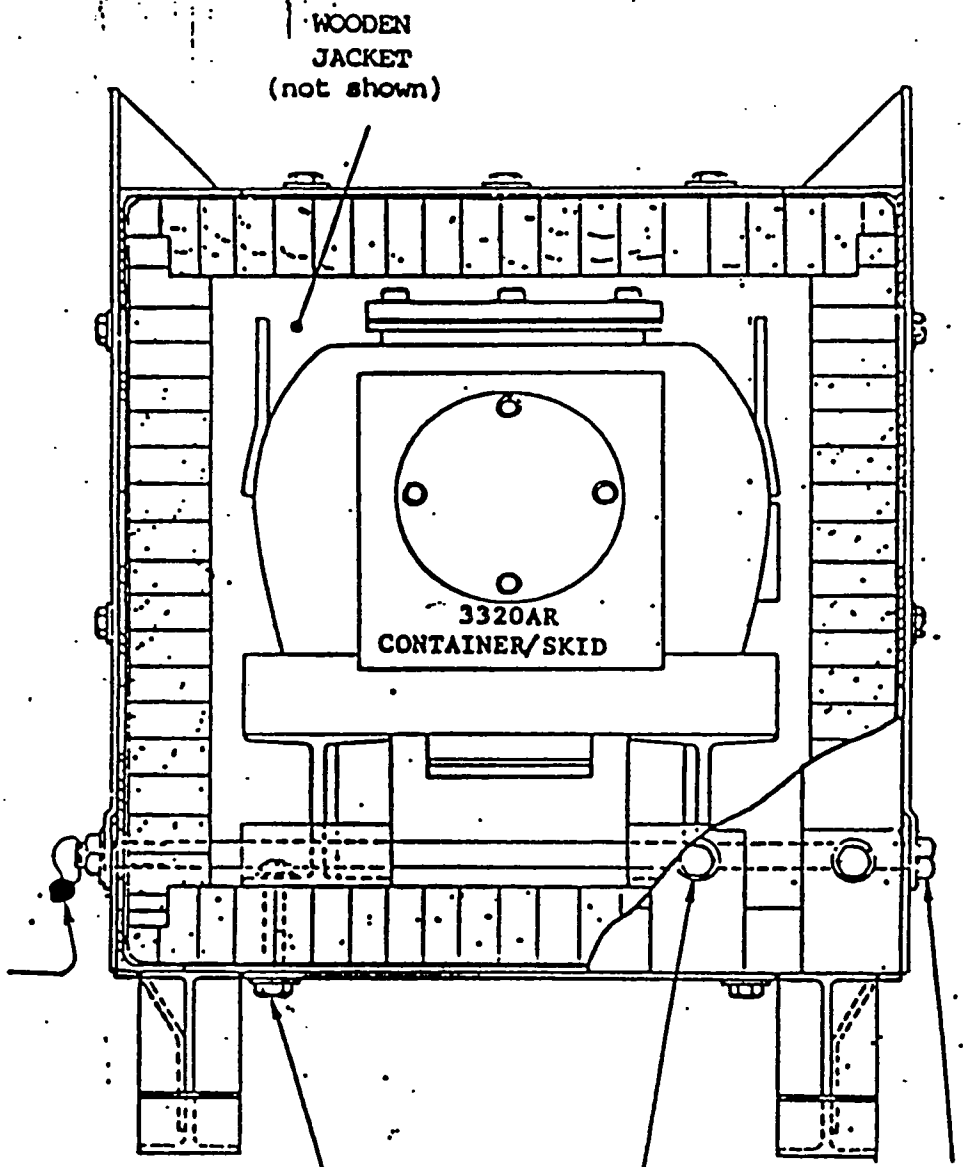
K. Apply the proper labels to the package. Verify that the package content description and caution markings are visible.

L. Complete the shipping papers.
Copies of QA 1014, shipping papers and other documentation should be returned to Advanced Medical Systems for record keeping purposes.

M. All shipments of radioactive material destined for Advanced Medical Systems should be shipped to:

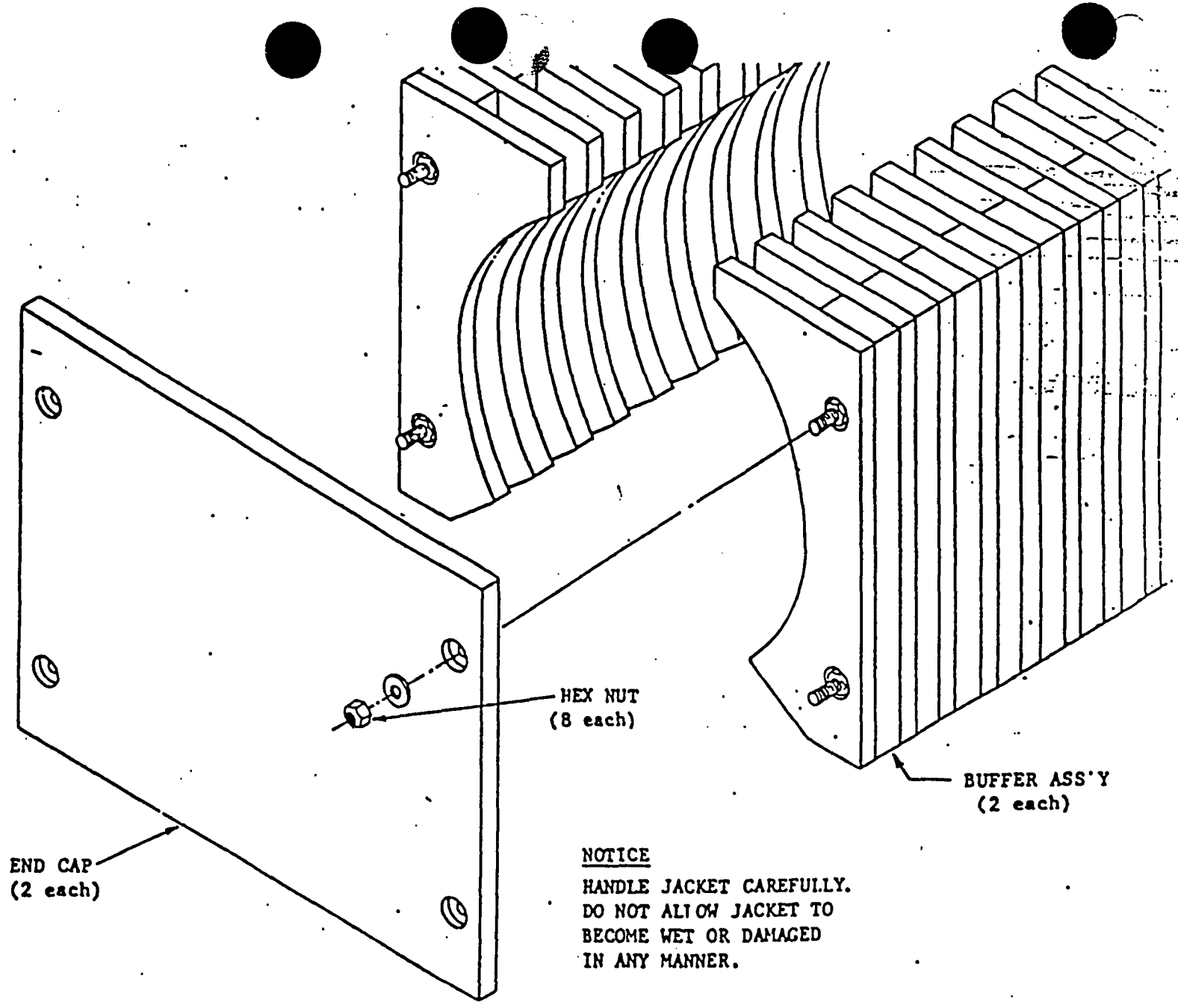
Advanced Medical Systems, Inc.
1020 London Road
Cleveland, Ohio 44110

3320AR SOURCE CONTAINER OVERPACK #181361



CAUTION

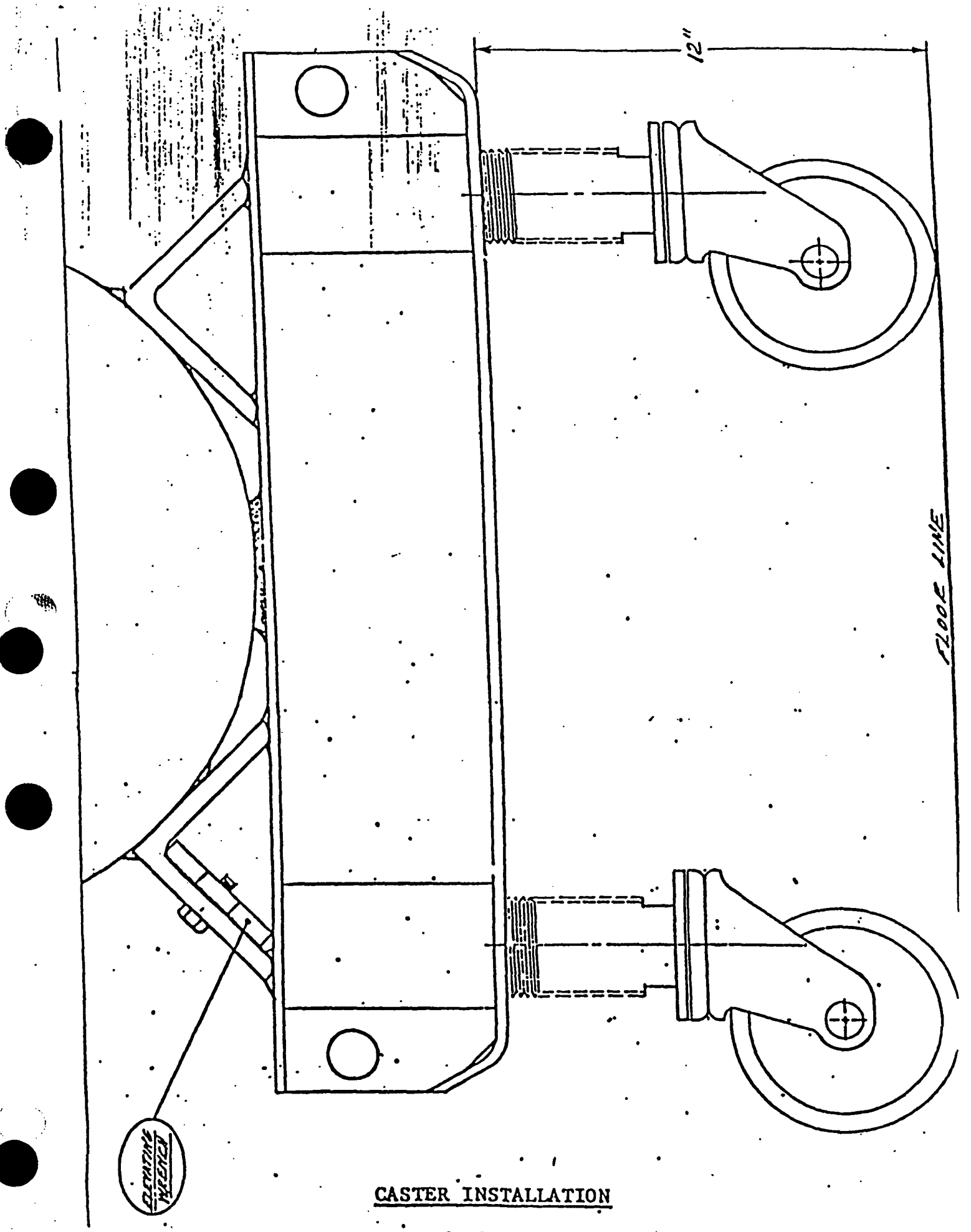
A RADIATION SURVEY MUST BE PERFORMED BEFORE REMOVAL OF A LOADED SOURCE CONTAINER FROM THE OVERPACK.



NOTICE

HANDLE JACKET CAREFULLY.
DO NOT ALLOW JACKET TO
BECOME WET OR DAMAGED
IN ANY MANNER.

WOODEN JACKET FOR 3320AR
SOURCE CONTAINER OVERPACK



CASTER INSTALLATION

SOURCE S/N

ADVANCED MEDICAL SYSTEMS

TITLE: Exchange Container Contamination Control Record	Procedure No: QA 1014B Revision: Date Issued: 3/20/87

Prior to next use and/or shipment, the container must be wiped clean of contamination. Clean is considered to be less than 200 CPM above background, using the office well counter.

Take wipes on the following areas. Record the 1st wipe before cleaning, and all subsequently counted wipes for that particular area.

Container S/N_____ last contained source S/N_____

Background_____CPM

STD Activity_____uCi
STD Counts _____CPM

	1st Wipe	
A. Skid Runners bottom		
B. Skid Runners top		
C. Exterior Surface		
D. Cover- bottom		
E. Cover- top		
F. Cover- side		
G. Push rod		
H. Trap		
I. Drawer		
J. Drawer cavity		
K. Vertical hole		
L. Top plug		
M. Lifting Ears		

Date:_____ By:_____

Advanced Medical Systems — Quality Assurance Department

Prepared by	Approval	Revisions
	Howard R Stern	

Number QA 101-A

RADIOACTIVE MATERIAL SHIPPING RECORD

Revision 0

Date Issued: Nov. 5, 1984

CUSTOMER: _____
LOCATION _____

CONTROL NUMBER

CERTIFICATE OF COMPLIANCE NO. _____

CERTIFICATE OF COMPLIANCE HOLDER: _____

CERTIFICATE IN OUR FILES _____

AMS REGISTERED USER: _____

DATE OF SHIPMENT _____

B/L NUMBER _____

SOURCE INFORMATION:

Isotope _____
Mfg./Cat.No. _____
Curies _____
Wipe Test Reading _____

Serial No. _____
Curies Date _____
Wipe Test Date _____

CONTAINER INSPECTION AND MAINTENANCE

CONTAINER INFORMATION

Model No. _____

Serial No. _____

	CHECK IF OK	REPAIR NOTES
Internal Contamination		
External Contamination		
Preliminary Radiation Survey		
Mechanical Functions		
Shutter or Drawer Locked		
Shutter or Container Sealed		
Gaskets in Good Condition (if any)		
Lifting Loops in Good Condition (if any)		
Tie Down Devices in Good Condition and Secured		
Casters in Good Condition		
Container Identification Legible		
Radiation Warning Signs		

Prepared by	Approval	Revisions
Norman Kelbley	Howard K. Stern	0 Delete Kelbley, Reposition ID info.

RADIOACTIVE MATERIAL SHIPPING RECORD

OVERPACK QA INSPECTION AND MAINTENANCE

OVERPACK INFORMATION

Model No. _____ Serial No. _____

	CHECK IF OK
Mechanical Functions	
All Wood Joints Tight	
No Holes or Voids	
Lifting Loops in Good Condition	
Tie Down Devices in Good Condition and Secure	
Skid in Good Condition and Tight	
All Bolts Tight	
Overpack Identification Legible	
Overpack Sealed	
Maximum Radiation Level at 1m.	_____ mR/hr
Maximum Radiation Level on Surface	_____ mR/hr
Transport Index Labels Attached	
Opening Instructions Attached	
General Condition	

INSTALLATION KIT	INITIAL
Complete per O/M	
Survey Meter	
Model No. _____	_____
Serial No. _____	_____
Date Calibrated	
_____	_____

List Any Items in Need of Repair

_____

_____

_____

_____

_____

_____

_____

DATE INSPECTED: _____ INSPECTOR (Initials) _____

APPROVAL OF LICENSED PERSON _____

REPAIR NOTES: ******** Enter repairs made to bring container or overpack into proper condition. Include initials of individual(s) making repairs and date of repairs.

FIELD NOTE: THIS SHEET MUST BE RETURNED IN THE PRESTAMPED, SELF ADDRESSED ENVELOPE ALONG WITH THE WAYBILL. IN THE EVENT THE WAYBILL AND THIS SHEET ARE SEPARATED, RETURN THESE SHEETS AS INDICATED BELOW:

Advanced Medical Systems, Inc.
Radiation Safety Officer
1020 London Road
Cleveland, Ohio 44110

AUDIT _____
DATE _____

Advanced Medical Systems Quality Assurance Department

Prepared by	Approval	Revisions
Norman Kelbley	Howard R Lewis	

SOURCE S/N

ADVANCED MEDICAL SYSTEMS

TITLE:
Exchange Container Contamination Control Record

Procedure No: QA 1014B
Revision:
Date Issued: 3/20/87
Page 1 of 1

Prior to next use and/or shipment, the container must be wiped clean of contamination. Clean is considered to be less than 200 CPM above background, using the office well counter.

Take wipes on the following areas. Record the 1st wipe before cleaning, and all subsequently counted wipes for that particular area.

Container S/N_____ last contained source S/N_____

Background_____CPM

STD Activity_____uCi
STD Counts _____CPM

	1st Wipe	
A. Skid Runners bottom		
B. Skid Runners top		
C. Exterior Surface		
D. Cover- bottom		
E. Cover- top		
F. Cover- side		
G. Push rod		
H. Trap		
I. Drawer		
J. Drawer cavity		
K. Vertical hole		
L. Top plug		
M. Lifting Ears		

Date:_____ By:_____

Advanced Medical Systems — Quality Assurance Department

Prepared by	Approval	Revisions
	Howard R Jones	

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

PACKAGING OF SOLID RADIOACTIVE WASTE

ISP-25 Rev. 1/95

1.0 PURPOSE: To ensure that solid radioactive waste is safely and properly packaged in preparation for shipment.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure applies to all contaminated solid material that must be disposed of at an authorized radioactive waste disposal site.

2.2 All waste is to be compacted in order to reduce the volume unless a significant airborne hazard will result.

2.3 No liquid material is to be packaged. The waste disposal site will not accept liquids. Liquids must be solidified using approved methods prior to transportation.

2.4 Full face respirators should be worn when handling and compacting material which has been in the Hot Cell.

2.5 To reduce airborne contamination, material which has been in the Hot Cell should be bagged before extensive handling or compaction.

2.6 Waste is to be packaged on an ongoing basis. It should not accumulate.

2.7 This procedure requires that protective clothing and personal dosimetry equipment be worn.

2.8 A breathing zone air sample shall be taken during compactor operation to verify adequate respiratory protection.

2.9 Minimize stay time near high level waste materials.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Compaction

3.1.1 Waste should be surveyed prior to compaction. Any material reading over 800mR/hr should be segregated and brought to the attention of the RSO.

3.1.2 After meeting all precautions and limitations, load the material into the compactor and compact it.

3.1.3 Once the compactor bag is filled, remove bag from compactor and tape down top flaps.

3.1.4 Survey the surfaces of the bag to insure that no part reads greater than 800mR/hr. If a reading is greater than 800mR/hr, mark the bag with the maximum radiation level found.

3.2 Packaging

3.2.1 Prepare a steel drum for loading by removing the lid, inserting a poly bag liner and placing the drum on kraft paper on the step off line in the air lock.

CAUTION: Be careful not to contaminate the drum.

3.2.2 A second individual, situated on the clean side of the airlock, is required for packaging.

3.2.3 Move the compacted waste bags out from the lab and place them inside the lined drum. Four bags will easily fit into one drum.

3.2.4 Survey the drum surfaces to insure that no reading is greater than 800mR/hr.

3.2.5 Fold the excess poly liner onto the top of the bags and replace the drum lid.

3.3 Contamination Control

3.3.1 Wipe down the drum exterior prior to surveying.

3.3.2 Smears of the drum exterior shall be taken and recorded on Form ISP-25A. Smears should be taken on the drum top and ring area, on the side of the drum and along the bottom of the drum.

3.3.3 No drum shall be removed from the airlock if any smears shows contamination in excess of 1,000 dpm/100cm^2.

3.3.4 If any smear indicates contamination greater than 1,000 dpm/100cm^2, then the drum must be decontaminated and resurveyed until the contamination levels are below the above limits.

3.3.5 If the drum surface contamination is below the limit, then it should be marked with an ID number and removed from the airlock to a low background area for surveying.

3.4 Survey

3.4.1 Survey the package surfaces and record on Form ISP-34A the highest readings found on the top, side and bottom surfaces. If the survey meter readings are in the upper 90% of the scale, the next higher scale should be used.

CAUTION: Readings that fall within 20% of the maximum (800mR/hr) will be verified with at least one other instrument.

3.4.2 Mark the package hot spot with spray paint.

3.4.3 Survey the package at a distance of one (1) foot from all surfaces. For purposes of documentation, divide the package into quadrants and record the highest reading in each quadrant on Form ISP-25A.

3.4.4 Compute the average of the four (4) quadrant readings and record on Form ISP-25A.

3.4.5 Survey the package at a distance of one (1) meter and record under Transport Index on Form ISP-34A.

NOTE: Not needed for LSA exclusive use.

3.5 Package Description

3.5.1 Apply a permanent ID number sticker to the package and record it on Form ISP-34A.

3.5.2 Weigh the package and record the weight.

3.5.3 Describe the contents of the drum (i.e. compacted trash, cell waste, cardboard, wood, used protective clothing, etc.).

3.5.4 Apply a "Class A Waste" label to the top of the package.

3.6 Storage

3.6.1 Transfer the package to the designated waste storage area and place it so that the ID number is readily visible.

3.6.2 High activity packages (greater than 200mR/hr contact) should be segregated from lower activity packages.

3.7 Documentation

3.7.1 Calculate the Curie content of the package using the 6CE formula following:

$$\text{mR/hr@1foot} = 6 \times \text{Curie content} \times \text{Gamma Energy}$$

$$\text{or Curies} = \frac{\text{mR/hr @ one foot}}{6 \times \text{Gamma Energy}}$$

EXAMPLE: For Cobalt-60

$$\text{Curies} = \frac{\text{mR/hr @ one foot}}{6 \times (1.33 + 1.17)} \quad \text{or} \quad \frac{\text{mR/hr @ one foot}}{15}$$

SOLID RADWASTE DATA SHEET

ISP-25A

Drum ID#:_____ Weight:_____

Contents:_____

_____

_____

SURVEY RESULTS

Meter used:_____ Ser.#:_____ Cal due:_____

Surface Readings

Top_____mR/hr Bottom_____mR/hr Sides_____mR/hr

Readings @ 1 foot (by quadrants)

_____mR/hr _____mR/hr _____mR/hr _____mR/hr

Average 1 foot reading _____mR/hr

Transport Index:_____ Curie content:_____Ci

SURFACE CONTAMINATION

Top_____dpm/100cm^2 Bottom_____dpm/100cm^2 Sides_____dpm/100cm^2

Highest smear _____dpm/100cm^2

Performed by:_____ Date:_____

Reviewed by RSO:_____ Date:_____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

SHIPMENT OF SOLID RADIOACTIVE WASTE

ISP-26 Rev. 1/95

1.0 PURPOSE: To ensure that the solid radioactive waste is Shipped in accordance with the current federal, state and local regulations and requirements.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure applies to all shipments of solid radioactive waste.

2.2 The shipment of radioactive material is a highly regulated activity. The shipper must be familiar with the current rules and regulations in order to prevent violations and penalties.

2.3 It is prudent to communicate with the Regulatory affairs personnel at the disposal site prior to shipment in order to answer any questions they may raise regarding the material being shipped and determine any special local requirements.

3.0 INSTRUCTIONS:

3.1 For Each Package or Container

3.1.1 Determine the radionuclide(s) present.

3.1.2 Determine whether the material is normal or special form. (49CFR173.403)

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.1.3 Determine the DOT subtype (type quality).

Subtype	Cobalt 60
Limited Quantity	≤0.007Ci
Type A Quantity	≤7Ci
Type B Quantity	>7 but <21,000Ci
Highway Route Controlled	>21,000Ci

3.1.4 Determine if the material is LSA.

a. Convert the activity to mCi.

b. Determine the A_2 value for each nuclide. (49CFR173.435)

c. Determine the LSA limit for each nuclide. (49CFR713.403(n))

NOTE: For Cobalt 60 the LSA limit is 0.3mCi/g.

d. Determine the weight of the package contents in grams. (454g/lb) Do not include the weight of the drum, cask, shielding, etc.

e. Determine specific activity for each nuclide by dividing total activity of nuclide by total gram weight of package contents.

f. For each nuclide, divide the specific activity, as determined in step e, by the LSA limit.

g. For single nuclide waste, if the result of step f is less than or equal to one (1), then the material qualifies as LSA.

h. For mixtures of nuclides, if the sum of the fractions determined in step f is less than or equal to one (1), then the material qualifies as LSA.

i. If the result in step f is greater than one (1), the material would be a Type A, B or HRC Quantity.

j. For LSA material, determine if it is an LSA Type A or LSA Type B quantity.

For each nuclide, divide the total activity, in Curies, by the A_2 value.

For single nuclide waste, if the result is less than or equal to one (1), the material is LSA Type A.

For mixtures of nuclides, if the sum of the fractions is less than or equal to one (1), the material is LSA Type A.

If the result is greater than one (1), the material is LSA Type B.

3.2 Determine the packaging required for transport

3.2.1 The following chart summarizes the type packaging required for each DOT subtype quantity.

DOT SUBTYPES	LIMITED QUANTITY	TYPE A QUANTITY	TYPE B QUANTITY	LSA TYPE A EXCLU-SIVE USE	LSA TYPE A NON-EXCLUSIVE USE	LSA TYPE B NON-EXLUSIVE USE	LSA TYPE B EXCLUSIVE USE
TYPE PACKAGING	STRONG TIGHT CONTAINER	TYPE A PACKAGING	TYPE B PACKAGING	TYPE A PACKAGING	STRONG TIGHT CONTAINER	TYPE B PACKAGING	TYPE A PACKAGING WITH NRC
REGULATORY AGENCY	DOT	DOT	NRC	DOT	DOT	NRC	NRC
DOT REGS.							
173.24	X	X	X	X	X	X	X
173.411		X	X	X	X	X	X
173.412		X	X	X except (a)(b)(d) & ( )		X	X
173.413			X			X	
173.415		X		X			
173.416			X			X	
173.465		X	X	X		X	X
173.466		X					
NRC REGS.							
71.43			X			X	X
71.45			X			X	X
71.51			X			X	
71.52							X
71.71			X			X	X
71.73			X			X	

Note that the steel drums typically used to contain radioactive waste are a DOT specification packaging; however, they do not qualify as Type A packaging. Therefore, they must either be transported in a Type A package or an exclusive use vehicle.

3.2.2 Multiple types of packages may be transported on the same vehicle as long as they are appropriate for the material being shipped.

3.3 Obtain the proper packaging and load the radioactive material.

3.4 Package Limits and Communication Requirements

3.4.1 The package may be any of the following:

a. Type A packaging with contents.

b. Type B packaging with contents.

c. Strong tight container containing either LSA Type A material or limited quantity material.

3.4.2 Radiation level limits.

a. Survey the package on all surfaces including the bottom. Readings that are equal to or greater than 80% of the maximum limits shall be verified with at least one other instrument. Document the results.

b. Packages with any reading equal to or greater than 90% of the maximum limits will not be released for shipment.

Strong tight containers containing LSA Type A quantity material that read equal to or greater than 90% of the maximum limits will be held for shipment in a cask with adequate shielding.

Casks that read equal to or greater than 90% of the maximum limits will have the particular material causing the high reading removed or repositioned in order to bring the reading down.

3.4.3 Contamination limits.

a. Smears shall be taken in the locations most likely to yield significant removable contamination.

b. The maximum permissible contamination limit is 2,200 dpm/100cm^2.

3.4.4 Specification marking

a. DOT subtypes "Limited Quantity" and "LSA exclusive use" are excepted from the specification marking requirements.

b. DOT subtypes "Type A", "Type B" and "Highway Route Controlled Quantity" are required to be marked with the following:

Proper shipping name and ID number
Consignee's or Consignor's name and address
Gross weight
"Type A", "Type B", "LSA", etc.

3.4.5 Labeling

a. DOT subtypes "Limited Quantity" and "LSA exclusive use" are excepted from the labeling requirements.

b. The proper label to be affixed is determined by surveying the package and applying the criteria of 49CFR172.403(c).

c. Multiple hazards must be so labeled.

3.4.6 Waste classification.

a. Each package of radioactive waste must be classified in accordance with the criterion of 10CFR61.55 and clearly labeled to identify its class.

b. Each package must meet the minimum requirements for waste packages as specified in 10CFR61.56.

3.5 Transport Vehicle Communication Requirements

3.5.1 Placarding requirements.

a. Verify that placards are attached to transport vehicle (all 4 sides) if it is carrying any package with a Radioactive Yellow III label or an exclusive use LSA shipment.

b. Verify that each placard is visible from the direction it faces.

c. Photograph all sides of the transport vehicle before release to document that all placards were in place.

3.5.2 Shipping paper requirements.

a. Bill of Lading must contain the following:

1. Proper shipping name prescribed for the material in 49CFR172.101 and 102.

2. The hazard class "Radioactive" if not included in the proper shipping name.

3. The identification number, "UN--" or "NA--".

4. The total quantity of the hazardous material covered by the description.

5. The name of each radionuclide.

6. A description of the physical and chemical form of the material, if not special form.

7. The activity contained in each package in the shipment in terms of Curies, millicuries or microcuries.

NOTE: If the Bill of Lading is accompanied by a manifest, then the total Curies in the shipment may be listed instead of individual packages.

8. The category of label applied to each package.

9. For a DOE or NRC approved package, a notation of the package identification marking.

10. A signed certification statement that the materials are properly classified, described, packaged, marked and labeled.

NOTE: In filling out the Bill of Lading, identify the hazardous material description by placing an "X" in the column captioned "HM".

b. Shipping manifest requirements.

Each disposal site has a shipping manifest document for itemizing the individual drums/packages that form the shipment. Instructions are provided with the documents. A copy of the completed manifest must accompany the shipment.

c. State notification forms.

The state(s) which have radioactive material disposal sites may have prior notification requirements, typically three (3) days prior to shipment. A copy of the notification form(s) must accompany the shipment.

d. State certification forms.

The state(s) which have radioactive material disposal sites may require that a state certification form be completed for each shipment. A copy of this certification form must accompany these shipments.

e. Drivers' instructions for the maintenance of exclusive use certification.

See ISP-22

3.6 Transport Vehicle Requirements

3.6.1 Non-exclusive use shipments.

a. No package shall exceed 200mR/hr on any surface and have a Transport Index in excess of ten (10).

3.6.2 Exclusive use shipments.

a. No package shall exceed one thousand (1,000) mR/hr on any surface.

b. Shipment shall be in a closed transport vehicle.

c. The package(s) must be secured within the vehicle so that its position remains fixed.

d. There shall be no loading or unloading operations between the beginning and the end of transportation.

3.6.3 The radwaste packages shall be loaded onto the transport vehicle in such a manner that the following radiation levels are not exceeded:

a. 200mR/hr at any point on outer surfaces of vehicle including top and bottom. For flatbed trailer, at any point on the vertical planes projected from the outer edges of the vehicle.

b. 10mR/hr at any point two (2) meters from the outer lateral surfaces of the vehicle (excluding top and bottom). For flatbed trailers, at any point two (2) meters from the vertical planes projected from the outer edge of the vehicle.

c. 2mR/hr in any normally occupied cab space.

d. The surveys required shall be made with properly calibrated instruments by at least two (2) individuals utilizing different instruments. Readings will be taken along the entire surface.

The results of the surveys will be compared and any discrepancies investigated. Readings equal to or greater than 80% of the maximum limits will be verified.

e. No vehicle with a reading equal to or greater than 90% of the maximum limits will be released for shipment.

f. A copy of the Transportation Vehicle Survey, Form ISP-26A, should accompany the shipment.

TRANSPORTATION VEHICLE SURVEY

ISP-26A

Shipment ID:_____ Shipment Date:_____

Meter used:_____ Cal Due:_____

Meter used:_____ Cal Due:_____

All readings in mR/hr

Comments: _____

_____

_____

_____

Maximum Allowable Readings

Surface - 200mR/hr
@ 2 meters - 10mR/hr
Cab - 2mR/hr

Performed by:_____ Date:_____

Performed by:_____ Date:_____

Reviewed by RSO:_____ Date:_____

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

INSPECTION AND PROCEDURE FOR CONTAINERS WITH OVERPACKS AUTHORIZED FOR THE SHIPMENT OF RADIOACTIVE MATERIAL

ISP-33 Rev. 01/95

1.0 REQUIREMENTS AND DESCRIPTION:

1.1 In order to comply with NRC/DOT regulations concerning shipment of radioactive materials, this inspection procedure must be completed for each shipment of radioactive materials prior to movement of the material to the carrier for transportation. Defects found during inspections must be corrected prior to material movement.

1.2 The requirements are applicable when moving radioactive material in authorized containers from one customer location to another, from the field back to the Isotope facility, to the field from the Isotope Facility.

1.3 Authorized Shipping Containers

1.3.1 Cobalt 60 Shipments

1.3.1.1 590C, D, E, F and G Head in Overpack No. 181375.

1.3.1.2 C-12 Head in Overpack No. D-MEH-00-00004.

1.3.1.3 3320 AR Exchange Container in Overpack No. 181361.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

1.3.2 Cesium 137 shipments - 3320B Exchange Container in Overpack No. 181361.

1.4 Audit

In accordance with 10CFR 71.137, the Radiation Safety Officer will make an audit of the maintenance of the containers and overpacks according to the checklist. The audit shall be on an unannounced basis at intervals not to exceed one (1) year.

2.0 INSPECTIONS

2.1 The Inspection Data Sheet for Radioactive Material Containers and Overpacks (QA1014A) must be completed and forwarded to the Radiation Safety Officer and Isotope Facility for audit and record retention. Field operations are to return the Inspection Data Sheet in the pre-stamped, self-addressed envelope along with the waybill copy of the return shipment.

2.2 The only personnel permitted to perform the inspection and maintenance are those individuals qualified under the conditions of the license. Repairs may be permitted by an outside contractor; however, these repairs must be inspected before use.

3.0 HEAD OR SOURCE EXCHANGE CONTAINER PROCEDURE

Perform each inspection step as indicated. Defects found during inspection must be corrected and reinspected. Repairs must be listed on the Data Sheet along with the signature of the inspector. A check mark (✓) is to be placed on the Stat Sheet after each step.

3.1 Make a wife survey of the external surface of the container. Field operations are to use a Victoreen 491 or equal to evaluate the wipe. The meter must read less than 220 DPM/100cm^2 when the wipe is held 1/4" from the Geiger Tube (Beta shield open). Factory operations are to use a well counter to determine wipe activity. Results must indicate 220 DPM/100cm^2 or less of removable contamination.

3.2 Perform a preliminary radiation survey of the container. Results should be 200mR/hour or less on the surface and 10mR/hour or less at 1 meter from the surface.

3.3 Verify that the shutter or drawer is locked.

3.4 Verify that the gaskets on 3320 AR are in good condition.

3.5 Inspect the lifting loops on 3320 AR. Loops must be in good condition, not bent, and welds must not exhibit cracks.

3.6 Inspect the container to insure there is no mechanical damage which will affect the radiation integrity of the unit.

4.0 OVERPACK PROCEDURE

Perform each inspection step as indicated. Defects found during inspection must be corrected and reinspected. Repairs must be listed on the Data Sheet along with signature of the inspector. A check mark (✓) is to be placed on the Data Sheet after each step.

4.1 Inspect the overpack for the following mechanical characteristics:

4.1.1 All wood joints inside the overpack must be tight. Tighten reinforcing bars if necessary.

4.1.2 The wood joints inside the overpack should be free of holes and voids. Holes can be filled with wood plugs.

4.1.3 Lifting loops should be free of damage.

4.1.4 Welds on the framework must be free of cracks and damage.

4.1.5 Inspect the skid runners for damage.

4.2 Inspect the container hold-down system to insure it is properly secure.

4.3 Inspect that the bolts securing the overpack cover to the skid are tight, but not stripped.

4.4 Inspect the package and insure it is seal wired.

4.5 Survey the package with container inside. The radiation level must be less than 10mR/hour at any point 1 meter from the surface of the container and 200mR/hour or less at the surface.

4.6 Inspect the outside package for the following labels:

4.6.1 Two yellow Radioactive III diamond labels filled out indicating the radioactive material, number of curies and transport index (maximum radiation units at 1 meter) as measured in 4.5. These labels must be on opposite sides of the package.

4.6.2 Verify that the overpack bears an 11" x 18" yellow sign with magenta lettering listing AMS, Cleveland, Ohio, U.S.A., part number of the overpack, Package I.D. Number, gross and empty weights, Made in U.S.A. and Radiation Symbols. All markings must be clear and legible.

4.6.3 Verify that the opening instructions have been included with the package.

AMS MODEL 181375 SHIPPING PACKAGE

USNRC CERTIFICATE OF COMPLIANCE NO. 5

COBALT HEAD SHIPPING CONTAINER

PACKING/UNPACKING

INSTRUCTIONS

IMPORTANT - READ CAREFULLY

Revised ./20/91

Revisic B - 8/1992

1.0 Preparing a source loaded head container (Model 1[illegible]75) for shipment.

Only properly qualified service engineers may remo[illegible] a loaded teletherapy head from a machine. Once the head is [illegible]moved and properly secured to the container base, the follow[illegible] procedure applies.

NOTE: QA Procedure 1014 and 1014A must be compl[illegible] prior to shipment.

A. Position the tie down head assembly around t[illegible] machine head. Align the trunnion bolt holes with th[illegible] tie down bracket slots such that the tie down strap i[illegible]esting firmly against the machine head. (Use shims [illegible]derneath the tie down bracket and/or head in order t[illegible]hieve proper alignment.)

B. Secure the tie down head assembly by first t[illegible]ightening the bracket-to-pallet base bolts, then tigh[illegible]ing the bracket-to-head trunnion bolts. Verify tha[illegible]he strap is tight against the head.

C. Attach the wooden support pads into place a[illegible]nd the machine head.

D. With a lifting device capable of lifting 10[illegible] lbs., place the overpack in position over the hea[illegible]n the pallet base.

E. Secure the overpack to the pallet base with [illegible]e four one inch bolts and eight 1/2 inch bolts.

F. Attach an appropriate shipping seal to one [illegible] the side lugs.

G. Perform a radiation survey of the package a[illegible]he surface (maximum reading 200 mR/hr). If the radiati[illegible] levels exceed these limits, the package shall not b[illegible] released for shipment. Notify the Radiation Safety O[illegible]ficer for further instructions.

H. Apply the proper labels to the container. V[illegible]ify that the package content description and caution [illegible]rkings are visible.

I. Complete the shipping papers.
Copies of QA 1014 and 1014A, shipping paper[illegible]d other documentation should be returned to Advanced[illegible]edical Systems for record-keeping purposes.

J. All shipments of radioactive material destined for Advanced Medical Systems should be shipped to:

Advanced Medical Systems, Inc.
1020 London Road
Cleveland, OH 44110

2.0 Unpacking a source loaded head container (Model 18375)

A. The package must be removed from the transport vehicle with material handling equipment of a capacity equal to or greater than the gross package weight of 4000 lbs.

B. Perform a radiation survey of the container to insure that the external radiation level does not exceed 200 mR/hr at the surface and 10 mR/hr at a distance of 1 meter from the surface. [If the level does exceed these limits, the appropriate NRC Regional Office and the final delivery carrier must be notified.]

C. Verify that the shipping seal is intact. The shipping seal may be removed only by a person qualified to install the equipment. Until such a person is present, the container should be stored in accordance with 10CFR20.

D. Upon the authorization of removal of the shipping seal, the overpack may be removed. Remove the four one-inch and eight 1-2-inch bolts securing the overpack to the pallet base (save hardware for reuse).

E. With a lifting device capable of lifting 1000 lbs., lift the overpack off the machine head and pallet base.

CAUTION: The machine head may not be removed from the pallet base until it has been moved into the room in which it is to be installed. This is to insure that the skid shield remains in place under the head.

F. Move the pallet base with head attached into the therapy room.

G. Remove the twelve bolts securing the tie down head bracket to the machine head and pallet bases (save hardware for reuse).

H. Remove the wooden support pads and slide the tie down head assembly forward, away from the machine head. The head installation including the removal of the machine head from the pallet base, may only be performed by a qualified service engineer.

3.0 Preparing an empty head container (Model 1813754) for shipment.

NOTE: QA Procedure 1014 and 1014A must be completed prior to shipment.

A. Bolt the skid shield into place on the pallet base

B. Bolt the tie down head bracket with attached wooden support pads, to the pallet base.

C. Place the overpack into position on the pallet base and secure it with the twelve bolts.

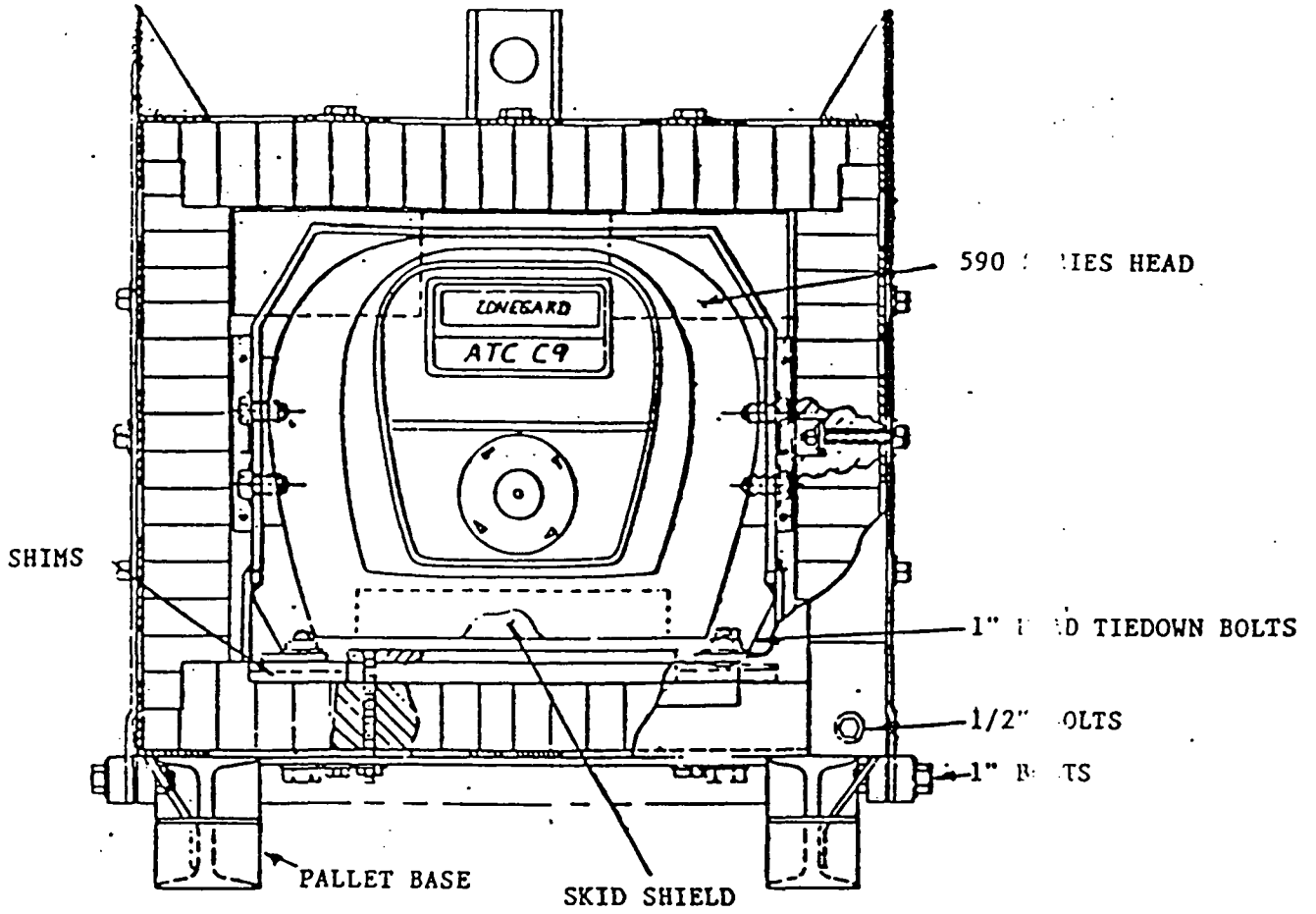
D. Mask out any "Radioactive Material" labels and marks (tape may be used).

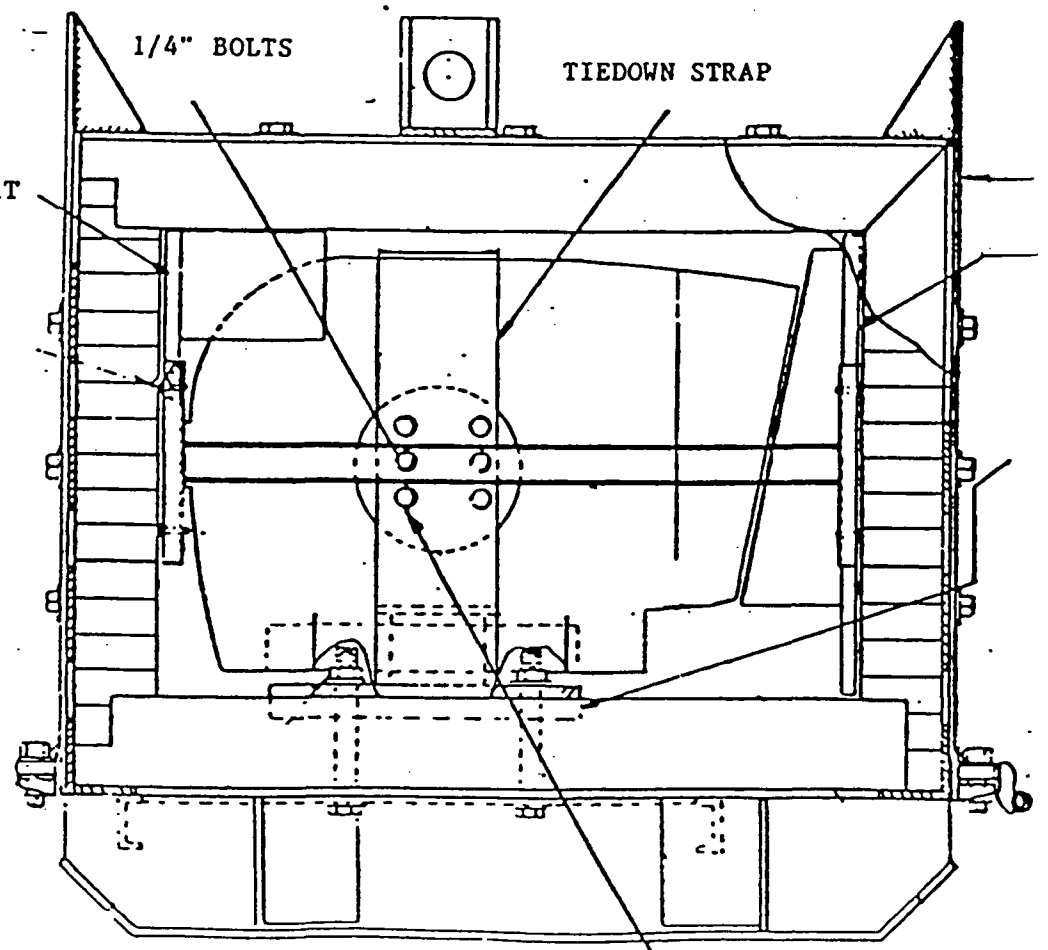
E. Remove the Radioactive Yellow III labels and apply "Empty" labels to the container.

F. Apply proper shipping labels.

All return shipments destined for Advanced Medical Systems should be shipped to:

Advanced Medical Systems, Inc.
1020 London Road
Cleveland, Ohio 44110


590 : IES HEAD
LONEGARD
ATC C9
SHIMS
1" : D TIEDOWN BOLTS
1/2" OLTS
1" B TS
PALLET BASE
SKID SHIELD


1/4" BOLTS
TIEDOWN STRAP
AR SUPPORT PAD
VERPACK
RONT SUPPORT PAD
NOTE:
SHIM AS REQ'D.
AT PACKING TOTAL SHIM
EIGHT NOT TO EXCEED
/2"
P/N 200742 1 thru 5
P/N 200743 1 thru 5
SHIPPING SEAL
1/2" BOLTS

Control No_____

Source S/N_____

Source Shipment Documentation Checklist

for 181375 (head) Container

A. Pre-shipment Documents

1. Container inspection report (QA1014A) _____
2. Head survey sheet _____
3. Shipping tags or stencils _____
4. Work sheet _____

B. Service Engineer Package

1. Presentation folder with:
   a) Calibration certificate _____
   b) Decay Tables (2) _____
   c) Certificate of Wipe _____
   d) Source Warranty _____

2. Return documents

		returned
a) Five year inspection report	_____	_____
b) Head survey sheets (2)	_____	_____
c) Service ticket	_____	_____
d) Return Bill of Lading	_____	_____
e) Container Inspection Report (QA1014)	_____	_____
f) Diamond labels (2)	_____	NA
g) State Notification Letters	_____	NA

C. Customer file

The following should be in file before shipment:

1. AMS work order _____
2. Customer license _____
3. Calibration data sheets _____
4. Calibration certificate _____
5. Wipe data sheets _____
6. Wipe certificate _____
7. Source work sheet _____
8. Source shipment checklist _____
9. Consignee notification letter _____

The following should be placed in file once returned shipment is received:

10. Head survey sheet _____
11. Five year inspection report _____ _____
12. Bills of Lading _____

D. Shipping Documents

1) Bill of Lading _____
2) Instructions to Driver (ISP-30) _____
3) Placards _____
4) Export only - Container Loading/Unloading Instructions _____
5) Export only - IAEA Certificate of Competent Authority _____

LOOSE SURFACE CONTAMINATION SURVEY

page_____ of _____

TE:_____ INST.:_____ S/N:_____ BKG._____ CPM

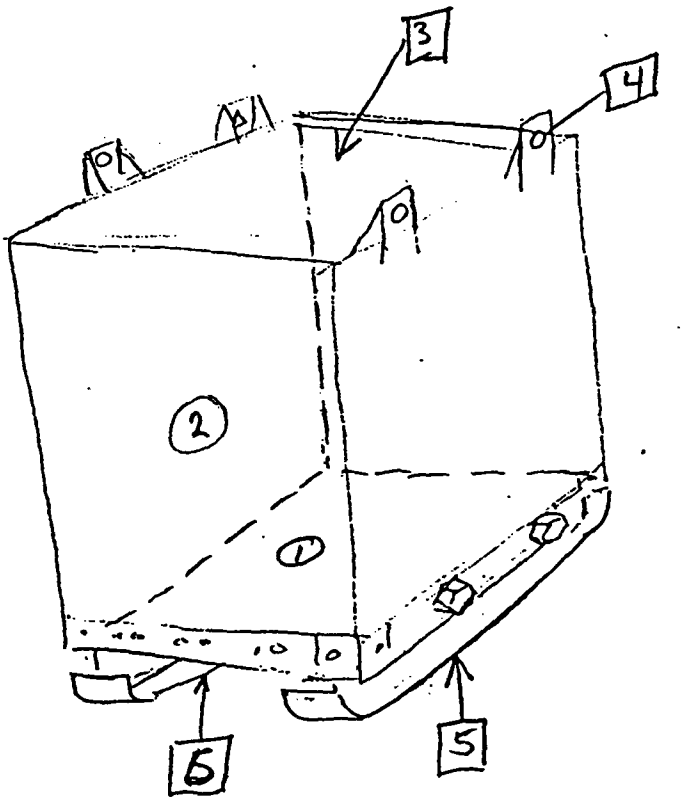
ME:_____ CAL. DATE:_____ C_{eff}_____ %

AME:_____ AREA/ITEM SURVEYED _____

Avg. smear area_____ cm^2

No.	G_{cpm}	C_{cpm}	DPM

DRAWING



○ INTERNAL SMEAR

□ EXTERNAL SMEAR

Comments #7 GROSS MASSLIN OVER ALL

Reviewed by _____

MODEL 181361 SHIPPING PACKAGE
USNRC CERTIFICATE OF COMPLIANCE NO. 5796
FOR
3320 SERIES
COBALT SOURCE EXCHANGE CONTAINER

PACKING/UNPACKING INSTRUCTION

IMPORTANT - READ CAREFULLY

ADVANCED MEDICAL SYSTEMS, INC.
ISOTOPE FACILITY
1020 LONDON RD.
CLEVELAND, OHIO 44110

Revised 1/87

INTRODUCTION

This procedure is intended to provide enough information to allow the handler of a radioactive source container to safely pack, unpack, load, or unload a 3320AR Source Transport Container.

WARNING

THE FOLLOWING PROCEDURES MUST BE CAREFULLY AND THOROUGHLY ADHERED TO AS TO AVOID EXPOSURE TO HARMFUL RADIATION AND/OR SERIOUS BODILY INJURY.

1.0 Unpacking a loaded source exchange container (Model 181361)

Upon receipt of the container at the destination the following general procedure applies:

A. The package must be removed from the transport vehicle with material handling equipment of a capacity equal to or greater than the gross package weight of 4000 lbs.

B. Perform a radiation survey of the container to insure that the external radiation level does not exceed 200 mR/hr at the surface and 10 mR/hr at a distance of 1 meter from the surface. [If the level does exceed these limits, the appropriate NRC Regional Office and the final delivery carrier must be notified.]

C. Verify that the shipping seal is intact. The shipping seal may be removed only by a person qualified to install the equipment. Until such a person is present, the container should be stored in accordance with 10CFR20.

D. Upon the authorized removal of the shipping seal, the overpack may be removed.
Remove the four 1 inch and twenty 1/2 inch bolts securing the overpack to the pallet base (save the hardware for reuse).

E. Remove the hex nuts from the thru rods, and the thru rods from the package.

F. With a device capable of lifting 1000 lbs., lift the overpack from the pallet base.

NOTE: The overpack fits very close to the inner package.

G. Remove the wooden jacket from the source exchange container. Do not allow the jacket to become wet or allow it to become misaligned due to rough handling (save the hardware for reuse).

H. Remove the four bolts securing the source exchange container to the pallet base.

I. With a lifting device capable of lifting 3000 lbs., lift the source exchange container off the pallet base.

J. Install the casters (shipped in a separate box) to the base of the source exchange container. Using the elevating wrench (shipped attached to the inside of the skid rail), adjust the casters so that the distance between the floor and the bottom of the skid rails is 11 3/4 ± 1/4 inches.

K. Move the source exchange container, still sealed, into the therapy room.

WARNING

THE CONCENTRATED WEIGHT ON THESE CASTERS WILL CRUMBLE MOST FLOOR SURFACES. SHEETS OF MASONITE SHOULD BE PLACED ON THE FLOOR FOR SURFACE PROTECTION (PLYWOOD WILL NOT SUFFICE, AS THE CASTERS WILL SINK IN AND MAKE MOVEMENT VERY DIFFICULT.) MASONITE SHOULD ALSO BE PLACED OVER DOOR SILLS TO FACILITATE CONTAINER MOVEMENT. DO NOT ATTEMPT TO USE THE MOMENTUM OF THE CONTAINER TO JUMP OVER DOOR SILLS OR OTHER SURFACE IRREGULARITIES. THE CASTERS WILL BE DAMAGED AND THE CONTAINER MAY TOPPLE OVER.

All further unpacking shall be performed by a properly qualified service engineer.

2.0 Preparing a loaded source exchange container (Model 181361) for shipment.

The following procedure applies once the source has been loaded into the 3320 source exchange container by a qualified service engineer.

NOTE: QA Procedure 1014 must be completed prior to shipment.

A. Inspect the source exchange container to insure that all components and covers are in place, bolted and seal wired.

B. Make a wipe survey of the external surfaces of the container.

C. Apply two Radioactive Yellow III labels to the container.

D. With a lifting device capable of lifting 1000 lbs., lift the container, remove the casters, and place the container on the pallet base, using orientation marks as a guide.

E. Carefully secure the wooden jacket around the container. Take care that the jacket is properly aligned with the container.

F. Insert the thru rods as a check for proper alignment. Secure the container to the pallet base with the four 1 inch bolts.

G. Remove the thru rods. Lower the overpack onto the pallet base, using the colored index markings for alignment. NOTE: There is only 1/4 inch clearance between the overpack and the jacket.

H. Insert the thru rods, seating the square ends to prevent rotation. Secure the thru rods with the hex nuts.

I. Attach the seal wire to the pallet base.

J. Perform a radiation survey of the package at the surface (maximum reading 200 mR/hr), and at 1 meter from the surface (maximum reading 10 mR/hr). If the radiation levels exceed these limits, the package shall not be released for shipment. Notify the Radiation Safety Officer for further instructions.

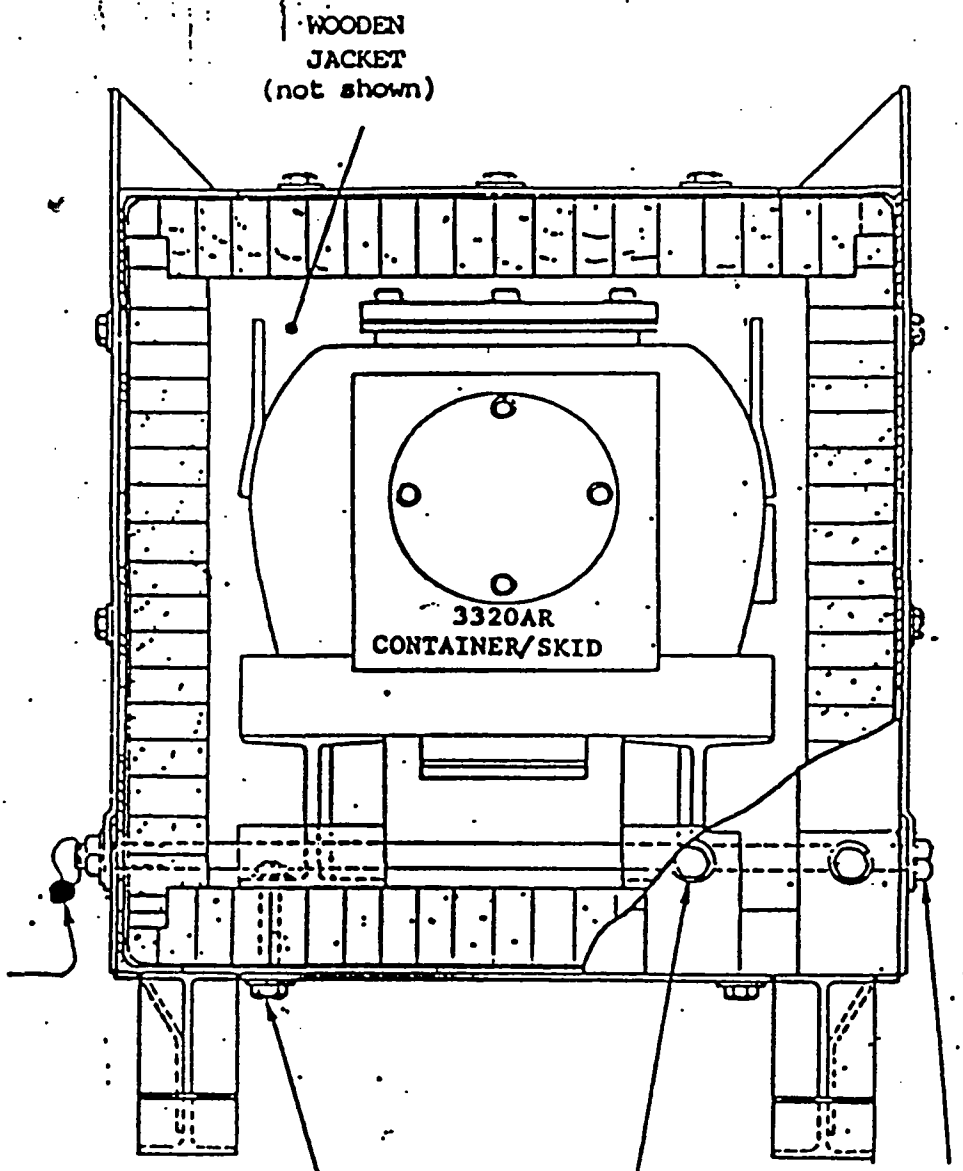
K. Apply the proper labels to the package. Verify that the package content description and caution markings are visible.

L. Complete the shipping papers.
Copies of QA 1014, shipping papers and other documentation should be returned to Advanced Medical Systems for record keeping purposes.

M. All shipments of radioactive material destined for Advanced Medical Systems should be shipped to:

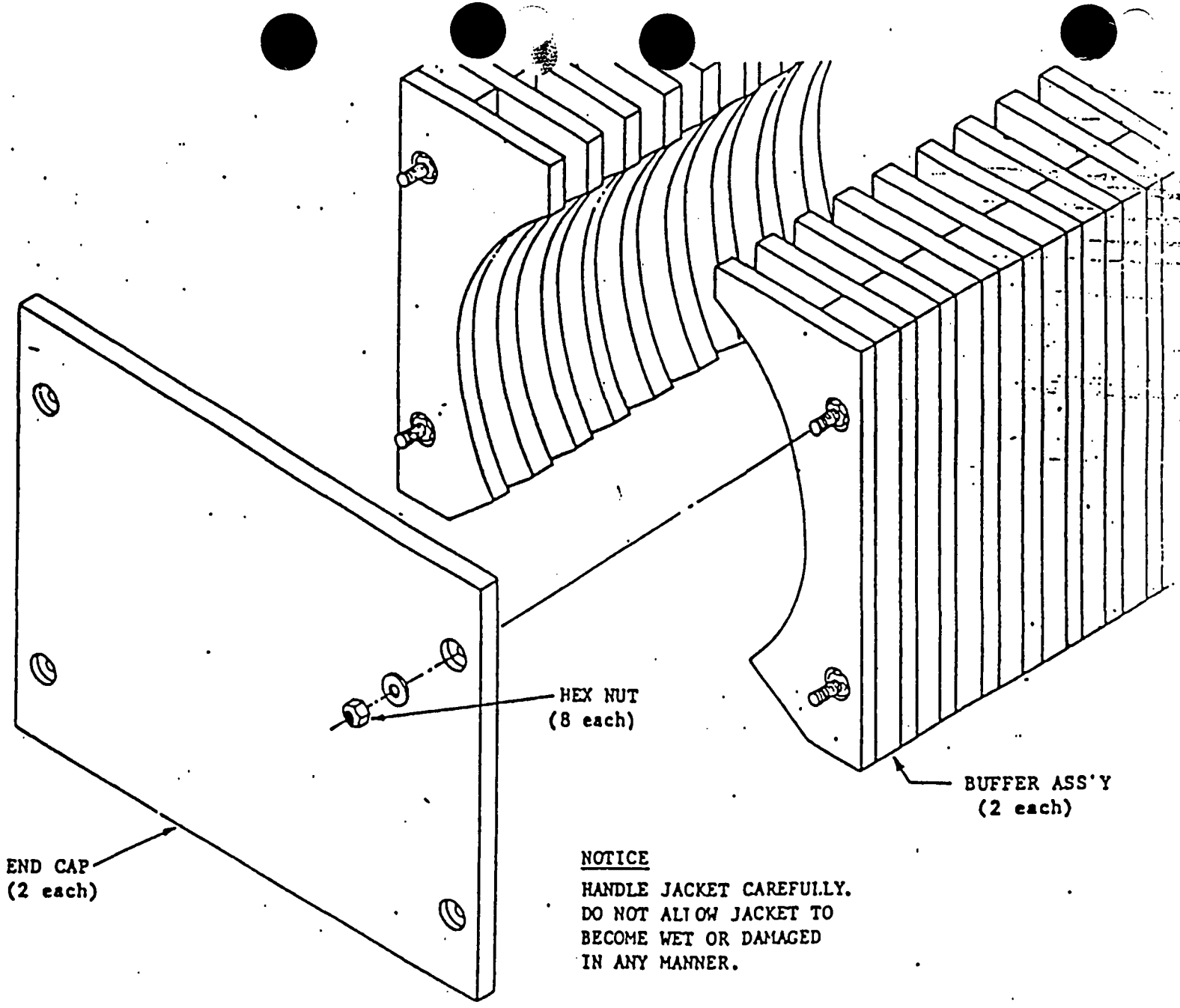
Advanced Medical Systems, Inc.
1020 London Road
Cleveland, Ohio 44110

3320AR SOURCE CONTAINER OVERPACK #181361



CAUTION

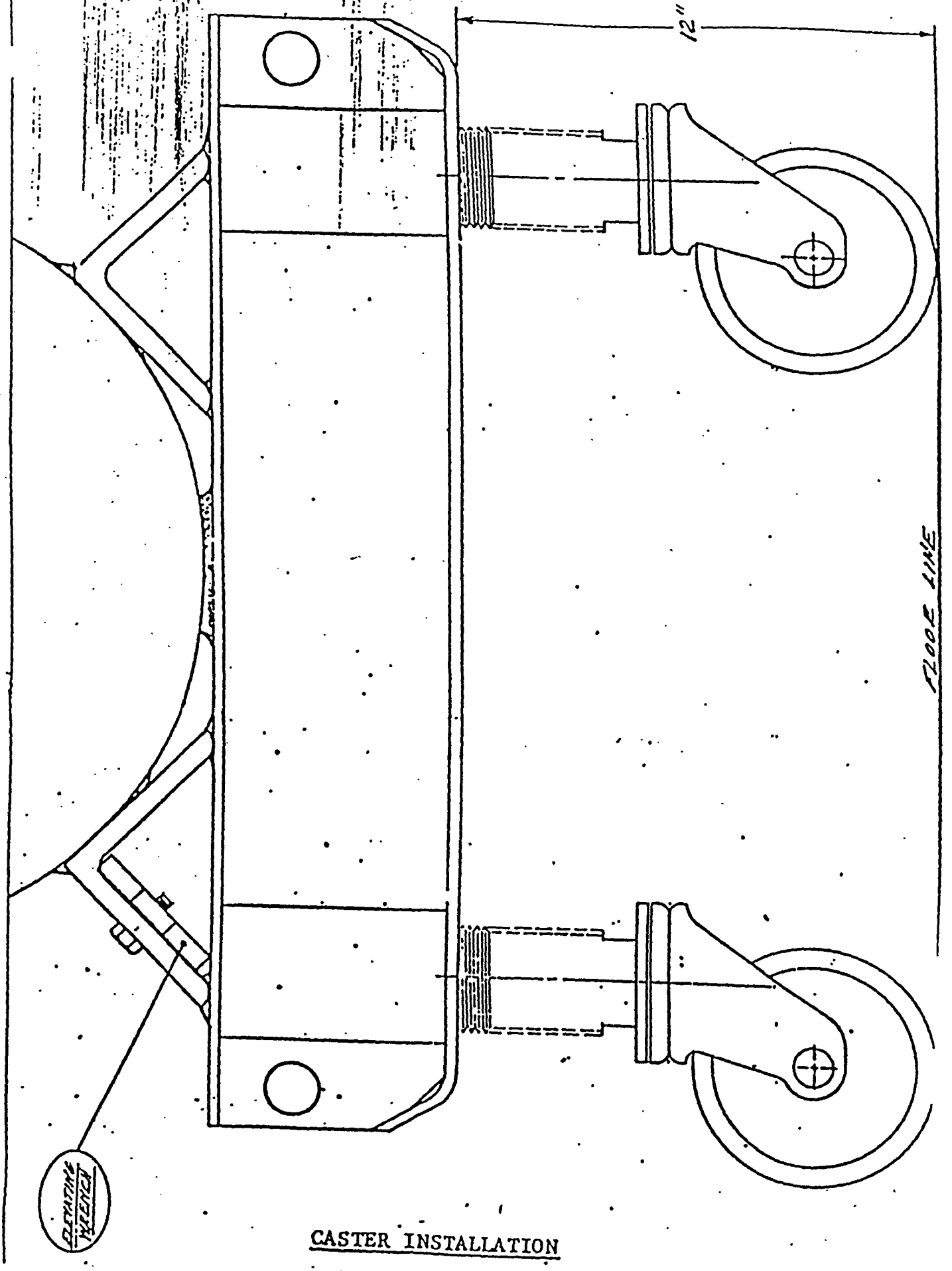
A RADIATION SURVEY MUST BE PERFORMED BEFORE REMOVAL OF A LOADED SOURCE CONTAINER FROM THE OVERPACK.



NOTICE

HANDLE JACKET CAREFULLY.
DO NOT ALLOW JACKET TO
BECOME WET OR DAMAGED
IN ANY MANNER.

WOODEN JACKET FOR 3320AR
SOURCE CONTAINER OVERPACK



CASTER INSTALLATION

SOURCE S/N

ADVANCED MEDICAL SYSTEMS

TITLE:
Exchange Container Contamination Control Record

Procedure No: QA 10148
Revision:
Date Issued: 3/20/87
Page 1 of 1

Prior to next use and/or shipment, the container must be wiped clean of contamination. Clean is considered to be less than 200 CPM above background, using the office well counter.

Take wipes on the following areas. Record the 1st wipe before cleaning, and all subsequently counted wipes for that particular area.

Container S/N_____ last contained source S/N_____

Background_____CPM

STD Activity_____uCi
STD Counts _____CPM

	1st Wipe	
A. Skid Runners bottom		
B. Skid Runners top		
C. Exterior Surface		
D. Cover- bottom		
E. Cover- top		
F. Cover- side		
G. Push rod		
H. Trap		
I. Drawer		
J. Drawer cavity		
K. Vertical hole		
L. Top plug		
M. Lifting Ears		

Date:_____ By:_____

Advanced Medical Systems — Quality Assurance Department

Prepared by	Approval	Revisions
	Howard K Stern	

Number QA 10[illegible]

RADIOACTIVE MATERIAL SHIPPING RECORD

Revision D

Date Issued: Nov. 5, 1984

CUSTOMER: _____
LOCATION _____

CONTROL NUMBER

CERTIFICATE OF COMPLIANCE NO. _____

CERTIFICATE OF COMPLIANCE HOLDER: _____

CERTIFICATE IN OUR FILES _____

AMS REGISTERED USER: _____

DATE OF SHIPMENT _____

B/L NUMBER _____

SOURCE INFORMATION:

Isotope _____
Mfg./Cat.No. _____
Curies _____
Wipe Test Reading _____

Serial No. _____
Curies Date _____
Wipe Test Date _____

CONTAINER INSPECTION AND MAINTENANCE

CONTAINER INFORMATION

Model No. _____

Serial No. _____

	CHECK IF OK	REPAIR NOTES *****
Internal Contamination		
External Contamination		
Preliminary Radiation Survey		
Mechanical Functions		
Shutter or Drawer Locked		
Shutter or Container Sealed		
Gaskets in Good Condition (if any)		
Lifting Loops in Good Condition (if any)		
Tie Down Devices in Good Condition and Secured		
Casters in Good Condition		
Container Identification Legible		
Radiation Warning Signs		

RADIOACTIVE MATERIAL SHIPPING RECORD

OVERPACK QA INSPECTION AND MAINTENANCE

OVERPACK INFORMATION

Model No. _____ Serial No. _____

	CHECK IF OK
Mechanical Functions	
All Wood Joints Tight	
No Holes or Voids	
Lifting Loops in Good Condition	
Tie Down Devices in Good Condition and Secure	
Skid in Good Condition and Tight	
All Bolts Tight	
Overpack Identification Legible	
Overpack Sealed	
Maximum Radiation Level at 1m. _____ mR/hr	
Maximum Radiation Level on Surface _____ mR/hr	
Transport Index Labels Attached	
Opening Instructions Attached	
General Condition	

INSTALLATION KIT	INITIAL
Complete per O/M	
Survey Meter	
Model No. _____	
Serial No. _____	
Date Calibrated	
_____	

List Any Items in Need of Repair

_____
_____
_____
_____
_____
_____
_____

DATE INSPECTED: _____ INSPECTOR (Initials) _____

APPROVAL OF LICENSED PERSON _____

REPAIR NOTES: ******** Enter repairs made to bring container or overpack into proper condition. Include initials of individual(s) making repairs and date of repairs.

FIELD NOTE: THIS SHEET MUST BE RETURNED IN THE PRESTAMPED, SELF ADDRESSED ENVELOPE ALONG WITH THE WAYBILL. IN THE EVENT THE WAYBILL AND THIS SHEET ARE SEPARATED, RETURN THESE SHEETS AS INDICATED BELOW:

Advanced Medical Systems, Inc.
Radiation Safety Officer
1020 London Road
Cleveland, Ohio 44110

AUDIT _____
DATE _____

Advanced Medical Systems Quality Assurance Department

Prepared by	Approval	Revisions
Norman Kelley	Howard R Lewis	

SOURCE S/N

ADVANCED MEDICAL SYSTEMS

TITLE: Exchange Container Contamination Control Record	Procedure No: QA 1014B Revision: Date Issued: 3/20/87

Prior to next use and/or shipment, the container must be wiped clean of contamination. Clean is considered to be less than 200 CPM above background, using the office well counter.

Take wipes on the following areas. Record the 1st wipe before cleaning, and all subsequently counted wipes for that particular area.

Container S/N_____ last contained source S/N_____

Background_____CPM

STD Activity_____uCi
STD Counts _____CPM

	1st Wipe	
A. Skid Runners bottom		
B. Skid Runners top		
C. Exterior Surface		
D. Cover- bottom		
E. Cover- top		
F. Cover- side		
G. Push rod		
H. Trap		
I. Drawer		
J. Drawer cavity		
K. Vertical hole		
L. Top plug		
M. Lifting Ears		

Date:_____ By:_____

Advanced Medical Systems — Quality Assurance Department

Prepared by	Approval	Revisions
	Howard R Olsen	

GLOSSARY OF TERMS

A

absorber — Any material that absorbs or lessens the intensity of ionizing radiation. Concrete, steel, and lead are used in shielding x or gamma rays. A thin sheet of paper or metal will absorb or weaken alpha particles and all except the most energetic beta particles.

absorption — The process by which the number of particles or photons entering a body of matter is reduced or attenuated by interaction with the matter.

ALARA — Acronym for "As Low as Reasonably Achievable," a basic concept of radiation protection that specifies that radioactive discharges and radiation exposure to personnel be kept as far below regulation limits as feasible. The term was originally "As Low as Practicable."

alpha particle — A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus that has a mass number of 4 and an electrostatic charge of +2. It has low-penetrating power and short range. The most energetic alpha particle will generally fail to penetrate the skin. Alphas are hazardous when an alpha-emitting isotope is introduced into the body.

atom — The smallest particle of an element that cannot be divided or broken up by chemical means. It consists of a central core called the nucleus, which contains protons and neutrons. Electrons revolve in orbits in the region surrounding the nucleus.

atomic energy — Energy released in nuclear reactions. Of particular interest is the energy released when a neutron initiates the breaking up of fissioning of an atom's nucleus into smaller pieces (fission), or when two nuclei are joined together under millions of degrees of heat (fusion). It is more correctly called "nuclear energy."

atomic number — The number of positively charged protons in the nucleus of an atom and the number of electrons on an electrically neutral atom.

attenuation — The process by which a beam of radiation is reduced in intensity when passing through some material. It is the combination of absorption and scattering processes and leads to a decrease in flux density of the beam when projected through matter.

B

background radiation — The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements, both outside, and inside the bodies of humans and animals. It is also called natural radiation. The usually quoted average individual exposure from background radiation is 125 millirem per year in mid latitudes at sea level.

beta particle — A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Large amounts of beta radiation may cause skin burns, and beta emitters are harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal or plastic.

binding energy	The minimum energy required to separate a nucleus into its component neutrons and protons.
bioassay	The collection and analysis of human hair, tissue, nasal smears, urine or fecal samples to determine the amount of radioactive material that might have been ingested by the body.
biological half-life	The time required for a biological system, such as that of a human, to eliminate by natural processes half of the amount of substance (such as a radioactive material) that has entered it.
body burden	The amount of radioactive material which if deposited in the total body will produce the maximum permissible dose rate to the body organ considered the critical organ.
bone seeker	A radioisotope that tends to accumulate in the bones when it is introduced into the body. An example is strontium-90, which behaves chemically like calcium.

C

charged particle	An ion. An elementary particle carrying a positive or negative electric charge.
contamination	The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.
controlled area	A defined area in which the occupational exposure of personnel to radiation or radioactive material is under the supervision of an individual in charge of radiation protection.

cosmic radiation	Penetrating ionizing radiation, both particulate and electromagnetic, originating in space. Secondary cosmic rays, formed by interactions in the earth's atmosphere, account for about 45 to 50 millirem of the 125 millirem background radiation that an average individual received in a year.
counter	A general designation applied to radiation detection instruments or survey meters that detect and measure radiation. The signal that announces an ionization event is called a count.
critical organ	The body organ receiving a radionuclide or radiation dose that results in the greatest overall damage to the body.
cumulative dose	The total dose resulting from repeated exposures of radiation to the same region, or to the whole body, over a period of time.
curie (Ci)	The basic unit used to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second. Named for Marie and Pierre Curie, who discovered radium in 1898.

D

daughter products	Isotopes that are formed by the radioactive decay of some other isotope. In the case of radium-226, for example, there are 10 successive daughter products, ending in the stable isotope lead-206.

decay, radioactive	The decrease in the amount of any radioactive material with the passage of time, due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation.
detector	A material or device that is sensitive to radiation and can produce a response signal suitable for measurement or analysis. A radiation detection instrument.
dose	A quantity (total or accumulated) of ionizing radiation received. The term "dose" is often used in the sense of the exposure dose, expressed in roentgens, which is a measure of the total amount of ionization that the quantity of radiation could produce in air. This should be distinguished from the absorbed dose, given in rads, that represents the energy absorbed from the radiation in a gram of any material. Furthermore, the biological dose, given in rem, is a measure of the biological damage to living tissue from the radiation exposure.
dose equivalent	A term used to express the amount of effective radiation when modifying factors have been considered. The product of absorbed dose multiplied by a quality factor multiplied by a distribution factor. It is expressed numerically in rem.
dosimeter	A portable instrument for measuring and registering the total accumulated exposure to ionizing radiation.
dosimetry	The theory and application of the principles and techniques involved in the measurement and recording of radiation doses. Its practical aspect is concerned with the use of various types of radiation instruments with which measurements are made.

dose rate	The radiation dose delivered per unit of time. Measured, for example, in rem per hour.
E	
effective half-life	The time required for the amount of a radioactive element deposited in a living organism to be diminished 50 percent as a result of the combined action of radioactive decay and biological elimination.
electromagnetic radiation	A traveling wave motion resulting from changing electric or magnetic fields. Familiar electromagnetic radiations range from X-rays (and gamma rays) of short wavelength, through the ultraviolet, visible, and infrared regions, to radar and radio waves of relatively long wavelengths. All electromagnetic radiations travel in a vacuum with the velocity of light.
electron	An elementary particle with a unit negative charge and a mass 1/1837 that of the proton. Electrons surround the positively charged nucleus and determine the chemical properties of the atom.
element	One of the 103 known chemical substances that cannot be broken down further without changing its chemical properties. Some examples include hydrogen, nitrogen, gold, lead and uranium.
exposure	The absorption of radiation or ingestion of a radionuclide. Acute exposure is generally accepted to be a large exposure received over a short period of time. Chronic exposure is exposure received during a lifetime.
external radiation	Exposure to ionizing radiation when the radiation source is located outside the body.

extremities	The hands and forearms and, with restrictions, the head, feet, and ankles. (Permissible radiation exposures in these regions are generally greater than in the whole body because they contain less blood-forming material and have smaller volumes for energy absorption.)
F	
film badge	A pack of photographic film used for approximate measurement of radiation exposure for personnel monitoring purposes. The badge may contain two or three films of differing sensitivity, and it may contain a filter that shields part of the film from certain types of radiation.
fission	The splitting of a nucleus into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.
flux	A term applied to the amount of some type of radiation crossing a certain area per unit time. The unit of flux is the number of particles, energy, etc., per square centimeter per second.
fusion (thermonuclear reaction)	A nuclear reaction characterized by joining together of light nuclei to form heavier nuclei, the energy for the reactions being provided by violent thermal agitation of particles at very high temperatures. If the colliding particles are properly chosen and the agitation is violent enough, there will be a release of energy from the reaction. The energy of the stars is derived from such reactions.

G

gamma ray (gamma radiation)	High-energy, short wavelength electromagnetic radiation (a packet of energy) emitted from the nucleus. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded against by dense materials, such as lead or uranium. Gamma rays are similar to X-rays, but are usually more energetic.
Geiger-Mueller counter	A radiation detection and measuring instrument. It consists of gas-filled tube containing electrodes, between which there is an electrical voltage, but not current flowing. When ionizing radiation passes through the tube, a short, intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted. The number of pulses per second measures the intensity of radiation. It was named for Hans Geiger and W. Mueller who invented it in the 1920's. It is sometimes called simply a Geiger counter, or G-M counter.
gray	A unit, in the International System of Units (SI), of absorbed dose which is equal to 1 joule per kilogram.

H

half-life	The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also called physical half-life.
half-life, biological	The time required for the body to eliminate half of the material taken in by natural biological means.

half-live, effective	The time required for a radionuclide contained in a biological system, such as a human or an animal, to reduce its activity by half as a combined result of radioactive decay and biological elimination.
half-thickness	The thickness of any given absorber that will reduce the intensity of a beam of radiation to one-half its initial value.
health physics	The science concerned with recognition, evaluation and control of health hazards from ionizing and non-ionizing radiation.
high radiation area	Any area in which a major portion of the body could receive a radiation dose of 100 millirem (0.1 rem) in one hour. These areas must be posted as "high radiation areas" and access into these areas is maintained under strict control.

I

induced radioactivity	Radioactivity that is created when stable substances are bombarded by neutrons. For example, the stable isotope cobalt-59 becomes the radioactive isotope cobalt-60 under neutron bombardment.
internal radiation	Nuclear radiation resulting from radioactive substances in the body. Some examples are iodine-131 found in the thyroid gland, and strontium-90 and plutonium-239 found in bone.
ion	A atom that has too many or too few electrons, causing it to be chemically active; an electron that is not associated (in orbit) with a nucleus.

ionization	The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions. High temperatures, electrical discharges, or nuclear radiations can cause ionization.
ionization chamber	An instrument that detects and measures ionizing radiation by measuring the electrical current that flows when radiation ionizes gas in a chamber, making the gas a conductor of electricity.
ionizing radiation	Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. Examples: alpha, beta, gamma, X-rays, neutrons and ultraviolet light. High doses of ionizing radiation may produce severe skin or tissue damage.
irradiation	Exposure to radiation.
isotope	One of two or more atoms with the same number of protons, but different number of neutrons in their nuclei. Thus, carbon-12, carbon-13 and carbon-14 are isotopes of the element carbon, the number denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but often different physical properties (for example, carbon-12 and -13 are stable, carbon-14 is radioactive).

K

kilo-	A prefix that multiplies a basic unit by 1000. Example: 1 kilometer = 1000 meters.
kilovolt (kV)	The unit of electrical potential equal to 1000 volts.

kinetic energy	The energy that a body possesses by virtue of its mass and velocity; the energy of motion.
L	
LD 50/30	The dose of radiation expected to cause death within 30 days to 50 percent of those exposed. Generally accepted to range from 400 to 450 rem received over a short period of time.
M	
mass-energy equation	The equation developed by Albert Einstein which is usually given as $E = mc^2$, showing that, when the energy of a body changes by an amount E (no matter what form the energy takes), the mass, m, of the body will change by an amount equal to E/c^2. The factor c^2, the square of the speed of light in a vacuum, may be regarded as the conversion factor relating units of mass and energy. The equation predicted the possibility of releasing enormous amounts of energy by the conversion of mass to energy. It is also called the Einstein equation.
mass number	The number of nucleons (neutrons and protons) in the nucleus of an atom. Also known as the atomic weight of an atom.
mega-	A prefix that multiplies a basic unit by 1,000,000.
megacurie	One million curies.
micro-	A prefix that divides a basic unit into one million parts.
microcurie	A one-millionth part of a curie.

milli-	A prefix that divides a basic unit by 1000.
millirem	A one-thousandth part of a rem.
milliroentgen	A one-thousandth part of a roentgen.
monitoring	Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region, as a safety measure, for purposes of health protection.

N

nano-	A prefix that divides a basic unit by one billion.
nanocurie	One billionth part of a curie.
neutron	An uncharged elementary particle with a mass slightly greater than that of the proton, and found in the nucleus of every atom heavier than hydrogen.
neutron capture	The process in which an atomic nucleus absorbs or captures a neutron.
nuclear energy	The energy liberated by a nuclear reaction (fission or fusion) or by radioactive decay.
nuclear force	A powerful short-ranged attractive force that holds together the particles inside an atomic nucleus.
nucleon	Common name for a constituent particle of the atomic nucleus. At present, applied to protons and neutrons, but may include any other particles found to exist in the nucleus.

nucleus	The small, central, positively charged region of an atom that carries essentially all the mass. Except for the nucleus of ordinary (light) hydrogen, which has a single proton, all atomic nuclei contain both protons and neutrons. The number of protons determines the total positive charge, or atomic number; this is the same for all the atomic nuclei of a given chemical element. The total number of neutrons and protons is called the mass number.
nuclide	A general term referring to all known isotopes, both stable (279) and unstable (about 5000), of the chemical elements.

P

parent	A radionuclide that upon radioactive decay or disintegration yields a specific nuclide (the daughter).
personnel monitoring	The determination of the degree of radioactive contamination on individuals using survey meters, or the determination of radiation dosage received by means of dosimetry devices.
photodosimetry	The determination of the cumulative dose of ionizing radiation by use of photographic film.
photon	A quantum (or packet) of energy emitted in the form of electromagnetic radiation. Gamma rays and X-rays are examples of photons.
pocket dosimeter	A small ionization detection instrument that indicates radiation exposure directly. An auxiliary charging device is usually necessary.

positron	Particle equal in mass, but opposite in charge, to the electron: a positive electron.
proportional counter	An instrument in which an electronic detection system received pulses that are proportional to the number of ions formed in a gas-filled tube by ionizing radiation.
proton	An elementary nuclear particle with a positive electric charge located in the nucleus of an atom.

Q

quality factor	The factor by which the absorbed dose is to be multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiations, the biological damage to exposed persons. It is used because some types of radiation, such as alpha particles, are more biologically damaging than other types.
quantum theory	The concept that energy is radiated intermittently in units of definite magnitude called quanta, and absorbed in a like manner.

R

rad	Acronym for radiation absorbed dose. The basic unit of absorbed dose of radiation. A dose of one rad means the absorption of 100 ergs (a small but measurable amount of energy) per gram of absorbing material.
radiation, nuclear	Particles (alpha, beta, neutrons) or photons (gamma) emitted from the nucleus of an unstable (radioactive) atom as a result of radioactive decay.

radiation area	Any accessible area in which the level of radiation is such that a major portion of an individual's body could receive in any one hour a dose in excess of 5 millirem, or in any five consecutive days a dose in excess of 100 millirem.
radiation detection instrument	A device that detects and records the characteristics of ionizing radiation.
radiation shielding	Reduction of radiation by interposing a shield of absorbing material between any radioactive source and a persons work area or radiation sensitive device.
radiation sickness (syndrome)	The complex of symptoms characterizing the disease known as radiation injury, resulting from excessive exposure of the whole body (or large part) to ionizing radiation. The earliest of these symptoms are nausea, fatigue, vomiting, and diarrhea, which may be followed by loss of hair (epilation), hemorrhage, inflammation of the mouth and throat, and general loss of energy. In severe cases, where the radiation exposure has been relatively large, death may occur within two to four weeks. Those who survive 6 weeks after the receipt of a single large dose of radiation may generally be expected to recover.
radiation standards	Exposure standards, permissible concentrations, rules for safe handling, regulations for transportation, regulations for industrial control of radiation and control of radioactive material by legislative means.
radiation warning symbol	An officially prescribed symbol (a magenta trefoil) on a yellow background that must be displayed where certain quantities of radioactive materials are present or where certain doses of radiation could be received.

radioactive	Exhibiting radioactivity or pertaining to radioactivity.
radioactive contamination	Deposition of radioactive material in any place where it may harm persons or equipment.
radioactivity	The spontaneous emission of radiation, generally alpha or beta particles, often accompanied by gamma rays, from the nucleus of an unstable isotope.
radioisotope	An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. Approximately 5000 natural and artificial radioisotopes have been identified.
radiological survey	The evaluation of the radiation hazards accompanying the production, use, or existence of radioactive materials under a specific set of conditions. Such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment.
radiosensitivity	The relative susceptibility of cells, tissues, organs, organisms, or other substances to the injurious action of radiation.
rem	Acronym of roentgen equivalent man. The unit of dose of any ionizing radiation that produces the same biological effect as a unit of absorbed dose of ordinary X-rays.

restricted area	Any area to which access is controlled for the protection of individuals from exposure to radiation and radioactive materials.
roentgen (r)	A unit of exposure to ionizing radiation. It is that amount of gamma or X-rays required to produce ions carrying 1 electrostatic unit of electrical charge in 1 cubic centimeter of dry air under standard conditions. Named after Wilhelm Roentgen, German scientist who discovered X-rays in 1895.

S

scattered radiation	Radiation that, during its passage through a substance, has changed direction. It may also have been modified by a decrease in energy. It is one form of secondary radiation.
scintillation detector or counter	The combination of phosphor, photomultiplier tube, and associated electronic circuits for counting light emissions produced in the phosphor by ionizing radiation.
shielding	Any material or obstruction that absorbs radiation and thus tends to protect personnel or materials from the effects of ionizing radiation.
somatic effects of radiation	Effects of radiation limited to the exposed individual, as distinguished from genetic effects, which may also affect subsequent unexposed generations.
stable isotope	An isotope that does not undergo radioactive decay.

survey	A study to (1) find the radiation or contamination level of specific objects or locations within an area of interest; (2) locate regions of higher-than-average intensity; i.e., hot spots.
survey meter	Any portable radiation detection instrument, especially adapted for inspecting an area, to establish the existence and amount of radioactive material present.

T

tenth thickness	The thickness of a given material that will decrease the amount (or dose) of radiation to one-tenth of the amount incident upon it. Two-tenth thicknesses will reduce the dose received by a factor of 10 x 10; i.e., 100, and so on.
terrestrial radiation	The portion of natural radiation (background) that is emitted by naturally occurring radioactive materials in the earth.

U

ultraviolet	Electromagnetic radiation of a wavelength between the shortest visible violet and low-energy X-rays.
unrestricted area	The area outside the owner-controlled portion of a nuclear facility (usually the site boundary).

W

whole-body exposure — An exposure of the body to radiation, in which the entire body rather than an isolated part is irradiated. Where a radioisotope is uniformly distributed through the body tissues, rather than being concentrated in certain parts, the irradiation can be considered as a whole-body exposure.

wipe sample — A sample made for the purpose of determining the presence of removable radioactive contamination on a surface. It is done by wiping, with slight pressure, a piece of soft filter paper over a representative type of surface area. It is also know as a "swipe sample."

X

X-rays — Penetrating electromagnetic radiation (photon) having a wavelength that is much shorter than that of visible light. These rays are usually produced by excitation of the electron field around certain nuclei. In nuclear reactions, it is customary to refer to photons originating in the nucleus as gamma rays, and to those originating in the electron field of the atom as X-rays. These rays are sometimes called roentgen rays after their discoverer, W.K. Roentgen.

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Name:_____

Date:_____

QUIZ 1

30 Points

(1 pt.) 1. The structural difference between various nuclides of an element are due to different numbers of:

a) electrons

b) protons

c) neutrinos

d) neutrons

(1 pt.) 2. Beta minus decay results in:

a) decrease in atomic number and mass number of nucleus

b) decrease in atomic number

c) increase in atomic number

d) increase in atomic number and mass number

e) increase in atomic number and decrease in mass number

(1 pt.) 3. One millicurie equals:

a) 3.7 x 10 dps

b) 3.7 x 10 dps

c) 2.22 x 10 dps

d) 2.22 x 10 dpm

e) none of the above

(1 pt.) 4. The decay constant, λ , is equal to:

a) A/N

b) 0.693/T

c) 0.693/t

d) e^{-NT}

(1 pt.) 5. The activity of a radioactive sample is measured in which of the following units?

a) Roentgens

b) Curies

d) Rems

e) Rads

(2 pts.) 6. What is the difference between the two terms Roentgen and rem?

(4 pts.) 7. Briefly described the following: an alpha particle, a beta particle, and x-ray, and a gamma ray?

(1 pt.) 8. An exposure to 1 mR of gamma, 10 mRad of B particles, and 5 mRad of fast neutron radiations would give an individual a dose equivalent of:

a) 16 mRem

b) 16 uCi

c) 61 mRem

d) 61 mRads

(2 pts.) 9. K_{α} x-rays are produced when?

(4 pts.) 10. Complete the following

Given: $^{60}_{27}Co$

a) elemental name =

b) how is $^{60}_{27}Co$ produced?

c) Number of protons _____?
Number of neutrons_____?
Number of electrons_____?

d) complete the following decay scheme:

$^{60}_{27}Co \longrightarrow$

(1 pt.) 11. Why is there no beta exposure from an encapsulated ^{60}Co source?

(2 pts.) 12. A particular radioisotope sample with a half-life of 30 minutes is determined to have an activity of 10,000 dpm at noon.

a) What is the value of its decay constant ( )? (show units too)_____

b) how many dpm will it exhibit at 1:30 pm?_____

(4 pts.) 13. You count a radioactive sample. Your measurement system detects 120,000 counts per minute (cpm). You then count a known radioactive "standard" has been certified to be decaying at 2.22×10^6 disintegrations per minutes (dpm). What is the radioactivity in microcuries (uCi.) of your radioactive sample?

Given 1.0 curie = 3.7×10^{10} disintegrations per second (dps).
Measurement system efficiency =

$$\frac{\text{counts per unit time}}{\text{disintegrations per unit time}} = \frac{\text{cpm}}{\text{dpm}}$$

What is the radioactivity of your radioactive standard in uCi?

(1 pt.) 14. Which of the following is <u>not</u> an example of gamma ray interaction with matter?

a) bremsstrahlung

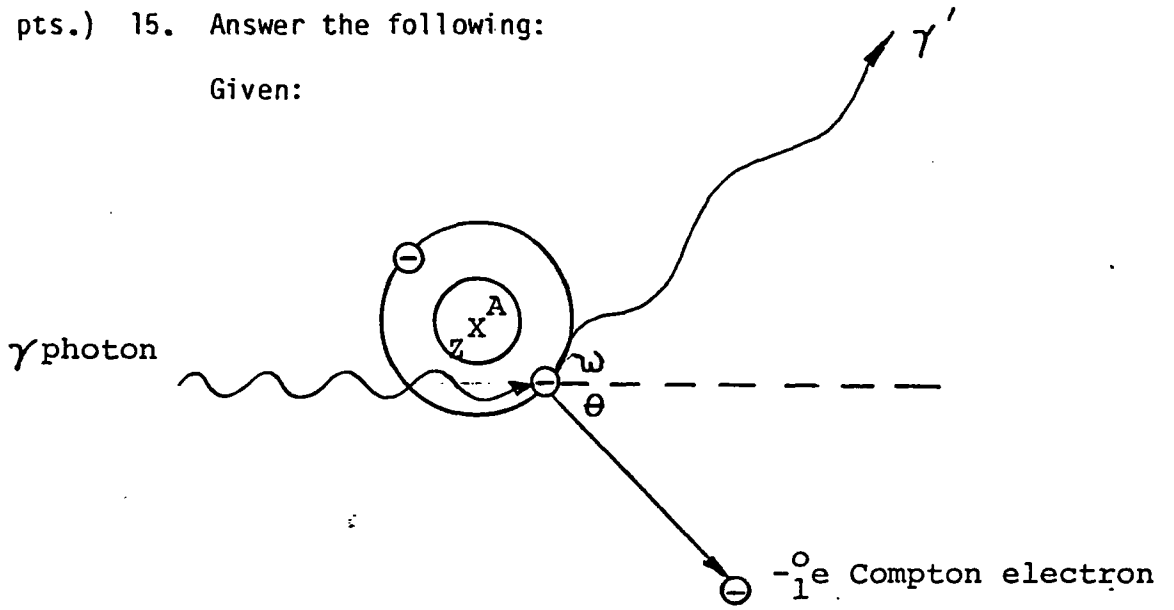
b) compton effect

c) photoelectric effect

d) pair production

(4 pts.) 15. Answer the following:

Given:



a) which photon interaction is illustrated above?

b) what is the energy (K.E.) of the compton electron?

c) what happens to the compton electron?

d) what happens to the scattered photon (γ')?

Name: _____

Date: _____

QUIZ 2

10 Points

(1 pt.) 1. What are the two categories of harmful effects resulting from radiation exposure? _____ and _____

(1 pt.) 2. The most radiosensitive state in the history of an organism is:

a) embryonic development

b) childhood

c) adolescence

d) adulthood

(1 pt.) 3. An acute dose of 1 Rem to the whole body may result in:

a) significant blood changes

b) nausea, vomiting

c) sterility

d) no observable effects

(1 pt.) 4. What is the LD-50/30 dose for most mammals including man?

a) 100 to 300 rads

b) 600 to 800 mrads

c) 600 to 800 rads

d) 100 to 300 mrads

(1 pt.) 5. The primary cause of death following an LD-50/30 in humans is directly associated with irreparable and irreversible damage to:

a) the nervous system

b) the heart, liver, and kidneys

c) the hematopoietic organs (blood tissue producing)

d) the skeletal bone

(1 pt.) 6. The primary indirect effect of ionizing radiation upon biological target is:

a) erythema response

b) free radical formation

c) leukegenic response

d) target absorption of the radiation

(4 pts.) 7. What is the primary basis for limiting occupational exposures to ionizing radiation?

Name: _____

Date: _____

QUIZ 3

10 Points

(.5 pt.) 1. How often must AMS's radiation survey instruments be calibrated?

(2 pts.) 2. Prior to using a survey meter to make radiation measurements, the following checks should be performed?

_____,

_____,

_____, and

_____.

(1 pt.) 3. A 0.0440 uCi standard yields 89,200 counts in two minutes. The counter Bkg is 200 cpm. What is the efficiency of the detector?

(.5 pt.) 4. Gamma (NaI) detectors are based upon what physical property?

a) radiolysis of an organic solvent

b) absorption of electromagnetic energy

c) emission of visible light

d) ionization of a gas

(2 pts.) 5. Explain the danger associated with tube "saturation" in GM survey instruments.

(1 pt.) 6. Under what conditions would you use the audible feature featured on some GM survey instruments?

(1 pt.) 7. Why is frisking for contamination only performed in low background areas?

(.5 pt.) 8. Ion chamber type instruments are best suited for:

a) radiation field intensity measurements

b) radioactive contamination monitoring

c) determination of radiation energy

d) identification of radioisotopes

(.5 pt.) 9. GM type instruments are best suited for:

a) radiation field intensity measurements

b) radioactive contamination monitoring

c) determination of radiation energy

d) identification of radioisotopes

(1 pt.) 10. What would you do should your pocket dosimeter read off-scale?

Name: _____

Date: _____

QUIZ 4

10 Points

(2 pts.) 1. A. What is the maximum permissible dose allowed in a calendar quarter to the whole body: head and trunk: active blood forming organs: lens of eye: or gonads?

B. In what document are the dose limits found?

(.5 pt.) 2. What is the maximum permissible whole body dose allowed in the calendar quarter for workers under 18 years of age?

(.5 pt.) 3. When are personal monitoring devices, e.g., film badges, TLD, required to be worn?

(.5 pt.) 4. What is a RESTRICTED AREA?

(2 pts.) 5. What are the maximum permissable radiation levels allowed in an unrestricted area?

What is the maximum recommended contamination levels allowed in unrestricted areas?

(4 pts.) 6. Given the following:

	S	M	T	W	T	F	S	S	M	T
mpc-hr	0	0	10	2	0	5	0	0	18	
exposure (mR)	0	0	50	10	0	10	0	0	50	

Work Area Radiation Exposure Levels 25 mR/hr
Work Area Airborne Radioactivity Levels 2×10^{-6} uC/ml

Based upon not exceed 100 mR per week and 40 mpc-hrs in any period of 7 consecutive days, what would be your stay-time in this work area?

(.5 pt.) 7. Why is the permissible dose to the hands and forearms: feet and ankles (extremities) more than the whole body permissible dose?

Name: _____

Date: _____

QUIZ 5

20 Points

(3 pts.) 1. What are the primary methods of radiation protection?

a) _____

b) _____

c) _____

(1 pt.) 2. To protect oneself when handling radiation sources, one should:

a) keep your distance from the sources

b) keep the sources or yourself shielded

c) work quickly

d) limit the amount of radioactivity stored

e) all of the above

(1 pt.) 3. Who is allowed to perform leak test samples on AMS' teletherapy sources at customer facilities?

(1 pt.) 4. What is the acceptable contamination limit on ^{60}Co teletherapy sources?

(1 pt.) 5. Which is more penetrating, the ^{60}Co gammas or the ^{137}Cs gammas?

(1 pt.) 6. What items must be performed prior to offering a shipment of radioactive material for transport?

(1 pt.) 7. What radiation measurement is used for the Transport Index (TI) on Radioactive Yellow II or Yellow III.

(5 pts.) 8. During a source transfer procedure at a client's facility a 5000 ^{60}Co curie source falls to the floor. Describe your actions.

(2 pts.) 9. What is the dose rate at 3 meters from an unshielded 5000 curie ^{60}Co source?

(4 pts.) 10. If you are standing 3 meters from a unshielded 5000 ^{60}Co source, how long would it take you to receive 100 mR?

How much lead (in inches) would be needed to reduce the exposure rate at 3 meters such that your stay-time at 3 meters is 15 mins (total exposure = 100 mR)?

SUPPLEMENTAL RADIATION TRAINING

During the course of job specific and on-the-job training, candidates will receive an additional 16 hours (approximate) of training. Topics to be covered are outlined below. This training will be given in several time increments.

A. Radiation Protection Standards
(Reference 10CFR 19, 20, 35)

Definition of Radiation Terms

Units of Radioactivity

Exposure limits

Posting Requirements - signs, radiation levels

Licensing - NRC, Agreement States, customer

License Types - general, broad scope, specific, by-product, and source material, license conditions

B. Radiation Protection Methods
(Reference AMS Safety Manual)

Inverse Square Law - practical examples and calculations

Stay time calculations

Shielding materials

Half value layers

Survey meter care, reading, selection of proper meter for job

Expected dose rates in service situations

Review of basic math-problem solving

C. Service Procedures - Radiation Protection

Cobalt Service Procedure Manual

Therapy Room Surveys

Personnel dosimetry and instrumentation - pocket dosimeters, chirpers, meters

Emergency procedures and notification

Forms and documentation - service ticket, therapy service record, unauthorized field modification, customer evaluation, etc.

Unit checkout procedures

Service manuals - operator, maintenance, installation

D. Packaging & Transportation of Radioactive Material (Reference 10CFR71, 49CFR172-177)

Types of Packaging and regulatory requirements

Packaging typically used in AMS operations

Packing/unpacking instructions

Shipping paper requirements

Marking and labeling - proper selection and interpretation

Transport index determination

Certificates required or issued (NRC & DOT)

QA procedures

DOT motor carrier regulations

Emergency procedures

State permits

E. Written Examination

Advanced Medical Systems, Inc.

SAFETY MANUAL

INTRODUCTION TO RADIATION THEORY

AND

BASIC PRINCIPLES OF RADIATION SAFETY

Revised: September, 1986

Table of Contents

INTRODUCTION

To safely service a Cobalt therapy unit, personnel must have a working knowledge of basic nuclear radiation and be well versed in the practice of radiation safety. In addition, the service engineer must be trained and experienced in the specific service techniques and emergency procedures applicable to Cobalt units.

For, unlike radiation from an X-ray tube, which is turned on or off by electronic control, the Cobalt source continuously emits high energy radiation. Radiation exposure is accomplished by mechanically moving the source to an aperture in the head shield. Constructed of lead and depleted Uranium, the shield provides both radiation protection and collimation.

Redundant safety features and heavy shielding provide a high level of safety for personnel working with the therapy unit. However, as with any machine which produces radiation, the hazard of accidental exposure always exists. Therefore, only qualified service engineers should attempt major repairs to the equipment.

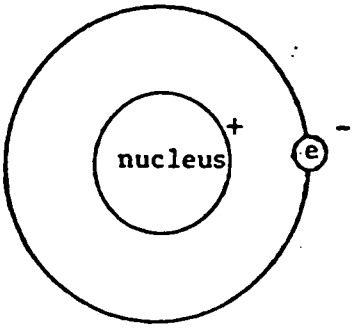
The U.S. Nuclear Regulatory Commission is responsible for the public safety concerning radiation from nuclear reactor by-product material. Advanced Medical Systems, Inc. divides Cobalt therapy service into two types: operations which must be licensed and non-licensable service work. Licensed operations include work involving the source or parts of the unit which could result in increased exposure to the source. This includes work on the source shutter or other mechanisms which could expose the source, reduce shielding around the source, or compromise the safety of the unit and result in increased exposure levels. All other work is considered non-licensable.

This section of the training manual reviews the fundamental concepts of nuclear radiation, with particular emphasis on Cobalt, so that the service engineer may fulfill the knowledge and formal training requirements for licensed service.

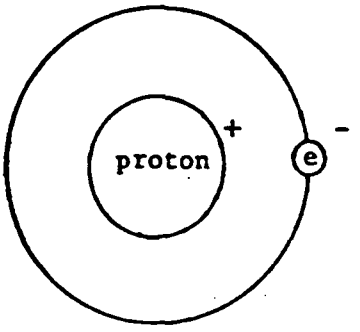
ISOTOPES, RADIOISOTOPES AND RADIOACTIVITY

ISOTOPES are atoms which have the same number of protons, but different numbers of neutrons in the nucleus. All of the chemical elements are isotopic, that is, each element occurs as a series of isotopes which exist naturally or are man made. Isotopes may be readily understood by considering the hydrogen atom.

You will recall that an atom consists of a compact nucleus and one or more electrons.



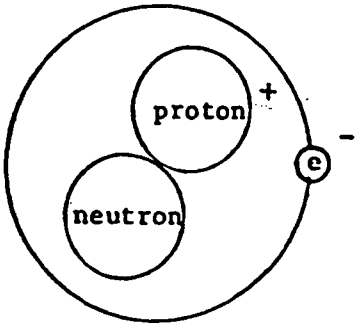
ATOM



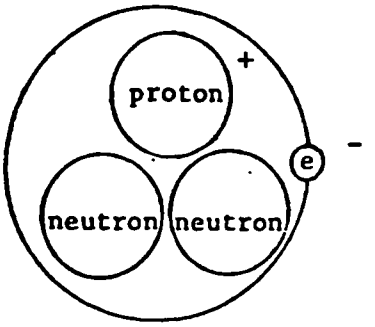
HYDROGEN ATOM (H)

The nucleus of a hydrogen atom consists of a proton which carries one unit of positive charge. A single electron, with one unit of negative charge, is somewhere in space near the nucleus. The electron is no longer thought to be orbiting about the proton, but is said to inhabit certain energy levels associated with the nucleus. The atom is electrically neutral due to the balance of the positive and negative charge.

The element hydrogen actually occurs as three isotopes called hydrogen, deuterium and tritium. Each of these isotopes has one proton but different numbers of neutrons in the nucleus. Hydrogen has no neutron, deuterium has one neutron and tritium has two neutrons. In each case there is one electron to balance the charge of the proton. The neutron has no charge, but is about equal in mass to the proton.



DEUTERIUM (D)



TRITIUM (T)

The identical chemical properties of these three isotopes are determined by the single electron which determines how these isotopes combine with other elements. The different physical characteristics of the three isotopes (mass and nuclear stability) depend upon the number of neutrons in the nucleus.

For example, each of these isotopes combine with oxygen to make water,

$$H_2O \qquad D_2O \qquad T_2O$$

but because of the neutron in the deuterium nucleus, deuterium water is 11% heavier than water. For this reason deuterium is commonly called heavy water. Deuterium occurs naturally and is a stable isotope, while tritium is a reaction by-product which is unstable or RADIOACTIVE. The instability of the tritium is characterized by the emission of radiation. Therefore, tritium is a RADIO-ISOTOPE. Tritium is made by bombarding the isotope lithium 6 with neutrons and collecting the tritium gas.

Each element in nature is assigned an atomic number equal to the number of nuclear protons, and a mass number equal to the sum of the protons and neutrons. This is the basis for the commonly used notation of a subscript for the atomic number and a superscript for the mass number. Accordingly, the hydrogen isotopes are symbolized:

$$^{1}_{1}H, \quad ^{2}_{1}H, \quad ^{3}_{1}H$$

Other examples are: Carbon; $^{12}_{6}C, \quad ^{13}_{6}C, \quad ^{14}_{6}C$

Oxygen; $^{16}_{8}O, \quad ^{17}_{8}O, \quad ^{18}_{8}O$

Uranium; $^{234}_{92}U, \quad ^{235}_{92}U, \quad ^{238}_{92}U$

NUCLEAR REACTION

Isotopes which do not occur naturally may be artifically produced by adding neutrons to a nucleus during an intense neutron irradiation. When cobalt is irradiated by neutrons and a neutron is captured by a cobalt nucleus, the product isotope is unstable. This interaction between a cobalt nucleus and a neutron is called a nuclear reaction.

STABLE COBALT ISOTOPE + NEUTRON = RADIOISOTOPE

Using appropriate notation, this nuclear reaction can be put into an equation:

$$^{59}_{27}Co + ^{1}_{0}n = ^{60}_{27}Co$$

This describes how cobalt 60 is made in a nuclear reactor, although the reaction is usually written as Co^{59} (n,γ) Co^{60}.

When an unstable isotope emits radiation, it is transformed to a new state, which is sometimes, but not always stable. In the stable state there is no additional emission of radiation. Each transformation to this state is called a DISINTEGRATION. The number of disintegration per second is a measure of the radio - activity of a source.

CURIE

The unit of radioactivity is called a curie and is abbreviated Ci. A radioactive source has one curie of activity if it is disintegrating at a rate of: 3.7×10^{10} (37 billion) disintegrations per second. The average rate of dis - integration for a given source can be measured with a radiation detector and an electronic counting system.

In a typical cobalt therapy unit containing a 5000 curie source, the source is disintegrating at a rate of $(5 \times 10^{3}) \times (3.7 \times 10^{10}) = 1.85 \times 10^{14}$ disintegrations per second. It is seen that kilocurie sources emit a large amount of radiation and special precautions must be taken to ensure safety when servicing a ther - apy unit. Each disintegration of a cobalt 60 nucleus results in a transformation to an isotope of nickel. The nickel isotope is actually formed in an excited state. Emission of additional radiation leaves the nickel in a stable state.

Although it is correct to refer to the therapy isotope as cobalt 60, it is actually the radiation from the excited nickel nucleus that is used for therapy.

The actual reaction is: $_{27}Co^{60} - _{-1}e^{0} = _{28}Ni^{60*} + \gamma = _{28}Ni^{60}$

RADIOISOTOPE - RADIATION = STABLE NICKEL ISOTOPE

The radiation and its notation will be defined in a later section.

Some radioisotopes, rather than decaying into a stable element, disintegrate into another radioactive element. Radium and uranium are of this type. They disintegrate into a chain of unstable daughter products which eventually end in a stable isotope of lead.

$$_{88}Ra^{226} - {}_{2}He^{4} = {}_{86}Rn^{222} - {}_{2}He^{4} = {}_{84}Po^{208} - {}_{2}He^{4}, \text{ etc, } \rightarrow {}_{82}Pb^{206}$$

$$_{92}U^{235} - {}_{2}He^{4} = {}_{90}Th^{231} - {}_{2}He^{4} = {}_{88}Ra^{227} - {}_{2}He^{4}, \text{ etc, } \rightarrow {}_{82}Pb^{207}$$

SPECIFIC ACTIVITY

Specific activity is the number of curies per gram of material. This is an important characteristic of source materials which must be considered in cobalt teletherapy unit design. There are two reasons for this; the maximum number of curies which can be encapsulated in a given container is limited by the size of the container and the specific activity, and because of self absorption of the radiation in the source material, it is desirable to minimize the amount of material and use material of high specific activity. In this way, the maximum efficiency of the source, in terms of radiation output vs. amount of contained material is obtained.

There is a limit to the specific activity which can be attained because the material will always consist of both radioactive atoms and stable atoms. These exist, either because of incomplete activation, or because of the trans - formed atoms which are present as decay products. There may also be impur - ities in the material. AMS therapy sources use material in the range of 7 to 350 curies per gram. Due to the expense of purification, separation and long term irridiation, it is to be expected that the relative cost of radioisotopes is a function of the specific activity, the availability of material and the de - mand.

HALF LIFE

Half life is the time required for one - half of the original atoms in a source to decay. The notation for half life is $T 1/2$. The decay or disintegration rate and therefore the half life is different for each radio isotope and follows an exponential law. This means that in one half life the source strength is reduced to 1/2 and in two half lives the source strength is reduced to 1/4, in 3 half lives to 1/8, etc.

The half life of Co^{60} is 5.3 years. If a therapist has a 5000 Ci cobalt source, in 5.3 years the radiation from the source will have decayed to one half the original intensity and the source will be down to 2500 curies. This is the reason for source exchange. The decayed source can be returned and reused, (both the activity and specific activity are now different than originally) or the material can be mixed with other radio cobalt to adjust the specific activity of a source. Over a period of 10 half lives a source will have decayed to 0.1% of its original value. See figure 1.

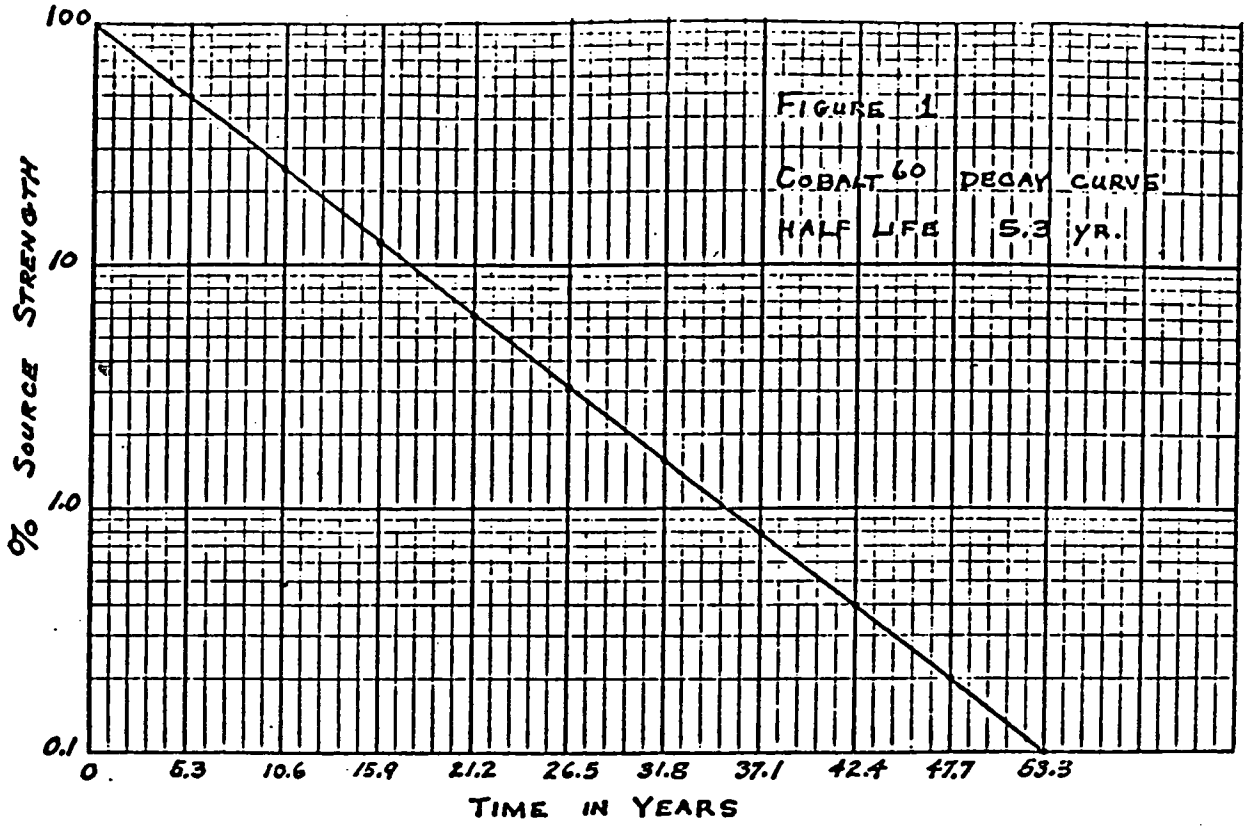


FIGURE 1
COBALT 60 DECAY CURVE
HALF LIFE 5.3 YR.

Half lives of isotopes vary from billions of years to fractions of microseconds. Typical values are:

Uranium	238	4.5 billion years
Uranium	235	707 million years
Plutonium	239	34000 years
Carbon	14	5700 years
Radium	226	1620 years
Cesium	137	27 years
Cobalt	60	5.3 years
Cobalt	60m	10.7 minutes
Iodine	128	25 minutes
Carbon	15	2.3 seconds

In the above list, the letter m indicates that the isotope is an isomer. This means that Co^{60} and Co^{60m} are identical except that they are formed at different energy levels and decay with different half lives. It is seen that the Co isomer with the shorter half life decays to a negligible value by the time the source is used for therapy and is therefore of no consequence.

ALPHA, BETA AND GAMMA RADIATION

The three basic kinds of radiation emitted by radioactive isotopes are tabulated below:

RADIATION	SYMBOL	DESCRIPTION	ENERGY RANGE	TYPICAL SOURCE		PENETRATION
ALPHA	$\alpha\ {}_2He^4$	Helium nucleus	3 - 10 Mev	Uranium Radium - Uranium	235 226 238	Stopped by a few mils of paper or paint.
BETA	$\beta\ {}_{-1}e^0$	Nuclear Electron	.1 - 1 Mev	Uranium Strontium Cesium Cobalt	238 90 137 60	Stopped by a few mils of aluminum or plastic.
GAMMA	γ	Electro - Magnetic Wave	.105 - 2 Mev	Cesium Cobalt	137 60	Stopped by concrete steel or lead

Alpha radiation is characteristic of the heavier elements such as uranium or plutonium. Alpha particles are emitted from the nucleus and have the mass of a helium nucleus. They are mono - energetic -- that is, they are emitted at discrete energy levels. Due to its heavy mass, an alpha particle has low penetrating power and is easily stopped.

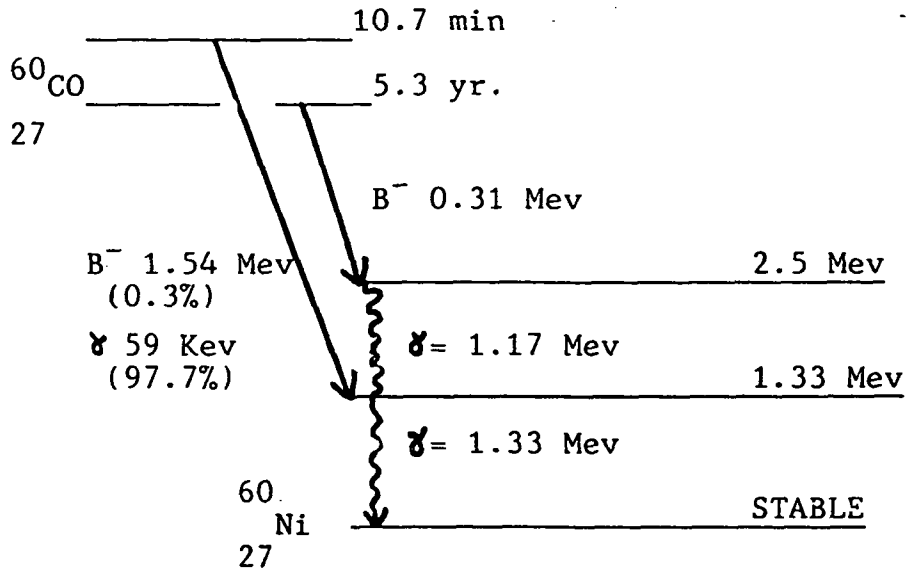
Beta radiation is characteristic of many of the radio - isotopes and consists of high energy electrons which are emitted from the nucleus. Beta radiation is not mono - energetic, but is emitted in a continuum from 0 to the maximum energy available. If a particular isotope emits 1 Mev betas, then the average beta energy is about .4 Mev. Beta rays are more penetrating than alpha particles, but they are readily stopped by a moderate amount of shielding. However, as would be expected, as the betas stop in the shielding, x -rays are produced.

Gamma radiation usually accompanies beta radiation. The gamma rays are electromagnetic waves similar to x - rays, except that gamma rays are emitted from the nucleus, while x - rays originate in the electron shells near the nucleus. Also, gamma rays are always monoenergetic, although several gammas at discrete energy levels are usually emitted. This is opposed to x - ray emission, where due to the physics of x - ray production, the characteristic K radiation appears in a spectrum of x - rays with energies from 0 to the maximum potential (kVp) across the tube.

COBALT RADIATION

Cobalt 60 emits beta radiation with an average energy of 0.3 Mev. The betas are absorbed in the source material and capsule. The betas are accompanied by a gamma cascade with energies of 1.17 and 1.33 Mev. The gamma photons are actually emitted during the de-excitation of the nickel 60 daughter product.

The decay scheme for Cobalt 60 is as follows:



Since the average energy of the photons is 1.25 Mev, they are slightly more penetrating than the radiation from a 2 Mev X-ray generator, and can destroy tissue deep inside the body. The advantage of a Cobalt therapy unit is that it requires only a small room rather than the 3 story building necessary to house a 2 Mev X-ray machine.

The service engineer should note that the energy of Cobalt gammas is 10 times higher than the average X-rays from a 250 kVp Vanguard therapy unit and 25 times more energetic than the average X-rays from a 100 kVp RF generator.

The wave length of a gamma ray at a given energy may be calculated by the formula:

$$\text{Wavelength in Angstroms} = \frac{12.398}{\text{Energy (Kev)}}$$

Comparative wavelengths for light, X-ray and Cobalt gamma radiation are:

Energy	Wavelength
3.1 ev light (violet)	4500 Angstroms
75 Kev X-ray	0.165 Angstroms
1.25 Mev X-ray	0.01 Angstroms

An Angstrom is a unit of length equal to 10^{-8} centimeters.

The beta and gamma radiation emitted from a Cobalt source cannot produce radioactivity in surrounding materials. The betas are absorbed in the source stainless steel and cause a small temperature rise in the container. The gammas can scatter electrons in surrounding air and shielding, but the electrons and gammas are subsequently absorbed. A few photo-disintegration reactions are known; however, the energy thresholds for these reactions are above 1.6 Mev and are only weakly efficient in neutron production.

ELECTRON VOLT

The energy unit for nuclear radiation is the electron volt (ev). An electron volt is the kinetic energy an electron acquires when accelerated through a potential difference of one volt. For example, if 100 kVp is applied to an x - ray tube, the electrons from the cathode arrive at the anode with an energy of 100,000 ev (100kev or 0.1 Mev). High energy is expressed in million electron volts or Mev.

IONIZATION, SCATTER AND ABSORPTION

The radiation field strength must be considered when working in a radiation field, or setting up temporary shielding. One property of gamma rays is that they can disrupt molecules of gas or matter and produce positively and nega - tively charged particles called ions. This ionizing property is used as basis for measuring the amount of radiation. It is also the mechanism for tissue destruction.

The unit of radiation, the ROENTGEN or R, is defined as the quantity of X - or γ radiation which will produce 1.6×10^{12} ion pairs in one gram of dry air at $0^{o}C$, 760mm Hg. Another convenient unit is the mR or milliroentgen which is 1/1000 of an R. In terms of energy released, one roentgen releases 87.7 ergs of energy in one gram of air.

The roentgen unit is not a function of the origin or type of radiation and does not consider the radiation energy. There is, therefore, no direct relationship between curies of different isotopic sources and the roentgen. There is how - ever, a separate relationship for each kind of radioactive material in terms of roentgens per hour at one meter (RHM).

Cesium	0.33 RHM per curie
Radium	1.0 RHM per curie
Cobalt	1.35 RHM per curie

These factors do not include absorption of the radiation by the source material or container and assume point source geometry.

The rep (roentgen equivalent physical) is another unit of radiation. One rep will produce the same number of ion pairs in one gram of standard air as does 1 roentgen. The radiation may be any type, ie., neutrons, Betas, mesons, etc. Obviously, one Roentgen equals one rep for X or rays. One rep of X or γ rays releases 97.7 ergs in one gram of tissue.

There are two units dealing with absorbed dose which are useful:

rad = 100 ergs per gram of tissue (any radiation)

rem = RADS x RBE (relative biological effectiveness)

The rem (roentgen equivalent man) is the quantity of radiation of any type which produces the same effect on a biological object as does one R of X- or γ radiation. RBE is 1 for X or γ rays and is a variable factor for other ra - diation, eg., for neutrons it varies as a function of energy from 2 to 10.5.

It is seen that for gammas or X - rays the Rem and Rad are the same.

TIME, DISTANCE AND SHIELDING

Having reviewed the basics of radiation theory which are important to radiation safety. there are three major factors which must be considered in order to safely service a cobalt unit. Shielding will be considered first.

SHIELDING

Gamma radiation is exponentially attenuated by matter. In the same manner that we have a half life for exponential decay, there is a half - value layer (hvL) for the thickness of material required to absorb half of the previous ra - diation intensity.

While the service engineer will not be able to erect temporary shielding around a therapy unit, the half value layers for common shielding materials are tab - ulated below. A comparison for X - rays is also given.

HALF VALUE LAYERS

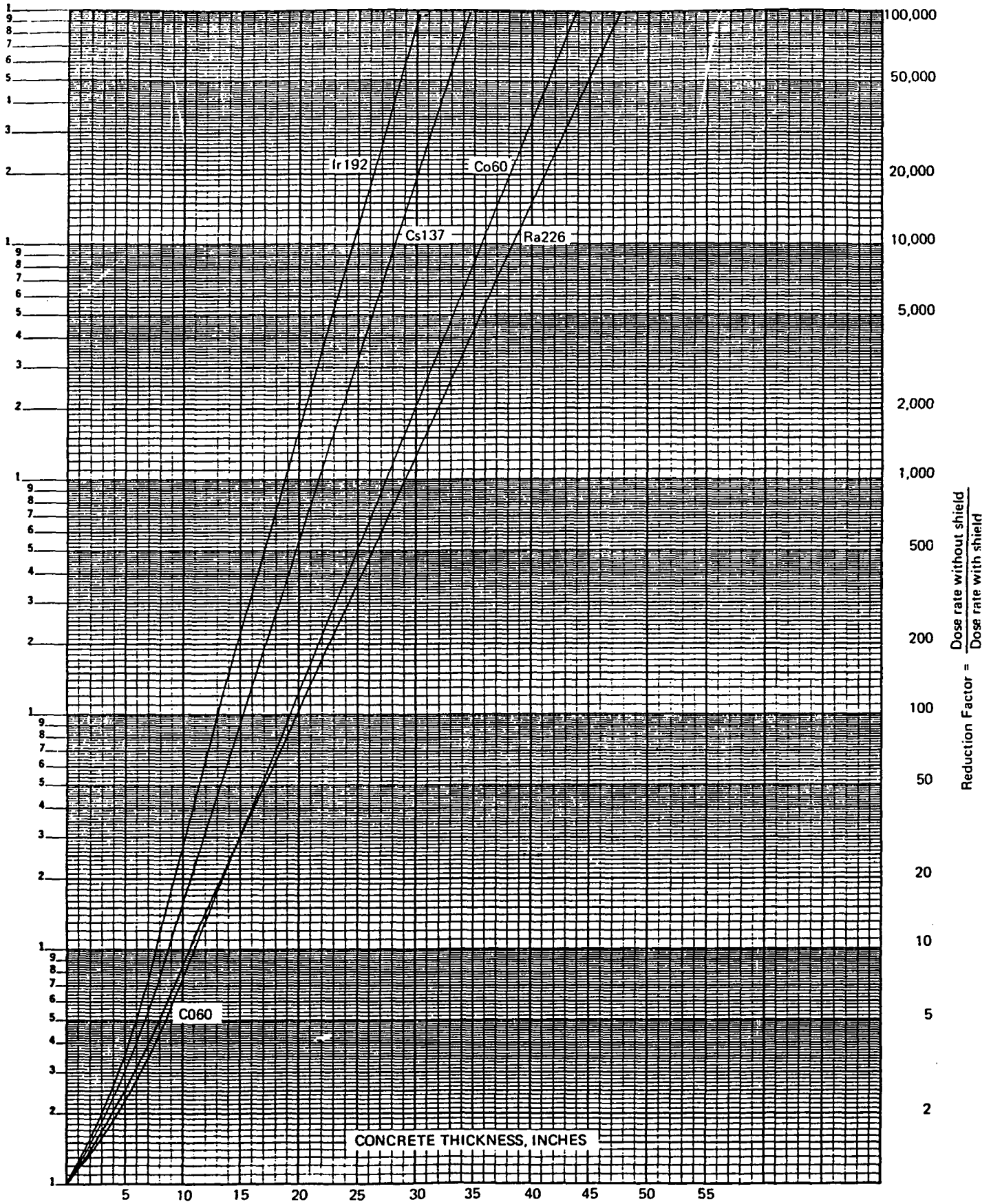
Shield Material	Co - 60 HVL (Inches)	2Mev X-ray HVL (Inches)	100kVp X - ray HVL (Inches)
Concrete	2.7	2.5	0.7
Lead	0.49	0.47	0.09
Uranium	0.26	-	-

The above data includes the effects of scattering and may be used in practical shielding problems. However, it is more convenient to use a graph of reduction factor vs. shielding thickness when calculating a shielding requirement. (see pages 13 & 14).

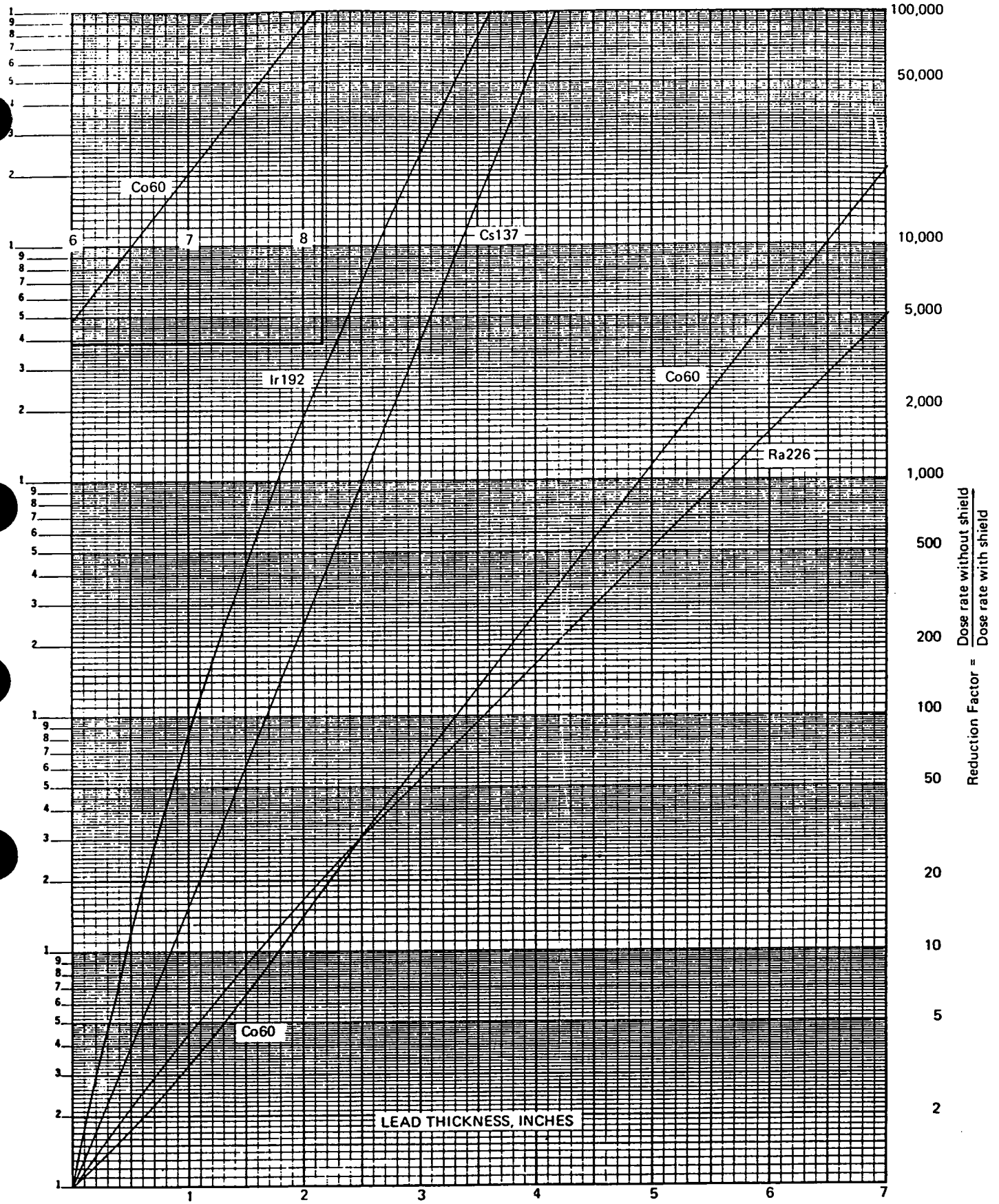
Reduction factor is defined as the dose rate without the shield divided by the dose rate with the shield. Dose being the amount of absorbed radiation (R) and dose rate being the amount of absorbed radiation per unit time (R/hr).

As an example, assume that a service engineer has a lead apron which can be draped over the cobalt head. The apron is equivalent to 0.5 mm of lead, but the radiation dose rate is 100 mR/hr at the head surface. How much will the apron attenuate the radiation?

One half millimeter equals 0.02 inches. By checking the graph, it is seen that for cobalt, .02 inches of lead gives a reduction factor of only slightly more than one, therefore a typical x - ray apron affords no protection from co - balt gamma radiation. Indeed, a reduction factor of 2 requires about 5/8 inch of lead.



Broadbeam shielding for absorption of Ir192, Cs137, Co60 and Ra226 gamma rays in concrete.
(Basic data from NBS 93, Appx. D, Fig. 3)



Broadbeam shielding for absorption of Ir192, Cs137, Co60 and Ra226 gamma rays in lead.
(Basic data from NBS 93, Appx. D, Fig. 5)

One may use this graph to determine the approximate radiation levels external to the walls of a therapy facility. Assume the concrete walls are thirty - six inches thick. Checking the graph, one finds the reduction factor is about 12000.

Therefore, if the radiation intensity is 1000 mR/hr inside the room when the shutter is open, the levels outside will be:

$$\frac{1000}{12000}\ \text{mR/hr} = .08\ \text{mR/hr}$$

This level, of about 0.1 mR/hr, would be considered a safe working area, since in 2 hours, a person would accumulate a .2 mR radiation dose. This is a factor of 10 less than the maximum 2 mR dose an individual may receive in an un - restricted area in 1 hour.

TIME

During emergency procedures, the licensed service engineer may be required to enter a HIGH RADIATION AREA. This area is defined as one in which the major portion of an individual's body could receive in any one hour, a dose in excess of 100 millirem. In lieu of shielding, one may effectively reduce the dose by rotating the head, staying out of the direct beam, and closing the collimator, but time spent in the area is most important. The total accumu - lated dose is equal to the time spent in the radiation field multiplied by the radiation dose rate.

The time can be minimized by knowing exactly what to do before entering the high radiation area and promptly executing the emergency procedure which has been practiced beforehand.

If one must enter a 1000 mR/hr field (as measured by the survey meter) and the time required to complete the procedure is 2 minutes or 1/30 of an hour, the integrated dose will be limited to:

$$1000\ \frac{\text{mR}}{\text{hr}} \times \frac{1}{30}\ \text{hr} = 33\ \text{mR}$$

If six minutes were spent working in the radiation field, the dose would be $1000\ \frac{\text{mR}}{\text{hr}} \times \frac{1}{10}\ \text{hr} = 100\ \text{mR}$. This is the recommended maximum for a 40 hr work week.

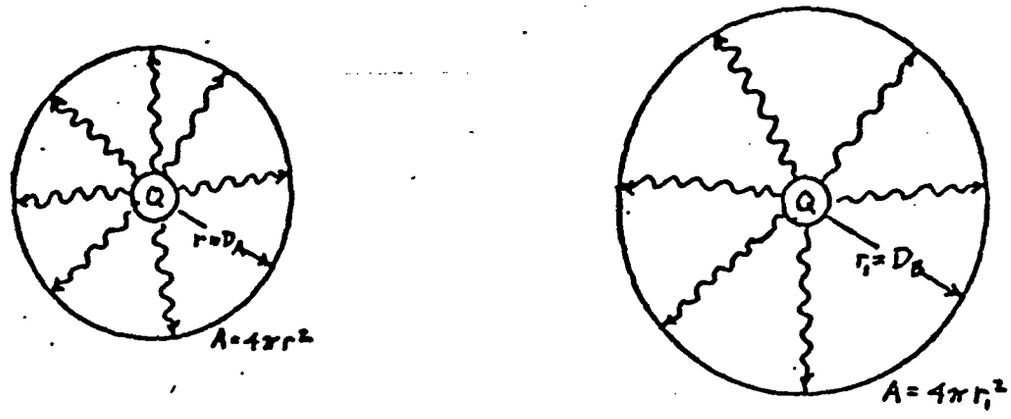
DISTANCE AND THE INVERSE SQUARE LAW

A radioactive source is like a small light bulb, which instead of emitting light in all directions, emits gamma rays in all directions. We know that as we get farther from the bulb the light appears weaker. In a similar fashion, the radiation intensity is a function of the distance from a source. The mathema - tical expression for this relationship is the INVERSE SQUARE LAW: Intensity varies inversely as the square of the distance.

The law may be easily derived. Consider a point source with total emission of Q gammas per second. Envision a spherical surface around the source with radius D_A.

The intensity, I_A in gammas per second per unit area at a distance D_A is equal to the total source strength divided by the area of the spherical surface ($A = 4\pi r^2$), where $r = D_A$.

$$I = \frac{Q}{\text{Area}}, \quad I_A = \frac{Q}{4\pi(D_A)^2}, \quad Q = 4\pi(D_A)^2 I_A$$



The intensity at a greater distance D_B is:

$$I_B = \frac{Q}{\text{Area}} = \frac{Q}{4\pi(D_B)^2}, \quad Q = 4\pi(D_B)^2 I_B$$

The source strength is constant, therefore equating the two equations for Q:

$$Q = Q$$

$$4\pi(D_A)^2 I_A = 4\pi(D_B)^2 I_B$$

The 4π's cancel out giving:

$$I_A(D_A)^2 = I_B(D_B)^2$$

Or in the more familiar form:

$$\frac{I_A}{I_B} = \frac{(D_B)^2}{(D_A)^2}$$

This formula allows one to calculate the approximate radiation dose at any distance from a source.

In reality, a therapy head does not contain a point source and the scattering of the direct beam from the barrier and room causes the calculation to be in error.

However, the inverse square law is an important concept in radiation protection, and it should be remembered that as one doubles the distance to the source, the radiation dose rate decreases by a factor of four.

An unshielded point source of Co^{60}, mounted high above and away from heavy scattering material, gives the following dose rates per curie:

Dose Rate in R/hr	1 Meter (39.7 inches)	1 ft.	2	4	8	10
	1.35	14.5	3.6	0.9	0.23	0.145

These are theoretical values which can be used as a rule of thumb or for pro - blem calculations.

NOTE

AMS therapy sources are rated in RHM or Roentgens per hour at a meter. This is a convenient rating which accounts for head and source geometry and provides the user with the actual dose rate for each therapy unit. The nominal rating for an AMS source is 1.1 RHM per curie.

Therefore, if a head is rated at 5000 RHM, it will contain approximately:

$$\frac{5000 \text{ RHM}}{1.1 \text{ RHM/Ci}} = 4545 \text{ Curies of } Co^{60}$$

If the theoretical value of 1.35 RHM per Ci were used, less cobalt would have been needed to give the same dose rate:

$$\frac{5000 \text{ RHM}}{1.35 \text{ RHM/Ci}} = 3703 \text{ Curies}$$

The difference between the two values or 842 curies is needed to make up for source self - absorption, geometry and collimation.

Inverse Square Law problems.

1. A source for a C9 head contains 5000 curies of Co^{60}. What is the exposure rate at 5 feet, 1 foot and 1 inch from the source?

   The dose rate is 14.5 R/Hr per curie at 1 foot, therefore;

   5000 Ci at 1 foot gives: $14.5 (5 \times 10^3) = 7.25 \times 10^4$ R/Hr.

   Using the inverse square law, the dose rate at 5 feet can be calculated:

   $$\frac{I_A}{I_B} = \frac{(D_B)2}{(D_A)^2}$$

   Where I_A = dose rate at 1 ft.
   D_A = 1 foot
   D_B = 5 feet

   $$\frac{7.25 \times 10^4}{I_B} = \frac{5^2}{1^2}$$

   $$I_B = \frac{7.25 \times 10^4}{25} = 2.9 \times 10^3 \text{ R/Hr}$$

The dose rate at one inch is:

$$\frac{I_A}{I_B} = \frac{(D_B)^2}{(D_A)^2}$$

$$\frac{7.25 \times 10^4}{I_B} = \frac{(1/12)^2}{1^2}$$

$$I_B = 144\ (7.25 \times 10^4)$$

$$I_B = 1.04 \times 10^7 \text{ R/Hr}$$

The dose is seen to be extremely high at the surface of the source.

Anyone who was so foolish as to pick up the bare source with his fingers could receive a mega rad dose to his fingertips!

2. The radiation level from an unshielded 4000 RHM source is 100 mR/Hr. What is the distance?

$$\frac{(D_B)^2}{(D_A)^2} = \frac{I_A}{I_B}, \quad (D_B)^2 = \frac{(D_A)^2 I_A}{I_B} \qquad 100 \text{ mR/Hr} = 0.1 \text{ R/Hr}$$

$$(D_B)^2 = \frac{(1)^2(4000)}{.1} = 40000$$

$$D_B = 200 \text{ meters}$$

3. At a distance of 4 meters from a C9 with the collimator full open, the direct beam is remotely measured with an ion chamber and found to be 200 R/Hr. What is the source strength in curies? Use 1.1 RHM per curie and ignore scattering.

$$\frac{I_A}{I_B} = \frac{(D_B)^2}{(D_A)^2} \qquad I_A = I_B \frac{(D_B)^2}{(D_A)^2}$$

$$I_A = \frac{200\ (4)^2}{(1)^2} \qquad I_A = 3200 \text{ RHM}$$

$$\frac{3200 \text{ RHM}}{1.1 \text{ RHM/curie}} = 2910 \text{ curies}$$

4. Before removing a collimator on a therapy unit, a service engineer measures the radiation levels to check for contamination. The shutter is closed and the isotope operation advises that the normal radiation level at the collimator throat (3 inches from the source) is 1 R/Hr. Approximately what radiation level should be expected at the collimator mouth? Assume the throat to mouth distance is 2 feet.

$$\frac{I_B}{I_A} \quad \frac{(D_A)^2}{(D_B)^2} \qquad\qquad I_B = I_A \frac{(D_A)^2}{(D_B)^2}$$

$$I_B = 1 \frac{(3)^2}{(24)^2} = \frac{9}{576} = .016 \text{ R/Hr} .$$

The survey meter should read approximately 16 mR/Hr.

It must be emphasized that inverse square law calculations only approximate the radiation levels which will be found in the field. Calculations will give the minimum radiation levels to be expected. Scattering within the therapy room will raise the radiation levels considerably, therefore, a calibrated survey meter must be used to measure the actual working conditions which may be encountered.

MEASUREMENT OF X AND GAMMA RADIATION

When X or Gamma rays interact with matter, a large share of the energy absorbed eventually is dissipated in the form of ionization. This is true especially in gases with energy levels of radiation below 5 Mev. Because of the practicability of the method, air ionization was accepted as a means of measuring the X - ray or Gamma ray dose particularly since air may be considered as an approximate tissue equivalent material.

POCKET DOSIMETERS

Pocket dosimeters are about the size and shape of fountain pens. They have a small collecting volume of air or similar gas, a quartz fiber electrometer and a calibrated lens - reticule system for viewing the quartz fiber. Exposure to radiation changes the relative position of the fiber to the calibrated reticule and the accumulative dosage can be read directly. The range most commonly used for personnel dosimetry is 0 - 200 mR. The dosimeter is charged or rezeroed with a separate charger.

Since any leakage of charge will produce a reading, the resistance of the insulation must be extremely high. The collecting electrode and insulation are protected from atmospheric conditions by a sealed diaphragm containing an external electrode. The diaphragm is collapsed on charging so that the electrodes make contact. This may be a source of erratic readings in a new dosimeter since the outer electrode retains some of the charge which influences the inner system as the external charge bleeds away very slowly. In used units, because of the accumulation of small amounts of dust and dirt on the diaphragm, the external charge bleeds away rapidly and the instrument becomes stable. With new dosimeters, the effect can be simulated by grounding the outer electrode by touching it with the end of something like a paper clip held in the fingers. The initial reading may be disturbed to the extent of 2 or 3 mR in the 200 mR range unit, but increased stability will result. State of the art dosimeter chargers automatically remove the residual charge on the outer electrode as the dosimeter is withdrawn from the charger.

POCKET CHAMBER

The pocket chamber is a device exactly like the dosimeter except the reading unit is mounted in the charger. Here, all advantage of instantaneous reading is lost since the instrument must be brought to the charger to be read. Furthermore, the charge is destroyed upon reading so that the chamber must be recharged again before reuse. However, because the reading unit is not integrated with the chamber, the unit can be manufactured more economically. The 'blind' feature is an advantage in instances where workers unfamiliar with radiation effects may decide erroneously that they have received injury from observing that the dosimeter has increased a few mR.

Both the dosimeter and the pocket chamber are designed to have a nearly linear response to radiation from several Mev down to 80 Kev or so where the absorption of the radiation by the walls of the unit become appreciable. The accuracy within this range is typically $\pm$ 15 percent. The dosimeter seems to be a little more reliable than the pocket chamber as usually manufactured although the chamber can be made as a precision instrument.

A common source of error is caused by the effect of temperature. A dosimeter or chamber charged at several degrees below room temperature and then worn next to the body may suddenly show an increase of 6 to 8 mR because of the warming up of the instrument. It is good practice to warm-up the units by wearing them a half hour or so before charging if this effect is noticed.

Both instruments may be discharged or damaged by a shock such as a drop to the floor. In case of damage, the cost of repair is usually higher than the price of a new instrument. However, these instruments are usually quite rugged and a life of several years can be expected with normal handling.

FILM BADGE

It is a good health physics practice for workers to wear both a film badge and a pocket dosimeter.

The greatest advantage of the film badge is the permanent and authoritative record it provides since the result usually is obtained by an independent and expert agency. The greatest disadvantage is the length of time necessary to obtain the result since the badge must be mailed to the laboratory, processed, read, and the result mailed back. It may take as long as two weeks before the radiation dosage is known. Therefore, it is good practice, as well as a necessary requirement, to provide radiation workers with dosimeters or pocket chambers for the determination of the immediate radiation dose, and film badges for the permanent and legal record.

All films are very energy dependent with an order of sensitivity of about 25 times greater for about 40 Kev radiation than Mev radiation. Corrections are made by the use of filters in two general methods. In the first method a combination of filters is used to obtain as flat a response as possible over a wide energy range. The second method determines the energy of the incident radiations by the various filter combinations and, therefore, the proper corrections to apply. Since both methods have serious limitations, the test film must be compared eventually with calibrated films exposed to known energies and doses of radiations. The problem is still more complex when the film badge is exposed to a wide variety of different energies of radiations. Extremely careful control of the development process is required to prevent errors of great magnitude. At least one control badge usually is furnished with the monitoring badges. This film is not designed to be intentionally exposed but to show the effect of any adverse storage condition or accidental exposure to the film badges during transit or storage so that proper corrections may be made if possible.

In spite of all the corrections and possible sources of error, the film badge has proved to be a reliable device for personnel monitoring. Many laboratories claim ± 10 percent accuracy. However, when the energies of the radiations are unknown to the laboratory or when a wide variety of different energies are used, the accuracy is not likely to be this high. Variation of response with temperature, angle of incidence of the radiation to the filter - film combination, and position of the badge on the wearer's body relative to the incident radiation are factors which may cause considerable variation in results. Most film badges will cover the range from a few mR to 1000 R or more. Special badges may be obtained for other ranges.

Many people are concerned because the film badge readings do not check closely with the readings from the pocket dosimeter or chamber. It is not unusual for the dosimeter or chamber to drift as much as 5 to 6 mR a week. If the total accumulative dose for the week is in the same order of magnitude, an apparent error of 100 percent can be easily obtained. Also with very small doses, particularly with 1 Mev radiations, the blackening of the film in the badge will be so slight that it becomes difficult to determine above the fog level of the film itself. Here again, the error may be as much as 100 percent. However, the accuracy of both units increases rapidly as the accumulative dose is increased until in the area of most concern the film badge usually checks within ± 25 percent of the dosimeter or chamber. If the two systems do not check this closely in the 100 mR per week range, checks should be made to determine if the units are worn properly. One discrepancy may be caused by the fact that the dosimeters or chambers are rate dependent. If a high intensity dose is applied for a very short time, these units almost invariably will read lower than the film badges under the same circumstances. The dosimeter may be easily checked for excessive drift and improper calibration. Finally, an additional badge service from another laboratory may be obtained temporarily for additional comparisons.

TLD - Thermoluminescent Dosimetry

A very accurate dosimeter, which is rapidly replacing film badges, is the thermoluminescent dosimeter. Instead of film the dosimeter uses a small crystal of lithium fluoride which is found to be linear in response to radiation over a wide range from high energy, high dose rates to low energy, low dose rates.

Operation of a TLD is as follows: Exposing the crystal to radiation causes electrons in the material to be raised to meta stable states or traps. The electrons remain at this level until heat is applied to the crystal. When the crystal is heated, the electrons drop to a lower energy level, emitting light in the process. The light out put is an accurate measurement of the original radiation exposure

In practice, a thin piece of crystal is laminated into a plastic card. The card is identified with the user's name and number or can take the form of an identification badge. The badge is worn for 30 days and then inserted into a reader which heats the crystal. A photo multiplier detects the light out put and indicates the exposure on a digital read - out.

The advantages of TLD over a film badge are:

1) LiF has the same energy response as tissue and is linear from 10 mR to 10^5 R.

2) LiF is essentially energy independent down to 10 keV, whereas correctly shielded film grossly underestimates dose below 60 keV and over estimates by a factor of 2 in the 100 keV region.

3) Instantly readable.

SURVEY INSTRUMENTS

Because of scatter, emphasis is placed on the fact that the radiation hazard cannot be estimated entirely from a knowledge of the radiation output but must be determined from actual measurement. The most useful measuring device is the ionization type rate meter. These have considerably larger ionization chambers than the pocket dosimeters and have a compact amplifier system with self contained batteries to produce a portable, light weight sur - vey meter. Units of this type have a nearly flat response from low energy to high energy radiation and are guaranteed usually to $\pm$ 10 percent accuracy. There are two general types in use. The most popular standard type is char - acterized by its ruggedness and fast response to radiation. However, the lowest limit it can measure accurately is of the order of 1 or 2 mR per hour.

Moreover, the walls of the ionization chamber have appreciable absorption at low energies so that the range of the instrument is from about 50 Kev to sev - eral Mev.

Consequently, this instrument may underestimate scatter by a large percentage in the low energy ranges as seen in the following table:

SCATTER MEASUREMENTS WITH STANDARD AND THIN WINDOW IONIZATION METERS

RADIATION	STANDARD METER mR/hr	THIN WINDOW METER mR/hr
Scatter from Iridium 192	11	12.5
Scatter from 160 KV X -ray	31	47
Scatter from 100 KV X - ray	19	40
Scatter from 50 KV X - ray	4	24

The other type of ionization meter characterized by most 'Cutie Pie' instru - ments, has a very thin window in the ionization chamber. The response of some of these instruments is very good down to 10 Kev with about $\pm$ 10 per - cent accuracy. Recently Victoreen Model 440 was introduced, responding down to 6.5 Kev with $\pm$ 15 percent accuracy. Lower energy radiation can still be detected but air absorption at such low energies becomes an appre - ciable factor. Such instruments usually can measure small radiation levels as little as 0.1 mR per hour or so, as well as much higher levels, but the time constant is rather inconveniently long. Moreover, they require care in handling since they are delicate by comparison with the standard survey meter. For diffraction and other low energy work, the thin window ioniza - tion meter is a necessity, but for most isotope radiographic work, the stan - dard instrument such as the Victoreen 592B is by far the most useful all around meter.

Geiger Counter type instruments, in spite of their great sensitivity, usually are not recommended for the precise measurement of radiation because of their severe energy dependence. However, units of this type are used in automatic monitoring and warning systems. Below a preset level, usually about 2 mR per hour, one type of instrument will indicate 'safety' by a green light. Above this level, a red flashing light will be actuated. Alarms and door interlocks can be actuated with the warning light. These units are, without doubt, the greatest system for preventing accidents now in use since they operate inde - pendently of the source of radiation and are not 'fooled' by faulty operation of other safety devices. The previously mentioned instruments will read accur - ately only if the whole chamber is covered by the field of radiation. Pin point leaks in radiation shielding will be determined inadequately or missed en - tirely by most instruments for this reason. Location and severity of such leaks can be determined by the use of X - ray films covering the joints in the radiation shielding or location of suspected leaks.

There are many other radiation detection instruments which are designed for special purposes such as cloud chambers, proportional counters, scintillation counters and chemical effects such as changes in color or precipitation of colloids. Even the heating effect of radiation may be measured in special calorimeters.

AUDIBLE ALARM RADIATION MONITORS

Personnel radiation monitors are available which give an audible alarm (high frequency chirps) when a preset radiation level is exceeded. Among many manufacturers, the Victoreen 'Tattler' and the Eberline 'Rad - Tad' are recommended.

These instruments are about the size of a pack of cigarettes and can be carried in a shirt pocket or clipped to the trouser belt. The unit contains a miniature G - M tube, HV supply, battery and solid state circuitry. About 2 chirps per minute indicates a dose rate of 1 mR/hr.

THE CARE AND USE OF SURVEY METERS

NRC regulations require that licensees maintain sufficient calibrated and operable radiation survey instruments to make physical radiation surveys as required by its regulations. In its application for a license, the applicant must describe the instruments that will be utilized, including the type, number, measurement range capabilities, and activities for which they will be utilized. In addition the frequency and method of calibration must be stated. If the applicant wishes to calibrate the instruments in house, then written procedures must be submitted with the application.

An operability check should be made prior to the first use of a survey meter each day. If the meter has a battery check position, then the batteries should be checked for proper capacity. Secondly, a check source should be utilized to verify that the meter is responding to radiation.

The calibration tag affixed to the instrument should be reviewed to insure that the instrument is still within the recommended calibration period. Should the 'calibration due date' be past, the meter should not be used for survey purposes but should be returned for calibration.

Gamma survey meters are senstitive to shock, moisture and abuse. The most frequent causes of malfunctions are dead batteries or poor contact of the battery terminals. New batteries are available at radio shops and drug stores and poor contacts can be cleaned and adjusted. Occasionally an inoperative instrument is found to be wet. Open the case and dry with very low heat. If the survey meter must be used under wet conditions, place a plastic bag over the instrument. The slack in the bag will let you operate the controls. It should be noted that all dry batteries become 'dead' at low temperatures. The mercury

cells are useless at freezing temperatures and the remaining dry cells are inoperative at $0^{o}F$. Therefore, if the instrument is to be used outdoors during cold weather, it must be stored in a warm place and used only for the short intervals of time necessary to make the survey. An exception to this is the new type managanese battery which is said to be operable at $-40^{o}F$.

Since a survey meter is required during all service operations, it is good practice to have at least two instruments in order to insure that one is operable at all times.

All persons using survey meters should be thoroughly familiar with the particular instrument and its use.

SURVEY METER OPERATIONS

Appendix A contains specifications and data sheets for the various meters and other equipment that are a part of the AMS radiation safety program. The operator manual for this equipment should be consulted for more detailed information.

GENETIC EFFECT

The effects of radiation on living tissue is generally assumed to be almost entirely due to the ionization process. Actually the disruption of molecules by recoiling atoms is also a factor especially in the case of neutrons. The effect of continual exposure to small amounts of radiation can be very subtle, producing no apparent change in the health of the individual, but perhaps changing the genes so as to cause mutations in later generations. Just how much radiation can cause this kind of damage is now the subject of violent argument between various geneticists or physicians. It may be safely assumed, however, that if the present NRC requirements are met, no appreciable genetic change will be observed when the individual effect is diluted over the popu - lation as a whole.

One of the insidious effects is the destruction of the blood producing tissue in the marrow of the bone causing symptoms of anemia and other blood cell damage.

Effects of acute radiation doses within a 24 hour period over the whole body:

0 - 25	R	No obvious injury - 5 R first detectable blood change, 25 R definite blood change.
25 - 50	R	Blood changes - No serious injury.
50 - 100	R	Blood changes, some injury, no disability.
100 - 200	R	Injury - Possible disability.
200 - 400	R	Injury and disability certain, death possible.
400 - 600	R	Fatal to 50%
600 - 1000	R	Survival possible.
1000 - R or More		100% Fatal.

SUMMARY OF EFFECT RESULTING FROM WHOLE BODY EXPOSURE TO RADIATION

TIME AFTER EXPOSURE	LETHAL DOSE 600 R +	MEDIUM LETHAL DOSE 400 R	MODERATE DOSE 300 - 100 R
First Week	Nausea and vomit - ing after 1 - 2 hours. No definite symp - toms. Diarrhea, vomiting, infla - mmation of mouth and throat.	Nausea and vomiting after 1 - 2 hours. No definite symptoms	No definite symptoms
Second Week	Fever, rapid emaciation, mortality 100%		

TIME AFTER EXPOSURE	LETHAL DOSE 600 R +	MEDIUM LETHAL DOSE 400 R	MODERATE DOSE 300-100 R
Third Week		Beginning epilation, loss of appetite and general malaise. Fever - severe inflammation of mouth and throat.	
Fourth Week		Pallor, petchiae, diarrhea and nosebleeds. Rapid emaciation, mortality 50%	Moderate emaciation. Recovery likely unless complicated by poor health, injuries or infections.

ESTIMATED DOSES FOR VARYING DEGREES OF INJURY

DOSE RATE	PERIOD OF TIME	EFFECT
500 R/day	2 days.	Mortality close to 100%.
100 R/day	Until death.	Mean survival time 15 days, 100% mortality in 30 days.
60 R/day	10 days.	Morbidity and mortality high with crippling injuries.
30 R/day	10 days.	Disability moderate.
10 R/day	365 days.	Some deaths.
3 R/day	Few months.	No drop in efficiency.
0.5 R/day	Many months.	No large scale drop in life span.

Comparison of above and preceding indicates that it makes a difference how the dose is received. It apparently is much less injurious to receive numerous smaller dosages rather than a single large exposure of the same total dose.

BLOOD TESTS

Much reliance had been placed on blood tests in the early days when other means of determining exposure rates were either unreliable, unavailable or unknown.

A competent Roentgenologist may be able to determine that radiation damage has occurred in the blood with an exposure of 1 R providing he has the com - plete medical history of the patient, including blood test reports taken at least monthly over an extended period of time. Lacking this previous history, it is doubtful if the Roentgenologist can be certain that damage has occurred with exposures less than 5 R. It is good policy for a company engaged in industrial radiography to require medical examination of their radiation wor - kers before employment and once a year thereafter primarily to detect naturally anemic persons. If the NRC requirements are followed, the dosage rate allow - able is much below the level which can be determined medically.

NATURAL AND DIAGNOSTIC EXPOSURES

Cosmic rays, average	0.1 R/year
Cosmic rays, Denver	0.5 R/year
*Routine chest X - ray	0.5 to 5 R/exposure
*Routine gastro - intestinal X - ray	1 r/exposure
*Fluoroscopic examination @	10 to 20 R/minute
*Cinefluorographs (X - ray movie) @	25 R/examination
Average annual exposure of all Hanford and Oak Ridge workers 1949	0.2 R/year
Average 10 highest of Oak Ridge 1949	4.2 R/year

* These exposures are to parts of body only.
@ Use of the image amplifier may reduce these doses to 10% of the value shown.

THE MAXIMUM PERMISSIBLE DOSE

About thirty days after Roentgen's announcement of his discovery of X- rays, in December 1895, Emil Grubbe of Chicago reported radiation damage to him - self in the form of dermatitis on his hands. Thus, the first attempts to estab - lish maximum permissible limits were based on the dose required to produce skin erythema.

Subsequently, the haemopoietic system was included in this tolerance dose concept. In the last fifteen years, emphasis has shifted to the genetic effects which are not thought to be subject to the repair process, and hence, there can be no tolerance dose. Consequently, the accumulative population dose from all sources of radiation including background, is the prime consideration rather than the individual dose, and a small number of radiation workers may be subjected to somewhat higher levels of radiation as long as the hazard of genetic effects to the total population are not considered to be increased.

In 1958, the International Committee on Radiation Protection recommended a maximum accumulation whole body dose for occupational personnel of 5 (N - 18) rems where N is the age of the individual. This amounts to an average dose of 5 rems per year over age eighteen. It was further specified that no more than 3 rems should be accumulated in any 13 week period. Medical exposures are excluded. It was recommended that non - occupational people or persons outside a controlled area should receive no more than 0.5 rem per year from external radiations. The Federal regulations (Title 10, 20) are more restrictive requiring a maximum permissible dose of 1 - 1/4 rems per calendar quarter for most radiation work. However, the U. S. NRC is now permitting the various states to set up their own regulatory agencies providing certain minimum requirements are met.

RISK

Appendix B contains a copy of NRC Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure."

Federal Regulations

To protect the public and to promote the peaceful application of radioisotopes, a Federal agency, the U.S. Nuclear Regulatory Commission (NRC) has been established. The NRC issues and updates regulations which set standards and licensing requirements for the possession and use of radioactive material. These regulations are found in title 10 of the Code of Federal Regulations (10CFR).

Four parts of title 10 are particularly applicable to the operations of Advanced Medical Systems, Inc. These are parts 19, 20,30, and 40.

Part 19 - Notices, Instructions and Reports to Workers; Inspections

This part applies to Advanced Medical Systems, as an NRC licensee. Briefly, it requires posting of (1) the regulations in Parts 19 and 20; (2) the license, conditions, and documents incorporated by reference in the license; (3) operating procedures; (4) notices of violation; (5) form NRC-3, "Notice to Employees." It requires that employees working in restricted areas be properly informed of the radiation hazards in those areas. It requires that the company report workers' documented exposure to radiation to any worker who requests it.

It allows the NRC to inspect the company's facilities, and to consult with it's workers.

A copy of the current Part 19 is included in Appendix C of this manual.

Part 20 - Standards for Protection Against Radiation

This part establishes standards for protection against radiation hazards arising out of activities under license issued by the NRC. It defines the terms used in the regulations, the units of radiation dose, and the units of radioactivity. It sets the radiation dose standards for individuals working in restricted areas, for minors, for individuals working in unrestricted areas. It requires the use of surveys, personnel monitoring equipment. It describes the proper caution signs, labels, signals and controls that are required in radiation areas. It sets forth requirements for the disposal of radioactive material. It requires specific recordkeeping and reporting.

A copy of the current Part 20 is included in Appendix C of this manual.

Part 30 - Rules of General Applicability to Domestic Licensing of Byproduct Material

This part prescribes rules applicable to all persons in the U.S. governing domestic licensing of byproduct material. Cobalt 60 is a byproduct material, since it is made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material.

Basically, this part covers licensing, transfer of material, recordkeeping requirements, inspections by the NRC, etc.

A copy of this part may be found in the company offices.

Part 40 - Domestic Licensing of Source Material

This part estabishes procedures and criteria for the issuance of licenses to receive possess, use, transfer, or deliver source and byproduct materials.

The depleted Uranium used in teletherapy heads as shielding material is considered source material.

A copy of this part may be found in the company offices.

ADVANCED MEDICAL SYSTEMS, INC. LICENSES

AMS is licensed by the U.S.N.R.C. to conduct various activities related to the possession and use of byproduct and source material in the teletherapy business. A summary of license follows.

License 34-19089-01

This license authorizes AMS to possess Cobalt 60 metal, Cobalt 60 sources, Cesium 137 sources and depleted Uranium. It authorizes AMS to install, dismantle, service and maintain Picker and AMS teletherapy equipment; use depleted Uranium as shielding in teletherapy heads; install or exchange sources in teletherapy equipment. It authorizes the above uses by or under the direct supervision of named company individuals. It authorizes the transportation of licensed material in accordance with 10CFR71. It requires that AMS possess and use licensed material in accordance with the statements, representations and procedures submitted to the NRC.

A summary of the information submitted with license application follows:

Material to be possessed, quantity and intended use
Qualifications for Radiation Safety Officer
Description of Training Program for Users (ISP-31 and ISP-32)
Qualifications of Users
Description of Facilities (ISP-1)
Radiation Safety Program (ISP Manual in its entirety)
Instrument Calibration Procedures (ISP-23)
Personnel Monitoring Devices, Bioassay Program
Waste Management
ALARA Program (ISP-14)
QA Procedures for Shipping Containers

STATE REGULATIONS

The U.S. NRC has entered into agreements with 28 states whereby the individual state has assumed the licensing and regulatory functions of the NRC within its borders. These states, called 'Agreement States,' are as follows:

Alabama	Idaho	Nebraska	Oregon
Arkansas	Iowa	Nevada	Rhode Island
Arizona	Kansas	New Hampshire	South Carolina
California	Kentucky	New Mexico	Tennessee
Colorado	Louisiana	New York	Texas
Florida	Maryland	North Carolina	Utah
Georgia	Mississippi	North Dakota	Washington

Basically, each of these states has published its own regulations for the protection of workers and the possession and use of radioactive material. For the most part, these regulations are nearly the same as the NRC regulations. Under reciprocity policies, these states recognize and honor our NRC license; therefore, we do not have to obtain a license from each state.

Certain states charge an annual fee for performing service work within their boundaries. In addition, most states require prior notification of our intention to perform work in their state.

The service technician should be prepared for a visit by a state inspector when doing work in an agreement state.

A summary of the states and their requirements which affect our work follows:

1. Mississippi requires that AMS service engineers have a copy of the state regulations in their possession while working in the state.

2. The following states require that AMS certifies that its service personnel have read and understand the state reguations:

   Arizona, New Mexico, North Carolina, South Carolina

A copy of these state's regulations will be issued to each qualified service engineer.

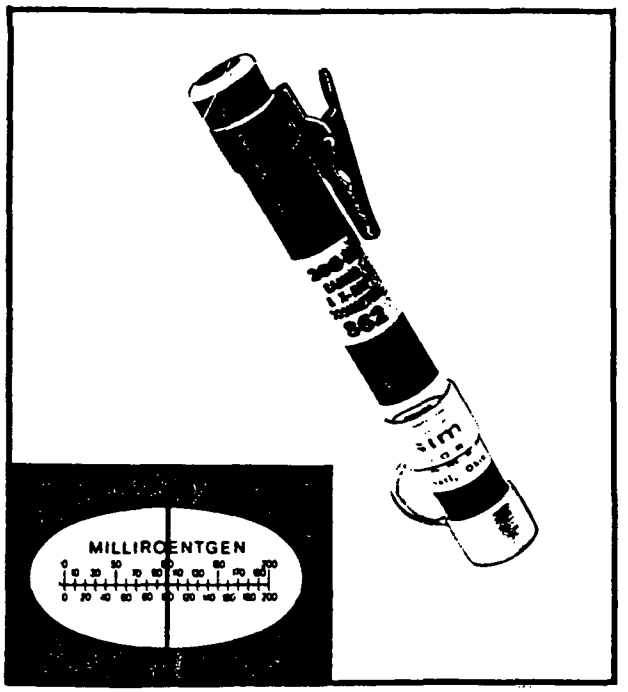
dosimeter

Direct Reading Gamma and X-Ray Dosimeters

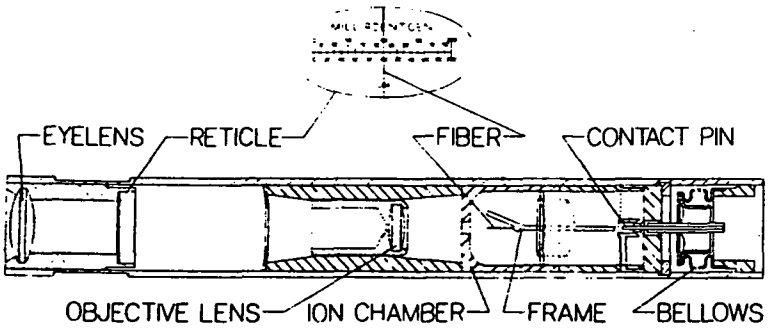
The Confidence Builders

Dosimeter Corporation Direct Reading Dosimeters (DRD's) are the most rugged, reliable, and inexpensive self-reading dosimeters available today. Hermetically sealed for consistent readings under a broad range of environmental conditions, Dosimeter Corporation DRD's meet A.N.S.I. Specification N13.5-1972 and are manufactured and tested to A.N.S.I. Specification N322-1977.

We call DRD's the confidence builders because they provide for the Health Physicist and for every occupationally-exposed worker, a continuous and immediately accessible monitoring of radiation exposure. Only DRD's can be read out at anytime by looking through them at any light source.



- The Health Physicist knows he'll be alerted to any unusual exposure conditions immediately, allowing prompt and effective corrective action.
- The workers know they can check on their exposure whenever they want.



Only DRD's offer these confidence building advantages for all occupationally exposed personnel. Only Dosimeter Corporation offers this value and low price.

Direct-Reading Dosimeters

Models
862
862Sv
883
883G
883SI
866
611
611G
608
622
610
619
638
686

dosimeter

DOSIMETER CORPORATION
11286 Grooms Road/P.O. Box 42377/Cincinnati, Ohio 45242
(513) 489-8100 / Telex 214-648

dosimeter
DOSIMETER CORPORATION
COMS ROAD P.O. BOX 42377 Cincinnati, Ohio 45242
(513) 489 8100 Telex 214 648

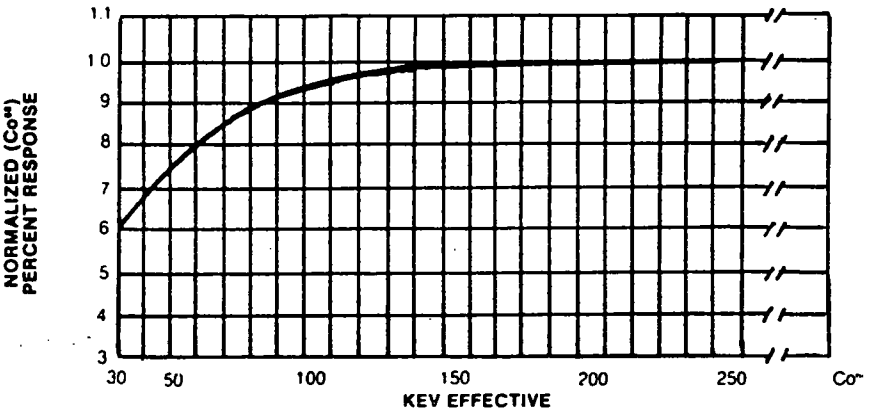
WARNING

CLEAN DOSIMETER EYEPIECE WITH A MILD DETERGENT AND WATER (OR) ALCOHOL ONLY! USE OF OTHER SOLVENTS IS UNACCEPTABLE

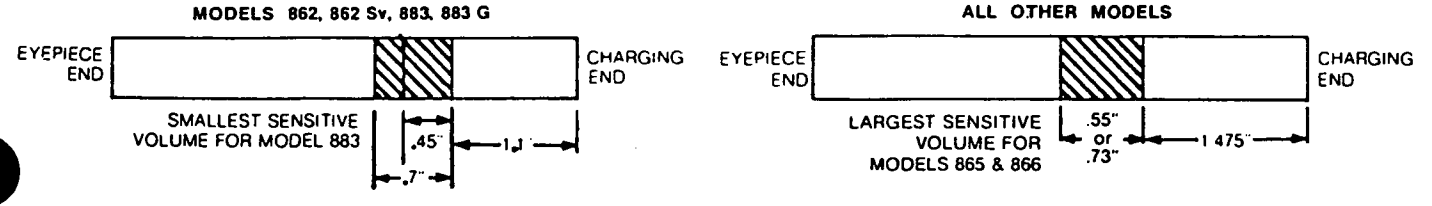
GAMMA & X—RAY DOSIMETERS
INSTRUCTION SHEET
(Models 862, 862 Sv, 883, 883 G, 866, 865, 611, 611 G, 608, 622, 610, 619, 638, 686)

ANSI CERTIFICATION INFORMATION — Manufactured to specification N322-1977 and meets performance specification N13.5-1972. When an inconsistency exists between the standards, DCA dosimeters meet the newer (N322) standard.

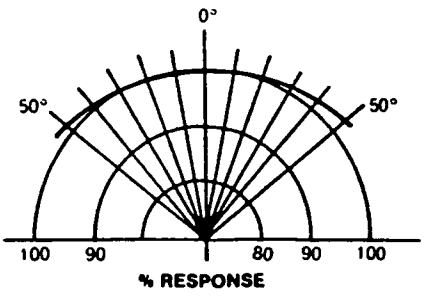
1. INSTRUMENT TYPE — Direct Reading Gamma & X-Ray Dosimeters Models 862, 862 mSv, 883, 883G, 866, 865, 611, 611G, 608, 622, 610, 619, 638, 686
2. MANUFACTURER — Dosimeter Corporation
3. FULL SCALE EXPOSURE VALUE — Model 862-200 mR; 862 mSv - 2.0 mSv, 883 - 500 mR; 883 G - 0 - 5mGy; 866 - 1000 mR; 611 - 5R; 611 G O - 50 mGy; 608 - 10 R; 622 - 20 R; 610 - 50 R; 619 - 100 R; 638 - 200 R; 686 - 600 R; 865 - 1500 mR
4. ENERGY DEPENDENCE CURVE — for X-Ray or Gamma radiation field



5. LOCATION AND DIMENSIONS OF SENSITIVE VOLUMES



6. CHAMBER IS AIRTIGHT, HERMETICALLY SEALED
7. MAXIMUM PERMISSIBLE EXPOSURE RATE, 10,000 R/hr
8. WALL THICKNESS IS 350 mg/cm² WITH A COMPOSITION OF ALUMINUM AND PLASTIC.
9. ANGULAR DEPENDENCE AT ± 50° FROM PRIMARY AXIS OF DOSIMETER OR PRIMARY DOSIMETER AXIS.



WARRANTY

Products manufactured by DOSIMETER CORPORATION (DCA) are hereby warranted to be free from defects in materials and workmanship for a period of two years from the date of delivery to DCA's customer. This warranty is contingent upon DCA *being advised of any defects within this two-year period.* Any defective products must be returned with all shipping charges prepaid and accompanied by a detailed written explanation of the observed defects. Returned products are subject to inspection by DCA, and DCA reserves the right to make the final decision as to responsibility.

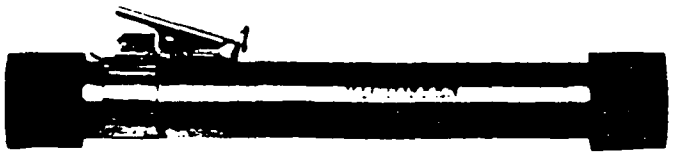
The liability of Dosimeter Corporation under this warranty is limited to free repair or replacement of the defective product, or defective component parts thereof, at the sole option of DCA, and does not extend to any consequential damages or other damages of any type whatsoever.

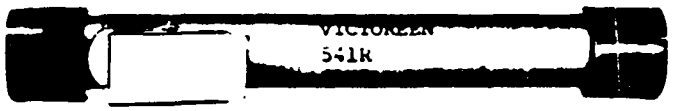
DCA makes no warranties of fitness for purpose or merchantability and no other warranties, either expressed or implied, regarding the purchase and use of its products and hereby denies and disclaims all liability beyond the liability expressed herein.

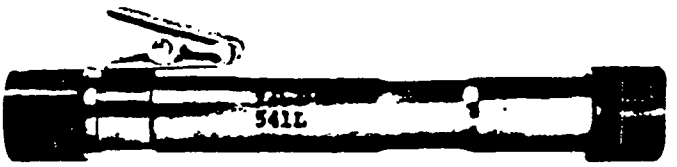
VICTOREEN

VICTOREEN, INC.
A Subsidiary of Sheller-Globe

Direct-Reading Dosimeters 656R/541R/541L







- **"Bright-View" Optics**
- **Superior Energy Response**
- **Rugged – Meets ANSI N13.5-1972**

These direct-reading dosimeters allow the wearer to read total radiation exposure at any given time, without a separate readout device. The integrated exposure is read on a built-in scale which is illuminated by an external light source with a high illumination factor that provides especially easy readability.

These dosimeters include a built-in string electrometer and ion chamber. Their superior energy response improves exposure accuracy. The housings are hermetically sealed and the strong, alligator-type swivel clip allows attachment in any orientation. To "zero" the dosimeter either the VICTOREEN Model 2000A Charger may be used or similar chargers on the market.

Specifications

Models: 656R, 541R, 541L

Radiation Detected: Gamma, X-Ray

Range: 656R 0 - 500 mR
541R 0 - 200 mR
541L 0 - 200 mR

Precision: Within 10% of full scale

Energy Response: 656R 30 keV to 2 MeV
541R 30 keV to 2 MeV
541L 17 keV to 667 keV

Geotropism: Less than 1 minor scale division in any orientation.

Environmental Effects: Temperature Limits: – 10°C to + 50°C. Humidity Limits: 0-99% Non-Condensing.

Detector: Hermetically sealed ionization chamber.

Leakage: Less than 2% of full scale in 24 hours.

Display: Internal translucent scale

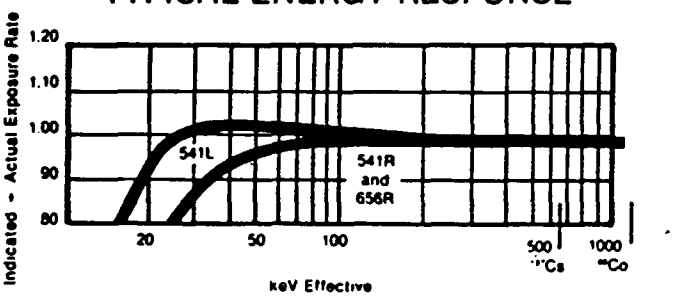
Construction: Nickel-plated aluminum barrel.

Power Source: Model 2000A Charger.

Dimensions: 10.2 cm long, 1.27 cm dia. (4 in. x 1/2 in.)

Weight: 28g (1.0 oz.)

TYPICAL ENERGY RESPONSE



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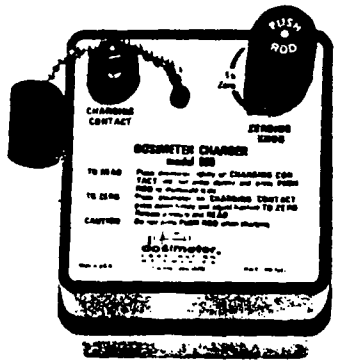
dosimeter CORPORATION 11286 Grooms Road / P.O. Box 42377 / Cincinnati, Ohio 45242 / (513)489-8100 / Telex 214-648

DOSIMETER CHARGER MODEL 909*
INSTRUCTION SHEET



NOTE: This charger has the same size and shape as the Model 906, but is completely different in operation. (It makes all other chargers obsolete.) Please read these instructions before using the charger to assure the promised performance.

GENERAL

The Dosimeter Corporations's (DCA) Model 909 Dosimeter Charger is a totally new, self-contained, battery operated instrument capable of charging any self-reading pencil dosimeter. Unlike other model and make chargers, which do not "kick" all dosimeters properly, Model 909 assures grounding of the dosimeter charging pin and removal of the residual charge, also known as "kick." Failure to remove this residual charge can cause spurious upscale fiber movement of 2 to 8% of the full scale length, which could be falsely interpreted as either additional radiation exposure or excessive drift. When Model 909 automatically "kicks" low range dosimeters, a small upscale fiber jump will be seen. This stabilizes the reference readings, resulting in more accurate radiation exposure readings.

The new blue charger is contained in a two-part plastic case held together with a single captive screw. The charging contact is located in the upper left-hand corner and the zeroing knob in the upper right-hand corner. The charging contact contains spring clips which guarantee constant contact and is equipped with a dust cover which is permanently attached by chain to the case. The zeroing knob has a push rod in its center that permits reading of the dosimeter without removing it from the "charging contact pedestal." The dosimeter circuit is powered by a 1.5 volt battery and is capable of producing a variable voltage up to 220 volts at the center electrode of the charging contact. The push rod is actually a two-position switch that first shuts off the high voltage to the charging contact and then illuminates it for reading dosimeters.

BATTERY INSTALLATION

1. Unscrew single captive screw on back of case and remove charger bottom.
2. Install a "D" cell (1.5V) in the battery holder. Make sure that the positive terminal of the battery is installed at the end the battery holder marked "+". Reassemble the charger.

TO CHARGE (ZERO) DOSIMETER

(Note: Please read entire instructions before charging dosimeter.)

1. Do *not* press "PUSH ROD" when *charging* a dosimeter. (The dosimeter could be damaged.)
2. Remove the plastic end cap from the charging end of the dosimeter.
3. Place dosimeter on CHARGING CONTACT and push down firmly until the dosimeter barrel makes contact with the blue base of the charging pedestal. Failure to do so may result in erratic behavior of the dosimeter fiber or the charger. The fiber image, as seen through the eyepiece end of the dosimeter, will now move fluidly across the scale when the zeroing knob is rotated. It is impossible to damage a dosimeter by exerting too much pressure when using a DCA charger.
4. Slowly rotate ZEROING KNOB clockwise and/or counter-clockwise until the fiber is at zero. In the case of low-range dosimeters (less than 10R), the hairline may have to be placed to the left of zero to accommodate the "kick," or fiber movement. See the dosimeter instruction sheet or General Information above for an explanation of "kick."

   Do not remove the dosimeter from the CHARGING CONTACT, but release the pressure until it sits loosely on the pedestal.

   Check the reading by pressing the PUSH ROD on the ZEROING KNOB to illuminate the scale. Rezero until the fiber is exactly on zero.

*Patent No. 4,224,522

VICTOREEN

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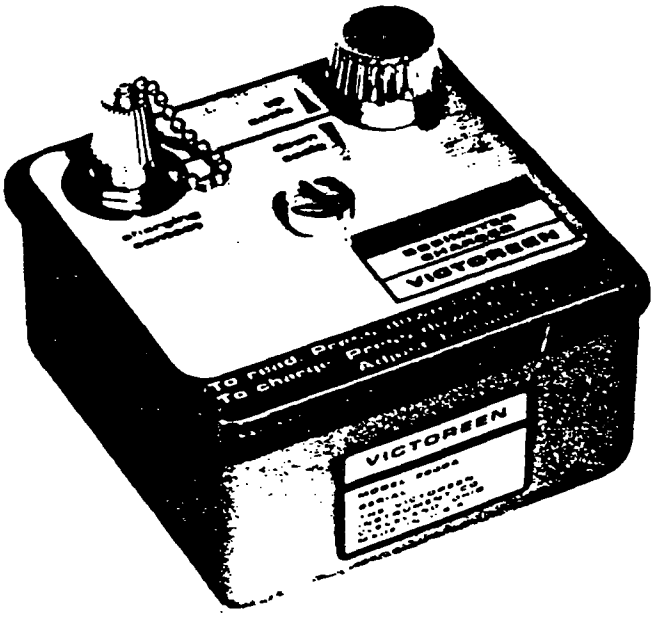
Model 2000A Dosimeter Charger



Victoreen direct-reading dosimeters are charged on the compact lightweight Model 2000A Dosimeter Charger. Power is furnished by a single size "D" flashlight type battery, capable of recharging dosimeters thousands of times before replacement is necessary, thus making it an economical and reliable charger to operate. A safety spring located in the charging socket of the Model 2000A prevents damage to the dosimeter in the event that excessive pressure is exercised when charging.

Specifications

Voltage Supplied: 180-240 volts

Power: One 1½ volt type "D" battery (no switch, dosimeter activated)

Construction: Splash and dust-proof, all metal case, printed aluminum operating panel, special mar-resistant matte finish.

Controls: Rotary potentiometer utilized to zero dosimeters.

Dimensions: 4-1/2 inches (11.4 cm) long, 3-5/8 inches (9.2 cm) wide x 2-3/4 inches (7 cm) high.

Net Weight: 2 pounds (0.91 Kg).

Shipping Weight and Volume: 3 pounds (1.36 Kg.), 0.1 cubic feet (.003 m^3).

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dosimeter

Desk Top Dosimeter Calibrator

The Convenient Calibrator

osimeter Calibrator Model 3060

Model 3060 dosimeter calibrator, with 4 and 8 hole rings around the source:

- Permits quick accuracy verification of dosimeters.
- Can be used with all common brands of osimeters.
- s designed for 200mR and 500mR dosimeters but is usable with all ranges.
- Requires no (specific) NRC license.
- Has radiation levels outside of the case so low hat it can be left on your desk.
- ls effectively labeled to ensure radiation source wareness by all viewers.
- Has special base indents guaranteeing correct dosimeter positioning, thus allowing highest reproducibility.
- Can be used as a teaching aid for studies on reproducability of readings, self-shielding, inverse square law, etc.

Conveniently available on your desk when there is a question about a dosimeter functioning properly.

dosimeter

DOSIMETER CORPORATION
11286 Grooms Road/P.O. Box 42377/Cincinnati, Ohio 45242
(513) 489-8100 / Telex 214-648

SPECIFICATIONS

I. OPERATING CHARACTERISTICS

Environmental Conditions

Temperature Range	0°F - 120°F (– 18°C - 49°C)
Relative Humidity	Up to 98%

Radiation Levels

Inner Holes	~50mR in 6 hours
Outer Holes	~50mR in 24 hours

II. PHYSICAL CHARACTERISTICS

Calibration Holes

1 (inner) ring of 4 holes and 1 (outer) ring of 8 holes

Mechanical

Case	Aluminum
Finish	Black anodized
Dimensions	
Diameter	4" (10.1 cm)
Height	2-7/16" (6.25 cm)
Net Weight	300 g. (11 oz.)
Shipping Weight	1 lb. (500 g.)

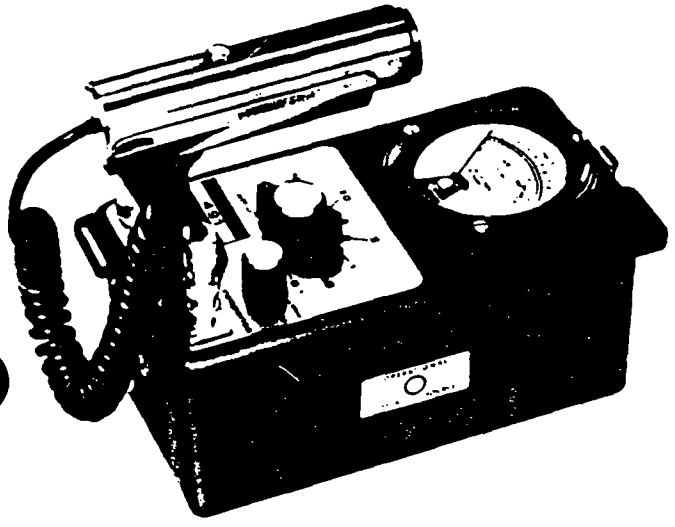
10/82 Printed in U.S.A.

Distributed by:

VICTOREEN

VICTOREEN, INC.
A Subsidiary of Sheller-Globe

Model 491
Wide Range GM Survey Meter



- **High sensitivity...fullscale readout capability from 0.1 to 100 mR/hr for ^{137}Cs in seven linear ranges.**
- **High accuracy and linearity.**

The Victoreen Model 491 is a high performance, wide range GM survey instrument, featuring superior characteristics in all important design areas: accuracy, linearity and sensitivity. Dependable surveys can be performed with the 491 in virtually any application calling for a GM Survey Meter. Linearity of the 491 is ± 10% of fullscale on all ranges with agreement of better than ± 5% between ranges when calibrated with ^{137}Cs. The 491 also features temperature independence within ± 10% from −20°F to +120°F.

Specifications

Radiation Detected: Alpha, beta, gamma and X-Ray depending upon detector selected.

Operating Ranges: 0-150, 450 150,000 cpm in seven overlapping linear ranges. Corresponds to 0-0.1, 0.3 100 mR/hr when used with 491-30 probe calibrated with ^{137}Cs.

Precision: Within 10% of full scale at standard temperature over operating ranges.

Response Time: 90% of full scale within 12 seconds, 5 seconds and 0.8 seconds, nominal switch selected.

Calibration: Within 10% using an electronic pulser referenced to the sensitivity of the Model 491-30 probe to ^{137}Cs.

Geotropism: Within 2% of full scale in any orientation.

Environmental Effects: Temperature Limits −30°C to +50°C with Alkaline batteries. Humidity Limits: 0-99% non-condensing. Temperature dependence within 0.2%/°C.

Detector: Not included. Model 491-30 standard probe. See "probe" section of this catalog.

Display: 7.7 cm (3") ruggedized meter.

Battery Complement: Four "D" size cells, NEDA type 13 included.

Battery Life: Over 100 hours at 4 hours use per day.

Connectors: MHV connector for detector. Microphone threaded connector for loudspeaker or earphone.

Controls: 9 position function switch, including battery check, 3 position response time switch.

Check Source: Depleted uranium mounted on case side.

Construction: Splash-proof, shock-proof, rugged Aluminum case. Circuit board mounted on rugged cast-in supports.

Dimensions: 11.4 cm (4-1/2") wide, 22.2 cm (8-3/4") long, 17.8 cm (7") high overall.

Weight: 2.25 kg (5 lbs.) net; 3.6 kg (8 lbs.) shipping.

Shipping Volume: 0.042 m^3 (1.5 cu. ft.)

Optional Accessories: GM Probes, model 490-31 headset, model 490-50 speaker.

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GM Probes

Victoreen GM probes are the first choice for use in portable survey instruments, area monitoring systems, and precision laboratory measuring equipment. These probes are also ideally suited for multiple tube counters or for coincidence and anti-coincidence circuits.

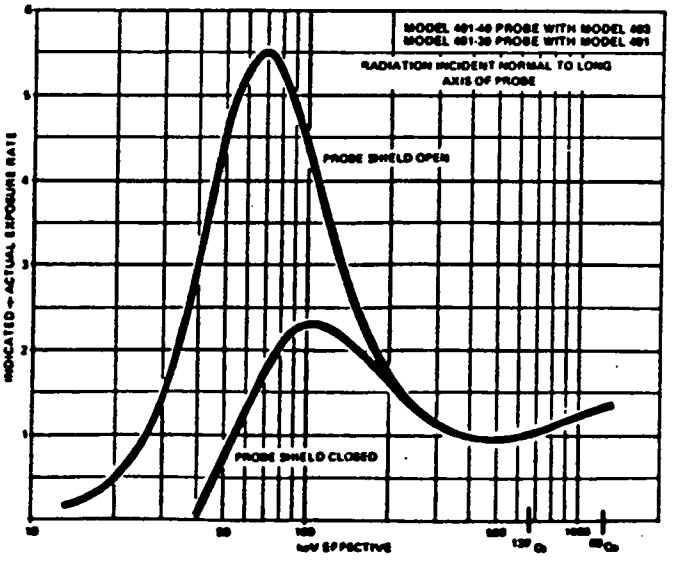
Model No.		489-4	491-30	491-40	489-35	493-50	489-110
Type		Beta - gamma G-M probe with sliding 360° metal shield for beta discrimination			Alpha, beta, gamma G-M probe with thin end window	Beta - Gamma	Pancake
Radiation Detected		Gamma above 6 keV Beta above 200 keV	Gamma above 12 keV Beta above 200 keV		Alpha above 4 MeV Beta above 70 keV Gamma above 6 keV	Gamma above 12 KeV Beta above 200 KeV	Alpha above 3.5 MeV Beta above 35 KeV Gamma above 6 KeV
Energy Dependence		Supplied on Request					NA
Exposure Rate Limitations (Typical)		Recovery time approximately 100 μ sec					NA
		Unsaturated* at 2000 R/hr with Model 490					NA
		Saturates above 1.6 R/hr with Model 491 3 R/hr with Model 493 6 R/hr with Model 425	Saturates above 4 R/hr with Model 491 10 R/hr with Model 493 20 R/hr with Model 425		Saturates above 4.7 R/hr with Model 491 11.5 R/hr with Model 493 25 R/hr with Model 425	Saturates above 7 R/hr with Model 491 18 R/hr with Model 493 40 R/hr with Model 425	NA
Temperature Range		−20°F to +165°F (−30°C to +75°C)	−65°F to +185°F (−56°C to +85°C)				
Pressure Range		To 5 psig	To 15 psig		To 5 psig	To 15 psig	To 5 psig
Humidity Range		0 - 95% relative humidity					
Voltage Operating		900V on all probes					
Detector Construction	Wall Material	Aluminum	Stainless steel		Stainless steel with mica end window	Stainless Steel	Stainless steel mica window
	Wall Thickness	30 mg/cm²			1.4 mg/cm² end window	30 mg/cm²	1.4 mg/cm² window
	Active Length	2-3/4 in. 7 cm	2-3/8 in. (6 cm)	2-1/4 in. (5.7 cm)	4 in. nominal (10.2 cm)	1-3/8 in.	1-1/2 in. dia.
	Quench	Organic	Halogen				
Probe Connector		Standard MHV type					
Overall Probe Dimensions (Excluding Cable)	Dia.	1-3/16 in. (3.2 cm)			1-5/16 in. 3.34 cm)	1-1/4 in.	2-11/16 in.
	Length	5-3/8 in. (13.6 cm)			7-1/2 in. (19.1 cm)	5-5/16 in.	9-3/4 in.
Cable Length		48 in. (125 cm)					
Weight		Approximately 1 pound (0.45 Kg)					

*Saturation is interpreted as a decrease in meter fullscale indication with increasing radiation intensity

When using the probe/survey meter combination shown on the response curves the meter is read directly in mR/hr. Calibration point is indicated as either ^{137}Cs or ^{60}Co. When other combinations are utilized, divide the meter reading by the appropriate factor.

Survey Meter	Probe				Calibration Source
	489-4	489-35	491-30	493-50	
490	Read Directly	.95	.45	.2	^{60}Co
491	2.3	2.2	Read Directly	.45	^{137}Cs
493	5.3	5.1	2.3	Read Directly	^{137}Cs

RESPONSE CURVES



MiniMonitor II
X-Gamma Ray Survey Meter

- **Miniaturized. . .Lightweight. . .Rugged**
- **Wide Energy Response (40 keV to 1.2 MeV)**
- **Ideal For Use With Technetium Generators Where 1 R Range is Necessary**

"MiniMonitor II" is the ideal survey meter for detecting radiation levels from radioactive sources, radiation areas and x-ray machines.

Radiation Detected: Gamma and x-ray.

Detector: Energy-compensated GM tube.

Readout: 2½" analog meter, marked "0-10 mR/hr."

Ranges: 0-10, 0-100, 0-1000 mR/hr (x1, x10, x100).

Accuracy: ± 10% of full scale when calibrated with ^{137}Cs.

Energy Dependence: 40 keV to 1.2 MeV, −5 + 50%; usable below 30 keV (end-on exposure).

Controls: Off, Battery Test, x100, x10, x1 ranges on one switch.

Time Constants: 10 secs. (x1); 2 secs. (x10); 0.3 secs. (x100).

Battery Complement: Four "AA" alkaline cells (500-hour life)

Operating Temperature: −20°C to +55°C (−4°F to +130°F).

Temperature Dependence: ±15% over noted temperature range.

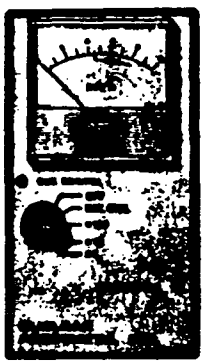
Construction: All solid state electronics. High-impact plastic case.

Overall Size: 6" high x 3½" wide x 1½" thick.

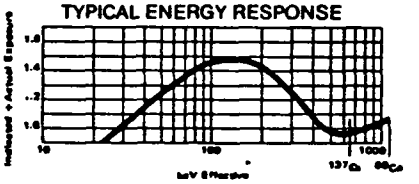
Weight: 15 ounces.

05-571 "MiniMonitor II" Survey Meter

62-103 Optional check source. About 10μ Ci of ^{137}Cs on a flat plastic disc, 1" D.

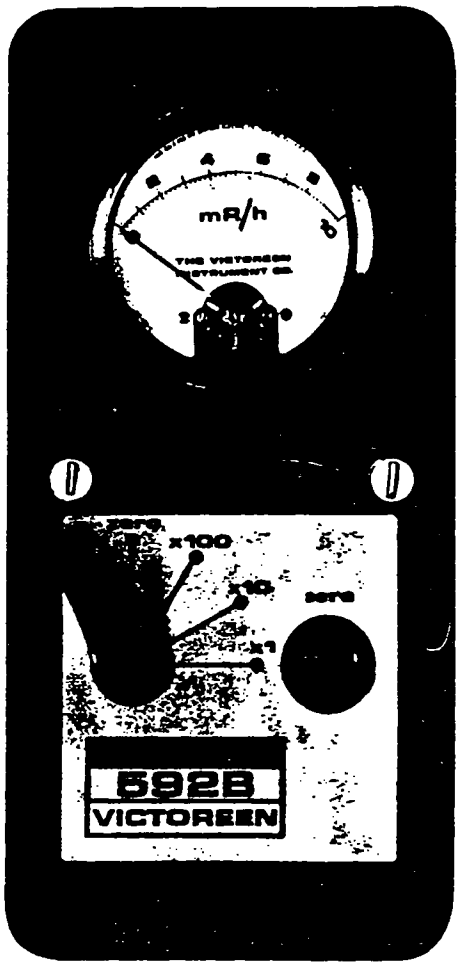


TYPICAL ENERGY RESPONSE



RADIOGRAPHIC SURVEY DOSIMETRY

VICTOREEN



GAMMA SURVEY METER

592B provides fast, accurate determination of X and gamma radiation leaks at X-ray installations, hospitals and industrial facilities. The instrument satisfies many requirements of regulating agencies for leakage measurements as well as personnel safety programs.

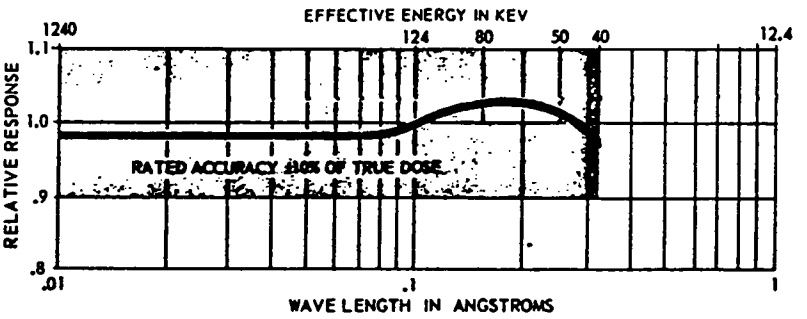
FAST METER RESPONSE — 90% of final indication in less than one second.

"FLAT" ENERGY RESPONSE over a broad range — within ±10% from 50 Kev to 1.3 Mev.

POSITIVE "ZEROING" even in high radiation fields.

RUGGEDIZED HIGH-IMPACT CONSTRUCTION designed for hard field use.

ENERGY DEPENDENCE



592B SPECIFICATIONS

Radiation Detected: X-ray and gamma.

Ranges: 0-10, 0-100, 0-1000 mR/hr.

Energy Dependence: Within ±10% of true dose from 50 Kev to 1.3 Mev.

Detector: Ionization Chamber.

Accuracy: Maximum instrument inaccuracy, exclusive of energy dependence, is less than ±10% of fullscale indication.

Battery Complement: Three 1.3 volt batteries (mercury cells), six 22½ volt batteries.

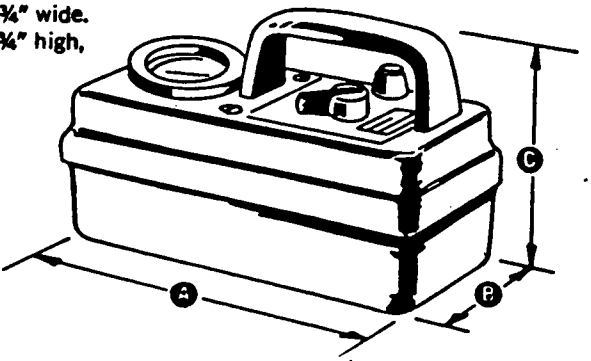
Battery Life: Over 250 hours on 1.3 volt supply. Over 500 hours on 22½ volt supply.

Net Weight: 5 pounds.

Shipping Weight and Volume: 10 pounds; 2.5 cu. ft.

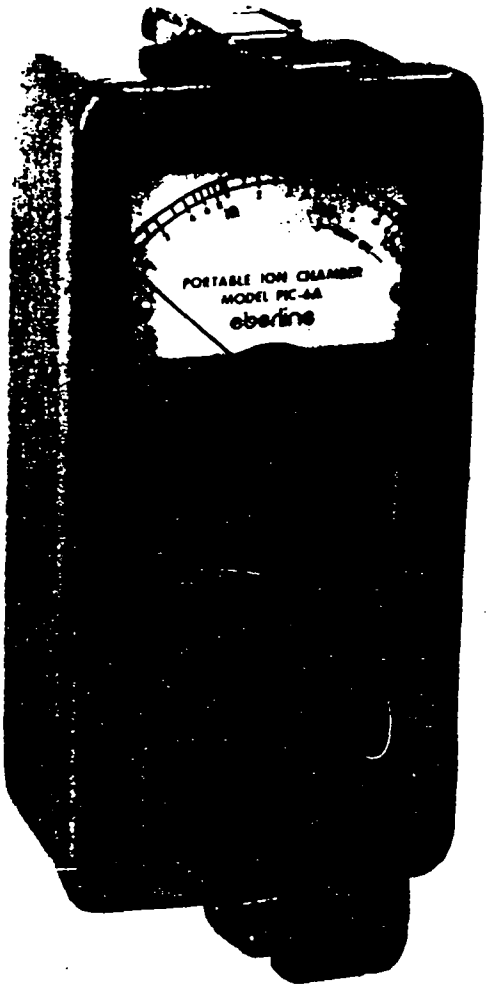
Overall Dimensions:

A 10" long.
B 4¾" wide.
C 6¾" high,



4/81

Portable Ion Chamber
Model PIC-6A



GUARDED GAS FILLED ION CHAMBER REDUCES SENSITIVITY TO HUMIDITY

GAMMA EXPOSURE RATE MEASUREMENT

NO WARM-UP TIME, FAST RESPONSE

LARGE METER DISPLAY

SIX DECADES OF READOUT

SMALL, LIGHTWEIGHT, RUGGED

eberline

PIC-6A

Portable Ion Chamber, Model PIC-6A

GENERAL DESCRIPTION

The Model PIC-6A is a small, lightweight portable instrument which measures exposure rate from gamma radiation. The detecting element is a gas filled ionization chamber operating in the proportional (gas multiplication) region. Six decades, from 1 mR/hr to 1000 R/hr, are measured in two ranges of three decades each. A single rotary switch turns the instrument OFF, provides a BATTery check, and selects the range. A beta window in the bottom of the instrument provides for the detection of energetic beta particles.

SPECIFICATIONS

DETECTOR

Wall: 30 mg/cm^2 stainless steel.

Active Volume: 0.46 inch i.d. x 4.0 inch length=0.66 inch^3 (11 cm^3).

Gas Filling: Pure grade propane to approximately 60 cm Hg pressure.

Photon Energy Response: Nominal ±10% from 60 keV to 1.3 MeV (see curve below). Guarded insulator greatly reduces effects of humidity and leakage.

INDICATOR

Scale Length: 3 inches (7.6 cm).

Scale Marking: Three decades: 1 to 10, 10 to 100 and 100 to 1000, with 10 increments per decade.

Range: Switch selected "mR/hr" or "R/hr," yielding continuous coverage from 1 mR/hr to 1000 R/hr.

Response Time: R/hr range – essentially instantaneous. mR/hr range – approximately 2 seconds for increasing reading, approximately 3 seconds per decade for decreasing reading.

Linearity: Within ±20% of reading.

Battery Dependence: Calibration shifts less than 20% of reading with battery voltage change from 9 to 6.5 V (new battery to end point).

BATTERIES

Two each miniature NEDA type 1604 with voltage between 6.5 and 9 V.

Life: Variable depending on cell type, age and temperature. Nominal life with new batteries near room temperature is: CZn – 60 hours, alkaline – 60 hours, mercury – 120 hours.

ENVIRONMENTAL

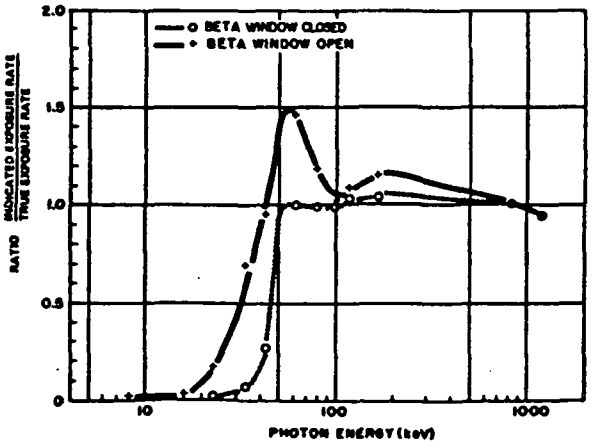
Temperature: Operational from -10°F to +140°F (-23°C to 60°C). Typically the reading shift is less than 0.5% of reading per °F (0.9% per °C).

RF Sensitivity: Reading unaffected by pulsed or continuous radar fields up to 20 mW/cm^2.

MECHANICAL

Dimensions: 8-3/8 inches long x 4 inches wide x 5-5/8 inches high (21.3 x 10.2 x 14.3 cm), including handle.

Weight: 3-1/4 pounds (1.48 kg), with mercury batteries.

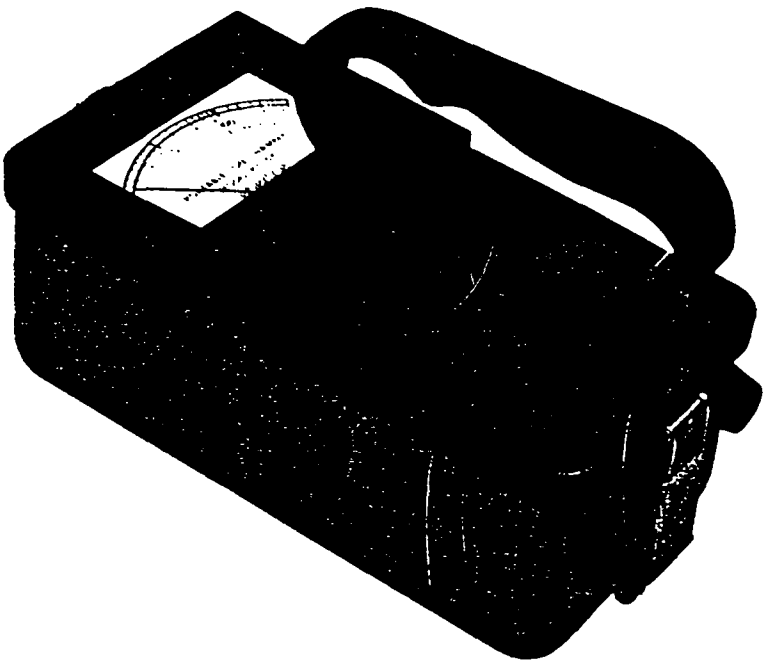


TYPICAL PHOTON ENERGY RESPONSE OF THE MODEL PIC-6A

eberline P.O. Box 2108, Santa Fe, New Mexico 87501 (505) 471-3232 TWX:910-985-0678

Portable Ion Chamber

Model PIC-6B



- PRESSURIZED ION CHAMBER
- NO WARM-UP TIME
- SIX-DECADE DISPLAY
- MEASURES GAMMA EXPOSURE RATE

Eberline

A DIVISION OF Thermo Electron CORPORATION

PIC-6B

Model PIC-6B, Portable Ion Chamber

GENERAL DESCRIPTION

The PIC-6B is a small, lightweight, portable instrument which measures exposure rate from gamma radiation over a six-decade range. The detector is a pressurized ion chamber operating in the proportional (gas multiplication) region.

Recent testing has proven the PIC-6B to be an excellent emergency response unit in areas where radioactive gas may be present. The sealed ion chamber precludes radioactive gas contamination inside the chamber.

While the unit has a beta window, Eberline does not recommend the PIC-6B for beta measurements. Gamma or X-ray measurements should be made with the beta window closed.

SPECIFICATIONS

Range: 1 mR/h to 1000 R/h

Detector: Pressurized ion chamber, 0.66 in^3 (11 cm^3) active volume, 30 mg/cm^2 stainless steel wall, pressurized to 60 cm Hg with propane

Linearity: ± 20 percent reading

Energy Response: See curve

Response Time: R/h range 1 second, mR/h range 2 seconds

Battery Complement: Two NEDA 1604 9 V

Battery Life: Nominal 60 hours with C-Zn or alkaline

Temperature: Operational from -9 °F to 140 °F (-23 °C to 60 °C)

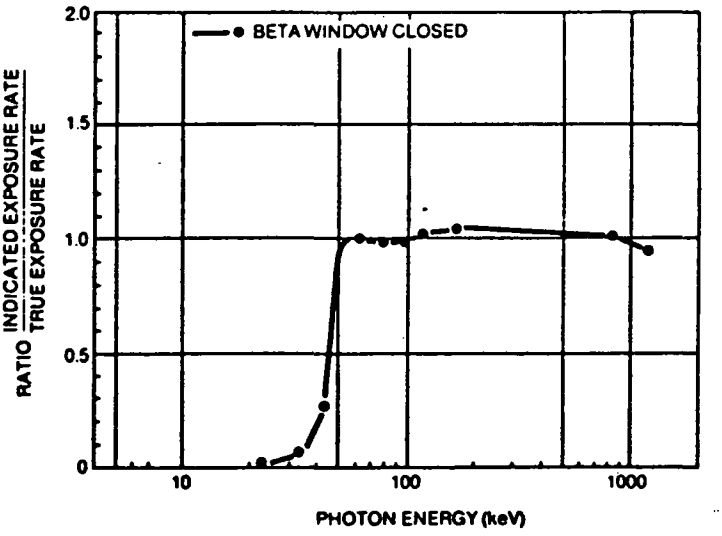
Dimensions: 8¾ inches long × 4 inches wide × 5⅝ inches high (including handle) (21.3 cm × 10.2 cm × 14.3 cm)

Weight: 3.25 pounds (1.47 kg)

RF Sensitivity: Reading not affected in pulsed or continuous RF fields up to 20 mW/cm^2

AVAILABLE ACCESSORIES

Radioactive Check Source: CS-7A, ^{137}Cs gamma check source



TYPICAL PHOTON ENERGY RESPONSE OF THE MODEL PIC-6B

Eberline — A DIVISION OF Thermo Electron CORPORATION

P.O. Box 2108
Santa Fe, New Mexico 87504-2108
(505) 471-3232 TWX: 910-985-0678

dosimeter

SuperDAD®

Digital Alarm Dosimeter

SuperDAD is designed to help the Health Physicist keep worker exposures As Low As Reasonably Achievable (ALARA*), wherever a risk of high radiation exposure exists.

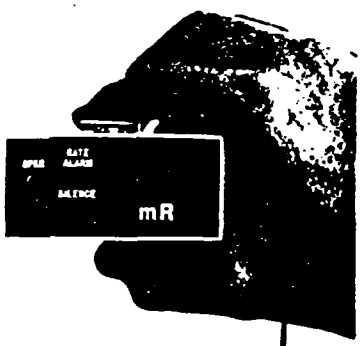
SuperDAD features:

- Dose alarm that controls radiation exposure from 10-9990 mR (0.1-99.9mSv).
- Rate alarm that prevents unauthorized, or unknown exposure to radiation levels of 100 mR/hr. to 900 mR/hr. and 1 R/hr. to 9 R/hr (1-9mSv and 10-90mSv).
- Audible 1 chirp/mR (1 per 0.01mSv) warning ensures exposure awareness.
- Controls are inside of case, where they cannot be accidentally changed.
- Preset dose alarm which, when activated, requires resetting by knowledgeable person; ensures total exposure for any procedure will not be accidentally exceeded.

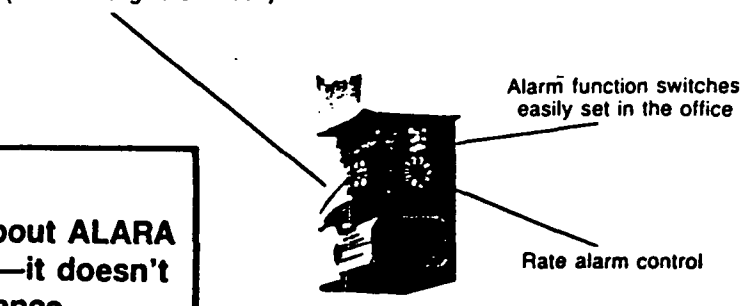
- Separate control of "memory" and "on-off" functions so data is not lost when turning instrument off.

SuperDAD®

Models
1888
1888Sv



HP's concerned about ALARA specify SuperDAD—it doesn't leave things to chance.



*Meets ANSI N13.27 requirements
Meets NRC Reg. Guide 8.28 requirements

dosimeter

DOSIMETER CORPORATION
11286 Grooms Road/P.O. Box 42377/Cincinnati, Ohio 45242

SPECIFICATIONS

I. RADIATION DETECTED

Gamma and X-Ray

OPERATING CHARACTERISTICS

Accuracy

±20% referred to ^{137}Cs

Energy Dependence: ±30% from 60 KeV to 1.25 MeV

Rate Dependence: Above 10R/hr some decrease in accuracy occurs

Operating Ranges

Model	Range
1888	0-9999 mR
1888Sv	0-99.99 mSv

Exposure Rate Limit

(Saturation) >10,000R/hr (100Sv/hr) (see "Rate Dependence" above)

Environmental Conditions

Temperature Range: −20°C to 50°C

Temperature Dependence: (ΔR vs. Temp.: 0.7% average)

Relative Humidity Range: 0-95%

Alarm Trip Point

Total exposure: 10mR-9900 mR; 0.1mSv-99mSv
Exposure rate: 100 mR/hr to 9R/hr; 1mSv-90mSv

III. PHYSICAL CHARACTERISTICS

Detector Type

Halogen Quenched, Energy Compensated G-M Tube (Model 1-5318)

Detector Operating Voltage

550 V

Readout

Visual: 4-Digit LCD

Audio: 75 dBa at 30 cm, 1 chirp per mR (or 1 per 0.01 mSv) accumulated

Controls

On-off, Memory, Alarm set, Calibration—all protected inside case; opening in case so "on-off" switch can be operated with special tool.

Power

Batteries: Primary: One 9V Transistor, NEDA type 1604
Backup: Two 1.5V Silver Oxide

Battery Dependence: Primary battery life: 200 hrs. in a 10mR/hr field, Backup battery life >8 hrs.

Mechanical

Case: Extruded Aluminum
Finish: Anodized
Dimensions:
- Width: 2.7" (6.9cm)
- Length: 5.7" (14.5cm)
- Thickness: 1.3" (3.0cm)

Net Weight: 10.6 oz. (300gm) without battery
Shipping Weight: 16 oz. (454gm)

Accessories Included

Earphone
Carrying case
On-off tool

1/83 Printed in U S A

Distributed by:

U.S. NUCLEAR REGULATORY COMMISSION

July 1981

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 8.29
(Task OH 902-4)

INSTRUCTION CONCERNING RISKS FROM OCCUPATIONAL RADIATION EXPOSURE

A. INTRODUCTION

Section 19.12 of 10 CFR Part 19, "Notices, Instructions and Reports to Workers; Inspections," requires that all persons working in or frequenting any portion of a restricted area be instructed in the health protection problems associated with exposure to radioactive materials or radiation. This guide describes the instruction that should be provided to the worker concerning biological risks from occupational radiation exposure. Additional guides are being or will be developed to address other aspects of radiation protection training.

B. DISCUSSION

It is generally accepted by the scientific community that exposure to ionizing radiation can cause biological effects that are harmful to the exposed organism. These effects are classified into three categories:

Somatic Effects: Effects occurring in the exposed person that, in turn, may be divided into two classes:

Prompt effects that are observable soon after a large or acute dose (e.g., 100 rems[1] or more to the whole body in a few hours), and

Delayed effects such as cancer that may occur years after exposure to radiation.

Genetic Effects:[2] Abnormalities that may occur in the future children of exposed individuals and in subsequent generations.

Teratogenic Effects: Effects that may be observed in children who were exposed during the fetal and embryonic stages of development.

Concerns about these biological effects have resulted in controls on doses to individual workers and in efforts to control the collective dose (person-rems) to the worker population.

NRC-licensed activities result in a significant fraction of the total occupational radiation exposure in the United States. Regulatory action has recently focused more attention on maintaining occupational radiation exposure at levels that are as low as is reasonably achievable (ALARA). Radiation protection training for all workers who may be exposed to ionizing radiation is an essential component of any program designed to maintain exposure levels ALARA. A clear understanding of what is presently known about the biological risks associated with exposure to radiation will result in more effective radiation protection training and should generate more interest on the part of the worker in minimizing both individual and collective doses. In addition, radiation workers have the right to whatever information on radiation risk is available to enable them to make informed decisions regarding the acceptance of these risks. It is intended that workers who receive this instruction develop a healthy respect for the risks involved rather than excessive fear or indifference.

At the relatively low levels of occupational radiation exposure in the United States, it is difficult to demonstrate a relationship between exposure and effect. There is considerable uncertainty and controversy regarding estimates of radiation risk. In the appendix to this guide, a range of risk estimates is provided (see Table 1). Information on radiation risk has been included from such sources as the 1980 National Academy of Sciences' Report of the Committee on the Biological Effects of Ionizing Radiation (BEIR-80), the International Commission on Radiological Protection (ICRP) Publication 27 entitled "Problems in Developing an Index of Harm," the 1979 report of the science work group of the Interagency Task Force on the Health Effects of Ionizing Radiation, the 1977 report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR report), and numerous published articles (see the bibliography to the appendix).

[1] In the International System of Units (SI), the rem is replaced by the sievert. 100 rems is equal to 1 sievert (Sv).

[2] Genetic effects exceeding normal incidence have not been observed in any of the studies of exposed humans.

APPENDIX TO REGULATORY GUIDE 8.29

INSTRUCTION CONCERNING RISKS FROM OCCUPATIONAL RADIATION EXPOSURE

This instructional material is intended to provide the user with the best available information concerning what is currently known about the health risks from exposure to ionizing radiation.[1] A question and answer format has been used. The questions were developed by the NRC staff in consultation with workers, union representatives, and licensee representatives experienced in radiation protection training. Risk estimates have been compiled from numerous sources generally recognized as reliable. A bibliography is included for the user interested in further study.

The biological effects that are known to occur after exposure to high doses (hundreds of rems[2]) of radiation are discussed early in the document; discussions of the estimated risks from the low occupational dose (<5 rems per year) follow. It is intended that this information will help develop an attitude of healthy respect for the risks associated with radiation, rather than unnecessary fear or lack of concern. Additional guidance is being or will be developed concerning other topics in radiation protection training.

* * * * * * *

1. What is meant by risk?

Risk can be defined in general as the probability (chance) of injury, illness, or death resulting from some activity. However, the perception of risk is affected by how the individual views its probability and its severity. The intent of this document is to provide estimates of and explain the basis for possible risk of injury, illness, or death resulting from occupational radiation exposure. (See Questions 9 and 10 for estimates of radiation risk and comparisons with other types of risk.)

2. What are the possible health effects of exposure to radiation?

Some of the health effects that exposure to radiation may cause are cancer (including leukemia), birth defects in the future children of exposed parents, and cataracts.[3] These effects (with the exception of genetic effects) have been observed in studies of medical radiologists, uranium miners, radium workers, and radiotherapy patients who have received large doses of radiation. Studies of people exposed to radiation from atomic weapons have also provided data on radiation effects. In addition, radiation effects studies with laboratory animals have provided a large body of data on radiation-induced health effects, including genetic effects.

The observations and studies mentioned above, however, involve levels of radiation exposure that are much higher (hundreds of rems) than those permitted occupationally today (<5 rems per year). Although studies have not shown a cause-effect relationship between health effects and current levels of occupational radiation exposure, it is prudent to assume that some health effects do occur at the lower exposure levels.

3. What is meant by prompt effects, delayed effects, and genetic effects?

a. Prompt effects are observable shortly after receiving a very large dose in a short period of time. For example, a whole-body[4] dose of 450 rems (90 times the annual dose limit for routine occupational exposure) in an hour to an average adult will cause vomiting and diarrhea within a few hours; loss of hair, fever, and weight loss within a few weeks; and about a 50 percent chance of death within 60 days without medical treatment.

b. Delayed effects such as cancer may occur years after exposure to radiation.

c. Genetic effects can occur when there is radiation damage to the genetic material. These effects may show up as birth defects or other conditions in the future children of the exposed individual and succeeding generations, as demonstrated in animal experiments. However, excess genetic effects clearly caused by radiation have not been observed in human populations exposed to radiation. It has been observed, however, that radiation can change the genes in cells of the human body. Thus, the possibility exists that genetic effects can be caused in humans by low doses even though no direct evidence exists as yet.

4. In worker protection, which effects are of most concern to the NRC?

The main concern to the NRC is the delayed incidence of cancer. The chance of delayed cancer is believed to depend

[1] Ionizing radiation consists of energy or small particles such as gamma, beta, or alpha radiation emitted from radioactive materials which, when absorbed by living tissue, can cause chemical and physical damage.

[2] The rem is the unit of measure for radiation dose and relates to the biological effect of the absorbed radiation.

[3] Cataracts differ from other radiation effects in that a certain level of dose to the lens of the eye (~200 rems) is required before they are observed.

[4] It is important to distinguish between whole-body and partial-body exposure. 100 rems to the whole body will have more effect than 100 to a hand. For example, exposure of a hand would affect a small fraction of the bone marrow and a limited portion of the skin.

on how much radiation exposure a person gets; therefore, every reasonable effort should be made to keep exposures low.

Immediate or prompt effects are very unlikely since large exposures would normally occur only if there were a serious radiation accident. Accident rates in the radiation industry have been low, and only a few accidents have resulted in exposures exceeding the legal limits. The probability of serious genetic effects in the future children of workers is estimated in the BEIR[5] report, based on animal studies, at less than one-third that of delayed cancer (5-65 genetic effects per million rems compared to 160-450 cancer cases). A clearer understanding of the cause-effect relationship between radiation and human genetic effects will not be possible until additional research studies are completed.

5. What is the difference between acute and chronic exposure?

Acute radiation exposure, which causes prompt effects and may also cause delayed effects, usually refers to a large dose of radiation received in a short period of time; for example, 450 rems received within a few hours or less. The effects of acute exposures are well known from studies of radiotherapy patients, some of whom received whole-body doses; atomic bomb victims; and the few accidents that have occurred in the early days of atomic weapons and reactor development, industrial radiography, and nuclear fuel processing. There have been few occupational incidents that have resulted in large exposures. NRC data indicate that, on the average, 1 accidental overexposure in which any acute symptoms are observed occurs each year. Most of these occur in industrial radiography and involve exposures of the hands rather than the whole body.

Chronic exposure, which may cause delayed effects but not prompt effects, refers to small doses received repeatedly over long time periods; for example, 20-100 mrem (a mrem is one-thousandth of a rem) per week every week for several years. Concern with occupational radiation risk is primarily focused on chronic exposure to low levels of radiation over long time periods.

6. How does radiation cause cancer?

How radiation causes cancer is not well understood. It is impossible to tell whether a given cancer was caused by radiation or by some other of the many apparent causes. However, most diseases are caused by the interaction of several factors. General physical condition, inherited traits, age, sex, and exposure to other cancer-causing agents such as cigarette smoke are a few possible contributing factors. One theory is that radiation can damage chromosomes in a cell, and the cell is then directed along abnormal growth patterns. Another is that radiation reduces the body's normal resistance to existing viruses which can then multiply and damage cells. A third is that radiation activates an existing virus in the body which then attacks normal cells causing them to grow rapidly.

What is known is that, in groups of highly exposed people, a higher than normal incidence of cancer is observed. Higher than normal rates of cancer can also be produced in laboratory animals by high levels of radiation. An increased incidence of cancer has not been demonstrated at radiation levels below the NRC limits.

7. If I receive a radiation dose, does that mean I am certain to get cancer?

Not at all. Everyone gets a radiation dose every day (see Question 25), but most people do not get cancer. Even with doses of radiation far above legal limits, most individuals will experience no delayed consequences. There is evidence that some radiation damage can be repaired. The danger from radiation is much like the danger from cigarette smoke. Only a fraction of the people who breathe cigarette smoke get lung cancer, but there is good evidence that smoking increases a person's chances of getting lung cancer. Similarly, there is evidence that the larger the radiation dose, the larger the increase in a person's chances of getting cancer.

Radiation is like most substances that cause cancer in that the effects can be seen clearly only at high doses. Estimates of the risks of cancer at low levels of exposure are derived from data available for exposures at high dose levels and high dose rates. Generally, for radiation protection purposes these estimates are made using the linear model (Curve 1 in Figure 1). We have data on health effects at high doses as shown by the solid line in Figure 1. Below about 100 rems, studies have not been able to accurately measure the risk, primarily because of the small numbers of exposed people and because the effect is small compared to differences in the normal incidence from year to year and place to place. Most scientists believe that there is some degree of risk no matter how small the dose (Curves 1 and 2). Some scientists believe that the risk drops off to zero at some low dose (Curve 3), the threshold effect. A few believe that risk levels off so that even very small doses imply a significant risk (Curve 4). The majority of scientists today endorse either the linear model (Curve 1) or the linear-quadratic model (Curve 2). The NRC endorses the linear model (Curve 1), which shows the number of effects decreasing as the dose decreases, for radiation protection purposes.

It is prudent to assume that smaller doses have some chance of causing cancer. This is as true for natural cancer-causers such as sunlight and natural radiation as it is for those that are man made such as cigarette smoke, smog, and man-made radiation. As even very small doses may entail some small risk, it follows that no dose should be taken without a reason. Thus, a principle of radiation protection is to do more than merely meet the allowed regulatory

[5]The National Academy of Sciences established a committee on the Biological Effects of Ionizing Radiation (BEIR) whose 1980 report on the effects on populations of exposure to low levels of ionizing radiation provides much of the background for this guide.

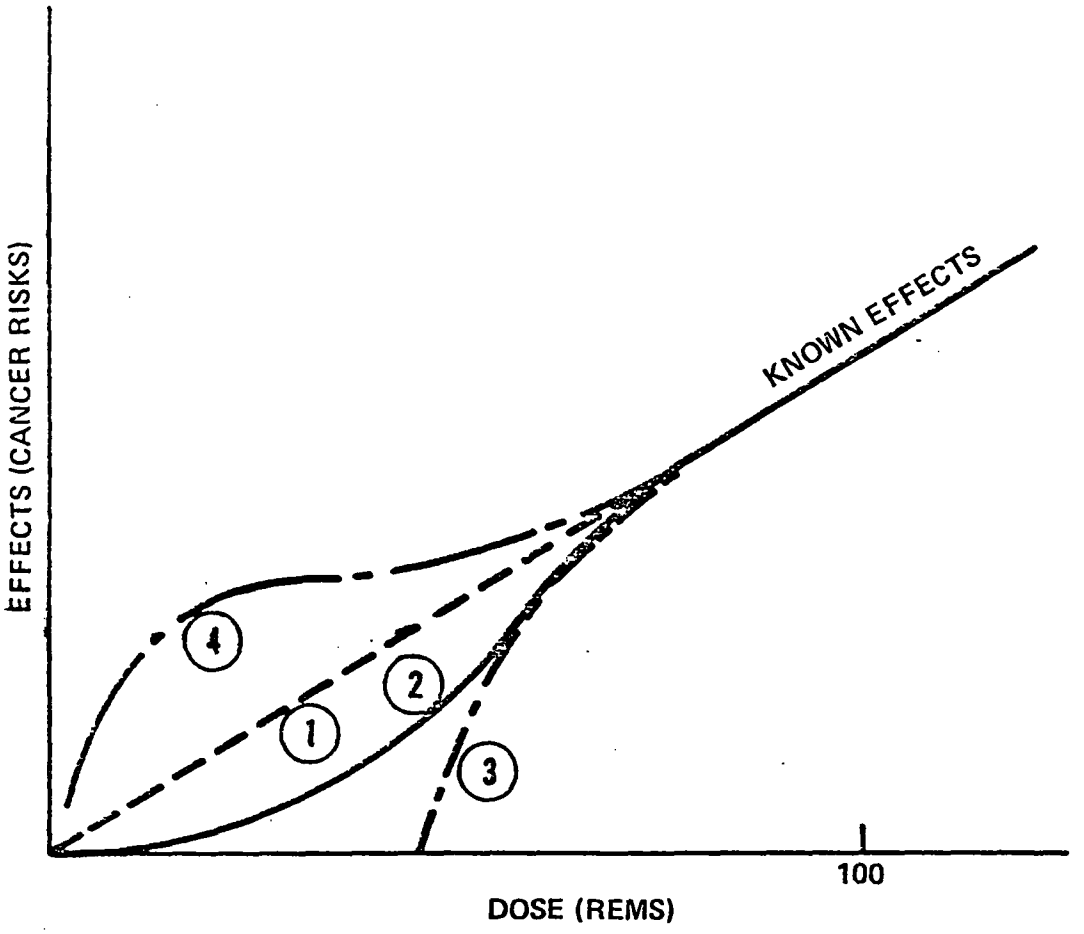


Figure 1. Some proposed models for how the effects of radiation vary with doses at low levels.

limits: doses should be kept as low as is reasonably achievable (ALARA).

We don't know exactly what the chances are of getting cancer from a low-level radiation dose, but we can make estimates based on extensive scientific knowledge. The estimates of radiation risks are at least as reliable as estimates for the effects from any chemical hazard. Being exposed to typical occupational radiation doses is taking a chance, but that chance is reasonably well understood.

It is important to understand the probability factors here. A similar question would be: If you select one card from a full deck, will you get the ace of spades? This question cannot be answered with a simple yes or no. The best answer is that your chances are 1 in 52. However, if 1000 people each select one card from full decks, we can predict that about 20 of them will get an ace of spades. Each person will have 1 chance in 52 of drawing the ace of spades, but there is no way that we can predict which persons will get the right card. The issue is further complicated by the fact that in 1 drawing by 1000 people, we might get only 15 successes and in another perhaps 25 correct cards in 1000 draws. We can say that if you receive a radiation dose, you will have increased your chances of eventually developing cancer. It is assumed that the more radiation exposure you get, the more you increase your chances of cancer.

Not all workers incur the same level of risk. The radiation risk incurred by a worker depends on the amount of dose received. Under the linear model explained above, a worker who receives 5 rems in a year incurs 10 times as much risk as another worker (the same age) who receives only 0.5 rem. The risk depends not only on the amount of dose, but also on the age of the worker at the time the dose is received. This age difference is due, in part, to the fact that a young worker has more time to live than an older worker, and the risk is believed to depend on the number of years of life following the dose. The more years left, the larger the risk. It should be clear that, even within the regulatory dose limits, the risk may vary a great deal from one worker to another. Fortunately, only a very few workers receive doses near 5 rems per year; as pointed out in the answer to Question 19, the average annual dose for all radiation workers is less than 0.5 rem.

A reasonable comparison involves exposure to the sun's rays. Frequent short exposures provide time for the skin to repair. An acute exposure to the sun can result in painful burning, and excessive exposure has been shown to cause skin cancer. However, whether exposure to the sun's rays is short term or spread over time, some of the injury is not repaired and may eventually result in skin cancer.

The effect upon a group of workers occupationally exposed to radiation may be an increased incidence of cancer over and above the number of cancers that would normally be expected in that group. Each exposed individual has an increased probability of incurring subsequent cancer. We can say that if 10,000 workers each receive an additional 1 rem in a year, that group is more likely to have a larger incidence of cancer than 10,000 people who do not receive the additional radiation. An estimate of the increased probability of cancer from low radiation doses delivered to large groups is one measure of occupational risk and is discussed in Question 9.

8. What groups of expert scientists have studied the risk from exposure to radiation?

In 1956, the National Academy of Sciences established advisory committees to consider radiation risks. The first of these was the Advisory Committee on the Biological Effects of Atomic Radiations (BEAR) and more recently it was renamed the Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR). These committees have periodically reviewed the extensive research being done on the health effects of ionizing radiation and have published estimates of the risk of cancer from exposure to radiation (1972 and 1980 BEIR reports). The International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurement (NCRP) are two other groups of scientists who have studied radiation effects and published risk estimates (ICRP Publication 26, 1977). These two groups have no government affiliation. In addition, the United Nations established an independent study group that published an extensive report in 1977, including estimates of cancer risk from ionizing radiation (UNSCEAR, 1977).

Several individual research groups or scientists such as Alice Stewart, E.S. Gilbert, T.F. Mancuso, T.W. Anderson, to name a few, have published studies concerning low-level radiation effects. The bibliography to this appendix includes several articles for the reader who wishes to do further study. The BEIR-80 report includes analysis of the work of many independent researchers.

9. What are the estimates of the risk of cancer from radiation exposure?

The cancer risk estimates (developed by the organizations identified in Question 8) are presented in Table 1.

In an effort to explain the significance of these estimates, we will use an approximate average of 300 excess cancer cases per million people, each exposed to 1 rem of ionizing radiation. If in a group of 10,000 workers each receives 1 rem, we could estimate that three would develop cancer because of that exposure, although the actual number could be more or less than three.

TABLE 1

Estimates of Excess Cancer Incidence from Exposure to Low-Level Radiation

Source	Number of Additional[a] Cancers Estimated to Occur in 1 Million People After Exposure of Each to 1 Rem of Radiation
BEIR, 1980	160-450[b]
ICRP, 1977	200
UNSCEAR, 1977	150-350

[a] Additional means above the normal incidence of cancer.

[b] All three groups estimated premature deaths from radiation-induced cancers. The American Cancer Society has recently stated that only about one-half of all cancer cases are fatal. Thus, to estimate incidence of cancer, the published numbers were multiplied by 2. Note that the three groups are in close agreement on the risk of radiation-induced cancer.

The American Cancer Society has reported that approximately 25 percent of all adults in the 20- to 65-year age bracket will develop cancer at some time from all possible causes such as smoking, food, alcohol, drugs, air pollutants, and natural background radiation. Thus in any group of 10,000 workers not exposed to radiation on the job, we can expect about 2,500 to develop cancer. If this entire group of 10,000 workers were to receive an occupational radiation dose of 1 rem each, we could estimate that three additional cases might occur which would give a total of about 2,503. This means that a 1-rem dose to each of 10,000 workers might increase the cancer rate from 25 percent to 25.03 percent, an increase of about 3 hundredths of one percent.

As an individual, if your cumulative occupational radiation dose is 1 rem, your chances of eventually developing cancer during your entire lifetime may have increased from 25 percent to 25.03 percent. If your lifetime occupational dose is 10 rems, we could estimate a 25.3 percent chance of developing cancer. Using a simple linear model, a lifetime dose of 100 rems may have increased your chances of cancer from 25 to 28 percent.

The normal chance of developing cancer if you receive no occupational radiation dose is about equal to your chance of getting any spade on a single draw from a full deck of playing cards, which is one chance out of four. The additional chance of developing cancer from an occupational exposure of 1 rem is less than your chances of drawing an ace from a full deck of cards three times in a row.

Since cancer resulting from exposure to radiation usually occurs 5 to 25 years after the exposure and since not all cancers are fatal, another useful measure of risk is years of

life expectancy lost on the average from a radiation-induced cancer. It has been estimated in several studies that the average loss of life expectancy from exposure to radiation is about 1 day per rem of exposure. In other words, a person exposed to 1 rem of radiation may, on the average, lose 1 day of life. The words "on the average" are important, however, because the person who gets cancer from radiation may lose several years of life expectancy while his coworkers suffer no loss. The ICRP estimated that the average number of years of life lost from fatal industrial accidents is 30 while the average number of years of life lost from a fatal radiation-induced cancer is 10. The shorter loss of life expectancy is due to the delayed onset of cancer.

It is important to realize that these risk numbers are only estimates. Many difficulties are involved in designing research studies that can accurately measure the small increases in cancer cases due to low exposures to radiation as compared to the normal rate of cancer. There is still uncertainty and a great deal of controversy with regard to estimates of radiation risk. The numbers used here result from studies involving high doses and high dose rates, and they may not apply to doses at the lower occupational levels of exposure. The NRC and other agencies both in the United States and abroad are continuing extensive long-range research programs on radiation risk.

Some members of the National Academy of Sciences BEIR Advisory Committee and others feel that risk estimates in Table 1 are higher than would actually occur and represent an upper limit on the risk. Other scientists believe that the estimates are low and that the risk could be higher. However, these estimates are considered by the NRC staff to be the best available that the worker can use to make an informed decision concerning acceptance of the risks associated with exposure to radiation. A worker who decides to accept this risk should make every effort to keep exposure to radiation ALARA to avoid unnecessary risk. The worker, after all, has the first line responsibility for protecting himself from radiation hazards.

10. How can we compare radiation risk to other kinds of health risks?

Perhaps the most useful unit for comparison among health risks is the average number of days of life expectancy lost per unit of exposure to each particular health risk. Estimates are calculated by looking at a large number of persons, recording the age when death occurs from apparent causes, and estimating the number of days of life lost as a result of these early deaths. The total number of days of life lost is then averaged over the total group observed.

Several studies have compared the projected loss of life expectancy resulting from exposure to radiation with other health risks. Some representative numbers are presented in Table 2.

These estimates indicate that the health risks from occupational radiation exposure are smaller than the risks associated with many other events or activities we encounter and accept in normal day-to-day activities.

TABLE 2

Estimated Loss of Life Expectancy from Health Risks[a]

Health Risk	Estimates of Days of Life Expectancy Lost, Average
Smoking 20 cigarettes/day	2370 (6.5 years)
Overweight (by 20%)	985 (2.7 years)
All accidents combined	435 (1.2 years)
Auto accidents	200
Alcohol consumption (U.S. average)	130
Home accidents	95
Drowning	41
Natural background radiation, calculated	8
Medical diagnostic x-rays (U.S. average), calculated	6
All catastrophes (earthquake, etc.)	3.5
1 rem occupational radiation dose, calculated (industry average for the higher-dose job categories is 0.65 rem/yr)	1
1 rem/yr for 30 years, calculated	30

[a]Adapted from Cohen and Lee, "A Catalogue of Risks," *Health Physics*, Vol. 36, June 1979.

A second useful comparison is to look at estimates of the average number of days of life expectancy lost from exposure to radiation and from common industrial accidents at radiation-related facilities and to compare this number with days lost from other occupational accidents. Table 3 shows average days of life expectancy lost as a result of fatal work-related accidents. Note that the data for occupations other than radiation related do not include death risks from other possible hazards such as exposure to toxic chemicals, dusts, or unusual temperatures. Note also that the unlikely occupational exposure at 5 rems per year for 50 years, the maximum allowable risk level, may result in a risk comparable to the average risks in mining and heavy construction.

Industrial accident rates in the nuclear industry and related occupational areas have been relatively low during the entire history of the industry (see Table 4). This is believed to be due to the early and continuing emphasis on tight safety controls. The relative safety of various occupational areas can be seen by comparing the probability of death by accident per 10,000 workers over a 40-year working lifetime. These figures do not include death from possible causes such as exposure to toxic chemicals or radiation.

11. Can a worker become sterile or impotent from occupational radiation exposure?

Observation of radiation therapy patients who receive localized exposures, usually spread over a few weeks, has

TABLE 3

Estimated Loss of Life Expectancy from Industrial Hazards[a]

Industry Type	Estimates of Days of Life Expectancy Lost, Average
All industry	74
Trade	30
Manufacturing	43
Service	47
Government	55
Transportation and utilities	164
Agriculture	277
Construction	302
Mining and quarrying	328
Radiation accidents, death from exposure	<1
Radiation dose of 0.65 rem/yr (industry average) for 30 years, calculated	20
Radiation dose of 5 rems/yr for 50 years	250
Industrial accidents at nuclear facilities (nonradiation)	58

[a]Adapted from Cohen and Lee, "A Catalogue of Risk," *Health Physics*, Vol. 36, June 1979; and World Health Organization, *Health Implications of Nuclear Power Production*, December 1975.

TABLE 4

Probability of Accidental Death by Type of Occupation[a]

Occupation	Number of Accidental Deaths for 10,000 Workers for 40 Years
Mining	252
Construction	228
Agriculture	216
Transportation and public utilities	116
All industries	56
Government	44
Nuclear industry (1975 data excluding construction)	40
Manufacturing	36
Services	28
Wholesale and trade	24

[a]Adapted from National Safety Council, *Accident Facts*, 1979; and Atomic Energy Commission, *Operational Accidents and Radiation Exposure Experience*, WASH-1192, 1975.

shown that a dose of 500-800 rems to the gonads can produce permanent sterility in males or females (an acute whole-body dose of this magnitude would probably result in death within 60 days). An acute dose of 20 rems to the testes can result in a measurable but temporary reduction in sperm count. Such high exposures on the job could result only from serious and unlikely radiation accidents. Although high doses of radiation can affect fertility, they have no effect on the ability to function sexually. Likewise, exposure to permitted occupational levels of radiation has no observed effect on fertility and also has no effect on the ability to function sexually.

12. What are the NRC external radiation dose limits?

Federal regulations currently limit occupational external whole-body radiation dose to 1¼ rems in any calendar quarter or specified 3-month period. However, when there is documented evidence that a worker's previous occupational dose is low enough, a licensee may permit a dose of up to 3 rems per quarter or 12 rems per year. The accumulated dose may not exceed 5(N-18) rems[6] where N is the person's age in years, i.e., the lifetime occupational dose may not exceed an average of 5 rems for each year above the age of 18.

An additional whole-body dose of approximately 5 rems per year is permitted from internal exposure. (See Question 28.)

13. What is meant by ALARA?

In addition to providing an upper limit on a person's permissible radiation exposure, the NRC also requires that its licensees maintain occupational exposures as far below the limit as is reasonably achievable (ALARA). This means that every activity at a nuclear facility involving exposure to radiation should be planned so as to minimize unnecessary exposure to individual workers and also to the worker population. A job that involves exposure to radiation should be scheduled only when it is clear that the benefit justifies the risks assumed. All design, construction, and operating procedures should be reviewed with the objective of reducing unnecessary exposures.

14. Has the ALARA concept been applied if, instead of reaching dose limits during the first week of a quarter, the worker's dose is spread out over the whole quarter?

No. For radiation protection purposes, the risk of cancer from low doses is assumed to be proportional to the amount of exposure, not the rate at which it is received. Thus it is assumed that spreading the dose out over time or over larger numbers of people does not reduce the overall risk. The ALARA concept has been followed only when the individual and collective doses are reduced by reducing the time of exposure or decreasing radiation levels in the

[6]The NRC has published a proposed rule change for public comment that would eliminate the 5(N-18) formula. This proposal is currently under consideration by a task force reviewing all of 10 CFR Part 20. Recent EPA guidance recommends eliminating the 5(N-18) formula. If adopted, the maximum allowed annual dose will be 5 rems rather than 12.

individual and collective doses are reduced by reducing the time of exposure or decreasing radiation levels in the working environment.

15. What is meant by collective dose and why should it be maintained ALARA?

Nuclear industry activities expose an increasing number of people to occupational radiation in addition to the radiation doses they receive from natural background radiation and medical radiation exposures. The collective occupational dose (person-rems) is the sum of all occupational radiation exposure received by all the workers in an entire worker population. For example, if 100 workers each receive 2 rems, the individual dose is 2 rems and the collective dose is 200 person-rems. The total additional risk of cancer and genetic effects in an exposed population is assumed to depend on the collective dose.

It should be noted that, from the viewpoint of risk to a total population, it is the collective dose that must be controlled. For a given collective dose, the number of health effects is assumed to be the same even if a larger number of people share the dose. Therefore, spreading the dose out may reduce the individual risk, but not that of the population.

Efforts should be made to maintain the collective dose ALARA so as not to unnecessarily increase the overall population incidence of cancer and genetic effects.

16. Is the use of extra workers a good way to reduce risks?

There is a "yes" answer to this question and a "no" answer. For a given job involving exposure to radiation, the more people who share the work, the lower the average dose to an individual. The lower the dose, the lower the risk. So, for you as an individual, the answer is "yes."

But how about the risk to the entire group of workers? Under assumptions used by the NRC for purposes of protection, the risk of cancer depends on the total amount of radiation energy absorbed by human tissue, not on the number of people to whom this tissue belongs. Therefore, if 30 workers are used to do a job instead of 10, and if both groups get the same collective dose (person-rems), the total cancer risk is the same, and nothing was gained for the group by using 30 workers. From this viewpoint the answer is "no." The risk was not reduced but simply spread around among a larger number of persons.

Unfortunately, spreading the risk around often results in a larger collective dose for the job. Workers are exposed as they approach a job, while they are getting oriented to do the job, and as they withdraw from the job. The dose received during these actions is called nonproductive. If several crew changes are required, the nonproductive dose can become very large. Thus it can be seen that the use of extra workers may actually increase the total occupational dose and the resulting collective risks.

The use of extra workers to comply with NRC dose limits is not the way to reduce the risk of radiation-induced cancer for the worker population. At best, the total risk remains the same, and it may even be increased. The only way to reduce the risk is to reduce the collective dose; that can be done only by reducing the radiation levels, the working times, or both.

17. Why doesn't the NRC impose collective dose limits?

Compliance with individual dose limits can be achieved simply by using extra workers. However, compliance with a collective dose limit (such as 100 person-rems per year for a licensee) would require reduction of radiation levels, working times, or both. But there are many problems associated with setting appropriate collective dose limits.

For example, we might consider applying a single collective dose limit to all licensees. The selection of such a collective dose limit would be almost impossible because of the wide variations in collective doses among licensees. A power reactor could reasonably be expected to have an average annual collective dose of several hundred person-rems. However, a small industrial radiography licensee could very well have a collective dose of only a few person-rems in a year.

Even choosing a collective dose limit for a group of similar licensees would be almost as difficult. Radiography licensees as a group had an average collective dose in 1977 of 9 person-rems. However, the smallest collective dose for a radiography licensee was less than 1 person-rem, and the largest was 401 person-rems.

Setting a reasonable collective dose limit for each individual licensee would also be very difficult. It would require a record of all past collective doses on which to base such limits. Setting an annual collective dose limit would then amount to an attempt to predict a reasonable collective dose for each future year. In order to do this, it would be necessary to be able to predict changes in each licensed activity that would increase or decrease the collective dose. In addition, annual collective doses vary significantly from year to year according to the kind and amount of maintenance required, which cannot generally be predicted in advance. Following all such changes and revising limits up and down would be very difficult if not impossible. However, these efforts would be necessary if a collective dose limit were to be reasonable and help minimize doses and risks.

18. How are radiation dose limits established?

The NRC establishes occupational radiation dose limits based on guidance to Federal agencies from the Environmental Protection Agency (EPA) and, in addition, considers NCRP and ICRP recommendations. Scientific reviews of research data on biological effects such as the BEIR report are also considered.

For example, recent EPA guidance recommended that the annual whole-body dose limit be established at 5 rems per year and indicated that exposure, year after year, to 5 rems would involve a risk to a worker comparable to the average risks incurred by workers in the higher risk jobs

such as mining. In fact, few workers ever reach such a limit, much less year after year, and the risks associated with actual exposures are considered by the EPA to be comparable to the safer job categories. A 5-rem-per-year limit would allow occasional high dose jobs to be done without excessive risk.

19. What are the typical radiation doses received by workers?

The NRC requires that certain categories of licensees report data on annual worker doses and doses for all workers who leave employment with licensees. Data were received on the occupational doses in 1977 of approximately 100,000 workers in power reactors, industrial radiography, fuel processing and fabrication facilities, and manufacturing and distribution facilities. Of this total group, 85 percent received an annual dose of less than 1 rem; 95 percent received less than 2 rems; fewer than 1 percent exceeded 5 rems in 1 year. The average annual dose of those workers who were monitored and had measurable exposures was about 0.65 rem. A study completed by the EPA, using 1975 exposure data for 1,260,000 workers, indicated that the average annual dose for all workers who received a measurable dose was 0.34 rem.

Table 5 lists average occupational exposures for workers (persons who had measurable exposure above background levels) in various occupations, based on the 1975 data.

TABLE 5

U.S. Occupational Exposure Estimates[a]

Occupational Subgroup	Average Whole-Body Dose (millirems)	Collective Dose (person-rems)
Medicine	320	51,400
Industrial Radiography	580	5,700
Source Manufacturing	630	2,500
Power Reactors	760	21,400
Fuel Fabrication and Reprocessing	560	3,100
Uranium Enrichment	70	400
Nuclear Waste Disposal	920	100
Uranium Mills	380	760
Department of Energy Facilities	300	11,800
Department of Defense Facilities	180	10,100
Educational Institutions	206	1,500
Transportation	200	2,300

[a]Adapted from Cook and Nelson, *Occupational Exposures to Ionizing Radiation in the United States: A Comprehensive Summary for 1975*, Draft, Environmental Protection Agency.

20. What happens if a worker exceeds the quarterly exposure limit?

Radiation protection limits, such as 3 rems in 3 months, are not absolute limits below which it is safe and above which there is danger. Exceeding a limit does not imply that you have suffered an injury. A good comparison is with the highway speed limit, which is selected to limit accident risk and still allow you to get somewhere. If you drive at 75 mph, you increase your risk of an auto accident to levels that are not considered acceptable by the people who set speed limits, even though you may not actually have an accident. If a worker's radiation dose repeatedly exceeds 3 rems in a quarter, the risk of health effects could eventually increase to a level that is not considered acceptable to the NRC. Exceeding an NRC protection limit does not mean that any adverse health effects are going to occur. It does mean that a licensee's safety program has failed in some respect and that the NRC and the licensee should investigate to make sure the problems are corrected.

If an overexposure occurs, the regulations prohibit any additional occupational exposure to that person during the remainder of the calendar quarter in which the overexposure occurred. The licensee is required to file an overexposure report to the NRC and may possibly be subject to a fine, just as you are subject to a traffic fine for exceeding the speed limit. In both cases, the fines and, in some serious or repetitive cases, suspension of license are intended to encourage efforts to operate within the limits. The safest limits would be 0 mph and 0 rem per quarter. But then we wouldn't get anywhere.

21. Why do some facilities establish administrative limits that are below the NRC limits?

There are two reasons. First, the NRC regulations state that licensees should keep exposures to radiation ALARA. By requiring specific approval for worker doses in excess of set levels, more careful risk-benefit analysis can be made as each additional increment of dose is approved for a worker. Secondly, a facility administrative limit that is set lower than the quarterly NRC limit provides a safety margin designed to help the licensee avoid overexposures.

22. Several scientists have suggested that NRC limits are too high and should be lowered. What are the arguments for lowering the limits?

In general, those critical of present dose limits say that the individual risk is higher than is estimated by the BEIR Committee, the ICRP, and UNSCEAR. Based on studies of low-level exposures to large groups, some researchers have concluded that a given dose of radiation may be more likely to cause biological effects than previously thought. Some of these studies are listed in the bibliography (Mancuso, Archer) and the BEIR-80 report includes a section analyzing the findings of these and other studies. Scientific opinion differs on the validity of the research methods used and the methods of statistical analysis. The problem is that the expected additional incidence of radiation-caused effects such as cancer is difficult to detect in comparison with the much larger normal incidence. It cannot be shown without question that these effects were more frequent in the exposed study group than in the unexposed group used for comparison, or that the observed effects were caused

by radiation. The BEIR committee concluded that claims of higher risk had "no substance."

The NRC staff continually reviews the results of research on radiation risks. With respect to large-scale studies of radiation-induced health effects in human populations exposed to low-level ionizing radiation, the NRC and EPA have recently concluded that there is no one population group available for which such a study could be expected to provide a more meaningful estimate of the low-level radiation risk. This is due, in large part, to the observed and estimated low incidence of radiation health effects from low doses. However, the results of ongoing studies, such as that on nuclear shipyard workers, will be carefully reviewed and the development of a radiation-worker registry is being considered as a possible data base for future studies.

23. What are the reasons for not lowering the NRC dose limits?

Assuming that the 5-rem-per-year limit is adopted, there are three reasons:

a. Health risks are already low.

The estimated health risks associated with current average occupational radiation doses (e.g., 0.5 rem/yr for 50 years) are comparable to or less than risk levels in other occupational areas considered to be among the safest. If a person were exposed to the maximum of 5 rems per year for 50 years, which virtually never occurs, he or she might incur a risk comparable to the average risks in mining and heavy construction. An occasional 5-rem annual dose might be necessary to allow some jobs to be done without a significant increase in the collective dose. If the dose limits were lowered significantly, the number of people required to complete many jobs would increase. The collective dose would then increase since more individuals would be receiving nonproductive exposure while entering and leaving the work area and preparing for the job. The total number of health effects might go up as the collective dose increased.

b. The current regulations are considered sound.

The regulatory standards for dose limits are based on the recommendations of the Federal Radiation Council. At the time these standards were developed, about 1960, it was considered unlikely that exposure to these levels during a working lifetime would result in clinical evidence of injury or disease different from that occurring in the unexposed population. The scientific data base for the standards consisted primarily of human experience (x-ray exposures to medical practitioners and patients, ingestion of radium by watch dial painters, early effects observed in Japanese atomic bomb survivors, radon exposures of uranium miners, occupational radiation accidents) involving very large doses delivered at high dose rates. The data base also included the results of a large number of animal experiments involving high doses and dose rates. The animal experiments were particularly useful in the evaluation of genetic effects. The observed effects were related to low-level radiation according to the linear model explained in Question 7. Based on this approach, the regulations in 10 CFR Part 20, "Standards for Protection Against Radiation," also state that licensees should maintain all radiation exposures, and releases of radioactive materials in effluents, as low as is reasonably achievable. More recent scientific reviews of the large body of experimental data, such as the BEIR-80 and the recent EPA guidance, continue to support the view that use of a 5-rem-per-year limit is acceptable in practice. Experience has shown that, under this limit, the average dose to workers is near 0.5 rem/yr with very few workers consistently approaching the limit.

c. There is little to gain.

Reducing the dose limits, for example, to 0.5 rem/yr has been analyzed by the NRC staff. An estimated 2.6 million person-rems could be saved from 1980 through the year 2000 by nuclear power plant licensees if compliance with the new limit were achieved by lowering the radiation levels, working times, or both, rather than by using extra workers. It is estimated that something like $23 billion would be spent toward this purpose. Spending $23 billion to save 2.6 million person-rems would amount to spending $30 to $90 million to prevent each potential radiation-induced premature cancer death. Society considers this cost unacceptably high for individual protection.

24. Are there any areas of concern about radiation risks that might result in changing the NRC dose limits?

Yes. Three areas of concern to the NRC staff are specifically identified below:

a. An independent study by Rossi and Mays and other biological research have indicated that a given dose of neutron radiation may be more likely to cause biological effects than was previously thought. Other recent studies cast doubt on the issue. The NCRP is currently studying the data related to the neutron radiation question and is expected to make recommendations as to whether neutron dose limits should be changed. Although the scientific community has not yet come to agreement on this question, workers should be advised of the possibility of higher risk when entering areas where exposure to neutrons will occur.

b. It has been known for some time that rapidly growing living tissue is more sensitive to injury from radiation than tissue in which the cells are not reproducing rapidly. Thus the embryo or fetus is more sensitive to radiation injury than an adult. The NCRP recommended in Report No. 39 that special precautions be taken when an occupationally exposed woman could be pregnant in order to protect the embryo or fetus. In 1975, the NRC issued Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure," in which it is recommended that licensees instruct all workers concerning this special risk. The guide recommends that all workers be advised that the NCRP recommended that the maximum permissible dose to the embryo or fetus from occupational exposure of the mother should not exceed 0.5 rem for the full 9-month pregnancy period. In addition, the guide suggests options

available to the female employee who chooses not to expose her embryo or fetus to this additional risk.

The United States Department of Health and Human Services is similarly concerned about prenatal exposure from medical x-rays. In 1979 they published proposed guidelines for physicians concerning abdominal x-rays for possibly pregnant women. The guidelines in effect encourage the x-ray staff to make efforts to determine whether a female patient is pregnant and to defer x-rays if possible until after the child is born.

c. Also of special interest is the indication that female workers are subject to more risk of cancer incidence than male workers. In terms of all types of cancer except leukemia, the BEIR-80 analysis indicates that female workers have a risk of developing radiation-induced cancer that is approximately one and one-half times that for males. This increased risk is primarily due to the incidence of breast and thyroid cancer in women. These types of cancer, however, have a high cure rate. Thus the difference between men and women in cancer mortality is not great. Incidence of radiation-induced leukemia is about the same for both sexes. Female workers should be aware of this difference in the risks of radiation-induced cancer in deciding whether or not to seek work involving exposure to radiation.

25. *How much radiation does the average person who does not work in the nuclear industry receive?*

We are all exposed from the moment of conception to ionizing radiation from several sources. Our environment, and even the human body, contains naturally occurring radioactive materials that contribute some of the background radiation we receive. Cosmic radiation originating in space and in the sun contributes additional exposure. The use of x-rays and radioactive materials in medicine and dentistry adds considerably to our population exposure.

Table 6 shows estimated average individual exposure in millirems from natural background and other sources.

TABLE 6

U.S. General Population Exposure Estimates (1978)[a]

Source	Average Individual Dose (mrem/yr)
Natural background (average in U.S.)	100
Release of radioactive material in natural gas, mining, milling, etc.	5
Medical (whole-body equivalent)	90
Nuclear weapons (primarily fallout)	5-8
Nuclear energy	0.28
Consumer products	0.03
Total	∿200 mrem/yr

[a]Adapted from a report by the Interagency Task Force on the Health Effects of Ionizing Radiation pubished by the Department of Health, Education, and Welfare.

Thus, the average individual in the general population receives about 0.2 rem of radiation exposure each year from sources that are a part of our natural and man-made environment. By the age of 20 years, an individual has accumulated about 4 rems. The most likely target for reduction of population exposure is medical uses.

26. *Why aren't medical exposures considered as part of a worker's allowed dose?*

Equal doses of medical and occupational radiation have equal risks.[7] Medical exposure to radiation should be justified for reasons quite different, however, from those applicable to occupational exposure. A physician prescribing an x-ray should be convinced that the benefit to the patient of the resulting medical information justifies the risk associated with the radiation. Each worker must decide on the acceptance of occupational radiation risk just as each worker must decide on the acceptability of any other occupational hazard.

For another point of view, consider a worker who receives a dose of 2 rems from a series of x-rays or a radioactive medicine in connection with an injury or illness. This dose and the implied risk should be justified on medical grounds. If the worker had also received a dose of 2 rems on the job, the combined dose of 4 rems would not incapacitate the worker. A dose of 4 rems is not especially dangerous and is not large compared to the cumulative lifetime dose. Restricting the worker from additional job exposure during the remainder of the quarter would have no effect one way or the other on the risk from the 2 rems already received from medical exposure. If the individual worker accepts the risks associated with the x-rays on the basis of the medical benefits and the risks associated with job-related exposure on the basis of employment benefits, it would be unfair to restrict the individual from employment in radiation areas for the remainder of the quarter.

Some therapeutic medical doses such as those received from cobalt-60 treatment can range as high as 6000 rems to a small part of the body, spread over a period of several weeks or months.

27. *What is meant by internal exposure?*

The total radiation dose to the worker is the external dose (measured by the film badge and reported as "whole-body dose") plus the dose from internal emitters. The monitoring of the additional internal dose is difficult. Because there is the possibility of internal doses occurring, a good air-monitoring program should be established when warranted.

The uptake of radioactive materials by workers is generally due to breathing contaminated air. Radioactive materials may be present as fine dust or gases in the workplace atmosphere. The surfaces of equipment and workbenches

[7]It is likely that a significant portion of reported medical x-ray exposure is to parts of the body only. An exposure of 100 mrem to the whole body is more significant than a 100-mrem chest x-ray.

may be contaminated. Radioactive materials may enter the body by being breathed in, taken in with food or drink, or being absorbed through the skin, particularly if the skin is broken.

After entering the body, the radioactive material will migrate to particular organs or particular parts of the body depending on the biochemistry of the material. For example, uranium will tend to deposit in the bones where it will remain for a long time. It is slowly eliminated from the body, mostly by way of the kidneys. Radium will also tend to deposit in the bones. Radioactive iodine will seek out the thyroid glands (located in the neck) and deposit there.

The dose from these internal emitters cannot be measured either by the film badge or by other ordinary dosimeters carried by the worker. This means that the internal radiation dose must be separately monitored using other detection methods.

Internal exposure can be estimated by measuring the radiation emitted from the body or by measuring the radioactive materials contained in biological samples such as urine or feces. Dose estimates can also be made if one knows how much radioactive material is in the air and the length of time during which the air was breathed.

28. How are the limits for internal exposure set?

Standards have been established for the maximum permissible amount of each radionuclide that may be accumulated in the critical organs[8] of the worker's body.

Calculations are made to determine the quantity of radioactive material that has been taken into the body and the total dose that would result. Then, based on limits established for particular body organs similar to 1¼ rems in a calendar quarter for whole-body exposure, the regulations specify maximum permissible concentrations of radioactive material in the air to which a worker can be exposed for 40 hours per week over 13 weeks or 1 calendar quarter. The regulations also require that efforts be made to keep internal exposure ALARA.

Internal exposure is controlled by limiting the release of radioactive material into the air and by carefully monitoring the work area for airborne radioactivity and surface contamination. Protective clothing and respiratory (breathing) protection should be used whenever the possibility of contact with loose radioactive material cannot be prevented.

29. Is the dose a person received from internal exposure added to that received from external exposure?

Exposure to radiation that results from radioactive materials taken into the body is measured, recorded, and reported to the worker separately from external dose. The internal dose to the whole body or to specific organs does not at this time count against the 3-rem-per-calendar-quarter limit. ICRP recommends that the internal and external doses should be appropriately added. This recommendation is currently under study by the staffs of the NRC, the EPA, and the Occupational Safety and Health Administration (OSHA).

30. How is a worker's external radiation dose determined?

A worker may wear three types of radiation-measuring devices. A self-reading pocket dosimeter records the exposure to incident radiation and can be read out immediately upon finishing a job involving external exposure to radiation. A film badge or TLD badge records radiation dose, either by the amount of darkening of the film or by storing energy in the TLD crystal. Both these devices require processing to determine the dose but are considered more reliable than the pocket dosimeter. A worker's official report of dose received is normally based on film or TLD badge readings, which provide a cumulative total and are more accurate.

31. What are my options if I decide not to accept the risks associated with occupational radiation exposure?

If the risks from exposure to radiation that may be expected to occur during your work are unacceptable to you, you could request a transfer to a job that does not involve exposure to radiation. However, the risks associated with exposure to radiation that workers, on the average, actually receive are considered acceptable, compared to other occupational risks, by virtually all the scientific groups that have studied them. Your employer is probably not obligated to guarantee you a transfer if you decide not to accept an assignment requiring exposure to radiation.

You also have the option of seeking other employment in a nonradiation occupation. However, the studies that have compared occupational risks in the nuclear industry to those in other job areas indicate that nuclear work is relatively safe. Thus, you will not necessarily find significantly lower risks in another job.

A third option would be to practice the most effective work procedures so as to keep your exposure ALARA. Be aware that reducing time of exposure, maintaining distance from radiation sources, and using shielding can all lower your exposure. Plan radiation jobs carefully to increase efficiency while in the radiation area. Learn the most effective methods of using protective clothing to avoid contamination. Discuss your job with the radiation protection personnel who can suggest additional ways to reduce your exposure.

32. Where can I get additional information on radiation risk?

The following list suggests sources of useful information on radiation risk:

a. Your Employer

The radiation protection or health physics office in the facility where you are employed.

[8] Critical organ refers to those parts of the body vulnerable to radiation damage such as bone, lungs, thyroid, and other systems where certain radioactive materials will concentrate if taken into the body.

b. Nuclear Regulatory Commission

Regional Offices

King of Prussia, PA 19406	215-337-5000
Atlanta, GA 30303	404-221-4503
Glen Ellyn, IL 60137	312-932-2500
Arlington, TX 76012	817-334-2841
Walnut Creek, CA 94596	415-943-3700

Headquarters

Occupational Radiation Protection Branch
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Telephone: 301-443-5970

c. Department of Health and Human Services

Office of the Director
Bureau of Radiological Health (HFX-1)
Department of Health and Human Services
5600 Fishers Lane
Rockville, MD 20857

Telephone: 301-443-4690

d. Environmental Protection Agency

Office of Radiation Programs
U.S. Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460

Telephone: 703-557-9710

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C. REGULATORY POSITION

Strong management support is considered essential to an adequate radiation protection training program. Instruction to workers performed in compliance with § 19.12 of 10 CFR Part 19 should be given prior to assignment to work in a restricted area and periodically thereafter. In providing instruction concerning health protection problems associated with exposure to radiation, all workers, including those in supervisory roles, should be given specific instruction on the risk of biological effects resulting from exposure to radiation.

The instruction should be presented both orally and in printed form to all affected workers and supervisors. It should include the information provided in the appendix to this guide.[3] The information should be discussed during training sessions. Each individual should be given an opportunity to ask questions and should be asked to acknowledge in writing that the instruction has been received and understood.

[3]Copies of the appendix to this guide are available at the current Government Printing Office price, which may be obtained by writing to the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Publications Sales Manager. This appendix is not copyrighted, and Commission approval is not required to reproduce it.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which an applicant or licensee proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the methods described in this guide will be used in the evaluation of the training program for all individuals working in or frequenting any portion of a restricted area and for all supervisory personnel after December 15, 1981.

If an applicant or licensee wishes to use the material provided in this guide on or before December 15, 1981, the pertinent portions of the application or the licensee's performance will be evaluated on the basis of this guide.

APPENDIX C CONTENTS

NAME _____

DATE _____

NRC COBALT QUIZ DAY 2

1. What is an isotope?

2. What is specific activity?

3. Define the curie and the microcurie.

4. What was the purpose and why would you never attempt to dissassemble a Co-60 teletherapy head in the field as was performed in Lab 1?

5. What two types of shutter rotor systems are used in all Picker Co-60 units and how do they differ?

NAME _____

DATE _____

NRC COBALT
QUIZ
DAY 3

1. What is a(an)

   a. Alpha Particle?

   b. Beta Particle?

   c. Gamma Ray?

2. Define the electron volt.

3. What are the energies of Cobalt gamma rays?

4. What differences can be noted on drive trains from the 590A and D head to the 583 and 581 heads?

5. Generally, what service problem presents itself when bearings on the 590A and D drive casting and the belt idler pulley are worn or frozen?

NAME _____

DATE _____

NRC COBALT
QUIZ
DAY 4

1. List the five pieces of dosimetry equipment you need to service a Co-60 unit safely.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

2. Distinguish the difference between dose and dose rate.

3. During a wipe test after the removal of a collimator, at what point in counts per minute would you consider the source may be leaking and contacting your Radiation Safety Officer is warranted?

4. From all the different types of equipment used to safely service a Co-60 unit, what device represents the greatest margin of safety for the service personnel?

5. What is the dose rate from a 5000 RHM source at 5 meters?

NAME _____

DATE _____

NRC COBALT
QUIZ
DAY 5

1. Why is it necessary to remove the 3347 collimator from the unit prior to its disassembly?

2. What is the function of the zoneguard circuitry?

3. What is the purpose of the by-pass switch on the C-9 unit?

4. The 3347 collimator is retained in its bearing ring by four 1/4-20x1-1/4 set screws. If these screws were inadvertently removed and the collimator positioned above a patient, what would happen?

5. During a wipe check, a reading of 13,000 cpm is indicated on the G-M meter. What action should be taken?

NAME _____

DATE _____

NRC COBALT
QUIZ
DAY 6

1. To replace the mirror on a 3347 collimator, is it necessary to remove the collimator from the entire unit?

   _____

2. How is the mirror adjusted on the 3347 collimator?

3. If a dial cable assembly is lost during reassembly of a collimator, what operation must follow? What would prevent this?

4. What are the two gamma ray interactions with matter that are responsible for absorption and scattering?

   _____

   _____

5. Distinguish between the genetic and somatic effects of radiation.

NAME _____

DATE _____

NRC COBALT
QUIZ
DAY 7

1. Is it appropriate procedure to remove one of the special lockings during bearing lubrication?

2. During bearing lubrication, why is it important to install the special locking bar during the removal of the shutter stop arm?

3. Who may perform a bearing lubrication?

4. How often should a bearing lubrication be done?

5. On what heads may a bearing lubrication be performed?

NAME _____

DATE _____

NRC COBALT
QUIZ
DAY 8

1. In the licenses between the NRC and A.M.S., what types of byproducts material are mentioned?

2. According to the license, what part of the Federal Rules and Regulations must the licensee comply with?

3. During a bearing lubrication how is the radiation controlled?

4. What dose may be expected from a bearing lubrication procedure?

5. According to the license, what type of dosimetry equipment is required and how often must it be calibrated?

NAME _____

DATE _____

NRC COBALT
QUIZ
DAY 9

1. According to 10 CFR20.101 paragraph (a), what is the maximum permissable dose to the whole body, extremities, and skin?

2. What is an incident? Who must be notified and when?

3. Who may interpret the Federal Rules and Regulations 10CFR20?

4. What is the purpose of the isocenter adjustment?

5. Is it important to check the C-arm with a level prior to the isocenter adjustment? Why?

NAME _____

DATE _____

NRC COBALT
QUIZ
SUPPLEMENTAL

1. Does the service license authorize the transportation of radioactive material ?

2. Who may work under the AMS -02 service license ?

3. What does the license allow ?

4. After completing the training course are you to be permitted to service cobalt units or is there additional requirements to be met and if so name them ?

5. Who is responsible for the administration of the service license ?

Name _____

DATE _____

NRC COBALT
TIME & DISTANCE PROBLEMS

FORMULAS: A. Distance

Inverse Square Law

$$\frac{I_A}{I_B} = \frac{D_B^2}{D_A^2}$$

Where: D_A = Nearer Distance

I_A = Dose Rate at Nearer Distar

D_B = Farther Distance

I_B = Dose Rate at Farter Distar

B. Time

$$\frac{mR_1}{T_1} = \frac{mR_2}{T_2}$$

Where: mR = Dose

T = Time

THEREFORE

$\frac{mR}{T}$ = Dose Rate

Examples:

#1 A service engineer is in a 1R/h field for a period of 3 minutes. What is his dose?

$mR_1 = 1000$ (1R = 1000 mR)

$T_1 = 60$ min. (1 hr = 60 min)

mR_2 = Unknown Dose

$T_2 = 3$ min.

IF: $\frac{mR_1}{T_1} = \frac{mR_2}{T_2}$

THEN: $\frac{1{,}000 \text{ mR}}{60 \text{ min}} = \frac{mR_2}{3 \text{ min}}$

$$mR_2 = 3 \text{ min.} \times \frac{1{,}000 \text{ mR}}{60 \text{ min.}}$$

$$mR_2 = 3 \text{ min.} \times 16.66 \text{ mR/min.}$$

$$mR_2 = 49.98 \text{ or } 50 \text{ mR}$$

THEREFORE: His dose is 50 mR.

EXAMPLES:

#2 A service engineer determines that he wishes not to receive a dose greater than 100 mR. He must work in a 42 mR/h field. How long can he work in the field?

$mR_1 = 42$

$T_1 = 1$ hour

$mR_2 = 100$

$T_2 =$ Unknown

IF: $\frac{mR_1}{T_1} = \frac{mR_2}{T_2}$

THEN: $\frac{42 \text{ mR}}{1 \text{ hour}} = \frac{100 \text{ mR}}{T_2}$

$T_2 \times 42 \text{ mR} = 1 \text{ hour} \times 100 \text{ mR}$

$T_2 = \frac{1 \text{ hour} \times 100 \text{ mR}}{42 \text{ mR}}$

$T_2 = 2.38$ hours or 2 hours and 23 minutes

PROBLEMS:

1. You find the dose rate from a source to be 30 mR/h at 11 ft.

   a. What is the dose rate at 3 ft?

   b. What is the dose if you stand 3 ft. from the source for 1 minute?

   ANSWER: a. 403 mR/h
   b. 6.7 mR

2. You find the dose rate from a source to be 11 mR/h at 24 ft.

   a. What is the dose rate at 1 ft?

   b. What is the dose if you stand 1 ft. from the source for 30 seconds?

   ANSWER: a. 6336 mR/h
   b. 52.8 mR

3. You find the dose rate from a source to be 245 mR/h at 1 meter.

   a. How far back from the source must you move before the dose rate drops to 5 mR/h?

   b. How long could you stay in the 5 mR/h field before you exceeded 25 mR?

   ANSWER: a. 7 meters
   b. 5 hours

4. You find the dose rate from a source to be 20 mR/hr at 15 ft.

   a. What is the dose rate at 6 ft?

   b. How long could you stay in this field before exceeding 100 mR?

   ANSWER: a. _____

   b. _____

5. a. At what distance would you receive a dose rate of 5 R/hr from a 1280 RHM Cobalt source?

   b. How long could you stand at the distance determined in part "a" before exceeding 1.25 R?

   ANSWER: a. _____

   b. _____

THERAPY SERVICE TRAINING

FINAL EXAMINATION A

NAME _____

DATE _____

GRADE _____

1. The hydrogen atom has one proton and one electron. (T)

2. Atoms which have the same number of protons, but different numbers of electrons are called isotopes. T

3. All radioactive isotopes emit gamma radiation. T

4. The isotope cobalt 60 emits beta and gamma radiation. (T)

5. Gamma rays are electromagnetic radiation emitted by unstable nuclei. (T)

6. Gamma rays and x-rays of equal energy have the same penetrating power. (T)

7. The half life of the isotope cobalt 60 is 6 years. T

8. The curie is a quantity of radiation. T

9. Gamma radiation can ionize air. (T)

10. The roentgen is the unit of radiation quantity. (T)

11. One thousand milliroentgens equals one roentgen. (T)

12. Integrated dose is the same as dose rate. T

13. A pocket dosimeter may be substitutued for a film badge, since they are used for the same purpose. T

14. The dose rates from a 2000 curie Co60 source and a 3000 curie Co60 cource are the same when shielded by two inches of lead. T

15. A service engineer working in an area where the dose rate is 2 roentgens per minute receives a dose of about 33 mR in 10 seconds. T

16. At one foot from a one curie cobalt 60 point source, the dose rate is 14.5 roentgens per hour. (T)

17. Since gamma and x-radiation are similar, a Victoreen 491 Survey Meter may be used to accurately survey a cobalt therapy head or an x-ray tube. (T)

18. A good rule to follow is to limit radiation dose to 100 mR per 40 hour work week. (T)

19. An unlicensed service engineer may not operate the cobalt shutter from the control console. (T)

20. The allowable dose to the hands may exceed 1-1/4 R per calendar quarter. (T)

21. Federal regulations require the survey meter used with cobalt therapy units to be calibrated at intervals not to exceed three months. T

22. A whole body exposure of 5 rems or more must be reported to the NRC within 24 hours by telephone and telegraph. (T)

23. One curie equals 3.7×10^{10} disintegrations per second. (T)

24. In an unrestricted area, one could receive 5 mrem in any one hour period, but less that 100 mrem in any seven consecutive days. T

25. A cobalt therapy unit must be serviced in compliance with Title 10, Code of Federal Regulations, Part 34. T

26. During a shutter bearing lubrication procedure, it is OK to remove one of the safety locking tools on the shutter shaft. (T)

27. When operating the shutter on C4 through C9 units, if the red and green lights stay on, a malfunction is indicated. (T)

28. There is a malfunction in a C9 if the zone guard light goes out when the shutter is fully open. T

29. A dose of 0.1 rem is equal to 100 mR/hr of gamma or x-radiation. T

30. Depleted uranium, used as shielding in certain therapy heads, is not radioactive. T

31. The collimator must be removed from the therapy head in order to replace the mirror in a 3347 Series collimator. (T)

32. The shutter wheel bearings on a 590A head can be lubricated. T

33. A 590E shutter lock can be used to lock a cesium shutter wheel. (T)

34. The gamma radiation from a cesium 137 therapy source has an energy of 1.05 Mev. T

35. When a collimator bulb is replaced the isocenter must be redetermined. T

36. In a C9 unit, if relay RE12A is energized, the shutter is returned to the safe position. (T)

37. Gamma radiation from a cobalt therapy source can cause radio-activity in aluminum. T

38. When the C9 halo switch is energized, relay RE8 is energized after 1.2 seconds. T

39. The C9 localizer transformer is located in the head. (T)

40. The C9 hanger can be rotated from the remote control without operating the shutter. (T)

1. The time for one half of the radioactive atoms to disintegrate is called
   (A) the inverse square law
   (B) a curie
   (C) half life

42. One million electron volts is
(A) the average energy of cobalt gamma radiation
(B) 1000 kev
(C) hazardous because of scatter

43. Radioisotope specific activity is measured in
(A) millicuries
(B) curies per gram
(C) rem per minute

44. Of the three isotopes below, which has the longest half life ?
(A) Cesium 137
(B) Cobalt 60
(C) Radium 226

45. You find the dose rate from a source to be 1200 mR/hr at 6 feet. What would the dose rate be at 24 feet ?
(A) 120 mR/hr
(B) 300 mR/hr
(C) 75 mR/hr

46. The HVL of lead for cobalt 60 is about 1/2 inch. If the dose rate on the source side of a 2 inch lead shield is 64 roentgens per minute, the radiation dose rate on the opposite side of the shield is about
(A) 16 R/m
(B) 8 R/m
(C) 4 R/m

47. A cobalt source gives a dose rate of 900 mR/hr at 10 feet. At what distance from the source is the dose rate 100 mR/hr ?

(A) 18 feet
(B) 25 feet
(C) 30 feet

48. The wavelength of a gamma ray is
(A) directly proportional to energy
(B) longer than visible light
(C) inversely proportional to its energy

49. In practice, when the shutter is open, the dose rate from a 5000 curie cobalt 60 source is approximately
(A) 4000 RHM
(B) 5000 RHM
(C) 7000 RHM

7.4×10^{10} disintegrations per second is
(A) 1 curie
(B) 2 curies
(C) 3 curies

51. When a therapy source has been installed for a time equal to 2 half lives, the dose rate from the source will be
(A) 1/2 the original rate
(B) 1/4 the original rate
(C) 1/8 the original rate

52. Radiation which can be stopped by a few centimeters of air or a few sheets of paper is
(A) Alpha radiation
(B) Beta radiation
(C) Low energy x-rays

53. A survey meter containing an ionization chamber is preferred for surveys in a high radiation area because it
(A) has an energy independent response
(B) is not saturated by high dose rates
(C) requires a low operating voltage

54. One inch of lead is a better shield for gamma radiation than one inch of steel because it
(A) has higher density
(B) does not become radioactive when irradiated
(C) has fewer impurities

55. A whole body gamma radiation dose of 10 rem is
(A) hazardous to the skin
(B) detectable in a blood sample taken within 24 hours of exposure
(C) within the allowable yearly dose

56. A cobalt gamma ray looses energy when passing through concrete by
(A) ionization
(B) scattering, photo-electric effect and Compton Effect
(C) pair production

57. Ionizing radiation in small quantities
(A) is beneficial like sunlight
(B) has no effect on living tissue
(C) can disrupt normal cell function and may destroy cells

58. Smoking, eating or drinking is not permitted during a contamination wipe test procedure because
(A) these are poor work habits
(B) it is possible to ingest radioactive material
(C) this may affect the accuracy of the meter.

59. Rem means
(A) roentgens emitted per meter
(B) roentgen equivalent man
(C) roentgens per minute

60. A whole body dose of 300 rems will result in
(A) no apparent effect
(B) temporary nausea and ill feeling
(C) serious effects requiring immediate medical attention

61. Primary protection against radiation is provided by
(A) a film badge and care when working with radiation
(B) time, distance and shielding
(C) a control key and a shielded room

62. The inverse square law can be applied to a cobalt therapy unit when
(A) the source is open
(B) the source is closed
(C) calculating the required wall thickness

63. The maximum permissable whole body radiation dose in a 13 week calendar quarter, except as provided in 10 CFR 20, paragraph 20.101 (b) is
(A) 7-1/2 rem
(B) 1-1/4 rem
(C) 3 rem

64. The rad is equivalent to an energy release of
(A) 87 ergs per gram of air
(B) 97.7 ergs per gram of tissue
(C) 100 ergs per gram of tissue

65. The energy required to create one ion pair in air is approximately
(A) 50 electron volts
(B) 20 electron volts
(C) 33 electron volts

66. Cobalt gamma radiation is
(A) equal in penetration to a 1.25 Mev x-ray generator
(B) slightly more penetrating than the radiation from a 2 Mev x-ray generator
(C) 10 times more powerful than a 100 kVp x-ray

67. One angstrom is
(A) 1×10^{-8} centimeters
(B) 3.7×10^{10} centimeters
(C) the wavelength of an alpha particle

68. Beta radiation is
(A) electrons released by energetic particles
(B) electrons emitted by an atomic nucleus
(C) similar to bremstralung

69. Tritium is
(A) a radioactive isotope
(B) a relatively stable gas
(C) an alpha emitter

70. In a restricted area, minors under 18 years of age may not receive a radiation dose in excess of
(A) 10 percent of the limits given in 10 CFR 20
(B) 10 mR
(C) 1-1/4 R per calendar quarter

71. In a high radiation area, personnel could receive
(A) in any one hour, a dose in excess of 100 m Rem to a major portion of the body
(B) 100 mR/hr
(C) 300 mR

72. One microcurie is
(A) 3.7×10^6 dps
(B) 3.7×10^7 dps
(C) 3.7×10^4 dps

73. Federal regulations require the radiation detection instrument, used to test for contamination o: a therapy head, to have sensitivity sufficient to detect
(A) .005 microcuries
(B) .01 microcuries
(C) .05 microcuries

74. One of the advantages of a pocket dosimeter compared to a film badge is
(A) more accurate dose measurement
(B) instant indication of dose
(C) energy independence

75. The operating range of a film badge is about
(A) 10 mR to 100 R
(B) 1 mR to 300 R
(C) 0 to 200 mR

76. A Victoreen 592-B survey meter reads 7.5 mR/hr with the range switch at X 100. The dose rate is therefore
(A) 75 mR/hr
(B) 7.5 mR/hr
(C) 750 mR/hr

. When working in an area where the dose rate is 75 mR/hr, a service engineer exceeds the recommended weekly dose of 100 m Rem after
(A) 75 minutes
(B) 80 minutes
(C) 90 minutes

78. A Cobalt 60 therapy source is considered to be leaking if the wipe counts
(A) approximately 200 cpm
(B) between 2000 and 20000 cpm above background
(C) less than 200 cpm

79. A service engineer is called to close a stuck shutter. The first thing he should do is
(A) use a survey meter and turn the manual shutter wheel
(B) close the room and notify the Radiation Safety Officer
(C) push the emergency bar in

80. A C9 therapy unit has a
(A) 590 C head
(B) 590 D head
(C) 590 E head

81. In order to manually rotate the shutter on a C4M/60, the hand wheel must be turned
(A) clockwise
(B) counter clockwise
(C) counter clockwise if the collimator is pointing up

82. To lock the shutter in a 590A head (C-3000) therapy unit
(A) remove the head front cover and wedge the pulley
(B) remove the distance localizer handle and install a 3/8-16 X 1-1/2 bolt
(C) remove the head cover and install a special Z-bar.

83. The C-9 Zone Guard
(A) is adjusted to operate when the head is pointed at inadequately protected walls
(B) stops yoke rotation if the shutter is open
(C) makes remote head rotation difficult during emergencies

84. The source drive motor is found to be overheating. The service engineer should
(A) notify the RSO
(B) shut the therapy unit down until the motor is replaced
(C) check motor voltage and improve ventilation

The shutter drive motor on C-1000 therapy units
(A) operates at 60 to 80 volts
(B) is set at about 75 volts for equal opening and closing times
(C) operates at line voltage.

86. On a C-4 therapy unit, the normal shutter opening time of 2 seconds is found to have increased to 6 seconds. The first step to take is
(A) check the drive belt adjustment and motor voltage
(B) replace the drive motor
(C) lubricate the spring

87. A 3347B collimator is designed to fit a
(A) C9
(B) C8
(C) C3000

88. In order to adjust the C9 isocenter, a service engineer does not need
(A) an NRC license
(B) special training and experience
(C) a #181704 alignment fixture

During an emergency, the dose received while manually closing the shutter, can be minimized b
(A) using a survey meter
(B) wearing a dosimeter and working rapidly
(C) remote head rotation and approaching the head from the proper direction.

90. The Johns McKay type 3313 collimator
(A) fits a 590E head
(B) fits a 583 head
(C) fits a 581 series head

91. The reading on a pocket dosimeter should be recorded
(A) immediately after a therapy unit service procedure
(B) before the next time the dosimeter is used
(C) only if greater than zero

92. The front cover on 590E type heads
(A) is part of the shielding
(B) should only be removed by licensed personnel
(C) is not a shield

93. Under federal regulations, a therapy room is used for necessary medical exposures, therefor the room
(A) need not be posted, "Caution, high radiation area"
(B) must comply with 10 CFR 20
(C) must have walls at least 3 feet thick

94. A C9 therapy unit emits high pitched squeeling sounds during rotation. The unit nee
(A) shutter wheel lubrication
(B) slack in the vee belt
(C) lubriplate on the sliprings

95. A 3706A collimator provides variable field sizes from 3 x 3 cm minimum to a maximum of
(A) 25 x 25 cm
(B) 30 x 30 cm
(C) 35 x 35 cm

96. S.S.D is defined as
(A) shutter shaft diameter
(B) source to skin distance
(C) shipping skid depth

97. Quartz collimator lamps should not be touched with the fingers as this will cause
(A) low light field intensity
(B) reduction of lamp life
(C) blurred field image

98. The distance from the source to the lowest trimmer bar on a 3706A collimator is
(A) 35 cm
(B) 40 cm
(C) 45 cm

99. In order to locate a point 80 cm from the source, the distance from the bottom edge of the trimmer bar on a 3706A collimator must be
(A) 35 cm
(B) 40 cm
(C) 45 cm

100. What is the purpose of a survey meter and why is it important to use one? Write as much as you can on this, for example, compare a survey meter to a film badge or a pocket dosimeter, etc.

THERAPY SERVICE TRAINING

NAME _____
DATE _____
GRADE _____

FINAL EXAMINATION B

1. Isotopes are atoms which have the same number of neutrons, but different numbers of protons. T (F)
2. Tritium is a radioisotope. (T) F
3. All radioactive isotopes, or radioisotopes, emit beta radiation. T (F)
4. The number of disintegrations per second is a measure of the radioactivity of the source. (T) F
5. The curie is a unit of activity. (T) F
6. Specific activity is the number of curies per gram of material. (T) F
7. The half life of Cobalt 60 is 5.6 years. T (F)
8. Alpha particles, Beta particles and Gamma radiation are all emitted from the nucleus of the atom. (T) F
9. An Angstrom is a unit of radioactivity. T (F)
10. The material in a teletherapy head becomes radioactive once a source is installed. T (F)
11. An electron volt is a measure of kinetic energy acquired by a neutron. T (F)
12. Ions are electrically charged particles. (T) F
13. The roentgen is the unit of radiation quantity. (T) F
14. For Gamma and X-rays, the rem and rad are the same. (T) F
15. The half-value layer of lead is 1.49 inches. T (F)
16. A dose of 0.2 rem is equal to 200m R/hour of gamma or X-radiation. T (F)
17. A lead apron will provide adequate shielding from Gamma radiation. T (F)
18. The dose rates from a 1500 RHM source and a 2000 RHM source are the same when shielded by three inches of lead. T (F)
19. A service engineer working in an area where the dose rate is 3 Roentgens/minute receives a dose of about 333m R in 10 seconds. T (F)
20. The nominal rating for an AMS source is 1.1 RHM per curie. (T) F
21. It is good practice to warm up a pocket dosimeter by wearing it for a half hour or so before charging it. (T) F

22. The film badge protects its wearer from the harmful effects of radiation. T (F)

23. The accuracy of the survey meters used by service personnel is ± 20 percent. T (F)

24. The Victoreen 491 Meter is a G-M type meter. (T) F

25. When conducting a contamination check with a Victoreen 491 Meter, the beta shield should be closed. T (F)

26. One of the effects of radiation in humans is the destruction of blood-producing tissue in bone marrow. (T) F

27. The NRC regulations are found in Title 10 of the Code of Federal Regulations. (T) F

28. All service work on teletherapy equipment requires an NRC license. T (F)

29. The allowable dose to the hands may exceed 5-1/4 rems per calendar quarter. (T) F

30. The maximum radiation level allowable in an unrestricted area is 2 R/hour. T (F)

31. Film badges and pocket dosimeters are required to be worn when performing licensable work. (T) F

32. More than half of the 50 states in the U.S. are agreement states. (T) F

33. Agreement states have their own regulations for the protection of workers and the possession and use of radioactive materials. (T) F

34. The shutter wheel bearings on a 590A head can be lubricated. T (F)

35. During a shutter bearing lubrication procedure, it is okay to remove one of the safety locking tools on the shutter shaft. (T) F

36. A contamination check must be performed each time a collimator is removed. (T) F

37. During a contamination check, a wipe reading less than 2000 cpm is considered clean. T (F)

38. The four basic styles of Picker heads are 381, 583, 590A, 590C, D, E. T (F)

39. The C9 hanger can be rotated from the remote control without operating the shutter. (T) F

40. Prior to the commencement of service work on teletherapy equipment, the service engineer should take over control of the equipment. (T) F

41. The HVL of concrete for Cobalt 60 is approximately 2.5 inches. If the dose rate on the source side of a 10-inch concrete wall is 100 R/min., the dose rate on the opposite side of the wall is:

(a) 50 R/min.
(b) 12.5 R/min.
(c) 6.25 R/min.

42. You find the dose rate from a source to be 2 R/hour at 1 foot. What would the dose rate be at 8 feet?

(a) 500m R/hour
(b) 31.25m R/hour
(c) 62.5m R/hour

43. A cobalt source gives a dose rate of 800m R/hour at 10 feet. At what distance from the source is the dose rate 50m R/hour?

(a) 40 feet
(b) 30 feet
(c) 20 feet

44. An AMS 6000 RHM Cobalt 60 source contains approximately _____ curies of Cobalt 60.

(a) 6450
(b) 4450
(c) 5450

45. Smoking, eating or drinking is not permitted during a contamination wipe test procedure because

(a) damage could occur to your equipment.
(b) it is possible to ingest radioactive material.
(c) hospital rules prohibit it.

46. The maximum permissible whole body dose per calendar quarter, except as provided for in 10CFR20.101(b), is

(a) 1-1/4 REM
(b) 7-1/2 REM
(c) 18-3/4 REM

47. One millicurie equals

(a) 3.7×10^{10} dps
(b) 3.7×10^{7} dps
(c) 3.7×10^{4} dps

48. A survey meter reads 4.5m R/hour with the rate switch at X3.0. The dose rate is, therefore,

(a) 135m R/hour
(b) 1.35m R/hour
(c) 13.5m R/hour

49. In order to adjust isocenter, a service engineer does not need

(a) an NRC license
(b) special training and experience
(c) a 181704 alignment paddle

50. The distance from the source to the lowest trimmer bar on a 3706A collimator is

(a) 35 cm
(b) 45 cm
(c) 40 cm

Name: _____

Date: _____

THERAPY SERVICE TRAINING
EXAMINATION C

1. The primary NRC regulation relating to notices, instruction, and standards for protection are found where (title and part)?

2. Who is our NRC license issued to?

3. Each licensee is required to post certain regulations, licenses, Form NRC 3. In our facility, where are these documents posted?

4. When can an employee request his radiation exposure data?

5. What is a restricted area?

6. What is occupational dose?

7. What is the difference between "dose" and "dose rate"?

8. What are the units of dose and dose rate?

9 The maximum quarterly dose to the whole body in REMS is:

a) 1250 b) 1.25 c) 7500 d) 7.5

10. For unrestricted areas, the radiation levels must be such that max. received in one hour is _____ MR?

11. List the basic dosimetry equipment and instruments issued to a service engineer.

12. Define a radiation area?

13. Define a high radiation area.

14. List the specific radioactive material that AMS may possess.

15. Our license allows the possession of radioactive material in what form?

16. "ALARA" is an anacronym for what expression?

17. Calculate the stay time in order to receive 15 mRem dose in a 25mR/hr. radiation field.

18. The stay time is calculated to be 90 minutes for work in a 50 mR/hr. radiation field. What is the estimated dose that will be received?

19. On which range of the Victoreen 491 survey meter would you measure a radiation level of 1.5 mR/hr. and why did you choose that range?

20. You enter a teletherapy room and your Victoreen 491 meter goes off scale, what should you do?

21. Your head leakage survey shows 50 mR/hr. at 1cm from the top surface of a teletherapy head. At what distance would the radiation level be 5mR/hr.?

22. What is the dose rate from a 6700 RHM source at 1 meter?_____
at 3 meters?_____

23. Using the factor of 1.1 RHM/curie for Cobalt 60, what is the expected dose rate from a source containing 5400 curies?

24. How many curies is 4.25 m curies? _____

25. A service engineer works in a 500 mR/hr. field for 3 minutes. What dose will he receive?

26. The film badge protects its wearer from the harmful effects of radiation. T F

27. The accuracy of the survey meters used by service engineers is ±15%. T F

28. All service work on teletherapy equipment requires an NRC license. T F

30. Agreement states have their own regulation for the protection of workers and the possession and use of radioactive materials. T F

31. What is the calibration frequency for survey instruments and 200 MR pocket dosimeters?

32. When taking a wipe and reading it with the Victoreen 491, what is the contamination level action point?

33. What should you do if you lose your film badge?

34. The federal regulation for the shipment and transportation of radioactive materials are found where?

35. The transport index for a package with a surface reading of 20mR/hr. indicates what?

36. Which of the many different readings that may be taken to determine transport index should be used?

37. For non-exclusive use shipment, what is the maximum package surface level allowable?

38. Placarding a vehicle is required when?

39. For a type B package, which of the following are attached directly to the package?

    a. Shipping papers

    b. Yellow III label

    c. Package ID plate

    d. Placards

40. Why is a seal placed on a teletherapy source transportation package?

41. On how many sides of a transportation package must Yellow III labels be placed?

42. What information is written or typed onto the Yellow III label?

43. Who may sign the DOT certification statement found on hazardous bills of lading?

44. Cobalt 60 emits what forms of radiation?

45. What is the activity of 5000 curie Cobalt 60 source after 3 half lives?

46. How often should your pocket dosimeter be recharged?

47. A customer requests that you perform some task or service which you are not familiar with. What do you do?

48. Your survey instruments are damaged in transit to a customer site. What do you do?

49. You find that the therapy room door interlock has been by-passed. What do you do?

50. Where are the highest radiation areas on a teletherapy unit head?

CLASS 2 SERVICE ENGINEER TRAINING PROGRAM

1.0 PURPOSE: To develop a staff of trained individuals capable of maintaining customer equipment in good operating condition.

2.0 SCOPE: This program is applicable to all individuals who work independently on teletherapy equipment at customer facilities, in accordance with proper service and assembly procedures.

3.0 OBJECTIVES: Upon completion of training, the candidate will be approved by the U.S. NRC as a qualified service engineer, and will be able to perform the following tasks:

A. Service procedures specified in ISP-25, Cobalt Service Procedures Manual (as limited by certificate of training).

B. Installation and dismantling of teletherapy equipment.

C. Packaging and transportation of radioactive material.

D. Use radiation safety instrumentation and basic tools and equipment associated with service work.

4.0 REQUIREMENTS:

4.1 The training program shall consist of (1) approximately 5 days (40 hours) of classroom instruction on basic radiation theory and safety practices, (2) approximately 6 weeks of job-specific training on the procedures methods, etc. required to perform service tasks, and (3) approximately 3 months of on-the-job training.

4.2 A trained health physicist and/or other qualified instructors under the direction of the RSO shall provide the classroom instruction. The job specific training shall be coordinated by the RSO and supervised by the Production Manager or a qualified assembly supervisor. Job specific laboratories and on-the-job shall be coordinated by the RSO and supervised by an NRC qualified service engineer.

4.3 For the classroom instruction, a written examination(s) shall be administered to determine comprehension of the material presented. The examination shall be prepared, administered, and scored by the instructor. The minimum passing grade shall be 80%.

4.4 Throughout the course of the job specific training, oral (which may be supported by written essay responses) walk-througn, job understanding

and performance exams will be administered. The examinations will be prepared by the RSO with guidance from the Production Manager and Service Engineers. The minimum passing grade shall be 80%.

4.5 For on-the-job training, the candidate will perform the tasks at least two times under the supervision of an NRC approved service engineer. The service engineer will write a performance evaluation and submit it to the RSO for review and file.

4.6 Upon completion of all facets of this program, the RSO will submit the candidate's name and qualifications to the Isotope Committee. Upon approval of the Isotope Committee, the candidate's name and qualifications will be submitted to the U. S. NRC for approval.

4.7 Candidates who are approved by the NRC will be awarded a certificate of training. In addition, the individual will be issued an additional badge or wallet card which includes Company name and address, individual's name, NRC license number. AMS retains the right to change the form of this identification.

4.8 Candidates will continue their training until all of the above criteria has been met.

4.9 Refresher training shall be provided on an annual basis and whenever there is a change in procedures, regulations, or the license.

4.10 Documentation of all training shall be maintained by the RSO.

5.0 PROGRAM OF INSTRUCTION

5.1 Basic Radiation Therapy and Safety Practices

5.1.1. Radiation Safety Training Course (24 hours) by outside Consultant

See TAB 2.

5.1.2 Supplemental Radiation Training (16 hours) by RSO (See TAB 3)

5.2 Job Specific Training

The job specific training outlined below will be conducted at the Geneva or Cleveland facilties of Advanced Medical Systems, utilizing actual machines and equipment as available.

5.2.1 Assembly of teletherapy Units (135 hours)

Blueprint reading - mechanical & schematic

QA procedures and unit acceptance criteria

Electrical circuitry - head tilt, rotation swtiches

Part number system - manuals

Operation of control console

5.2.2 Unit teardown for shipment (9 hours)

Packing, crating, and marking

Disassembly procedures

Documentation

5.2.3 Unit Installation (34 hours)

Unpacking, assembly, and adjustment

Rigging equipment and installation tools

Radiation safety considerations regarding source loaded heads

Unit acceptance criterion and documentation requirements

Accessory names, uses, installation, and adjustment

Laser alignment

5.2.4 Machine Models (4 hours)

Comparison of different models

Operating and maintenance manuals

5.2.5 Basic Troubleshooting (8 hours)

Cobalt heads, units, tables, controls

5.2.6 Laboratory Exercises

LAB 1 - Preventive Maintenance Checks - Rotational/ Vertical Units (8 hours)

LAB 2 - 3706 Collimator removal and contamination check (1 hour)

LAB 3 - 3347 Collimator removal and contamination check (1 hour)

LAB 4 - 3347 Mirror replacement (3 hours)

LAB 5 - Isocenter determination and adjustment (1 hour)

LAB 6 - Head leakage surveys (1 hour)

LAB 7 - Loaded head installation and removal (3 hours)

LAB 8 - Shutter bearing lubrication (590 series and 581 series) (4 hours)

LAB 9 - Unit checkout, service tickets & customer forms (1 hour)

LAB 10 - Leak testing (1 hour)

LAB 11 - Radiation light field congruency check (1 hour)

5.2.7 Emergency Procedures (3 hours)

Stuck shutter closing - laboratory exercise

Response to radiation workplace accidents

Contamination control measures (leaking source)

Incident reporting

Obligation to report non-compliance activities

5.3 On-the-Job Training

5.3.1 Performance of each task as outlined in 5.2.6 a minimum of two times under supervision.

5.4 Copies of written quizzes, exams, and evaluation forms are attached.

5.5 Documentation forms for job specific and on-the-job training are attached.

5.6 A certificate of training issued to Class 2 Service Engineer candidates who successfully complete the training program is attached.

Name:_____

Date:_____

QUIZ 1

1. What is the main cause of squeal during C-Arm rotation?

2. What will cause a squeal when the yoke or head rotates?

3. Yoke or Head Drift - How do you stop it?

4. Two of the 3 possible causes of slow shutter opening and closing times:

5. What lubrication is used on the slip rings?

6. What is the only lubrication used on rotor bearings?

7. Name of the AMS Radiation Safety Officer:

8. What does the halo ring do on a Picker Cobalt unit?

9. When balancing the hanger, which end is balanced light and what amount?

10. How many rotations can a C-9 C-Arm make in each direction?

Name:_____

Date:_____

QUIZ 2

1. How do you adjust the optical distance indicator and what tolerance are you allowed?

2. What is the function of the head tilt limit switches and the location of these switches?

3. When performing a brake tension test on the yoke brake, what value or number are you trying to achieve on the pull scale?

4. What voltage is present on the:

   a) back pointer lamp?

   b) collimator drive motors?

5. What is the allowable chain deflection on the main rotation drive chain?

6. A. To what value are the stand to C-Arm bolts torqued?

   B. To what value should the barrier bolts be torqued?

7. True or False - When the "Red" zonegard lamps are on, the source is pointed off the barrier.

8. What solvent is used to clean the slip rings?

9. What functions are controlled from the pendant switch on a C-9?

10. Describe use and operation of emergency bar.

Name:_____

Date:_____

QUIZ 3

1. Define Agreement State.

2. What does the Digi-Pot on the control console allow the operator to do?

3. Where is the template for the floor mounting holes found?

4. Why should C-9 collimator lamps never be touched with your fingers?

5. For installations, what is the minimum clearance between the head and the floor?

6. What is the measurement from the top of the yoke to the floor when installing a C-9 Cobalt Unit? Note: The C-Arm is in the vertical position.

7. What does the collimator field lamp do?

8. What does the 80cm mean when describing a unit, i.e., C-9 80cm?

9. What is the distance from the source in the "on" position to the lowest of the tungsten trimmer bars?

10. What is the true Source to Axis Distance (SAD) of a unit and how is it determined by the Service Engineer?

Name: _____

Date: _____

QUIZ 4

1. Who normally would perform or verify the collimator film check, and what does it show?

2. On limit switches, what is over-travel?

3. Where is the "C" Arm centering switch located?

4. True or False - The C-Arm centering switch operates at slow and fast speed settings.

5. What is the range of the optical distance indicator?

6. True or False - 35cm is equal to 13-29/32 inches.

7. Where are relays RE6 and RE7 located and what do they do?

8. How many thicknesses of x-ray film should pass between the rotor and the head shutter bore?

9. True or Fales - A V-9 has yoke rotation.

10. A 3702 is:

    a) a collimator (C-9)

    b) the C-9 stand

    c) a treatment table

Name:_____

Date:_____

QUIZ 5
ELECTRICAL SYSTEM

Ref: Supplied E-200070 Rev. B Schematic Diag.

1. What relay could be called the "source control" relay? What conditions have to be met in order for this relay to energize?

2. If the shielding of the treatment room permitted irradiation in any angle or head position, on or off the barrier, where could a jumper be placed to permit shutter operation? There are more than one possibilities.

3. Which switch resets the elapsed timer? At what time does the reset occur?

4. When do the red "source on" lights come on?

   a) when shutter starts to open

   b) when shutter has reached 142 degrees rotation.

   c) when shutter has completely opened.

5. What relay number controls the source off and on state during "skip-scan" treatment? What action is required to energize the skip-scan relay?

6. Which relays carry the main rotation motor armature current?

7. If both collimator motors are inoperative, which fuse could possibly be bad?

8. When does RE26 energize? What does it do?

9. When does RE1 energize? On an AMS machine, when will it de-energize?

10. If the zonegard light is on at 0 degrees rotation but goes out at 50 degrees, what could be the cause?

Name:_____

Date:_____

QUIZ 6

1. True or False - The handwheel on the head can be used to close and open the source.

2. True or False - A counterweight attenuates radiation.

3. What is the recommended safe weight that a 3702A table can support?

4. What is the attenuation of the 3702A table top?

   a) 1"

   b) 1/4" of aluminum

   c) 2" with pad

5. Effective source transfer time, i.e., source off to source on, takes how long?

6. The distance from the bottom of the optional trimmers to the axis of rotation.

7. Where is and what does the contamination barrier do?

8. What is the isocentric accuracy of a rotating C-9?

9. What is the input power required for a C-9?

10. What are the 3 emergency source closure systems on a C-9?

Name:_____

Date:_____

QUIZ 7
C-8 UNIT

1. What is the model number of the collimator used on a C-8?

2. What is the elapsed time totalizer used for?

3. Does the totalizer counter terminate treatment?

4. Do you apply 3 in 1 oil to the shutter drive gears on a C-8?

5. What lubricant is used on the shutter rotor return spring?

6. Why does the 3347 collimator have a teflon lining on one side of the lead collimator vanes?

7. Define skip scan operation.

8. Is the C-8 treatment table (3324B) manual or motorized?

9. What does a shutter locking bar do?

10. True or False - If your pocket dosimeter reads zero exposure, you do not have to log the reading on your exposure record sheets.

SERVICE ENGINE[illegible]RAINING RECO[illegible] COBALT TE[illegible]ERAPY UNITS

STUDENT NAME:_____

UNIT #	COURSE IDENTIFICATION	NO. HOURS	STUDY AIDE	LOCATION & DATE ATTENDED	TESTING RESULTS	STUDENT SIGNATURE	INSTRUCTOR SIGNATURE
LAB 1	PM Checks						
LAB 2	3706 Collimator Removal						
LAB 3	3347 Collimator Removal						
LAB 4	3347 Collimator Mirror Replacement						
LAB 5	Isocenter						
LAB 6	Head Leakage Surveys						
LAB 7	Loaded head install/removal						
LAB 8	Shutter bearing lubrication						
LAB 9	Unit checkout/customer forms						
LAB 10	Leak testing						
LAB 11	Light field congruency						

Isotope Committee Review Date:_____

Comment:_____

_____

Member Officer Signature:_____

SERVICE ENGINE[illegible]RAINING RECO[illegible]L COBALT TE[illegible]ERAPY UNITS

STUDENT NAME:_____

UNIT #	COURSE IDENTIFICATION	NO. HOURS	STUDY AIDE	LOCATION & DATE ATTENDED	TESTING RESULTS	STUDENT SIGNATURE	INSTRUCTOR SIGNATURE

Isotope Committee Review Date:_____

Comment:_____

_____

Member Officer Signature:_____

PERFORMANCE EVALUATION

Candidate: _____

Date: _____

Type of Unit Involved: _____ Head Model: _____

Task:

Preventive Maintenance _____	Isocenter _____
3706 Collimator _____	Head Leakage _____
3347 Collimator _____	Head Install/Remove _____
3347 Mirror _____	Shutter Bearing Lube _____
Leak Testing _____	Light Field Congruence _____
Unit checkout/customer forms _____	
Other _____	
_____	

Evaluation of Performance	Satisfactory	Unsatisfactory
1. Has proper tools and manuals	_____	_____
2. Uses proper tools and parts	_____	_____
3. Knowledgeable of procedures	_____	_____
4. Self-Confident	_____	_____
5. Proper work habits	_____	_____
6. Use of radiation survey instruments	_____	_____
7. Task properly performed	_____	_____
8. Documentation properly completed	_____	_____

Comments/Problems:

Instructor/Evaluator: _____

Date: _____

Advanced Medical Systems, Inc.
121 North Eagle Street • Geneva, Ohio 44041
(216) 466-4671 TWX 810-4272-183

CERTIFICATE OF TRAINING

Class 2 Service Engineer

This is to certify that _____ has successfully completed the prescribed course of formal instruction in the installation, adjustment and maintenance of teletherapy units offered by Advanced Medical Systems, Incorporated.

The above named individual has demonstrated to the Advanced Medical Systems, Incorporated Isotope Committee that he/she can safely and competently perform the duties necessary in full compliance with the procedures and conditions of U. S. Nuclear Regulatory Commission License Number 34-19089-01.

The individual is certified as qualified to service the following units:

AMS	C9	Model 76296	All services
AMS	V9	Model 76268	"
Picker	C9	Model 6296	"
Picker	V9	Model 6268	"
Picker	C8	Model 6223	"
Picker	C4	Model 6234	"
Picker	V4	Model 6235	"
Picker	C12	Model 6376	"
Picker	C1000	Model 6182	"
Picker	V1000	Model 6177	"
Picker	C3000	Model 6183, 6204	"
Picker	C5000	Model 6096	"
Picker	C1000	Model 6103	"
Picker	C2000	Model 6150	"

Signed,

_____
Radiation Safety Officer

_____
Date

C-12 TRAINING

Description of the Work to be Authorized
(Reference: AMS Training Manual, Tab 4, Page 1, Paragraph 3.0)

A. Candidates are qualified to conduct the service procedures specified in ISP-25 as they pertain to the Picker C-12 Teletherapy unit.

B. Installation and dismantling of C-12 Teletherapy unit.

C. Packaging and transportation of radioactive material as associated with the C-12 unit.

D. Use radiation safety instrumentation and basic tools associated with the service of the C-12 unit.

Unit Identification

Model	-	Picker C-12 No. 6376
Cat. No.	-	6376A
Head No.	-	182972A
Collimator No.	-	183435
Control No.	-	3930
Stand No.	-	183445
Stretcher No.	-	3931

Technical Manual (Furnished to each Service Engineer)

Picker H60:TM August 1976

Description of Training

A. Instructors (Reference: AMS Training Manual, Tab 1, Instructors)

Engineering/Production Manager - Ed Svigel

Radiation Safety Officer - Howard Irwin

B. Instructional Aids

Picker Technical Manual H60:TM

C-12 Unit and Sub-assemblies

Blueprints and mechanical schematics

C. Mechanical Specifications (1.5 hours)

1. Source Head

2. Zonegard

3. Shutter Drive Mechanism

4. Collimator

5. Beam Interceptor

6. Stand and Drive Mechanisms

7. Stretcher and Components

8. Hand Switch Controls

D. Calibration Procedures (1.5 hours)

The C-12, unlike the C-9, has:

1. PCB Used

2. Card Rack Stand and Gantry Control

3. Card Rack Gantry Yoke Control

4. Card Rack Stretcher Control

5. Card Rack Shutter Control

E. Table #3931 (1 hour)

1. Description

2. Operation

F. Head #182972A (1 hour)

1. Head Construction

2. Head Surveys

3. Comparisons with 590 Series Head

4. Shutter Drive Mechanisms

G. Collimator #183435 (1 hour)

1. Operation

2. Similarities and Differences with C-9 Collimator 3706

H. Control #3930 (1 hour)

1. Operation

2. Function

I. Radiation and Radiation Safety (1 hour)

(Reference: AMS Training Manual, Tab 4 (For C-12/C-9 Comparisons), Pages 3 and 4)

1. Reference 5.2.6 (Lab 6) Head Leakage Surveys
2. Reference 5.2.6 (Lab 10) Leak Testing
3. Reference 5.2.7 Emergency Procedures
4. Review Door Interlocks, Unit Security, Room Surveys

CLASS 1 SERVICE ENGINEER TRAINING PROGRAM

1.0 PURPOSE: To develop a staff of trained individuals capable of installing, removing, and exchanging sealed isotope sources and conducting maintenance services requiring the removal of sources.

2.0 SCOPE: This program is applicable to all individuals who will work independently on teletherapy or radiography equipment at customer facilities in accordance with proper source handling procedures.

3.0 OBJECTIVES: Upon completion of training, the candidate will be approved by the USNRC as a qualified source handler and will be able to perform the following tasks:

A. Source exchanges required to install sources into customer equipment.

B. Source exchanges necessary to perform routine five year inspections of customer equipment.

C. Source removal necessary to decommission existing equipment.

4.0 REQUIREMENTS

4.1 A prerequisite for this job classification is the successful completion of the Class 2 Service Engineer training program (see separate program for content).

4.2 The training program shall consist of:

(1) approximately 2 days of job specific training on the procedures and equipment

(2) at least 3 actual source exchanges involving loaded heads

4.3 The job specific training shall be coordinated by the RSO and supervised by either a qualified Class 1 Service Engineer or an Isotope Handler. The on-the-job (field) training shall be coordinated by the RSO and supervised by an NRC qualified Class 1 Service Engineer or a licensed Isotope Handler.

4.4 For the job specific training, an oral and written exam(s) will be prepared by the RSO and administered at the end of the instruction. The minimum passing grade shall be 80%.

4.5 For on-the-job training, the performance of the candidate will be evaluated and documented by an approved service engineer. This documentation will be submitted to and retained by the RSO.

4.6 Upon completion of all facets of this program, the RSO will submit the candidate's name and qualifications to the Isotope Committee. Upon approval of the Isotope Committee, the candidate's name and qualifications will be submitted to the U. S. NRC for approval.

4.7 Candidates who are approved by the NRC will be awarded a certificate of training. In addition, the individual will be issued an identification badge or wallet card which includes Company name and address, individual's name, NRC license number, and a statement of authorization to perform service. AMS retains the right to change the format of this identification.

4.8 Candidates will continue their training until all of the above criteria has been met.

4.9 Refresher training shall be provided on an annual basis and whenever there is a change in procedures, regulations, or the license.

4.10 Documentation of all training shall be maintained by the RSO.

5.0 PROGRAM OF INSTRUCTION

5.1 Prerequisite - Successful Completion of Class 2 Service Engineer Training Program

5.2 Job Specific Training

The job specific training outlined below will be conducted at the Geneva or Cleveland facilities of Advanced Medical Systems utilizing actual machines and equipment.

5.2.1 Classroom Session (3 hours)

Review of exchange procedures (ISP-23 and ISP-24)

Radiation hazards associated with the procedures

Design and use of source exchange containers

5.2.2 Laboratory Exercise (8 hours)

Operation and use of exchange container

Trapping and exchange of dummy sources

Trapping and exchange of live sources

Radiation Safety practices

5.2.3 Packaging sources for transportation (4 hours)

Design and use of 18136l container

Installation Tool kit

Labeling and QA checklist

5.2.4 Five Year Inspections (1 hour)

Documentation Review

5.3 On-the-job Training

5.3.1 Performance of each task as outlined in 5.2.2 - 5.2.4 a minimum of three times under supervision.

5.4 Copies of written quizzes, exams, and evaluation forms are attached.

5.5. Documentation forms for job specific and on-the-job training are attached.

5.6 A certificate of training issued to Class 1 Service Engineer candidates who successfully complete the training program is attached.

Name:_____

Date:_____

CLASS 1 SERVICE ENGINEER EXAM

1. Why are source exchanges performed in the supine position?

2. What are the two basic reasons that contamination might be present in a machine head?

3. During the contamination check procedure, what is the action level indicating a potential contamination level?

4. True or False - The source installation and exchange procedure (ISP-23) covers exchanges for only C8 and C9 machines.

5. Describe the actions of the assisting person during a source exchange.

6. The 3320AR source exchange container is designed to hold how many sources?

7. What is the basic difference between installation tool kits for domestic and foreign source exchange jobs?

8. Who is responsible for the return source shipping papers?

9. With the source exchange container top plug removed and the drawer opened, what is the approximate radiation level from a 5500 RHM source at a point 33 cm from the source?

10. How does a Service Engineer determine that the sources have actually been exchanged on a source exchange job?

NAME_____

DATE_____

CLASS 1 SERVICE ENGINEER - EXAM 2

1. Personnel performing source exchanges must be NRC approved or in the physical presence of NRC approved individuals. T F

2. A wipe test on the container plug reveals 300 cpm above background. It is appropriate to proceed with the exchange. T F

   Explain your answer:

3. The shutter locking bar must be removed in order for the actual source transfer to take place. T F

   Explain your answer:

4. Explain why both a 200mR and 5R dosimeter are required when performing a source exchange.

5. Why is it a good practice to post a "Unit Being Serviced" sign at the control console?

6. The reason that the exchange assistant takes a survey meter with him is to remove unnecessary equipment from the work area. T F

   Explain your answer:

7. Why is the machine head secured to the exchange container during a source exchange?

8. a.) Where may a copy of ISP-23, "Source Installation and Exchange Procedures", be found?

   b.) Should a copy be present during a source exchange job? Yes No

   Explain your answer:

9. With the source exchange container top plug removed and the drawer opened, the approximate radiation level from a 3000Rhm source at a point .25m from the source is 48000R/hr. T F

   Explain how you determined your answer:

10. The following steps are part of a typical source exchange job. Number them in the order in which they should be performed.

_____ Verify that sources have been exchanged
_____ Mate head to exchange container
_____ Lock shutter
_____ Install new source into head
_____ Remove old source from head
_____ Inspect the source exchange container
_____ Have assisting person leave room
_____ Perform 5-year inspection on head
_____ Remove collimator
_____ Initiate audible checklist with assistant
_____ Unmate container from head
_____ Lock shutter

SERVICE ENGIN[illegible]TRAINING REC[illegible] COBALT T[illegible]ERAPY UNITS

STUDENT NAME:_____

UNIT #	COURSE IDENTIFICATION	NO. HOURS	STUDY AIDE	LOCATION & DATE ATTENDED	TESTING RESULTS	STUDENT SIGNATURE	INSTRUCTOR SIGNATURE

Isotope Committee Review Date:_____

Comment:_____

_____

Member Officer Signature:_____

PERFORMANCE EVALUATION

Candidate: _____

Date: _____

Type of Unit Involved: _____ Head Model: _____

Task:

Preventive Maintenance _____	Isocenter _____
3706 Collimator _____	Head Leakage _____
3347 Collimator _____	Head Install/Remove _____
3347 Mirror _____	Shutter Bearing Lube _____
Leak Testing _____	Light Field Congruence _____
Unit checkout/customer forms _____	
Other _____	
_____	

Evaluation of Performance	Satisfactory	Unsatisfactory
1. Has proper tools and manuals	_____	_____
2. Uses proper tools and parts	_____	_____
3. Knowledgeable of procedures	_____	_____
4. Self-Confident	_____	_____
5. Proper work habits	_____	_____
6. Use of radiation survey instruments	_____	_____
7. Task properly performed	_____	_____
8. Documentation properly completed	_____	_____

Comments/Problems:

Instructor/Evaluator: _____

Date: _____

Advanced Medical Systems, Inc.
121 North Eagle Street • Geneva, Ohio 44041
(216) 466-4671 TWX 810-4272-183

CERTIFICATE OF TRAINING

Class 1 Service Engineer

This is to certify that _____ has successfully completed the prescribed course of formal instruction in the installation of Cobalt 60 and Cesium 137 teletherapy sources given by Advanced Medical Systems, Incorporated.

The above named individual has demonstrated to the Advanced Medical Systems, Incorporated Isotope Committee that he/she can safely and competently perform the duties necessary in full compliance with the procedures and conditions of U. S. Nuclear Regulatory Commission License Number 34-19089-01.

The individual is certified as qualified to exchange sources in the following units:

AMS	C9	Model 76296
AMS	V9	Model 76268
Picker	C9	Model 6296
Picker	V9	Model 6268
Picker	C8	Model 6223
Picker	C4	Model 6234
Picker	V4	Model 6235
Picker	C12	Model 6376
Picker	C1000	Model 6182
Picker	V1000	Model 6177
Picker	C3000	Model 6183, 6204
Picker	C5000	Model 6096
Picker	C1000	Model 6103
Picker	C2000	Model 6150
Picker	CS600	Model 6152

Signed,

_____
Radiation Safety Officer

_____
Date

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

ISOTOPE TECHNICIAN TRAINING PROGRAM

ISP-31 Rev. 01/95

1.0 PURPOSE: To develop a staff of training individuals capable of assisting the RSO and Isotope Handler by performing routing radiation safety-related checks and measurements.

2.0 SCOPE: This program is applicable to all individuals who will work independently in restricted areas at the London Road Isotope Facility for the performance of specified tasks.

3.0 OBJECTIVE: Upon completion of training, the candidate will be able to perform the following tasks:

A. Safety assurance checks specified in ISP-4 and Form 4A.

B. Receipt of radioisotope shipping containers.

C. Release of packaged radioactive materials for transportation.

D. Calibration of survey instruments and meters.

4.0 REQUIREMENTS:

4.1 The training program shall consist of (1) approximately 3 days of classroom instruction on basic radiation theory and safety practices; (2) approximately 2 days of training on the procedures, methods and precautions required to perform given tasks; and (3) approximately 1 month of on-the-job training.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

4.2 A trained health physicist and other qualified instructors, under the direction of the RSO, shall provide the classroom instructions. The job-specific training and the on-the-job training shall be coordinated by the RSO and supervised by the RSO or an approved Isotope Handler.

4.3 For the classroom instruction, a written examination(s) shall be administered to determine comprehension of the material presented. The examination(s) shall be prepared, administered and scored by the instructor. The minimum passing grade shall be 80%.

4.4 An oral (supported by quiz) walk-through, job performance exam will be administered after completion of the on-the-job training. The examination shall be prepared and administered by the RSO. The minimum passing grade shall be 80%.

4.5 A certificate shall be awarded to each candidate who successfully completes the training.

4.6 Candidates who do not successfully complete the primary training shall be given additional training and retested.

4.7 Refresher training shall be provided on an annual basis and whenever there is a change in duties, procedures or regulations.

4.8 Documentation of all training shall be maintained by the RSO.

4.9 Prior to assuming duties as an Isotope Technician, the candidate's qualifications must be reviewed and approved by the Isotope Committee.

5.0 PROGRAM OF INSTRUCTION

5.1 Basic Radiation Therapy and Safety Practices Course (24 Hours)

5.2 Job Specific Training

5.2.1 Radiation Surveys (1.5 Hours)

Knowledge of unrestricted and restricted areas;

Proper selection and operation of portable survey instrumentation;

Notification procedures; proper documentation and posting of areas.

5.2.2 Contamination Surveys (2.5 Hours)

Proper technique for sample collection;

Proper selection of counting equipment;

Smear counting and analysis procedures;

Isolation and proper tagging;

Procedures for performing personnel body contamination checks;

Notification procedures

5.2.3 Instrumentation (2 Hours)

Knowledge in procedures for operation and calibration of survey meters, counting equipment, air monitors;

Inspecting and tagging out inoperative instruments.

5.2.4 Air Monitoring (2 Hours)

Knowledge of operation and proper functioning of the permanent air monitoring system;

Location of sampling lines, use and operation of portable air samplers, inspection of air monitor chart and alarms;

Notification procedures.

5.2.5 Radiation Work Permit Coverage (1.5 Hours)

Obtain adequate information about the job;

Identifying, monitoring, mitigating and controlling direct radiation hazards;

Proper methods for locating and controlling contamination hazards;

Demonstrating proficiency in the use of anti-contamination clothing and respiratory equipment.

5.2.6 Waste Management (1 Hour)

Solid waste generation, handling, packaging for disposal;

Liquid waste management;

Designated waste handling and storage areas;

Notification procedures.

5.2.7 Radioactive Material Receipt/Shipping Procedures (1.5 Hours)

Survey and contamination requirements;

Documentation requirements - inventory control;

Handling and storage procedures, storage areas;

Notification procedures.

5.2.8 Emergency Action Plan (4 Hours)

Familiarization with facility alarm system and response activities of civil agencies;

Knowledge of Emergency Pre-Plan;

Maintenance and testing of emergency generator, fire pump;

Location of potential chemical and radiation hazards.

5.3 On-the-Job Training

5.3.1 Performance of each task as outlined in 3.0 a minimum of two times under supervision.

5.4 Copies of written quizzes, exams and evaluation forms are attached.

5.5 Documentation forms for job specific and on-the-job training are attached.

5.6 A certificate of training issued to Isotope Technician candidates who successfully complete the training program is attached.

ISOTOPE TECHNICIAN JOB PERFORMANCE EVALUATION 85 Points

Candidate:_____

Date:_____

RSO:_____

		SATISFACTORY	UNSATISFACTORY
1.	Daily Checks		
2.	Use of Survey Instruments		
3.	Use of Well Counter		
4.	Analysis of Wipes		
5.	Knowledge of Hazards		
6.	Generator Test		
7.	Air Monitor Calibration		
8.	Analysis of Air Samples		
9.	Gamma Alarm Settings		
10.	Air Monitor Calibration		
11.	Receiving Radioactive Material		
12.	Shipping Radioactive Material		
13.	Survey and Wipes		
14.	Calibration of Instruments		
15.	Application of RWP		
16.	Emergency Plans		
17.	Use of Anti-C Clothing		
18.	Personal Contamination		
19.	Methods for Reducing Exposure		
20.	Surface Contamination Limits		
21.	Decontamination Methods		

Comments:

ON-THE-JOB TRAINING RECORD FOR ISOTOPE TECHNICIANS

STUDENT NAME:_____

UNIT #	COURSE IDENTIFICATION	# HOURS	STUDY AIDE	LOCATION/DATE ATTENDED	TESTING RESULTS	STUDENT SIGNATURE	INSTRUCTOR SIGNATURE
ISP 4	Daily Checks						
ISP 2	Unrestricted Area Surveys						
ISP 2	Unrestricted Area Wipes						
ISP 5.1	Emergency Generator Test						
ISP 10	Generator Battery Check						
ISP 7	Air Monitor System						
ISP 6	Gamma Alarm Function						
ISP 6	Contaminated Water Level						
ISP 8	Air Monitor Calibration						
ISP 23	Survey Meter & Dosimeter Calibration						
ISP 13	Receipt of Rad. Material						
	Release of Rad. Material to Carrier						
ISP 2	Restricted Area Surveys						
ISP 2	Restricted Area Wipes						

Isotope Committee Review Date:_____

Comments:_____

_____

Member Officer Signature:_____

JOB SPECIFIC TRAINING RECORD FOR ISOTOPE TECHNICIANS

STUDENT NAME:_____

UNIT #	COURSE IDENTIFICATION	# HOURS	STUDY AIDE	LOCATION/DATE ATTENDED	TESTING RESULTS	STUDENT SIGNATURE	INSTRUCTOR SIGNATURE
1	Radiation Surveys						
2	Contamination Surveys						
3	Instrumentation						
4	Air Monitoring						
5	Radiation Work Permits						
6	Waste Management						
7	Rad. Material Receipt/Shipping						
8	Emergency Actions						

Isotope Committee Review Date:_____

Comments:_____

_____

Member Officer Signature:_____

Advanced Medical Systems, Inc.

121 North Eagle Street • Geneva, Ohio 44041
5) 466-4671 FAX (216) 466-0186

CERTIFICATE OF TRAINING

ISOTOPE TECHNICIAN

This is to certify that _____ has successfully completed the Isotope Technician Training Program offered by Advanced Medical Systems, Inc.

The above-named individual has demonstrated to the Advanced Medical Systems, Inc. Isotope Committee that he/she can safely and competently perform the routine radiation safety procedures at the London Road Isotope Facility under U.S. Nuclear Regulatory Commission License No. 34-19089-01.

Signed,

_____
RADIATION SAFETY OFFICER

_____
Date

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

ISOTOPE HANDLER TRAINING PROGRAM

ISP-32 Rev. 01/95

1.0 PURPOSE: To develop a staff of trained individuals capable of handling sealed and unsealed sources of radioactive material at the London Road facility.

2.0 SCOPE: This program is applicable to all individuals who will work independently and/or who can supervise others in restricted areas at the London Road Facility.

3.0 OBJECTIVE: Upon completion of training, the candidate will be approved by the USNRC as a qualified Isotope Handler and will be able to safely perform the following tasks:

A. Operate the hot cell equipment.

B. Operate the source storage garden and related equipment.

C. Leak test and calibrate sources.

D. Install and remove sealed sources from machine heads and source exchange containers.

E. Maintain hot cell and related equipment.

F. Handle and package radioactive waste.

G. Prepare machine head and source exchange container shipping packages.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

4.0 REQUIREMENTS:

4.1 A prerequisite for the job classification is the successful completion of the Isotope Technician Program (see separate program for content).

4.2 The training program shall consist of (1) approximately 13 days of job-specific training on the procedures and equipment; and (2) approximately 3 months of on-the-job training.

4.3 Both the job specific and on-the-job training shall be coordinated by the RSO and supervised by a qualified Isotope Handler.

4.4 Oral and written examinations will be prepared and administered by the RSO. The minimum passing grade shall be 80%.

4.5 For on-the-job training, the performance of the candidate will be evaluated and documented by either the RSO or an approved Isotope Handler.

4.6 Candidates who are approved by the NRC will be awarded a Certificate of Training.

4.7 Candidates will continue their training until all of the above criteria has been met.

4.8 Refresher training shall be provided on an annual basis and whenever there is a change in procedures, regulations or the License.

5.0 PROGRAM OF INSTRUCTION

5.1 Prerequisites (15 Hours)

(1) Successful completion of Isotope Technician Training Program.

(2) Parts 5.2.1 - 5.2.3 of the Job Specific Training Program for Class 1 Service Engineers.

5.2 Job Specific Training

5.2.1 Isotope Facility Safety Procedures (6 Hours)

Review of ISP-1 Manual

5.2.2 LAB - Hot Cell Equipment (4 Hours)

Familiarization with manipulators and ancillary fixtures, etc.

5.2.3 LAB - Source Processing and Transfer (8 Hours)

Transfer out of cell;

Calibration;

Transfer out of Isotope Shop for shipment;

Contamination checks.

5.2.4 LAB - Storage Garden Operation (6 Hours)

Equipment;

Radiation hazards and safety.

5.2.5 LAB - Decontamination of Areas and Equipment (2 Hours)

Action levels and techniques.

5.2.6 Solid Waste Management (2 Hours)

Collection, packaging;

Processing for shipment, storage;

Documentation requirements.

5.2.7 Hot Cell Entry (1 Hour)

Review of procedure ISP-11.

5.2.8 Hot Cell Equipment Room (1 Hour)

HEPA Filter System;

Filter change procedure - ISP-12.

5.2.9 London Road Facility Security System (8 Hours)

Supervisory system - alarms, equipment;

Proper response - troubleshooting;

HVAC System;

Fire System.

5.3 On-the-Job Training

5.3.1 Performance of each task as outlined in 3.0 a minimum of two times under supervision.

5.3.2 Performance of source transfer procedures a minimum of six times.

5.4 Copies of written quizzes, exams and evaluation forms are attached.

5.5 Documentation forms for job specific and on-the-job training are attached.

5.6 A Certificate of Training issued to Isotope Handler candidates who successfully complete the training program is attached.

JOB SPECIFIC TRAINING RECORD FOR ISOTOPE HANDLERS

STUDENT NAME:_____

UNIT #	COURSE IDENTIFICATION	# HOURS	STUDY AIDE	LOCATION/DATE ATTENDED	TESTING RESULTS	STUDENT SIGNATURE	INSTRUCTOR SIGNATURE
1	ISP-1 Manual Review						
2	Solid Waste Management						
3	Hot Cell Entry						
4	Hot Cell Equipment Room						
5	Facility Systems						
LAB 1	Hot Cell Equipment						
LAB 2	Source Processing & Transfer						
LAB 3	Storage Garden Operation						
LAB 4	Decontamination						

Isotope Committee Review Date:_____

Comments:_____

_____

Member Officer Signature:_____

ISOTOPE HANDLER TRAINING RECORD

CANDIDATE_____

OUTLINE OF TECHNICAL TRAINING AND INSTRUCTION	INSTRUCTOR INITIALS	DATE PERFORMED
1. Work Authorization and Radiation Work Permit Requirements		
2. Use of Radiation Monitoring Equipment		
3. Familiarization with Hot Cell Ventilation System and Safety Interlock System		
4. Transfer of Inert Materials Into Hot Cell		
5. Slave Manipulator System - Use and Dexterity		
6. Purpose and Use of Hot Cell Ancillary Equipment a) Crane and Electromagnets b) Beam Scales c) Miscellaneous Tools and Fixtures		

CANDIDATE_____

OUTLINE OF TECHNICAL TRAINING AND INSTRUCTION	INSTRUCTOR INITIALS	DATE PERFORMED
7. Raising Hot Cell Floor Plug and Accessing Isotopes a) Floor Plug Removal b) Storage Capsule Identification c) Storage Capsule Removal		
8. Bulk Isotopes Storage and Floor Plug Insertion		
9. Decontamination of Cell Deck		
10. Source Receptacle Loading a) Use of Source Holder b) Application of Retaining Ring c) Inspection of Retaining Ring		
11. Transfer of source Into Cell Wall		
12. Hot Cell Decontamination and Waste Disposal		

CANDIDATE_____

OUTLINE OF TECHNICAL TRAINING AND INSTRUCTION	INSTRUCTOR INITIALS	DATE PERFORMED
13. Securing Hot Cell Equipment		
14. Transfer of Source to Transfer Monster from Cell Wall		
15. Source Transfer Between Transfer Monster and Source Exchange Container		
16. Source Transfer Between Exchange Container and Calibration Head		
17. Source Calibration and Documentation		
18. Source Surface Contamination Inspection		

CANDIDATE_____

OUTLINE OF TECHNICAL TRAINING AND INSTRUCTION	INSTRUCTOR INITIALS	DATE PERFORMED
19. Source Transfer Between Machine Head and Exchange Container		
20. Packing/Unpacking of Machine Head and Source Exchange Shipping Container		
21. Operation of Source Storage Garden		
22. Hot Cell Machinery Maintenance		
23. Solid Waste Packaging		

Advanced Medical Systems, Inc.

121 North Eagle Street • Geneva, Ohio 44041
) 466-4671 FAX (216) 466-0186

CERTIFICATE OF TRAINING

ISOTOPE HANDLER

This is to certify that _____ has successfully completed the Isotope Handler Training Program offered by Advanced Medical Systems, Inc.

The above-named individual has demonstrated to the Advanced Medical Systems, Inc. Isotope Committee that he/she can safely and competently perform the duties necessary in full compliance with the procedures and conditions of U.S. Nuclear Regulatory Commission License No. 34-19089-01.

Signed,

_____
RADIATION SAFETY OFFICER

_____
Date

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

INSTRUCTIONS TO ANCILLARY PERSONNEL

ISP-28 Rev. 1/95

1.0 PURPOSE: To instruct part time or occasional workers on the presence, storage and use of radioactive materials and the associated safety precautions and procedures.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure applies to all part time or occasional workers who will be working in the Restricted Areas of the facility or in the vicinity of radioactive materials. It applies to both AMS and non-AMS personnel.

2.2 The RSO or designee shall be responsible for providing training to these workers.

2.3 Ancillary personnel will receive training prior to performing job assignments.

2.4 Refresher training will be provided on an annual basis to permanent AMS employees, unless the employee requests or the RSO insists upon a more frequent basis.

2.5 Ancillary personnel may be asked general questions relating to the training to determine their overall comprehension.

2.6 Personnel with a previous radiation exposure history should complete Form ISP-28A, Certificate of Prior Dose.

2.7 A copy of the signed record of training will be maintained at the Isotope Facility, and for AMS employees, also in their personnel file.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

3.0 INSTRUCTIONS:

3.1 Outline of Worker Training.

3.1.1 Background discussion.

a. Radiation.
b. Radioactive contamination.
c. Airborne contamination.
d. Biological effects (acute and chronic).
e. Prenatal exposure (Reg. Guide 8.13).

3.1.2 Personal monitoring.

a. Film badges.
b. Pocket dosimeters.
c. Whole body frisking.
d. ALARA concept - time, distance, shielding.
e. Exposure limits - previous work history.
f. Expected exposure levels.
g. Right to receive exposure reports.

3.1.3 Facility tour.

a. Locations of Restricted Areas.
b. Areas of storage.
c. Areas of transfer.
d. Interpretation of signs and placards.
e. Areas of unauthorized entry.

3.1.4 Protective devices.

a. Protective clothing.
b. Respirators.
c. Fixed gamma ray detectors.
d. Shielding materials.
e. Equipment and tool monitoring.
f. Trained radiation workers.

3.1.5 Response to warnings and alarms.

a. Location of emergency exits.
b. Personal safety first.
c. Heed instructions of trained radiation worker.

3.1.6 The right to inquire or respond to any condition which they believe to constitute a violation of NRC Regulations.

CERTIFICATE OF PRIOR DOSE

ISP-28A

This certification is to be completed prior to the first entry into a Restricted Area during a work assignment under such circumstances that the individual could receive a dose in excess of 125mrem.

I certify that I have had no prior occupational dose during the current calendar year.

Printed Name:_____

Signature:_____ Date:_____

OR

I certify that my occupational dose for the current calendar year is _____mrem.

Printed Name:_____

Signature:_____ Date:_____

Comments:_____

_____

_____

_____

_____

_____

Reviewed by RSO:_____ Date:_____

STATEMENT OF TRAINING

ISP-28B

Name:_____ Soc. Sec. No.:_____

Employer:_____

I have been trained to Advanced Medical Systems Operating Procedure "Instructions to Ancillary Personnel", ISP-28, and Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure".

Comments: _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Signature of Trainee:_____ Date:_____

Signature of Trainer:_____ Date:_____

Reviewed by RSO:_____ Date:_____

ANNUAL REFRESHER TRAINING PROGRAM

1.0 PURPOSE: To meet training requirements in accordance with 10CFR19.12

2.0 SCOPE: This program is applicable to all individuals who work independently as Service Engineers, Isotope Technicians, and Isotope Handlers

3.0 OBJECTIVES: Upon completion of training, the individual will have reviewed fundamental radiation safety, current procedures and practices, license status and conditions, DOT and NRC regulations, job specific problems.

4.0 REQUIREMENTS

4.1 The training will consist of approximately 8 hours of instruction and review.

4.2 The instructor will be the RSO.

4.3 An oral or written examination as well as observation of hands on activities will be used to determine comprehension of the material presented. If the RSO determines that comprehension is not sufficient, provisions will be made for individual training in the deficient areas.

4.4 Individuals who complete the training will be issued a certificate of training which will generally outline the topics discussed.

4.5 Documentation of all training will be maintained by the RSO.

5.0 Program of Instruction

5.1 Radiation Theory

Isotopes

Types of radiation

Biological effects

Units of measurement

5.2 Radiation Protection Standards

Review of current regulations

Signs and labels

License status, conditions

Personnel exposure (actual vs. reg. limits)

5.3 Radiation Protection Methods

Use of instruments

Review of stay time, inverse square law, shielding

5.4 Specific procedures

Review of all change/modifications in procedures.

Training in all new procedures

Comment and discussion period regarding procedural changes

Review emergency procedures

5.5 Packaging and Transportation

Review proper package selection

DOT labeling, marking, placarding, shipping papers

Review DOT/NRC regulations

Packing and unpacking instructions

5.6 Job Specific Problems

Round table discussion within each job category regarding common problems, unusual situations encountered, etc.

Discussion of corrective action measures

Review of unauthorized field modification reports

Review observations from audits

Scenarios - discussion of response with regard to personal and radiation safety

5.7 Hands on Activities

Survey instrument use

Emergency procedures - mock drills (e.g., stuck shutter)

Examination of teletherapy equipment modifications (AMS engineering changes)

Contaminated source head, off scale dosimeter

ADVANCED MEDICAL SYSTEMS

OPERATING PROCEDURE

TITLE: COBALT SERVICE PROCEDURES MANUAL	Procedure No: ISP-25 Revision: C Date Issued: 8/11/87

Prepared by	Approval	Revisions
	Howard R Sturm	See Revision Sheets

REVISION SHEET

Effective Date	Revision Letter	Pages Affected	Description of Change
11/12/84	A	All	Reformatted for 34-19089-01 license renewal
10/23/86	B	Title Page	Change to B and date
		4	Rewrite paragraph 5 for procedure for off-scale dosimeters. Additional contact names
		10-11	Revise B 3 to eliminate decontamination activities.
		ISP-23	Revision B
		ISP-29	Revision D
8/11/87	C	Title Page	Revision level and date
		ISP-23	Revision C
		ISP-29	Revision E
		New	ISP-38
3/8/89	D	4	Revised Contact Names & RSO
8/17/90	E	4	Revised Contact Names & RSO

INTRODUCTION

These procedures are to be followed by Advanced Medical Systems, Inc.'s service technicians when performing service on Advanced Medical Systems, Inc. and Picker Corporation Cobalt 60 Teletherapy and Industrial Radiography Systems.

If, during service, licensable work is to be performed but has been omitted from these procedures, the Radiation Safety Officer shall be notified before proceeding. The Radiation Safety Officer will then establish a procedure.

ADMINISTRATION OF LICENSED SERVICE

Advanced Medical Systems, Inc. has organized its service organization to operate under the guidance of the Radiation Safety Officer and Engineering Manager. The Radiation Safety Officer is responsible for RAD safety and the Engineering Manager is responsible for equipment operation.

The Radiation Safety Officer is responsible for employee and customer safety. He has the authority to:

1. Administer the Radiation Safety Program for service personnel and delegate responsibility as necessary.

2. Develop policy and oversee compliance with Radiation Safety Procedures.

3. Develop record forms, reports and notifications and to establish a record keeping system.

4. Require a documentation of surveys, dosimeter readings and instrumentation calibration.

5. Establish an Internal Audit System.

6. Direct the purchase of instrumentation.

7. Control emergency situations and remedial action.

8. Investigate incidents and institute preventive action.

GENERAL

These instructions have been prepared for use a a check list and reference for persons trained in Shutter Service on Advanced Medical Systems, Inc. and Picker corporation Cobalt Therapy Units. It is to be used in conjunction with the service manual furnished with the unit.

Shutter service will be performed only by, or in the physical presence of, persons specifically certified by Advanced Medical Systems, Inc., Isotope Committee.

The person or persons licensed to perform shutter service may perform only those operations authorized in the instruction manuals which are incorporated, by reference. Service personnel are obligated to refuse to attempt any service operation should any condition or action present a situation wherein the service cannot be made within the spirit and the letter of the law.

Prior to the commencement of the operations outlined in this manual, the licensee for whom the service is being performed will relinquish control over the use of, and the keys for, the equipment and it's controlled areas to the licensed person in charge until such time as it has been determined by the licensed person that the equipment is in safe operating condition. The licensed person will then return control of the equipment and controlled areas to the licensee.

Inasmuch as the licensed person performing the service is considered an agent of the source manufacturer, the equipment radiation leakage survey he performs does not constitute an acceptable survey of equipment as required by the customer's Radioactive Material License.

The calibration certificate furnished with each source by the manufacturer is for billing purposes only and does not constitute an acceptable source output calibration for therapy purposes as required by the customer's Radioactive Material License.

The wipe test certificate furnished with each source by the manufacturer DOES constitute an acceptable wipe test as required by the customer's Radioactive Material License, with regard to testing before initial use.

Officially acceptable survey and source leakage tests can be performed only by personnel outside Advanced Medical Systems, Inc.

Radiation Protection Program

Exposure of personnel to ionizing radiation will be kept "as low as reasonable achievable" and within the current limits specified in 10 CFR 20. Records and reports will be specified in 10CFR 20.

All individuals, while performing licensable service work, must wear radiation monitoring equipment including film badges, personal dosimeters and audible detectors.

Film badges will be changed and processed at least monthly. Reports of film badges will be retained by the Radiation Safety Officer.

Dosimeters will be set to zero before the start of each work day, then read and recorded at the end of each work day. A report of these readings is to be sent to the Radiation Safety Officer at the end of each month for review and record keeping.

In the event that a personal dosimeter is found to be off scale during the course of a service operation, it is to be considered an emergency. Immediate notification shall be made to the Radiation Safety Officer at the telephone numbers listed below. He will record the incident and give instructions for the immediate processing of the film badge or TLD. A written memo explaining the circumstances resulting on the off scale reading shall be signed by the individual and submitted to the Radiation Safety Officer as soon as possible.

Radiation Safety Officer - Robert Meschter

Telephone: (216) 692-3270
Home: (216) 298-1462

Address: Advanced Medical Systems, Inc.
1020 London Road
Cleveland, OH 44110

Revised 01/95

MONTHLY DOSIMETER LOG

NAME

This form is to be completed for each day work is done on or around radiation producing equipment. Submit with Therapy Service Record form for Cobalt and Cesium unit service work.

	MON.	TUES.	WED.	THUR.	FRI.	SAT.	SUN.
FIRST WEEK							
SECOND WEEK							
THIRD WEEK							
FOURTH WEEK							
FIFTH WEEK							

This record is for film badge dated: _____

Mail this report each time your film badge is changed to:

Radiation Safety Officer
Advanced Medical Systems, Incorporated.
1020 London Road
Cleveland, Ohio 44110

TOTAL MONTHLY EXPOSURE _____

NDK/cmc

RADIATION SAFETY CHECKLIST

Film Badge-Dosimeter-Survey Meter-Control Key Shutter Locked.

Dosimeter Reading _____ mR

Survey Meter _____ Date Calibrated _____

Serial No. _____ Supervisor _____

RADIATION SURVEY
ROUTINE SERVICE AND LICENSED PROCEDURES

S/M Reading _____ mR/hr. at end of Maze and Shield Wall

S/M Reading _____ mR/hr. at Top of Head

Head Type _____ Serial No. _____

SERVICE PERFORMED _____

IF COLLIMATOR IS REMOVED - WIPE TEST RESULTS _____ cpm SURVEY METER _____

Wipe Sample Disposed At: _____ SERIAL NO. _____

EMERGENCY SERVICE
S/M Reading _____ mR/hr. at End of Maze

S/M Reading after Head is Rotated or Repositioned _____ mR/hr.

BRIEFLY DESCRIBE PROBLEM: _____

ACTION TAKEN: _____

CUSTOMER: _____

CITY: _____ STATE: _____

Final Dosimeter Reading: _____ mR Total Dose: _____ mR

Service Engineer: _____ Date: _____

Mail This Report To: ADVANCED MEDICAL SYSTEMS, INCORPORATED
1020 LONDON ROAD
CLEVELAND, OHIO 44104

ATTENTION: Radiation Safety Officer

In an Emergency, if assistance is required, contact the Radiation Safety Officer at 216-692-3269.

EMERGENCY NOTIFICATIONS AND PROCEDURES

If under any of the circumstances noted in this manual, a source cannot be returned to the off position, or it is believed the source is leaking, the following steps must be taken immediately in the order given:

1. Restrict the area from entry by locking or posting a guard. Post a signed, dated notice on the entry side of door to the room, that entry can be made only on authorization of the responsible person (physicist, chief radiologist, etc.) given on the customer's isotope license.

2. Call the Radiation Safety Officer (see page 4) for further instructions.

3. Take no further action except under the direction of the RSO or appropriate state or federal officials.

PERSONNEL MONITORING

A. Any person engaged in Licensable opertions or directly assisting in these operations must have on his person at all times during these operations the film badge provided by the Advanced Medical Systems, Inc.

B. In addition to the above mentioned film badge, a direct reading pocket dosimeter shall be worn. This dosimeter must have a range of 0-200 milliroentgens (mR), and must be read at intervals not exceeding 15 minutes during any periods when the operations being performed may permit radiation to be emitted in excess of 10 mR/hr at one meter from the source.

C. The licensed person shall wear an audible gamma alarm during service operations. The alarm should be the Tattler, Rad-Tad or equivalent.

D. In general, it is rare for service personnel to receive a total dose in excess of 15 milliroentgens during the performance of any Cobalt Service Procedure. If during the operations it appears that the dose being absorbed is at a rate which would exceed a total of 15mR, the personnel involved will retire to a low radiation background area and review their procedures to determine what steps must be taken to reduce their exposure.

NOTE: 1. Dosimeters, which are cold when they are first put on, may show a reading of up to 10 mR when they reach body temperature. Make sure they are fully warmed up before taking the initial reading.

2. Wear the film badge on the trouser belt.

SUMMARY OF LICENSABLE SERVICE OPERATIONS

This section of the manual includes those operations which may be performed only by an individual authorized under our NRC license.

They are as follows:

CONTAMINATION CHECKS

A. General

A contamination or leak test must be performed prior to removal of a collimator. This test is for the protection of AMS personnel and does not constitute an official wipe test.

There are basically two reasons for contamination being present:

1. The source or equipment was not thoroughly clean when shipped or installed. This type of contamination generally would be of low level (less than 2000 cpm) and only in isolated spots which are easily cleaned to wipe less than 200 cpm.

2. The source is leaking. This type of contamination is usually of high level (about 50,000 cpm) and cannot be easily cleaned up. If this type is found, the emergency procedure outlined in this manual will be put into operation.

B. Wet Smear Contamination Procedure

Coveralls and rubber gloves should be worn during this procedure.

1. Place the No. 491 (or equivalent) Victoreen survey meter in a low radiation background area, turn on and check against "check source" for proper operation. Set to most sensitive scale. Open the beta window or shield. Note background rate in cpm.

2. Moisten a small pad (2 or 3 square inches) of absorbant paper with water or alcohol. Wipe the area to be checked with the moist paper pad.

3. Hold the wipe within 1/4 inch of (but not touching) the Geiger tube.

   a. If the meter indicates less than 200 cpm above background, the area wiped is considered to be clean.

   b. If the meter indicates greater than 200 cpm above background, stop work. Notify the customer of a potential contamination problem. The customer is responsible for decontamination activities and waste disposal under his radiation safety program.

(Cont' Wet Smear Contamination Check)

c. If the meter indicates greater than 20,000 cpm above background, the source should be considered to be leaking. Implement the emergency procedure outlined in this manual. Monitor exposed portions of body and clothing for contamination.

C. Waste Disposal

Seal any contaminated waste (wipes and/or clothing) in plastic bags. Label as "Radioactive Materials." Check with the customer to see if they have a Nuclear Medicine Department that will accept the contaminated waste. If not, properly package the waste and call the Radiation Safety Officer for instructions on shipping it back to Cleveland.

EMERGENCY CLOSING OF A STUCK SHUTTER

If, in spite of all precautions, an emergency situation develops, the Emergency Procedures must be followed precisely. The procedures give the name and telephone number of the individual to be called in case of an emergency. To attempt to close a shutter without the proper knowledge, both of the principles of radiation and of the head involved, and without the proper equipment is not only foolhardy, but most likely will make a bad situation worse.

The emergency procedures are as follows:

1. If you are present when the emergency arises, remove all personnel from the treatment room and close the door. If possible, obtain the key and lock the door. If there is no door, make sure no one enters the room.

2. Calmly assess the situation and follow the procedures given below.

EMERGENCY SHUTTER CLOSURE

In general, there are three reasons why a shutter will not return to the closed position:

1. The return spring is broken.

2. The shutter bearings are frozen.

3. The shutter is jammed because of foreign matter or particles in the gap between the shutter and head (this situation is highly unlikely).

In all these cases, the shutter can usually be returned to the closed position by depressing the EMERGENCY BAR. This energizes the shutter motor and drives the shutter back to the closed position.

Therefore, *do not* enter the room and attempt to manually close the shutter.

POWERED SHUTTER CLOSURE

First; Make sure everyone is out of the treatment room. Close the door and make sure personnel do not enter.

Second; Find out what happened, whether there were unusual symptoms prior to the failure and whether hospital personnel tried to close the shutter.

Third; Read the section on shutter locks given in this manual. Locate the shutter lock or obtain one locally. Now, turn on the control and observe the shutter position lights. If the red light or red and green lights are on, there is a good chance that the spring has not returned the shutter to the off position.

1. Rotate the "C" arm or yoke until the collimator points at the floor.

2. Operate the key switch, timer and switch in an attempt to return the shutter to the off position. If unsuccessful,

3. Depress the EMERGENCY BAR and hold it in. Observe the shutter position

lights. The red light should go out and the green light should come on. Release the EMERGENCY BAR (prolonged application of power to the reverse winding on the shutter motor may over heat the winding). The green light should stay on, indicating that the shutter is closed. If the shutter won't close, try rocking the head. If the EMERGENCY BAR closed the shutter, the shutter lock must now be installed. If the BAR closed the shutter, but it opens upon release of the BAR, you will need an assistant to hold the BAR down while you are removing the front cover of the head and installing the shutter lock.

PREPARATIONS FOR ENTERING THE ROOM

1. Wear your film badge, pocket dosimeter and tattler. Switch the survey meter to the X1 scale (0-10 mR/hr).

2. Open the treatment room door. Do not enter the room, but survey the area through the open door. If the shutter is closed, the survey meter will indicate about 1 mR/hr or less. If the shutter is open the reading will be in the 1-10 mR/hr range depending on the number of curies and the collimator setting. If the survey meter indicates the shutter is open, do not enter the room. REFER TO MANUAL SHUTTER CLOSURE BELOW.

3. If the shutter is closed, you will not need assistance at the EMERGENCY BAR, so you must have the control key in your pocket before entering the room.

ENTERING THE TREATMENT ROOM

Hold the survey meter out in front of you as you walk into the room. If readings are less than 10 mR/hr, you will have plenty of time to lock the shutter. Set the meter on the floor next to the barrier or about three feet away from a point below the head (to avoid kicking the instrument as you work). Remove the manual wheel.

LOCKING THE SHUTTER - C9 TYPE UNITS

Remove the 4 screws from the front cover of the head and remove the head cover. Install the shutter lock.

C10 TYPE UNITS

Remove the 2 screws and split cover. Install the shutter lock mechanism.

C3000 TYPE UNITS

Remove the arm of the optical distance indication and install the locking bolt.

MANUAL SHUTTER CLOSURE

If the EMERGENCY BAR will not close the shutter, the manual method must be used. This requires entering a high radiation area and relatively unknown radiation field. The levels will be 4 to 10 R/hr next to the head, depending on source strength and collimator opening.

The only factor which can be used to minimize the whole body dose is TIME, since personnel must approach the source at a close distance to manually close the shutter. Therefore, the procedure must be completed as rapidly as possible. In some cases, certain angles from the head afford lower radiation levels, but these would have to be determined by factory survey, not in the field.

Before entering the room, estimate the time required to close the shutter. Multiply the time by an estimate of the dose rate, ie., 5 R/hr. If it takes a full minute to turn the shutter wheel (worst case), the dose will be:

$$5 \frac{R}{hr} \times \frac{1\ hr}{60} = \frac{1}{12} R = 83mR$$

The survey meter will pin above 1000 mR/hr (1 R/hr) so it will be useless at 5 R/hr. However it must be used as before to indicate the levels of the area.

ENTERING THE ROOM

1. Only one person should enter the room while an assistant outside monitors the time. Wear dosimeter and film badge as before. Remove tattler, as it's screaming will be annoying.

2. Switch the survey meter to the X100 (0-1000 mR/hr) range and hold it out in front of you as you walk in. Set the meter on the floor when you have reached the 1000 mR/hr perimeter. (applies to vertical units only).

3. Rapidly approach the head. Grip the shutter wheel in both hands and turn the wheel in the CLOCKWISE direction until the shutter is closed.

4. If the manual wheel will not turn, and one minute has elapsed, pick up the survey meter and leave the room. Execute the EMERGENCY NOTIFICATION procedure on page 7.

5. If shutter closure was successful, remove the manual shutter wheel and lock the shutter as before.

After completing the procedure read your pocket dosimeter and record the accumulated dose.

HEAD LEAKAGE RADIATION SURVEY

A. Model 583 and 590 series heads

1. Using the Geiger type survey meter, beta window closed, check the radiation leakage at the mouth of the collimator when set with its smallest opening, with the meter probe touching the end of the collimator and the collimator pointing straight down. Normal leakage is 1.5 to 3.0 mR/hr per 1000 RHM of source strength. If readings fall within this range, proceed with service work. If radiation levels exceed the values given above, then a check of inverse square correlation must be made. The distance to the active portion of the source from the bottom of the collimator is 45 cm, while the distance to the dust cover is only 25 cm. For example, if all the radiation is from the source, then the reading 10 cm from the end of the collimator should be about 2/3 of the reading at the end of the collimator. Readings appreciably above 1.5 to 3.0 mR/hr per 1000 RHM may be caused by contamination on the dust cover. It must be remembered that these tests are only indicative, and only in the case of relatively high levels of activity on the dust cover will readings be meaningful. 100 μci of Cobalt 60 on the dust cover would only increase the radiation level about 2 mR/hr. If it is suspected that there is contamination on the dust cover, immediately put on a respirator or surgical mask and make the following check for contamination.

B. Model 581 and 583 series heads

2. Turn the head so the collimator is pointing towards the ceiling. Take a cotton swab stick (available at all medical institutions) and moisten with water or alcohol. Carefully remove the plug from the shutter locking bolt hole and swab the portion of the shutter wheel that is exposed through this hole. Replace plug. Check swab with survey meter, beta window open.

3. If more than 2000 cpm is detected the source must be considered to be leaking and the emergency procedure outlined in this manual must be put into operation.

4. If less than 2000 cpm is detected, wash and/or check hands for contamination, and proceed with the service operation.

UNIT CHECKOUT AFTER COMPLETION OF SERVICE

Warning: Make sure you have the control key in your possession each time you enter the room.

Evacuate personnel from the room and make the following operational tests of the completely reassembled unit: (Make corrections where necessary in accordance with applicable unit manuals.)

1. Check that the shutter opens and completely closes at 0°, 90°, 180° abd 270° or at maximum angles in both directions allowable for this particular installation.

2. Make sure, where applicable, that the shutter will not open beyond allowable angles for this particular installation.

3. Check that the timer switch properly closes the shutter.

4. Make sure the "shutter close" or "emergency" button properly closes the shutter.

5. Check that the shutter closes when main power is turned off and that it does not reopen when main power is restored.

6. Make sure the shutter closes when the room door is opened and that the shutter does not reopen when the door is reclosed.

7. Where applicable, verify that back pointer, collimator and localizer lights function properly and are calibrated properly.

8. Verify that control panel and room warning lights work properly.

FINAL CLEAN UP

Monitor hands, feet and clothing of all persons involved. Clean if necessary. Seal any contaminated wipes or clothing in plastic bags. If the hospital Radiation Therapy Department will accept the waste material, dispose of it in their facility. If not, arrange for shipment of the contaminated material back to the Cleveland Isotope Facility. At this point, and upon satisfactory completiton of the operational checks, jurisdiction of the unit and it's key may be returned to the licensee.

1. Remove the collimator as follows:

On this type unit, the dust shield is part of the head rather than part of the collimator. The collimator can therefore be removed without fear of spreading contamination from a leaking source. Inasmuch as this dust shield is so close to the source and the collimator is so long, a leakage radiation survey at the mouth of the collimator would be of little value.

a. Place a soft pad on the floor to the right side of the unit directly under the collimator on track mounted units or for fixed stand units, on a flat top "dolly" (can be rented locally if needed) capable of holding 1000 lbs.

b. Adjust head into a straight down position and lock. (See manual for unit).

c. Lower the collimator electrically to about one inch above the resting place described above.

d. Manually lower collimator (see instruction manual for unit being worked on) until it is resting on floor or "dolly" (with soft pad).

e. Turn off main power switch.

f. Remove chrome plated ring at top of collimator. Mark and disconnect all wires running from the head to the collimator. Temporarily jumper all collision switch wires. (See schematic). Tape bare ends of all wires. Turn on the main power switch.

g. Remove all the socket head cap screws holding the collimator to the head.

h. Manually raise head from collimator until wires can be pulled through hole in the top flange of the collimator.

i. Make a wet smear contamination check of the bottom of the head.

j. Put a plastic bag over the collimator to keep it clean and move it aside if on a "dolly" or move the unit to one side if on tracks.
   Caution: The head must not be moved from the vertical position after the collimator is removed since it is badly unbalanced and the tilting gears may be damaged or broken. Brake on tilt gear assembly must be locked tightly.

k. Place a pad of soft material to the right of the unit on which to place the collimator and bearing ring. Open a plastic bag large enough to hold the collimator and bearing ring and place on pad.

l. Prepare a 3" square patch of masking tape and hang nearby.

m. Lift the collimator and bearing ring (about 175 lbs.) by the four handles of the collimator service tool and place it on pad and bag provided. One man then brings the plastic bag up around collimator and tapes the bag closed while the other man covers the orifice in the head with the 3" square of masking tape.

Warning: Keep head and trunk as far away from bottom of head as possible as the radiation leakage on this surface may be several hundred milli-roentgens per hour.

2. Wet smear contamination checks will then be made in this order.

a. The newly exposed bottom of the head.

b. The area of the shutter wheel just under the 3" square of tape (lift momentarily and then replace).

c. The newly exposed top of the collimator (can be tipped by one person and wiped by the other). Bag may be opened momentarily.

d. Remove the 3" square of masking tape and check as a wet smear.

e. Remove the tungsten or brass saddle (on 583 A, B, C and 590 series heads).

3347 COLLIMATOR REMOVAL
Model 583 & 590, A,B,C,D, Heads

1. Remove the Collimator as follows:

   a. Rotate unit so that collimator is pointing straight up.

   b. Lock the head so that it can not turn (refer to unit manual for details). Open collimator to widest opening.

   c. Remove the two stainless steel cover plates that are fastened to the sections with the field size dials.

   d. Put a cable clamp on each cable just above the point where it comes over the pulley.

   e. Remove the other two stainless steel cover plates.

   f. Carefully release cables so that cable clamps are resting just below pulleys.

   g. Remove the four roll pins and two pulleys holding bottom frame assembly of collimator in place. Mark assembly and collimator with masking tape so it can be reassembled in same relative position. Lift off bottom frame assembly and set aside.

   h. Close collimator. Place collimator service tool (part C14332) on the collimator where bottom assembly was fastened. Fasten in frame with 1/4-20 x 1" machine screws and hex nuts.

   i. Make sure main power switch is "off". Remove the four screws that hold the head positioning handle to the collimator bearing ring (on 583 model heads). Remove the light switch and tape so that bare terminals cannot short to head (on 583 model heads). Unsolder collimator light wire from bearing ring terminal and tape bare wire end.

   j. Set rotational arm so position dial reads 180° and turn on main power switch so that magnetic brake will hold rotational arm at 180°. Check to make sure brake holds properly.

   k. Remove collimator light.

   l. Remove the eight screws holding the bearing ring and collimator to the head.

   m. Prepare a 3" square patch of masking tape and hang nearby.

   n. Place a pad of soft material to the right of the unit on which to place the collimator and bearing ring.

   o. Lift the collimator and bearing ring (about 175 lbs.) by the four handles of the collimator service tool and place it on pad. Cover the orifice in the head with the 3" square of masking tape.

   Warning: Keep head and trunk as far away from bottom of head as possible as the radiation leakage on this surface

may be several hundred milli-roentgens per hour.

2. Wet smear contamination checks will then be made in this order.

   a. The newly exposed bottom of the head.

   b. The area of the shutter wheel just under the 3" square of tape (lift momentarily and then replace).

   c. The newly exposed top of the collimator (can be tipped by one person and wiped by the other).

   d. Remove the 3" square of masking tape and check as a wet smear.

3706 COLLIMATOR REMOVAL

Find a platform (dolly, table, box, etc.) within about one inch of the height of the lower end of the collimator which will safely hold the nearly two hundred pound load and position it under the collimator.

1. Lower the head until the collimator rests on the platform.
2. Remove the eight screws holding the collimator tp the head.
3. Prepare a 3 inch square piece of masking tape and hang loosely on head.
4. Lift the head electrically to about 6 inches above the collimator.
5. Place the 3 inch square of masking tape over the port in the head and a plastic bag over the collimator.
6. Make wet smear contamination checks of the bottom of the head and the newly exposed surface of the collimator; remove the 3 inch square of masking tape and check as a wet smear.

INBOARD BEARING LUBRICATION (581 & 581A) HEADS

Procedure to be Performed only by Licensed Personnel.

The collimator is not removed during this procedure. Close the collimator and securely fasten a 2" lead block over the end of the collimator. There is no locking bolt hole on the 581 head. There is a hole on the 581A and 581B. On the 581 head, a hole must be drilled into the head ½" deep and tapped for a 1/4-20 bolt. This hole must line up with the locking bolt hole in the shutter stop arm.

Be sure to mark all the items in sequence and direction in the following procedure.

1. Remove the wires from the terminal board going to the motor.

2. Remove the three screws holding the gear train and motor assembly. Remove this unit carefully. Do not pull on the outer casting of the gear train or the train will fall apart.

3. The shutter plug and head must be scribed to assure proper alignment during reinstallation. The off microswitch and terminal board will be damaged if the plug is not reinstalled properly.

4. CAUTION: When the shutter stop arm is removed, later in this procedure, the source will be free to be turned on. The locking tools mentioned must be used to lock the source in its closed position. The first tool considered is a ¼" dia. rod, bent into a "U" shape (see attached drawings). The end of this tool without the chain will fit into a ¼" dia. hole in the end of the shutter shaft. If necessary, drill the shutter shaft out slightly, and fasten the tool to the shaft with a short set screw. Do not use a set screw longer than the dia. of the shutter shaft. Lock the chain to the closest outer bolt hole in the head.

5. Mark the shutter shaft with a reference mark. This mark is your indication of the source location. After all the hardware is removed and only the shutter shaft remains, be sure that the reference mark does not shift. If it shifts 180°, the source will be full on. The "U" tool is used to prevent this.

6. Remove all three allen screws holding the stop arm. Be careful of the spacers behind the screws. Remove the stop arm and let it hang in the "U" tool. Do not remove the chain from the "U" tool.

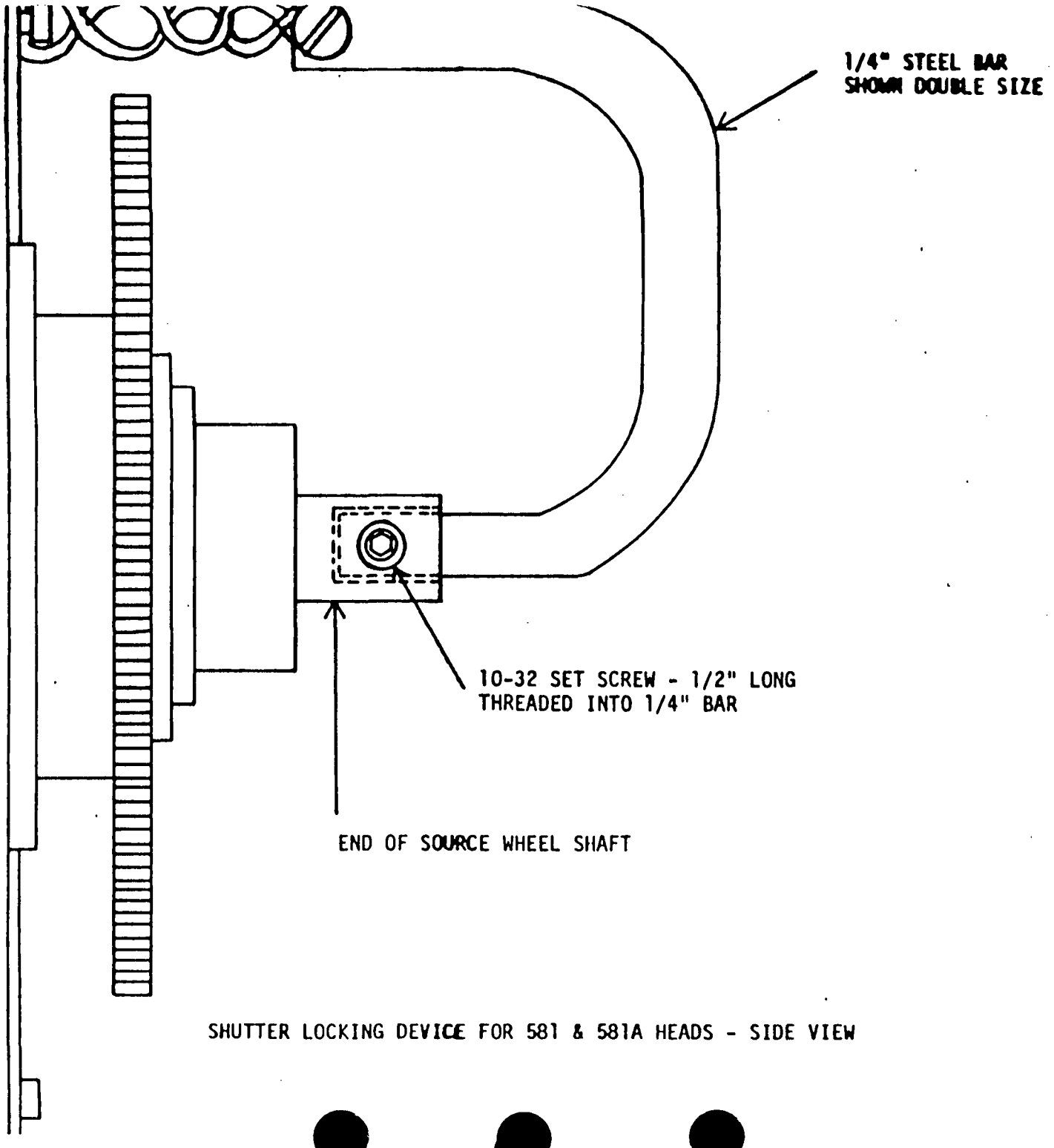
7. Drive the pin out of the gear and remove the gear. Back up the shaft when driving the pin so as not to bend the shaft.

8. Remove the spacer, the spring retainer, and the spring and let hang.

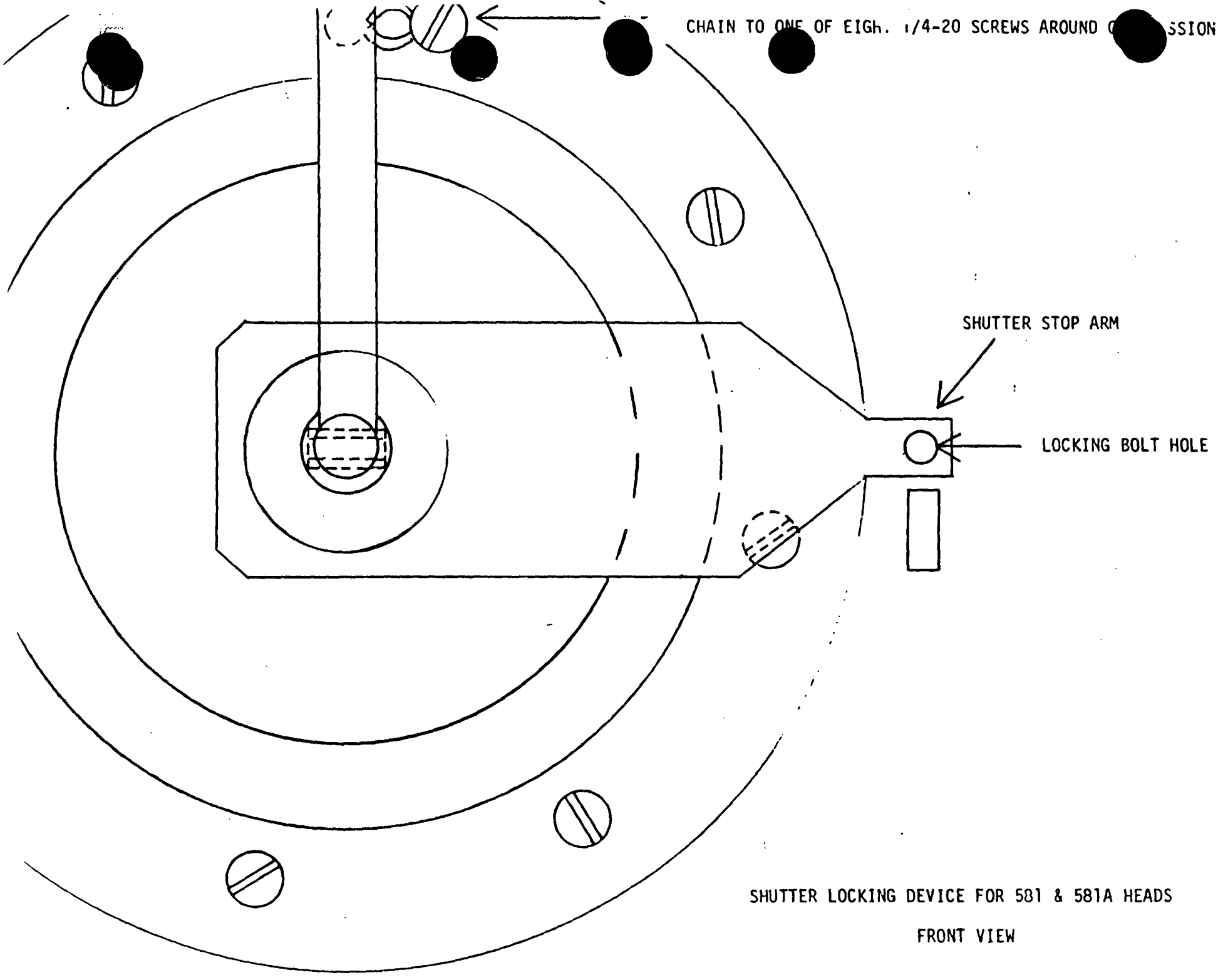
9. Insert the long locking rod with the chain into the hole in the shutter shaft that the gear pin was removed from. Lock the chain to the closest outer bolt hole in the head.

   NOTE: *From this point on, only one of the two locking tools can be removed at one time. Be certain that one tool is always connected.*

10. Remove the chain from the "U" tool and remove the loose parts. Replace the chain. Lay out the parts in order and direction. All resistance to the shutter rotation except the shutter wheel bearing and of course your safety



SHUTTER LOCKING DEVICE FOR 581 & 581A HEADS - SIDE VIEW



SHUTTER LOCKING DEVICE FOR 581 & 581A HEADS

FRONT VIEW

11. Reinstall the "U" tool safety chain. Leave a little slack in the chain. Rotate the shutter about 10° in either direction to check the bearing. Remove the brass spring hub, under the spring, and its taper pin and set screw.

12. Remove the four counter-sunk allen screws on the brass plate behind the spring hub.

NOTE: At all times keep one or both safety tools fastened to the unit.

13. Remove the snap ring from behind the spring hub.

14. Install the straight safety tool and remove the "U" tool.

15. Mount the bearing puller to the shutter shaft. The bearing puller on the three inch by three inch by 1/4" plate with 7 holes in it.

16. Disconnect the microswitch leads from the terminal board and remove the terminal board from the unit.

17. The outboard bearing pressed into the shaft, seldom fails. The inboard bearing, close to the source and not visible, can cause binding. It is pressed into the shutter plug.

18. Install, four each, 2" long bolts in the outer holes of the head. Put stop nuts about 1" back from the plug to prevent the plug from coming all the way out.

19. Tighten in on the bearing puller and the shutter plug will begin to pull out.

20. When the bearing drops off the small diameter of the shutter shaft, drive the plug back into the head with the 4 nuts on the safety bolts around the outer part of the head installed in step 18.

21. Remove the bearing puller.

22. Remove the outboard bearing. See the note after step 12.

23. Replace the bearing puller and pull the shutter plug back out about 1" (be sure to have the 4 outer safety 1/4 x 20 x 2" long bolts and stop nuts in place.

24. Remove the bearing puller.

25. The lubrication used in the foll wing procedure can only be "3 in 1" brand oil. No other household oil may be used. A fifty-fifty solution of "3 in 1" oil and lacquer thinner must be mixed. The lacquer thinner will loosen the hardened lubrication already in the bearing. Normally 1-1/2 to 2 cc of oil are needed. A maximum of 3 cc can be used. Any more oil than this can drip down into unwanted areas and harden.

26. It was mentioned in step 17 that the inboard bearing is pressed into the shutter plug. This bearing is 8-1/2" in from the outer face of the plug. This is measured at the shutter shaft hole in the plug.

27. Use a syringe and a 8-1/2" long thin catheter to insert the oil solution slowly around the bearing.

28. Readings of approximately 100mr/hr can be expected at the space between the shutter shaft and plug. Work off to one side and not directly in back of the head.

29. Pull the shutter wheel back into its seat, that is up onto the back bearing, by pulling the shutter shaft towards the back of the head.

30. Rotate the source wheel slightly to work in the lubricant.

31. Check the alignment of the plug.

32. Remove the two set screws from the plug and install 2 2" long bolts in these holes and pry the plug around until the alignment marks of step 2 match.

33. If too much friction is encountered in step 32,

34. Push in the shutter plug by tightening on the four 1/4 x 20 bolts in the outer ring.

35. Replace the 4 2" long bolts with the original bolts and install the remaining four bolts.

36. Install the bearing (see note after step 12). When the bearing is seated properly, there will be no in and out play of the shutter shaft.

37. Replace the tru-arc.

38. Clean all pieces before replacing.

39. Replace set screws removed in step 32.

40. Clean the burrs from the shutter shaft.

41. At this time, a plus and minus 10° rotation of the source wheel should indicate any improvement due to oiling of the bearing.

42. Replace the spring hub, the groove pin and set screw.

43. Replace the 1/4" thick brass bearing retainer and its four flat head 1/4 x 20 allens.

44. Lubricate and replace the spring.

45. Replace the thin outboard spring retainer and spacer washer.

46. Replace the gear, its pin and set screw.

    CAUTION: The hole in the gear or shaft can elongate and cause the gear to shift. Mark the gear and shaft and check for any shift. A shift will prevent proper alignment of the source in its open position.

47. Replace the stop arm, the outer stop arm retainer (large washer with three holes) and the three screws.

Lubrication Procedure
Inboard Bearing

581-B Heads Loaded With a Source
TO BE PERFORMED BY LICENSED PERSONNEL ONLY

1. Install the shutter locking bolt.
2. Close the collimator and securely fasten a 2" lead block over the center beam.
3. Remove the large brass drive gear.
4. Remove the snap ring, brass gear and "V" belt pulley.
5. Remove the hub for the large brass drive gear from the shutter rotor shaft.
6. Mark the position of and remove the micro switches for open and closed lights.
7. Remove the shutter drive casting assembly and set aside.
8. Remove the shutter power spring covers, power spring, brass anchor block and anchor pin.
9. Remove the cap screws from the shutter stop arm assembly.
10. Remove the taper pin from the shutter stop arm assembly.
11. Insert the special stop tool into the outermost taper pin hole and secure to ¼-20 hole for socket head cap screws used to secure the shutter plug retainer ring. Remove only 1 screw at this time and use a ¼-20 X 2 in. bolt for this.
12. Remove the shutter locking bolt and move the shutter stop arm assembly back to the special stop tool. Then take the bolts out of the outer bearing retainer plate and move it back also.
13. Insert a second special stop tool into the inner taper pin hole and anchor the same as the first one.
14. Remove the first special stop tool and take the stop arm and bearing retainer plate off the rotor shaft.
15. Insert the first special stop tool again and remove the second special stop tool.
16. Remove (3) ¼-20 cap screws at 90 degree increments from the bolt used to anchor the special stop tool and replace them with ¼-20 X 2" bolts.
17. Make alignment marks to accurately reposition the shutter plug in the head.

18. Remove the rest of the ¼-20 cap screws from the shutter plug retainer ring.

19. Install the special bearing puller onto the shutter rotor shaft using the ho holes for the outer bearing retrainer plates. Use collar over the 3/8" diameter part of the shutter shaft.

20. Press the shutter shaft with the bearing puller until the shutter plug moves back about one inch.

21. Remove the bearing puller and put the screws from the puller through the shutter plug retainer ring. Then press the shutter plug back into the head. This will remove the outer bearing from the shutter shaft.

22. Press the shutter shaft with the bearing puller until the shutter plug moves back about one inch.

23. Put a small amount (about 10 drops) 3 in 1 oil (USE NO SUBSTITUTES) down the shaft. Use liquid for biplane heads and drop straight down the shaft with the shaft pointed up. For fixed head and vertical units use aerosol can and catheter and spray in. The catheter may have to be flattened. If old grease has hardened, use about 0.5 cc of 50% lacquer thinner and "3 in 1" oil mixture.

24. Put the outer bearing on the shutter shaft and rotate slightly (about ± 45 degrees from full off) to work in the lubrication. For this the stop tool may be removed from the anchor bolt. NOTE: The position of the source must be carefully observed using a survey meter. Replace the anchor bolt.

25. Reassemble the unit making sure that the shutter plug is accurately lined up in the head.

26. Check out electrically from outside the room with the voltage to the motor set at 80VAC.
NOTE:
The shutter opening and closing times at the 0 degree position should be about equal and not exceeding 3 seconds. As the "C" arm is rotated the times will vary with the worst positions being from 135 degrees thru 225 degrees.

27. Check alignment, using Pinhole Camera.

SHUTTER GEAR REPLACEMENT INSTRUCTIONS - CAT. 581 & 581-A HEADS

To Be Performed by Licensed Personnel Only.

In order to orient the shutter lever in precisely the same position as it was originally, refer to D-13774 and B-13777 blueprints. The following instructions will assure this proper alignment of source "on" position.

CAUTION:
Be sure that you use a survey meter while making these repairs. During this repair, there will be times when the shutter wheel will not be held in any particular orientation. The instructions will be such that the chance of shutter wheel orientation getting mixed up will be very remote, but the possibility still exists. Do not attempt this repair single handed.

To replace the shutter gear, do the following:

1) Mark the end of the shutter shaft with a punch mark or a painted mark such that you will know that which side of the shaft the source is on. BE SURE YOU DO THIS.

2) Remove all of the soft parts on the shutter "off" position. This would include the shutter "off" switch, remains of the rubber grommet and so forth. The intent is that the shutter lever must be made to bottom on the shutter "off" adjusting screw to give you a positive "hard" position.

3) Remove the shutter drive.

4) Drill a ¼" hole axially into the shutter shaft until the drill breaks through the 3/16ths cross drilled hole in the shaft. This hole may already be there.

5) Insert the special wheel alignment pointer into the cross drilled hole with a light press fit at the knurled section. Pointer must be tight in the hole. Tap in if necessary. This pointer will be a gauge which will orient this cross drilled hole to a particular carefully measured scribed mark on the shutter plug clamping ring. It will be very necessary that you mark down, how this pointer is inserted and that you carefully construct a perpendicular (by using a machinist's square) between the shutter plug clamping ring and this pointer. This pointer will be inserted later after the new gear is installed. This will repeat for you the exact location of that shaft when the shutter lever is pressing against the adjusting screw of the "off" position. This must, of course, be done very accurately.

6) Remove the special wheel alignment pointer and install the approved shutter locking fixture.

7) Remove the shutter lever clamping screws and washer.

8) Press the shutter lever away from the shutter gear. Note that the shutter wheel is now free to swing since it has lost its "off" stop. The approved shutter locking fixture will prevent the source from coming "on".

9) Tap out the existing roll pin or taper pin which holds the shutter gear onto the shaft. Be extremely careful not to bend the shaft. Units before January of 1957 had 3/16ths diameter by 1" long roll pins. Units after that date had #3 standard taper pins 1" long for installation and holding the shutter gear.

10) Finish tapping out the roll pin and pull off the gear. The gear will slide over the approved shutter locking fixture.

11) Remove the washer in front of the shutter spring and carefully pull the spring hook off the spring pin. Don't let it fly off. This will now allow the shutter to be free swinging and it should be easier to clamp it in that position with the approved shutter locking fixture. Be careful, however, not to lose your shutter wheel orientation. KEEP THE SOURCE IN THE CENTER OF THE HEAD.

12) Remove the old gear from the outer end of the locking fixture and push the replacement gear onto the shaft, line up the holes.

13) Drill 3/16ths hole through the far side of the gear. On units before 1957, a roll pin can be installed, and units built after 1957, the hole should be taper reamed being sure that the reaming is done from the same side as it was originally. DO NOT DRILL A NEW HOLE IN THE SHAFT.

14) Thread the spring washers and the gear onto the approved shutter locking fixture. Holding the shutter wheel in this manner, rehook the spring onto the spring pin. Be sure the original amount of spring turns is duplicated. This operation will be very hard to do and the approved shutter locking fixture must be anchored securely. The spring should be almost coiled tight when you make the hook up.

15) Push the gear onto the shaft in its proper orientation and install either the roll pin or the taper pin as required.

16) Check again the alignment marks which were previously made on the shaft. Clamp the shutter lever to the gear with the right screws and washer.

17) Reinstall in exactly the original manner the wheel alignment pointer and then exactly duplicate the original method of constructing a perpendicular and bringing the alignment pointer to the same scribed mark on the shutter plug clamping ring, as was done in step 5. Make sure that the shutter lever is pressing against the shutter "off" set screw. If everything is exactly as it was in step 5, the source is now in perfect agreement with the original alignment.

18) Drill and install the 3/32ths diameter groove pins which hold the shutter lever in alignment with the shutter gear.

19) Reinstall switch parts and install new rubber grommet on shutter "off" set screw. This should complete the repair.

If it is found that the shutter lever switch actuating spring has been broken, then it should be replaced. The spring is included with the parts which were sent. The rivets for installing the spring are also included. Some springs had to be notched. If original was notched, then duplicate.

SEND THE FOLLOWING:

1	T21-35	Rubber Grommet	
1	T77-67	Spur Gear	
1	T14-950	Taper Pin	
1	T5-226	Tension Spring	
2	T15A-11	Round Head Rivet	
1	T14A-62	3/16 X 1 roll pin	
3	T14A-10	3/32 X ½ groove pin	
1	_____	Wheel alignment pointer)	MUST BE RETURNED TO FACTORY
1	_____	Approved lock fixture)	

583 HEAD REMOVAL AND SHUTTER CLEANING

1. Install shutter locking bolt.
   It is recommended that a case hardened bolt, long enough to bottom into the head, be used instead of the spring action assembly on some of the units.

2. Remove the stand covers from one side. The head will be at 5 o'clock or 7 o'clock during this operation. If at 5 o'clock, remove left-hand covers. If at 7 o'clock, remove the right-hand covers.

3. Check the stand to floor mounting bolts for tightness. If they are not tight, the unit could tip over during the procedure.

4. Remove shutter motor access cover from above and behind the head.

5. Remove the transformer and the cover and disconnect it from the terminal board.

6. Tilt the head in the C-arm to expose the terminal board and wiring.

7. Remove all wires coming up from the slip rings to the terminal board.

8. Remove the stainless trim covers from the back of the head and disconnect the wires from the mercury switches and distance localizer assembly.

NOTE: Eight pieces of 2"x2"x14" long are needed to build the cradle shown in figure # 3. This cradle is placed on a dolly of 2,000 pound capacity.

9. Swing the head around to the 5 o'clock position and position the head in the cradle with the collimator pointing toward the ceiling (use padding to protect paint). Set the wheels of the dolly so that it can be pulled straight out away from the stand after the head is removed.

10. Place a 4,000 lb. come-along hook into the top of the C-arm access hole. The other hook of the come-along is fastened to the outside of the left toe. See figure 1A, B & C. If the 7 o'clock position of the head allows more room for this procedure, the come-along is fastened to the right toe. The unit is now in position shown in figure 4.

11. Take up on the come-along until the head rests firmly in the cradle. The come-along will prevent the barrier from swinging down once the head is removed.

12. Remove the allen head bolts to separate the head from the stand. Loosen the last two bolts mentioned above, and watch to see if the come-along tension is right. This is done by watching to see that the C-arm and barrier are rigid and that the head is snug in the cradle.

13. In addition to the bolts that hold the head to the C-arm, there are two 3/8 inch centering pins holding the head. Use two screw drivers to separate the head and C-arm.

14. The head is now pulled away from the C-arm. Pull from the dolly and not from the head or cradle. Pull the dolly straight out, or the motor assembly will be damaged. Mount to an area out of the swing of the C-arm and barrier.

15. Remove all the wires between the motor drive assembly and the head from the terminal board.

16. Remove the motor assembly by backing off equally on the three hex shafts approximately 1-1/4" long.

17. Separate all the wires and remove the flat cable clamp at about the center of the head. The wires will have to go through a small hole in the head. Unsolder the fuse holder cap.

18. Remove the magnetic lock brackets from both sides of the head, remove the shutter open and shutter close switches with the magnets. Mark the switches to insure that they will not be reversed during reassembly. The cable harness with the three switches and two magnets is draped back out of the way. A third switch at the top of the head for head centering must be removed. Remove switch and switch bracket.

19. At this time the spring, spring hub, and gear are left on the head. You will see one cable harness going through a hole in the head, these wires must be separated and will be pulled through the hole.

20. Remove the gear from the end the shaft in front of the spring. It is held to the shaft by a taper lock. The taper lock is screwed to the gear and press-fitted to the shaft. Remove the bolts holding the taper lock to the gear. A gear puller is handy for removing this gear. The gear is 2-5/8" in diameter. The taper lock will probably be damaged during removal. Have a new one on hand.

21. Remove the brass spring keeper and the spring. The pin holding the spring should not be straight. It is bent to align the spring. Inspect the rivet on the spring. On the left side of the head there is a block. The shutter closed switch actuator, a 10-32 screw, in front of this block, will have to be backed off to allow clearance. Remove the locking screw from this 10-32 and back the 10-32 off 6 turns counterclockwise so it will clear the block.

22. Remove the four countersunk allens from the brass bearing retainer.

23. Remove the brass spring hub by taking out the set screw from one side, and the groove pin on the other side. Have someone back up the shutter shaft when driving out the pin so you do not bend the shaft.

24. Remove the snap ring from behind the hub at the center of the shaft.

25. Remove the five bolts from the outboard bearing mounting plate. This plate is held on with two locating pins. A special tool will be helpful in removing this plate because it is tightly fitted to the bearing.

NOTE: CAUTION:	The work from this point on should be done by standing off to one side of the head. There will be a slight amount of radiation leakage from the shaft. Make sure that the locking bolt is securely in place.

26. At this time the only thing that is holding the shutter plug into the head is the emergency locking bolt. The crack between the shutter plug and the head can be seen at this time. It is this crack that is cleaned to remove all foreign matter. At no time can the plug be removed from the unit because the source is embedded in this plug. A piece of x-ray film approximately 12" long and 1" wide with a small hook cut into the film is used to clean the foreign matter from the crack. It is necessary to clean around the shutter locking bolt for at no time can this bolt be removed. There is a slight clearance between the shutter plug and the head. It is necessary to lift up on the shutter plug to clean the crack at the bottom where the shutter plug is now resting on the head.

27. At this time the unit may be reassembled and checked out to see if the bind has been cleared.

583 HEAD RE-ASSEMBLY

1. Clean and remove all burrs from all pieces. Check for indications of wear.

2. Replace the outboard bearing retainer plate by locating the two 3/8 locating pins and 5 allen bolts.

3. Install the outboard bearing onto the shutter wheel shaft. Lift the shutter wheel while tapping the bearing in. Replace the snap ring.

4. Replace the spring hub and line up the groove pin. Drive the groove pin in thru the hub and shaft supporting other side of the shutter shaft so it will not bend. Reset the shutter off switch actuator screw, by turning it 6 turns clockwise. Replace the locking allen.

5. Replace the rear spring retainer and its four counter sunk screws. Clean and lubricate shutter spring and replace it. Tighten it full and back off 185°. Replace the front spring retainer. Center the spring on the hub so as not to touch the front or rear retainer. Bend the pin to prevent the spring from touching the retainer.

6. Clean the hardened lubrication from the gear. Position the taper lock into the gear and replace its screws. Do not tighten the screws. Replace the gear with the flange inboard. Alternately tighten the screws and tap the gear using a 1" pipe between the gear and the hammer to hammer against. If the gear is properly seated, the outboard spring retainer should be snug and not drop off the large shaft.

7. Replace the switches making sure that they are in their proper places.

8. Replace the magnet assemblies. The outboard face of the lock plates, not the lock face, should be flush with the outboard face of the head.

9. Replace the cable clamps. The wires must be kept flat through the 3" wide cable clamp.

10. Check the motor assembly and gear box. Install the motor assembly making sure the gears are meshed. Alternately tighten the 3 hex fasteners which fasten the motor assembly to the head.

11. Tape the wires flat to the cover of the motor gear box. These wires must be kept flat to allow the head to swivel.

12. Clamp the cables to the side of the terminal board cover with the round clamp. Reconnect the wires to the terminal board.

13. Roll the head and dolly back into the C-arm, not all the way.

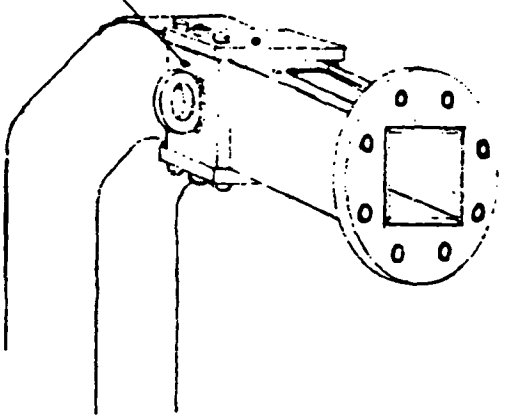
14. Feed the wires back through the hole at the top of the C-arm.

15. Line up the two locating pins and push the head up tight to the C-arm and replace the main bolts.

16. Complete reassembly of the unit and check the shutters operation.

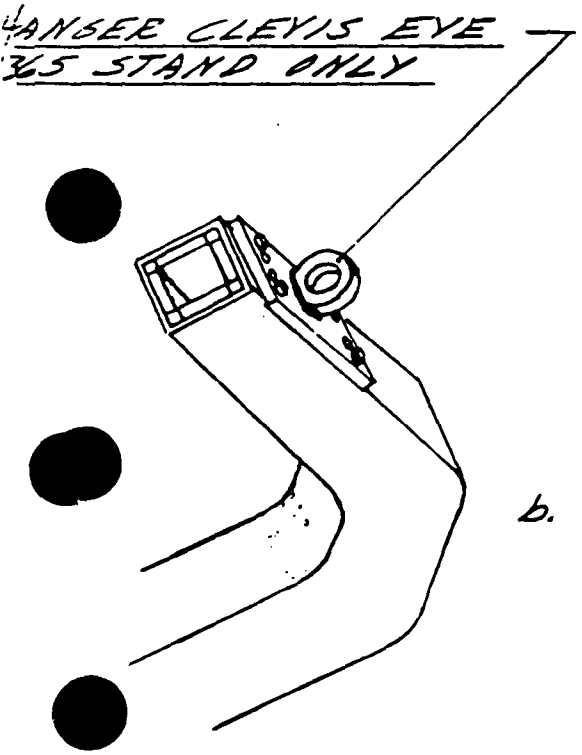
INSTALLATION ACCESSORIES

HANGER PULL BOX ASS'Y
1365-A STAND ONLY



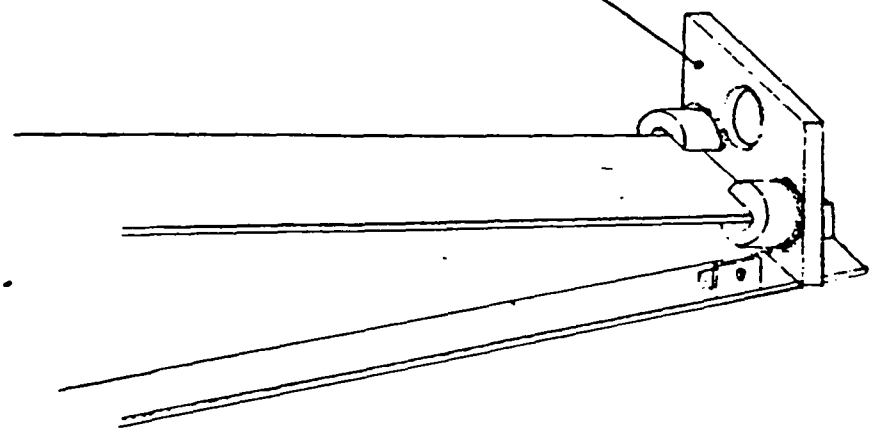
a.

HANGER CLEVIS EYE
1365 STAND ONLY



b.

HANGER PULL - SUPPLIED
WITH 1365 & 1365A STAND

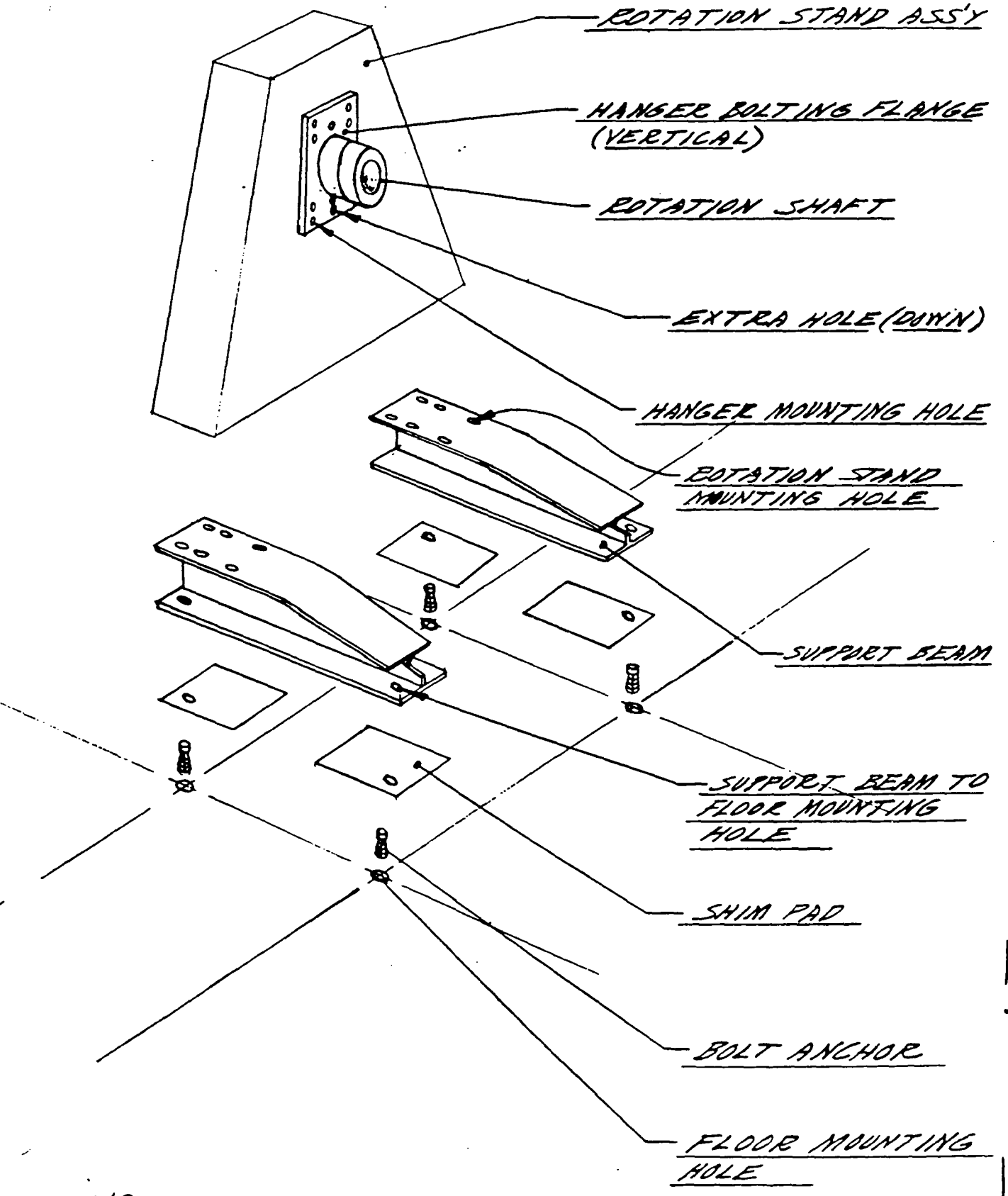


c.

T55-142

FIG. 1

BASE SUPPORTS & ROTATION STAND INSTALLATION



T55-142

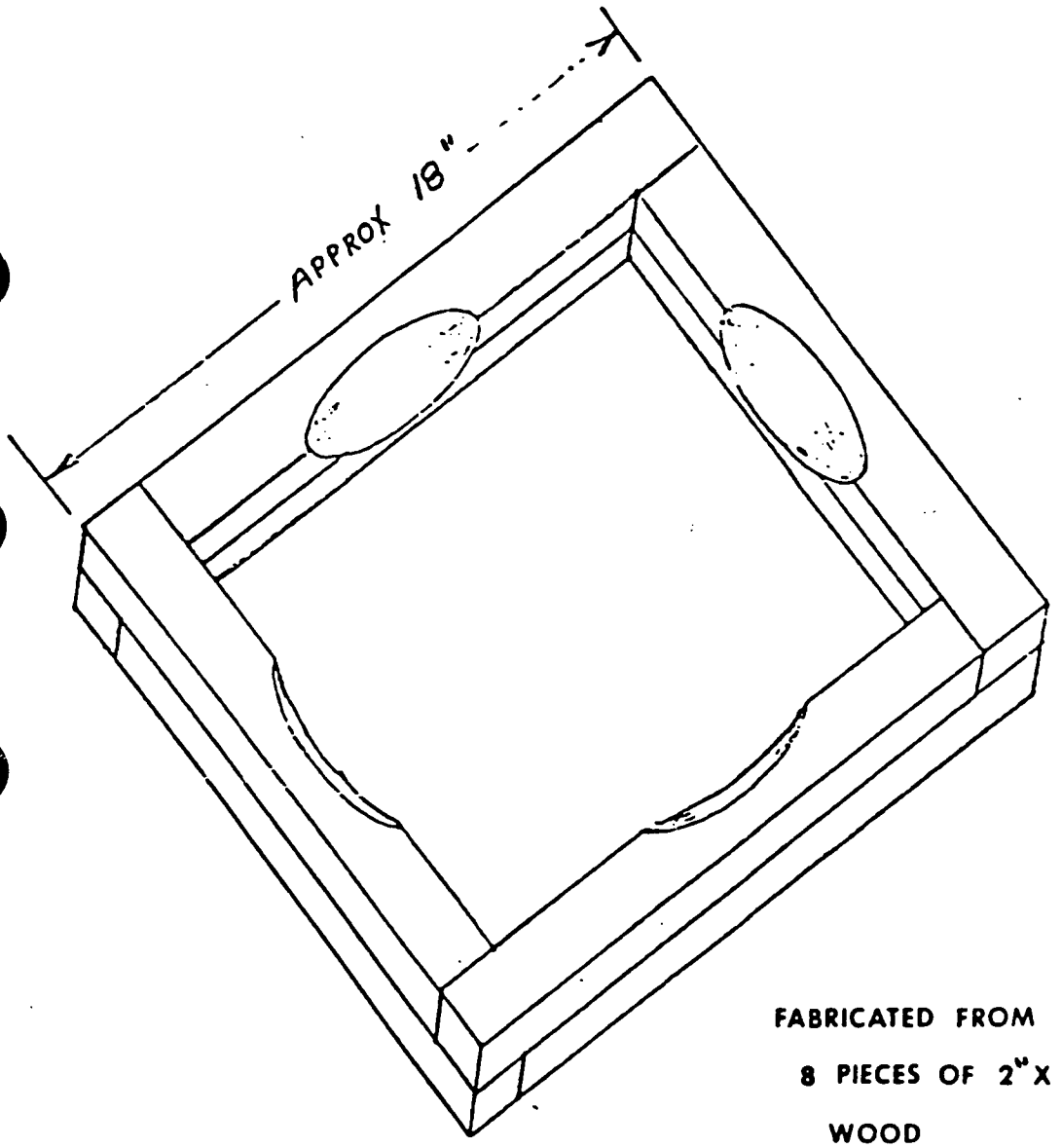
FIG. 2

Figure #3

CRADLE FOR

C 1000 OR C 2000

COBALT HEAD



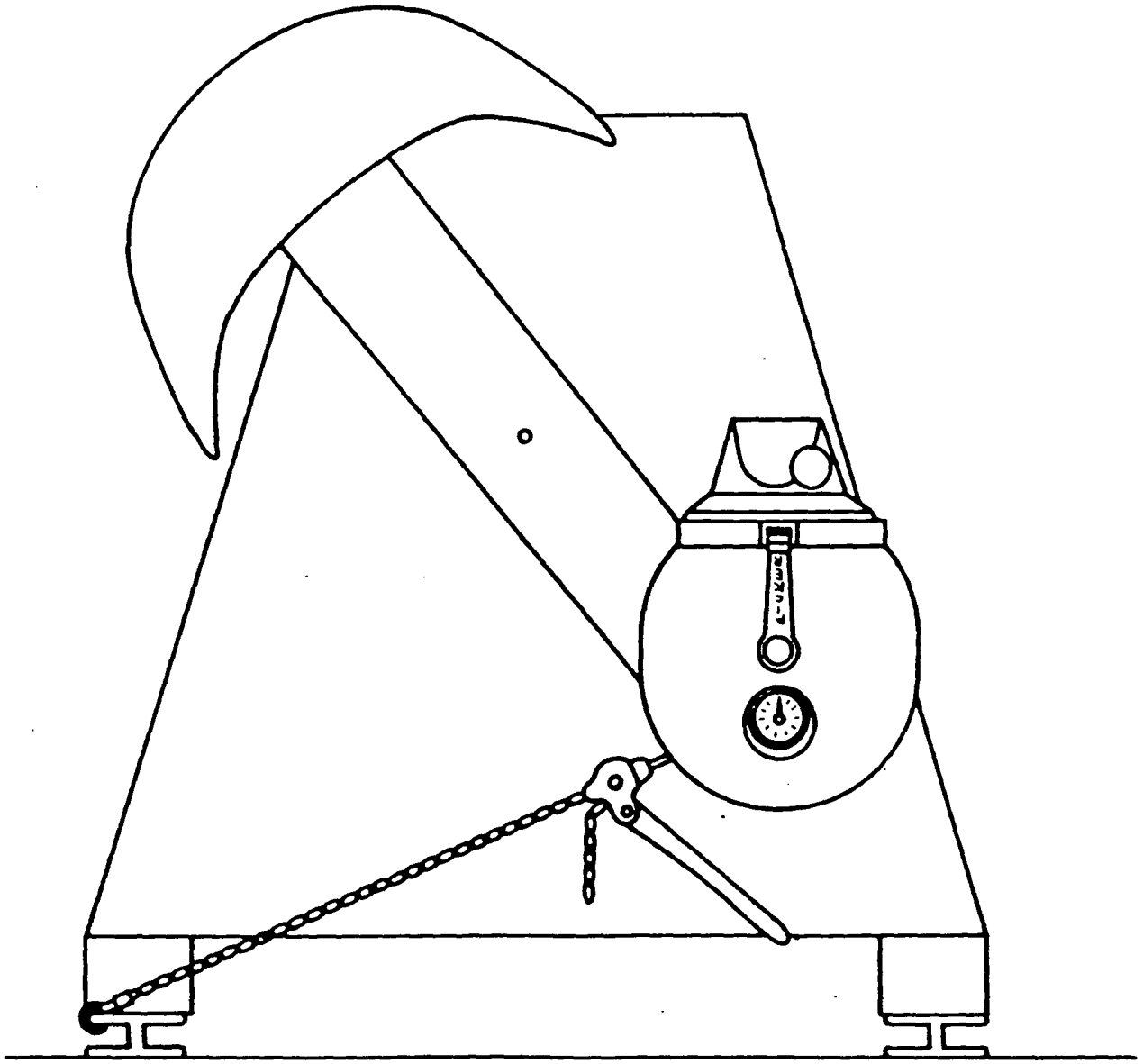
FABRICATED FROM

8 PIECES OF 2" X 4" X 14"

WOOD

Figure # 4

Position of head and "C"
arm for removal of head



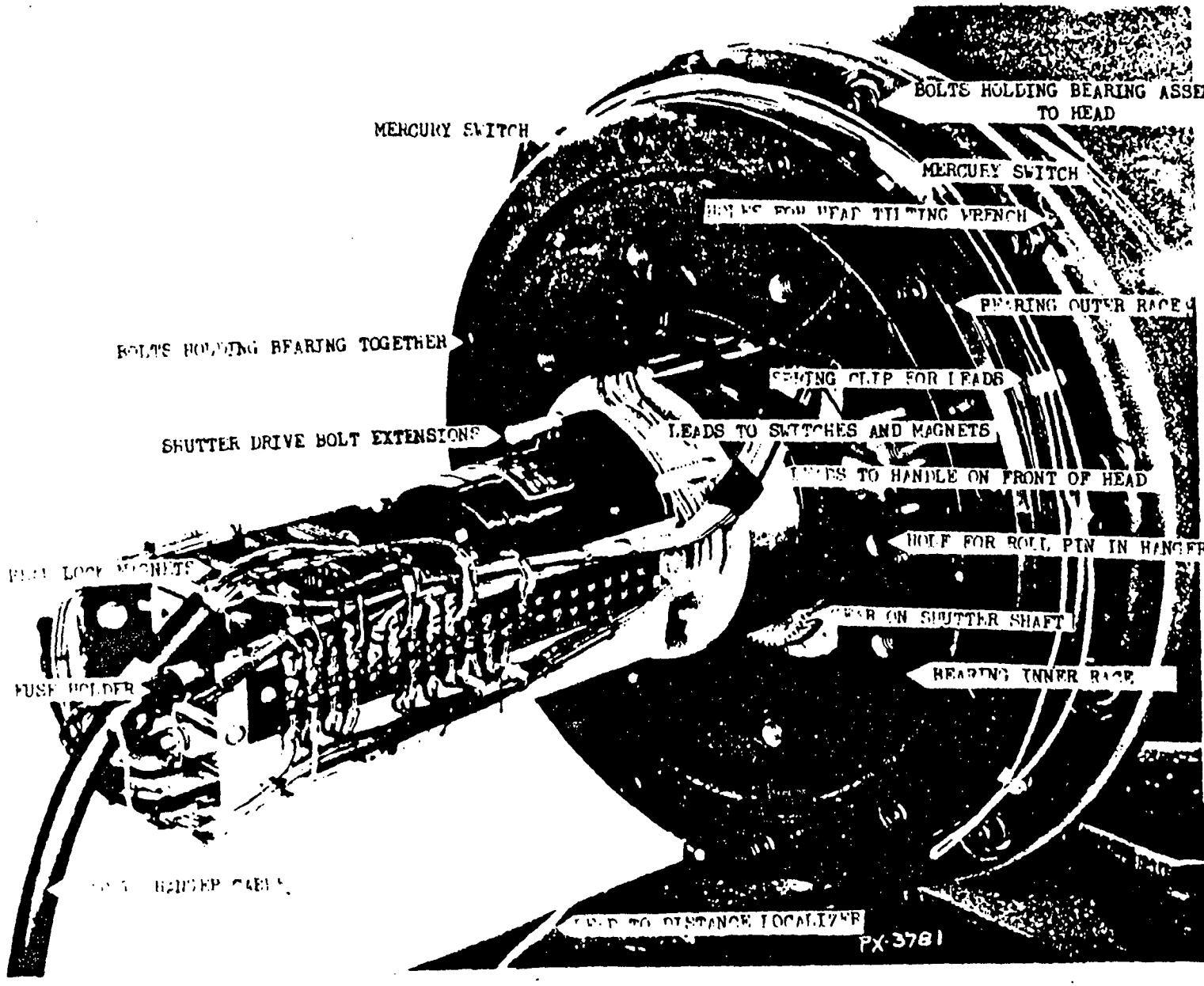
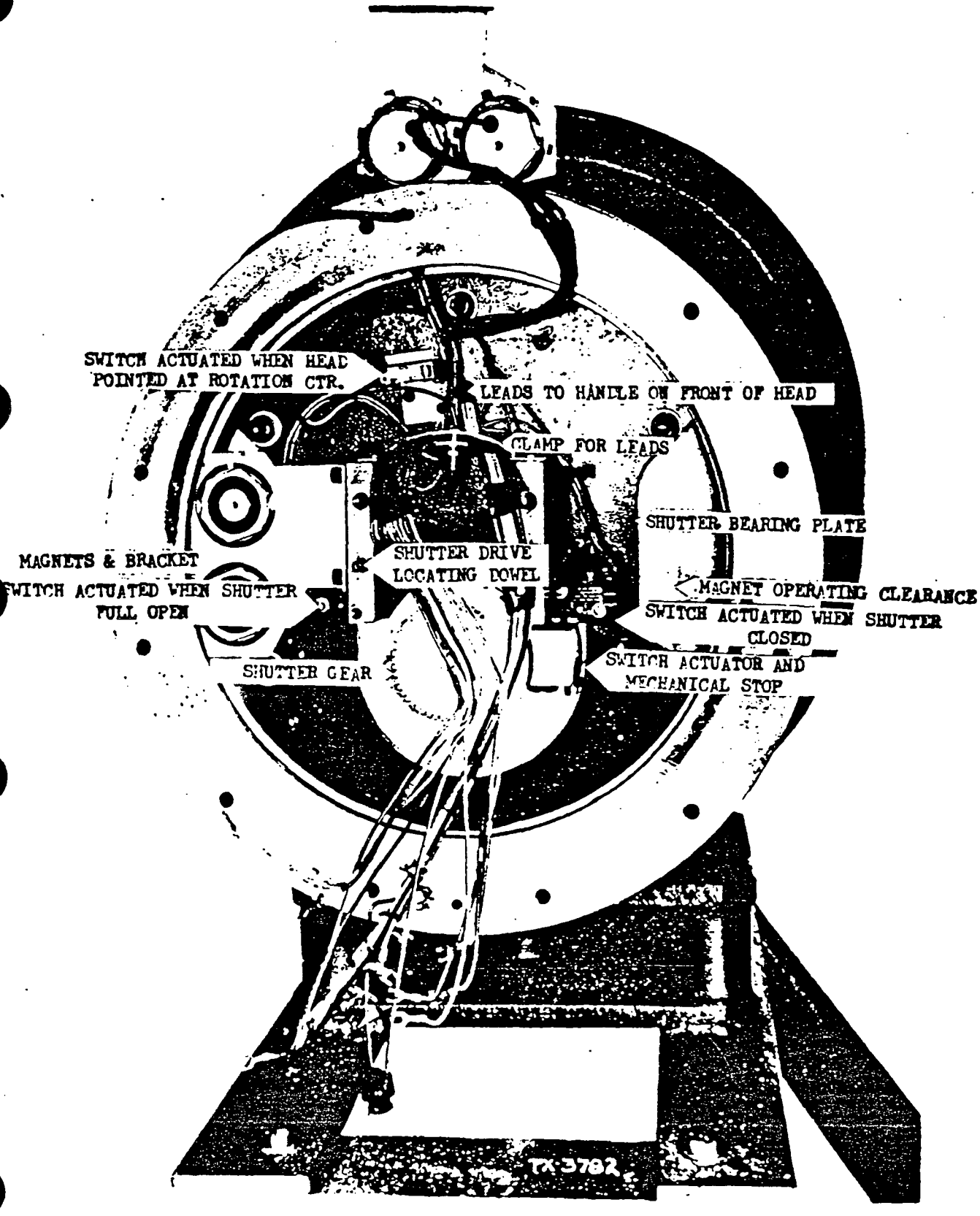


FIGURE 4R

583 HEAD



T55-142
5-57

483 Head

Fig. 5

Lubrication Procedure
Inboard Bearing

590C, D & E Heads Loaded With a Source
TO BE PERFORMED BY LICENSED PERSONNEL ONLY
V4 - C4 - C8 - V9 &C9 UNITS

1. Install the shutter locking bar.
2. Close the collimator and securely fasten a 2" lead block over the center beam.
3. Remove the large brass drive pulley.
4. Mark the position of and remove the micro switches for open and closed lights.
5. Remove the shutter power spring covers, power spring, brass anchor block.
6. Remove the cap screws from the shutter stop arm assembly.
7. Remove the taper pin from the shutter stop arm assembly.
8. Insert the special stop tool into the outermost taper pin hole and secure to 1/4-20 hole for socket head cap screw used to secure the front cover on the head.
9. Remove the shutter locking bolt and move the shutter stop arm assembly back to the special stop tool. Then take the bolts out of the outer bearing retainer plate and move it back also.
10. Insert a 2nd special stop tool into the inner taper pin hole and anchor the same as the first one.
11. Remove the first special stop tool and take the stop and bearing retainer plate off the rotor shaft.
12. Insert the first special stop tool again and remove the second special stop tool.
13. Remove four 5/16-18 cap screws used to secure the shutter plug assembly and replace with 5/16-18 x2" bolts.
14. Install the special bearing puller onto the shutter rotor shaft using the holes for the outer bearing retainer plate.
15. Press the shutter shaft with the bearing puller until the shutter plug moves back about one inch.
16. Remove the bearing puller. Then press the shutter plug back into the head. This will remove the outer bearing from the shutter shaft.

17. Put a small amount (about 10 drops) 3 in 1 oil (USE NO SUBSTITUTES) down the shaft. Use liquid for biplane heads and drop straight down the shaft with the shaf pointed up. For fixed head and vertical units use aerosol can and catheter and spray in. The catheter may have to be flattened.

18. Put the outer bearing on the shutter shaft and rotate slightly (about $\pm 45^{\circ}$ from full off) to work in the lubrication. For this the stop tool may be removed from the anchor bolt. NOTE!! The position of the source must be carefully observed using a survey meter. Replace the anchor bolt.

19. Reassemble the unit making sure that the shutter plug is accurately lined up in the head.

20. Check out electrically from outside the room with the voltage to the motor set at 80 V AC. NOTE!! The shutter opening and closing times at the 0° position should be about equal and not exceeding 3 seconds. As the "C" arm is rotated the times will vary with the worst positions being from 135° through 225°.

Service Manuals

There are individual manuals for each of the Picker and AMS teletherapy units. The chart on the following page lists the various units, component catalog numbers, manual numbers, and schematic diagrams. Copies of these manuals are available from the National Field Service Office on a lending library type basis.

The service technician should familiarize himself with the manual for each type of equipment he encounters in the field.

Included in this section of the Service Procedures Manual are copies of manuals and parts lists for the most frequently encountered equipment.

CKER
UNITS

LIST OF GAMMA THERAPY UNITS

UNIT TYPE	UNIT CAT.	STAND CAT.	COLL. CAT.	HEAD CAT.	CONTROL CAT.	SCHEM.	MANUAL
C 3000	6096	1364	3313	581	VG3	CT61-340A	T55-102
C 5000	6096	1364	3313	581 & A	VG3 & A	CT61-340A	T55-102
C 5000	6096A	1364A	3313	581 & A	VG3 & A	CT61-340A	T55-102
C 5000	6096B	1364B	3313	581 & A	VG3 & A	CT61-340A	T55-102
C 1000	6103	1365 & A	3347	583	VG5 & A, B, C	CT61-477	T55-142
C 2000	6150	1365B & C	3347B	583 A & B	VG5 & A, B, C	CT61-478	T55-142
C 3000	6183 & A	1365D	3347B	590A	VG5 & A	DT61A-37/39	T55-286
C 3000	6183 B & C	1365E	3347B	590A	VG5A	DT61A-37/39	T55-286
C 3000	6183 D & E	1365F	3347B	590A	VG5A	DT61A-37/39	T55-286
C 3000	6183 F & G	1365G	3347B	590A	VG5A	DT61A-37/39	T55-286
C 3000	6204 & A	1365H & J	3347B	590A	VG5A & C	DT61A-37/39	T55-286
V 3000	6202	1373B	3347B	590A	VG6	DT61A-123	T55-311
V 4	6235	1373C	3347D	590C	VG8D	CT61B-364	T55-426
V 10000	6177	1373A	3313A & B	581B	VG8D	DT61A-875	T55-275
C 10000	6182	1381 & A	3313B	581B	VG8 & A	ET61A-200 202	T55-326
C 4M/60	6234	1385 & B	3347D	590C	VG8B	ET61A-444	T55-672
C 4M/60	6234A	1385 & B	3347D	590C	VG8B	ET61A-444	T55-672
C 8M/80	6223	1385A	3347D	590D	VG8B	ET61A-444	T55-425
C 8M/80	6223A	1385A	3347D	590D	VG8B	ET61A-444	T55-425
C 9	6296	1385C & D	3706A	590E	VG8B	ET61B-590	T55-570
C 9	6296A	1385C & D	3706A	590E	VG8B	ET61B-590	T55-570
V 9	6268	1373D & E	3706A	590E	VG8D	DT61B-364	T55-571
V 4					VG8D	DT61B-364	T55-673
CS600	6152			592	VG8	CT61A-797	T55-226
V2000	6156	1373	3347B	583C	VG6	CT61-948	T55-276
C 12	6376 A	183445	183435	182972 A	3930		T55-775A
C 9	76296D,E	1385F	3706E	590G	VG8F,G	E200070	T55-570A
C 9	76296F,G	1385F	3706D	590G	VG8F,G	E200070	T55-570A
V 9	76268	1373E	3706D	590G	VG8D,E	DT61B-364	T55-571

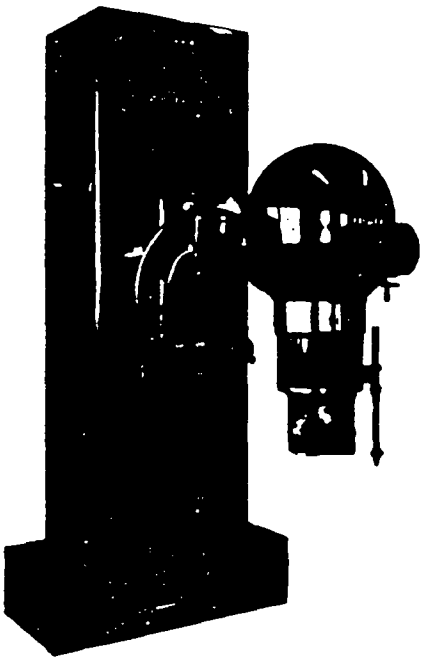
S UNITS

EXPLANATION OF C3000 DESIGNATIONS

Unit Cat. #	Rotation Drive	Head Drive	Rad. Barrier
6183	Yes	Yes	Yes
6183A	No	Yes	Yes
6183B	Yes	No	No
6183C	No	Yes	No
6183D	Yes	No	Yes
6183E	No	No	Yes
6183F	Yes	No	No
6183G	No	No	No
6204	Yes	Yes	Yes
6204-A	Yes	Yes	No

Fig. 1b

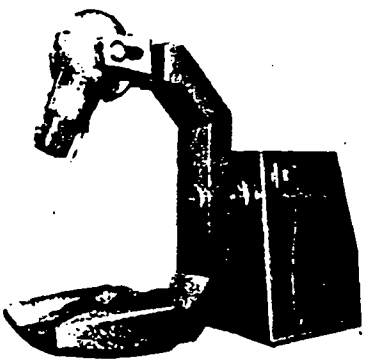
COBALT UNITS



C-5000, Cat. 6096, A, B Vertical Stand Unit
Original Capacity - 3,000 RHM
Later Capacity - 5,000 RHM
(Disc. 1960)

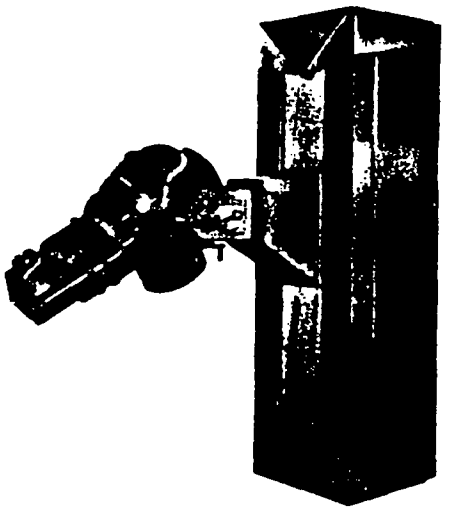
C-1000, Cat. 6103, A
C-2000, Cat. 6150 series
55 CM Rotational Units
Capacity 1,000 - 2,000 RHM
(Disc. 1960)

V-2000, Cat. 6156 Vertical Stand Unit
Capacity - 2,000 RHM
(Disc. 1961)

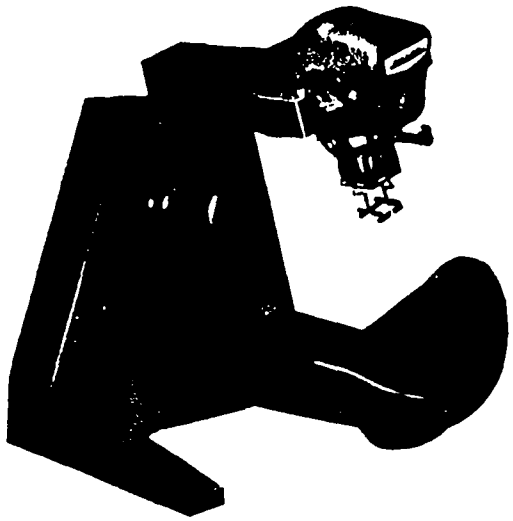


C-10,000, Cat. 6182 95 CM Rotational Unit
Capacity - 10,000 RHM
(Disc. 1964)

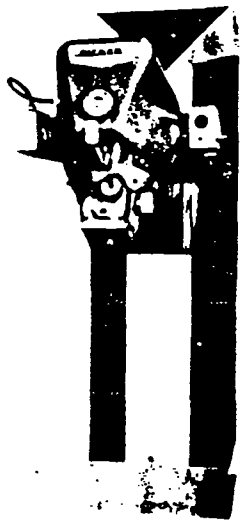
COBALT UNITS



V-10,000, Cat. 6177 Vertical Stand Unit
Capacity - 10,000 RHM
(Disc. 1967)



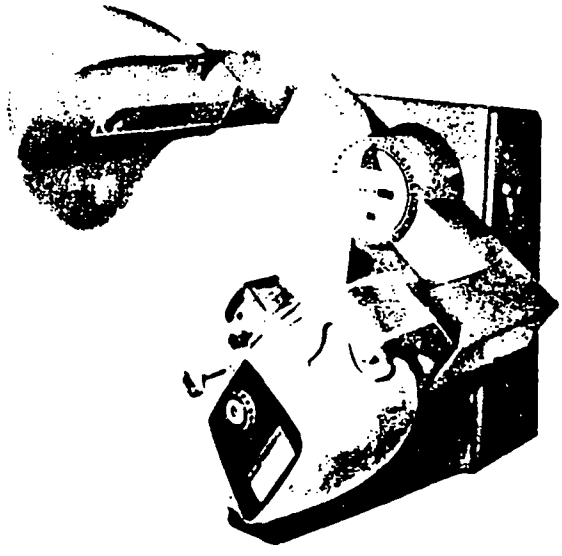
C-3000, Cat. 6183 Series 55 CM Fixed and Biplane and Cat. 6204 75 CM Biplane Rotational Units
Capacity - 3,000 RHM
(Disc. 1964)



V-3000, Cat. 6202 Vertical Stand Unit
Capacity - 3,000 RHM
(Disc. 1963)

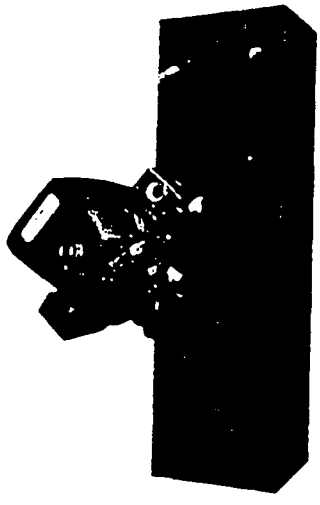
C8M/80, Cat. 6223, A 80 CM Rotational Unit
Capacity - 8,000 RHM
(Disc. 1968)

COBALT UNITS



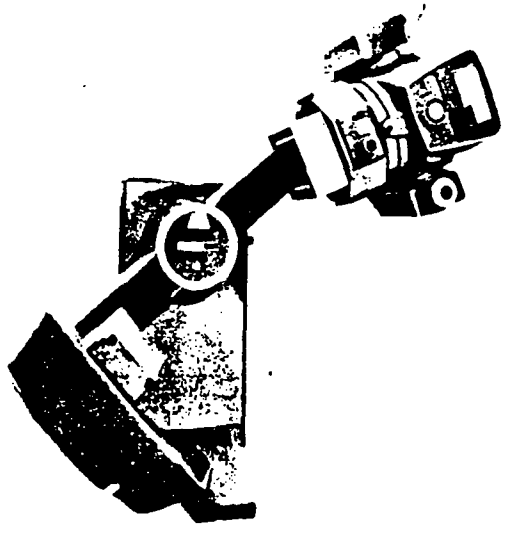
C4M/60, Cat. 6234, A 60 CM Rotational Unit
Capacity - 4,000 RHM

(Active)



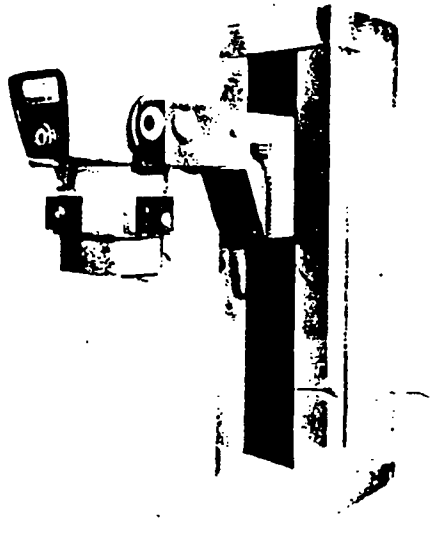
V4M/60, Cat. 6235 Vertical Stand Unit
Capacity - 4,000 RHM

(Active) H3



C-9, Cat. 6296, A 80 CM Rotational Unit
Capacity - 9,000 RHM

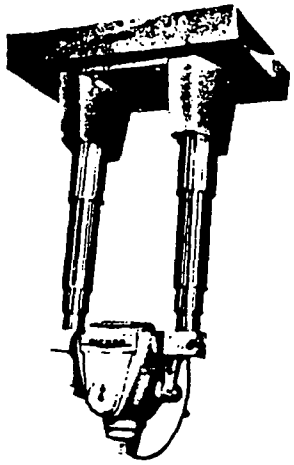
(Active)



V/9, Cat. 6268 Vertical Stand Unit
Capacity - 9,000 RHM

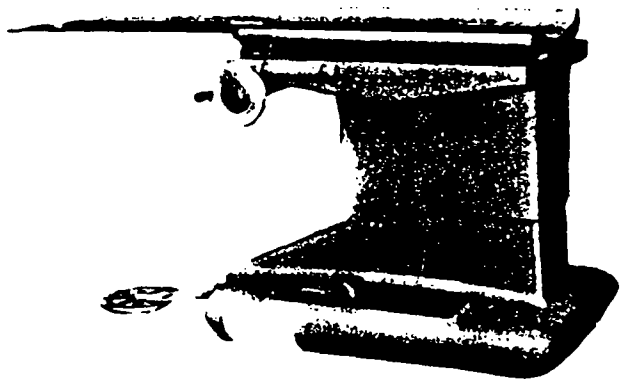
(Active)

CESIUM UNIT - TREATMENT TABLES

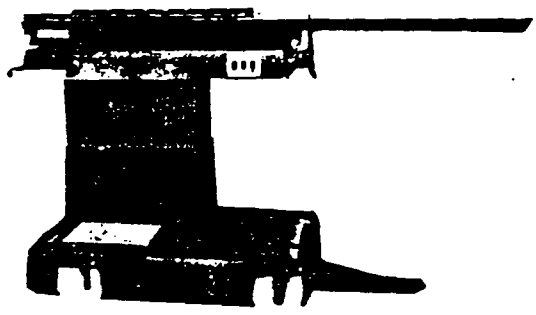


CS-600, CAT. 6152 CEILING MOUNTED CESIUM UNIT
Capacity - 600 RHM
(Disc. 1968)

CAT. 3345 VANGUARD THERAPY STRETCHER
(Disc. 1962)
CAT. 3345A VISCOUNT THERAPY STRETCHER
(Disc. 1967)



CAT. 3324 MANUAL PRECISION TREATMENT TABLE
(Disc. 1968)



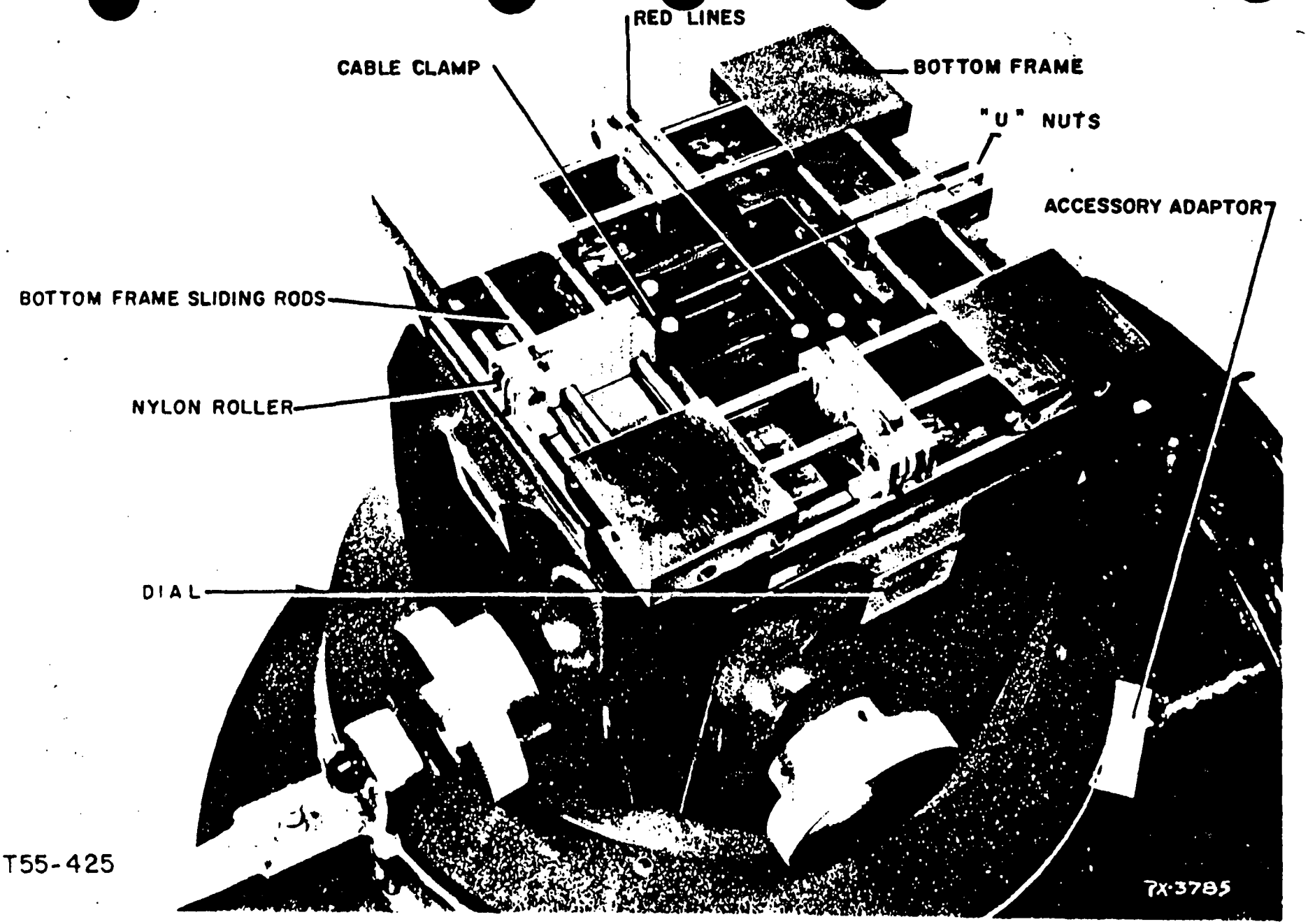
CAT. 3702 ISOCENTRIC MOTOR DRIVEN TREATMENT TABLE
(Active)

GENERAL

BEAM COLLIMATOR

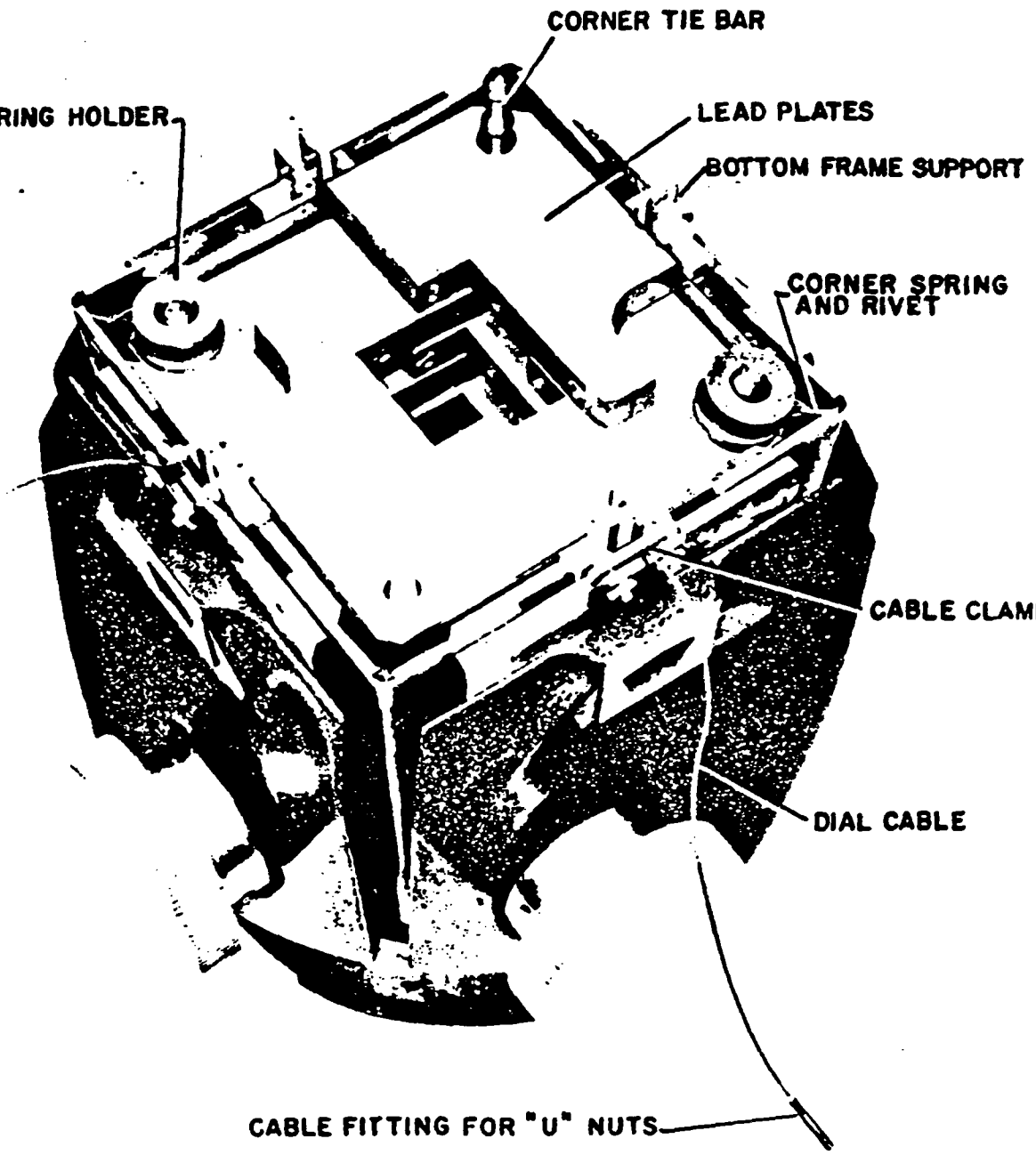
The collimator is shown in Figure 4A. The collimation of cobalt radiation presents a difficult problem because of its high energy, and because of the relatively large area of the face of the source. Experiment shows that a distance of 15 to 20 cm between the last diaphragm and the skin is necessary to minimize scattered electrons in the beam, but this distance coupled with a large diameter source and a relatively short SSD (source-to-skin-distance) can mean that a serious penumbra may be present around the beam. Furthermore, making the field size adjustable usually means that the collimator will be bulky and will interfere with proper "porting" of patients. The collimator used on the Picker Cobalt-60 Unit has been so designed that it in large measure overcomes the above problems. The system of articulating stainless-steel-faced lead plates, some of which are edged with tungsten, yields more than adequate attenuation of the beam outside the desired field (about 1.3 percent of primary beam is transmitted 6 cm outside a 10 x 10 cm field, by measurement) and at the same time permits the over-all size of the collimator to be conveniently small. The last collimating edge on the collimator alone is 25 cm from the source, or 25 cm from the skin when using a 60 cm SSD. Additional mechanical structure extends beyond this for 2 cms, so the distance from the bottom of the collimator to the source is 27 cm. When the collimator adjusting knob is turned, all of the lead plates and extenders move as if they were pivoted about the corresponding edges of the source. In this way all of the plates and extender bars act to define the beam regardless of field size, and a very small over-all size is achieved, particularly for small fields. The C3M/80 has a collimator extender consisting of collimator-driven tungsten bars which are calibrated to give field sizes at 60, 70, and 80 cm. The first set of bars are exactly 40 cm from the source at their outermost end. The bars are 42 cm from the source.

The compression cones (optional equipment on C4M/60 for 40 SSD) are made slightly larger than the total field, including penumbra, to avoid electron scattering from them. For the same reason, the compression cones are made with open ends. Note that the compression cones provide no radiation protection and do not act to define the beam. Each cone has four indexing holes which engage the dimples on the collimator covers. It is impossible to mount a cone unless the field size adjusting knobs have first been set to the field dimensions corresponding to that particular cone. These cones cannot be used with extender in place. Figure 12 shows the optical back pointer which gives the alignment of the exit beam. The scales on the collimator or collimator extender should be used to set the field size, rather than the field size illustrator, even though the latter gives an accurate representation of the radiation field without decreasing field illumination.



T55-425

Model 3347 COLLIMATOR WITH CABLE CLAMPS
FIG. 4A

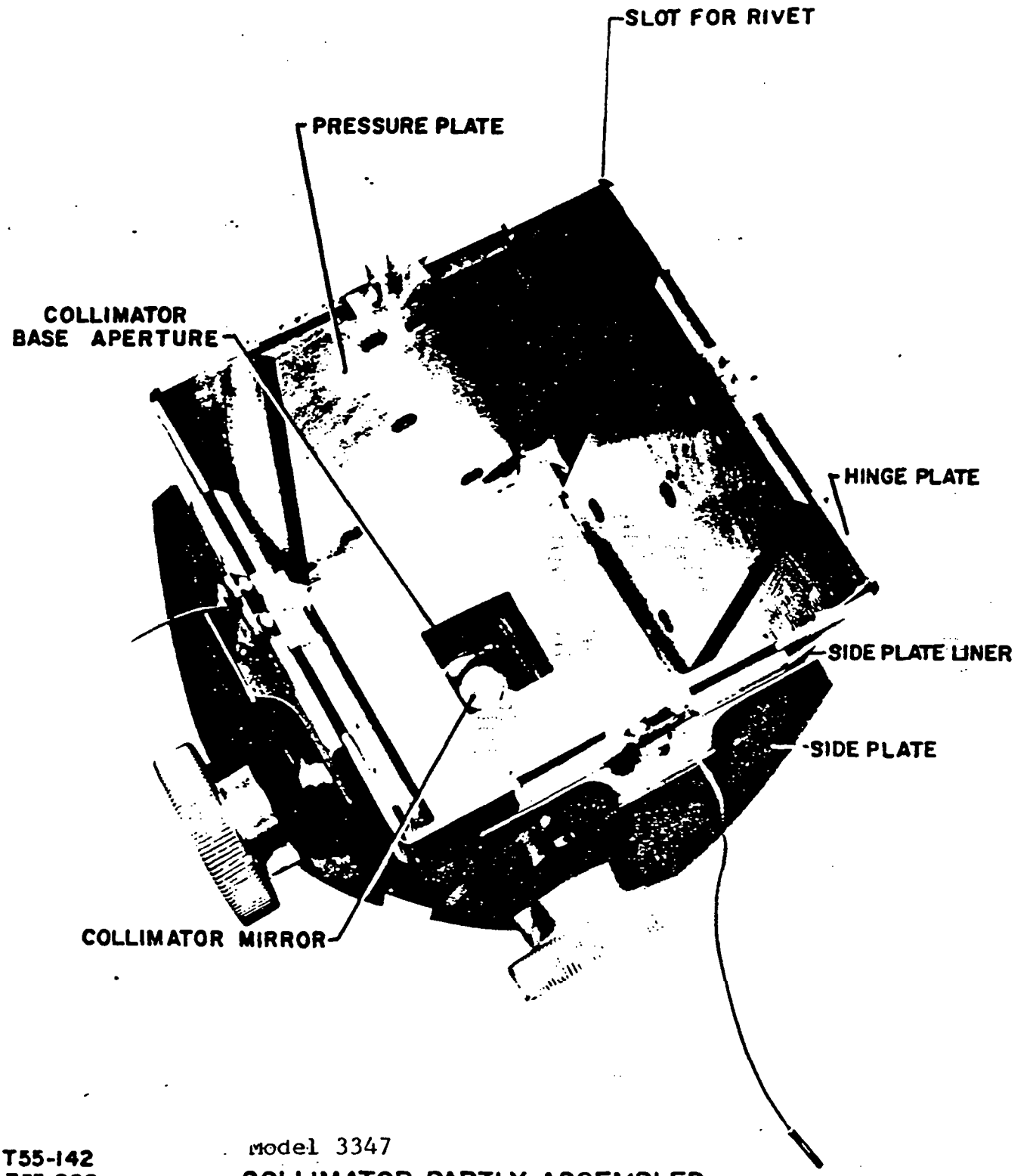


T55-142
T55-286

Model 3347

COLLIMATOR - LEAD PLATES

Fig. 4B

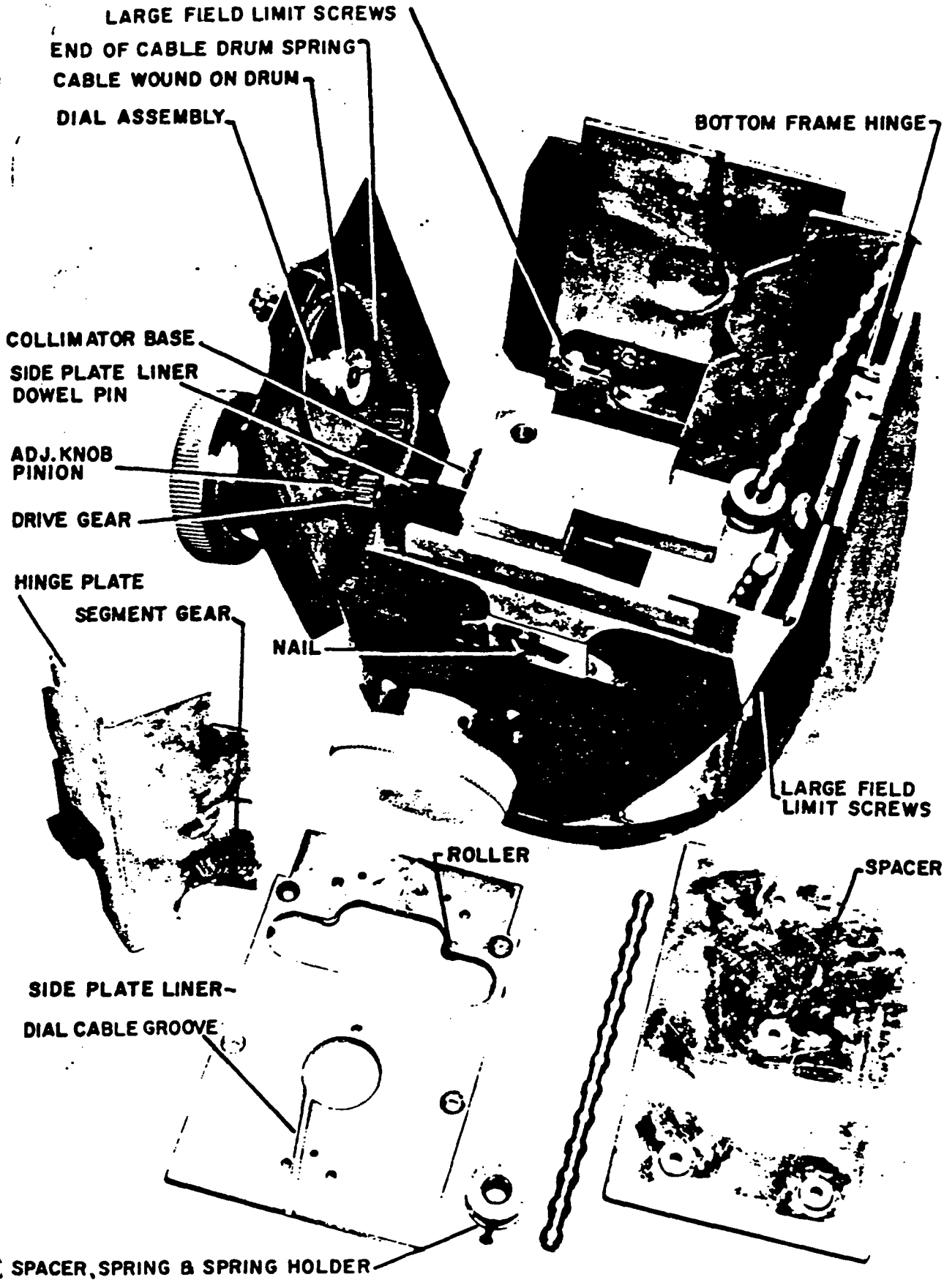


T55-142
T55-286

Model 3347

COLLIMATOR PARTLY ASSEMBLED

FIG. 4C



T55-286 Model 3347 COLLIMATOR INTERNAL MECHANISM
T55-142 FIG. 4D

The collimator (Fig. 4E) is shown schematically in Fig. 4F. The collimation of cobalt radiation presents a difficult problem because of the penetrating power and because of the relatively large area of the face of the source. Experiment shows that a distance of 15 to 20 cm. between the last diaphragm and the skin is necessary to minimize scattered electrons in the beam, but this distance coupled with a large source usually means that a serious penumbra will be present around the beam. Furthermore, making the field size adjustable usually means that the collimator will be bulky and will interfere with proper "porting" of patients.

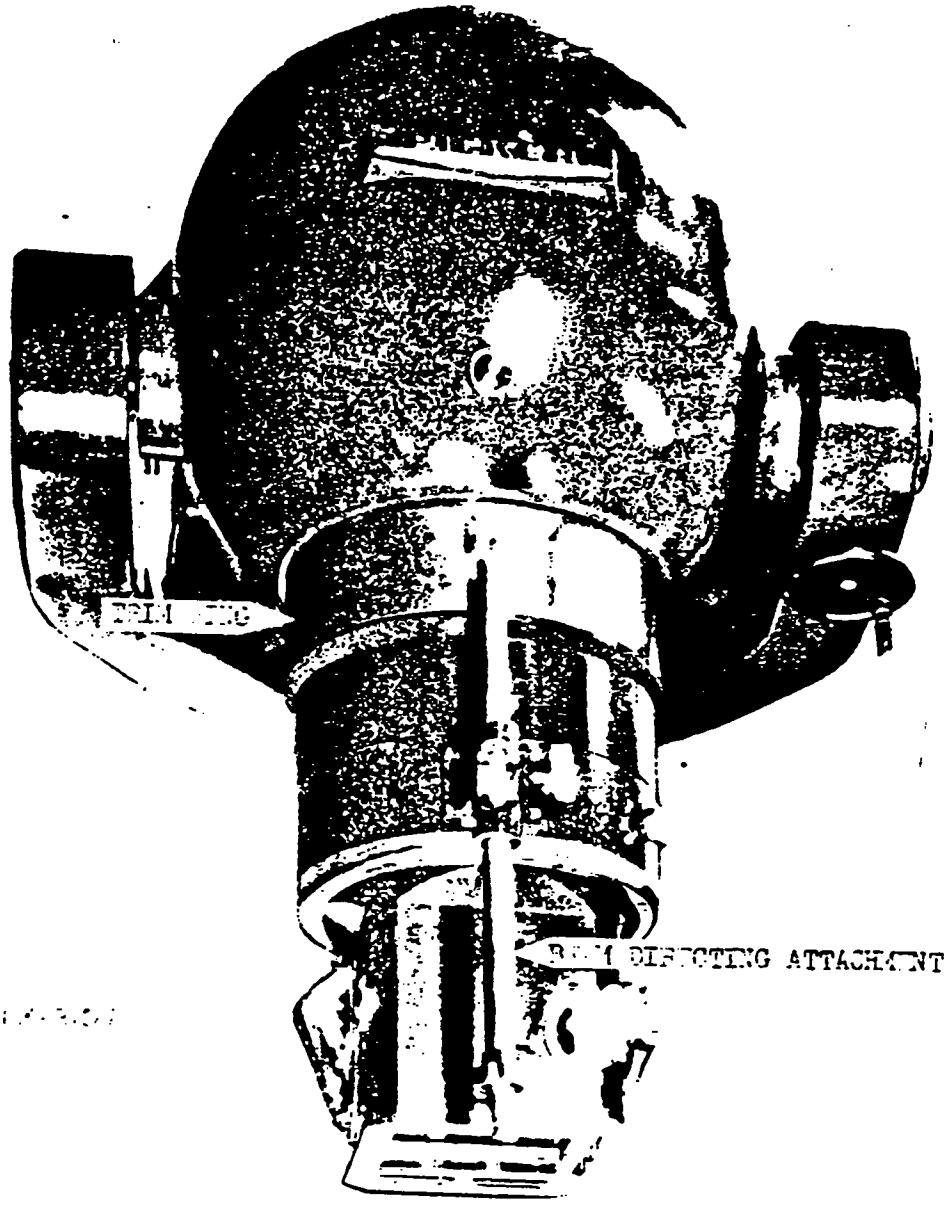
The Johns-MacKay collimator used on the Picker Cobalt-60 Unit has been so designed that it in large measure overcomes the above problems. The system of moving bar diaphragms interleaving the fixed bars yields more than adequate attenuation of the beam outside the desired field and at the same time permits the overall size of the collimator to be conveniently small.

In Fig. 4F the moving bars are shown set for a field size of 10 cm. This is a nominal field size determined by lines drawn from the center of the source through points YY, and extended to the skin surface. It is this field dimension that is marked on the field size control dials. The edges of the diaphragm bars are shaped to lie along the lines Y, Z and Y'Z', that is, lines from Y to the edges of the source. The slope of the faces of the bars actually changes midway along the thickness of each bar. On the upper half of the bars the slope corresponds to the line Y, Z when the diaphragms are set for <u>minimum</u> field size, and the slope of the lower half corresponds to the line Y, Z when the device is set for <u>maximum</u> field size.

When the field size adjusting dial is turned, all of the moving sets of bars move as if they were pivoted about the corresponding edges of the source. In this way all of the bars act to define the beam regardless of field size. Because of the finite size of the source, a small penumbra exists at the edges of the beam. The penumbra on one edge is defined by lines drawn from Z through Y' and Z' through Y' to the skin. The point Y' is 20 cm. from the skin, and the source is 80 cm. from the skin, so the width of the penumbra is 20/80–20 of the source diameter. For a 2.0 cm. source the penumbra is 0.66 cm. wide. This means the dosage rate starts to fall 0.33 cm inside the edge of the field, reaching 50% at the center of the penumbra and zero at a point 0.33 cm. outside the nominal field (neglecting scattering).

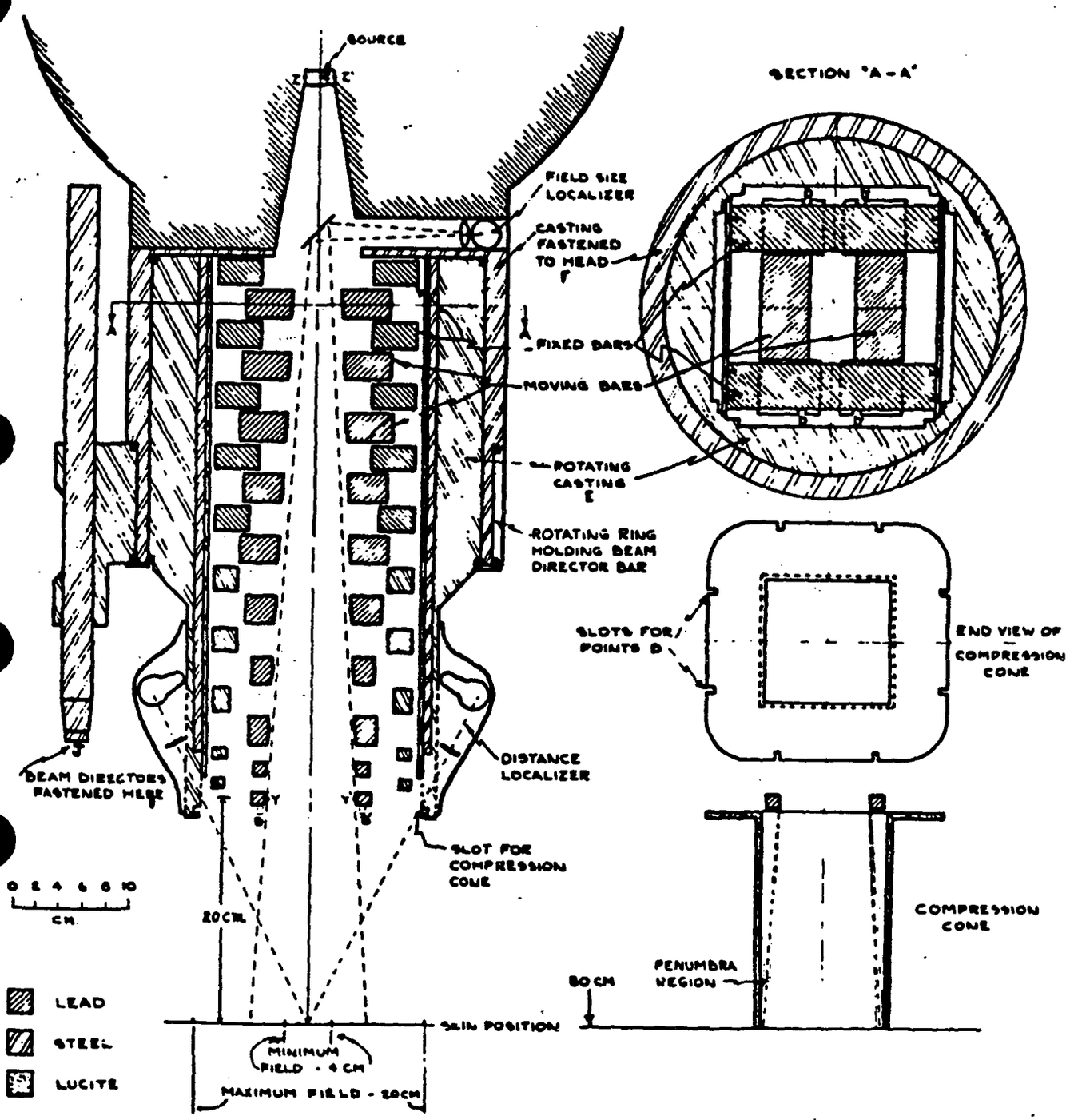
The compression cones are made slightly larger than the total field including penumbra to avoid electron scattering from them. For the same reason, the compression cones are made with open ends. Note that the compression cones provide no radiation protection and do not act to define the beam. Each cone, however, has notches in its mounting plate which engage the pins B and B' on the collimator. It is impossible to mount a cone unless the field-size adjusting knobs have first been set to the field dimensions corresponding to that particular cone.

The localizer lights for field size and distance are shown in Fig. 4F and in Fig. 4G.



Model 3313 Collimator

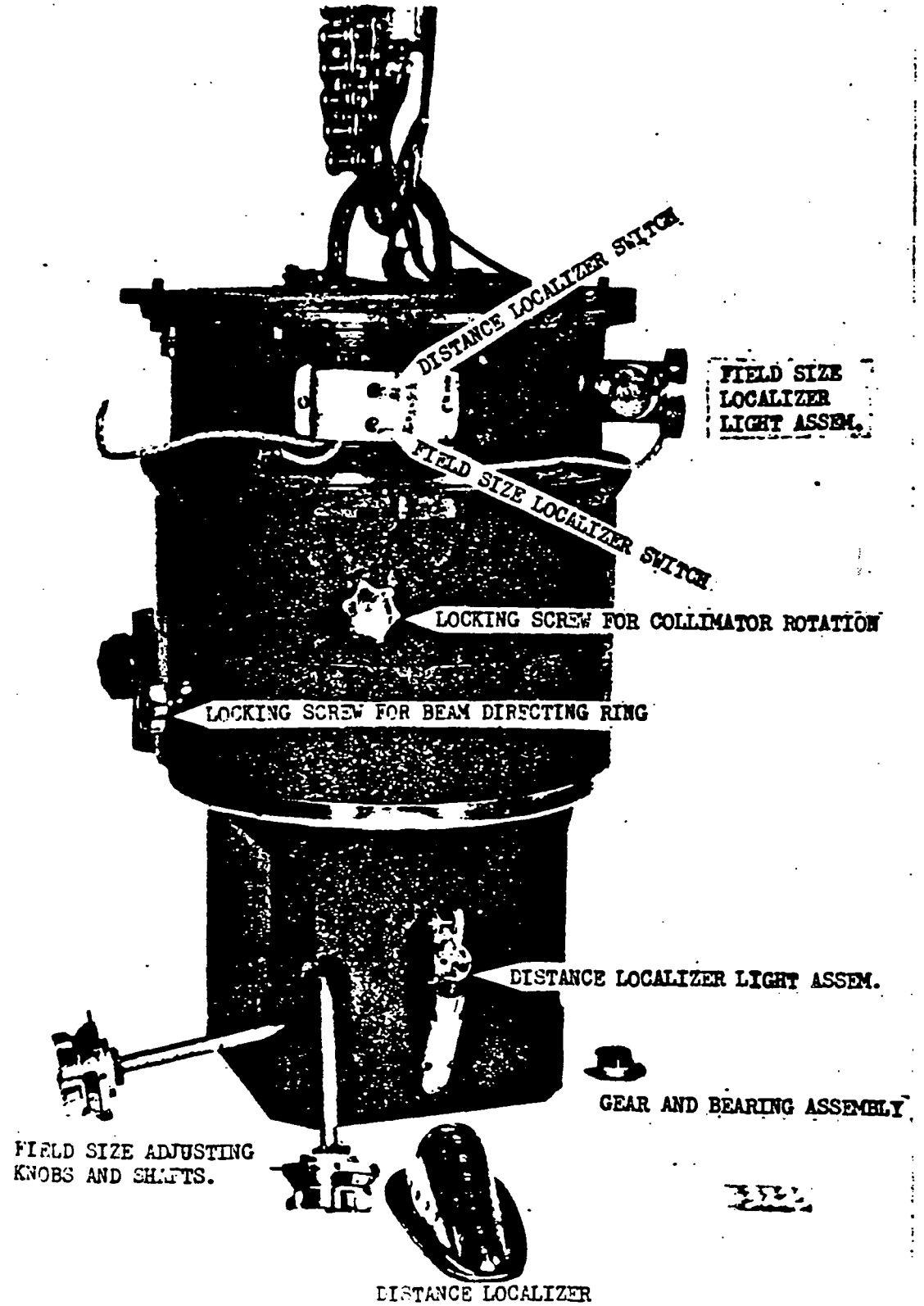
Fig. 4E



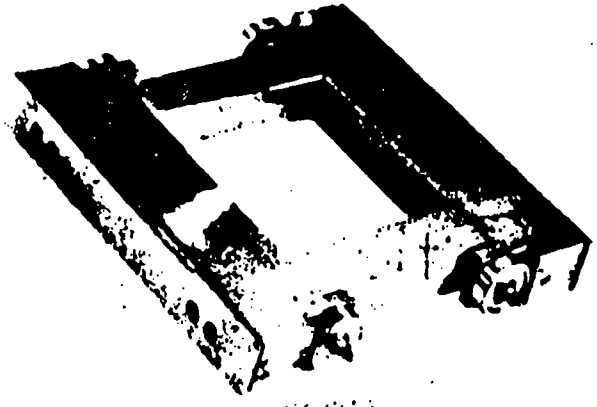
SCHEMATIC OF
MECHANICAL CONSTRUCTION

Model 3313 Collimator

Fig. 4F



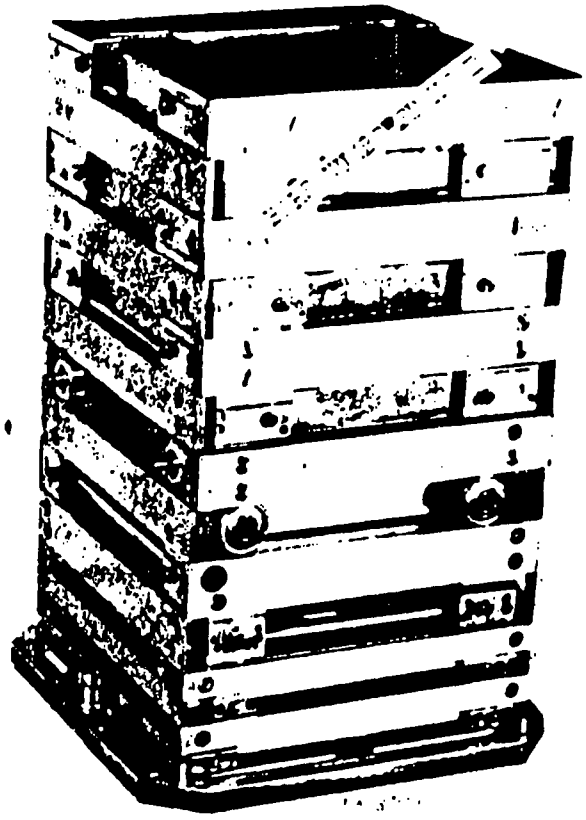
Model 3313 Collimator
Fig. 4G



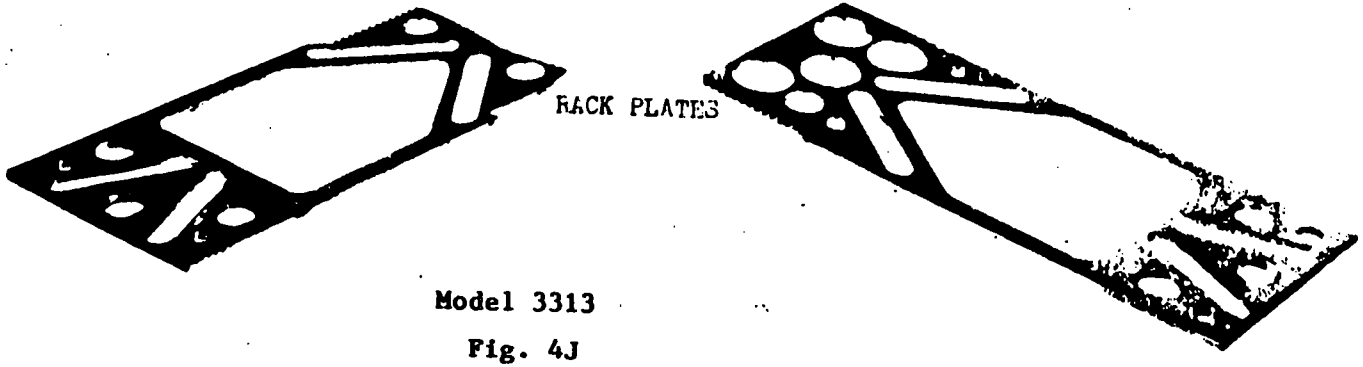
LOAD FILLED BAR ASSEMBLY

PX 3227

STACK WITH TIE BARS IN PLACE



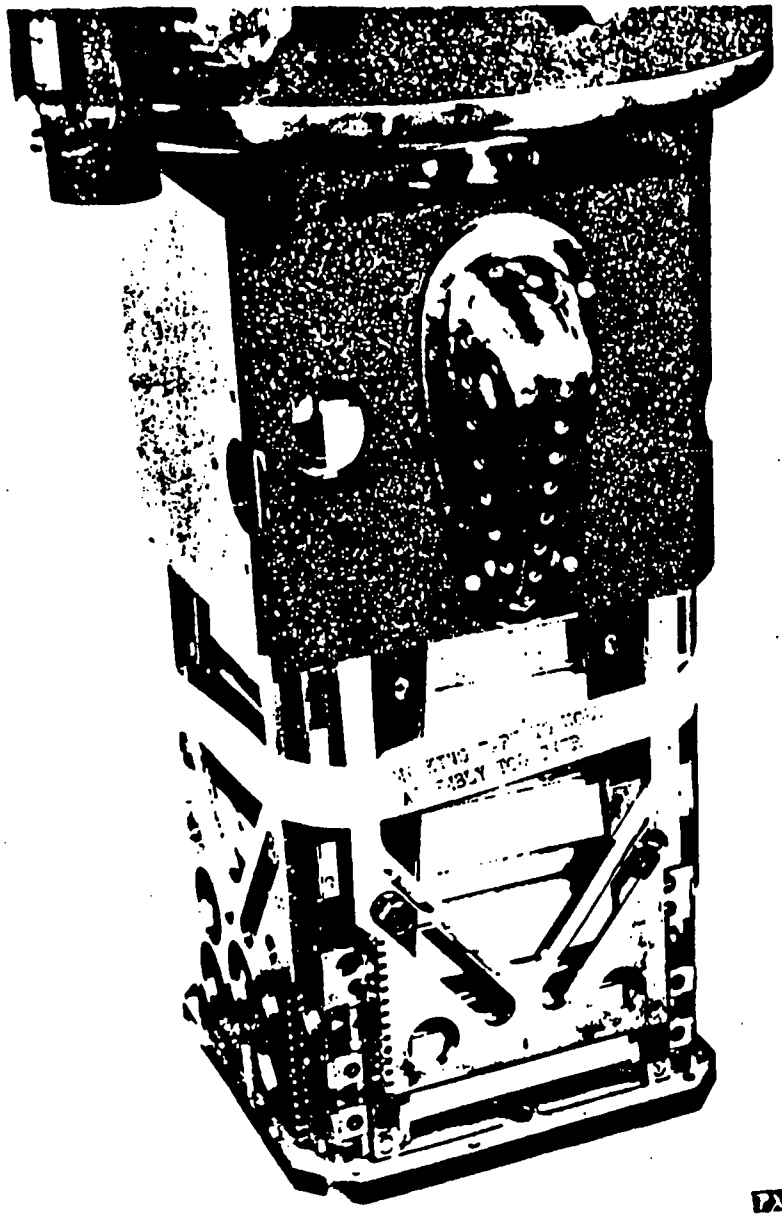
STACK WITH TIE BARS REMOVED



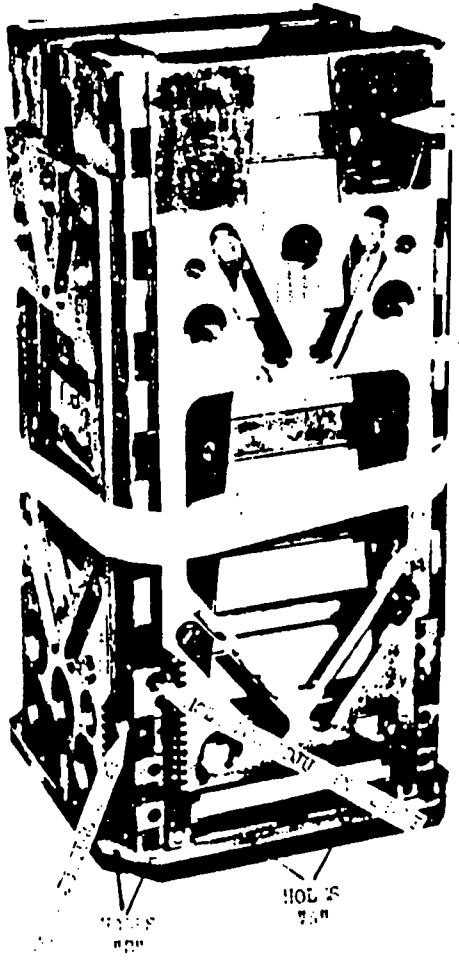
RACK PLATES

Model 3313

Fig. 4J

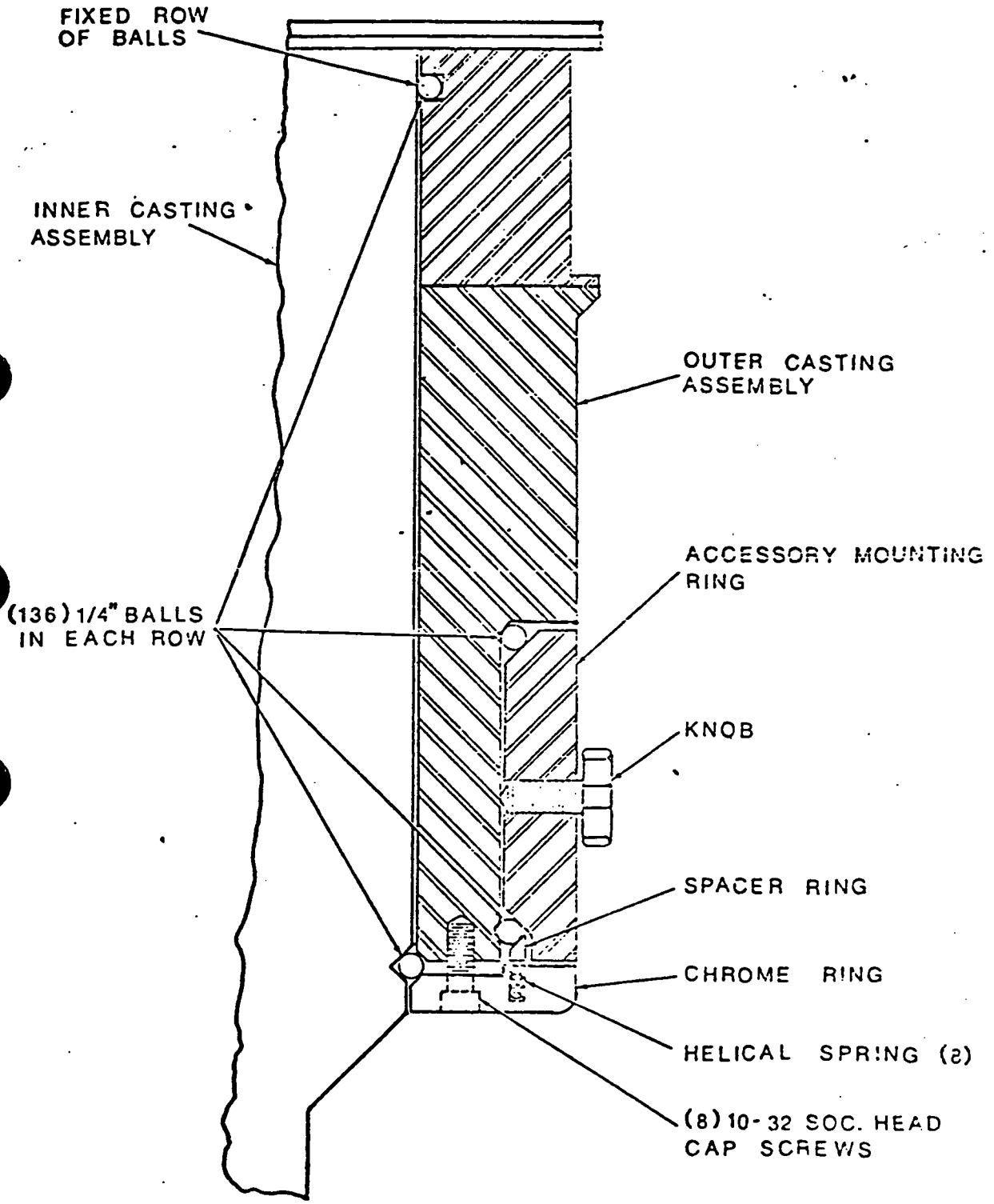


PX-3226



PX-3228

Model 3313 Collimator
Fig. 4H



ACTUAL CONSTRUCTION OF
3313 SERIES COLLIMATORS

Fig. 4K

JOHNS MCKAY COLLIMATOR

REMOVAL OF THE INNER CASTING ASSEMBLY FROM THE OUTER CASTING ASSEMBLY

Procure a 8" pipe spacer 10" long.

1. Be sure the shutter is closed and locked in place.
2. Turn head so that the collimator points vertically downward.
3. Remove the hanger shaft covers and install the yoke rotation locking bolt. (Prevent head and yoke from flipping over.)
4. Bring a hand truck or dolly underneath the collimator and vertically position the collimator so that it is resting on the 8" dia. pipe spacer. It must be perfectly level to prevent the inner casting assembly from toppling over.
5. Lock the head tilting gear train and remove the collimator rotation lock knob.
6. Remove any accessory device that may be attached to the collimator accessory ring and lock the ring in place with the locking knob. Tape as necessary.
7. Remove the two collimator knobs and shafts by first removing the flange screws, end covers and small gears with keys and chrome cover.
8. Remove the distance indicator covers and bulbs if necessary and the copper contact on the outer casting.
9. Make alignment marks on tape between the chrome compression ring and the lower edge of the outer casting assembly.
10. Make a paper catch-all for the 1/4" balls of the assembly.
11. Carefully remove the 8 screws on the chrome ring. Tape the floating ball track ring, located above the chrome ring and the lower section of the accessory ring, into place as each screw is removed.
12. Lower the chrome ring till it is below the squared chrome base and around the 8" pipe.

13. (2 men required) Remove the tape on the floating ring and carefully lower the ring to its lowest position. The balls will tend to fall out into the paper catch-all. There are about 136 in each V-grooved section. (Check for damage and clean - track and balls) DO NOT USE A MAGNET ON THE STEEL BALLS TO PREVENT A MAGNETIC TRANSFER ACTION.
14. Very slowly raise the outer track assembly about 1/4 to 3/8". (Another section of 136 (1/4") balls will be exposed. Allow these to fall into catch-all for inspection and cleaning.
15. (2 men required) Remove all tape from accessory ring. Firmly hold the lower edge of the accessory ring and loosen the clamping knob.
16. Lower the accessory ring, until the steel balls fall out of the upper grooves into the catch-all, and place in its lowest position.
17. Slowly raise the outer casting assembly until it clears the top of the inner casting assembly by about 2 inches.
18. Inspect, clean and lubricate the contained row of balls on the upper section of the inner casting assembly and the copper ring.
19. Inspect, clean and lubricate the lower ball grooves of the inner casting assembly and the outer surface too.
20. Inspect and clean the upper internal ball surface of the outer casting assembly.
21. Inspect and clean the floating ball track, the bearing grooves of the accessory ring and the chrome compression ring with the springs. Check the length of the springs and depth of spring holes.
22. Carefully lower the outer casting onto the inner casting until it (outer) is about 1" from being seated.
23. Install the 136 steel balls into the lower inner casting groove and then lower the outer casting until seated. (To contain the lower balls into position.)

24. (2 men required) Raise the accessory ring until it is 1/2" from its upper-most position and lock in place with tape or locking knob. Insert and position the 136 balls in place and then raise the accessory ring until seated. Lock in place and tape.

25. (2 men required) Apply grease to the floating ring and install the balance of the balls. Carefully raise the floating ring into its upper-most position and tape in place.

26. Vertically raise the chrome compression ring until it is properly aligned, and partially engage the socket head cap screws into place.

27. Remove the floating ring, tape and secure the compressing ring screws. Firmly seat.

28. Install the distance light covers and the two collimator shafts (with its gear) into place. Install the collimator rotation lock knob, the copper contact and the chrome ring.

Raise the collimator up off of the 8" pipe spacer, remove the yoke rotation lock bolt and partially loosen the head tilt gear mesh.

30. Check the inner casting assembly for shift by rotating the head till the collimator is aiming upward.

Check the rotation action of the inner casting assembly.

32. Install the accessory gear rack onto the accessory ring and check its rotation action.

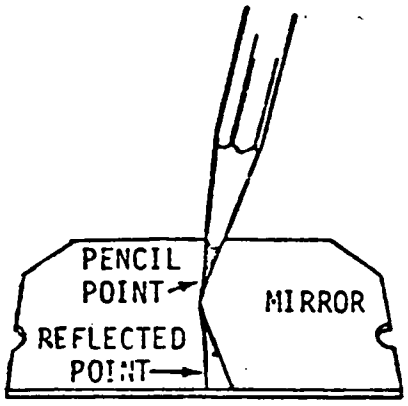
33. Recalibrate the collimator field sizes and dials by adjusting the gear train to the collimator gage.

34. Readjust the distance localizer lights to focus at 80 cm from the source or 6-7/8" from the end of the collimator. Use a 4 x 4 field to center the filament images.

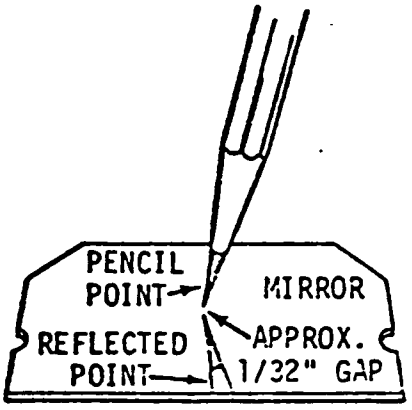
MIRROR REPLACEMENT

When replacing a mirror (Part no. 41772) it is of the utmost importance to distinguish between the "front" and "rear" sides of the mirror. The "front" side exposed to the radiation has a hardened aluminized surface and must be positioned so it is facing toward the field lamp projection assembly. If the mirror is reversed (not installed properly) the glass becomes discolored in a short time loosing its reflective ability.

To distinguish between the "front" and "rear" side of the above mirror, hold an ordinary lead pencil perpendicular to the mirror so the point is resting on the mirror surface. (See sketch below).



FRONT SIDE



REAR SIDE

If the reflected pencil point meets the pencil point without any spacing, this is the front side of the mirror. If a space exists of approximately 1/32-of an inch between the reflected point and the pencil point, this indicates the rear. Discolored mirrors will cause a reduction in the intensity of the illuminated field and can be corrected by reversing the mirror.

INSTRUCTION MANUAL

MULTIVANE COLLIMATOR FOR COBALT^{60} WITH BEAM DIRECTING DEVICES

TO ASSEMBLE COLLIMATOR

Procure a piece of 8" pipe about 6 to 8" long with both ends faced square. Cover one end with paper or some material that will not mar the finish on the end plate. Place pipe in convenient place under a chain hoist or if the castings of the collimator are attached to the Cobalt machine, place in a position that the castings can be let down vertically using the vertical travel of the machine. Check pipe for level and shim bottom if any rocking is present.

Center the end plate on pipe with the catch spring up and in the position indicated. The corners of end plate should be clear of pipe to allow room to assemble corner screws. Install the two cross wires onto end plate.

Start assembling lead filled bar assemblies. An O will be found on corner of end plate which should match up with the No. 1 on the first assembly. Center assembly as accurately as possible on end plate. The large end of taper on the movable lead bars should face the end plate on all the assemblies.

Continue placing No. 2 and No. 3 etc. on top of each other Make sure all numbers are right side up and appear at the corner indicated. When the 18 assemblies are stacked on top of each other, try moving the movable bars one at a time by holding opposite ends. They should all be free. If any stick, find and romove the cause. It may be a nick or some foreign material on the guide bars. Oil the outside surfaces of the guide bars and the sliding surfaces with a thin film of special oil. CAUTION: Do not use regular oils on any of the inner bars or bearings which are exposed to radiation. The intense radiation will oxidize and gum ordinary oil. Use only Teresso 43 by Standard Oil or Socony #V:77 Oil, which will not creep, oxidize or gum.

Assemble the 8 tie bars. 8 letters are stamped on the end plate which should match with the letters on the tie bars. Note the relative position of the indentation on one edge. Make sure the tie bar is correctly oriented.

Assemble bearing to shafts protruding through tie bars, making sure that the bearings are on all the way.

Assemble rack plates on bearings. The letters on the end plate should match with the letters on the rack plates. Carefully push all rack plates all the way down Tie a wire around the whole assembly to hold it together.

Shows the correct position of the outer castings with respect to the inner assemblies. Note relative position of holes.

Shows the correct position of the castings and the inside assemblies. Note relative position of holes. Position casting vertically and directly over inside assembly.

Carefully lower outer casting making sure that the square formed by the lead bar assemblies slips in the corner groove of the casting. Continue to lower till casting comes within ¼" of the rack plates

Raise rack plates and insert them in the grooves in the castings. Push them up as far as they will go taking care that opposite plates are moved up together. This will close the lead bars to the 4 X 4 Field size.

Continue lowering casting holding up rack plates with two hands. Rack plates may stick. A slight movement on the bottom will line them up. Watch that one rack plate does not move down and its mate on the opposite side stay up. This will jam the movable bars and may seriously damage them.

Continue lowering casting. When rack plates disappear into casting, hold tie bars closed with two fingers till casting reaches end plate.

Assemble end plate to casting by inserting two 8/32 X 3/4 Fillister head screws in each corner.

Push each pairs of rack plates up as far as they will go, making sure they both move at the same time. Use two screw drivers. They should not be tight.

Select gear assembly for "A". It is the one with the tops of the number closest the knob of the dial. Remove gear from the end of this assembly. Insert it in hole "A" and the corresponding dial assembly in "B". Place the corner block "C" between the dials and assemble both dials with 6/32 round head screws, making sure the screws are less than 3/8" long. Insert gears as indicated by the hand showing Make sure both rack plates are all the way up and that key in shaft enters keyway in gear. Then add the two bearings. Turn dials. They should move easily with a torque of about two to 3 in lbs. Play between the rack plate and the gears may be adjusted by loosening the three screws for each bearing.

Remove screw and washer on the end of the dial assembly. Remove knob. Loosen three clampong screws for the dial. Adjust angular position of dial so that there is the same amount of overtravel past 4 in the closed position and past 20 in the open position. Tighten 3 clamping screws and put the knob settings back on. Field sizes will now correspond to dial settings. Insert cellophane dust cover in the slot provided in the end plate if this has not been done before. (Not used on later units.)

Beam Directing Devices

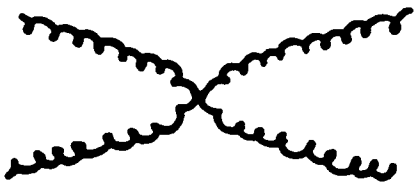
1. Back Pointer The back pointer should be correctly adjusted. If the ring R is rotated, the line defined by the back pointer should remain on the axis of the Unit at all times. If this is not so the necessary adjustments are obvious. These are three of them.

2. Compression Indicator This should require no adjustment but some is provided on the position of the index on the attachment rack bar. . Pull out catch C and pull compression rod R out until catch C falls into a groove Now turn the rack dial until the end of compression rod R is 80 cm from the source or 6-7/8" from the end of the collimator. Move the index until it is opposite zero. The compression rod is now adjusted. There is a scratch on the attachment rack bar where the zero of your scale should go.

Light Localizers

Two switches are provided . . . Switch A turns on the distance localizers. It is an "on" & "off" switch. Switch B is a spring switch and is on only when held on. It controls the field size localizer and is normally required on only when "setting up" the patient. The distance localizer which also marks the centre of the field may be left on continuously and watched from the control room. Both localizers should be excited with a 5 volt 10 amp transformer. 5 Volts gives sufficient light although both bulbs are designed to run off 6 - 8 Volts. With 6 - 8 volts the life of the bulbs is short (50 hours). Clinical experience shows that 5 Volts is sufficient.

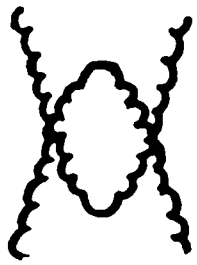
Distance Localizers - Uses two 21 c.p. bulbs Eveready #1129. They are focussed at a point 80 cm from the source or 6-7/8" from the end of the collimator. In this position the tips of the two filaments should be made to touch as indicated.



To adjust bulbs, remove cover plates. By loosening two screws the required number of adjustments can be made. Adjustments of this kind will be required whenever a new bulb is installed as no two are exactly identical. Select a bulb with the plane of the ring at the end of the V of the filament in the same plane as the V filament. To centre marker use a 4 X 4 field outlined by field size localizer. The tips of the filaments can be centered in this field by inspection.

Field Size Localizer - This uses 50 c.p. Eveready 1183. Use 5 Volts.

To get at the field size localizer remove cover plate (Fig. 17). The optical system for the light localizer can be removed by loosening two screws. Ground the device to light the filament. The focussed image should appear as two images of the filament one from the filament and a less intense inverted one from the spherical mirror. These should be super-imposed as indicated. If such an image is not obtained loosen the screws holding the bulb and move it slightly until such an image is obtained.



If the image from the mirror is larger than the direct image, move the lamp away from the mirror. The mirror need not be adjusted. Now move the lamp side ways until the images are superimposed correctly. The plane mirror in the X-ray beam is set correctly at 45 degrees and normally need not be adjusted. If required the mirror may be removed as follows: Set field size to 20 X 20. Remove field size light localizer. Remove dust cover. Now with a bar, loosen the slotted nut through the hole from which the light localizer was removed and reach away up inside the collimator and remove the mirror assembly.

Pin and Arc

This is set and should require no adjustment. Test setting as follows: Fasten Pin and Arc to attachment rack bar. Rotate Cobalt Unit until Collimator is pointing horizontally. Make this adjustment with a level. Rotate ring R (Fig. 17) until plane of arc is approximately vertical. Now move rider on arc until level on the rider shows zero. This means pin is at right angles to collimator. Check the line of the pin to see if it passes through the axis of the collimator. If it does not, loosen clamping screws S and adjust. Before tightening screws S retract attachment rack ber until it reads zero. Now slide "pin and arc" device in clamp S until pin is 6-7/8" from end of collimator. Tighten S. Now set the 90 degree of your arc scale under the index. Some adjustment is provided for this index. Adjust the pin so its end is on the axis of the beam. Place your scale in the pin and adjust the zero opposite index. A slight adjustment is provided for this index. All adjustments are now made.

Summary

1. The position of the rack bar scale index is determined from the compression rod.

2. The arc angular scale is adjusted by making the pin perpendicular to the axis and setting 90 degrees under the index.

3. The "pin and arc" is moved parallel to the axis screws S until the adjustment is correct.

4. The vertical scale in the pin and arc is adjusted to read zero when end of pin is on axis. The end of pin should stay on the axis as the rider moves over the arc when the pin is set at zero.

3347 COLLIMATOR INSTALLATION

1 To attach the collimator, rotate the teletherapy unit (help will be needed) so that the head is in an upside-down position which in effect put the counterweight or barrier up in the air. Watch head, yoke and skid clearance on C8M/80. Brace or tie the hanger securely, since it will be top-heavy when the head skid is removed and there will be a strong tendency for the barrier end to swing to the bottom. REMOVE THE HEAD SKID ONLY AFTER THE HANGER HAS BEEN SECURELY BRACED OR BOUND TO PREVENT ANY ROTATION. LIFT SKID STRAIGHT UP CAREFULLY; WEIGHT 280 POUNDS. As soon as the skid is removed it will mean that shielding built into the skid no longer be there. Radiation from the bottom of the head will be unusually high until the collimator is installed. Do not stay in the path of the head bottom recess. The radiation port at the bottom of the head has been sealed with tape at the factory to exclude dirt, and so forth. REMOVE THIS TAPE AND BE EXTREMELY CAREFUL NOT TO GET ANY CHIPS OR DIRT INTO THIS PORT. The collimator bearing is bolted to the head with the socket head cap screws by rotating so that the notch in the painted ring exposes one bolt hole at a time.

2 The collimator, collimator bearing ring and collimator light will be shipped as a single factory aligned assembly. This assembly weighs 250 pounds which means that three or four men will be required to lift it up and place it into position, or else a sling-boom portable crane will be required. BE SURE THE BOTTOM IS CLEARED. The collimator and bearing ring is to be carefully placed into the head recess with the lead wire on the ring centered within the milled slot at the rear of the head. Be careful of all wires during this operation. To install bearing ring bolts, rotate the collimator until collimator light chrome cup is in line with milled slot. Carefully loosen central screw and gently remove collimator field light and lay down in safe place. Rotate collimator to line up bolt loading slot with mounting holes. All bolts must be seated all the way at each position before moving on to the next. When all bolts are tight, repeat tightening all around and then carefully re-install pre-aligned collimator field light assembly. Remove collimator service wrench. Store it and mounting screws in the base of the machine if needed for further service.

3 An alternate way of installing the collimator is to separate the collimator from the bearing ring and install the bearing ring first and then the collimator back into the bearing ring. This will reduce the weights lifted to 150 pounds for the collimator and about 100 pounds for the bearing ring. The collimator can be removed by backing out the four set screws and locking set screws located down in the 45 degree conical area of the bearing ring. The collimator field light also has to be removed. Install the bearing ring as in 2 by loading and completely fastening one screw at a time. Stay out of the way of the recessed area at the bottom of the head because of excess temporary radiation.

After re-installing collimator tighten set screws and lock screws but be sure that collimator light is in position and installed first. Make sure collimator is clean on the bottom. Make rough adjustment of yoke drive.

The four-handled wrench and the fiber cable clamps should be stored and saved as collimator servicing tools.

If for any reason the collimator stainless covers have to be removed, always be sure to first open the collimator all the way and then fasten the cable clamps to the cables at the side of the collimator openings where the cables go to the dials. Then remove covers, otherwise the cables may be pulled into the side plate holes requiring dismantling of collimator. Note that two of the four covers marked with a number "2" have right angle legs which are 3/64 longer than the others. These two covers are fastened to the slotted cable guides LAST and should be fastened to the two cable guides that stick out a little further than the other two.

Note that removing the very heavy collimator produces a serious unbalance of the head about its center of rotation as well as a serious unbalance between the head and the barrier or counterweight, whichever the case may be. It is imperative that whenever the collimator needs to be removed, the head and hanger are so positioned that the head is at its lowest position and the the collimator is pointed straight up. The hanger should be locked in this position and braced against rotation.

With the collimator attached, the head is now balanced. The head tilting brake screws are adjusted to provide the proper friction to get smooth and jerk-free motion of the head when tilted with the hand wheel.

COLLIMATOR REPAIR AND SERVICE

a. Lubrication

Collimators have a teflon lining on one side of the lead plates. This eliminates the need to lubricate the plates. The bottom frame may still require lubrication after about one year of service. This is readily done by removing bottom covers and brushing Lubri-Plate onto the sliding rods with the collimator fully open as in Figure 4A. If the collimator gets too loose it may be necessary to spring the rods out of alignment in order to add friction.

b. Replacement of Lead Plates, Bottom Frame Assembly, Spring and Spacer Assembly

Removal of the plates is accomplished by revolving the head so that collimator points up. The bottom frame cover pieces are removed, at which stage the collimator will look like Figure 4A. Note: There are eight plates which have flat head screw heads showing on their inner edges. These are the tungsten-edged plates and should go in last. The dial cables must be clamped on as shown in Figure 4B. The four roll pins which hold in the bottom frame are then removed by pushing out with one inch long 10-32 screw and a pair of slip-joint pliers (do not hammer them out or you may damage the machine.) Then the bottom frame is lifted off (do not let it fall apart). The two exposed spacers and spring holders with attached springs are then pulled out, and the bottom two plates removed, then the next two exposed spacers and springs. Now close collimator almost completely, holding down on stack of lead plates to prevent them from buckling. Pull on exposed ends of corner tie bars (Figure 4B) wiggling as you pull, and holding down on stack of lead plates to prevent them from lifting and jamming in that corner where you are pulling. When the four tie bars are removed, open collimator wide and pick out the lead plates and spacers. Clean them carefully, inspect for wear and damage, replace any damaged parts. The teflon coating will become crazed due to radiation, especially near the source end of the collimator. This is normal and does not effect collimator operation. Check tightness of hexagon socket flathead screws that hold on pressure plates, (Figure 4C).

Now slip in four spacer and spring assemblies, one in each corner, two above the plates you just put in, and two flush with them. The heads of the rivets to which the springs are hooked must slide into the dovetail slots in the corners. (Figure 4-A,B,C). Make sure the plates are laid in with the covered corners down, so that when the collimator is open, the corner of the lead plate bearing against the pressure plate is covered not exposed.

Drop in the next pair of plates so that the rounded cutout in the corner clears the spacers on top of the last two plates (see Figure 4D) and making sure the covered corner is down as before. Add two spacers on top of this pair of plates, lubricate, and continue in this manner, adding the four pairs of tungsten-edged plates last. Keep plates pushed out into the frame corners as they are stacked in. Now close collimator carefully (do not force it if it jams — something must be caught that shouldn't be if it sticks) moving both sides at once, until fully closed. Then push in the corner tie rods, lubricating them first. Slightly opening the collimator may help be allowing some clearance for wiggling the rods as they go down — wiggle them down instead of hammering or violently pushing.

Reassemble bottom frame and covers after lubricating sliding rods on bottom frame. Check setting of large field limit screws (See Figure 4D) which are accessible with a hexagon key when collimator is fully open. There are eight altogether, and each set of four (two each on opposite sides) should be adjusted so that all four are in contact with the ends of the respective gear segments (Figure 4D). This adjustment should be made with collimator pointing up, down, and sideways, with other side of field both open and closed, so that in the position where the lead plates open up the most the ends of the outer layer still overlap the ends of the layer underneath by about 1/32 inch.

Repeat for the other side of the collimator. Now close collimator completely and adjust dial cable U-shaped nuts (Figure 4A) so both dials read at 4.0 on the 55 cm SSD scale. The bottom cover opposite the dial has to be removed to make this adjustment. The 4.0 setting is done with the collimator gage clamped in the collimator plates.

Now check maximum field size again, and, if necessary, readjust limit screws so that a reading of 17.9 is obtained on the 55 cm SSD scales at the largest setting.

c. Replacement of Dial Cable

Dismantle as in "b", then remove pressure plate over cable to be replaced by loosening completely the five hex socket flat head screws, BUT DO NOT REMOVE THE LOWER THREE SCREWS. Underneath the pressure plate on the lower three screws are round spacers (see Figure 4D) which may fall into the gap between the side plate (Figure 4C) and the base (Figure 4D and which are then difficult to remove. Hold your fingers against the heads of the three screws to keep them up against the holes from which you just unscrewed them, and close that side of the collimator, leaving the other side open. Tip the pressure plate in while keeping the screws in place so that the spacers are left hanging on the screws, and remove all at once the plate, three screws, and three spacers. The dial cable is now completely exposed (see Figure 4D). Remove and replace by pushing the brass ferrule on the new cable into the round hole in the cable drum, then kink cable next to ferrule so it leads out the slot to the rim of the drum, and feeds onto the circumference. Wrap cable around drum in a counterclockwise direction with each turn behind the previous one until about three turns are on the drum. Now pull cable to see if sufficient travel is remaining in spring for complete scale coverage on the dial. If not, remove one turn of the cable. Then turn dial so hole in scale shows in window of side plate and insert nail (head outside) to lock spring. Put cable clamp (Figure 4B) on cable and fasten down with adhesive tape to outside of side plate so cable lies snugly on drum and in groove of side plate liner (Figure 4D).

Reassemble pressure plate, being sure not to pinch cable with bottom frame hinge (Figure 4D) which also acts as a spacer for outer end of pressure plate. Make sure gear segments on hinge plate assemblies are properly mated with pinions on drive gear assemblies (Figure 4D) if they have come off, before completing this assembly by tightening screws holding pressure plate in position. Pull on dial cable to release the nail holding dial, remove nail, and gently release cable until cable clamp rests against side plate and bottom frame hinge and thus restrain cable. Reassemble collimator as in "b". All gears have timing marks which should be noticed and

repeated when assembling.

d. Replacement of Hinge Plate

Remove both pressure plates covering that hinge, insert new hinge plate assembly (Figure 4D). The position of the gear segments on the new hinge plate may be different than on the old one. This may necessitate retiming of the drive gear assemblies. The pinions should engage the gear assemblies. The pinions should engage the gear segments so that the hinge plates on each side of the side plate will move away from or towards the center line of the side plate by the same amount simultaneously. To do this, make a trial assembly of the new hinge plate, leaving only one of the pressure plates off. Close the collimator and observe if the inner edge of the new hinge plate is the same distance from the scribed center line on the side plate liner as the one on the other side of the side plate (Figure 4D). If it is further away, then the drive gear assembly must be rotated in such a direction as to move it in further, without moving any of the other gears. To move the right hand hinge plate in, the drive gear must move clockwise, and so forth. To do this, remove the side plate liner by removing the four hex socket flat head screws which fasten it to the side plate, then lift it off the two dowel pins at the bottom (Figure 4D). Mark the teeth of the main gear on the drive gear assembly where they mate with the other gear (or gears, depending which drive gear is to be moved), then holding position of other gears firmly, lift out drive gear enough to clear and rotate one tooth in the direction you wish to move it, and slip back into engagement. It should have moved one tooth in the same direction on each gear with which it mates — check by means of the marks you made. (NOTE: The position of the adjusting knob pinion is immaterial). Reassemble side plate liner and hinge plates, and check position of the two hinge plates as before. If more adjustment is needed, repeat. When the adjustment is as close as possible to correct, reassemble that pressure plate and remove pressure plate over other leg of the new hinge plate and repeat the procedure. When timing is complete, reassemble collimator.

e. Replacement of Side Plate Assembly - Licensed Work

The collimator must be removed to do this. When it is removed, unscrew the four flat head screws which hold the cadmium plated steel ring to the base, and remove the steel ring from the tungsten base. This sleeve is a snug fit on the collimator base, and if it becomes slightly cocked, will be very difficult to remove. If it is done carefully it should not be too difficult.

When the sleeve is removed, take out the lead plates (see "b") and remove the pressure plate from that side of the collimator. Drive out the long 1/4 inch pin through the bottom of the side plate which engages in holes in the base casting on either side. Use a 3/16 inch rod to do this, being careful not to damage the end of the 1/4 inch pin. It may be driven out from either end. Pull out the side plate assembly and replace with the new one, being careful to engage the square rod properly with the square broached hole in the universal joint on the lower end of the side plate. NOTE: Each side plate is different — be sure to order the correct one. A letter is stamped on them, A, B, C or D. Reinsert the hinge pin, time the gears as in "C" and reassemble.

f. Replacement of Collimator Mirror - Licensed Work

Remove collimator and turn upside down. Remove the four hex socket head cap screws in the tungsten block in source end of the base. Lift the tungsten block out of the tungsten base casting. CAUTION! DO NOT DROP THIS BLOCK, OR IT MAY CRACK! It is very expensive. Lift out the defective mirror and replace with new mirror. NOTE: Mirror must be oriented so the tilted polished surface faces the hole in which the collimator lamp is placed. Make sure the mirror is properly seated in its recess, then drop in gently the tungsten block and replace the screws. Mirror will become dull in time due to accelerated oxidation caused by irradiation. It can be repolished by a skilled jeweler without distorting the mirror surface.

g. General Data About Collimator

Though there will always be some backlash and "springiness" in the "feel" of the adjusting knobs, the dial system has been made so that it is independent of the adjustment system, and will always give a true indication of field size if the cable is properly adjusted. The scales should be used to set the field size rather than the field illumination, since the scales give a slightly more accurate indication of field size. The gage supplied with the collimator must be used to set the field sizes. The scales set with the collimator gage give the field size as specified by the 50 percent geometric penumbra. These sizes agree with the optical field illumination and as such are defined as the size of field that a point source would make.

The lead blocks must follow the housing as it expands. This is achieved by means of the springs pulling the spacers into the corners of the hinge plates. The spacers in turn pull on the corner tie bars which pull on the lead plates. If excessive friction is present in the stack of lead plates, they will not pull back snugly against the pressure plates when the collimator is open, and thus the field size will be distorted from that shown on the scales.

The bottom frame assembly provides an expansible platform to support the stack of lead plates when the collimator is pointing downwards, and also restrains the stack of plates from buckling outwards when the collimator is opened or closed. It must operate very freely or the collimator will be very difficult to adjust. Never turn the collimator end down when the bottom frame assembly is not attached.

The dial and cable assemblies serve two functions; they provide a means of measuring the collimator aperture independently of the adjusting mechanism, and they provide "cross hairs" so a shadow is formed showing the central axis of the beam. For this latter purpose they must be free of kinks and centered across the aperture. A gage is provided for this. Kinks should be carefully straightened out. The centering is accomplished by shifting the bottom frame hinge (Figure 4D) so that the cable lies across the center of the opening and is parallel to the side plates. The spring on the cable drum (Figure 4D) should be tight enough to keep the cables taut when the collimator is closed, but no tighter, since it adds to the effort required to open the collimator.

The hinge plates must slide freely in the space between the pressure plate and the side plate liner, yet if there is too much slack it increases the "sponginess" of the "feel" of the adjusting knob. The gear trains in the side plates should turn very freely under no load, (i.e., with lead plates

out of the collimator).

The universal shafts, with their telescoping connection through the collimator base, transfer the movement from the gear train on the side plate with the adjusting knob to the opposite side plate gear train. If the collimator drive gears and the gear segments of the hinge plates are not properly timed as marked, when the adjusting knob is turned, only one pair of hinge plates and one gear train are carrying the load of opening the collimator, and a pronounced "springy" feeling is imparted to the "feel" of the knob. In a properly adjusted collimator this will be minimized.

Since the weights of the lead plates on either side are balanced against each other in any position of the collimator, there should be no tendency of the collimator to open or close when adjusted to a given field size and then placed in a different orientation. This could happen if the dial cable spring was so strong that it could overcome the friction required to change the collimator setting, or if the collimator was improperly timed, or the connection from one side plate to the opposite through the gear train and universal shaft system was not functioning. The spring in the hinge plates could then permit an unstable condition for a particular field size setting resulting in a tendency for the field to decrease in size if the collimator was moved or jarred.

h. Replacing Collimator Light

(1) Turn the power off.

(2) Remove the halo switch assembly at the back of the head.

(3) Rotate the collimator until the light cup appears in the switch opening. Remove the button head screw from the cup, then pull the bulb and socket assembly out of the collimator. Replace the bulb and reassemble the socket into the collimator.

(4) Check collimator light adjustment. Use the special cross hair gage supplied with the collimator. Open the collimator side plates enough for the gage to be inserted, then retighten until the side plates grip the gage prongs on all four sides. The cross hairs should be in the exact center of the gage hole. A piece of paper placed on the floor and in the light beam will provide a clear view of the cross hair shadow.

ADJUSTMENT — Turn both adjusting screws in or out to position the bulb at the required depth in the light well. For side adjustment turn either screw separately to move the bulb as required. If more side adjustment is needed, crimp the sides of the bulb socket slightly to move the bulb in the desired direction.

IMPORTANT! When the light is projected on the barrier the cross hairs must not move more than 1/8 inch off center during one complete revolution of the collimator.

The adjustments to the light bulb are limited by the adjusting screws and the space available for the bulb. Total adjustment for the optical projections of the cross hairs are as follows:

DISTANCE TO FIELD	SIDE ADJUSTMENT	ADJUSTMENT ALONG BULB AXIS
80 cm	1.2 cm (.472 inches)	0.47 cm (.187 inches)
60 cm	0.9 cm (.35 inches)	0.35 cm (.140 inches)

Additional adjustments can be made by tipping the mirror as required to allow the above mirror adjustments to become effective.

9.0.2 OPTICAL ALIGNMENT

a. Collimator Field

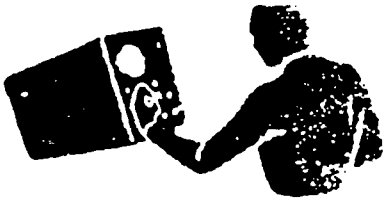
The wire cables on the collimator which project the cross hairs onto the field must be mechanically centered on the axis of the collimator. Small variations in machining and bulb manufacture will cause the intersection of the cross hairs, when projected, to wander when the collimator is revolved. This intersection should not wander in a circle bigger than 1/8 inch in diameter at 80 cm. This can be minimized by adjusting the light bulb along its axis. This is done by turning a screwdriver in the two small holes on either side of the button head screw. Turning the screwdriver clockwise brings the bulb closer to the screwdriver and will cause the cross hairs perpendicular to the bulb to move away from the screwdriver. This adjustment has been made at the factory for the bulb in the collimator and may not have to be made even if a bulb is replaced.
tions.

b. Collimator Cross Hairs and
Back Pointer Cross Hairs Alignment

With the hanger rotation dial reading zero degrees and the head tilting scales reading zero degrees, the cross hairs from the collimator and back pointer lamp should be nearly superimposed. If a piece of translucent white paper is held between them then both sets of cross hairs can be seen. The cross hairs from the barrier seen through the paper fade out as we move the paper toward the collimator and conversely as we move the paper toward the barrier.

It is common for the cross hairs from the barrier to be closer to the front of the machine in this position and for the collimator cross hairs to be back about 3 mm maximum from the barrier cross hairs as seen on the translucent white paper. With the barrier and head inverted, that is with the hanger rotation dial reading 180 degrees, and the head pointing toward the center of rotation the cross hairs reverse themselves with the collimator cross hairs coming forward and the barrier cross hairs moving back. This is due to natural deflections in the arms of the hanger and similar deviations occur at other positions. All deviations fall within the ± 3 millimeter range.

PICKER CORPORATION



NO. 671
DRS: H106:N1
DATE: 10/1/71

SERVICE NOTE

SUBJECT: LOOSE BEARING RINGS OR COLLIMATORS ON COBALT UNITS
#14188 Series Bearing Assembly and Cat. #3347 Series Collimators

EQUIPMENT: C-1000 (#6103), C-2000 (#6150), V-2000 (#6156)
C-3000/55 (#6183), C-3000/75 (#6204), V-3000 (6202)
C-4M/60 (#6223), C-8M/80 (#6234), and V4M/60 (#6235)

PROBLEM: Unable to maintain beam on isocenter due to shifting of bearing ring assembly or collimator. Assemblies shift as much as 1/16 inch during angulation or rotation because of loose mounting hardware or wear of the ball tracks.

CORRECTION: Non-licensed service personnel can inspect the #14188 series Bearing Assembly and tighten the bolts. Shutter locking bolt or bar *must be installed* before attempting the procedure. Refer to drawing of bearing ring assemblies (Fig. 1).

1. Rotate C-arm or position head so the collimator is pointing at the ceiling. (6 o'clock position on rotational units.) Turn off power and put key in pocket.

   A. Remove halo switch assembly (if applicable) and remove field light assembly. The mounting bolts are now accessible.

   B. Tighten the (8) 1/4-20 SHCS which attach the outer bearing ring to the head.

   C. Remove the (4) 1/4-20 locking Allen set screws from Adaptor Ring #37846.

   D. Tighten the (4) 1/4-20 Allen set screws which secure the collimator to the adaptor ring. Reinstall the locking set screws. Do not install field light and leave collimator pointing toward the ceiling.

2. Bearing inspection—all units. On C4, V4 and C8 units, rotate collimator until the gap between the outer bearing ring and the head adaptor ring is visible through the field light cavity. *Do not* use a metal feeler gauge. Place strips of paper into the gap until it is completely filled. Place paper in two places 180° apart. Rotate head until collimator points down. If more than .015 inch of paper can be added to the gap, contact the isotope operation to arrange for licensed personnel to repair or replace the bearing ring assembly.

TOOLS REQUIRED: Allen wrenches, micrometer.

TIME REQUIRED: Variable—depends on type of unit. Charge time to the customer.

- NOTE -

Service personnel must comply with all radiation safety regulations during service operations on cobalt therapy units. Effective September 26, 1971, violators of AEC Rules and Regulations can be fined up to $5000 per violation. Refer to Manual T55-443.

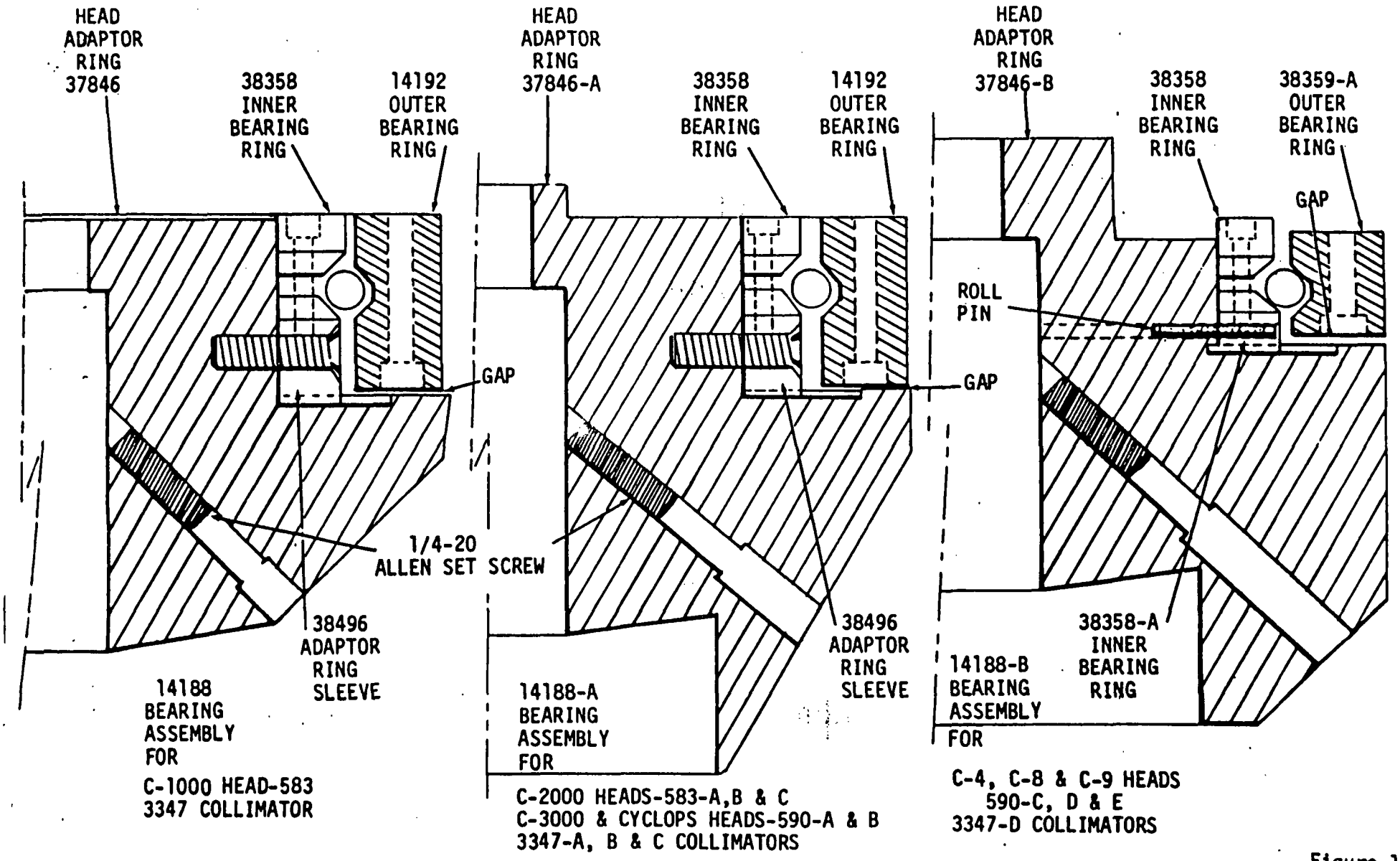

HEAD ADAPTOR RING 37846
38358 INNER BEARING RING
14192 OUTER BEARING RING
GAP
1/4-20 ALLEN SET SCREW
38496 ADAPTOR RING SLEEVE
14188 BEARING ASSEMBLY FOR C-1000 HEAD-583 3347 COLLIMATOR
HEAD ADAPTOR RING 37846-A
38358 INNER BEARING RING
14192 OUTER BEARING RING
GAP
38496 ADAPTOR RING SLEEVE
14188-A BEARING ASSEMBLY FOR C-2000 HEADS-583-A,B & C C-3000 & CYCLOPS HEADS-590-A & B 3347-A, B & C COLLIMATORS
HEAD ADAPTOR RING 37846-B
38358 INNER BEARING RING
38359-A OUTER BEARING RING
GAP
ROLL PIN
38358-A INNER BEARING RING
14188-B BEARING ASSEMBLY FOR C-4, C-8 & C-9 HEADS 590-C, D & E 3347-D COLLIMATORS

Figure 1

3347D Light Field
Alignment Proceedures

1. Remove the old mirror carefully and lay on a flat surface.

2. Lay the new mirror on top of the old mirror and check that it is flat across it. Adjust the new mirror to the same angle as the old mirror.

3. Put in the new mirror.

4. Back off the adjusting screws in the collimator lamp assembly.

5. Measure and mark a 10cm X 10cm area on a piece of paper.

6. Adjust the collimator to illuminate this 10cm X 10cm field at a source to skin distance which corresponds to the scale of the collimator which you are using.

7. Rotate the collimator 180 degrees.

8. If the field shifts bend the mirror to correct.

9. Repeat steps 6, 7, and 8 until the adjustment is very close.

10. Check dial readings versus light field. Adjust cables if off.

11. Put in the collimator aperture alignment tool with a piece of tape or paper over the outside circle.

12. Check the image on the tape and see if you have a circle with the crosshairs in the center. If not bend the cables, where they are welded to the adjusting screws, to get the centering. Work from corner to corner when adjusting.

13. Remove the alignment tool and put a dot on a piece of paper and check the run out of the crosshairs. Adjust the screws in the lamp assembly to correct. If not enough range try turning the lamp 180 degrees (or another bulb) and adjust the screws again.

14. Check the 10cm X 10cm field again.

15. Check the distance localizer and adjust if necessary.

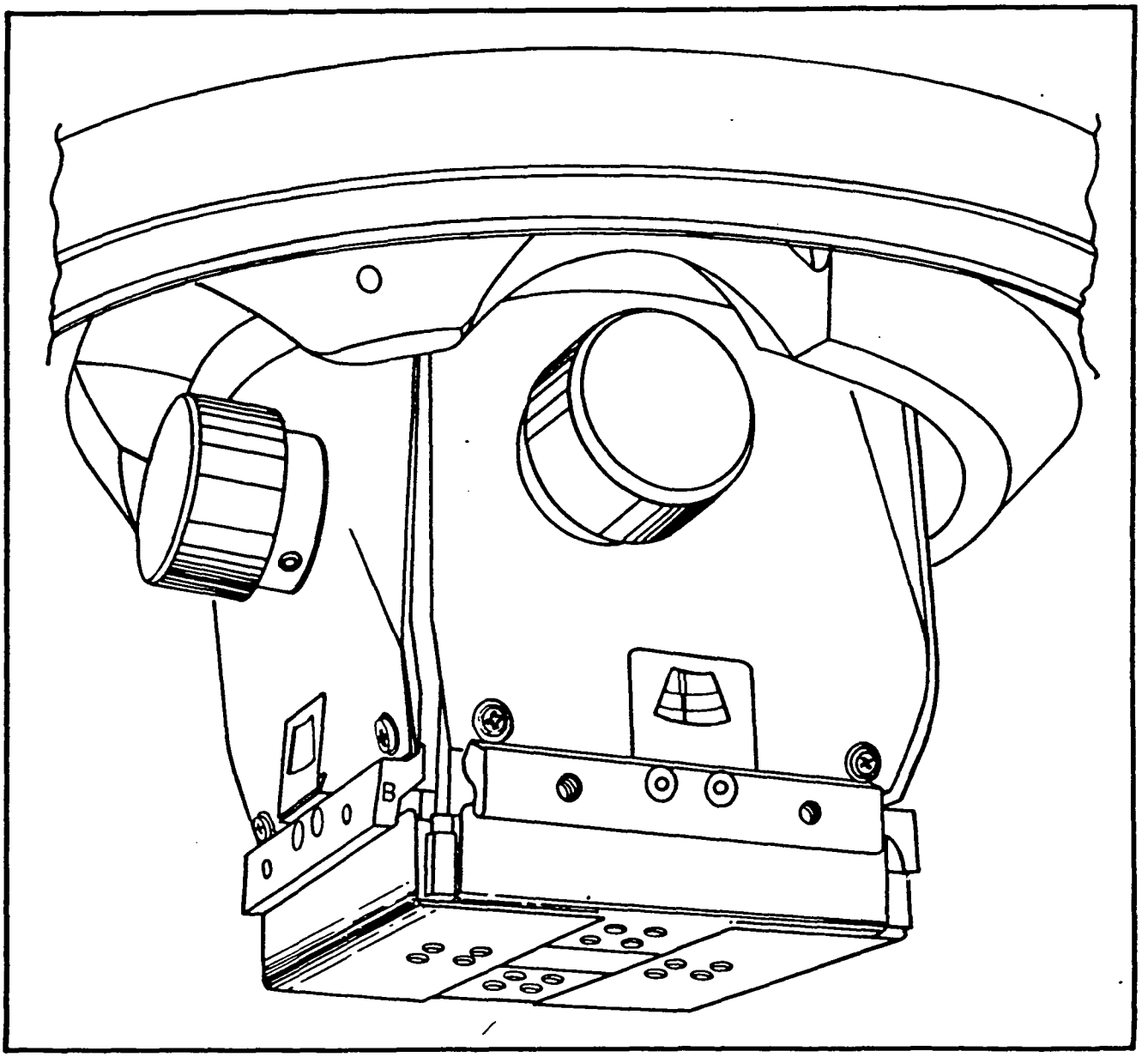
16. Make film tests to check radiation field versus light field.

COBALT COLLIMATOR

Cat. No. 3347D

PARTS LIST

H106:P



PICKER CORPORATION
MEDICAL PRODUCTS DIVISION
595 MINER ROAD, CLEVELAND, OHIO 44143

April '72

Printed in U.S.A.

CONTENTS

INTRODUCTION

PURPOSE

This parts list was written with the intent of providing the user with a complete listing of all parts and components used in the assembly of this unit, with the exception of hardware items such as screws, nuts, bolts and washers. The contents of this manual has been so arranged as to offer maximum usability to all users. Suggestions on improving the format, and/or corrections to this manual are welcome and encouraged. Send all correspondence concerning this book to Picker Corporation, Medical Products Division, National Service Department, 595 Miner Road, Cleveland, Ohio 44143, attention Parts Listing.

USE OF PARTS LIST (See Fig. i)

This parts list incorporates the indenture or assembly, subassembly method of parts listing. With this method of listing indenture 1 is the primary assembly for the indicated figure, indenture 2 is either a direct part or subassembly of indenture 1, and indenture 3 is either a direct part or subassembly of indenture 2, which is a subassembly of indenture 1, etc. This system is also useful because the user knows what parts are a part of which assemblies. All indent 2 items are a part of indent 1 and will be found on the indent 1 Bill of Material. All indent 3 items are a part of the preceding indent 2 item and will be found on that indent 2 Bill of Material. All parts are identified once and only once and in their proper sequence.

DIFFERENCE DATA SHEET

The Difference Data Sheet (DDS) is a supplement to an existing parts list and is referenced to the existing list by Figure No.

The DDS does not list any parts which are common to both units, but only those parts which are different. If the word "delete" is used then that part is not used on the unit of the DDS but is used on the referenced unit. If an item number is found on the DDS and not on the referenced parts list then that part is found on the unit of the DDS but not on the referenced unit.

NOTE

All parts found on the parts list of the referenced unit apply to the unit of the DDS except those parts indicated on the DDS.

1

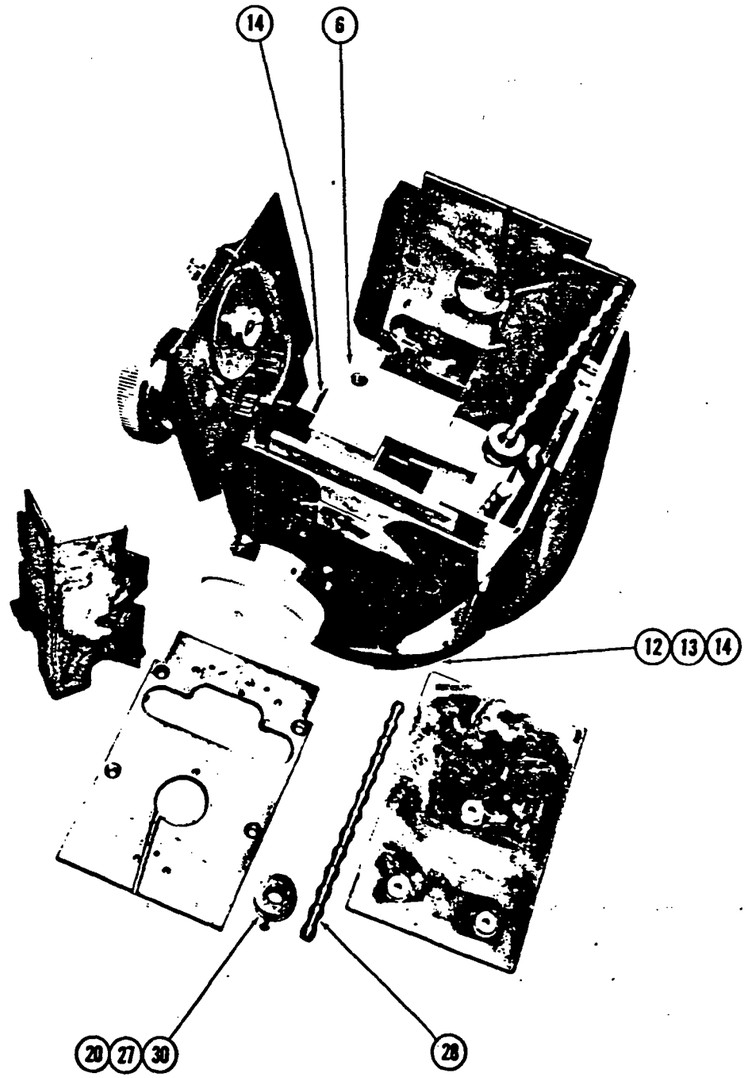
ORDERING

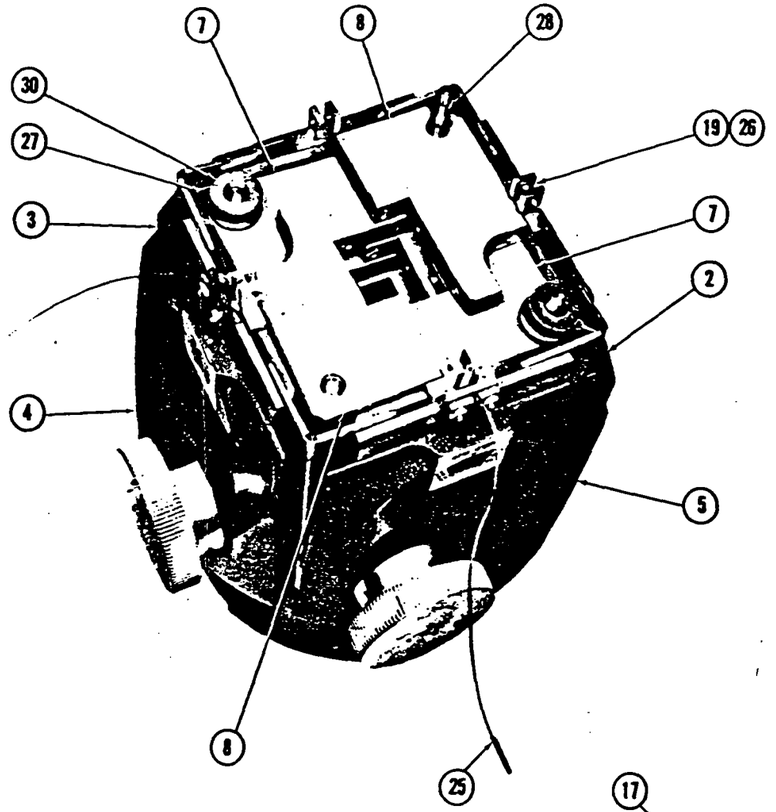
When ordering parts include the Parts List DRS No. and Date of Publication, Figure and Item No., and Part Description. If the part cannot be found in the parts list, include the Catalog Number of unit, Serial Number, and detailed description of part in question.

EXAMPLE: FIGURE 1

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
1 -	1348L	Mobile Chassis and Tubestand	1
- 1	13559	Cover, Back	1
- 2	T7D-117	Filter, 1/2 mm	2
- 3	11337A	Indexing Plate, Tube Arm, and Locking Assembly	1
- 4	27904	Nameplate	1
- 5	37797	Plug, Tube End	2
- 6	T5-204	Spring, Front Stop	1
- 7	T54-3	"O" Ring, 1 x 1-1/4"	2
- 8	40822	Bracket, Transport	1

FIG. 1 - COLLIMATOR
Part No. 3347D





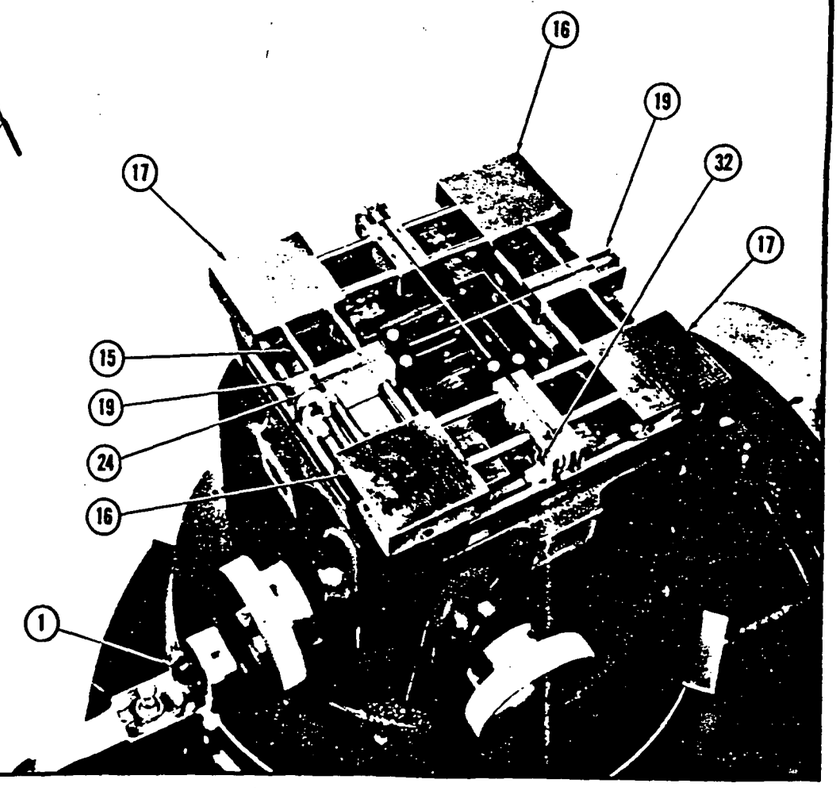


FIG. 1 - COLLIMATOR
Part No. 3347D

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
1 -	3347D	Collimator	1
1	14172	Holder Assembly, Lamp (See Fig. 2)	1
2	14175C	Plate, Side "C" - Collimator (See Fig. 3)	1
3	14175D	Plate, Side "D" - Collimator (See DDS 301)	1
4	14175E	Plate, Side "E" - Collimator (See Fig. 4)	1
5	14175F	Plate, Side "F" - Collimator (See DDS 401)	1
6	14176A	Plate, Lead without Tungsten	18
7	14176B	Plate, Lead with Tungsten	6
8	14176C	Plate, Lead with Tungsten	2
9*	14188B	Bearing, Head-to-Collimator (See Fig. 5)	1
10*	43346A	Mirror, Collimator	1
11*	43347	Base, Collimator Mirror	1
12	38281A	Aperture, Collimator Tungsten	1
13*	38298A	Sleeve, Collimator Base	1
14	38299B	Base, Collimator	1
15	38300	Rod, Guide - Bottom Frame	3
16	38302A	Corner, Bottom Frame	2
17	38302B	Corner, Bottom Frame	2
18*	38303	Rod, Square - Universal	2
19	38305	Support, Bottom Frame	2
20	38306	Holder, Spacer and Spring	26
21*	38308	Pin, Hinge - Side Plate	4
22*	38362	Cover, Bottom - 1-5/64 Lip, Farthest from Source	2
23*	38363	Cover, Bottom - 1-1/32 Lip, Closest to Source	2
24	38406	Idler, Dial Cable	2
25	38407	Nut, Dial Cable Adjust - C-750 Collimator	2
26	38408	Support, Bottom Frame	2
27	38694	Eye, Spring Retaining	26
28	38732	Bar, Corner Tie	1
29*	T2-304	Screw, Nylon Set - 10-32 x 3/8	4
30	T5-446	Spring, Spacer	26
31*	T14A-76	Pin, Roll - 3/32 x 1/2	3
32	T14A-86	Pin, Roll - 1/4 x 3/4	4
33*	T32-395	Decal, Rotation Scale	1
34*	T92-29	Nameplate, Patent Pending	1
35*	T92-176	Nameplate, Oval	1

*Not shown.

3

FIG. 2 - LAMP HOLDER ASSEMBLY
Part No. 14172

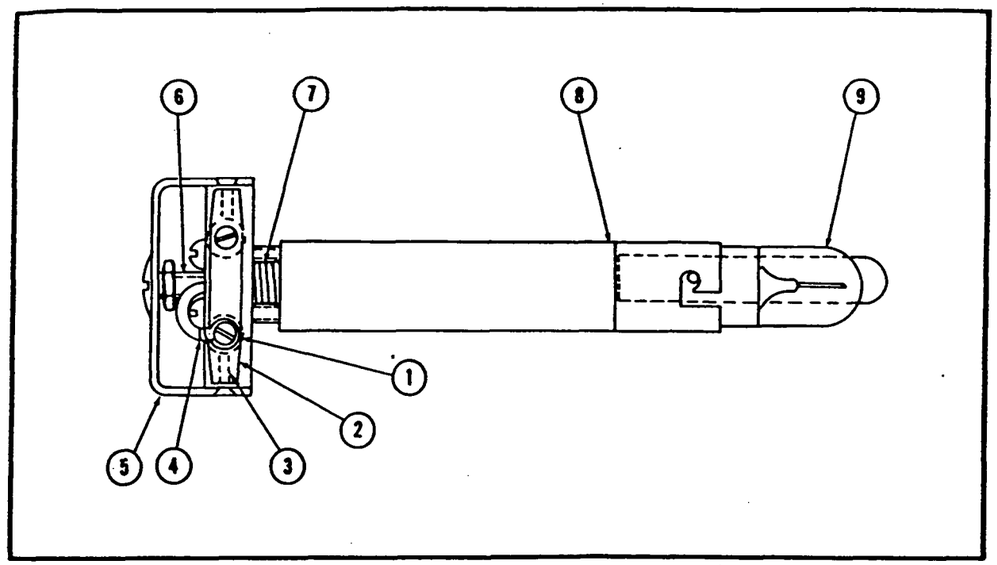


FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
2 -	14172	Holder Assembly, Lamp (See Fig. 1, Item 1)	1
1	T2A-61	Screw, Button Head - 4-36 x 3/8	2
2	38278	Holder, Brush	1
3	38280	Brush	1
4	T18-63	Lug	1
5	38279	Cover, Brush Holder	1
6	T2A-82	Screw, Button Head - 8-32 x 1	1
7	T5A-190	Spring	1
8	14171	Rod Assembly, Socket Holder - Lamp	1
9	T72-34	Bulb, G.E. 1489	1

FIG. 3 - COLLIMATOR "C" SIDE PLATE
Part No. 14175C

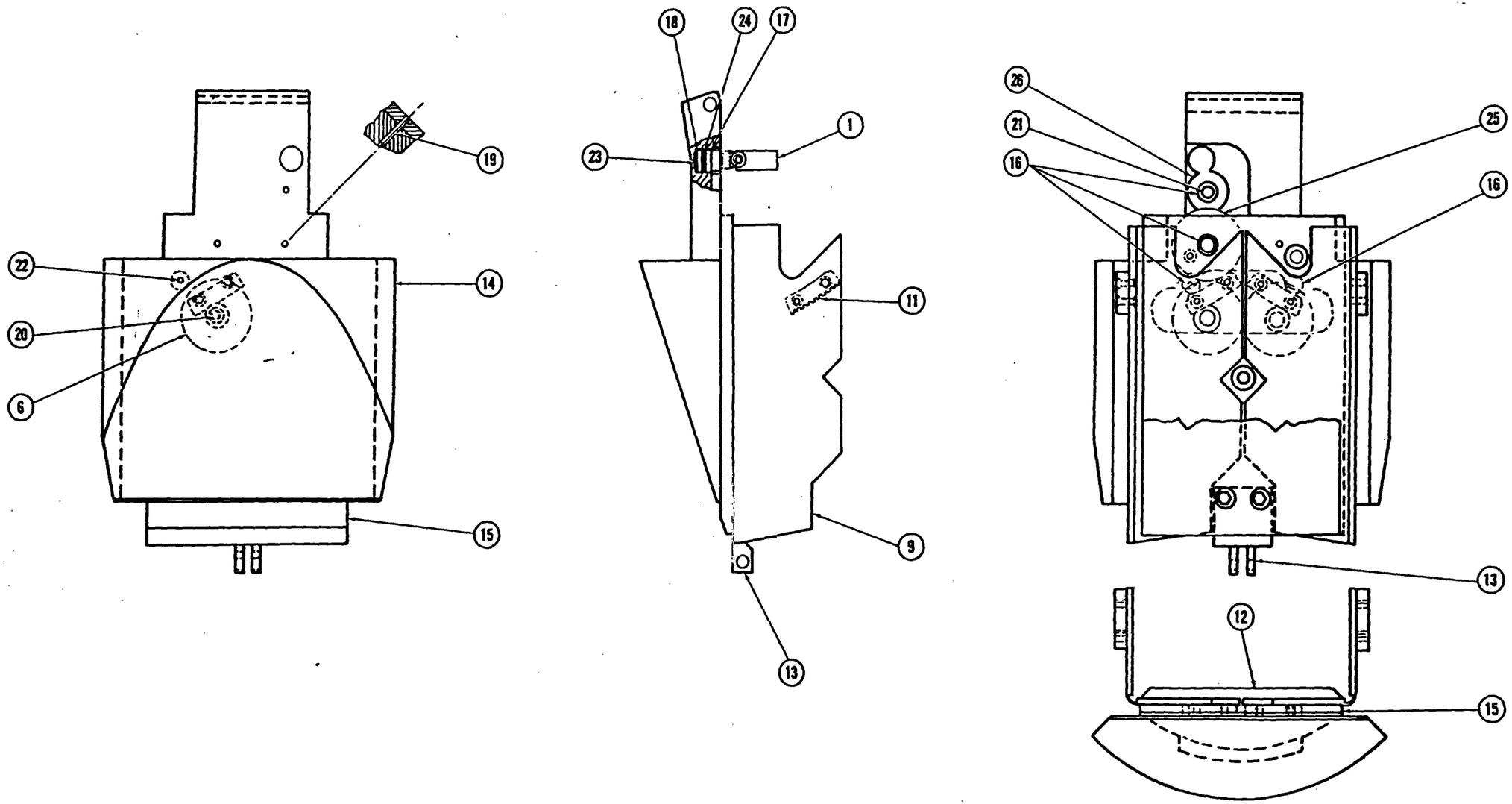


FIG. 3 - COLLIMATOR "C" SIDE PLATE
Part No. 14175C

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
3 -	14175C	Plate, Side "C" - Collimator (See Fig. 1, Item 2)	1
1	14179	Shaft Assembly, Universal	1
2	T77-94	Gear, Universal Shaft	1
3	T14A-57	Pin, Roll - 3/32 x 5/16	1
4	38321	Joint, Universal	1
5	T11-15	Washer, 3/16 x 19/32 x 3/64	1
6	14180	Gear Assembly, Drive	2
7	T77A-15	Gear	1
8	T12-176	Bearing	1
9	14276	Plate Assembly, Hinge	2
10	38691	Plate, Hinge - Collimator	1
11	38317	Rack, Curved	2
12	14558	Plate Assembly, Pressure	1
13	38309	Hinge, Bottom Frame	1
14	38094C	Plate, Side - Collimator	1
15	38312	Liner, Collimator Side Plate	1
16	T12-65	Bearing, Ball - 3/8 x 1/8	4
17	T12-97	Bearing, Ball	1
18	T12-108	Bearing, Ball	1
19	T14-891	Pin, Dowel - 1/8 x 3/4, Hardened	2
20	T14-892	Pin, Dowel - 3/16 x 3/4, Hardened	2
21	T14-904	Pin, Dowel - 1/8 x 1/2, Hardened	1
22	T14A-83	Pin, Groove - 1/8 x 1/4, Type 1	2
23	T22-36	Ring, Retaining	1
24	T22-40	Ring, Retaining	1
25	T77-91	Gear, Idler - 1.5 P.D.	1
26	T77-92	Gear, Idler - 0.750 P.D.	1

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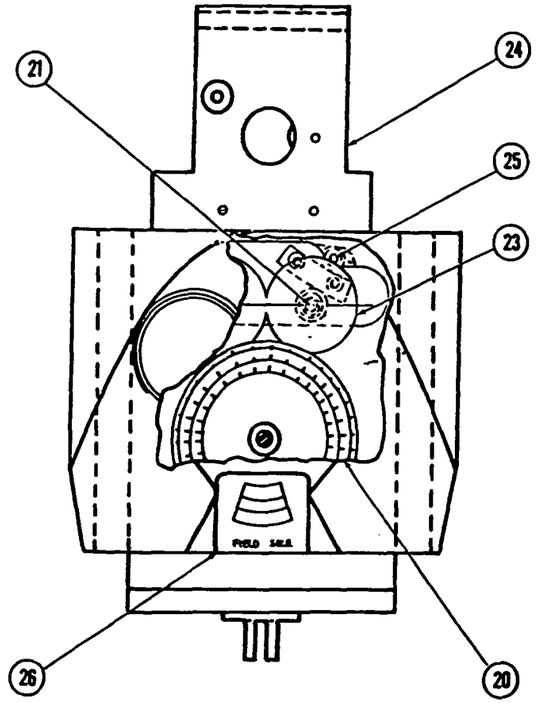
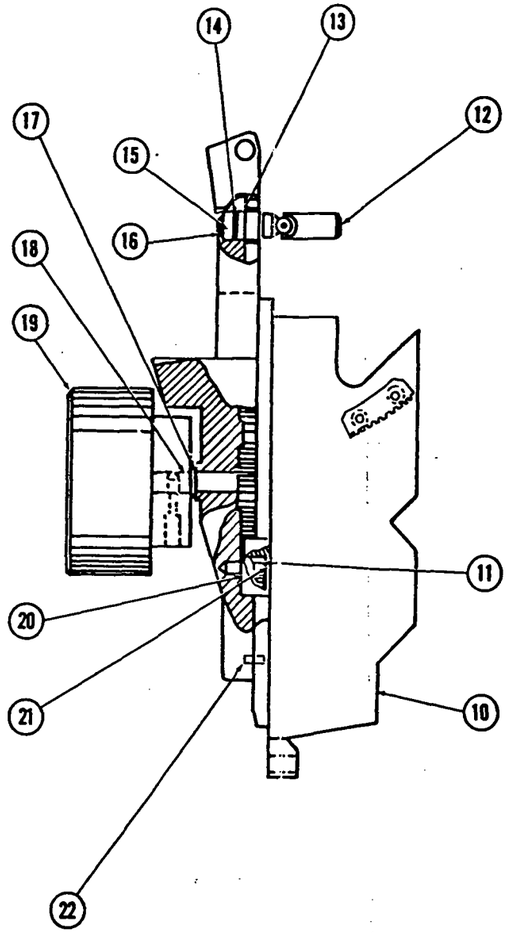
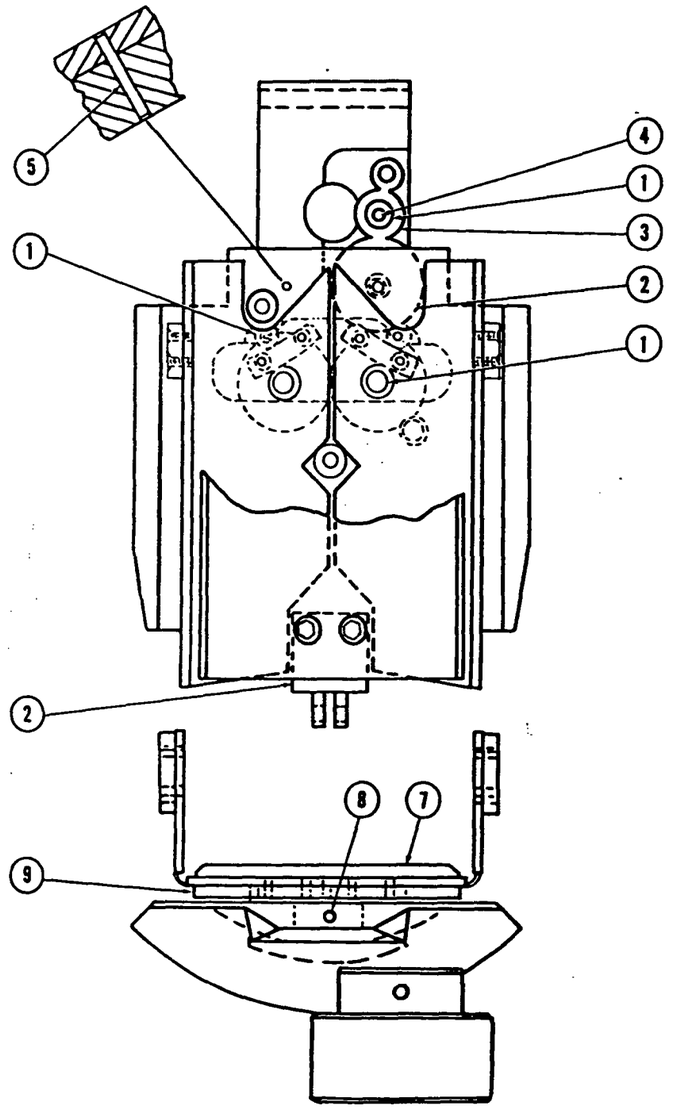
DDS 301 - COLLIMATOR "D" SIDE PLATE
Part No. 14175D

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
3 -	14175D	Plate, Side "D" - Collimator (See Fig. 1, Item 3)	1
9	Delete		
10	Delete		
11	Delete		
14	38094D	Plate, Side - Collimator	1
26	T77-93	Gear, Idler - 0.625 P.D.	1

FIG. 4 - COLLIMATOR "E" SIDE PLATE
Part No. 14175E







April 1972

FIG. 4 - COLLIMATOR "E" SIDE PLATE
Part No. 14175E

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
4 -	14175E	Plate, Side "E" - Collimator (See Fig. 1, Item 4)	1
1	T12-65	Bearing, Ball - 3/8 x 1/8	4
2	T77-91	Gear, Idler - 1.5 P.D.	1
3	T77-92	Gear, Idler - 0.750 P.D.	1
4	T14-904	Pin, Dowel - Hardened and Ground, 1/8 x 1/2	1
5	T14-891	Pin, Dowel - Hardened and Ground, 1/8 x 3/4	2
6	38309	Hinge, Bottom Frame	1
7	14558	Plate Assembly, C-1000 Pressure	1
8	38322	Pin, Index - Collimator Dial	1
9	38312	Liner, Side Plate - Hect. Coll.	1
10	14276	Plate Assembly, Hinge	2
11	T22-65	Ring, Grip	1
12	14179	Shaft Assembly, Universal	1
13	T1[illegible]-97	Bearing, Ball	1
14	T22-40	Ring, Retaining	1
15	T12-108	Bearing, Ball	1
16	T22-36	Ring, Retaining	1
17	T22-25	Ring, Retaining - Knob Shaft	1
18	T77-95	Shaft, Collimator Knob	1
19	T3A-52	Knob, Collimator	1
20	14181A	Dial Assembly, 50, 55, 60	1
21	T14-892	Pin, Dowel - Hardened and Ground - 3/16 x 3/4	3
22	T14A-84	Pin, Roll - 1/8 x 3/8	1
23	14180	Gear Assembly, Drive	2
24	38094A	Plate, Collimator Side	1
25	T14A-83	Pin, Groove - 1/8 x 1/4, Type 1	2
26	38413A	Plate, Index - Collimator, 50, 55, 60	1

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DDS 401 - COLLIMATOR "F" SIDE PLATE
Part No. 14175F

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
4 -	14175F	Plate, Side "F" - Collimator (See Fig. 1, Item 5)	1
3	T77-93	Gear, Idler - 0.625 P.D.	1
10	Delete		
24	38094B	Plate, Collimator Side	1

FIG. 5 - HEAD TO COLLIMATOR BEARING RING
Part No. 141888

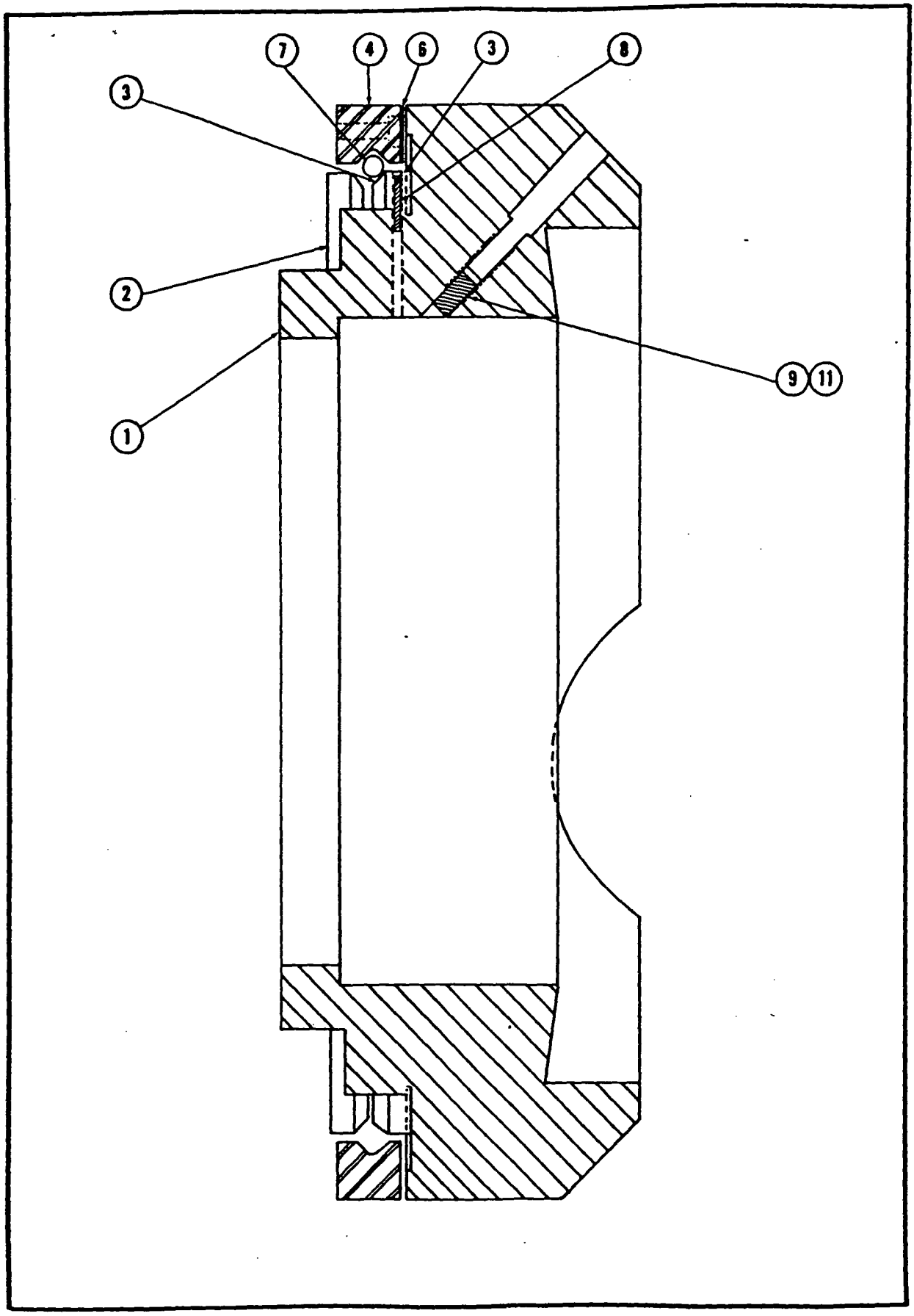

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FIG. 5 - HEAD TO COLLIMATOR BEARING RING
Part No. 14188B

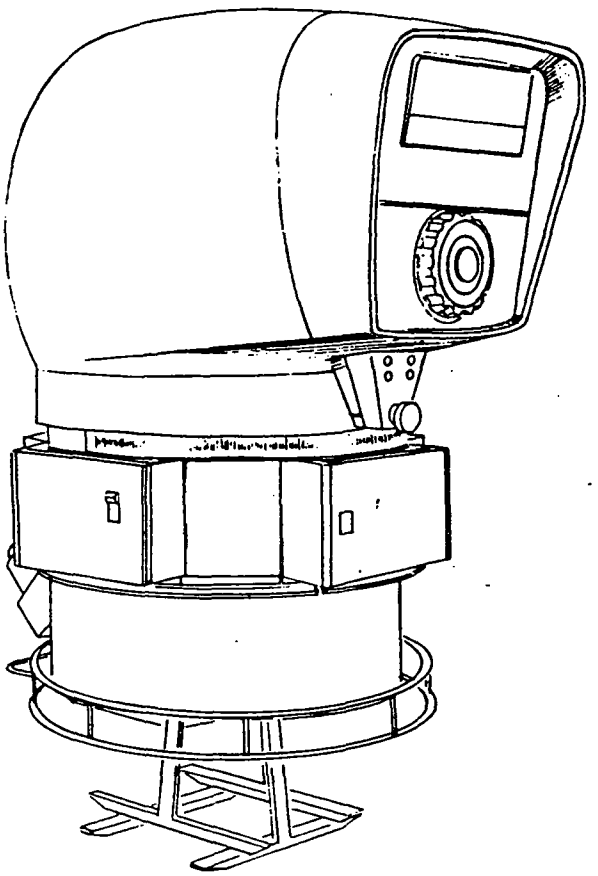
FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
5 -	14188B	Bearing Ring, Head to Collimator (See Fig. 1, Item 9)	1
1	37846B	Ring, Adapter - Head	1
2	38358	Ring, Inner Bearing - Head	1
3	38358A	Ring, Inner Bearing	1
4	38359A	Ring, Outer Bearing	1
5	43872A	Finger, Brush	6
6	46935	Printed Circuit, Slip Ring	1
7	T1A-5	Ball, Steel - 3/8	97
8	T14A-106	Pin, Roll - 1/8 x 7/8	8
9	T20D-1	Helicoil, 1/4-20 x 3/4	8
10*	T20D-2	Helicoil, 8-32 x 1/2	1
11	S45-3	Screw, Set - 1/4-20 x 1/8 Locking	4

*Not shown.

11

PARTS LIST

H57:TM/H59:TM JUN'77



1374

COBALT THERAPY COLLIMATOR

CAT. NO. 3706D,E FOR C9,V9

PICKER CORPORATION
595 MINER ROAD, CLEVELAND, OHIO 44143

PRINTED IN U.S.A.

CONTENTS

PURPOSE

This parts list was written to provide the user with a complete listing of all parts and components used in the assembly of this unit, with the exception of hardware items such as screws, nuts, bolts and washers. The content of this manual has been arranged to offer maximum usability.

USE OF PARTS LIST (See Fig. 1)

This parts list incorporates the indenture or assembly/subassembly method of parts listing. With this method indenture 1 is the primary assembly for the indicated figure; indenture 2 is either a direct part or subassembly of indenture 1; indenture 3 is either a direct part or subassembly of indenture 2 -- and so on. This method indicates which components are a part of which assemblies. All indent 2 items are a part of indent 1 and will be found on the indent 1 Bill of Material. All indent 3 items are a part of the preceding indent 2 item and will be found on that indent 2 Bill of Material. All parts are identified only once, and in their proper sequence.

DIFFERENCE DATA SHEET

The Difference Data Sheet (DDS) is a supplement to an existing parts list and is referenced to the existing list by Figure Number.

1. The DDS does not list any parts which are common to both units, but only those parts which are different.
2. All parts found on the list of the referenced unit apply to the unit of the DDS, except those parts indicated on the DDS.
3. If the word "delete" is used, then that part is not used on the unit of the DDS, but is used on the referenced unit.
4. If an item number is found on the DDS and not on the referenced parts list, then that part is found on the unit of the DDS but not on the referenced unit.

ORDERING

When ordering parts include the Parts List DRS Number and Date of Publication, Figure and Item Number, and Part Description. If the part cannot be found in the parts list, include the Catalog Number of unit, Serial Number, and detailed description of part in question.

EXAMPLE:

FIG. 1 MOBILE CHASSIS AND TUBESTAND – PART NO. 1348L

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
1 -	1348L	Mobile Chassis and Tubestand	1
- 1	13559	Cover, Back	1
- 2	T7D-117	Filter, 1/2 mm	2
- 3	11337A	Indexing Plate, Tube Arm, and Locking Assembly	1
- 4	27904	Nameplate	1
- 5	37797	Plug, Tube End	2
- 6	T5-204	Spring, Front Stop	1
- 7	T54-3	"O" Ring, 1 x 1-1/4"	2
- 8	40822	Bracket, Transport	1

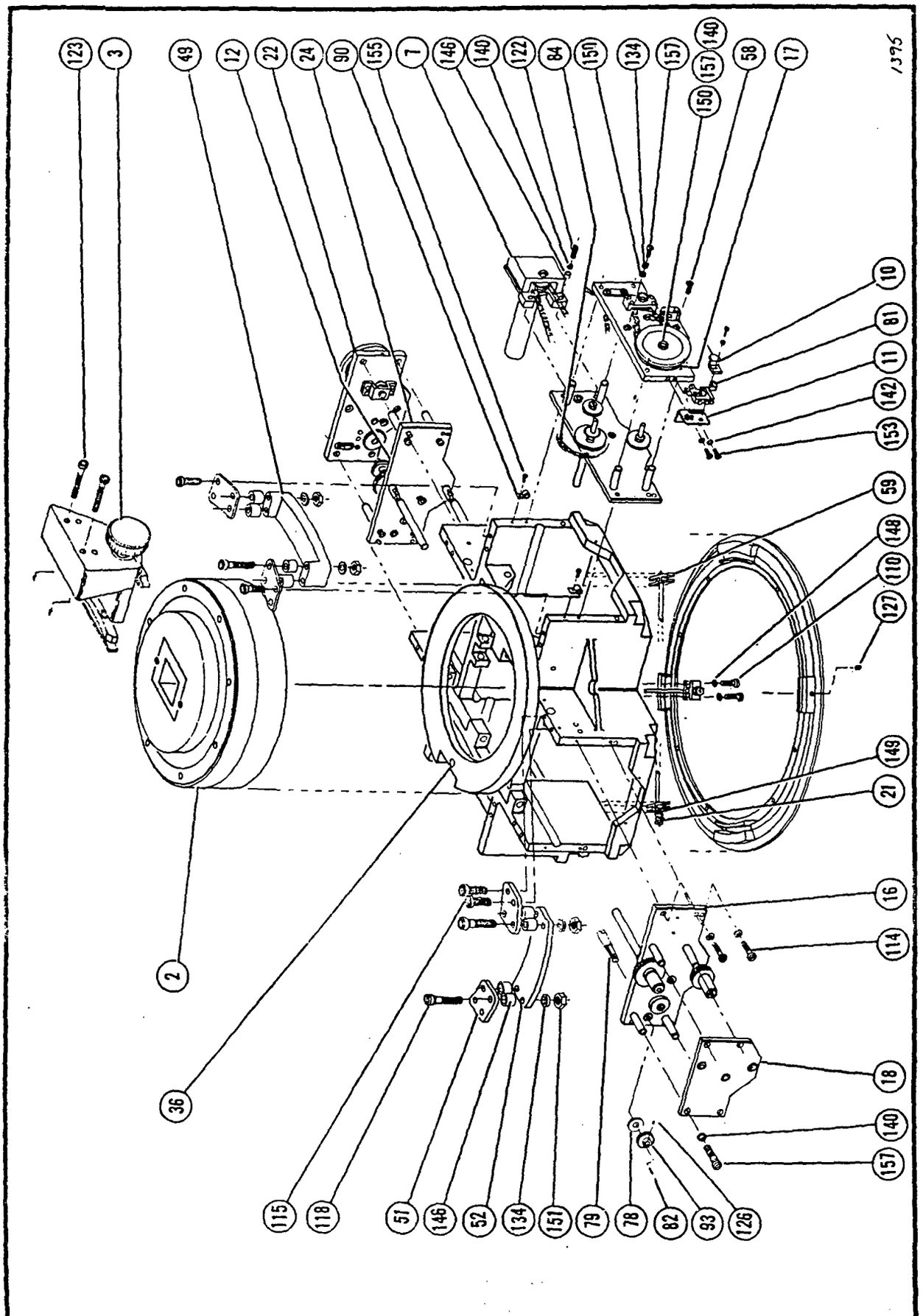


FIG. 1 - COBALT THERAPY COLLIMATOR - Part No. 3706D (1 of 3)

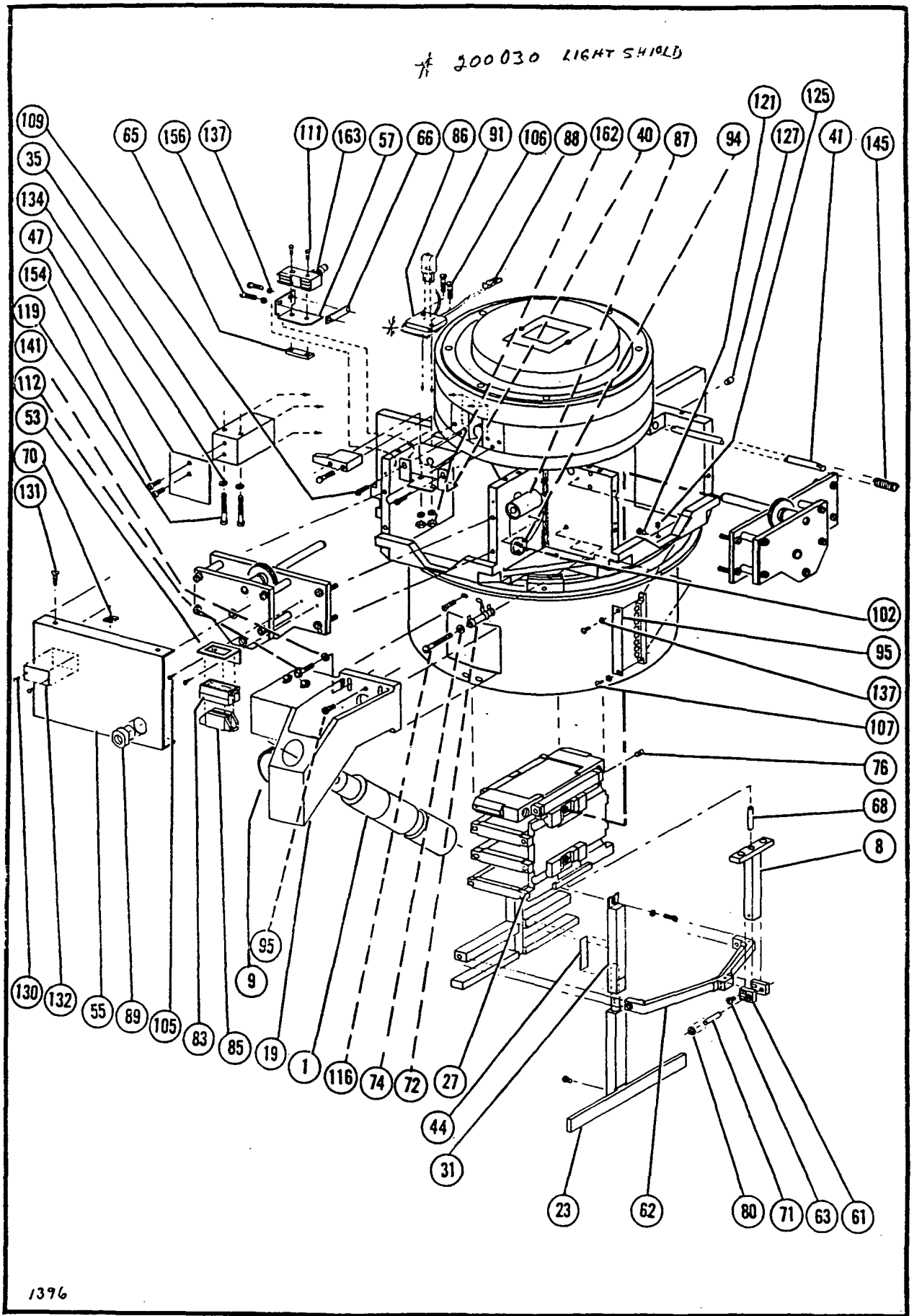


FIG. 1 - COBALT THERAPY COLLIMATOR - Part No. 3706D (2 of 3)

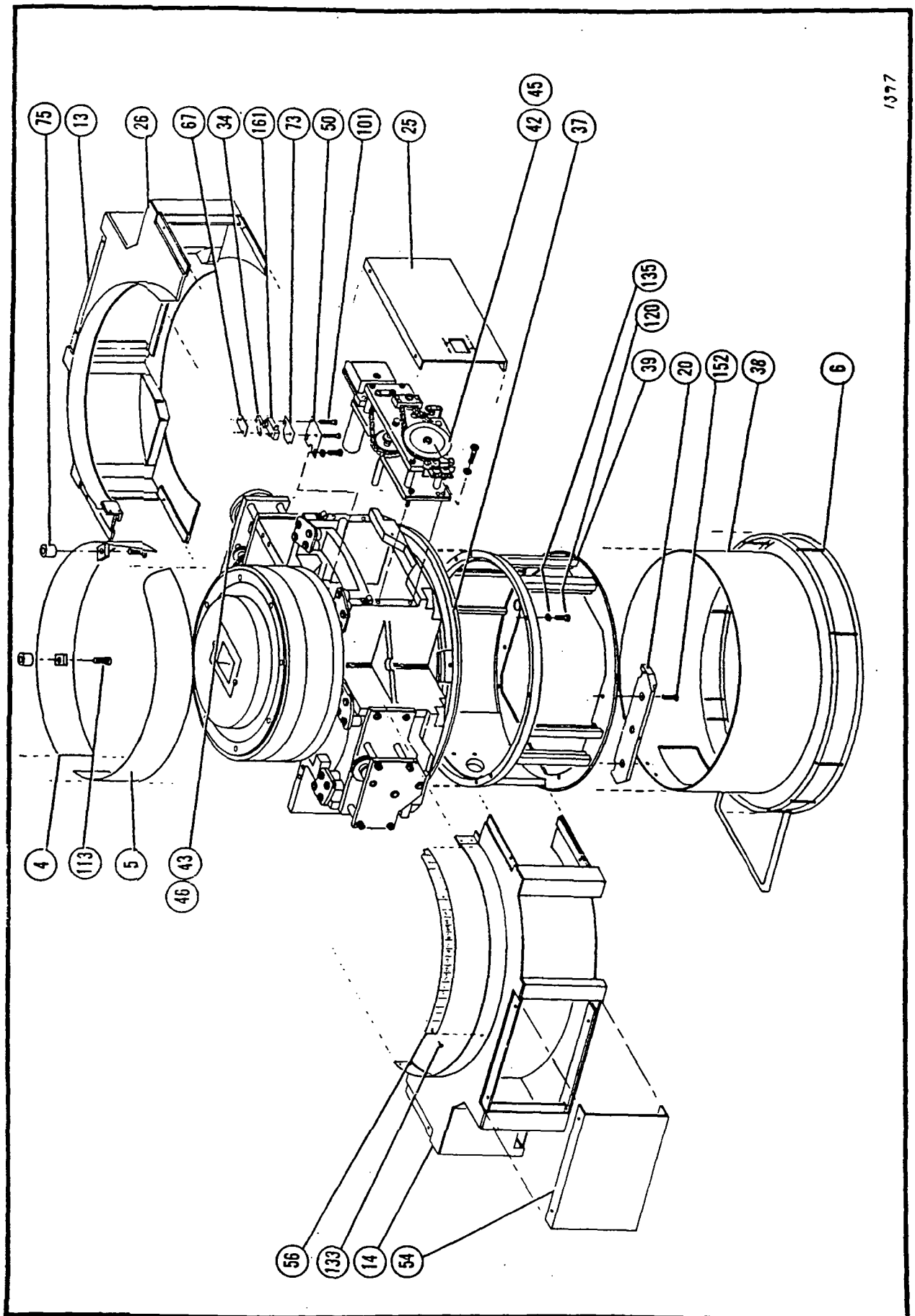


FIG. 1 - COBALT THERAPY COLLIMATOR - Part No. 3706D (3 of 3)

FIG. 1 - COBALT THERAPY COLLIMATOR - Part No. 3706D

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
1 -	3706D	Cobalt Therapy Collimator	
1	181010	Optical Distance Indicator (See Fig. 2)	1
2	181459A	Bearing Assembly (See Fig. 3)	1
3	181464	Rotational Brake Assembly (See Fig. 4)	1
4	181473	Skirt Adaptor (R.H.) Assembly	1
	55682	Skirt	1
	55684	Block	2
5	181474	Skirt Adaptor (L.H.) Assembly	1
	55683	Skirt	1
	55684	Block	2
6	181494	Halo Ring Feeler Assembly	1
	55643	Ring - Upper	1
	55922	Ring - Lower	1
	55647	Spacer	9
	55646	Channel	1
7	182095	Motor Mount Assembly (See Fig. 5)	2
8	181462	Support Bar Assembly	4
	55787	Mounting Plate	1
	55957A	Braze Washer	1
	55609	Support Bar	1
9	181558	Halo Switch Assembly (See Fig. 6)	1
10	182091	Pointer Assembly Dial	2
	57424	Pointer	1
	57425	Bracket	1
11	182140	Bracket Assembly - Pointer	2
	57578	Bracket	1
	T4-364	Weldnut - #6-32	1
12	182146	Collimator Gear Assembly	2
	T77-347	Gear	1
	T77-348	Gear	1
	T14A-84	Roll Pin - 1/8 Dia. x 3/8 Lg.	1
13	182150	Shroud Assembly (Right Side)	1
14	182151	Shroud Assembly (Left Side)	1
15*	182183	Gear Assembly (Spacer, Idler)	2
	T77-347	Gear	1
	T10B-580	Set Screw Collar	1
16	182184A	Rear Plate Opposite Dial (See Fig. 7)	2
17	182187	Dial Ring and Socket Assembly	2
	T77D-40	Sprocket	1
	55852A	Plate - Ring	1
	T14A-56	Roll Pin - 1/16 Dia. x 3/16 Lg.	1
18	182241A	Front Plate (Opposite Dial)	2
	T12-450	Bearing - 3/8 ID x 5/8 OD	2
	T12-464	Bearing - 1/4 ID x 1/2 OD	1
	57659A	Front Plate	1
19	182250	Localizer Mounting Bracket (See Fig. 8)	1

*Not shown.

(CONTINUED)

FIG. 1 - COBALT THERAPY COLLIMATOR - Part No. 3706D

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
	3706D	(Continued)	
20	182274	Accessory Mounting	2
	57563	Mounting Block	1
	57565	Accessory Clamp Nut	1
	S33-16	Screw - 8-32 x 3/8 Set	1
21	182275	Cross Hair Assembly	2
	57819	Wire Cross Collimator	1
	57828	Pin	1
	T2-559	Special Screw	1
	S111-11A	Nut - #8-32 Hex	1
22	182276A	Front Plate Assembly (See Fig. 9)	2
23	184228	Extender Assembly	4
	184207	Extension Rod Assembly	1
	62559	Collimator Extender	1
	62562	Shim	IND.
	62562A	Shim	IND.
	62562B	Shim	IND.
	S21-7A	Screw - 8-32 x 3/8 Socket Head Cap	2
24	182277A	Rear Plate Assembly (See Fig. 10)	2
25	182278	Cover Assembly - Shroud Front	1
	57757	Cover - Front	1
	55847	Window - Dial Pointer	1
	S301-87	Elmer's Epoxy	A/R
26	182279	Cover Assembly - Shroud Right Side	1
	57758	Cover (Right Side)	1
	55847	Window - Dial Pointer	1
	S301-87	Elmer's Epoxy	A/R
27	183031	Vane Assembly - "Y" Motion Side, Opposite Dial (See Fig. 11)	1
28*	183032	Vane Assembly - "Y" Motion Dial Side	1
29*	183033	Vane Assembly - "X" Motion Side, Opposite	1
30*	183034	Vane Assembly - "X" Motion Dial Side	1
31	183362	Housing Assembly	4
	59450	Housing (For Extenders)	1
	59451	Plunger	1
	S32-66	Screw - 3/8-16 x 1/2 Socket Set	1
	T5A-288	Compression Spring	1
32*	L-2901	Harness	1
33*	T63B-978	Wiring Instructions	REF.
34	35088	Roller Actuator	3
35	50234	Shield Block	1
36	55166B	Collimator (Casting Machine)	1
37	55575A	Ring - Accessory Mounting	1
38	55583	Shroud - Lower (Extender)	1
39	55589A	Extender - Encloser	1
40	55590A	Bracket - Lamp Mounting	1

*Not shown.

(CONTINUED)

FIG. 1 - COBALT THERAPY COLLIMATOR - Part No. 3706D

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
	3706D	(Continued)	
41	55597	Guide Rod	4
42	55850	Dial Outer (Long Vanes)	1
43	55850A	Dial Outer (Short Vanes)	1
44	62440,A,B	Shim	IND.
45	55851A	Dial Inner (Long Vanes)	1
46	55851B	Dial Inner (Short Vanes)	1
47	55977	Collimator Light Shield	1
48*	56544	Wrench - Allen (20" Long)	1
49	56786A	ARC Barrier (B-56786)	1
50	57339	Mounting Bracket - Switch	3
51	58922	Support - Arc Barrier	8
52	57355	Arc Barrier	3
53	57636	Bracket - Mat-N-Lock Connector	1
54	57759	Cover - Shroud - Left Side	1
55	57760	Cover - Shroud - Rear	1
56	57762	Scale - Rotational Scale	1
57	57801	Mounting Bracket - Zone Guard Switch	2
58	T2-349	Screw - 10-32 x 1/2 Button Head 2/Nylok	8
59	57820	Bracket - Cross Hair Mounting	4
60*	59449	Clamp Block Removable Trimmer	4
61	59512	Block	8
62	59524	Bar Support - Collimator Trimmer	4
63	T2-398	Screw - Pivot Shoulder	8
64*	T2M-24	Screw - 1/4-20 x 5/8 Socket Head Cap - (Lockwell)	8
65	T4-187	Nut Plate - Zone Guard Switch	2
66	T4-275	Nut Plate - Zone Guard Bracket	2
67	T4-279	Nut Plate - Switch	3
68	T14F-35	Pin - Connecting	4
69*	T4-363	Nut Plate - Switch	2
70	T4D-41	Cover - Tinnerman Speed Nut	16
71	T14D-189	Pin - .188 Dia. x 1.00 Lg.	4
72	T6-796	Resistor - Adjustable - 100 Ohms - 25W	REF.
73	T9-74	Switch - Fiber Barrier	6
74	T11L-43	Washer - Fiber	2
75	T10C-585	Skirt - Spacer	4
76	T14D-182	Pivot Pin - Vane	4
77*	T11P-126	Shims	15
78	T14L-86	Spacer (Line Shaft)	4
79	T14L-87	Shaft - Line	2
80	T22-65	Ring - Retainer - Truarc	8
81	T29E-9	Actuator	4
82	T31-52	Key (Line Shaft)	4
83	T36-352	Pin - Mat-N-Lock (HS6)	1
84	T26-144	Chain - Roller Drive	2
85	T36-353	Socket - Mat-N-Lock (HS6)	1

*Not shown.

(CONTINUED)

FIG. 1 - COBALT THERAPY COLLIMATOR - Part No. 3706D

FIG & ITEM	PART NO.	DESCRIPTION 1 2 3 4 5	QTY
	3706D	(Continued)	
86	T36-388	Socket - Lamp	1
87	T45-152	Condenser - Dry	REF.
88	T36N-2	Faston	2
89	T66D-6	Cable Grip	1
90	T66A-33	Cable Clamp (Front & Back)	2
91	T72-109	Lamp - High Silica Halogen	1
92*	T66A-34	Cable Clamp (R & L Side)	3
93	T77-346	Gear (Line Shaft)	4
94	T80-118	Rectifier - Full Wave Silicon	REF.
95	T81B-109	Marker Strip - 10 Position	1
96*	181844	Isodose Curves - 80SS, 65SDD (T55-601)	REF.
97*	181844A	Isodose Curves - 80SSD, 45SDD (T55-602)	REF.
98*	181844B	Isodose Curves - 60SSD, 45SDD (T55-603)	REF.
99*	181844C	Isodose Curves - 80SAD (T55-609)	REF.
100*	T61B-914	Wiring Diagram (Motorized)	REF.
101	S1A-42	Screw - 4-40 x 5/8 Round Head Machine	6
102	S1-69	Screw - 6-32 x 3/8 Round Head Machine	1
103*	S2-194	Screw - 8-32 x 1/8 Flat Head Machine	6
104	S5-102	Screw - 10-32 x 2-1/2 Round Head Machine	1
105	S5A-87	Screw - 8-32 x 3/16 Round Head Machine	2
106	S9A-43	Screw - 4-40 x 3/4 Round Head Machine	2
107	S9-66	Screw - 6-32 x 3/16 Round Head Machine	2
108*	S9-10	Screw - 2-56 x 7/8 Round Head Machine	4
109	S9-67	Screw - 6-32 x 1/4 Round Head Machine	2
110	S21A-4	Screw - 6-32 x 3/4 Socket Head	8
111	S21A-6	Screw - 6-32 x 1 Socket Head	4
112	S21-24	Screw - 1/4-20 x 1/2 Socket Head	4
113	S21-59	Screw - 3/8-16 x 1-1/2 Socket Head Cap	4
114	S22-14	Screw - 10-32 x 1/2 Socket Cap	32
115	S22-15	Screw - 10-32 x 5/8 Socket Head Cap	16
116	S5-102	Screw - 10-32 x 2-1/2 Round Head Machine	1
117*	S22-13	Screw - 10-32 x 3/8 Socket Head Cap	4
118	S22-18	Screw - 10-32 x 1 Socket Head Cap	8
119	S22-22	Screw - 10-32 x 2 Socket Head Cap	6
120	S22-26	Screw - 1/4-20 x 3/4 Socket Cap	8
121	S22-116	Screw - 10-32 x 5/16 Socket Head Cap	8
122	S22A-19	Screw - 10-32 x 1-1/4 Socket Head Cap	4
123	S22A-20	Screw - 10-32 x 1-1/2 Socket Head Cap	8
124*	S33-12	Screw - 8-32 x 1/8 Socket Set Cup Point	4
125	S34-48	Screw - 1/4-20 x 1/2 Socket Head Set	2
126	S36-1	Screw - 6-32 x 1/8 Socket Set	4
127	S36-13	Screw - 8-32 x 3/16 Socket Set	12
128	S36-44	Screw - 1/4-20 x 1/4 Socket Set	3
129*	S39-28	Screw - 10-32 x 1/2 Socket Set	4
130	S66-8	Screw - #2 x 3/16 Drive	2
131	S71B-17	Screw - 6-32 x 1/2 Flat Head PKST	16

*Not shown.

(CONTINUED)

FIG. 1 - COBALT THERAPY COLLIMATOR - Part No. 3706D

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
	3706D	(Continued)	
132	T92-419	Nameplate	1
133	S73A-14	Screw - #6-1/4 Pan Head Self Tap	2
134	S85-5	Lockwasher - #10	26
135	S85A-23	Lockwasher - 1/4	8
136*	S93-1	Washer - #4 Shakeproof	2
137	S93-2	Washer - #6 Shakeproof	6
138*	S93-3	Washer - #8 Shakeproof	2
139*	S94-1	Washer - #2 Shakeproof	4
140	S94-4	Shakeproof - #10	40
141	S94-6	Shakeproof - 1/4	4
142	S96A-11	Washer - 5/32 x 5/16 x .048 x .027	4
143*	S96A-14	Washer - 13/64 x 15/32 x 1/16	4
144*	S98-10	Washer - #2 Flat	4
145	T5-697	Spring - Compression	16
146	T10C-376	Spacer	12
147*	T10C-401	Spacer	4
148	S98A-11	Washer - #6 Flat	8
149	S98A-12	Washer - #8 Flat	2
150	S98A-15	Washer - #10 Flat	10
151	S111-27	Nut - #10-32 Hex	16
152	S263A-75	Screw - 1/4-20 x 3/4 Flat Head	4
153	S277A-5	Screw - 6-32 x 3/8 Button Head	4
154	S277-8	Screw - 8-32 x 1/4 Socket Head Button	6
155	S277L-10	Screw - 8-32 x 3/8 Button Head	5
156	S277A-12	Screw - 8-32 x 3/4 Socket Button Head	4
157	S277A-27	Screw - 10-32 x 1/2 Button Head	18
158*	S387-3	Screw - 6-32 x 1/4 Cone Point Set	2
159*	S22-16	Screw - 10-32 x 3/4 Socket Head Cap	8
160	T29-272	Toggle Switches	REF.
161	T29A-16	Micro Switch	REF.
162	S111-8A	Nut - #4-40 Hex	2
163	T29A-35	Switch	REF.

*Not shown.

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
	3706E	Cobalt Therapy Collimator	
10	182175	Dial Pointer Assembly	2
13	182229	Shroud Assembly - Right	1
32*	L-2902	Harness	1
33*	T63B-979	Wiring Instructions	REF.
164,165	Delete		
166	182178A	Rear Plate - Dial Side	2
167	182177A	Front Plate - Dial Side	2
168	182257	Cover Shroud - Front	1
169	182258	Cover Shroud - Right Side	1
170-173	Delete		
174	55845	Knob - Plug	2
175	T3-166	Knob - Dial	2
176-182	Delete		
183	T61B-915	Wiring Diagram	REF.
184-191	Delete		

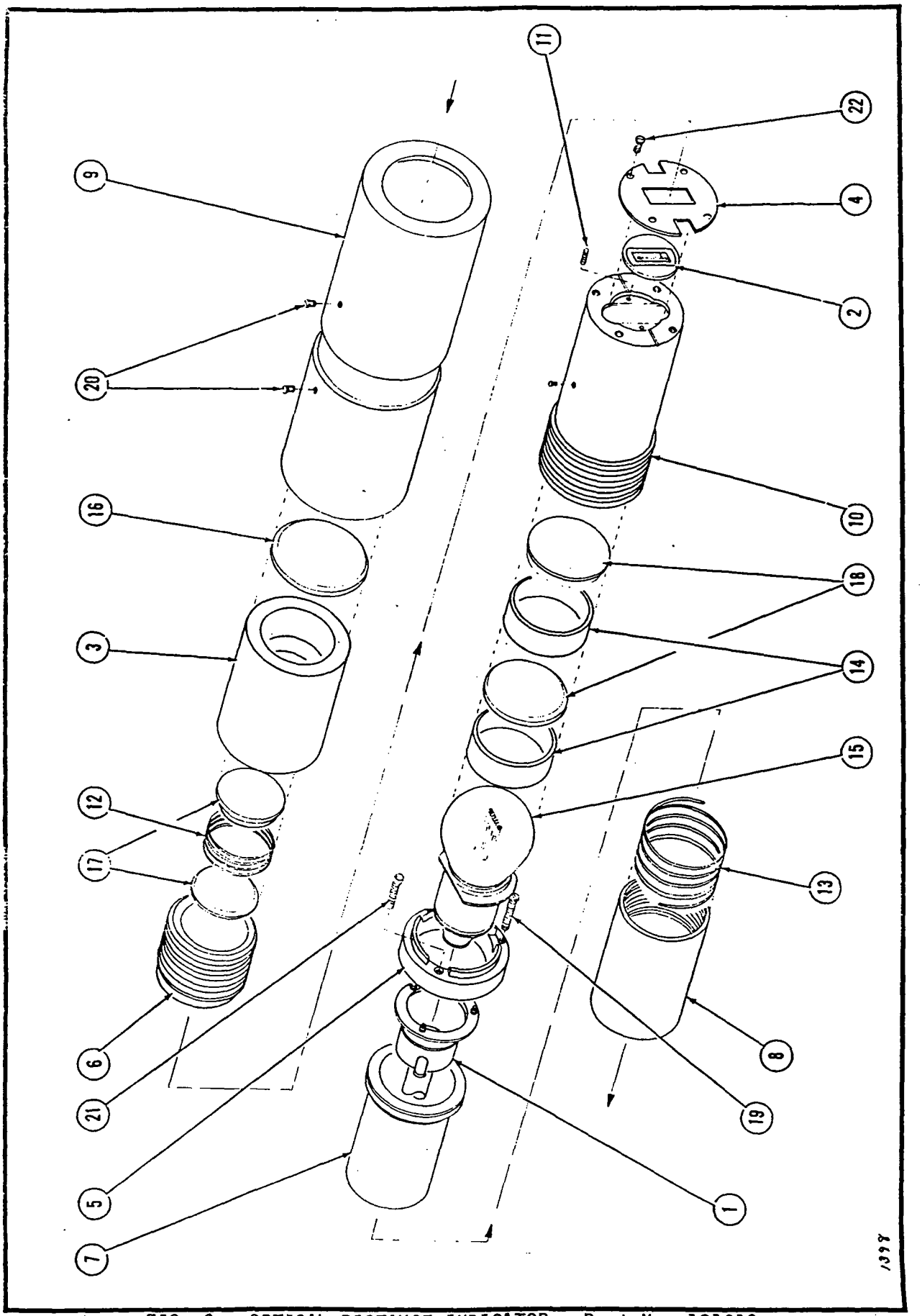


FIG. 2 - OPTICAL DISTANCE INDICATOR - Part No. 181010

FIG. 2 - OPTICAL DISTANCE INDICATOR - Part No. 181010

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
2 -	181010	Optical Distance Indicator (See Fig. 1, Item 1)	
1	L-2580	Socket Assembly	1
2	55546	Reticle	1
3	55829	Holder - Lens Front	1
4	55830	Mask	1
5	55831	Holder - Lamp Base	1
6	55832	Holder - Lens Rear	1
7	55833	Cover - Lamp Base	1
8	55834	Cap - End	1
9	55835	Housing	1
10	55836	Holder - Projection Lens	1
11	T5A-271	Spring Compression	2
12	T5A-272	Spring - Compression Collimator Lens	1
13	T5A-273	Spring - Lamp Base	1
14	T10C-584	Spacer - Condensing	2
15	T72-111	Lamp	1
16	T87-128	Lens - Plano 608mm F.L.	1
17	T87-129	Lens - Plano 39.25mm F.L.	2
18	T87-130	Lens - Plano 63.5mm F.L.	2
19	S239A-23	Screw - 4-40 x 3/8 Flat Head	2
20	S33-1	Screw - 6-32 x 1/8 Socket Set Cup Point	4
21	S21-126	Screw - 4-40 x 3/8 Socket Head Cap	1
22	S277-1	Screw - 4-40 x 1/4 Button Socket Head	4

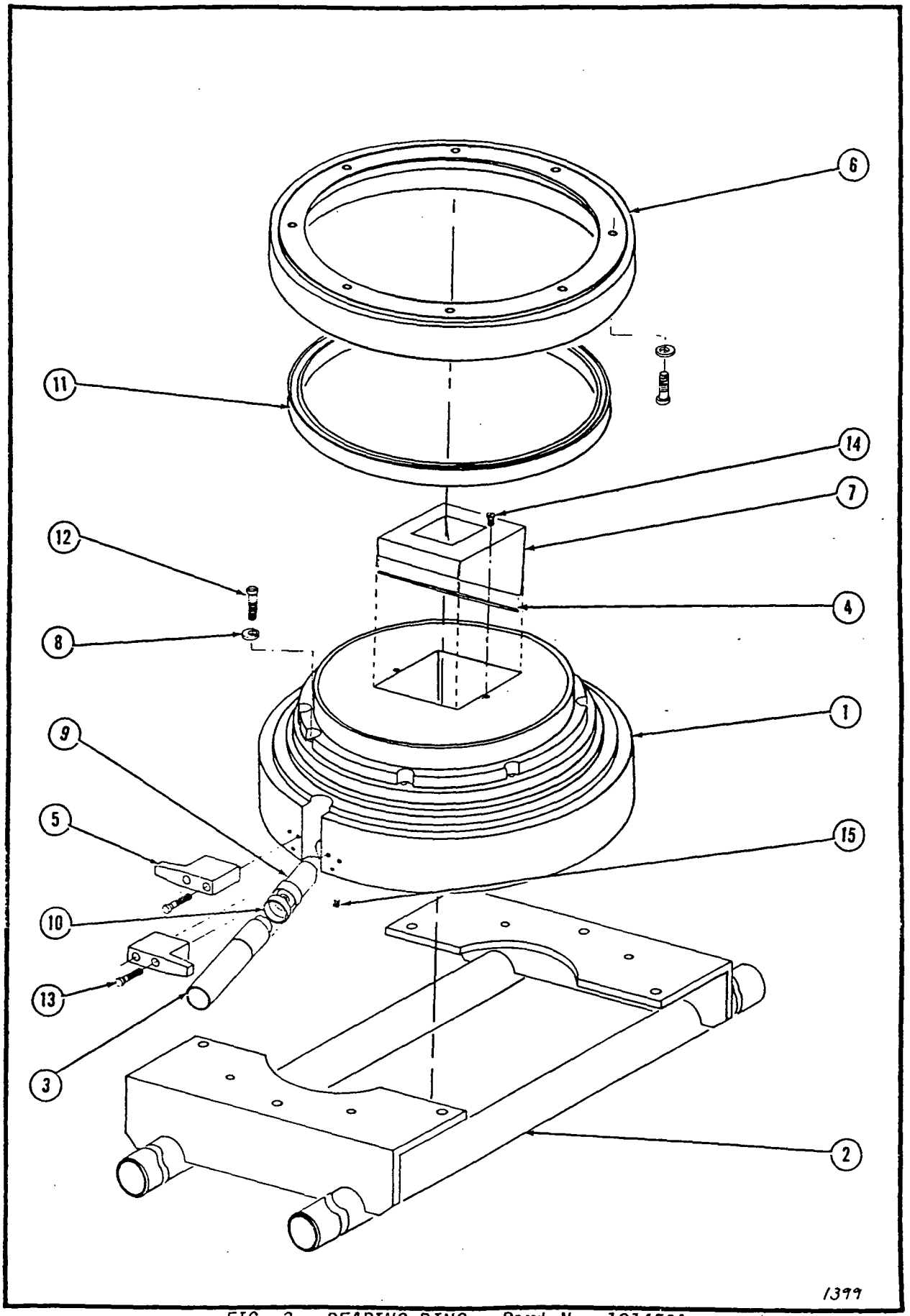


FIG. 3 - BEARING RING - Part No. 181459A

FIG. 3 - BEARING RING - Part No. 181459A

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
3 -	181459A	Bearing Ring (See Fig. 1, Item 2)	
1	57843	Bearing Ring - Machined Assembly	1
2	181802	Handle Bar - Weldment	1
3	181461	Field Illuminator Assembly	1
4	55432	Mirror - Collimator	1
5	55748	Block - Rotation Stop	2
6	55591	Ring - Bearing Adaptor	1
7	55592	Retainer - Mirror	1
8	55593	Retainer - Bearing	16
9	55594	Aperture	1
10	56210	Spacer	1
11	T12-438	Ball Bearing - 4 Point Contact	1
12	S21-24	Screw - 1/4-20 x 1/2 Socket Head Cap	22
13	S22-17	Screw - 10-32 x 7/8 Socket Head Cap	4
14	S69-32	Screw - #8 x 3/8 Flat Head PKST	2
15	S33-12	Screw - 8-32 x 1/8 Cup Point Set	1
16*	S301-88	"Locoic" Primer Grade "T"	IND.
17*	S301-97	"Loctite" - Grade "HV"	IND.
18*	T2M-26	Screw - 1/4-20 x 1-1/4 Socket Head(Lockwell)	8
19*	S371-1	Muslin Bag - 2-3/4 x 4	1

*Not shown.

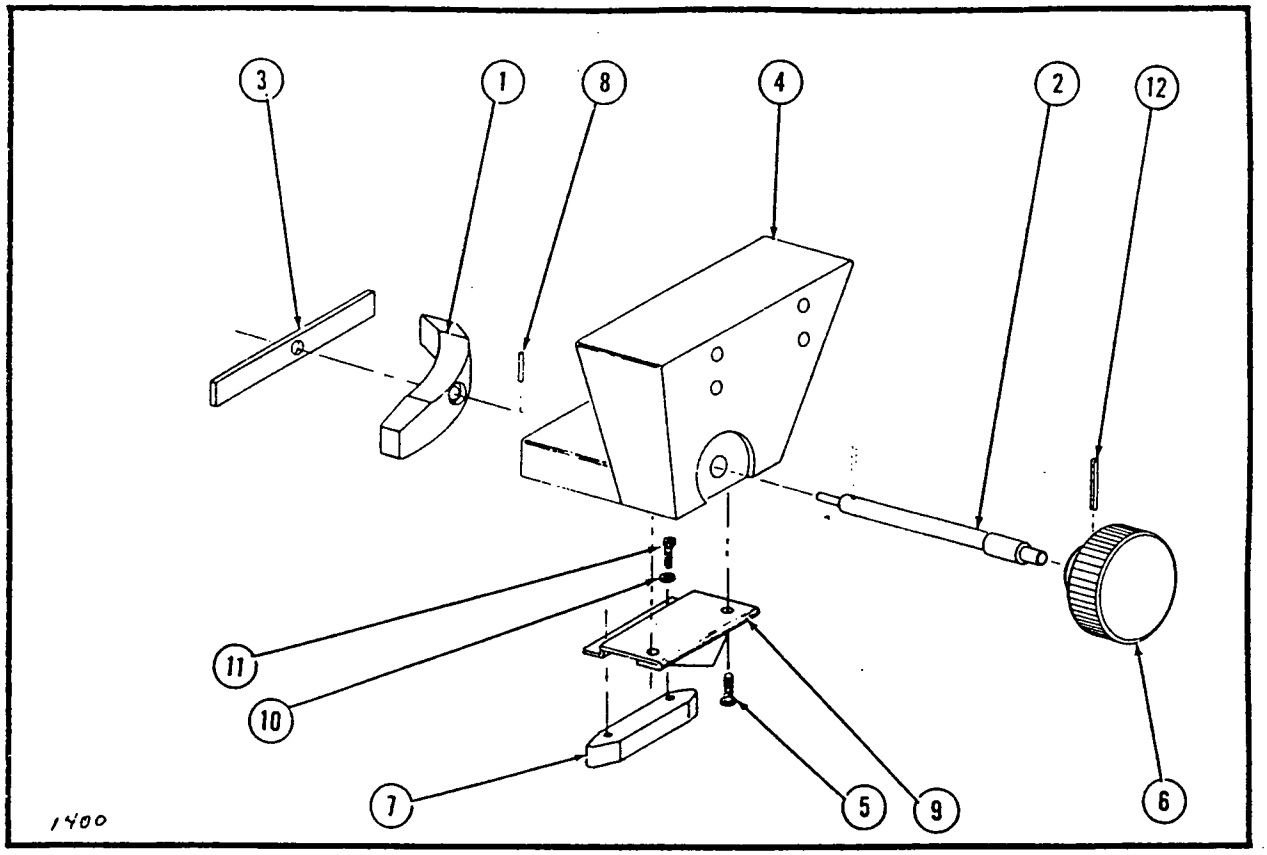


FIG. 4 - ROTATIONAL BRAKE - Part No. 181464

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
4 -	181464	Rotational Brake (See Fig. 1, Item 3)	
1	55656	Shoe - Brake	1
2	55657	Shaft - Brake	1
3	55658	Lining - Brake	1
4	55659A	Housing - Brake (Machined)	1
5	S229C-45	Screw - #6-32 x 3/8 Phillips Binding Head	2
6	T3-185	Knob	1
7	57341	Switch - Actuator Front	1
8	T14A-132	Pin - Roll 1/16 Dia. x 1/2	1
9	57340	Center Actuator	1
10	S85-3	Lockwasher - #6	2
11	S277-5	Screw - 6-32 x 3/8 Socket Button Head	2
12	T14A-55	Roll Pin - 3/32 x 7/8	1
13*	S301-50	Contact Cement - Minn. Mining #EC2099	IND.

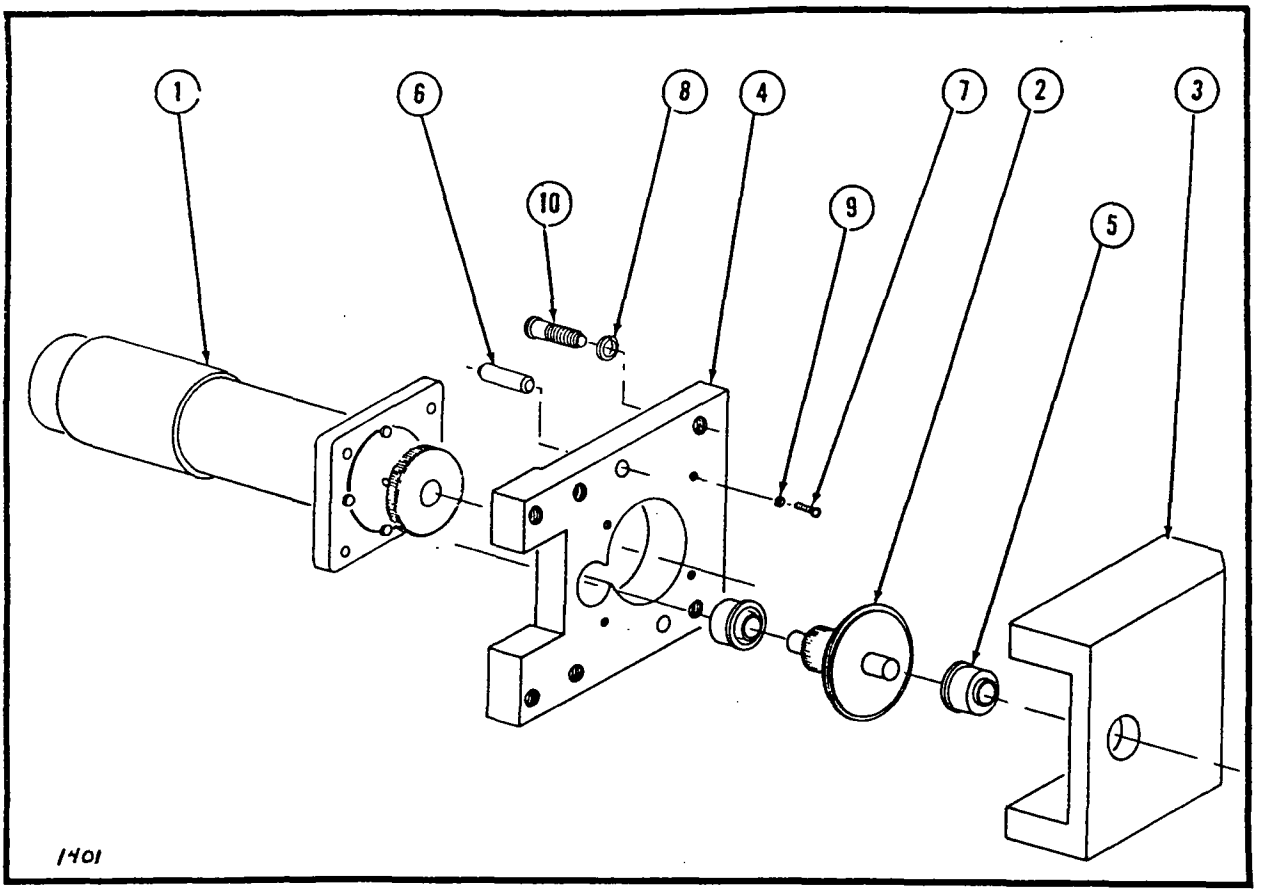


FIG. 5 - MOTOR MOUNT ASSEMBLY - Part No. 182095

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
5 -	182095	Motor Mount Assembly (See Fig. 1, Item 7)	
1	181781	Motor Drive Assembly	1
2	182141	Drive Gear and Shaft Assembly	1
3	57429	Cover (Motor Mount)	1
4	57434	Mount - Motor	1
5	T12-464	Radial Retainer - Flanged	2
6	T14D-197	Dowel Pin - 3/16 Dia. x 1/2	2
7	S21-128	Screw - 4-40 x 1/2 Socket Head	4
8	S85-5G	Lockwasher - #10	4
9	S85-2G	Lockwasher - #4	4
10	S277-29L	Screw - 10-32 x 3/4 Button Head	4

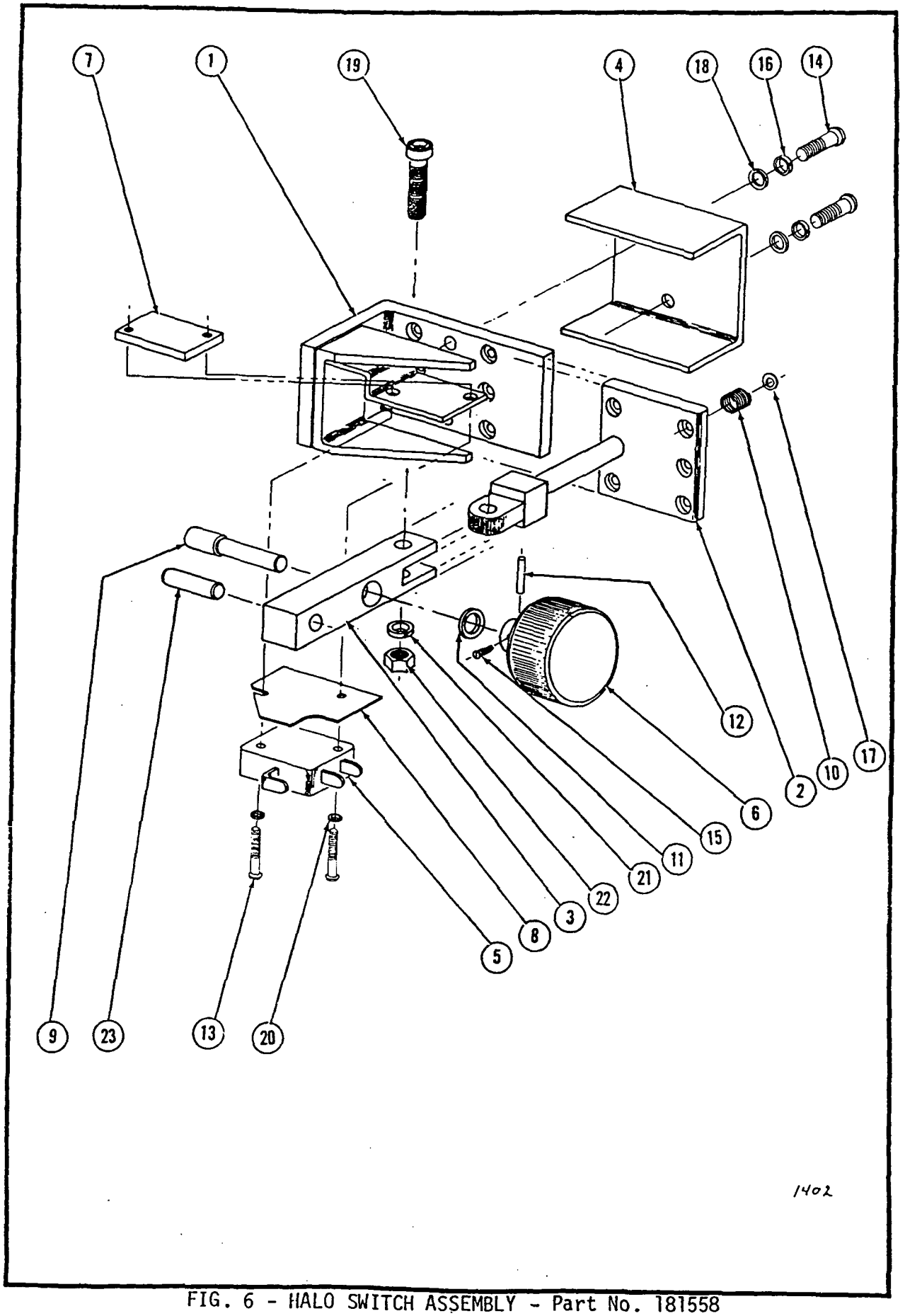


FIG. 6 - HALO SWITCH ASSEMBLY - Part No. 181558

FIG. 6 - HALO SWITCH ASSEMBLY - Part No. 181558

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
6 -	181558	Halo Switch Assembly (See Fig. 1, Item 9)	
1	181562	Angle Bracket (Weldment)	1
2	181563	Mounting Bracket - Halo	1
3	55971	Stem - Adjustable	1
4	55972	Guide - Feeler Plate	1
5	L-2729	Leads - Halo Switch	1
6	T3A-116	Knob	1
7	T4-165	Plate - Nut	1
8	T9-74	Barrier	1
9	T14L-75	Stud	1
10	T5A-93	Spring - Compression	6
11	T11P-67	Washer - Flat	1
12	T14A-76	Roll Pin - 3/32 Dia. x 1/2	1
13	S1A-29	Screw - 4-36 x 3/4 Round Head Machine	2
14	S5A-91	Screw - 10-32 x 1/2 Round Head Machine	2
15	S39-0	Screw - 10-32 x 1/8 Set Cup Point	1
16	S93-4	Washer - #10 External Shakeproof	2
17	S98-3	Washer - #4 Flat	6
18	S98A-7	Washer - 7/32 I.D. Plain	2
19	S22A-27	Screw - 1/4-28 x 7/8 Socket Head Cap	1
20	S98-2	Washer -#4 Internal Shakeproof	2
21	S86-23	Lockwasher - 1/4	1
22	S120A-1	Hex Nut - 1/4-28	1
23	T14A-86	Roll Pin - 1/4 Dia. x 3/4	1

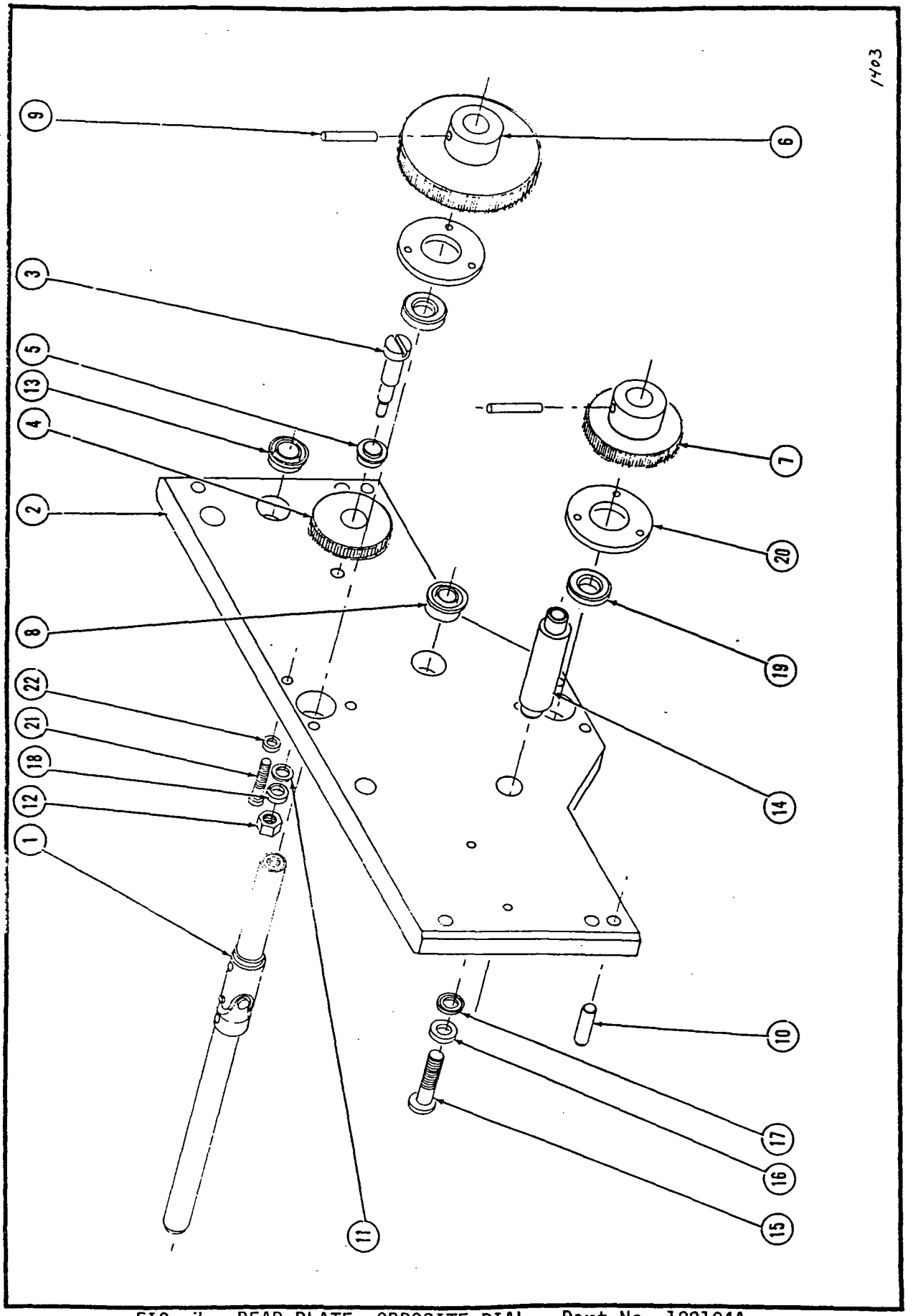


FIG. 7 - REAR PLATE, OPPOSITE DIAL - Part No. 182184A

FIG. 7 - REAR PLATE, OPPOSITE DIAL - Part No. 182184A

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
7 -	182184A	Rear Plate, Opposite Dial (See Fig. 1, Item 16)	
1	182182	Universal Screw Assembly (Left Hand)	2
2	57658	Plate	1
3	57622	Shoulder Screw	1
4	T77-345	Gear - Idler (55T 1.187 O.D.)	1
5	T12-467	Bearing - 1/4 I.D. x 3/8 O.D.	2
6	T77-341	Gear (96T 2.041 O.D.)	1
7	T77-342	Gear (66T 1.415 O.D.)	1
8	T12-464	Bearing - 1/4 I.D. x 1/2 O.D.	3
9	T14A-132	Dowel - 1/16 Dia. x 1/2	2
10	T14D-197	Dowel - 3/16 Dia. x 1/2	2
11	S96-11A	Washer - 5/32 x 5/16 x 3/64	1
12	T4A-44	Nut - #6-32	1
13	T12-466	Bearing - 5/16 I.D. x 1/2 O.D.	1
14	57639	Post - Gear Box	4
15	S277-27A	Screw - 10-32 x 1/2 Button Head	4
16	S96-14A	Washer - #10	4
17	S93-4-11100	Washer - #10 Shakeproof	4
18	S93-2-1106	Washer - #6 Shakeproof	1
19	T12-450	Bearing - 3/8 I.D. x 5/8 O.D.	2
20	59388	Retainer - Bearing	2
21	S21A-2	Screw - 6-32 x 1/2 Socket Head	6
22	S85A-3	Lockwasher - #6 Spring	6

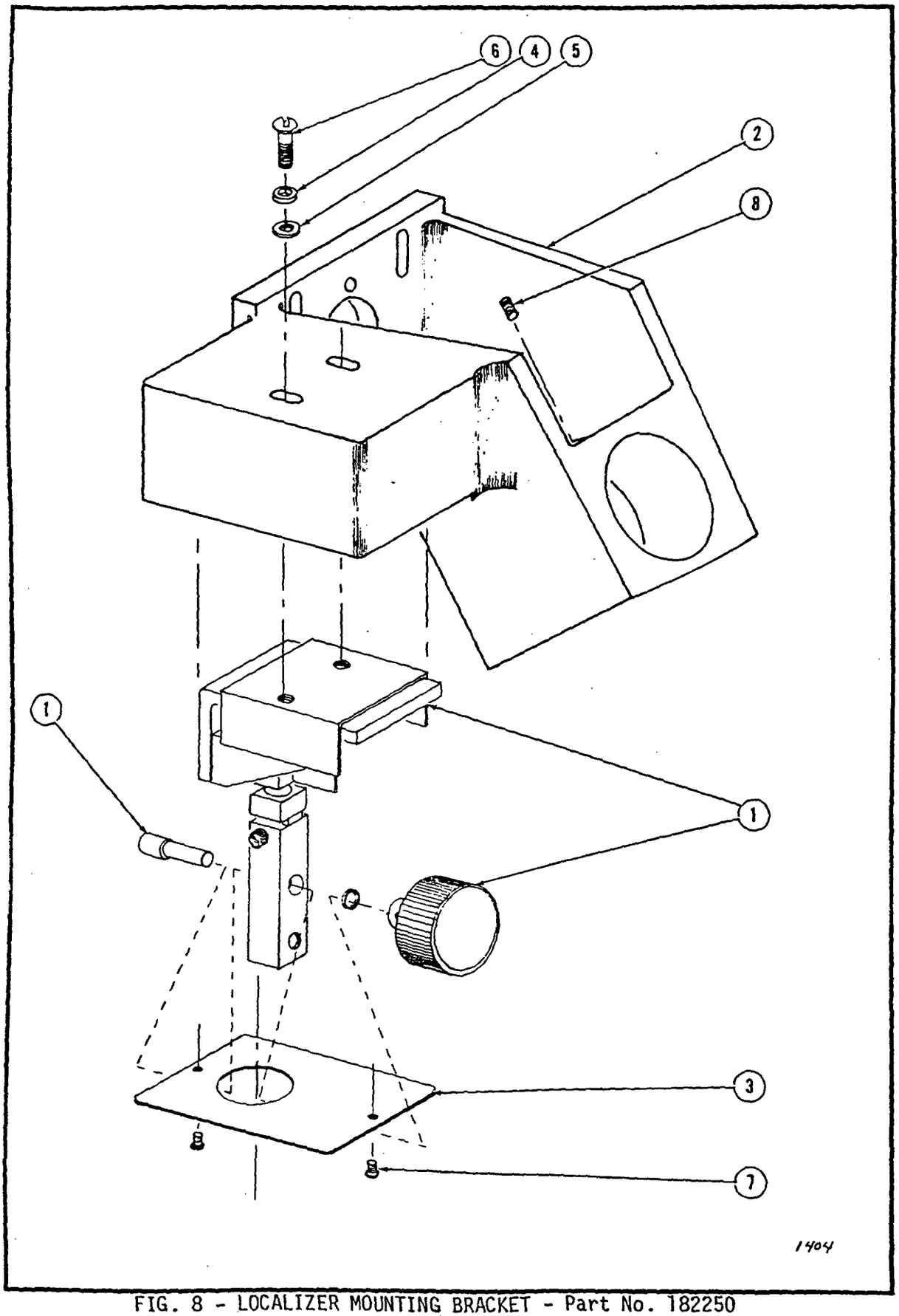


FIG. 8 - LOCALIZER MOUNTING BRACKET - Part No. 182250

FIG. 8 - LOCALIZER MOUNTING BRACKET - Part No. 182250

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
8 -	182250	Localizer Mounting Bracket (See Fig. 1, Item 19)	
1	181558	Halo Switch Assembly	1
2	55560A	Localizer (Machine)	1
3	55644	Cover - Localizer	1
4	S93-4	Washer - #10 Shakeproof	REF.
5	S98A-7	Washer - 7/32 I.D. Plain	REF.
6	S5A-91	Screw - 10-32 x 1/2 Round Head Machine	REF.
7	S33-12	Screw - 8-32 x 1/8 Socket Cup Point Set	1
8	S277-25A	Screw - 6-32 x 5/16 Pan Head	2

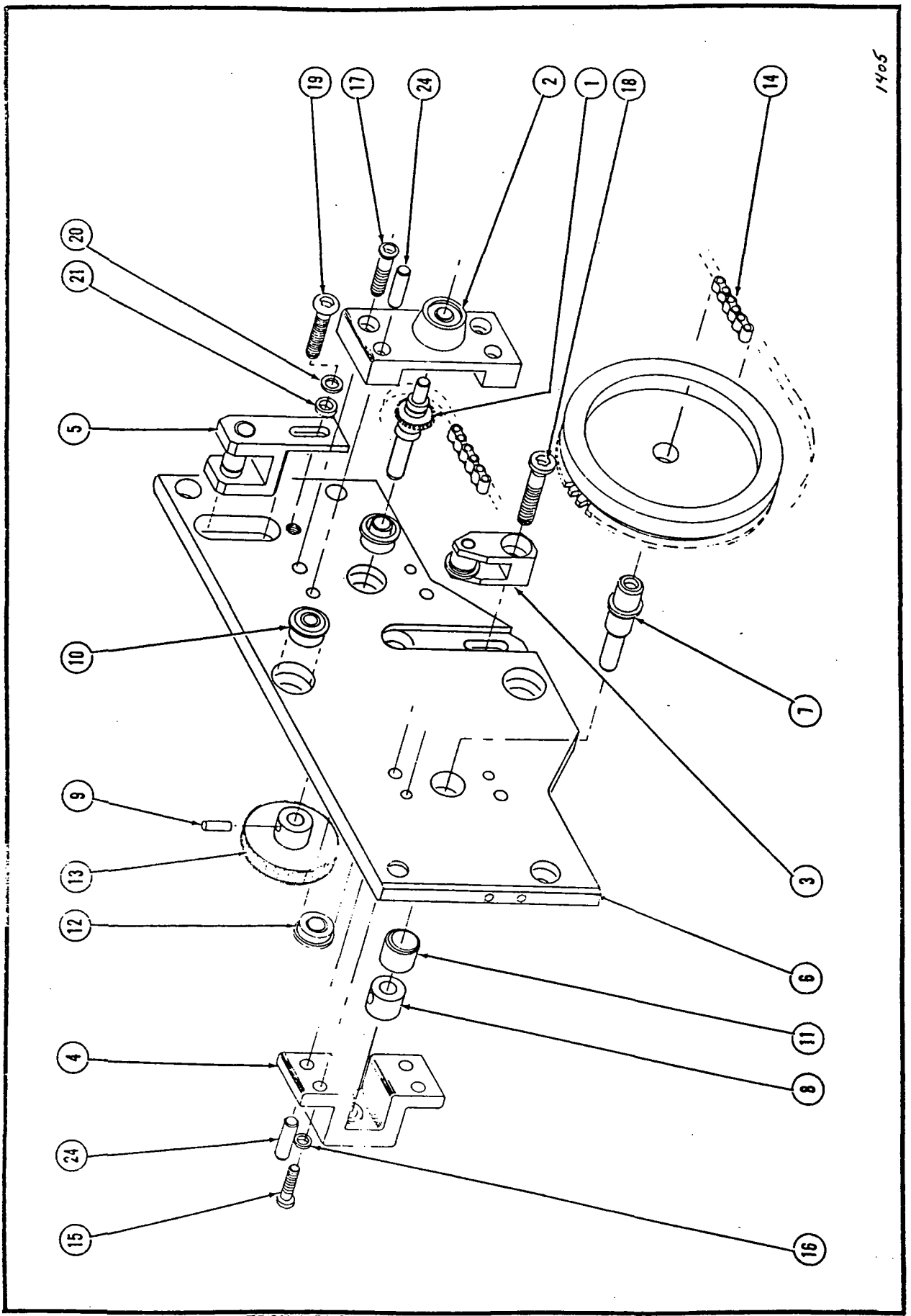


FIG. 9 - FRONT PLATE ASSEMBLY - Part No. 182276A

FIG. 9 - FRONT PLATE ASSEMBLY - Part No. 182276A

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
9 -	182276A	Front Plate Assembly (See Fig. 1, Item 22)	
1	182235	Shaft and Sprocket Assembly	1
2	182135	Bracket - Dial Chain	1
3	182098	Chain Tightener Assembly	1
4	182173	Bracket Bushing Assembly	1
5	182097	Sprocket Assembly	1
6	57437A	Front Plate	1
7	57428	Shaft - Dial	1
8	T10B-580	Collar	1
9	T14A-79	Roll Pin - 1/8 Dia. x 1/2 Lg.	1
10	T12-450	Bearing - 3/8 I.D. x 5/8 O.D.	2
11	T10F-90	Bushing - 1/4 I.D. x 3/8 O.D. x 5/16 Lg.	1
12	T12-464	Bearing - 1/4 Dia. x 1/2 O.D.	2
13	T77-327	Gear	1
14	T26-146	Chain - Dial Drive	1
15	S21A-7	Screw - 8-32 x 3/8 Socket Head	2
16	S93-3	Washer - Shakeproof	2
17	S22A-14	Screw - 10-32 x 1/2 Socket Head	2
18	S22A-17	Screw - 10-32 x 7/8 Socket Head	1
19	S277L-20	Screw - 10-32 x 1/2 Button Head	1
20	S93-4	Washer - #10 Shakeproof	1
21	S96A-14	Washer - 13/64 ID x 15/32 OD x 1/16 Thick	2
22*	S85A-5	Lockwasher - #10 Spring	1
23*	S111A-15	Nut - 10-32 Hex M.S.	1
24	T14D-197	Dowel - 3/16 Dia. x 1/2 Lg.	4

*Not shown.

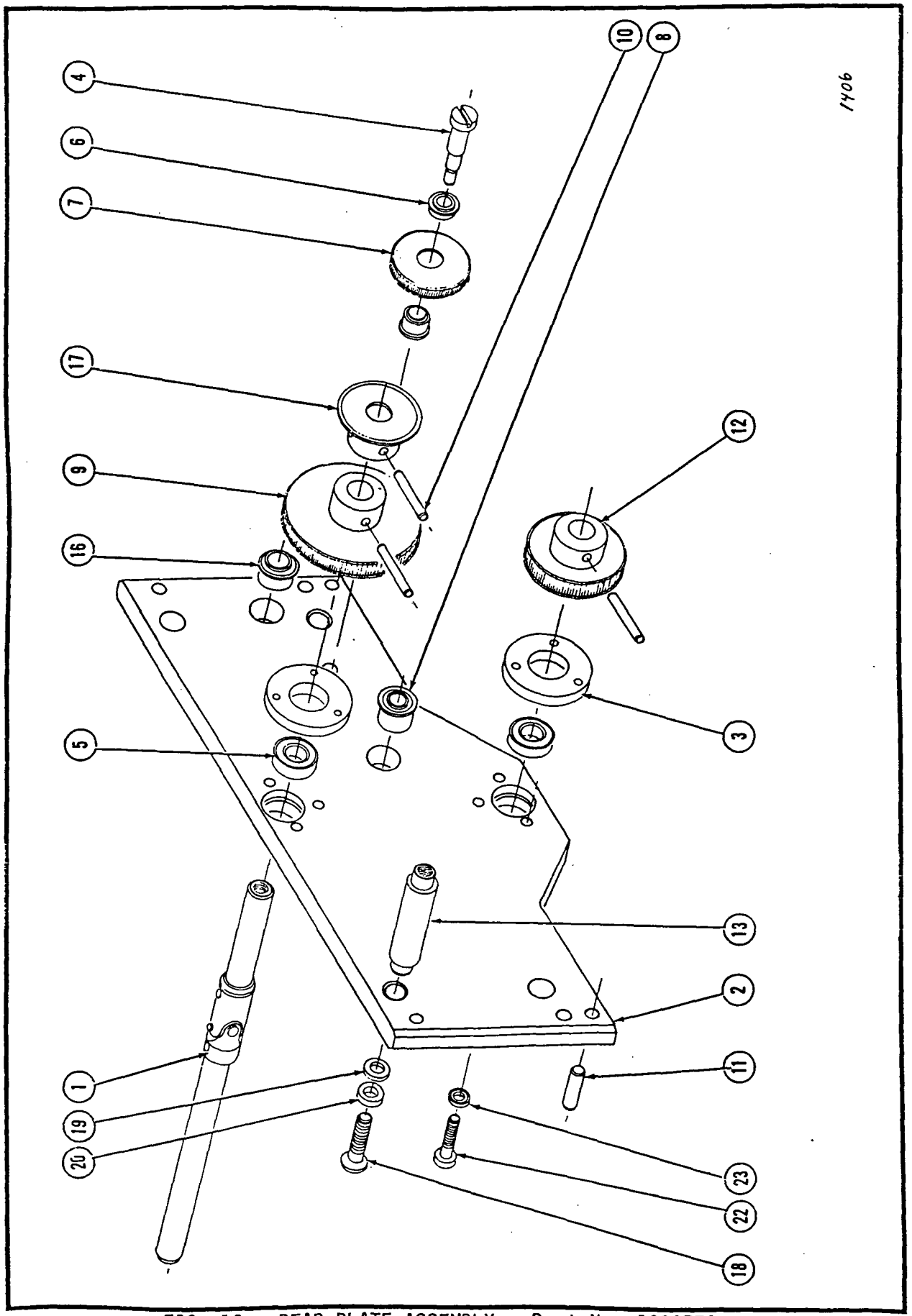


FIG. 10 - REAR PLATE ASSEMBLY - Part No. 182277A

FIG. 10 - REAR PLATE ASSEMBLY - Part No. 182277A

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
10 -	182277A	Rear Plate Assembly (See Fig. 1, Item 24)	
1	182176A	Universal Shaft and Screw Round Head Thread	2
2	57436A	Plate - Rear	1
3	59388	Retainer - Bearing	2
4	57622	Shoulder Screw	1
5	T12-450	Bearing - 3/8 ID x 5/8 OD	2
6	T12-467	Bearing - 1/4 ID x 3/8 OD	2
7	T77-345	Gear - Idler	1
8	T12-464	Bearing - 1/4 ID x 1/2 OD	1
9	T77-366	Gear	1
10	T14A-63	Roll Pin - 1/8 Dia. x 3/4 Lg.	3
11	T14D-197	Dowel - 3/16 Dia. x 1/2 Lg.	2
12	T77-367	Gear	1
13	57639	Post - Gear Box	4
14*	T4A-44	Nut - #6-32	1
15*	S96A-11	Washer - 5/32 x 5/16 x 3/64	1
16	T12-466	Bearing - 5/16 ID x 1/2 OD	1
17	T77E-138	Sprocket - 24T 1.182 OD	1
18	S277A-27	Screw - 10-32 x 1/2 Button Head	4
19	S96A-14	Washer - #10	4
20	S93-4	Shakeproof - #10 Washer	4
21*	S93-2	Washer - #6 Shakeproof	1
22	S21A-2	Screw - 6-32 x 1/2 Socket Head	6
23	S85A-3	Lockwasher - #6 Spring	6

*Not shown.

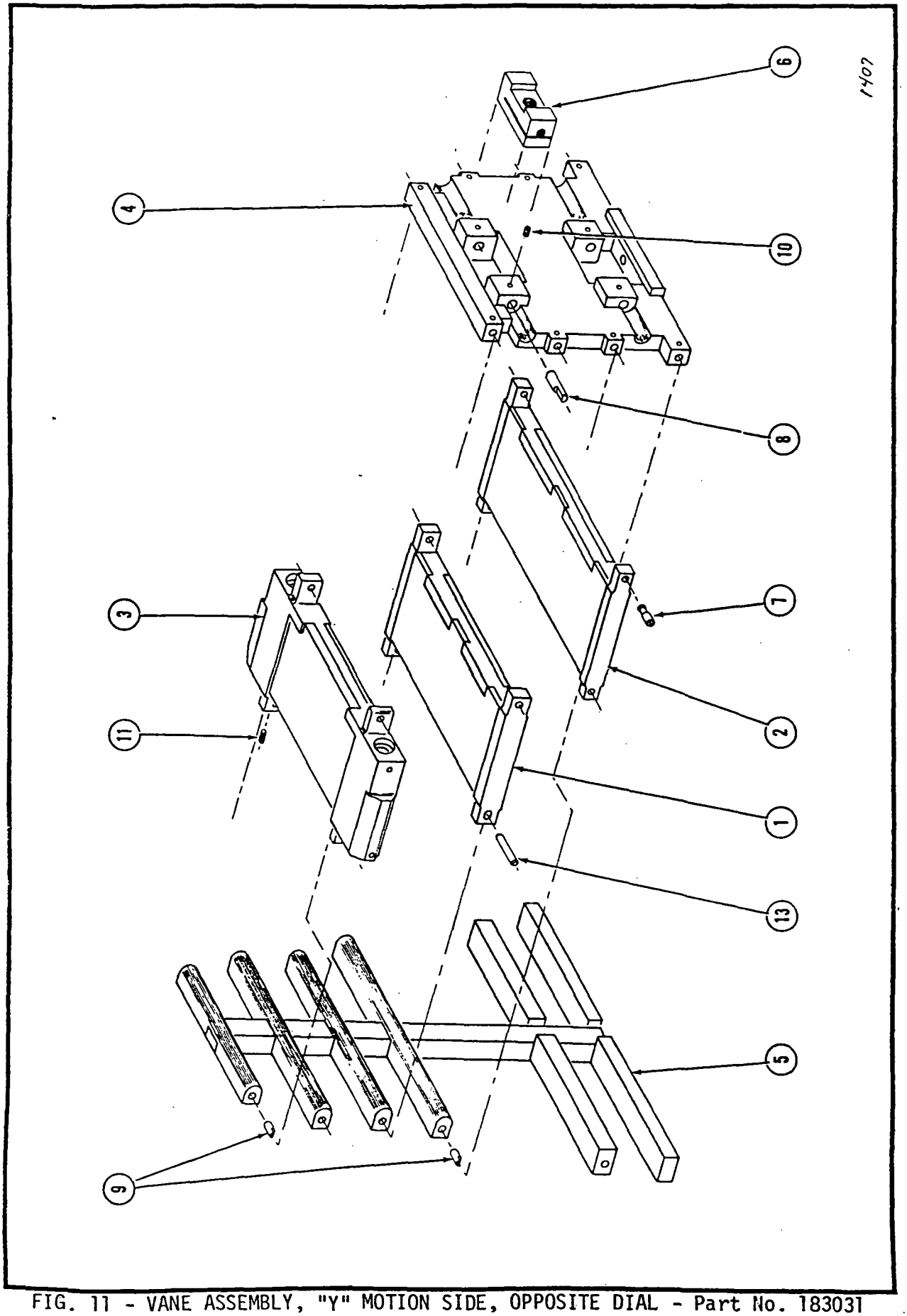


FIG. 11 - VANE ASSEMBLY, "Y" MOTION SIDE, OPPOSITE DIAL - Part No. 183031

FIG. 11 - VANE ASSEMBLY, "Y" MOTION SIDE, OPPOSITE DIAL - Part No. 183031

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
11 -	183031	Vane Assembly, "Y" Motion Side, Opposite Dial (See Fig. 1, Item 27)	
1	183030	Intermediate Vane	2
2	183029	Bottom Vane	1
3	184019	Vane - Bushing Assembly	1
4	54828B	Rear Plate	1
5	59519	Tungsten Tree Machining	1
6	T4-448	Lead Screw Nut (Left Hand)	2
7	T14D-182	Vane Pivot Pin	6
8	T14D-186	Lead Screw - Pivot Pin	4
9	T14D-198	Pin - Pivot Tungsten Tree	4
10	S33-12	Screw - 8-32 x 1/8 Socket Set Cup Point	10
11	S33-99	Screw - 4-40 x 3/16 Socket Set Screw, Cup Point	6
12	S301-97	Loctite - Grade "HV"	A/R
13	T14D-241	Pin - Dowel	4

C/9 MAINTENANCE MANUAL

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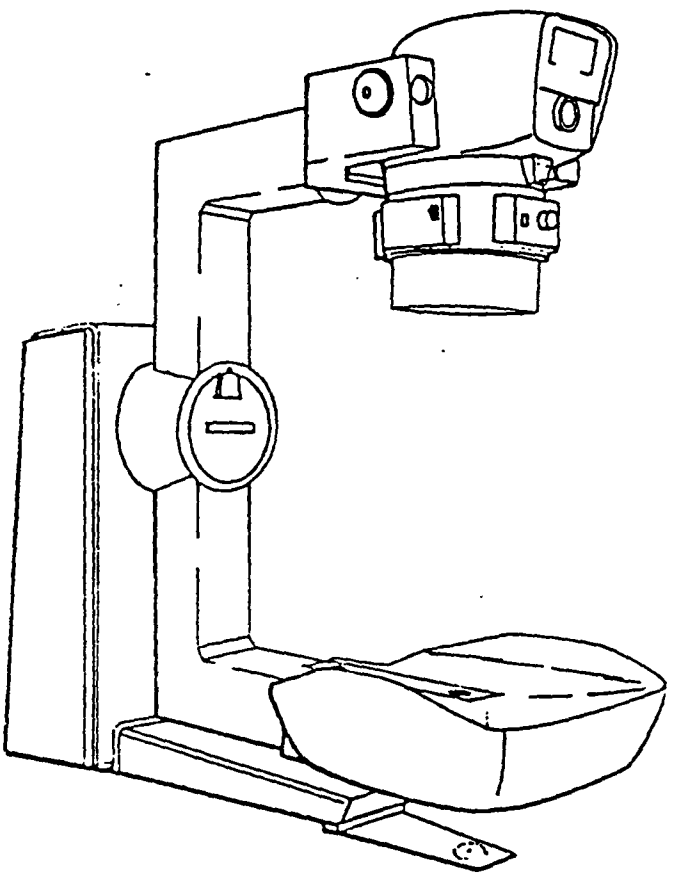


INTRODUCTION

This MAINTENANCE MANUAL has been compiled to instruct and aid in the general and preventative maintenance of the AMS C/9 unit. The procedures contained herein are not all-inclusive in regard to the total servicing and/or calibration required for the proper function of the equipment.

NOTE

Responsibility for securing the appropriate regulations and guidelines for the maintenance and calibration of radiation therapy equipment belongs to the equipment licensee (user).

Section 1 of this manual begins with a routine maintenance schedule. The schedule provides a suggested frequency for inspecting and servicing components and/or functions of the C/9 unit.

Those procedures with titles accompanied by an asterisk (*) are intended exclusively for a "qualified expert" in radiation therapy techniques. Also, the following "WARNING" pertains to the devices involved in any such procedure.

QUALIFIED EXPERT: With reference to radiation protection, a person having the knowledge and training to measure ionizing radiation, to evaluate radiation safety techniques, and to advise regarding protection needs. With reference to the calibration of radiation therapy equipment, a person having, in addition to the above qualifications, training and experience of the clinical applications of radiation physics to radiation therapy. (NCRP Rep. No. 33)

WARNING (*)

ANY MAINTENANCE OR REPAIR OPERATIONS ON A TELETHERAPY UNIT INVOLVING WORK ON A SOURCE DRAWER, THE SHUTTER, OR OTHER MECHANISM THAT COULD EXPOSE THE SOURCE, OR COMPROMISE THE SAFETY OF THE UNIT AND RESULT IN INCREASED RADIATION LEVELS SHALL BE PERFORMED ONLY BY PERSONS SPECIFICALLY AUTHORIZED BY THE NRC OR AN AGREEMENT STATE TO PERFORM SUCH SERVICES.

Section 2 is an electrical circuits description, composed to assist maintenance personnel in locating any particular electrical problem.

Section 3 contains troubleshooting charts including suggested corrective actions. The areas covered are; electrical troubleshooting, mechanical troubleshooting, and troubleshooting the VG8 unit.

CAUTION

UPON COMPLETION OF ANY INSPECTION OR SERVICING OF THE C/9 UNIT, A THOROUGH CHECK OF THE UNIT SET-UP AND TREATMENT FUNCTIONS IS REQUIRED. RESPONSIBILITY FOR THE VERIFICATION OF PROPER UNIT FUNCTION BELONGS SOLELY TO THE "QUALIFIED EXPERT".

Section 1
ROUTINE MAINTENANCE

The following is a schedule of the maintenance required on the C/9 Cobalt-60 Units. Following this chart is an explanation of each item listed and what should be done at the scheduled time. By carefully following these procedures, the risk of injury, maladjustment or prolonged shut-downs for servicing can be minimized.

PART/FUNCTION	PROCEDURE REQUIRED	FREQUENCY	Page
Mode selector switches	Check operation of each	1 week	1.2
Treatment Timer *	Check timer accuracy	"	1.2
Shutter *	Opening and closing time, Position Indicators	"	1.1
Optical distance indicator *	Check accuracy	1 month	1.2
Yoke centering switch *	Check zero-centering and isocentric accuracy	3 months	1.3
Head-Tilt centering switch *	Check zero-centering and isocentric accuracy	" "	1.4
C-arm centering switch *	Check zero-centering	"	1.2
Stand	Tighten bolts	6 months	1.5
C-arm and Drive sprocket	Tighten bolts	"	1.5
Head-Trunnion	Tighten bolts	"	1.5
Barrier/counterweight	Tighten bolts	"	1.6
Zonegard *	Check mercury switches, lamps	"	1.6
Shutter V-belt *	Check wear	"	1.6
Drive gear reducer/sprocket	Lubricate, inspect	12 months	1.7
Drive chain	Lube, adjust, inspect	"	1.8
Slip rings	Inspect, service	"	1.8
Skip-Scan switch	Verify function	"	1.8
Speed controls *	Check accuracy	"	1.13,14,15
Yoke drive	Lubricate gear	"	1.9
Tilt drive	Lubricate gear	"	1.11
Yoke limit switches *	Check function	"	1.9
Tilt limit switches *	Check function	"	1.11
Yoke, Head, C-arm centering switches *	Zero-centering, isocentric accuracy	When Required	1.2,3,4
Yoke-rotation brake	Check, adjust	"	1.9,10
Head-tilt brake	Check, adjust	"	1.11,12

* CAUTION: Service and/or adjustments may be performed only by personnel licensed by the NRC or an Agreement State to service Cobalt Units.

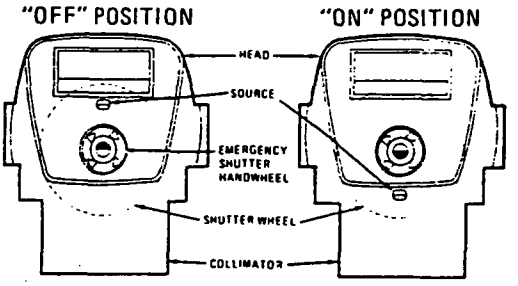
SHUTTER CLOSING AND OPENING TIME *

* CAUTION

WHENEVER CHECKING THE SHUTTER, DRIVE BELT, OR LAMPS, BE SURE YOU READ THE WARNINGS TO SERVICE PERSONNEL IN THE FRONT OF THIS MANUAL. SERVICE/ADJUSTMENTS MAY BE PERFORMED ONLY BY PERSONNEL LICENSED BY THE NRC OR AN AGREEMENT STATE TO SERVICE COBALT UNITS.

WARNING

IF THE SHUTTER OPENING OR CLOSING REQUIRES MORE THAN TWO SECONDS, CONTACT THE FACTORY FOR ASSISTANCE AND NOTIFY THE OPERATOR TO BE ON THE LOOKOUT FOR A SHUTTER FAILURE UNTIL REPAIRS ARE MADE. A STICKY SHUTTER CAN BE VERY DANGEROUS.



SOURCE TRANSFER MECHANISM

A motorized shutter-drive rotates the shutter wheel (and source) to the "ON" position. A V-belt pulley concurrently winds a heavy clock spring until the "ON" position is reached. The motor acts as a counterpoise against the tightly-wound spring. Counter-force is maintained by the stalled motor at low voltage (70-80VAC) as long as electrical power is applied.

Upon completion of the treatment time, or in the event of a power failure, the spring will automatically return the source to the safely-shielded "OFF" position. Note that while the complete source return process requires a 180-degree reversal of the shutter wheel, only during the first 20-degrees of closing is a meaningful amount of radiation emitted.

To make the shutter test, the treatment room doors must be closed, the white Zonegard lamp lit, and the treatment room cleared of all personnel. Set the Treatment Timer for 1 minute. Insert the shutter key in the control and actuate the keyswitch. Hold for approximately two seconds until the green source position indicator extinguishes leaving the red indicator on. Release the key.

The following sequence should occur:

SOURCE POSITION:	OCCURENCE:
0° (keyswitch off)	Green source position indicator lit
0° to 142° (keyswitch on, held)	Red and Green position indicators lit.
142°	Elapsed time meter starts.
180° (release keyswitch)	Green source position indicator extinguishes, Red indicator on, Red ZONEGARD lamp ON, TREATMENT TIMER starts, ELAPSED TIMER running.

After one minute, the shutter should close extinguishing the red indicator lamp in the control, leaving the green indicator lit.

OPTICAL DISTANCE INDICATOR

- Place the C-arm at its 0° position, with the extenders removed.
- Place the alignment fixture paddle at a distance of 35cm (13-29/32 inches) from the bottom edge of the lowest fixed trimmer bar.
- Turn on the collimator field and optical distance indicator lamps.

The etched reticle in the distance indicator contains a graduated scale ranging from 55cm to 100cm. The 80cm mark on the projected localizer scale should fall on the intersection of the collimator cross hairs, +/-2mm.

To adjust the distance indicator,

- Loosen the four screws that secure the lamp bracket to the collimator.
- Adjust the three set screws in the bracket until the 80cm graduation falls on the intersection of the cross hairs.
- Check the alignment (+/-2mm) at the 60 and 100cm positions. (Assure proper source to image distance.)
- Tighten the four lamp bracket screws.

TREATMENT TIMER *

Use an accurate stop watch to check the accuracy of the timer. The timer accuracy should fall within a tolerance of +/-1 percent. Use a large time period to minimize errors in measurement.

NOTE

THIS PROCEDURE IS NOT APPLICABLE TO "TIMER ERROR" MEASUREMENTS AS REQUIRED BY THE USNRC.

MODE SELECTOR SWITCHES

All the mode selector switches on the control should be checked for proper funtion. Refer to the General Description section of the OPERATORS MANUAL (T55B-28, Rev. A) for the function of each mode selector.

C-ARM CENTERING SWITCH *

The C-arm centering switch (SW32) is located at the rear of the large C-arm drive sprocket. An actuator depresses the centering switch when the C-arm reaches zero degrees. When rotated in the SLOW speed mode with the pendant handswitch, the C-arm must stop at 0° in either the clockwise or counterclockwise direction.

To adjust;

Place a 10-inch (25 cm) level across the upper-most cap screws which secure the main sprocket. Rotate the C-arm a little in both directions until the two cap screws are level. This is the accurate 0° position to set the C-arm centering switch.

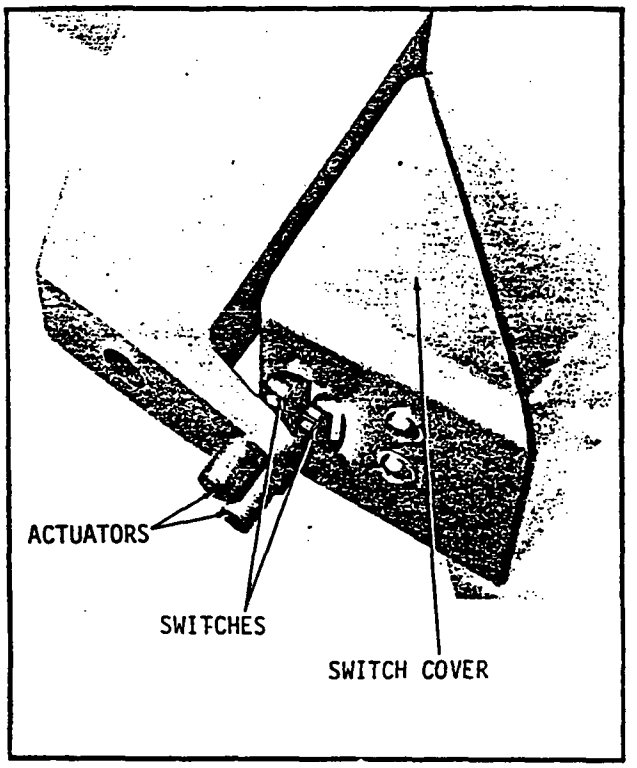
YOKE CENTERING SWITCHES *

During yoke rotation, the head must stop at zero degrees and the collimator cross hairs must focus on isocenter +/-2mm.

Service/adjustments are to be performed only by personnel licensed by the NRC or an Agreement State to service Cobalt Units.

Yoke centering adjustment:

- Referring to INSTALLATION manual T55-570, Rev.A, use the techniques explained to locate the true isocenter of the unit.
- Place the C-arm to its 0° position and turn on the collimator field lamp. The Field cross-hairs must intersect the alignment paddle cross-hairs, +/-2mm, at the true isocentric distance (SAD).
- Remove the covers over the yoke centering switches and actuators, located at the interface of the yoke and C-arm.
- Center the yoke and head for zero-positioning of the cross hairs on the alignment fixture by jogging with the pendant handswitch.
- Position the yoke centering switches so the rollers align with the actuators on the yoke.



- Loosen the lock-set screws in the yoke actuator bracket. Turn the threaded actuators against the switch rollers until a "click" is heard inside the switch. Both switches must be actuated at the same time.

CAUTION

BOTH SETS OF ACTUATORS MUST BE ADJUSTED SO THEY JUST TRIP THE SWITCHES, WITHOUT USING ALL THE OVERTRAVEL BUILT IN.

NOTE

Check actuator points. If a sharp tip is evident, file down to avoid any indentations on the switch roller. Replace switch if damaged.

- Rotate the yoke clockwise, then counterclockwise and observe the cross hair projection on the alignment fixture to verify that centering is consistent from both directions. If not, recenter yoke and readjust the actuator screws.

YOKE CENTERING (cont'd.)

- If the yoke stops before center consistently from one direction and the actuator screws do not correct this condition, then loosen the switch bracket and slide the switch assembly in the direction of rotation. Readjust the actuator screws.
- Check centering again and, if satisfactory, tighten all mounting screws and the actuator set screws.
- Reinstall covers.

HEAD-TILT CENTERING SWITCH *

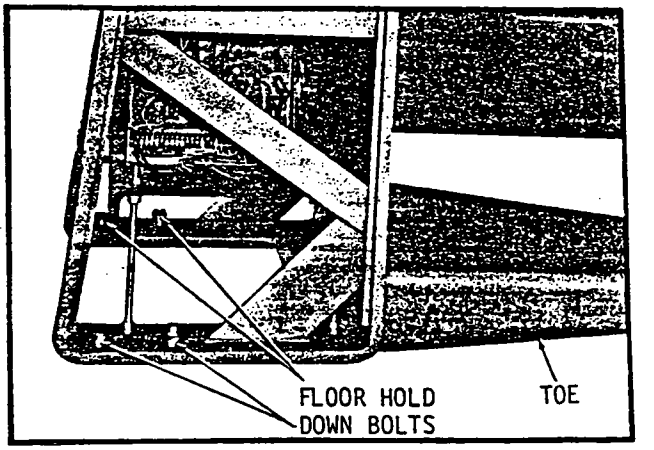
Service/adjustments are to be performed only by personnel licensed by the NRC or an Agreement State to service Cobalt Units.

The head-tilt centering switches (SW30 and 47) are located at the front center of the yoke. The actuators are mounted at the rear center of the cobalt head.

To adjust the head-tilt centering device refer to the Yoke Centering procedure. The head is tilted inward and outward, and the actuators and switches are adjusted to stop the head when centered at zero degrees.

STAND FLOOR BOLTS

Tighten the stand-to-floor mounting bolts/nuts using a large adjustable wrench or a 15/16 open-end wrench.



C-ARM DRIVE SPROCKET

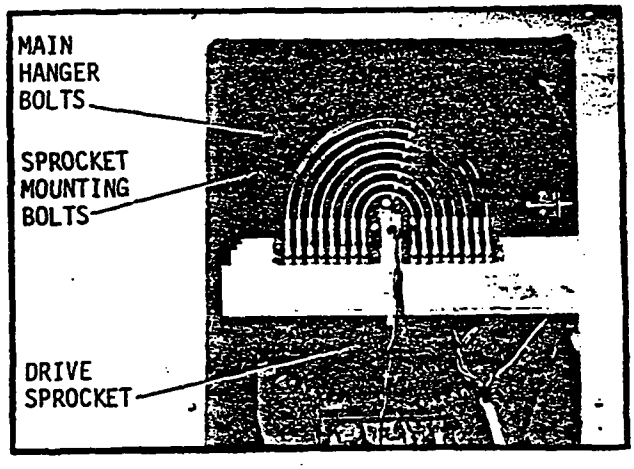
Remove the left-hand shroud from the Stand and note the location of the sprocket mounting bolts. (Ten 5/8 X 18 socket-head screws)

Rotate the C-arm in the SLOW speed mode until a mounting bolt is accessible through the opening above the upper diagonal brace on the left-hand side of the Stand. Mark this screw with a crayon or chalk.

With a 1/2" allen wrench, partially torque the screw. When each of the mounting bolts has been partially torqued, continue the rotation procedure and final-torque each bolt to 240 Ft.-Lbs.(33 Kg-m). (80 Lbs. with a three-foot extension or 120 Lbs. with a two-foot extension.)

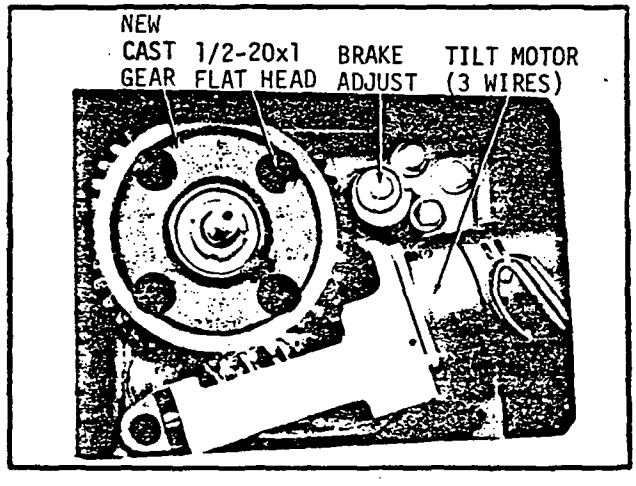
STAND TO C-ARM BOLTS

These bolts are accessible through the ten holes in the large C-arm drive sprocket. Proceed as above to torque each bolt to 240 Ft.-Lbs. (33Kg-m)



HEAD TO TRUNNION AND TRUNNION RETAINER BOLTS

Remove both Yoke arm covers. Rotate the C-arm to,the 90° position. Using 5/8" allen wrench, torque the four bolts in the lower-most arm to 40 Ft.-Lbs.(11Kg-m). Torque the trunnion bearing retainer bolts in the upper-most Yoke arm to the same specification. (The weight of the Head is pulling the trunnion bearing into its seat.) Rotate the C-arm to the 270° position and repeat the torquing process.



RRIER/COUNTERWEIGHT BOLTS

Remove the hanger cover (barrier end) or the counterweight shroud. Using a torque wrench and a 5/8-inch Allen wrench, torque these 3/4-16 bolts to 420 ft.-lbs.(58 Kg-m). Tighten the bottom bolts first. Then, rotate the unit 180° and tighten the remaining bolts. If a torque wrench is not available use a 3-foot extension pipe on the Allen wrench to exert a pressure of 140 pounds or a 2-foot pipe extension to exert 210 pounds pressure.

ZONEGARD LAMPS *

One white lamp and two red lamps illuminate the "Zonegard" window. When only the white lamp is on, the shutter is closed. When the red lamps are on, the shutter is open. The tilt switch (SW6) is located in the Yoke, between the head-tilt limit switches SW28 and SW29. When the head tilt is in the center position, SW6 is closed by the actuator arm, energizing the white Zonegard lamp L2. If the key in the trol is turned to the "ON" position, the white lamp goes out and the red lamps ht, indicating that the shutter is open. For a more detailed description see Section 2.

ZONEGARD MERCURY SWITCHES *

mercury switches, SW8 and SW9, located in the front part of the left-hand yoke , can be adjusted to close the shutter should the angle of yoke-rotation aim the beam toward unshielded areas of the treatment room.

The mercury switches, SW8 and SW9, are connected in series, and the tilt switch SW6, Zonegard Relay (RE22), Collimator limit switches SW23, 34, 35, 37, 38 are all connected in parallel across both SW8 and SW9. Thus, if either the tilt switch is closed or, if both mercury switches are closed, the shutter circuit is complete and shutter can be opened with the control key. The mercury switches are to be itioned to close when the collimator is pointed at a room wall (or floor) thick enough to shield adjacent areas from the direct radiation beam. Thus, the head can be tilted such that the radiation beam no longer strikes the radiation barrier, and the shutter opened, if the radiation beam is directed at a safe room wall.

The exact adjustment of the mercury switches, SW8 and SW9, must be determined in accordance with the radiation shielding design of the room.

SHUTTER V-BELT DRIVE *

As the Cobalt Unit is used, some wear of the V-belt in the shutter drive will occur. It is recommended that the head be vacuum-cleaned whenever the cover is removed, to extract any V-belt residue or dust trapped within.

n installing new V-belts, some adjustment of the idler spring is necessary to alize the shutter opening and closing times. Belt replacement also necessitates reful checking of the shutter operation several times to see that the belt does not take a quick set and begin to slip.

DRIVE GEAR REDUCER

- Remove the right-side stand shroud.
- Remove the oil filler plug (on top of the reducer) and check the level of the oil. If the oil is more than 1/2 inch (13mm) below the filler plug, add A.M.S. # S-304-49 Lubricant until the 1/2-inch level is reached.
- A visual inspection should be made of the gear box for any oil leaks. If oil is evident, tighten all the gear box screws and check that the oil drain plug is tight.
- Inspect the sprocket on the gear reducer shaft. Make sure this sprocket is tight on the shaft. If loose, inspect the 1/4-inch (6.35mm) key and, if worn, replace it with an oversized key.

Replacing sprocket key:

- To install the oversized key, raise the motor-mounting channel just enough to remove the drive chain from the drive sprocket.

WARNING

BE SURE THE C-ARM IS PROPERLY BALANCED OR SUPPORTED BEFORE REMOVING THE CHAIN. REMOVING THE DRIVE CHAIN ALLOWS THE C-ARM TO ROTATE FREELY.

- Remove the four motor-mounting bolts and turn the sprocket and shaft toward you.
- Remove the two sprocket set screws and, with a gear puller, remove the sprocket.
- Remove any burrs from the reducer shaft and the inside surface of the sprocket.
- Place the oversized key in the shaft keyway to assure a positive fit, then remove it.
- Reinstall the sprocket on the shaft with the sprocket and shaft keyways aligned.
- Partially tighten the sprocket set screws, then insert the oversized key.
- Place the sprocket in its original position on the shaft and tighten the set screws.
- Remount the motor/reducer, but do not tighten the mounting bolts.
- Lay a long straight edge (vertically) against the face of the large C-arm sprocket and align the reducer sprocket with the straight edge.
- Tighten the motor-mounting bolts.
- Reinstall the drive chain and lower the motor-mounting channel to tighten the chain. (Refer to Chain Adjust on page 1.8.)

DRIVE CHAIN CHECK/ADJUST

WARNING

REMOVAL OR FAILURE OF A CHAIN ALLOWS THE UNIT TO ROTATE FREELY AND COULD CAUSE INJURY.

Check over the chain for any worn or defective links. Replace the chain, if required.

Attach a pull scale to the drive chain at a point eight inches above the small reducer sprocket. With a horizontal pull of 10 lbs.(4.5 Kg), the chain deflection should be about 1/8" (3 mm).. If the deflection is greater or less, make the adjustments with the mounting channel adjustment studs. Final cneck the adjustment by rotating the C-arm in both directions while observing main drive chain deflection. Readjust as required. Be certain to secure any chain adjustment by tightening the adjust nuts against both sides of the motor-mounting channel!

SKIP-SCAN SWITCH ACTUATION

WARNING

REMOVE THE SHUTTER KEY FROM THE REMOTE CONTROL UNIT DURING THIS CHECK.

Place the C-arm at the 0° position, with all the tabs in the "Tab-out" position. Starting at the 15° tab on the rotational scale, depress four tabs, skip six tabs, then depress four more tabs. Continue in this sequence around the scale.

With the MAIN POWER OFF, remove the C-arm rotational scale pointer, exposing the cam switch, and place the leads of an ohmmeter across the switch terminals.

Energize the unit and, with the pendant handswitch, rotate the C-arm in the "SLOW" speed mode one complete revolution.

The ohmmeter should read zero ohms in the "Tab-in" range, and infinity in the "tab-out" range. If the ohmmeter reads a steady state, the skip/scan switch should be adjusted or replaced.

SLIP RINGS

The Slip Ring assembly should be visually checked. Over time, the lubricant turns black.

With electrical power off, apply alcohol to a soft cloth and carefully wipe the rings to remove all residue. Apply a small amount of Lubri-Plate to the clean rings to provide better slide action and prevent any squealing noise. (If any dust-producing remodeling is in progress, these rings should be cleaned before the unit is placed into operation.)

YOKE DRIVE GEAR

Rotate the C-arm to the 90° or 270° position. Rotate the Yoke so as to point the Collimator downward. Turn off all power to the C-9 unit.

Remove the cover from the Yoke drive assembly. Apply some Lubriplate to the Yoke drive gears. Do not get lubricant on the disc brake.

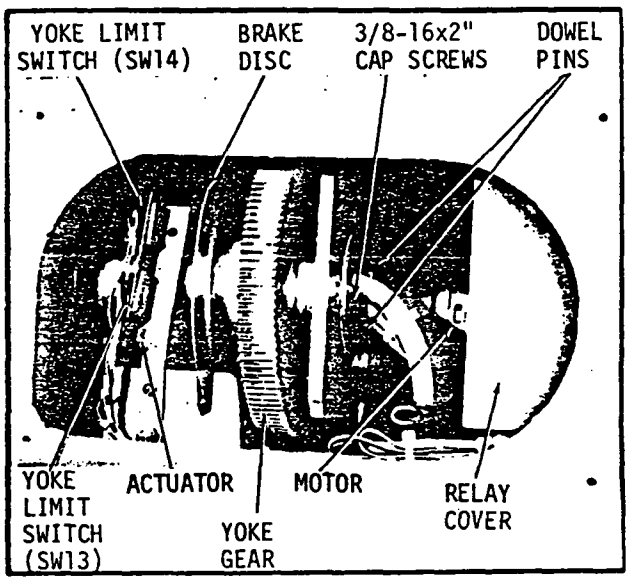
YOKE LIMIT SWITCHES *

The Yoke-rotation limit switches are located just forward of the Yoke drive assembly.

Place the Yoke in the 0° position as indicated on the Yoke angulation scale.

Remove the acces cover from the Yoke drive assembly.

Rotate the Yoke clockwise with the pendant handswitch. The limit switch (SW-14) should inhibit Yoke rotation at 175° from the 0° position. No override of the switch may be permitted. Repeat the check in the counter-clockwise direction. Limit switch 13 should inhibit rotation without overriding the switch. Should the Yoke travel beyond these limits, loosen and reposition the actuator band to actuate the switches at the correct moment.



CAUTION

TO PREVENT DAMAGING THE CABLE ASSEMBLIES CONTAINED WITHIN THE YOKE, NEVER ROTATE THE YOKE CONTINUOUSLY BEYOND 180° IN ANY ONE DIRECTION.

YOKE ROTATION BRAKE ADJUSTMENTS

Routine adjustment:

- With a wrench, turn the hex-head brake adjusting screws counter-clockwise until disengaged from the spring.
- Finger-tighten the same adjust screw in the clockwise direction. The screw is now in contact with the compression spring.
- With a wrench, turn each brake adjust screw 3-1/2 turns clockwise.

If the yoke motor is to be replaced, or the surface of the brake pads become glazed causing a squeal, the following adjustment should be made:

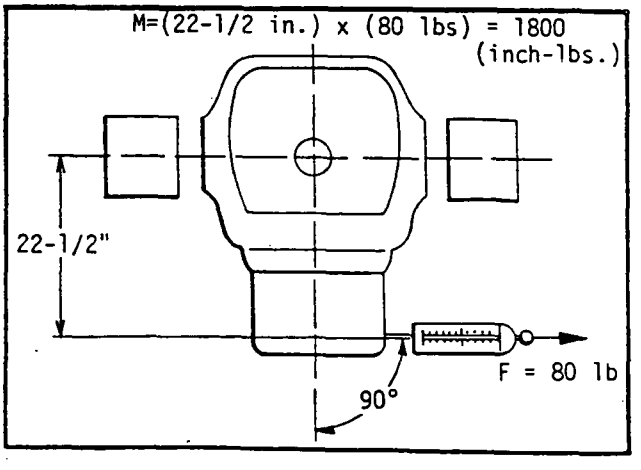
1. Rotate the C-arm to the 90° position, the collimator pointing toward the barrier.
2. Turn off all electrical power to the C/9 unit.
3. Remove the plate covering the yoke rotation assembly.
4. Remove the limit switch bracket, and lay it to one side.
5. Loosen both brake pad adjustment screws until the brake pads clear the brake disc by about 1/8 inch.
6. Remove the brake pad housing.
7. Inspect the brake discs for burrs. Remove any burrs with a flat mill file.
8. Clean brake discs with an alcohol-based solvent.
9. Completely remove the brake pad adjusting screws, tension springs, brake pad holders, and pads from the housing. (Do not attempt to remove the brake pads mounted in the rear of the housing.)
10. Using a flat mill file, remove the glazed surface from the brake pads. Make sure the pad surface remains flat and square. Round-off all sharp edges.
11. Clean pad surfaces with a cloth dipped in an alcohol-based solvent.
12. Apply a thin coat of grease to the brake pad tension spring.
13. Reassemble the brake components. Insert the brake adjusting screws and turn them one revolution.
14. Install the brake housing in the yoke. Position the housing so that the surface of the fixed pads just touch the brake disc. Secure the brake housing to the yoke, replace the four bolts and the dot plugs.
15. Turn the brake adjusting screws clockwise until the brake pads just touch the brake disc, then turn the screws an additional 3-1/2 revolutions.
16. Perform a brake tension test as follows;

    Remove the yoke drive motor from its mounting plate.

    Place the hook of a 100-pound pull scale under the bottom, right side of the collimator frame.

    Adjust brake tension for 80 lbs. (36 Kg) of pull.

    Reassemble yoke drive components and the limit switch function (pg.1.9).



TILT DRIVE GEAR

Rotate the C-arm to the 90° position. Rotate the yoke to the 0° position. Turn off all power to the C/9 unit.

Remove the cover on the right side of yoke, exposing the tilt drive motor and worm gear.

Apply Lubri-Plate to the worm drive.

HEAD-TILT LIMIT SWITCHES *

Switch SW28 limits the outward tilt of the head, while SW29 limits the inward tilt. Both switches are located in the left side of the yoke hanger. Remove cover and position the head to the angular tilt limit as defined in accordance with the radiation sheilding design of the room. Loosen the screw on the actuator arm and place the actuator directly over SW28, making sure the switch arm is fully-depressed. Tighten the actuator arm.

CAUTION

IN ADJUSTING SWITCH SW29 IN THE FOLLOWING STEP,
MAKE SURE THE COLLIMATOR DOES NOT STRIKE THE YOKE .

The actuator arm should depress the switch SW29 when the head is positioned 20° inward. Positon the actuator accordingly.

HEAD-TILT BRAKE ADJUSTMENT

Routine adjustment; (See photo, next page)

- Turn the brake adjusting screw counterclockwise until disengaged from the spring.
- Finger-thread the screw clockwise until a slight resistance is felt.
- Turn the screw an additional 3 to 3-1/2 turns.

Special adjustment;

If the tilt motor should need replacing, or the surface of the brake pad becomes glazed (causing a squeal), the following steps are recommended:

1. Rotate the C-arm to the 90° position, with the collimator pointing toward the barrier.

2. Turn off all electrical power to the unit.

3. Remove the dot plug, pointer cover, and pointer from the right side of the yoke.

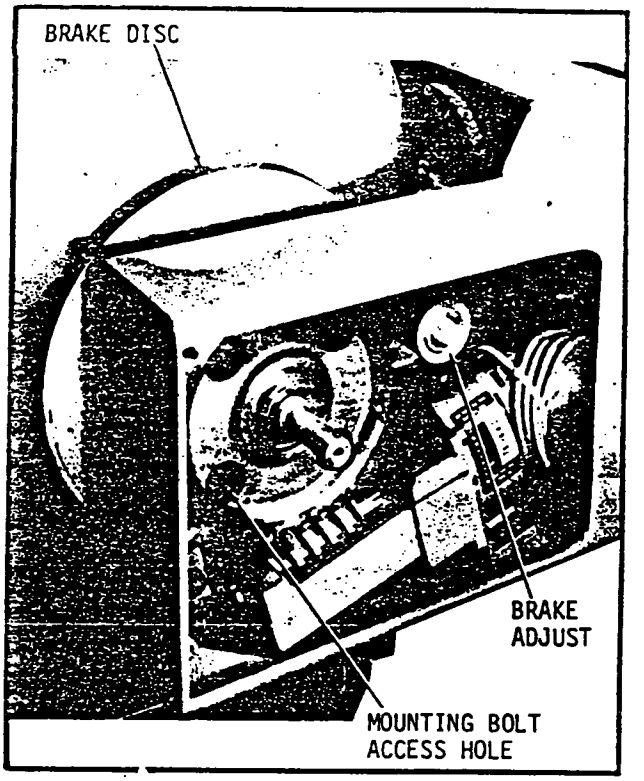
4. Remove the right side yoke cover.

5. Remove the brake adjusting screw, tension spring, and brake pad holder.

6. Remove the inner brake pad housing and any shims by unscrewing the three bolts which secure them to the yoke.

7. Using a flat mill file, remove the glazed surface from the brake pads. Make sure the pad surface remains flat and square. Round-off all sharp edges.

8. Clean pad surfaces with a cloth dipped in an alcohol-based solvent.



9. Reposition the inner brake pad housing on the yoke. The brake pad must touch the brake disc. If the pad does not touch the disc, remove shims until it does. If the pad does not touch the disc without shims, the pad must be replaced.

10. Secure the inner brake pad housing to the yoke with the three mounting bolts.

11. Rotate the yoke counterclockwise until the collimator points toward the floor.

12. Apply a thin coat of grease to the brake tension spring.

13. Reassemble the brake assembly. Insert the brake adjusting screw and turn clockwise until the pad just touches the brake disc. Then, turn the screw 3-1/2 additional revolutions.

14. Perform a brake tension test as follows;

    Remove the motor/worm-drive assembly by removing the three mounting screws.

    Attach the hook of a 100-pound pull scale to the front, bottom edge of the collimator and pull until head moves.

    The reading on the scale should be 55.5 lbs.(25 Kg). (55.5 lbs.x 22.5 in. exerts a momentary force of 1250 inch-pounds.)

    Remount the head-tilt motor/drive assembly.

15. Turn on electrical power and check braking action.

16. Check the head centering switch for proper operation. (See page 1.4)

RATIOTROL C-ARM DRIVE SPEED CONTROL *

The 1385F Stand incorporates a direct-current 1/4 H.P. C-arm rotational drive control. The RATIOTROL drive is a single-phase, 115 Volt, 50 or 60 Hz, SCR speed control. Detailed circuit descriptions, schematics, etc. are provided in Ratiotrol manuals which are part of the C/9 document package.

Controls

The RATIOTROL has been Factory-tested and adjusted prior to shipment. No adjustment should be necessary at the time of installation.

In some cases, due to a difference in line voltage, some adjustment may be necessary. The only controls that might require a readjustment are the MAX, MIN, and LOW SPEED potentiometers.

CAUTION

DO NOT ATTEMPT TO READJUST THE OTHER POTS. IF COMPONENT FAILURES OCCUR IN ANY OF THE PRINTED CIRCUITS, IT IS RECOMMENDED TO REPLACE THE PRINTED CIRCUIT BOARD.

The degree of accuracy is based upon +/- 1% of the maximum degree of rotation per minute. Since 399° is maximum in the stated time, the tolerance should be +/-4°. Therefore, at any setting between 40° and 399°, the accuracy should be within +/-4°.

NOTE: At speeds below 40°/Min. the +/- 1% regulation cannot be assured.

C-arm Speed Adjustments *

To adjust the C-arm rotation, the serviceman must observe the following:

SPECIAL WARNING

THE MACHINE MUST NOT BE TURNED ON IF THERE IS SOMEONE IN THE ROOM, AND NO-ONE SHOULD ENTER THE ROOM UNLESS HE IS ABSOLUTELY SURE THE SHUTTER IS TURNED OFF. THE SURVEY METER SHOULD BE USED AFTER EACH OPERATION OF THE SHUTTER AND BEFORE RE-ENTERING THE TREATMENT ROOM. ALSO, THE SURVEY METER SHOULD BE USED TO CHECK UNKNOWN RADIATION LEVELS BEFORE PERSONNEL WORK IN A GIVEN AREA. EACH TIME THE SERVICEMAN ENTERS THE TREATMENT ROOM, THE SHUTTER KEY MUST BE REMOVED FROM THE CONTROL AND PLACED IN HIS POCKET.

WARNING (*)

ANY MAINTENANCE OR REPAIR OPERATIONS ON A TELETHERAPY UNIT INVOLVING WORK ON A SOURCE DRAWER, THE SHUTTER, OR OTHER MECHANISM THAT COULD EXPOSE THE SOURCE, OR COMPROMISE THE SAFETY OF THE UNIT AND RESULT IN INCREASED RADIATION LEVELS SHALL BE PERFORMED ONLY BY PERSONS SPECIFICALLY AUTHORIZED BY THE NRC OR AN AGREEMENT STATE TO PERFORM SUCH SERVICES.

Minimum Speed Check *

To check the minimum speed the following steps are recommended:

1. Turn on the control. The field of the motor is now energized. It is recommended to leave the power on approximately 45 minutes before using the C/9 unit, in order to bring the motor up to the optimum temperature. Place the shutter key in your pocket.

2. Using the pendant switch, rotate the C-arm to zero degrees.

3. Clear the area around the C-arm arc of travel. Leave the room and close the door.

4. Set the speed selector (degrees/minute) on the VG-8 Control to 40-degrees/minute.

5. Set the timer for one minute.

WARNING

THE FOLLOWING STEP CREATES A "SOURCE ON" CONDITION, AND FULL RADIATION WILL BE PRESENT. TAKE ALL NECESSARY SAFETY PRECAUTIONS.

6. Set DIRECTION SELECT to clockwise, turn the Keyswitch and hold until the red source position lamp illuminates. At the instant the red light illuminates, depress the ROTATE Switch.

NOTE

Should the Rotate Switch not be depressed at the instant the red light comes on, a timing error will be induced by the operator and wrongly indicate an out-of-spec. condition.

7. When the C-arm stops rotating after one minute, and making sure the shutter is closed, enter the treatment room and note the angular position of the C-arm rotation scale pointer.

8. If the pointer indicates between 36° and 44°, the rotation speed falls within tolerance.

9. If the rotation speed is greater or less than specified in Step 8, then remove the back panel of the C/9 stand. Open the hinged cover of the RATIOTROL and proceed to adjust the MIN Speed Pot according to "FAST SPEED Adjustments," page 1.15.

Maximum Speed Check *

1. Repeat Steps 1, 2, and 3 under MIN Speed Check.
2. Set the speed selector on the VG-8 Control to 399°/min.
3. Repeat steps 5 through 7, above.
4. If the pointer indicates between 395 and 403 degrees, the rotation speed is acceptable, since it falls within the +/- 4-degree tolerance.
5. If the rotation speed is greater or less than specified in Step 4, open the hinged cover of the Ratiotrol and proceed to adjust the Maximum Speed. (See "Maximum Speed Adjust", page 1.16.)

"LOW SPEED" Adjustment of C-arm *

The pendant handswitch is used to control the C-arm in this procedure. The C-arm can be adjusted to as slow a speed as desired by the radiologist.

1. To adjust, place the FAST-SLOW switch to the SLOW position.
2. Rotate the C-arm with the pendant handswitch.
3. While the C-arm is rotating, adjust the LOW SPEED potentiometer, located on the cover of the RATIOTROL to the desired speed.

CAUTION

TOO HIGH A SETTING WILL CAUSE AN OVERRIDE CONDITION FOR THE C-ARM CENTERING SWITCH.

Circuit Protection

Line protection is provided by a 30 amp circuit breaker (CB-1). The drive motor armature circuit is protected by an electronic load sensing device. Both are contained within the Ratiotrol chassis.

"FAST SPEED" Adjustments:

Minimum Speed Adjust:

Should the C-arm be rotating too slow or too fast at the 40°/min. setting, adjust the large MIN SPEED (Fine adjust) potentiometer located in the bottom half of the Ratiotrol. Clockwise adjustments increase the rotation speed. Check the speed after each small adjustment of the potentiometer.

Should the adjustment of the fine MIN. SPEED potentiometer above be inadequate, proceed to make very small adjustments of the Min. Speed pot. (R-1), located on the Input printed circuit board inside the Ratiotrol cover. Note that very minor adjustments of R-1 have very large effects on the rotational speed.

After the minimum speed is set, check the maximum speed. These two controls interact with each other. The maximum speed may now have to be readjusted.

Maximum Speed Adjust:

Should the C-arm rotate faster or slower than required at the 399°/Min. setting, the Max. Speed Pot. will have to be adjusted. The pot is located on the lower left portion of the Control Board. CW rotation of the pot will increase the maximum speed as indicated by the arrow on the Control P.C. Board. Very small adjustments of this potentiometer have very large effects on the rotation speed.

After the maximum speed has been set, check the minimum speed function. As these two controls interact with each other, the minimum speed may now have to be readjusted.

Speed Setting Problems:

NOTE

When initiating rotation of the C-arm, one must turn the Keyswitch and hold it until the red source position lamp illuminates. At the instant the red light illuminates, depress the Rotate Switch. Should the Rotate Switch not be depressed at the instant the red light comes on, a timing error will be induced by the operator and wrongly indicate an out-of-spec. condition.

Due to manufacturing tolerances, aging, or line voltage differences, the proper speeds may not be attainable without further adjustments. Before making any further adjustments, every effort must be made to adjust the speeds using the Max. and Min. Speed Pots.

Refer to the Ratiotrol manual (page 15) before proceding with an adjustment of the I.R. compensation.

The I.R. Comp. Pot (R9) is located near the Max. Speed Pot. at the bottom of the Control P.C. Board. This pot is factory sealed with red paint and should be adjusted only as a last resort. Turn the pot R9 CW very slightly. When this is done both Min. and Max. Speed Pots. must be readjusted.

Caution must be taken as instability will occur should the I.R. Comp. Pot be turned too far CW. If this occurs, a "hunting" action will be observed as the C-arm is rotated. At this point the I.R. Comp. Pot must be turned CCW to regain stability.

Final Checks - IMPORTANT

After all speed settings are complete, check both Max. and Min. speeds in the CW and CCW directions. Speed checks at 100°/Min., 200°/Min., and 300°/Min. should be made to verify linearity. If any of the above do not meet specifications, the adjustments must be repeated. Should repeating these procedures prove inadequate notify Advanced Medical Systems service department.

SECTION 2
ELECTRICAL CIRCUITS DESCRIPTION

DEPENDENT CONDITIONS

The following circuit descriptions are applicable when;

SLOW/FAST switch (SW19) in SLOW position
C-arm at zero degrees (SW32 closed)
Yoke rotation at zero degrees (SW31 & 48 closed)
Head tilt at zero degrees (SW6, 30, & 47 closed)
Collimator field less than 32X32cm (SW33 & 34 closed)

These conditions shall be assumed to exist unless otherwise noted.

Refer to C/9 schematic diagram E-200070. All relays and switches are detailed in the quiescent state. Note that relays 13, 16, 19, & 23 are latching relays. Any 110 volt pulse will cause a latching relay to change position and mechanically latch in that position until pulsed again.

POWER ON

The MAIN power switch (SW1) engages the L1 (common) and L2 (hot) lines of a 117-VAC power source. When SW1 is tripped, the MAIN Switch Indicator (lamp 1), the white ZONEGARD lamp (lamp 2), and the Green SOURCE POSITION INDICATOR lamp (lamp 3) are illuminated.

Also, transformers T1 & T7 are energized. T1 supplies 6.3 VDC to the Localizer (Optical Distance Indicator) and Backpointer lamps; L9 & L11 respectively. T7 supplies 24 VDC to the Collimator Vane-positioning Motors. Relay 1 is energized, enabling the shutter circuits.

HEAD TILT CIRCUITS

These circuits are controlled from the pendant handswitch, only. There are no Head-tilt or Yoke-rotation controls at the Remote Control Console. As such, the two circuits are used only during treatment set-ups.

HEAD TILT IN

To actuate TILT-IN, depress the Handswitch Enable (SW49) and the Tilt-In push-buttons on the handswitch to energize the Tilt-In relay (RE17), closing contacts RE17B & RE17C. The Tilt Motor drives the Head toward the Stand until either of the depressed handswitches are released or the Tilt-In Limit Switch (SW29) is engaged.

HEAD TILT OUT

Depressing the Handswitch Enable and Tilt-Out pushbuttons energizes the Tilt-Out relay (RE18), closing contacts RE18B & RE18C, and powers the Tilt Motor in the CW direction. The tilt motion continues until either of the depressed handswitches are released or the Tilt-Out Limit Switch (SW28) is engaged.

HEAD TILT CIRCUITS (cont'd.)

NOTE

Switching capacitor leads from the Black motor lead to the Red motor lead reverses the direction of the armature.

HEAD-TILT CENTERING

Switches 30 & 47 are the Head-Tilt centering switches. When the head-tilt motion approaches zero degrees of tilt from either direction, the centering switches become engaged. The tilt-drive relay contacts RE17A or RE18A enable the tilt-centering relay (RE16) to latch, opening RE16B and inhibiting power to the drive motor. At the same time, RE16A closes to bypass SW30 & 47 and inhibit further operation until either the tilt-in or tilt-out pushbutton has been released.

YOKE ROTATION CIRCUITS

Yoke rotation is controlled from the pendant handswitch, only. Power to the rotation motor is supplied through the Handswitch Enable and either the HEAD CCW or HEAD CW pushbuttons.

YOKE ROTATION, CW

Depressing the Handswitch Enable (SW49) and the HEAD CW pushbuttons energize the Yoke CW relay (RE21) and closes contacts RE21B & RE21C. This powers the motor until the Yoke CW limit switch (SW14) is engaged or either of the pushbuttons are released.

YOKE ROTATION, CCW

Depressing the Handswitch Enable and HEAD CCW pushbuttons actuate the Yoke CCW relay (RE20), which closes RE20B & RE20C. The Yoke rotates CCW until either of the pushbuttons are released or the Yoke CCW limit switch (SW14) is engaged.

YOKE CENTERING

When the Head approaches zero degrees of Yoke rotation from either direction, the Yoke centering switches (SW31 & 48) close, latching the Yoke Disable relay (RE19). RE19B opens, inhibiting power to the rotation drive motor. At the same time, RE19A closes to complete a bypass about the centering switches. Only when the HEAD CW or CCW pushbutton is released and depressed again (energizing relay 20 or 21) will another pulse energize RE19 to close the drive circuit and open the bypass around the centering switches.

YOKE CENTERING (cont'd.)

The ZONEGARD Control Relay (RE22) is de-energized when the Yoke Centering Switches close and latch RE19A. Other conditions permitting (see ZONEGARD LAMPS), the de-energizing of RE22 will turn on the Zonegard lamp and enable the Shutter Drive circuits.

When the next latching pulse is delivered to RE19 (driving the Yoke off-center), RE22 is energized and contact RE22A opens to disable the Zonegard lamp, other conditions permitting.

Note that the Mercury switches (SW8 & 9) provide a bypass around RE22A. The position of the Mercury switches was determined in accordance with the radiation-shielding characteristics of the treatment room upon installation, and must not be altered.

C-ARM ROTATION CIRCUITS

HANDSWITCH CONTROL

Depressing the Handswitch Enable (SW49) and C-ARM CCW or CW pushbuttons energize the C-ARM CCW or CW relays (RE14 & 15, respectively). The relays energize RE6 for CCW rotation and RE7 for CW rotation of the C-arm. Rotation continues until either of the pushbuttons are released or, if in the SLOW speed mode, the C-arm centering switch is engaged.

REMOTE CONTROL

When C-arm rotation is initiated from the Remote Control Console, switch 20A energizes RE6 or RE7 directly. The direction of rotation is indicated at the control panel. Engaging the POSITION REMOTE switch CCW or CW (energizing RE6 or RE7) reverses the voltage polarity of the C-arm drive motor armature.

NOTE

The SPEED-DEG./MIN. control on the control console determines the C-arm rotational speed during therapy. A reference voltage is fed from the control to the Ratiotrol through RE14 & 15 normally-closed contacts.

C-ARM ROTATION CIRCUITS, (cont'd.)

SLOW/FAST SWITCH

Switch 19, in the SLOW position, enables the C-arm Centering Switch (SW32) and allows rotational speed adjustments by the LOW SPEED potentiometer, located on the cover of the Ratiotrol unit. (Automatic C-arm centering functions only when the unit is operated from the pendant handswitch, in the SLOW mode.)

Isolation Relay (RE24) enables the C-arm centering relay (RE23) for centering in either direction of C-arm rotation. (RE23A must be closed to energize the drive relays.)

(Assume Counterclockwise rotation) When the centering switch is engaged at zero degrees of C-arm rotation, latching relay 23 is energized, opening RE23A. (With the L1 side of relay 14 open, RE6 is de-energized and C-arm rotation stops.) At the same time, RE25 is energized, switching RE25A. Should the CCW pushbutton be depressed again, RE23 receives another pulse, latching RE23A for rotation. Relay 25 is also energized, switching RE25A. Thus, the automatic centering circuit is reset for actuation in the clockwise direction. Should the CW pushbutton be depressed (C-arm reached center in CCW direction), RE24 is energized, causing relays 23 & 25 to energize. RE23A closes, completing the drive circuit, while RE23B & 25A are reset for the next centering pulse. The C-arm will rotate until the pushbutton is released or the centering switch is engaged.

In the FAST mode, SW19 shorts the normally-closed contact 23A to inhibit the action of RE23. SW19 also directs the speed reference voltage to VCC buss for MAX SPEED.

DYNAMIC BRAKING

The dynamic braking function occurs when both the CCW relay (RE6) and the CW relay (RE7)are de-energized through the dynamic braking resistor (R6). Braking should occur when either of the C-arm (CCW or CW) pushbuttons are released.

RELAY 28

Relay 28 directs a D.C. voltage from the Ratiotrol control bridge to the internal Ratiotrol logic circuits.

HALO CONTROL RELAY

The Halo switch control relay (RE8) has been disabled at the factory and is shown for reference only with earlier C/9 units.

SHUTTER DRIVE CIRCUIT

SHUTTER ENABLE CIRCUITS

The following interlocks must be closed to enable the Shutter Drive motor.

A) Door interlock switch
B) Zonegard Mercury switches (SW8 & 9)
C) Halo Control relay (energized - Do not alter.)

OR

A) Door interlock switch
B) Halo Control relay (energized)
C) Head-Tilt at 0° on tilt scale (SW6)
D) Yoke at 0° on Yoke rotation scale (RE22)
E) Collimator field size less than 32X32cm (SW33 or 34)
OR
Collimator rotated to 0°, 90°CW, or 90°CCW on Collimator rotation scale (SW35, SW27, or SW38)

SHUTTER OPERATION

The above conditions being met, the Shutter Control relay (RE2) energizes when the Treatment Timer (SW4) is set and the Shutter Keyswitch is actuated.

When RE2A closes, power is supplied to the Shutter Drive motor through resistor R2. At 142° of shutter rotation, the Shutter-Open switch (SW39) is actuated to lock in the Control relay R2. R2 may also be locked in when the SKIP-SCAN relay (RE27) is energized. Once the Control relay is locked in, the Shutter Drive motor will remain under power until either the treatment time elapses, or a SKIP condition occurs in the SKIP-SCAN mode of operation.

The Shutter-Open condition may also be inhibited by opening the treatment-room door or by depressing the EMERGENCY bar on the remote control console.

The EMERGENCY bar, when momentarily depressed, de-energizes RE2, turning off the Shutter motor. Gravity and a tightly-coiled spring return the Shutter to the source-off position. Should the Shutter stick, the EMERGENCY bar may be held depressed to reverse-power the drive motor. The Shutter is then motor-driven to the source-off position.

CAUTION

POWERING THE SHUTTER TO THE SOURCE-OFF POSITION BY HOLDING THE EMERGENCY BAR DEPRESSED SUBMITS THE SHUTTER MECHANISM TO SEVERE STRESSES AND MAY DAMAGE IT. HOLD THE BAR DEPRESSED ONLY IF THE SHUTTER SHOULD FAIL TO RETURN WITH THE POWER OFF.

TIMER CICUITS

ELAPSED TIME METER

This timer is energized by switch 10 in the Head, which is mechanically-actuated at 142° of Shutter rotation.

The meter counts up from zero in .1-minute increments. The timer is incremented by a timing cam which actuates SW25 every .1 minutes. The cam is driven by a 50 or 60Hz timing motor with an output shaft speed of 10 RPM.

The ELAPSED TIME METER is reset to zero upon actuation of the SHUTTER KEYSWITCH.

TREATMENT TIMER

The Treatment Timer is a line frequency pulse counter. The counter is preset for a particular time span by the C/9 operator. Upon being energized, the timer will count down the preset treatment time in minutes and hundredths.

The counter may be reset to the original preset value by depressing the actuator, just below the read-out dial face. Resetting the timer in this manner will also reset SW4 to the normally-closed position.

The Timer Driver is located on a subchassis in the Remote Control. It is a line frequency counter and is thereby only as accurate as the main power line frequency regulation.

The timer has two power supplies: a 24VDC unregulated power supply to operate the counter, and a 15VDC regulated source for the intergrated circuits.

Transformer T1 feeds a 50 or 60Hz signal into the timer board which is half-wave rectified by diode CR1. The half-wave pulse train is fed into a Schmidt Trigger wave-shaping circuit in IC-1 (367A1). The output of IC-1 is a square-wave pulse train at the specific line frequency. These square-wave pulses are fed into a divide-by-5 or 6 counter (IC-2) which generates a .1 second clock pulse to trigger two J-K flip-flops in IC-3. There are two jumpers required on the board to determine the proper output frequency. This configuration requires that the line pulses through diode CR2 be in-sync with the counter clock pulses. The enable pulse is fed into IC-1 from normally-open contacts on relay K1. The Schmidt trigger output is fed in IC-4 to enable a NAND gate and buffer. The final output pulse from the buffer (IC-4) fires transistor Q4. Transistor Q4 masters the Darlington transistor Q5 (MJE700). Each Q5 pulse fires the counter index one unit. Diode CR6 and the RC network across the counter coil are used for transient protection of the Darlington Q5 transistor.

The Treatment Timer functions when the Timer Start Relay (K1) is energized by the closing of the Shutter-Open Limit Switch (SW39). When the frequency counter counts down to zero, the normally-closed counter contacts open, breaking the seal on the Shutter Control Relay (RE-2). As RE-2 drops out, the Shutter Rotor will close.

LAMP CIRCUITS

ZONEGARD LAMPS

The ZONEGARD lamp is illuminated WHITE when the C/9 unit is energized, but in the SOUCE-OFF condition, and ONLY when the Collimator central axis is aimed at an area of the treatment room which is safely shielded. The limits of the safe areas are defined by branch circuits including the Mercury switches (SW8 & 9), the Tilt switch (SW6), RE22A, and the parallel combination of collimator switches SW33, 34, 35, 37, and 38.

As the Shutter begins to rotate, the Shutter Home switch (SW11) opens, turning off the WHITE ZONEGARD lamp and turning on the RED ZONEGARD lamps.

The GREEN SOURCE POSITION INDICATOR functions in tandem with the WHITE ZONEGARD lamp.

RED SOURCE POSITION INDICATORS are illuminated when the Shutter rotates from the Home position. The indicators are located on the C/9 head (ZONEGARD RED), in the treatment room entryway, and on the Remote Control Console (RED SOURCE POSITION INDICATOR).

FIELD ILLUMINATION

The Feild lamp receives 20VAC from the T7 transformer, through the 10 amp lamp fuse F7. This lamp is extinguished when the Main power is off, treatment is initiated, or when the Field Lamp switch (SW15) is in the OFF position. The lamp function is mastered through the Field Illumination Relay RE29.

BACKPOINTER/LOCALIZER LAMPS

These lamps receive 6.3VAC from transformer T1. Circuit protection is supplied by line fuse F6.

The Backpointer lamp switch (SW36) is located on the radiation barrier, just behind the lamp port.

The Localizer lamp switch (SW40) is located on the Collimator shroud, along side of the Collimator Field Lamp switch.

MAIN POWER INDICATOR

The MAIN neon indicator (L1) is wired across the main power feed to the Remote Control Console, and is illuminated whenever the MAIN switch (SW1) is closed and fuse F1 is good.

OTE CONTROL UNIT FUNCTIONS

TREATMENT MODE SET-UP

The FAST/SLOW switch (SW19) is placed in the FAST mode in all moving-beam treatment modes. (The automatic centering circuit is locked out.) The Digi-Pot (R9) speed control (SPEED-DEG/MIN) is used to set the C-arm rotational speed at the Remote Control Console.

POSITION REMOTE SWITCH

The POSITION REMOTE switch (SW20) is a double-pole, double-throw type which changes the direction of C-arm rotation by directly energizing RE6 or RE7. The B side of the switch illuminates the CW lamp (L19) or the CCW lamp (L18) above the position emote switch.

DIRECTION SELECT SWITCH

Switch 14 is actuated to select the initial direction of C-arm rotation in the Skip/Scan treatment mode or, when depressed in conjunction with the POSITION REMOTE witch, to rotate the C-arm to the next treatment port in the Index mode.

Actuating the switch changes the position of the Gantry Direction Select Latching Relay (RE13). The CW lamp (L17) and the CCW lamp (L16) above the DIRECTION SELECT switch are controlled through RE13 to indicate the actual direction of rotation.

FIXED TREATMENT MODE

e conditions necessary to allow the shutter drive circuit to energize are;

L1 Side:

1a. Either collimator vane set at less than 32cm
b. Yoke at 0° on the Yoke rotation scale
c. Head Tilt at 0° on the head-tilt scale

OR 2a. Collimator rotated to 0°, 90°, or 270° on rotation scale
b. Yoke at 0° on Yoke rotation scale
c. Head Tilt at 0° on head-tilt scale

OR 3. Zonegard Mercury switches 8 & 9 closed

L2 Side:

1. Treatment Timer set to a time
2. Shutter Keyswitch turned and held

REMOTE CONTROL UNIT FUNCTIONS (cont'd.)

When the keyswitch (SW3) is actuated, relay 2 energizes, closing RE2B and driving the shutter motor to open the shutter. (See Shutter Drive section)

Switches 10, 11, and 39 are mechanically-actuated by the shutter rotor assembly.

Switch 11 opens when the shutter begins to open, extinguishing the white Zonegard lamp (on the head) and lighting the red source position lamps on the head, in the treatment room entryway, and at the remote control console.

Switch 10 actuates at 142° of shutter rotation, turning off the collimator field lamp (if on) by de-energizing relay 29 to open RE29B, and extinguishes the Green source position indicators. Also, the Counter Pulse Motor is energized, causing the elapsed time meter to increment.

Switch 39 actuates when the shutter is fully-open, extinguishing the green source position lamps on the remote control (L3) and in the treatment room entryway (L4), energizing Relay 26 and the exposure timer. The energizing of RE26 completes a seal around the keyswitch, allowing the operator to release the switch while maintaining a source-on condition. Until RE26 is energized, releasing the key-switch will cause the shutter to return, mechanically, to the source-off position.

Treatment will continue until the treatment timer times-out, opening the drive circuit.

ROTATE MODE

Switch 21 enables the Rotate mode and disables the Oscillate and Skip/Scan modes.

The DIRECTION SELECT switch (SW24) is actuated to preset the circuit for the desired direction of C-arm rotation during treatment. Lamps L16 and 17 indicate the CW or CCW direction selected.

To initiate treatment, the ROTATE switch is depressed while the shutter keyswitch is actuated.

The shutter-opening sequence is as described in the FIXED TREATMENT MODE description. The closing of RE2B provides power thru SW27 (4-5 contacts) and depressed SW21 to energize Rotation relay RE9. The ROTATE lamp (L13) is also lighted.

The Rotation Relay (RE-9) seals in and inhibits the Gantry Direction Select Relay (RE-13). Power is supplied thru relay RE6 or 7 to the C-arm Drive Motor. These relays are in-turn controlled by RE13, RE9, and Index Switch (SW-17).

NOTE

Though all push-tabs should be in the Tab-Out position when treating in the ROTATE mode, if Cam switch 23 should be closed when the ROTATE and SHUTTER switches are actuated, the switching of RE2C will send a pulse thru relay 13 before relay 9 can energize to open RE9C. The unintended pulsing of relay 13 will cause the C-arm to rotate opposite to the desired direction.

REMOTE CONTROL UNIT FUNCTIONS (cont'd.)

OSCILLATE MODE

The DIRECTION SELECT switch (SW24) must be momentarily actuated. Index tabs on the C-arm must be depressed for the degree of arc to be covered, with one tab out at each end of the arc to provide the reversing signal to the C-arm drive. The OSCILLATE switch (SW22) on the Control must be held depressed while the keyswitch is actuated.

Depressing the OSCILLATE switch and shutter keyswitch inhibits both the Skip/Scan and Rotate mdes, while energizing the Oscillation Relay (RE10). The Oscillate mode is locked in when RE10 energizes.

Relay contact 10B closes applying power to the common of contact RE13A. Depending upon the state of RE13A, the C-arm will rotate CW or CCW.

Rotation will continue until the end of the preset arc, when the closing of the Cam switch (SW23) will energize the Gantry Direction Select latching relay (RE13).

As previously described, relay 13A contacts are in series with the power drive relay 6 or 7 and will cause one to drop out and the other to energize, reversing the direction of C-arm rotation. This sequence will continue untill terminated by the treatment timer. (The Treatment Timer is represented as SW4 on the schematic.)

SKIP/SCAN MODE

When the Skip/Scan switch (SW27) is closed, relays RE27 (Skip/Scan Auxiliary) and RE11 (Skip/Scan Control relay) are enabled. The Rotate and Oscillate modes are disabled.

As the Cam switch (SW23) is is actuated by the depressed tabs, the source will go to the off position. In the "TAB OUT" areas, the source will be on. Several combinations may be selected around the periphery of the C-arm ring.

Skip/Scan switch 27 must be held depressed while the keyswitch is actuated. Relay 2 energizes as described under the "FIXED TREATMENT MODE" description. Power is provided thru relay 2C contacts to the Skip/Scan switch 27 plus relays 11 and 27.

The Skip/Scan Control relay (RE11) is sealed thru contact 11A. Relay contacts 11B close, energizing CW or CCW rotation as selected with the Direction Select switch (SW24).

Relay 2B contacts have opened the shutter at the start of the cycle, providing that the C-arm cycle was started at a tab-out position (SW23 open). As the C-arm rotates and trips switch 23, relay 12 is energized. Relay 12A is in series with the power drive to the shutter motor. As the shutter closes, switch 10 in the Head opens, stopping the exposure timer motor and de-energizing relay 26. Relay 27 normally-open contacts however are parallel to relay 26 contacts, maintaining the lock in circuit to relay 2. As the C-arm continues to rotate, it moves off the cam, allowing switch 23 to open, reopening the shutter for the next scan area. This Skip/Scan cycle will continue until the Treatment Timer terminates treatment.

REMOTE CONTROL UNIT FUNCTIONS (cont'd.)

INDEX MODE

The FAST/SLOW switch is in the FAST position for all moving-beam treatment modes. Thereby, the DIGI-POT (R-9) speed control is used to set the C-arm rotational speed at the control console, which inhibits the automatic C-arm centering circuit.

The choice of rotational direction is made with the POSITION REMOTE switch on the control console. The C-arm is positioned by depressing both the INDEX and POSITION REMOTE switches at the same time. The C-arm will rotate to the first Depressed-Tab position. The INDEX and POSITION REMOTE switches are released and treatment is initiated by actuating the shutter keyswitch. (The source is off during C-arm rotation.)

When depressing POSITION REMOTE and INDEX simultaneously, the C-arm rotates until a depressed-tab condition interrupts the drive circuit. Power is supplied to the Skip/Scan relay (RE11) via normally-closed contact RE2C when the INDEX switch (SW17B) is actuated. This enables the Skip/Scan Shutter-control relay (RE12). The C-arm rotates in the direction indicated by the Position Select Switch (SW20).

When the CW or CCW relay is powered thru normally-closed contacts RE12B and RE8C, the C-arm will continue to rotate until the INDEX switch is released or a depressed tab is encountered. When this happens, the Skip/Scan Control relay (RE-12) is energized. As RE12 actuates, contact RE12B opens, inhibiting RE6 or 7 by interrupting the SW17, RE12B,,RE8C, and Position Remote Switch (SW20) circuit. As the Cam switch (SW23) is actuated, the INDEX lamp (L15) lights to indicate that the desired position has been reached.

EMERGENCY BAR

The EMERGENCY bar (SW2) will interrupt and inhibit any and all operating functions. If the bar is momentarily depressed, the Shutter-Drive motor is de-energized and allows the Source to return to the home position by means of gravity and a tightly-wound coil spring. Should the rotor stick, the source may be powered to the home position by holding the Emergency Bar depressed.

CAUTION

Structural damage to the head may result should the rotor be powered to the home position. ONLY IN EMERGENCY SITUATIONS SHOULD THE EMEREGENCY STOP BAR BE HELD DEPRESSED.

COLLIMATOR VANE DRIVE MOTOR

24 VAC is supplied by transformer T-7, through fuse F8 to diode bridge CR. The 24 VDC is applied via dropping resistor R-11 to the common poles of the Long Vane Switch (SW-42) and the Short Vane Switch (SW-41). The reversing of these permenant magnet motors is accomplished by reversing polarity to the motor armature. The travel is limited by microswitches located in the collimator. Should an open-limit switch be actuated, the vane still may be powered in the opposite direction.

Section 3
TROUBLESHOOTING

ELECTRICAL TROUBLESHOOTING

TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
1. No power.	F1, CB-1, or line phase reversed.	Replace fuse/reset CB-1. Connect L1 to ground.
	Main power switch (SW1) in control defective.	Replace switch.
	No input power.	Check power to disconnect switch.
2. C-ARM CW, C-ARM CCW pushbuttons do not function.	Circuit Breaker on Ratiotrol.	Reset Circuit Breaker
	Motor defective.	Replace motor.
3. C-ARM CCW pushbutton inoperative.	Relay 6 defective.	Check for 120V AC across coil.
	C-ARM CCW switch defective.	Replace switch.
4. C-ARM CW pushbutton inoperative.	Relay 7 defective.	Check for 120V AC across coil.
	C-ARM CW switch defective.	Replace switch.
5. C-arm rotates in Fast speed only with handswitch.	Ratiotrol defective.	Check for proper speed settings.
	SLOW/FAST switch defective.	Replace switch.
6. C-arm will not rotate clockwise from control console (source off).	Relay contacts RE9B, 10B, 11B, or 8C not closed.	Replace relay.
	Switches SW17 or SW20 defective.	Replace if defective.
	Relay RE6 or RE7 defective	Replace relay.

TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
7. HEAD CW & HEAD CCW pushbuttons do not function.	Yoke motor defective.	Replace motor.
	Capacitor C7 defective.	Check capacitor C7.
	Defective contacts of RE21A, RE20C, RE19A.	Check contacts.
	Above relay coils open.	Check relay coil continuity.
	Pendant Enable switch (SW-49) defective.	Check SW-49 closure.
8. HEAD CW pushbutton inoperative.	Defective HEAD CW switch.	Check switch.
	Yoke limit switch (14) open.	Check switch (SW14).
	Relay 21 coil open.	Make continuity check of coil.
9. TILT IN & TILT OUT pushbuttons do not function.	Switch 17 not closed.	Check SW-17 contacts.
	Tilt motor defective.	Replace motor.
	Pendant Enable switch (SW-49) defective.	Check SW-49 closure.
10. TILT OUT pushbutton inoperative.	Relay 18 defective.	Replace relay.
	Switch (SW28) open.	Check switch (SW28).
	TILT OUT switch defective.	Replace hand tilt switc
	Switch SW30 and SW47 contacts fused together.	Check switch SW30 or 47.
11. TILT IN pushbutton inoperative.	Relay 17 defective.	Check relay.
	Switch (SW29) open.	Check switch.
	TILT IN switch defective.	Replace switch.
	Switch SW30 and SW47 contacts fused together.	Check switches.

TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
12. Shutter does not open.	Keyswitch (SW3) defective.	Replace switch.
	Relay 2 not operating.	Check voltage across relay coil.
	Door switch (SW5) open.	Check door switch.
	Relay 1 inoperative.	Check relay coil and contacts.
	C1 defective.	Check capacitor.
	R2 open.	Check resistance of R2.
	Shutter motor defective.	Replace motor.
	Head positioned beyond room shielding specs.	Reposition head.
	Relay 12 open.	Check coil and contacts.
	Defective Treatment Timer.	Check SW1 open contacts.
13. Shutter does not open in Skip/Scan mode. (source on)	Cam Switch (SW23) not actuated.	Reposition switch.
	Switch SW27 open.	Check switch.
	Relay 11 coil open.	Check relay coil.
	Relay contact RE2C defective.	Clean contacts; replace relay if required.
	RE27 malfunctioning.	Check relay coil and contacts.
	SW21 or 22 switches open.	Check for continuity.
14. Field Illumination Lamp (L10), Back Pointer Lamp (L11), and Localizer (L9) will not light.	Check collimator switch SW-15 and RE-29.	
	Transformer T7 open (L10). Transformer T1 open (L9, 11).	Check for 120V AC across primary and correct secondary voltages.
	Fuses F7, F8 blown.	Replace if defective.
	Ground connection open.	Check terminal 20 on yoke TB-4 for ground.

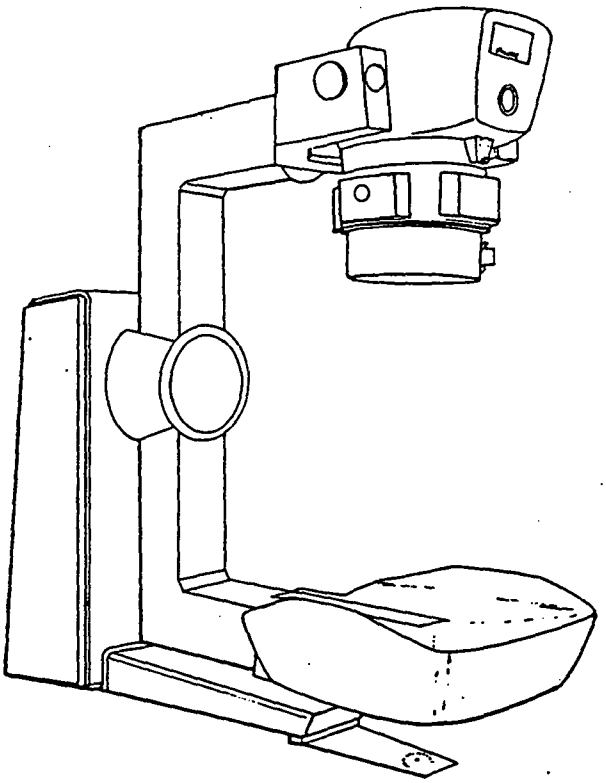
TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
15. Timer and counter do not operate (shutter open).	Switch (SW10) not actuated when shutter starts to open.	Replace if defective. Check switch actuator.
16. Routine check of emergency switch failed to close shutter.	Defective switch 2.	Replace if defective.
	Poor contact on slip ring.	Make continuity check across yoke terminals TB4-4 and TB4-9 with SW2 depressed. Circuit should be closed.
CAUTION CLOSE SHUTTER MANUALLY WITH SHUTTER WHEEL BEFORE CHECKING.	"Close" motor winding of shutter motor open.	Check continuity of motor winding across terminals TB4-2 and 4-9.
17. Elapse Time Counter	Defective SW10 *	Replace Switch
	Defective Timer motor	Replace motor
	Defective cam switch SW-25	Replace Switch
	Defective Counter	Replace Counter
18. Treatment Timer	Defective fuse F1 (inside VG3 timer control chassis).	Replace fuse.
	Defective diode bridge CR1	Replace Bridge
	Defective Power Regulator board.	Replace P.C. board 200018
	Defective Timer Start Relay	Replace K1
	Defective Timer Driver Board	Replace P.C. board 200041,A
NOTE: Should the Timer Driver Board be found defective check diode CR-6 and PC supression circuit located on the back of the counter.		
	Defective Counter	Replace Counter

MECHANICAL TROUBLESHOOTING

TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
1. Squeal present during C-arm rotation.	Slip rings dirty; no lubrication.	Clean with alcohol on soft cloth; apply Lubri-Plate.
2. Squeal present when yoke or head rotates.	Surface of brake pads glazed.	File with flat mill file to remove glaze and clean pads with alcohol.
3. Head or yoke drifts at centerline.	Brakes not adjusted properly.	Adjust brakes (refer to Routine Service).
4. Isocentric alignment varies at various positions of C-arm.	Trunnion mounting bolts require tightening.	Tighten bolts (refer to Routine Service).
	Yoke-to-drive gear bolts require tightening.	Tighten yoke-to-drive bolts.
5. Shutter opening and closing time increased.	Low shutter motor voltage.	Check voltage.
	Damaged gear teeth.	Replace worn gears.
	Excessive friction in motor drive or drive bearings.	Check belt tension; replace defective drive bearings.
6. Backpointer light out of alignment by more than 2mm.	Barrier mounting bolts loose.	Tighten barrier mounting bolts. (Refer to Routine Maintenance).
	Backpointer mirror not adjusted.	Readjust three Phillips head screws on top of backpointer assembly.
7. Optical Distance Indicator inaccurate.	Needs adjustment.	Adjust three set screws in lamp bracket (refer to T55-570 (Rev.A.).
8. Yoke or tilt motor groans.	Brake tight.	Back off 1/2-turn on brake adjust screw.

TROUBLESHOOTING GUIDE FOR RATIOTROL

TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
1. Line fuse blows.	Defective interconnection.	Check all wiring and connections between line, control, and motor.
	Shorted motor field.	Repair or replace motor.
	Defective suppressor.	Replace suppressor.
	Shorted field diode.	Replace all field diodes
	Shorted power diode.	Replace all power diodes
	Shorted SCR.	Replace all SCR's.
	Improper connection of control panel or magnetic contactor package.	Check wiring.
2. Loss of armature current.	Overload.	Remove cause of overload or resize drive HP.
	Defective control-to-motor wiring.	Check all cables and connections between control and motor.
	Open field diode.	Replace all field diodes
	Short circuit in motor.	Repair or replace motor.
	Improper connections of control panel or magnetic contactor package.	Check wiring.
3. Armature current OK, Motor does not run.	Open AC line.	Check branch disconnect switch and AC power sour
	Improper wiring.	Check all AC-to-control wiring and connections.
	Defective motor.	Repair or replace motor.
	Defective control board.	Replace control board.
	Defective IR board.	Replace IR board.
	Open power diode(s).	Replace all power diodes
4. Motor runs at top speed only.	Defective control board.	Replace control board.
	Defective speed pot.	Replace PCB.
	Open field diode(s).	Replace all field diodes
	Improper connection of control panel or magnetic contactor package.	Check wiring.
5. Control cannot be set at zero speed.	Minimum speed pot set too high.	Adjust minimum speed pot (Refer to Procedure).



C9 COBALT^{60} THERAPY UNIT

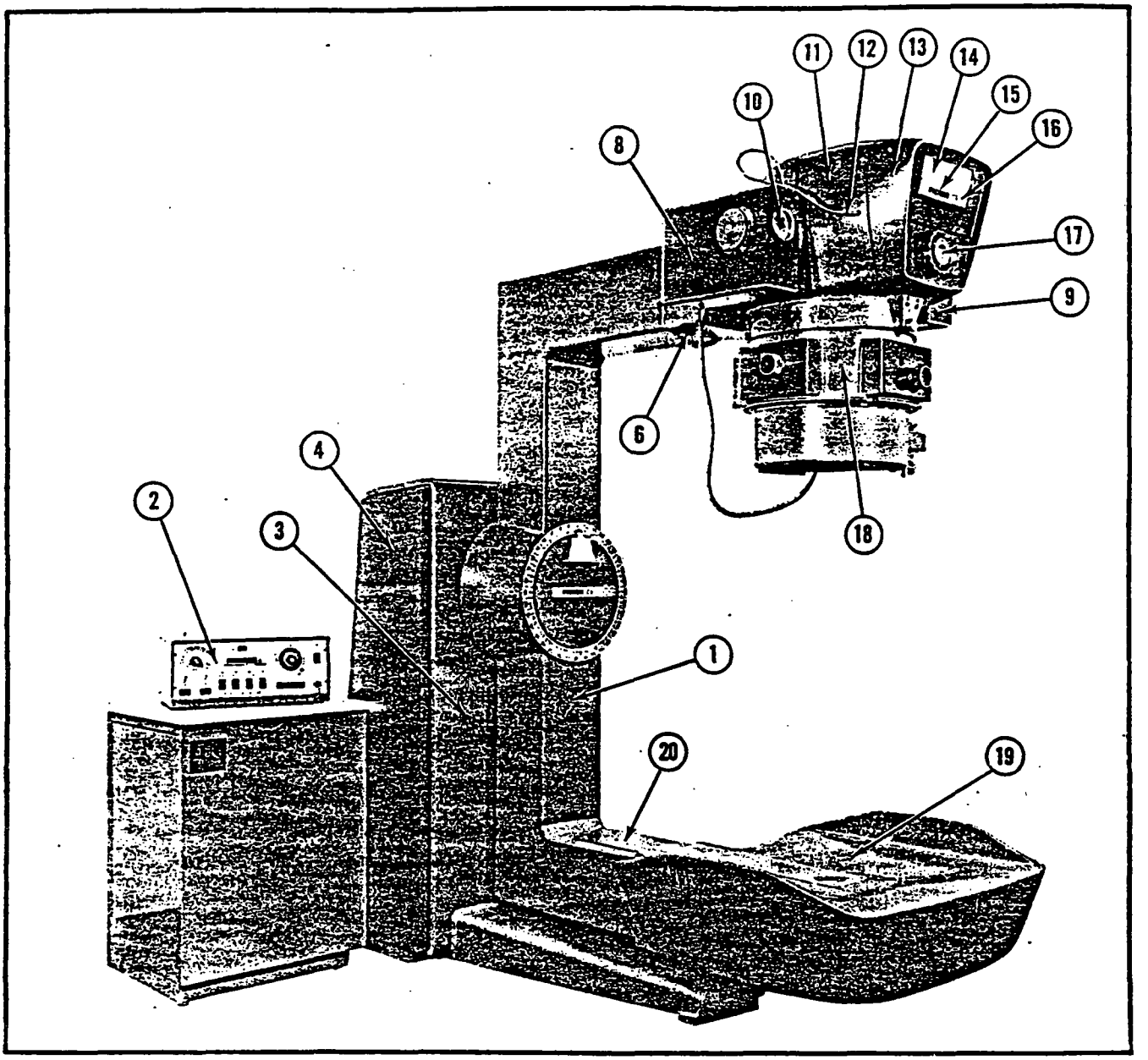
H57:P

PARTS LIST

Cat. 6296 Cobalt^{60} Unit

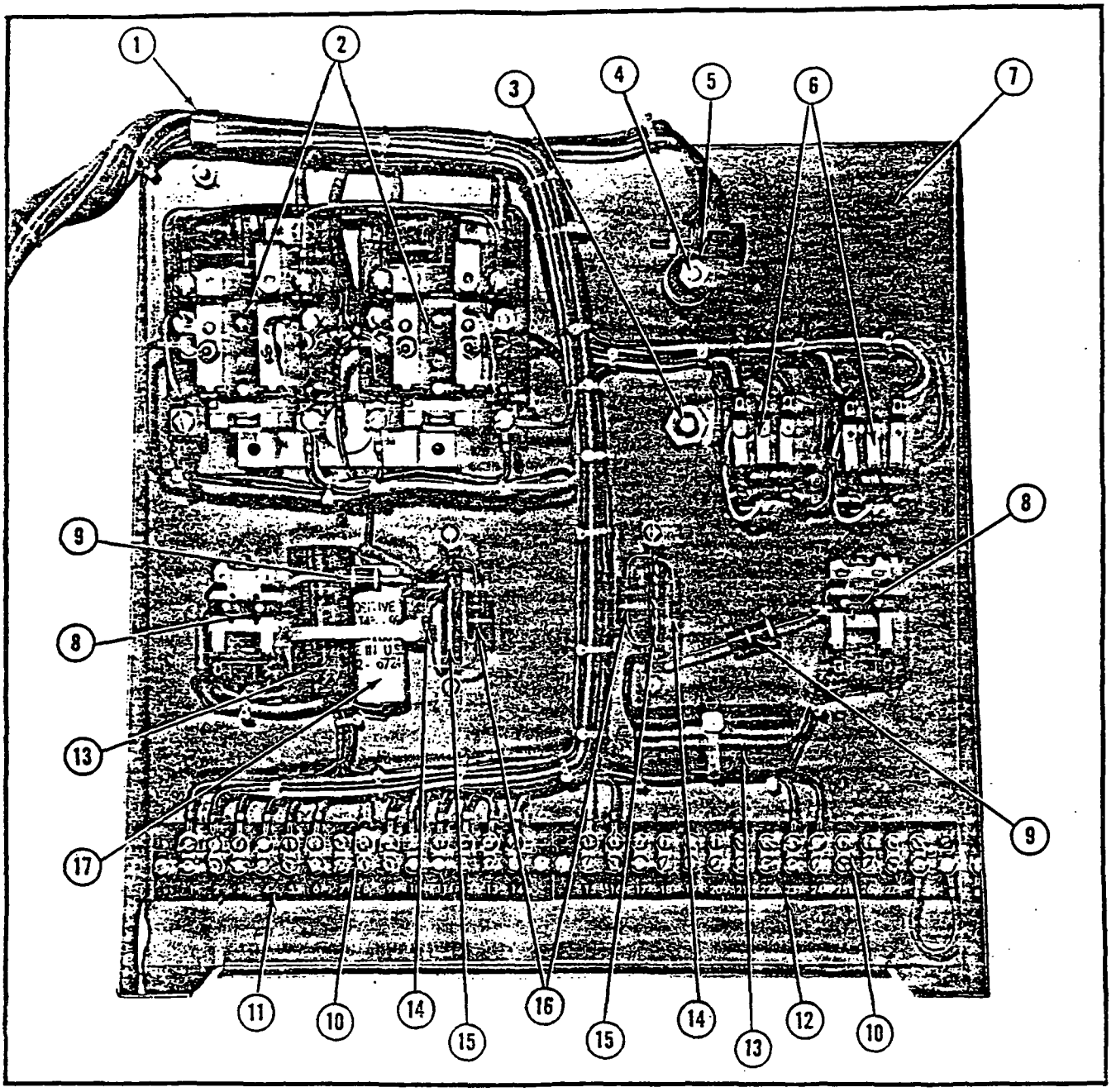
CONTENTS

Printed in U.S.A.



ITEM	DESCRIPTION	PART NO.
	C9 CO60 UNIT & ASSEMBLIES	6296
1	Weldment, C-Arm	46677-C
2	CO60 Control	VG8-B
3	Stand Assembly	1385-D
4	Shroud, Left Hand	46657-A
5*	Shroud, Right Hand	46657
6	Scale, Yoke Tilt	54150-A
7*	Pointer, Yoke Tilt	54151
*	Not Shown	
†	Parts List Not Available at this printing.	

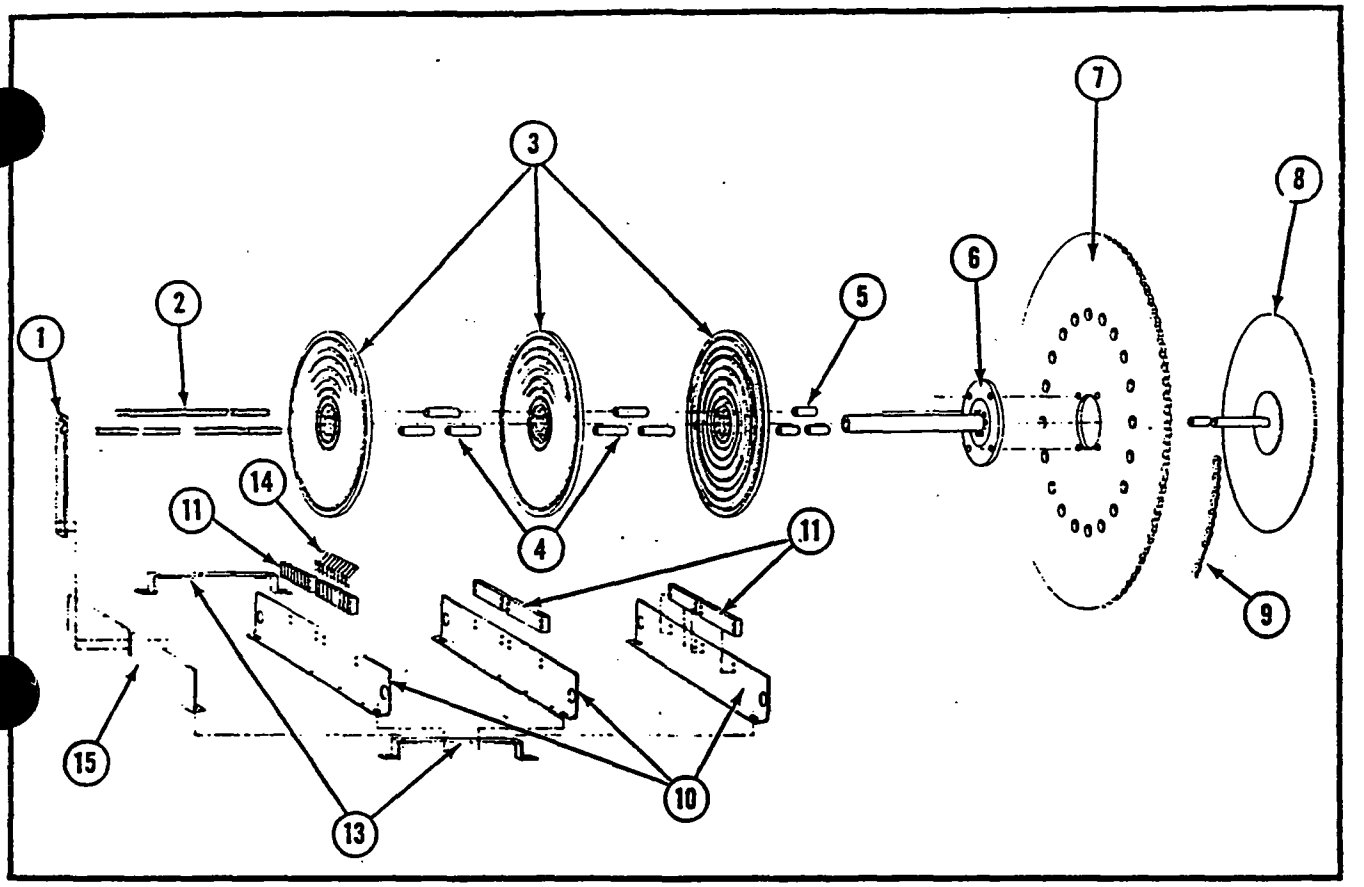
ITEM	DESCRIPTION	PART NO.
8	Cover, Yoke Arm, L.H.	54015-A
9	Cover, Yoke Arm, R.H.	54015
10	Scale, Angulation	13823-E
11	CO60 Head	590-E
12	Cable, Head to Yoke	BL1824-C
13	Front Cover, Head	46672
14	Window	46717
15	Nameplate	T92-193
16	Insert, Nameplate	T92-199
17	Shutter Handwheel	40378-B
18†	Collimator	3706-A
19	Barrier Assembly	16484-B
20	Cover, Hanger	46851



ITEM	DESCRIPTION	PART NO.
	CHASSIS ASSEMBLY	16478
1	Clamp, Cable	T66A-10
2	Relay, DPDT (RE-6,7)	T19A-53
3	Rheostat, 50Ω, 100W (R-3)	T6B-6
4	Resistor, 300Ω, 50W (R-6)	T6-39
5	Washer, Bakelite	T11F-9
6	Relay, 3PDT (RE-14,15)	T19A-150
7	Chassis Panel	46656
8	Relay, DPDT (RE-1)	T19A-105
9	Resistor, 3KΩ, 2W (R-7,9)	T6E-39
*	Not Shown	

ITEM	DESCRIPTION	PART NO.
10	Terminal Strip	T81A-4
11	Marker, Terminal Strip (1-14)	T81B-4
12	Marker, Terminal Strip (15-28)	T81B-21
13	Capacitor, 100mFd (C-1,3)	T45-225
14	Diode (CR-4,5)	T80-43
15	Terminal Strip	T81A-20
16	Resistor, 20Ω, 2W (R-5,8)	T6E-16
17	Capacitor, 30mFd (C-2)	T45-99
18*	Cable, Base to Toe	BL1891-C
19*	Toe Socket Assembly	16832

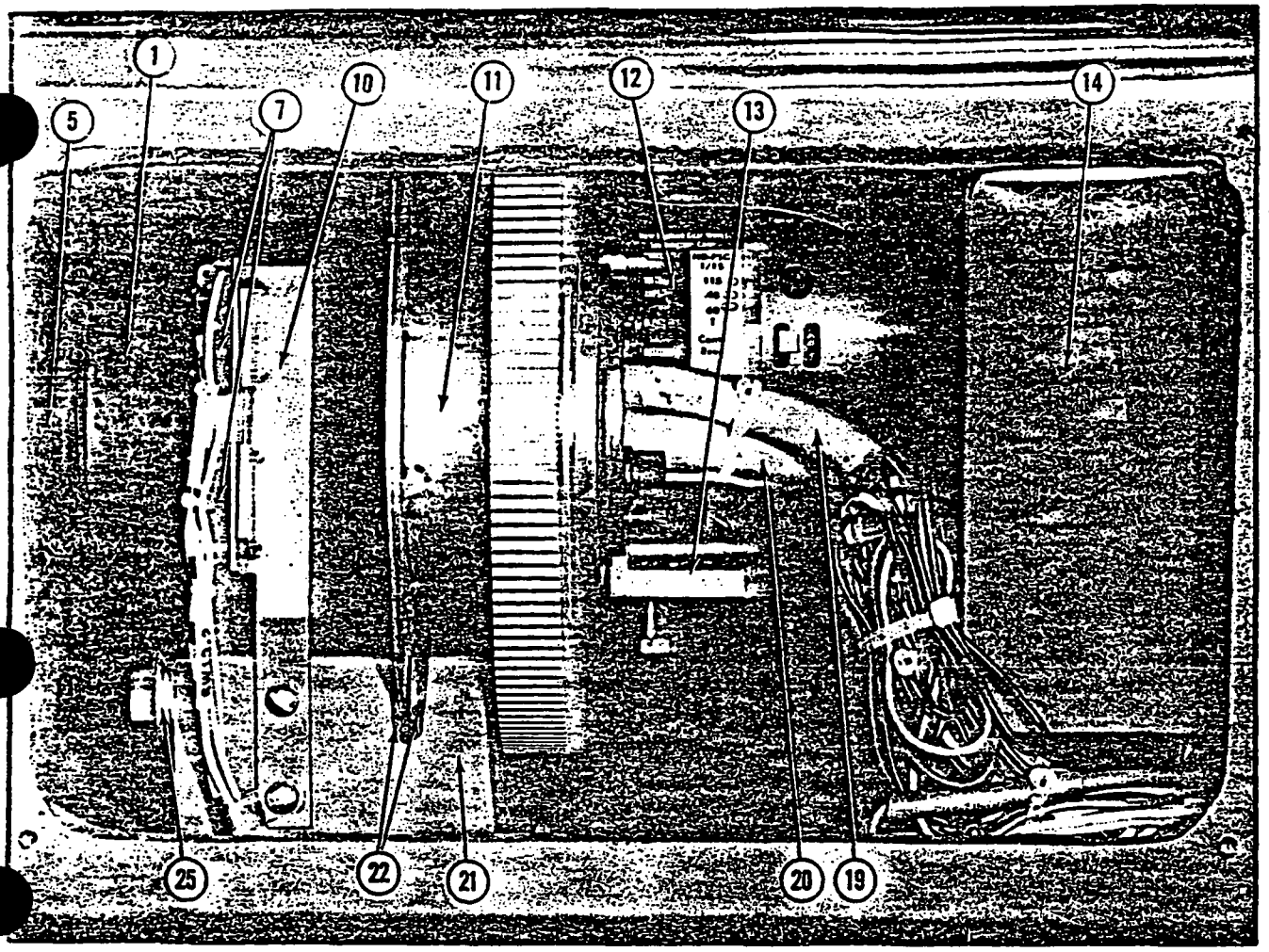
CHASSIS ASSEMBLY



ITEM	DESCRIPTION	PART NO.
	SLIP RING ASSEMBLY	Figure 1
1	Clamp, Fixed Tube	46603
2	Stud	T13-304
3	Slip Ring	46452
4	Stand Off	T10K-29
5	Spacer	T10K-28
6	Shaft Assembly, Slip Ring	15741-B
7	Sprocket	T77E-72
*	Not Shown	

ITEM	DESCRIPTION	PART NO.
8	Mounting Bracket, Rotation Scale Pointer	16441-A
9	Chain	T26-102
10	Angle Bracket	43873-A
11	Terminal Strip	T81A-33
12*	Maker, Terminal Strip	T81B-33
13	Bracket	46604
14	Brush Finger	15742-A
15	Angle Bracket	46605
16*	Rear Shield (Main Bearing)	46659
17*	Bearing (Main)	T12-325

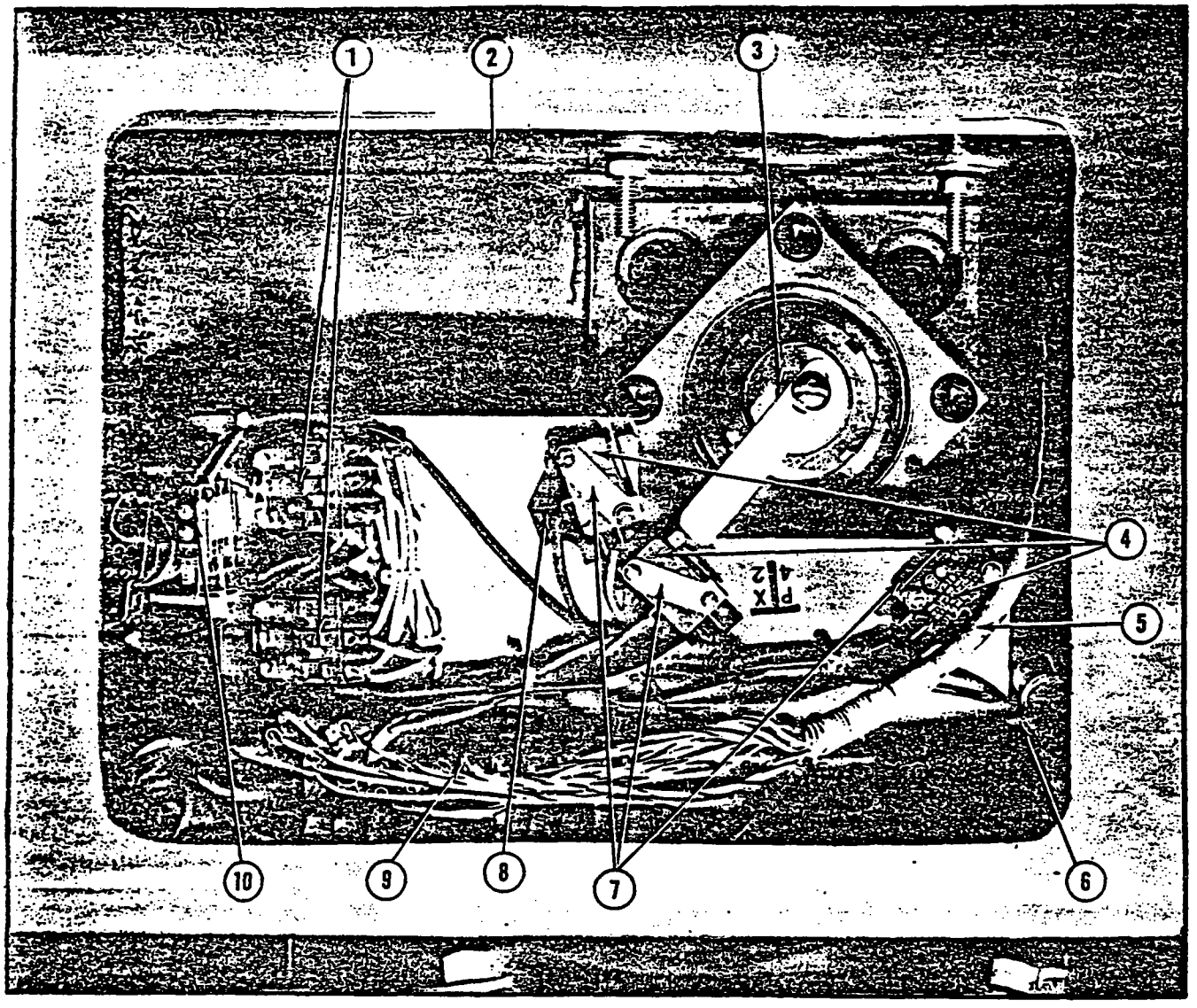
SLIP RING ASSEMBLY



ITEM	DESCRIPTION	PART NO.
	YOKE ROTATION ASSEMBLY	16833
1	Yoke Assembly	180997
2*	Dust Cover, Front Bearing	54135
3*	Roller Bearing, Front	T12-424
4*	Roller Bearing, Rear	T12-228
5	Locknut, Rear Bearing	T4-224
6*	Band, Actuator	54133
7	Microswitch, Yoke Limit (SW-13, 14)	T29A-16
8*	Actuator, Microswitch	34952
9*	Insulator, Microswitch	T9-74
10	Bracket, Limit Switch	54143
11	Gear and Brake Assembly	181007
*	Not Shown	

ITEM	DESCRIPTION	PART NO.
12	Motor, Yoke Rotation	T93G-16
13	Mounting Plate, Motor	55431
14	Yoke Rotation Control	181003
15*	Panel, Mounting	181004
16*	Relay, DPDT (RE-19)	T19A-130
17*	Relay, 3PDT (RE-20, 21, 22)	T19A-150
18*	Capacitor, 4mFd (C-7)	T45-464
19	Cable	BL2347-B
20	Cable	T48-96
21	Brake Housing	54155
22	Pad, Brake	53623
23*	Plunger, Brake Spring	54152
24*	Spring, Brake	T5A-256
25	Plug, Spring Retaining	181006
26*	Cover, Yoke Rotation Assy.	54140

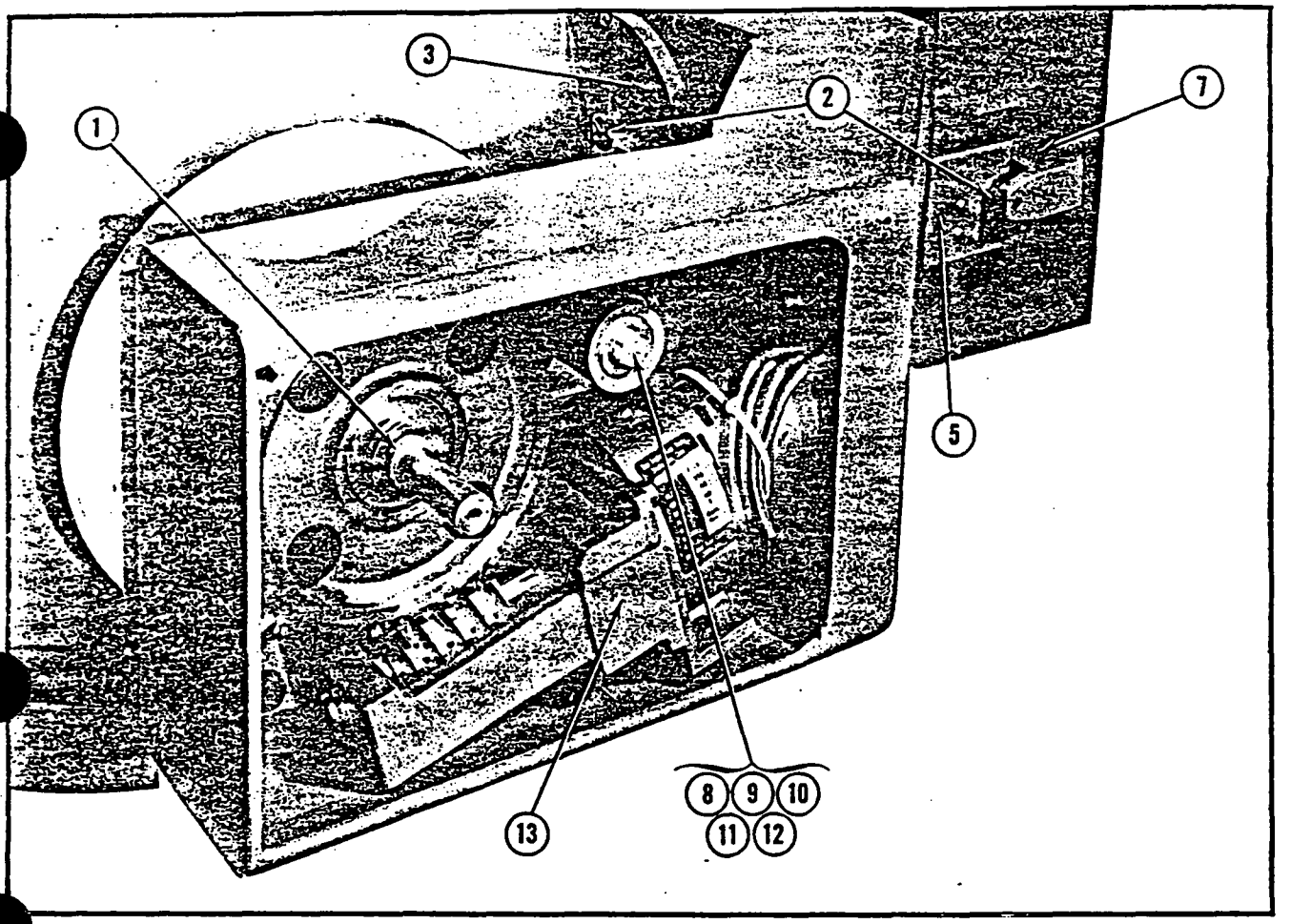
YOKE ROTATION ASSEMBLY



ITEM	DESCRIPTION	PART NO.
	YOKE (LEFT SIDE)	16833
1	Relay, 3PDT (RE-17, 18)	T19A-150
2	Balance Weight	38688
3	L.H. Trunnion Assembly	Figure 3
4	Microswitch (SW-6, 28, 29)	T29A-16
*	Not Shown	

ITEM	DESCRIPTION	PART NO.
5	Cable (Head to Yoke)	BL1824-C
6	Switch, Mercury (SW-8, 9)	T29-98
7	Actuator, Microswitch	35088
8	Spacer, Microswitch	T9-74
9	Terminal Strip	T81A-65
10	Relay, DPST (RE-13)	T19A-130
11*	Capacitor (C-6)	T45-464

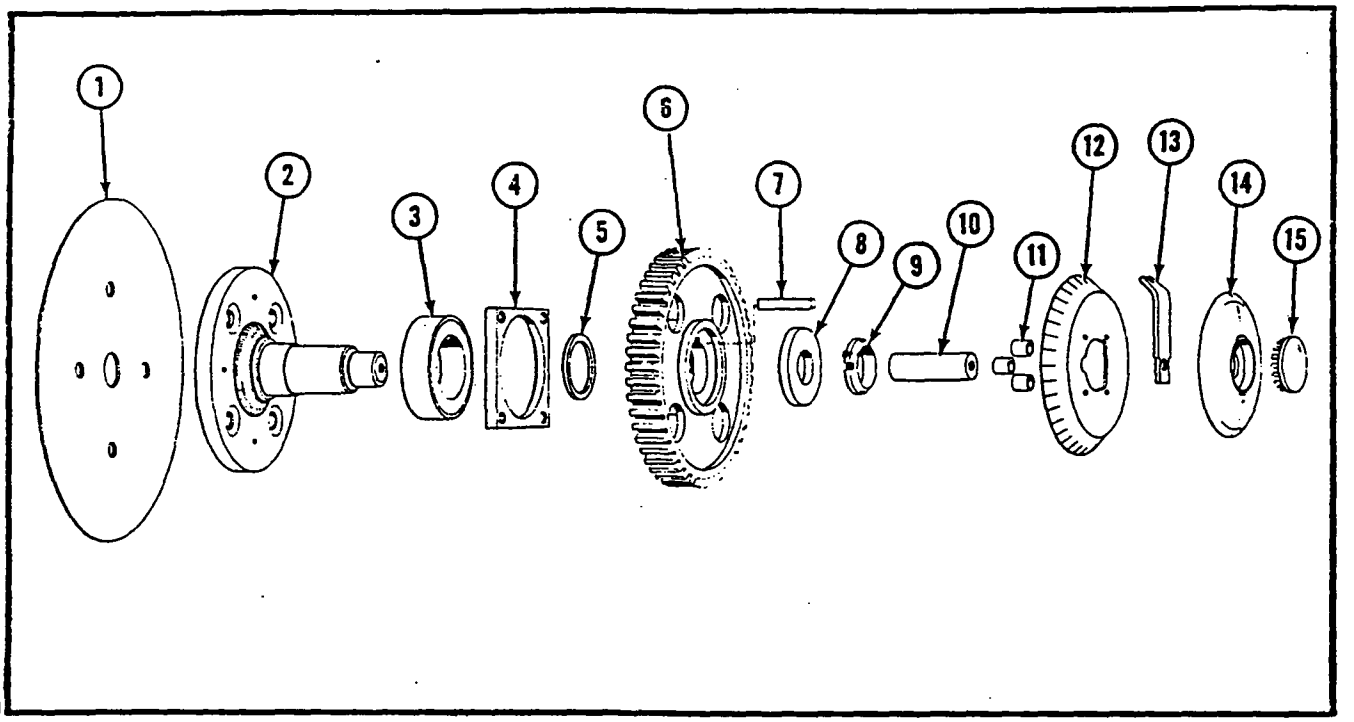
YOKE, LEFT SIDE



ITEM	DESCRIPTION	PART NO.
	YOKE (RIGHT SIDE)	16833
1	R.H. Trunnion Assembly	Figure 1
2	Cam Switch (SW-23)	T29A-37
3	Yoke Center Cover	54154
4*	Bracket, Mounting (Microswitch)	54153
5	Cover, Yoke Centering Switch	54134
*	Not Shown	

ITEM	DESCRIPTION	PART NO.
6*	Bracket, Mounting (Microswitch)	54136
7	Bracket, Mounting	54492
8	Plug, Spring Retaining	181006
9	Spring Brake	T5A-256
10	Plunger, Brake Spring	53621
11	Pad, Brake	55996
12	Housing, Brake Pad	53843-A
13	Worm Drive Assembly	180999

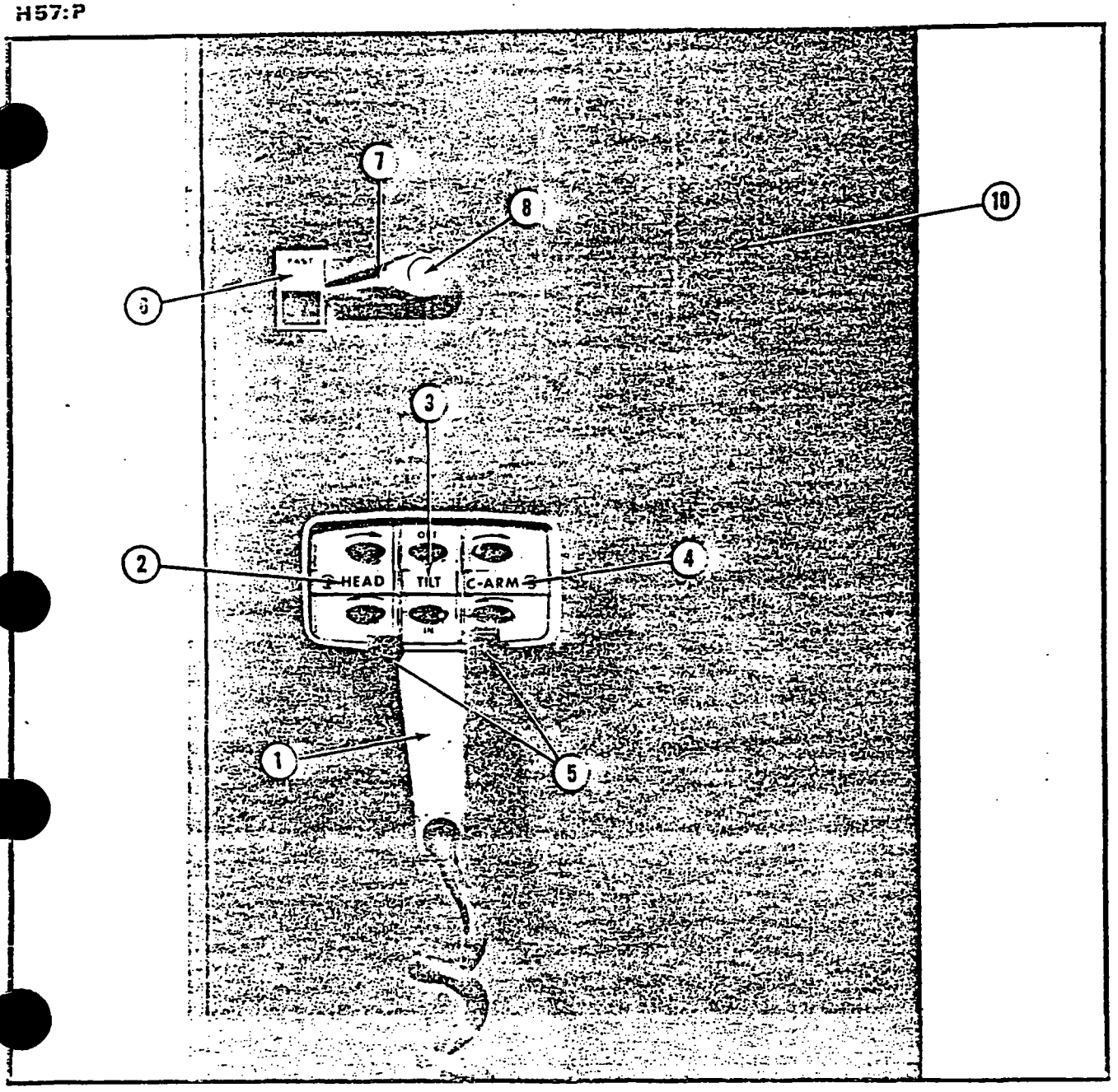
YOKE, RIGHT SIDE



ITEM	DESCRIPTION	PART NO.
	R.H. TRUNNION ASSEMBLY	Figure 4
1	Brake Disc	53628-A
2	Trunnion, R.H.	180967
3	Bearing	T12-260
4	Retainer, Trunnion Bearing	54131
5	Washer, Shim	T11-257
6	Gear, Worm	T77C-33
7	Key, Worm Gear	T31-44

ITEM	DESCRIPTION	PART NO.
8	Washer, Shim	T11-258
9	Locknut, bearing	T4-211
10	Spacer	T10B-557
11	Spacer	T10C-126
12	Scale, Angulation	35829-A
13	Pointer	45020
14	Cover, Angulation Scale	13471-C
15	Dot Plug	T30-53

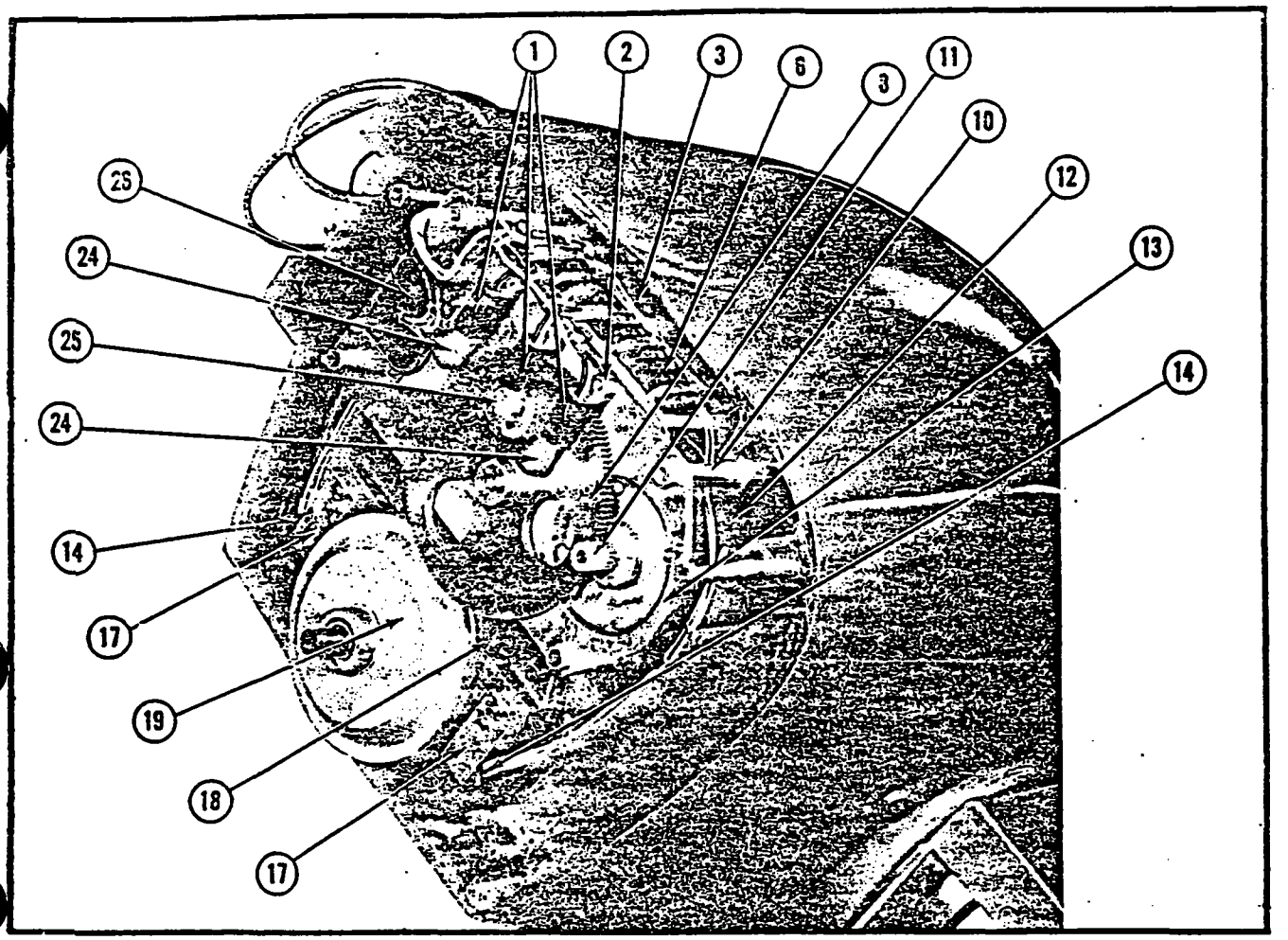
R.H. TRUNNION ASSEMBLY



ITEM NO.	DESCRIPTION	QTY.	PART NO.
	HAND SWITCH ASSEMBLY		16567
1	Switch Assembly		46841
2	Decal, Head		T92-286
3	Decal, Tilt		T92-287
*	Not Shown		

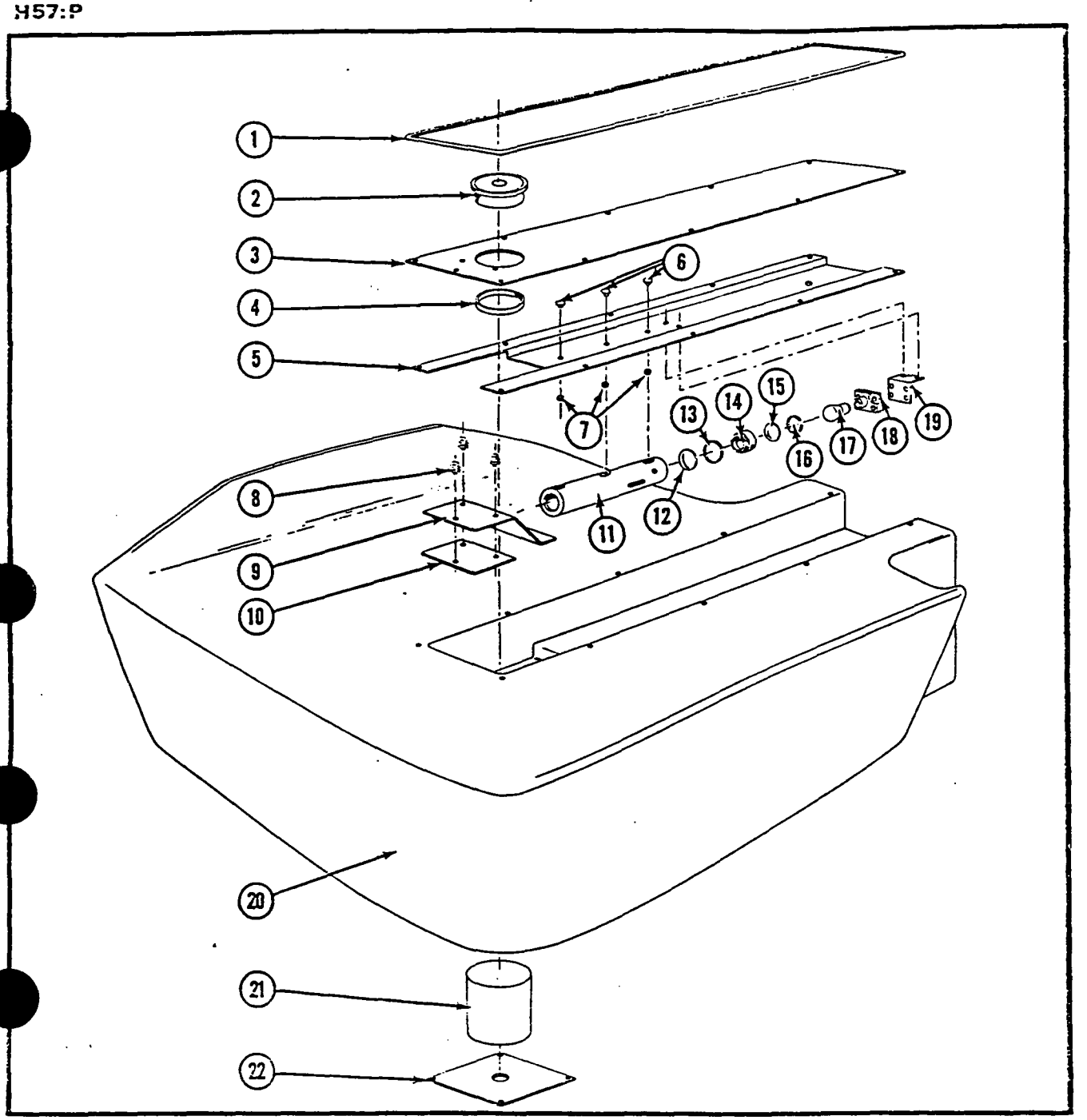
ITEM NO.	DESCRIPTION	PART NO.
4	Decal, C-Arm	T92-288
5	Hook, Hand Switch	16566
6	Nameplate, Slow-Fast	T92-204
7	Knob, Speed Switch	T3-102
8	Insert, Knob	36864-B
9*	Switch, Slow-Fast	T29-50
10	Shroud, R.H.	46657

HAND SWITCH ASSEMBLY



ITEM	DESCRIPTION	PART NO.
	COBALT^{60} HEAD	590-E
1	Socket, Lamp (Screw Type)	37169-A
	Socket, Lamp (Bayonet Type)	56148
2	Spacer, Lamp Socket	T10C-117
3	Resistor, 150Ω, 100W (R-2)	T6-20
4*	Spacer, Resistor	T11F-21
5*	Stud, Resistor	T13A-117
6	Terminal Strip (TB-5)	T81A-4
7*	Marker, Terminal Strip	T81B-4
8	Gear, Shutter Idler	T77-162
9*	Needle Bearing	T12-337
10	Spacer	T10C-117
11	Gear, Shutter Drive	T77-130
12	Motor, Shutter (B-1)	T93C-10
13	Casting, Shutter Drive	43153-A
14	Microswitch (SW-10, 11)	T29A-16
15*	Actuator, Microswitch	35088
16*	Barrier, Microswitch	T9-74
*	Not Shown	

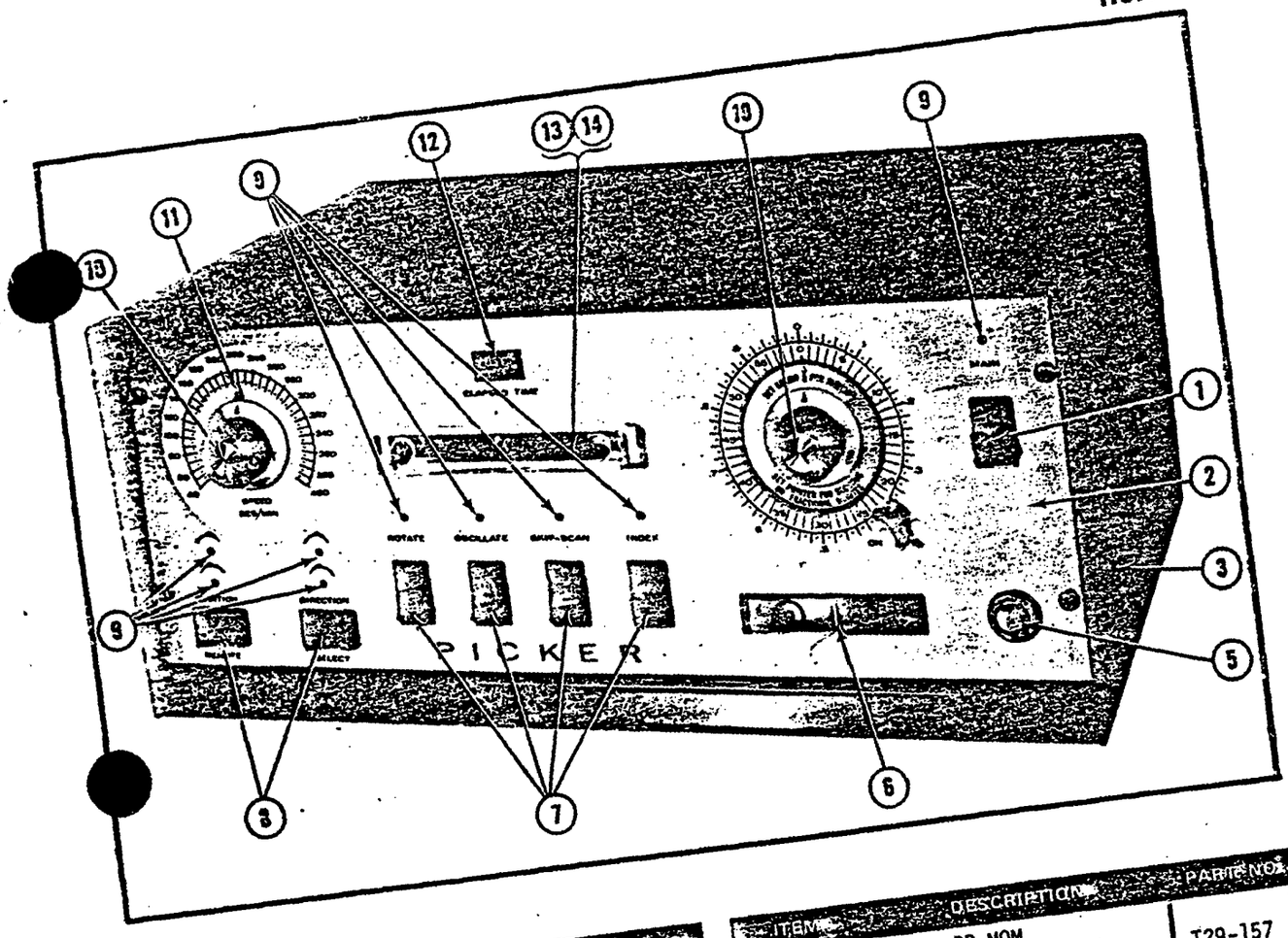
ITEM	DESCRIPTION	PART NO.
17	Mounting Plate, Microswitch	56326
18	V-Belt	T26A-11
19	Pulley, V-Belt	T84-21
20*	Cover, Shutter Spring (Outer)	37138
21*	Spring, Shutter Power	37137-A
22*	Collar, Shutter Spring	37144
23*	Cover, Shutter Spring (Inner)	37138-A
24	Lamp, Red, 110V (Screw Type)	T72-45
	Lamp, Red, 110V (Bayonet Type)	T72-112
25	Lamp, White, 110V (Screw Type)	T72-8
	Lamp, White, 110V (Bayonet Type)	T72-110
26	Filament Transformer (T-1)	T86B-8
27*	Capacitor, 4μFd, 600V(C-1)	T45-22



ITEM	DESCRIPTION	PART NO.
	BARRIER ASSEMBLY	16484-B
1	Trim, Plastic Panel	42429-J
2	Window Assembly	16422
3	Cover, Backpointer	46428
4	Ring, Rubber	T54-40
5	Bracket, Lamp Housing	46427
6	Rivet, Tubular	T15D-20
7	Washer, 0.195" I.D. x 7/16" O.D.	T11E-5
8	Spring	T5A-161
9	Mirror	46425
10	Nut Plate (Mirror)	46424
11	Housing	46426

ITEM	DESCRIPTION	PART NO.
12	Lens	38266
13	Spring	T5-435
14	Bushing	37945
15	Lens	38267
16	Spring, Condenser Lens	T5-434
17	Lamp	T27-36
18	Socket, Lamp	31414
19	Bracket, Lamp Mounting	38269
20	Radiation Barrier	54475
21	Barrier Plug	54805
22	Cover, Barrier Plug	54806

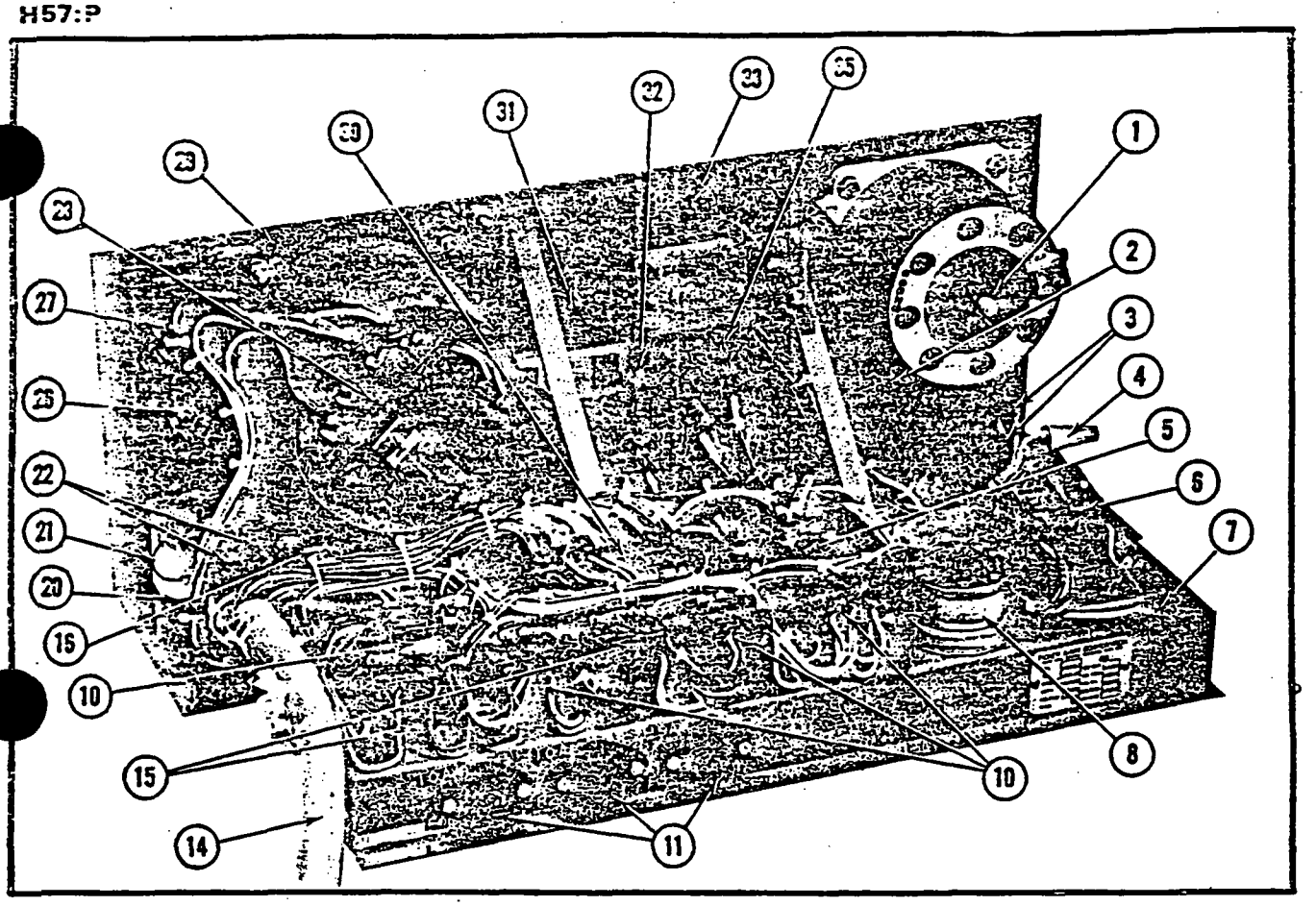
BARRIER ASSEMBLY



ITEM	DESCRIPTION	PART NO.
	CONTROL, COBALT60	VG8-B
1	Switch, Main, DPDT (SW-1)	T29-147
2	Nameplate	46744
3	Cabinet	160030
	Feet, Rubber	T21-140
4*	Lock and Keys	36759
5	Window, Shutter Indicating	38759
6		
*	Not Shown	

ITEM	DESCRIPTION	PART NO.
7	Switch, DP MOM (SW-17, 21, 22, 27)	T29-157
	Switch, DPDT (SW-20, 24)	T29-152
8	Lamp, Indicator	T72-78
9	Knob	T3A-85
10	Pointer, Rotation Speed	50050
11	Counter	34482
12	Exposure Bar	38975
13	Emergency Insert	40099
14	Spacer	T10B-194
15*	Spring	T5A-185
16*		

COBALT CONTROL



ITEM	DESCRIPTION	PART NO.
	CONTROL, CO60 (REAR VIEW)	VG8-B
1	Power Stat (Speed Control)	T86F-26
2	Bracket, Lamp	55839
3	Wire Nut (Small	32423
4	Wire Nut (Large)	36976
5	Panel, Terminal	T76-6
6	Relay, Latching (RE-13)	T19A-130
7	Chassis Assembly	16463
8	Motor, Synchronus	T93B-59
9*	Cam	46560
10	Relay, DPDT (RE-2, 8, 9,11)	T19A-107
11	Fuse Holder	36836
12*	Fuse, 5 Amp (F-5)	T27A-32
13*	Fuse, 10 Amp (F-1,2)	T27A-24
14	Cable, Control	BL1823-A
15	Relay, DPDT (RE-10,12)	T19A-108
16	Lamp Bracket	14547
17*	Spacer, 3/8"ODx5/8"L	T10C-159
18*	Socket, Lamp	37169
*	Not Shown	

ITEM	DESCRIPTION	PART NO.
19*	Lamp, 6W, 115 VAC	T72-8
20	Bracket, Key Switch	46536
21	Spring, Key Switch	T5-433
22	Switch, Micro (SW-3, 26)	T29A-16
23*	Spacer, Microswitch	T9-74
24*	Actuator, Microswitch (Flat)	34952
25*	Actuator, Microswitch (Roller)	35088
26	Switch, Main, DPDT (SW-1)	T29-147
27	Bracket, Lamp	55837
28	Timer	945-A
29	Bracket, Timer	46562
30	Terminal Strip	T81A-27
31	Cross Strap	38976
32	Bracket, Lamp	55837
33	Counter	34482
34*	Switch, Micro (SW-2)	T29A-15
35	Insulator, Switch	31358
36*	Grommet, Plastic	T21A-70

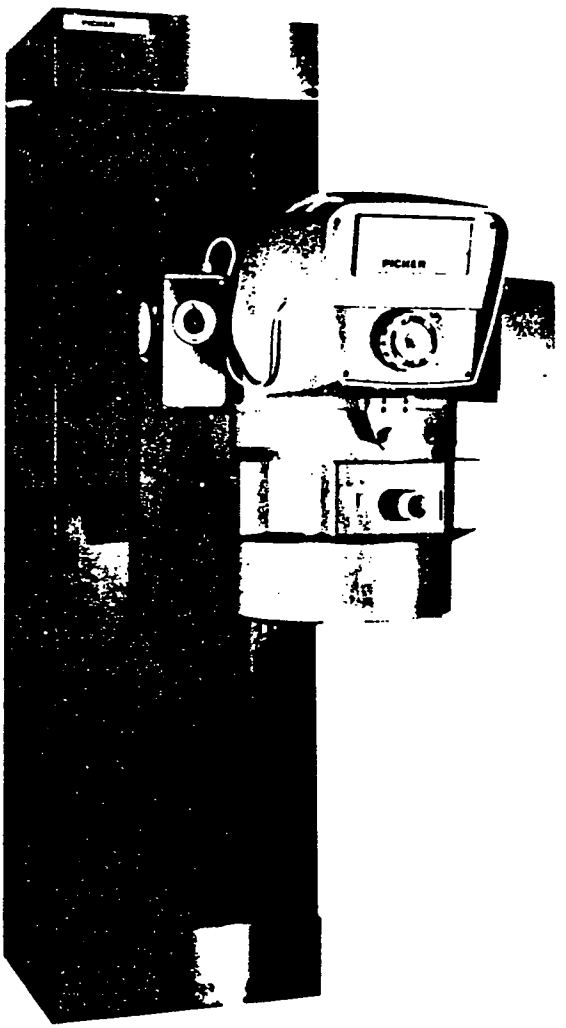
CONTROL (Rear View)

V9 COBALT TELETHERAPY UNIT

CAT. NO. 6268

INSTALLATION INSTRUCTION

PH59:I2 (T55-571)



PICKER CORPORATION
MEDICAL PRODUCTS DIVISION
595 MINER ROAD, CLEVELAND, OHIO 44143

Apr '70

Printed in U.S.A.

WARNING TO SERVICE PERSONNEL

FOR RADIATION HAZARDS DURING INSTALLATION OF COBALT 60 TELETHERAPY UNITS

EACH PERSON INSTALLING A COBALT UNIT SHOULD AT LEAST WEAR A 0 - 200 MR DIRECT READING POCKET DOSIMETER, AND PREFERABLY ALSO, A 0 - 5 R CHAMBER AS WELL. A PORTABLE SURVEY METER (G-M OR ION-CHAMBER TYPE) SHOULD BE AVAILABLE, PERHAPS BORROWED FOR THE DURATION OF THE INSTALLATION.

WEAR THE DOSIMETERS ON THE WAIST, CHECK THEM FREQUENTLY FOR INDICATION OF EXCESS RADIATION AND RECORD THE INITIAL AND FINAL READINGS. IN THE EVENT AN OVERDOSAGE IS SUSPECTED, READ THE DOSIMETERS IMMEDIATELY.

THE SURVEY METER *MUST* BE USED TO CHECK THE SHIPMENT AS SOON AS IT ARRIVES. AT 39-INCHES (1 METER) FROM THE CENTER OF THE HEAD(SOURCE) THE AVERAGE DOSE RATE SHOULD NOT BE HIGHER THAN 2 MR/HOUR. LOCALIZED SPOTS AROUND THE HEAD, WHERE RADIATION IS HIGHER, MAY OR MAY NOT BE NOTICEABLE DEPENDING ON THE TYPE OF METER USED AND THE CARE EXPENDED IN SEARCHING FOR THEM. THESE SPOTS SHOULD BE BELOW 10 MR/HOUR AT 39-INCHES FROM THE SOURCE.

THE AVERAGE DOSAGE AT THE SURFACE OF THE HEAD WILL BE ABOUT 35 MR/HOUR. IF THE DOSAGE RATES ARE HIGHER THAN STATED, THE WHOLE INSTALLATION *MUST* BE APPROACHED WITH CONSIDERABLE CAUTION.

IF EVERYTHING IS NORMAL AT THIS STAGE, THE WORK CAN PROCEED IN A REGULAR FASHION, BUT THE SHUTTER LOCKING BAR AND ITS WARNING TAG MUST *NOT* BE REMOVED UNTIL THE MACHINE IS COMPLETELY ASSEMBLED AND READY TO TURN OVER TO THE LICENSEE. THEN, AND ONLY THEN, SHOULD THE SHUTTER BE OPERATED, AND ONLY IF THE PROTECTIVE ROOM WINDOW IS IN PLACE AND THE DOOR SWITCH IS OPERATIVE.

SPECIAL WARNING

THE MACHINE MUST NOT BE TURNED ON IF THERE IS SOMEONE IN THE ROOM, AND *NO ONE* SHOULD ENTER THE ROOM UNLESS HE IS SURE THE SHUTTER IS TURNED OFF. THE SURVEY METER SHOULD BE USED AFTER EACH OPERATION OF THE SHUTTER BEFORE RE-ENTERING THE TREATMENT ROOM. ALSO THE SURVEY METER SHOULD BE USED TO CHECK UNKNOWN RADIATION LEVELS BEFORE PERSONNEL WORK IN A GIVEN AREA.

THE FIRST TIME THE SHUTTER IS OPERATED, USE A SURVEY METER TO BE SURE THAT THE CONNECTIONS TO THE WARNING LIGHTS HAVE NOT BEEN REVERSED. THE ABILITY OF THE SHUTTER TO TURN OFF WITH POWER FAILURE *MUST BE CHECKED* BY CUTTING THE POWER TO THE MACHINE AND USING THE SURVEY METER TO SEE THAT THE SHUTTER TURNS OFF.

THE SHUTTER MUST BE CHECKED FOR OPERATION WITHIN ALLOWABLE ROOM PROTECTION BY SETTING THE HEAD IN VARIOUS POSITIONS (45-DEGREES APART) AND MOMENTARILY TURNING THE SHUTTER ON (OPERATE BY SWITCH) THEN ONE SECOND LATER, DEPRESS "OFF" BUTTON ON TIMER. *SHUTTER MUST ALWAYS CLOSE.*

FINALLY, THE OPERATION OF THE DOOR INTERLOCK SWITCH AND THE ABILITY OF THE TIMER TO SHUT OFF THE BEAM MUST BE CHECKED. THE RADIOLOGIST MIGHT THEN WISH THE SHUTTER LOCKING BAR REPLACED UNTIL HE IS READY TO USE THE MACHINE. IT CAN READILY BE REMOVED WHEN NECESSARY.

RADIATION WARNING

X-Rays and Gamma-Rays are dangerous to both patient and operator unless established safe exposure procedures are strictly observed.

The useful beam can produce serious or fatal bodily injuries to any persons in the surrounding area if used by an unskilled operator. Adequate precautions must always be taken to avoid exposure to the useful beam, as well as to leakage radiation from within the source housing or to scattered radiation resulting from the passage of radiation through matter.

Those authorized to operate, participate in or supervise the operation of the equipment must be thoroughly familiar and comply completely with the currently established safe exposure factors and procedures described in the National Council on Radiation Protection and Measurements (NCRP) "Medical X-Ray and Gamma-Ray Protection for Energies up to 10 Mev — Equipment Design and Use" NCRP Report #33 as revised or replaced in the future.

Those responsible for the planning of X-Ray and Gamma-Ray equipment installations must be thoroughly familiar and comply completely with the structural shielding requirements outlined in NCRP #34 as revised or replaced in the future.

Failure to observe these warnings may cause serious or fatal bodily injuries to the operator, patient or those in attendance.

CONTENTS

Section 1
EQUIPMENT DESCRIPTION

Giving the radiologists the advantages of supervoltage radiation without the need for a high voltage generator, the Picker Model V9 Teletherapy Unit precisely controls and directs the gamma radiation of Cobalt^{60} contained in a sealed capsule within a 21-inch, spherical head of shielding lead, tungsten, and uranium.

The exact beam direction and field localization provided by the Model V9 makes this advanced equipment highly flexible in application. The radiation beam is turned "on" by rotating the radioactive source from the center of the protective sphere to an aperture at the bottom and turned "off" by returning it to the center.

A specially designed Collimator precisely defines the size and shape of the beam. To permit flexible directing of the beam for various therapeutic treatments, the entire Head and Collimator assembly is mounted on a Stand capable of moving and rotating the Head. Before installing the Model V9, you will want to become more familiar with the details of its operation.

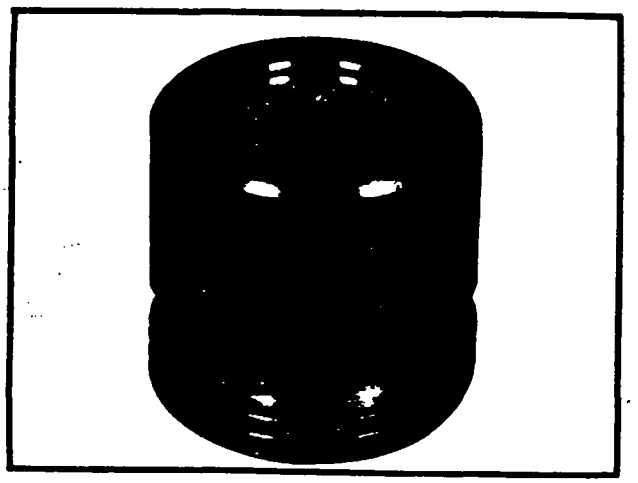
MAJOR ASSEMBLIES AND PARTS

Source

The Cobalt^{60} radiation Source, usually 1.5 to 2.5cm in diameter, is contained in a double-walled metal cylinder which is housed in the Isotope Container. (Refer to ED-775 and ED-776.)

The Source has been made radioactive by being bombarded by neutrons in a nuclear reactor. The Source, usually made up of a number of thin wafers or closely packed pellets, is carefully sealed within a thick-walled cylinder of tungsten with thin stainless steel caps on the ends. The container does four things:

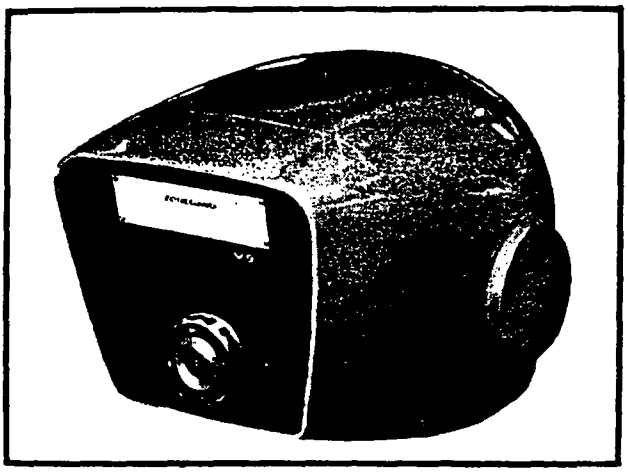
1. Prevents escape of radioactive matter within the cylinder.
2. The tungsten wall contributes to radiation protection.
3. The thin end windows stop beta radiation yet readily transmit the gamma radiation.
4. The external threads hold the source securely in the Head.



ISOTOPE CONTAINER

The Source is surrounded by a protective shield called the Head.

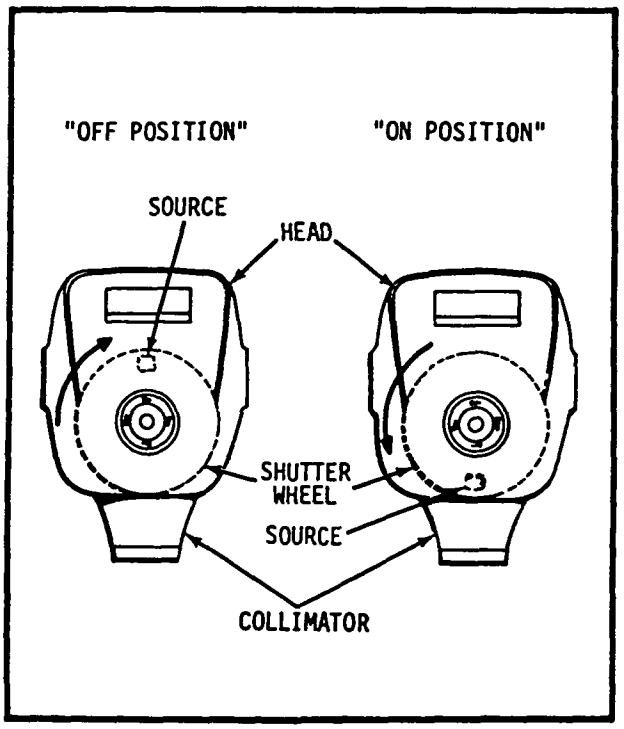
The Head, mostly solid lead, has within it a Shutter Wheel made of lead, tungsten, depleted uranium, and stainless steel. The Shutter Wheel axle is located off center of the Head so that by rotation it can move the Source from the center of the Head ("off" position to the bottom "on" position).



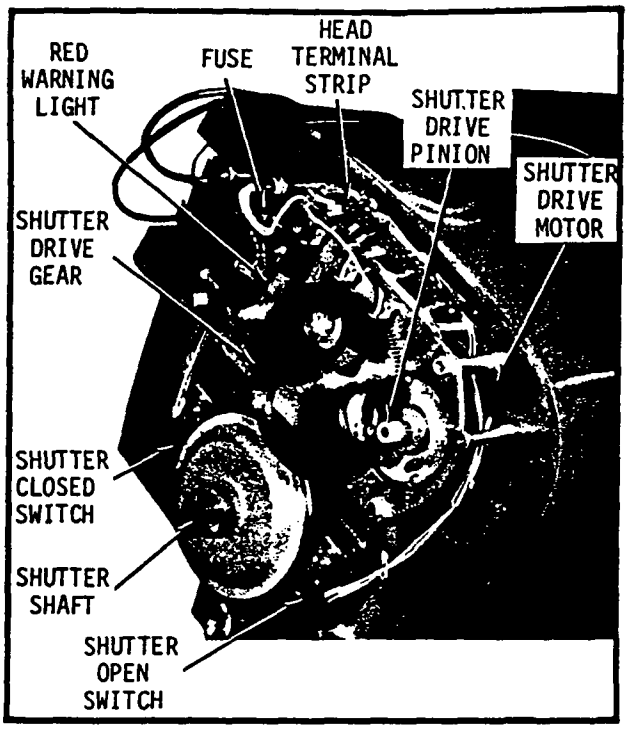
HEAD

Shutter

The Shutter Wheel is mounted in the Head with its shaft extending out into the Shutter Drive Housing at the front of the Head. The shaft of the wheel is below center in the Head; i.e., it is nearer the Collimator side of the Head than it is to the top of the Head. When the radiation beam is turned "off," the wheel is rotated until the Source is brought to the exact center of the Head where it is completely surrounded by lead and tungsten, except in the direction of the aperture. In this direction the radiation is blocked by a solid, depleted uranium rod which is a part of the Shutter Wheel. To turn the radiation "on," the wheel is rotated 180-degrees from its "off" position bringing the Source adjacent to the aperture in the bottom of the Head. The radiation is then free to pass through this opening out into the Collimator.



SHUTTER WHEEL OPERATION



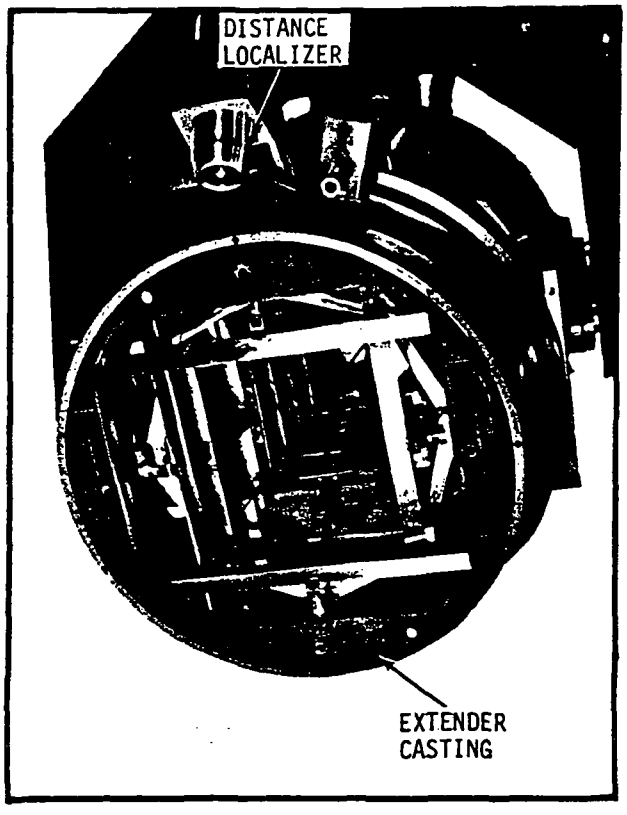
SHUTTER DRIVE MECHANISM

The Shutter Wheel is turned by a geared motor shutter drive, through a "V" belt, from the "off" to the "on" position. As it turns it winds up a heavy clock spring. In the "on" position, the motor stalls while pulling against the force of the coiled-up clock spring. If electrical power is interrupted or turned off from the control, the motor ceases to exert force, and the spring returns the Wheel to the "off" position.

Return to "off" position requires the wheel to turn 180-degrees, but only during the first twenty degrees is a significant amount of radiation emitted. Thus the sum of the effective shutter opening and closing times is only a fraction of a second. If the shutter should fail to close, the hand wheel on the Head cover can be used to close it, or the shutter can be electrically driven to the "off" position if the operator depresses an "EMERGENCY BAR" on the control.

Beam Collimator (3706A)

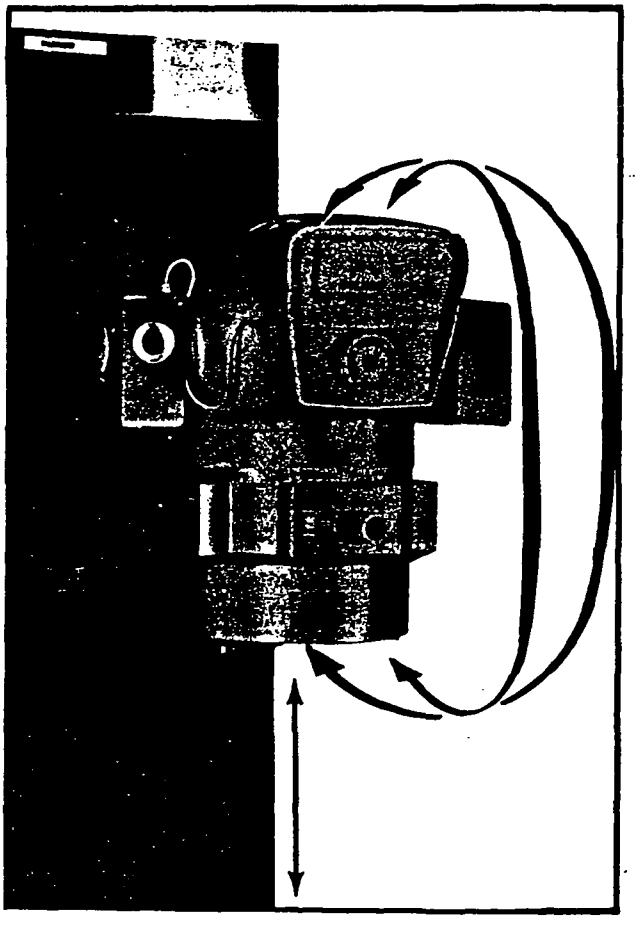
The Collimator is constructed of four sets of flat interleaved lead and tungsten vanes that move with a planar motion to provide variable field sizes. The planar motion of the vanes is necessary to avoid distortion of the edges of the treatment field. The inner defining edges of the collimator vanes are angulated to follow the divergence of the beam for each field size. It is possible at any time to set the collimator vanes for a specific source diameter so that a minimum penumbra will be maintained if an original source is replaced by one of a different diameter.



INSIDE VIEW OF COLLIMATOR

The Collimator provides continuously variable field sizes from 3 x 3cm to 35 x 35cm at a distance of 80cm from the source. It includes retractable penumbra trimmers so that the source-to-final collimation distance can be varied from 45cm to 65cm. (The minimum field size is 4 x 4cm if the trimmers are retracted.)

The Collimator contains a beam defining light that defines the radiation field at the geometric field size. Field size is defined by lines drawn from the center of the face of the source, past the edges of the outermost beam defining vanes to the skin. An optical distance indicator is provided that projects the source-to-skin distance (SSD) onto the skin of the patient. The Collimator can be rotated about the beam axis through 170-degrees to the left and 170-degrees to the right. A scale is provided to give the angular settings of 90-degrees to the right.



STAND AND YOKE

Positioning Mechanism

The Head is mounted on a Stand which makes possible the following motions:

1. The main support can be raised and lowered through 53-1/2 inches of travel via a safe friction drive.

2. The Yoke can be rotated in either direction, within the same rotational plane, about 175-degrees from its middle position on one horizontal axis; and the Head can be tilted a total of 110-degrees normal to the Yoke's rotational plane. Electrical limit switches and mechanical stops prevent further rotation.

3. Because of the built-in brake, the Head and Yoke rotation positions are automatically locked when the respective switch or handle is released. The Collimator is locked and unlocked with the Collimator Locking Knob.

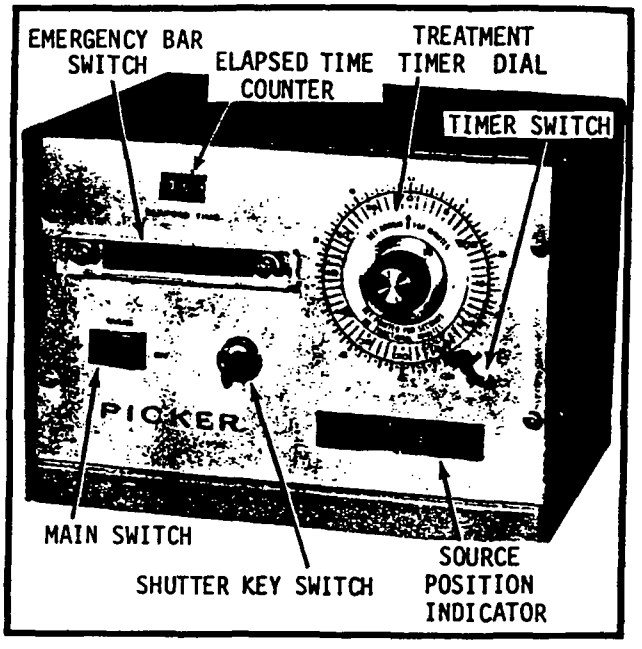
"Zonegard"

The source head includes an automatic safety system (Zonegard) which prevents an exposure when the head is so angulated that the beam would be directed toward areas of the treatment room that are not adequately shielded. A white indicator light on the top front of the head illuminates the head cover window when the head is pointed within the limits determined by the switches as a reminder to the operator of the Cobalt unit when setting up for treatment. If the light is off, no beam radiation can be programmed indicating that the head is pointed to a part of the treatment room not properly shielded.

Control Unit (VG-8D)

The Control Unit, containing all the elements necessary to control and monitor the radiation, consists of:

1. "MAIN" SWITCH (Rocker Type): Controls all electrical power to the equipment. Providing undervoltage protection, if the line voltage drops to a dangerously low value or is interrupted, the main power relay contacts will open and remain open after normal line voltage is restored until the "ON" push-button is again pressed.
2. SHUTTER SWITCH WITH KEY LOCK: Lock is a momentary contact switch which opens the shutter when operated (providing the time switch has been turned "on").
3. EXPOSURE "EMERGENCY" BAR: Pushing this bar switch closes the shutter in emergencies where it is desired to stop the exposure before the preset time has expired. It reverses power to the Shutter.



VG-8D CONTROL UNIT

NOTE

This bar should only be used in an emergency and not to stop the treatment during normal operation.

4. PRECISION TIMER: Permits selection of treatment times in 0.01-minute increments up to 55-minutes, and terminates the exposure at the end of the preset time. Timer is calibrated in minutes and decimal minutes, instead of minutes and seconds, to eliminate treatment time conversions.
5. SHUTTER INDICATOR LIGHTS: Symbolically show position of Shutter Wheel. When the Source is in the safe or "off" position, the green "shutter closed" light is on. When the key switch is operated, both the green "shutter closed" and the red "shutter open" lamps light as the Shutter Wheel begins to turn. At the end of about two seconds the Shutter is fully open and the green lamp goes out. If, for any reason, the Shutter should stick in a partially open position, both indicator lights remain on. This would indicate a malfunction in the unit thus preventing overexposure or an incomplete exposure to the patient.
6. ELAPSED TIME: Records total time for each treatment. Use of the elapsed time counter and proper records facilitates estimation of the radiation exposure should the treatment timer fail to function properly, or should the operator set the timer incorrectly.

COBALT HEAD AND CONTROL EXPOSURE LIGHT SEQUENCE

A microswitch (SW39) has been added to the Cobalt head to delay the turn-off of the green light in the control. The existing switch SW10 is repositioned to allow the time and counter to be started before the shutter is opened, which is at 142-degrees of rotation. The shutter locking bar is also redesigned to compensate for the above change.

The green lamp is extinguished when the shutter is fully opened, leaving only the red exposure lamp on.

If the shutter did not open fully, the red and green lamps would be on indicating a malfunction in the unit. This prevents an overexposure or an incomplete exposure to the patient.

Section 2
INSTALLATION

Be sure to read the "WARNING TO SERVICE PERSONNEL" in the front of this manual *BEFORE* proceeding.

READ THIS SECTION OVER THOROUGHLY BEFORE STARTING, PARTICULARLY THE NEW COLLIMATOR REVISED INSTALLATION INSTRUCTIONS.

ANCHORING EQUIPMENT

The unit must be anchored to the wall and floor to keep it upright. Since it weighs almost four tons, the wall and floor strength should be checked by the building architect for sufficient load strength. The total weight is much greater than for most X-ray equipment, so care must be exercised in selecting a site. Consideration must also be given to the problem of moving large, heavy equipment into the building and to the installation site. (Refer to D-T64-382.)

RADIATION PROTECTION

Cast concrete or solid concrete block is recommended for radiation protection. While it is usually impractical to use lead as a protective barrier for the direct beam, since the thickness required would be many inches, it is often useful for adding protection against scattered radiation. Protection requirements vary with each installation, and wall thicknesses should be specified by the physicist or radiologist in charge. In addition the registered physicist in the employ of the customer must specify safe head rotation limits before they are reset by the Picker installer to satisfy AEC regulation. The Factory cannot be responsible for the radiation safety of an installation.

The view window should provide protection equivalent to the wall in which it is placed. Various types of high-density glass are available, though ordinary plate glass may be used if of sufficient thickness. Mirror viewing systems can be installed as well as closed-circuit television systems.

A maze entrance, or radiation trap, to the treatment room is strongly recommended over lead doors. Unless the radiation reaching them has been scattered more than once, doors with sufficient lead are very heavy and quite expensive.

National Bureau of Standards Handbook #73 gives recommendations for room shielding design.

DESCRIPTION	V9
Control Unit, including controls, indicators, and timer. (This unit has an interconnecting cable for connection to a junction box which is part of the conduit system for the complete unit.)	VG-8D*
Therapy Head, including shutter and shutter-drive mechanism and bronze encased lead protection for the Cobalt^{60} Source. (Head usually shipped from the Factory with the Source already installed.)	590E
Stand, including columns, drive, hanger, counterweighting, and head support.	1373D
Beam Collimator, including localizer lights, and calibrated field dials.	3706A

*VG-8D is for 60-cycle power; the VG-8E replaces it for 50-cycle power.

UNPACKING

Arrangements are usually made with the customer to ship the Cobalt^{60} Source from the supplier to the installation site inside the Head of the Model V9 Teletherapy Unit. If this is the case, the Head will arrive sealed.

WARNING

DO NOT REMOVE ANY BOLTS WHICH ARE SEALED UNTIL TIME TO TEST SHUTTER OPERATION.

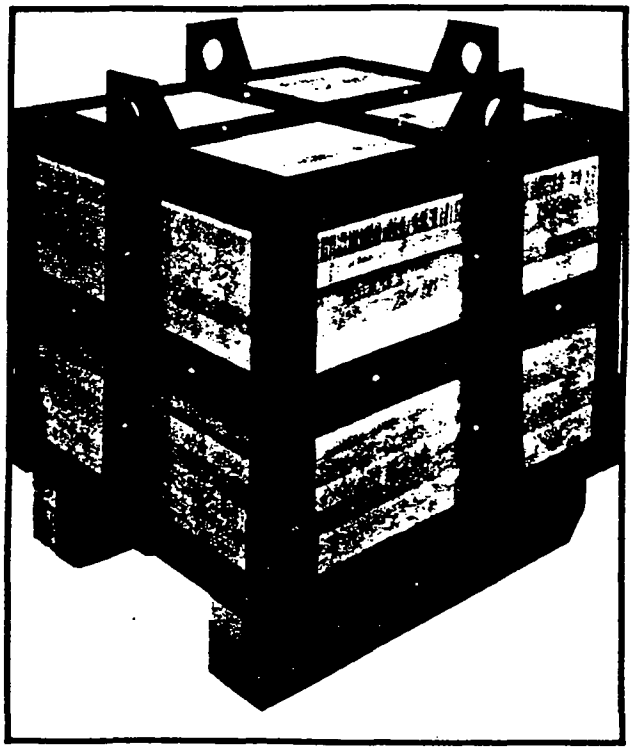
6

When a new source is to be exchanged for an old decayed source, the Source will arrive in a sealed container, *which is not to be opened.* Factory personnel will ordinarily make the exchange, *providing that the seals have not been broken.*

When shipped by railroad, the crating is as specified in the table following. For van shipments the packing cases are omitted, but parts are grouped similarly, with cartons being used to keep miscellaneous parts together. Weights and dimensions are for crated and uncrated equipment.

Check the material carefully against the Packing List to make sure that nothing has been omitted. The Collimator and the Control should be handled particularly carefully. It is best to leave the Collimator crated temporarily and open only enough of the Control crate to remove the instructions and wiring diagrams.

The other crates can be opened if moving the cases into the installation site is a problem. However, do not remove the skids and braces from them because they will be needed for assembly.



COBALT HEAD SHIPPING BOX

SHIPPING BOXES AND CONTENTS

CONTENTS	DIMENSIONS	GROSS WEIGHT	NET WEIGHT
Columns and Motor Drive on skid (Uncrated)	106L x 29W x 30H (99 x 28 x 24)	3420 lbs. (3230	3030 lbs. (3030)
Collimator and Bearing Ring (Uncrated with skid)	With Box (19-1/2 x 19-1/2 x 11)	525 (450)	* 310 *(310)
Treatment Head with Cobalt Source, skid, and in shipping box	38 x 35 x 39	3200	
Carriage and Hanger with skid (Uncrated)	80 x 30 x 68	1300 (1000)	824 (824)
Sheet Metal Covers and Trim Strips (Uncrated)		335 (115)	115 (115)
Control, Instructions, Wiring Diagrams, Miscellaneous Parts (Uncrated)	26 x 20 x 22 (20 x 11 x 10)	115 (63)	63 (63)
Counterweighting (50 lb. sacks)		350	300

*Without Skid.

INSTALLATION

Professional riggers should be employed to move the equipment into the building and to assist in the erection and assembly. It may be possible to rent a lift truck or use a chain hoist, jacks, and rollers, thus avoiding the need for riggers, a suitable alternative if personnel are available with some experience in handling heavy equipment.

The skids and installation accessories, listed next, are the property of Picker X-ray Manufacturing. They must be returned by rail or truck freight to Picker X-Ray Manufacturing, Cleveland, Ohio 44143, as soon as possible to avoid being billed to you. Assemble them compactly, including the hardware, and lash them together for efficient handling.

FACTORY OWNED EQUIPMENT

ITEM	DIMENSIONS*	PART NO.	WEIGHT
Head Shipping Box	38 x 35 x 39	D-181375	1000 lbs.
Carriage and Hanger Skid	79 x 29 x 12	D-15255	130 lbs.
Column Skid	106 x 29 x 12	C-13878A	110 lbs.
Wall-Eye	20 x 4 x 4	D-13910	20 lbs.

*L x W x H in inches.

Erecting the Stand

The following procedures are recommended for installing the Stand:

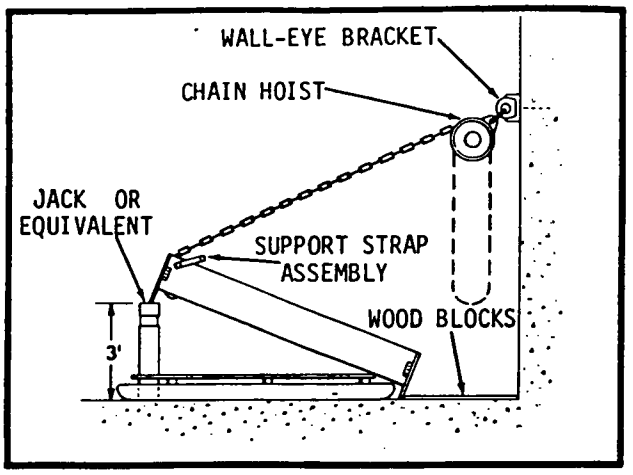
1. Locate the wall mounting holes or bolts as shown for the Stand assembly in the layout drawing D-T64-318.

2. Drill floor mounting holes and install the required bolt anchors.

3. Attach the Wall-Eye Assembly to the wall using the wall mounting bolt-anchors or through-bolts described in the drawing.

4. Move the Column-Skid Assembly into position and remove banding from the skid.

5. Rig a hand winch or "pull-lift" chain hoist between the Wall-Eye and the square hole in the top mounting plate of the Stand. Be sure the Wall-Eye and the rigging lie along the centerline of the Stand so that it will not sway to the side when tension is applied.



STAND ERECTION

6. Jack the top end of the Stand up three feet before putting the full weight of the stand on the winch or "pull-lift." Complete the job with the winch. *When the columns are almost upright, the Stand will tend to topple towards the wall. A snubbing rope should be used to ease the Stand back slowly.* The Stand should be far enough from the mounting wall to allow the Support Strap Assembly to be raised square to the wall, approximately in line with the wall mounting holes.

7. Remove the Wall-Eye and the winch. Use a pinch-bar or equivalent to remove the two blocks of wood under the floor plate.

NOTE

In corner installations where the bolting surface of the support strap assembly is closer than 31-inches from the corner, it will be necessary to assemble the Carriage and Hanger to the Stand before it is bolted into position. This can be done by carefully shifting the upright Stand forward or twisting it nearly parallel with one wall to allow the rear Roller Support Shaft to be assembled. The upright Stand can then be moved back into its final position.

8. Walk Stand toward wall so that the floor mounting bolt anchors are in line with the holes in the Floor Mounting Plate.

9. Install the four wall mounting bolts and washers and the two floor hold-down bolts and washers as shown in layout drawing D-T64-382. Use a straight-edge to check the columns for alignment and to make sure that they have not shifted during shipment or erection. Use a good spirit level to plumb the stand. *The stand should lean backwards about one-half bubble on the spirit level.* Shim if required. Secure the wall and floor mounting bolts.

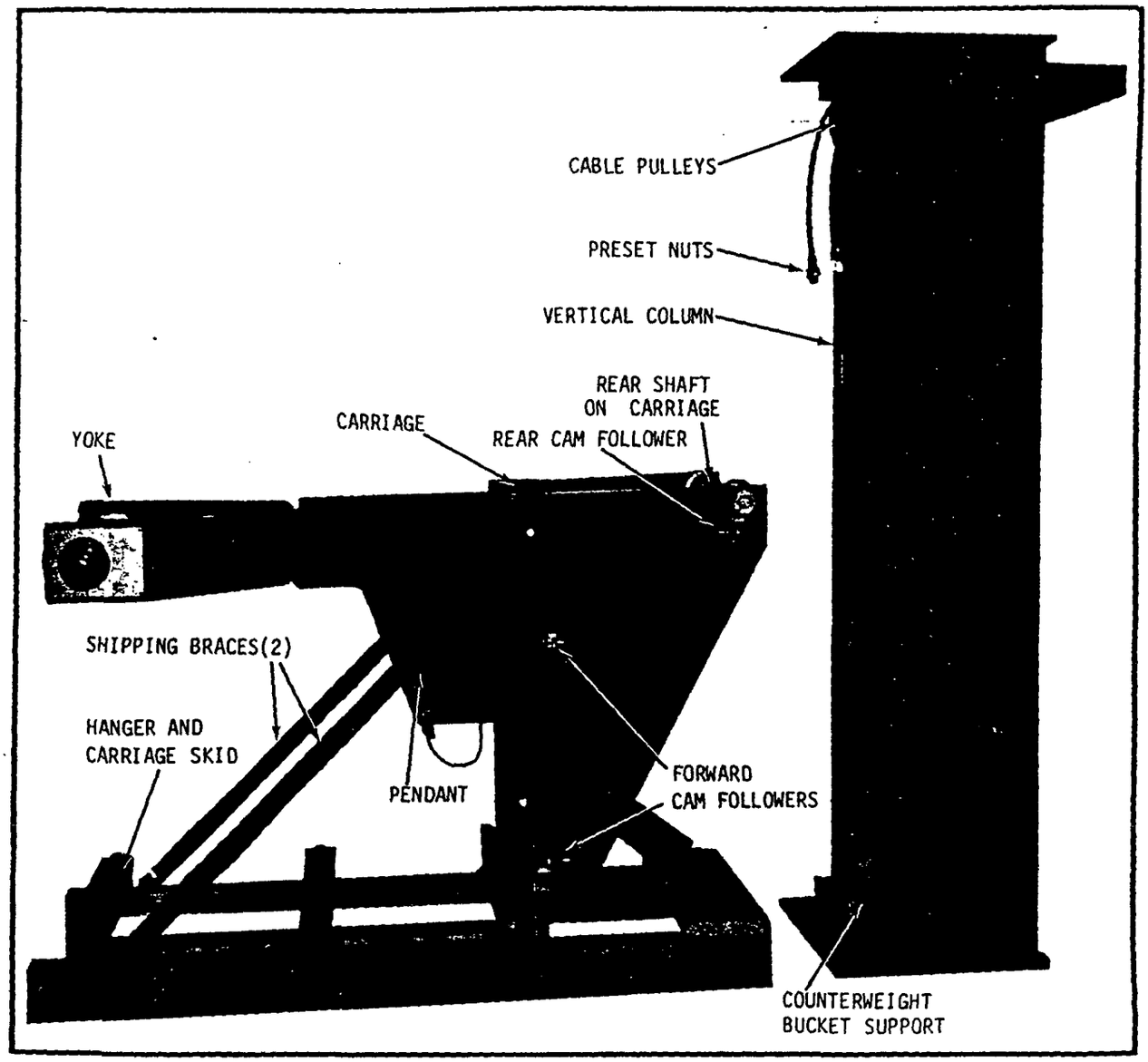
10. Remove stand skid from area.

CAUTION

DO NOT REMOVE THE 4 x 4 SUPPORTS UNDER THE COUNTERWEIGHT BUCKET UNTIL THE CARRIAGE AND HANGER ARE PROPERLY ATTACHED. (SEE PHOTO.)

To assemble the Carriage and Hanger Assembly to the Stand, follow these procedures:

1. Use a lift truck or large diameter wood rollers to bring the shipping skid with Hanger into room for assembly to columns.



CARRIAGE AND HANGER ASSEMBLY

2. Remove the 2 x 4 from the Carriage end of the shipping skid. Also remove the two 1/2-inch hex screws that hold the angles to rear inside of Carriage to free the angles from the rear of the Carriage.

3. Raise and position the skid approximately 24-inches from the floor and in line with the columns.

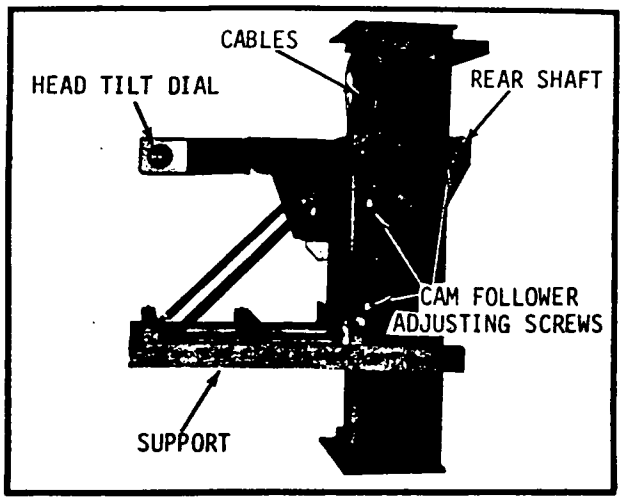
4. Remove the masking tape from the 1/2-inch diameter wire cable and snake the cable through the 7/8-inch diameter hole in the left-hand side of the Carriage.

5. Remove the rear shaft and guide rollers.

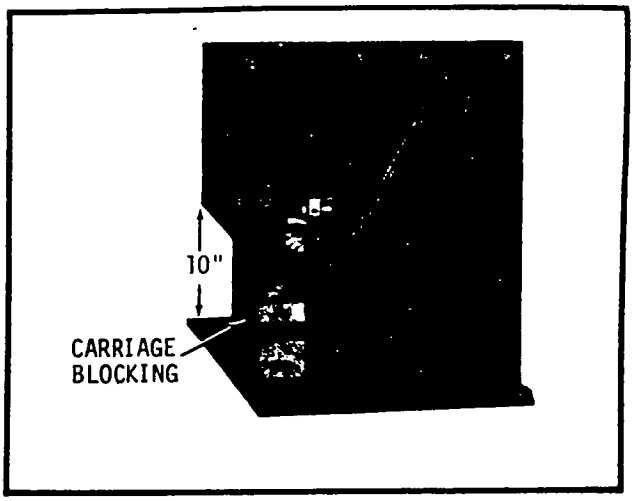
6. Ease the skid into the column so that the front cam followers nest around the right-hand channel.

7. Assemble the rear Cam Follower Bracket to the rear of the Carriage and assemble the Main Roller Support Shaft to the rear of the Carriage.

8. Remove the banding from the four-wire rope cables secured to the Stand.



ASSEMBLY IN POSITION



CARRIAGE SUPPORT BLOCKS

9. *Remove only the lower 5/8-inch nuts and washers from the cables and drape the cables over the top pulleys as shown in the photo of the roll shade.* Slip the ends into the outboard two holes in the Carriage.

10. Secure cables with 5/8-inch diameter washers and nuts. (The taped nuts are preset at the Factory.) With the Carriage in the present position, lower the Carriage via the lift truck making sure that the cables are properly seated in the outboard two grooves of the main pulley sheaves and that the "V" belt is between the two wire-ropes.

11. Place wood supports under the Carriage Assembly to prevent its lowering to more than ten inches from the floor. (Refer to photo.)

10 12. Jack up the Counterweight Bucket to bring the Carriage down against the wood supports and remove the 4 x 4 supports underneath the Counterweight Bucket.

13. Remove the remaining 1/2-inch hex head screws from the front of the Carriage that clamp the angles to the shipping skid.

14. Remove the skid.

The Head

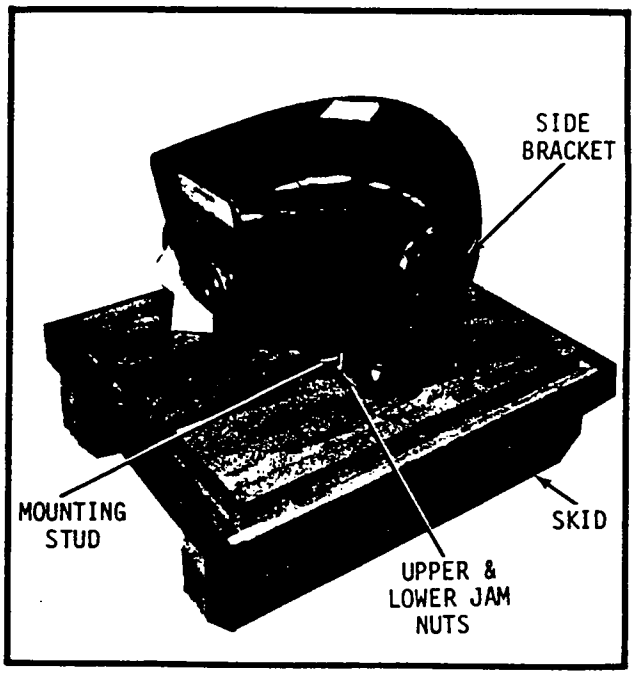
The Head is shipped from PXM with the Cobalt^{60} Source already installed and with the shutter locked in the "off" position with a bar bearing a red warning tag—

WARNING

DO NOT REMOVE THIS BAR—
RADIATION HAZARD.

Check the Head with the survey meter for the possibility of radiation leakage above 40 mr/hour at the surface (except bottom and top where it may approach 100 mr/hour at the surface). Also check for obvious shipping damage before proceeding. Follow the next set of instructions very carefully.

1. Place the Head bolting trunnions in position for mating of the Head and Stand by manually rotating the Hanger Yoke to the position shown.



HEAD MOUNTED TO SKID

CAUTION

THROUGHOUT THE FOLLOWING PROCEDURE IT IS ABSOLUTELY NECESSARY THAT THE ALIGNMENT OF THE ACCESSORIES ATTACHED TO THE HEAD NOT BE DISTURBED, INCLUDING THE SHUTTER DRIVE, AND SHUTTER LOCK SEALS.

2. Remove all packing and crating from the Head shipping skid, including the lifting rig assembly and its supporting angles (if supplied).

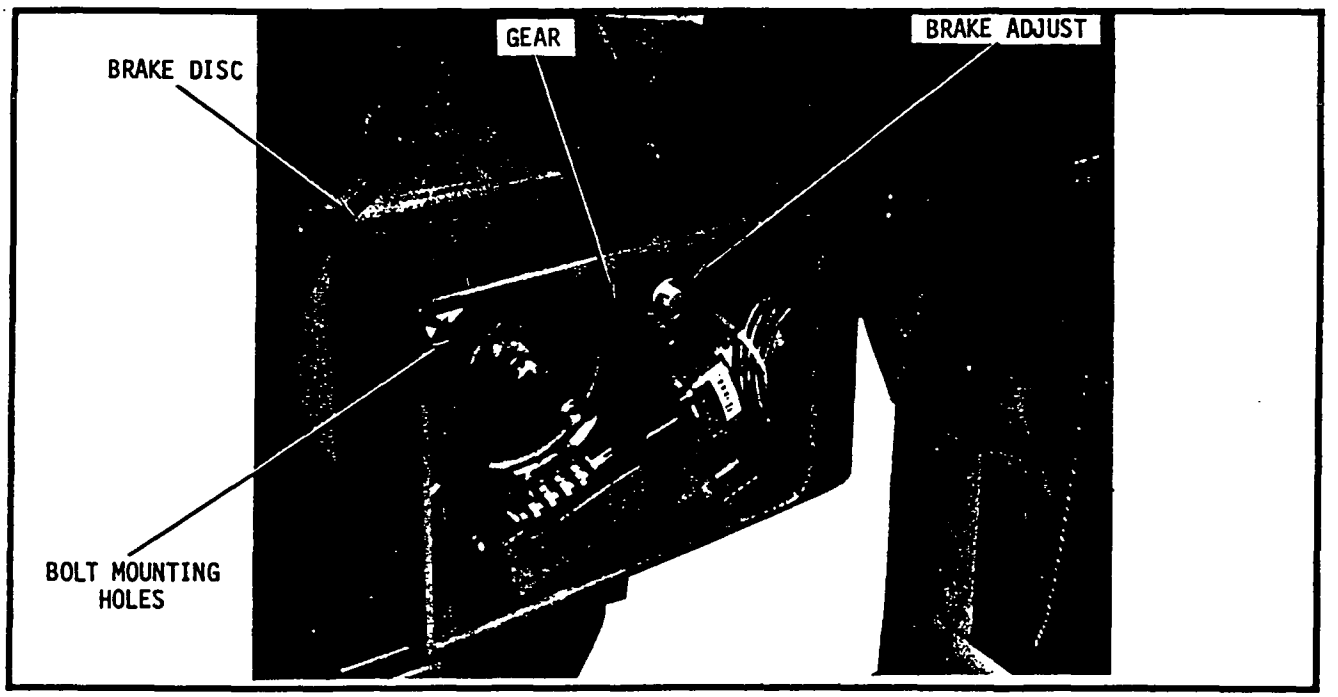
3. Position the skid on rollers in front of and in line with the Stand.

4. Remove the two hold-down brackets and the Head will be free of attachments to the skid except for four clamping studs through the base plate.

NOTE

Do not remove these studs at this stage. The Head skid must first be raised about 12-inches to align the trunnions.

5. With the Yoke in the horizontal position (make sure the head tilt motor is on your right side as you face the machine) raise the Head and skid into position and fasten with the four flat head heat-treated 1/2-20 x 1-inch screws provided. The right trunnion lug must line up with hole in the worm gear at the lower front of the Yoke Arm. Notice that the screws are to be installed through the holes in the worm gear. Rock the Head slightly to get proper seating of the bolts.



HEAD TILT MECHANISM

WARNING

DO NOT REMOVE THE SKID NOW. IT SERVES TO BALANCE THE HEAD AS WELL AS TO SHIP IT. TO REMOVE IT NOW WOULD CAUSE A SERIOUS IMBALANCE WHICH COULD RESULT IN INJURY TO PERSONS AND MACHINE IF THE YOKE WERE ROTATED FROM THE HORIZONTAL.

COLLIMATOR INSTALLATION

At this point the head, hanger and carriage are much heavier than the counterweight bucket and will remain on the blocks.

To install the collimator the head and skid must first be rotated 180-degrees as follows:

1. Release the tension on the yoke brake pucks by turning the brake tension screws in a counterclockwise direction. Refer to photo of yoke brake in Section 3.

CAUTION

DO NOT ROTATE THE HEAD AND SKID WITH THE YOKE MOTOR. THE CHANCES OF PREMATURE GEARBOX AND YOKE MOTOR FAILURE WILL BE LESSENED.

2. Remove the three 3/8-16 x 2-inch socket head cap screws and the two dowel pins from the yoke drive gear. To remove the dowel pins place three 5/8 flat washers and a hex nut on the exposed threaded end of the dowel pin. Turn nut with a wrench to free the pin. If pin does not come out easily, place a screwdriver between the flat washers and gear and pry outwards. This will disconnect the yoke drive gear from the yoke tube. (See photo on page 17.)

NOTE

Notice that three punch marks on the yoke tube are lined up with three punch marks on the yoke drive.

3. Manually (with extra help) rotate the head and skid *in a clockwise direction* (facing the unit) so the skid is facing upwards and two punch marks appear on top of the yoke tube inside the yoke.

CAUTION

THE HEAD AND DRIVE GEAR MUST ROTATE IN A CLOCKWISE DIRECTION TO PREVENT LIMIT SWITCH DAMAGE.

4. Place a temporary 120-volt AC source to terminals TB4-2 and TB4-4 located in the left-hand side of yoke. Manually depress RE-21 to energize yoke motor. (RE-21 is located in box forward of yoke motor.)

5. With one man holding the head and skid the other man should energize the yoke drive motor so the drive gear rotates *in a clockwise direction* until the two punch marks on the drive are aligned with the two punch marks on the yoke tube.

6. Insert and seat both dowel pins. Reinstall and tighten the three socket head cap screws that were removed in step 2.

7. Turn each puck adjustment brake screws clockwise until they just seat and then 3-1/2 full turns in the same direction. If coasting develops turn these screws an additional 1/2-turn in the same direction.

8. Manually depress RE-18 located in the left yoke arm until the skid is level.

9. Remove the temporary AC power source from TB4-2 and TB4-4.

INSTALLATION OF 3706A COLLIMATOR

It is recommended that the service personnel read over these instructions thoroughly before removing the head from the skid. The collimator must be assembled step by step as given in the following procedure.

Removing Skid from Cobalt Head

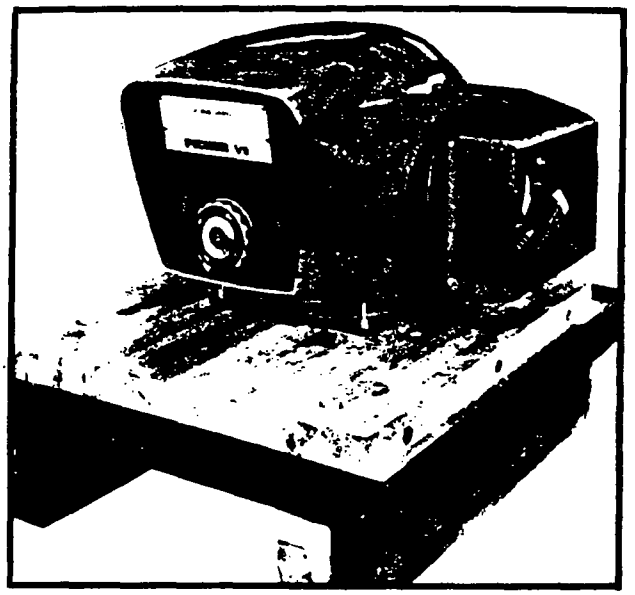
WARNING

FROM THE TIME THE SKID IS REMOVED UNTIL THE BEARING IS INSTALLED, EXCESSIVE RADIATION IS PRESENT AT THIS END OF THE COLLIMATOR. ALL WARNINGS TO SERVICE PERSONNEL PRINTED IN THE FRONT OF THIS MANUAL MUST BE OBSERVED.

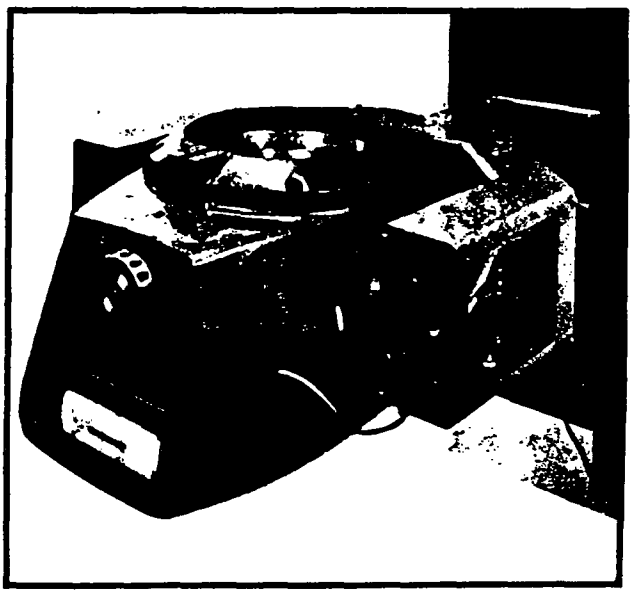
1. Back off on the upper jam nuts on the four threaded studs that secure the mounting lead plate to the head.

2. Back off on the lower jam nuts until they are tight against the upper jam nuts.

3. Turn the upper jam nuts in the direction so the studs screw out of the head.



INSTALLING HEAD TO YOKE



SHIPPING SKID REMOVED

13

NOTE

If it is difficult to turn the studs, loosen the countersunk nut on the opposite end of the stud.

4. Remove the skid with a lift truck. The skid and lead plate weight approximately 410 pounds.

WARNING

THE RADIATION LEVEL AT A DISTANCE OF TWO FEET FROM THE UNPAINTED PORTION OF THE HEAD IS 1000 TO 3000 MILLIROENTGENS PER HOUR. THE BEARING SHOULD BE INSTALLED IMMEDIATELY.

Installing Bearing Ring

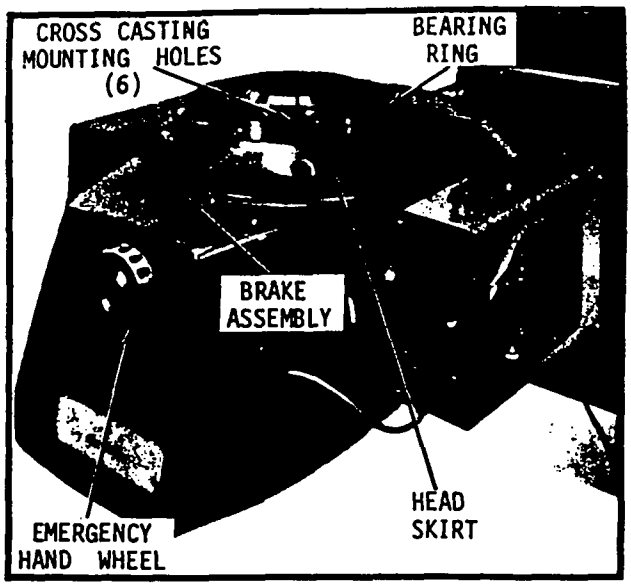
Before installing the bearing ring remove any chips of metal or tape from the bearing ring and the head.

1. Place the bearing ring in the head making sure the eight holes line up with the threaded mounting holes in the head. The bearing ring weighs approximately 40 pounds.

2. Move the inner race of the bearing ring and insert the eight 1/4-20 x 1-1/4-inch socket head cap screws one at a time when the light access opening is opposite each threaded hole.

3. Tighten the eight mounting bolts. Rotate the inner race making sure it rotates freely and does not rub against the head skirt.

4. Position the inner race bearing so the light access opening is at the rear of the head. See photo.



BEARING RING INSTALLED

Installing the Main Housing Assembly

1. Place the main housing assembly on the bearing ring so the collimator lamp socket fits in the access lamp opening. Also make sure the six mounting holes in the casting are directly opposite the threaded holes in the bearing.

CAUTION

CHECK TO SEE IF THE COLLIMATOR LAMP IS IN THE SOCKET. DO NOT TOUCH THIS LAMP WITH YOUR FINGERS; THIS WILL REDUCE THE LIFE OF THE LAMP. USE SPECIAL WRAPPING PAPER SHIPPED WITH EACH LAMP WHEN HANDLING.

2. Insert the six 1/4-20 x 3/4-inch socket head screws and tighten.

3. Install the brake assembly on the front of the head with the four 10-32 cap screws. Be sure the lead angle of brake is on the top. Refer to photo.

4. Adjust the front microswitch bracket so the microswitch is actuated by the pointer bracket on the brake assembly.

5. Rotate the housing clockwise and counterclockwise to the 90-degree positions, making sure the pointer bracket on the head skirt actuates the microswitches.

6. Place the accessory ring on top of the main casting with the two small cutouts on the ring facing the front of the collimator. The eight mounting holes in the ring should be in line with the eight holes in the main casting.

7. Place the extender casting on top of the accessory ring making sure the mounting holes in the extender casting are in line with the holes in the accessory ring and main housing casting.

8. Insert the eight socket head cap screws in the extender casting and tighten.

9. Place the extender trim cover around this casting with the cutout section at the rear of the collimator. The edge next to the accessory ring must be positioned between the ring and collimator. The opposite edge must seat on the shouldered surface of the collimator. Insert the four small screws and tighten.

10. Place the two shrouds around the main housing casting.

11. Insert the screws at the front and rear of the shroud to hold it together and lock in place with the four set screws on the accessory ring.

12. Mount the rotational scale to the shrouds with the two screws provided.

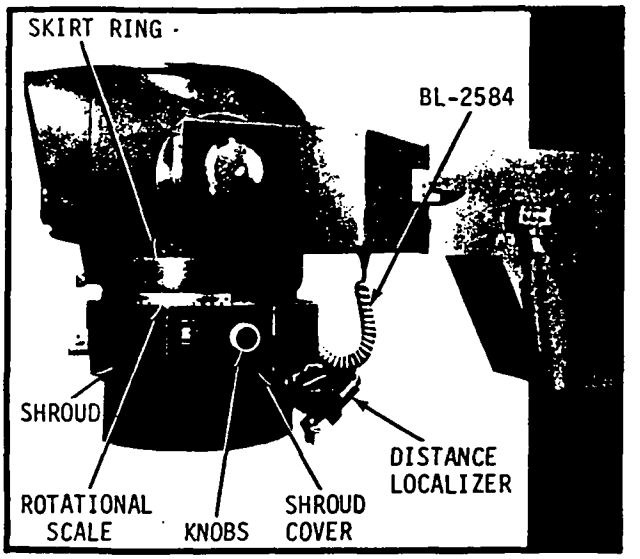
13. Place the shroud covers over the gearboxes and secure each cover with the four screws provided. The plastic windows must be centered over the scales. Reposition the two shrouds if necessary by loosening the four set screws in the accessory ring.

14. Place the knobs on the protruding shafts and tighten each with the two set screws.

15. Remove the two wires from the lamp switch making a note of the location of each wire on the switch.

16. Mount this switch in the opening of the side shroud cover by merely pushing the switch into the front opening. Reconnect the wires and install the shroud cover.

17. Mount the distance indicator bracket to the rear of the extender casting with the four socket head screws provided. (See Section 3 for Adjustment.)



COLLIMATOR INSTALLED

18. Place the two skirt rings (the angle ends at the front) mounting holes over the holes in the head. With a long Allen wrench or extension tighten the screws from the bottom of the collimator.

19. Adjust skirt ring shroud so when the collimator is rotated in either direction the main shroud does not rub against it.

20. Install the rectangular cover over the collimator lamp cavity with the two screws provided.

21. Rotate the yoke clockwise to the 90-degree position. Retighten the four bolts in the lower trunnion only. Use a 10-inch extension pipe on Allen wrench. Tighten until a stress is felt on the Allen wrench. 15

22. Tighten the upper trunnion retainer bearing bolts.

23. Rotate the yoke to the 270-degree position. Retighten the four bolts in the lower trunnion only in the same manner as in step 21.

24. Tighten the upper trunnion retainer bearing bolts.

CAUTION

THESE BOLTS SHOULD BE CHECKED PERIODICALLY ONCE EVERY THREE OR FOUR MONTHS.

Wiring Procedure—BL-2584 Cable

This cable consists of ten leads. One end in the yoke is already connected to TB4 at PXM. The opposite end of this cable must be routed into the collimator using the Heyco grip mounted to the collimator shroud cover and connect the leads to TB7 on collimator as shown below.

BL-2584 CABLE ENDS (NOT CONNECTED)	COLLIMATOR TERMINAL	LEAD COLOR	YOKE TERMINAL (CONNECTED AT PXM)	COMMENTS
Do Not Connect this End	TB7-1 TB7-2	Blue Brown	TB4-10 TB4-6	Used for C9 Halo Switch Only
	TB7-3 TB7-4	Black White	TB4-20 TB4-8	

BL-2584 CABLE ENDS (NOT CONNECTED)	COLLIMATOR TERMINAL	LEAD COLOR	YOKE TERMINAL (CONNECTED AT PXM)	COMMENTS
Do Not Connect	TB7-5	Red	TB4-2	Zonegard Only
	TB7-6 TB7-7 TB7-8	Tan Yellow Orange	TB4-4 TB4-19 TB4-18	
Do Not Connect	TB7-9	Gray	TB4-7	Zonegard Only
Purple Lead is Tied Back				

Zonegard

Within the Yoke, on the left front side, are two mercury switches which open the shutter circuit when the Head is tilted more than a preset angle. These switches have been set at the Factory so that the radiation beam can be angled 90-degrees to either side of center and still allow the Shutter to open, based on the assumption that the machine will not be located on an upper floor but will allow the direct beam to be expelled at the ground floor only.

These shutter safety switches must be adjusted so as to allow the Shutter to open only when the Head is aimed at walls which are adequately protected against primary radiation which must only be specified by a registered physicist. If room protection allows angles of more than 90-degrees to be set, then adjust mercury switches as required (see Stand Wiring Diagram E-T61B-363). If 16 angle limits of less than 90-degrees are desired, the parallel wired switches must be series connected instead and then adjusted.

The white "Zonegard" light, seen through the Head cover window, lights only when the Head is pointed within the limits determined by the switches, as a reminder to the operator of the machine when setting up for treatment. If the light is off, the shutter will not open even though the Control Key Switch is actuated.

Connecting Head to Yoke (Refer to E-T61B-363, BL-1824H)

The head can be connected by routing the Head to yoke cable (BL-1824H) through the cable grip on top of the left-hand side of yoke. Leave enough slack on cable for Head tilt. Tighten lock nut on cable grip, and connect leads as follows in the yoke:

1. Connect lead marked 4G to terminal strip TB4 terminal 1. (TB4 is located on left side of yoke.)
2. Connect lead marked 1G to terminal strip TB4-2.
3. Connect lead marked 2G to terminal strip TB4-4.
4. Connect lead marked 6G to terminal strip TB4-5.
5. Connect lead marked 12G to terminal strip TB4-9.
6. Connect lead marked 9G to terminal strip TB4-11.
7. Connect lead marked 3G to terminal strip TB4-12.
8. Connect lead marked 10G to terminal strip TB4-13.
9. Connect lead marked 11G and 14G to terminal strip TB4-19.
10. Connect lead marked 7G and 13G to terminal strip TB4-8.

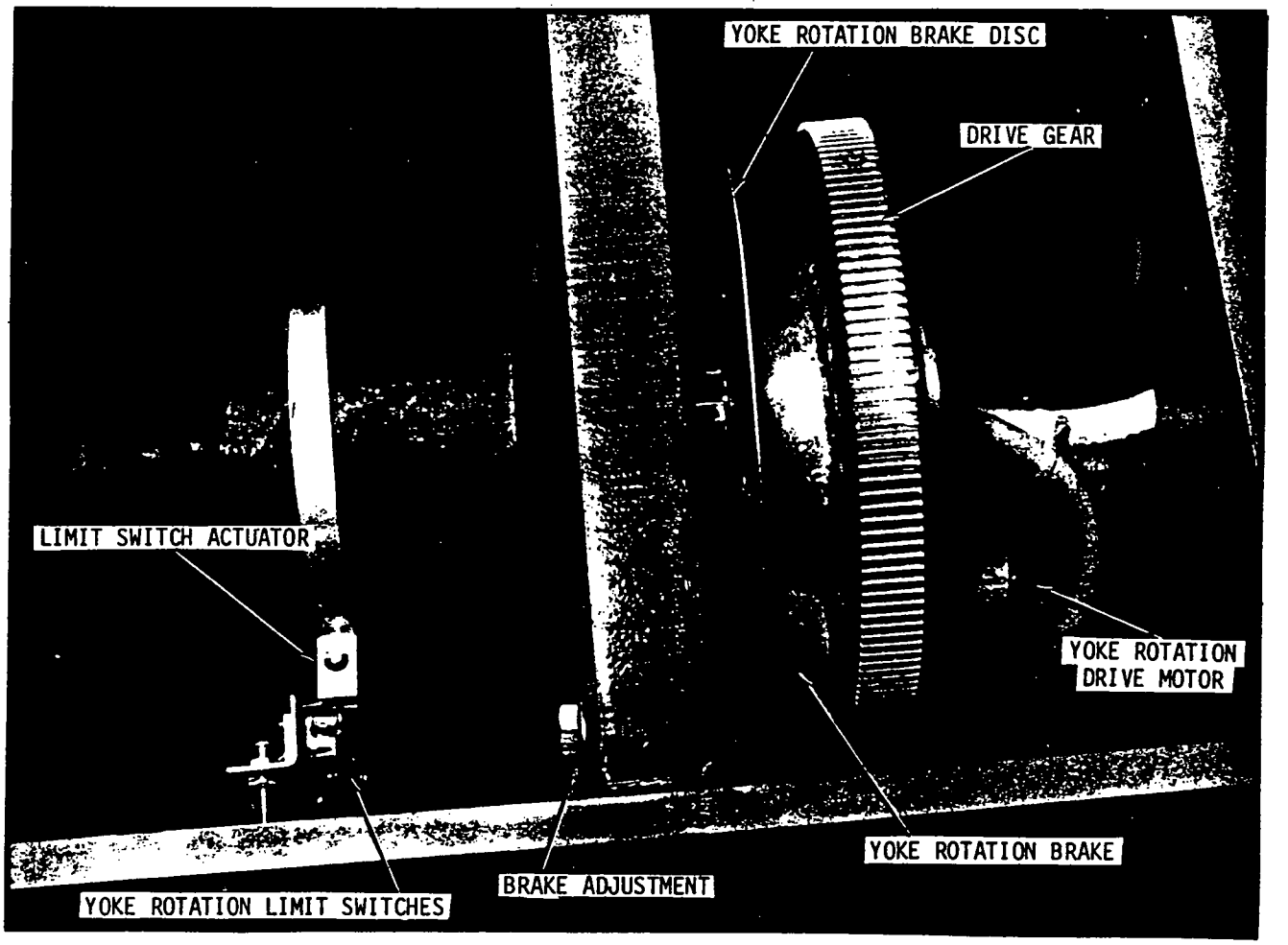
11. Connect lead marked 5G and 8G to terminal strip TB4-20.

Pendant Switch

The Pendant Switch, prewired on all units, is mounted on the right side of the Carriage according to the wiring diagrams and instructions included with it. This switch controls the direction of the yoke rotation, head tilting, and vertical drive. The Pendant Switch Cord connects into the receptacle on the bottom of the vertical carriage.

Setting the Yoke Rotation Brake

To the rear of the counterclockwise limit switch is the brake adjustment screw. To adjust this brake turn screw clockwise until the brake engages the brake disc, then turn screw 3-1/2 turns in clockwise direction.



YOKE ROTATION MECHANISM

Final Balancing and Leveling of Stand

With the Collimator completely attached, the Head will be balanced in rotation but will not be balanced perfectly with the counterweighting in the Stand. Additional counterweighting (from bags) will have to be added. While filling the counterweight, use a rawhide or rubber mallet from time to time to "shake down" the shot. Check the balance periodically. It is best that the upward motion be set so that the unit will move up with a light touch.

NOTE

Recheck the plumb of the stand. It must be level.

The "V" belt can be installed and adjusted after the balancing. Clean the large drum surface and "V" belt surface *oil free*. But if it has been done previously, it should be loosened to allow more sensitive adjustment of final balance. After the unit is balanced the tension of the "V" belt can be adjusted to overcome the rolling friction of the Carriage. To adjust the "V" belt loosen the two hex head screws approximately one full turn in the slotted holes of the motor mounting plate. Back off the two lock nuts on the two 1/4-20 x 2-inch Allen head screws located on the top rear of the motor plate. Tighten each screw the same amount until the "V" belt is snug. Tighten lock nuts and the motor mounting screws. This will be rechecked with power on later.

Adjust the tension of the idlers riding on the "V" belt by loosening the idler bracket screws that fasten the bracket to the motor mount. Tighten the nuts on the long threaded rod until the idlers move toward one another placing a tension on the belt. Tighten the bracket bolts.

Electrical Connections

The VG-8D Control ordinarily will rest on a desk or bench in the control room, near the view window or TV monitor. To connect the cables from the Control to the "B" box, refer to drawings D-T64-382 and E-T61B-363.

Connect the wires from the "C" box to the terminal strip at the top back of the Stand. Connect the Carriage cable to the terminal strip and dress it carefully so that the cable will not foul on the Carriage or Carriage roller bolts.

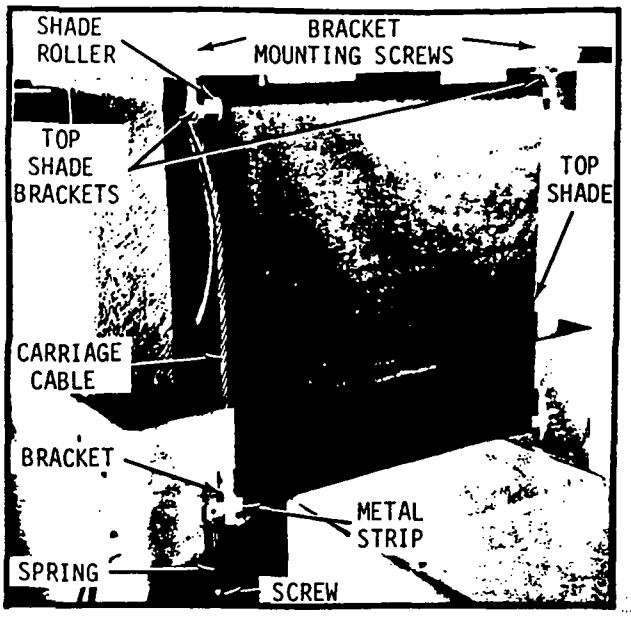
Connecting VG-8D Control (Refer to E-T61B-363, BL-1863A)

1. Connect green lead marked GND to earth ground.
2. Connect red lead marked L1 to the 117 VAC (Hot) side of 117 VAC power source.
3. Connect black lead marked L2 to the ("0" Volt) side of 117 VAC power source.
4. Connect the gray lead marked SW5-2 to door switch SW5 terminal 2.
5. Connect the violet lead marked 12 to terminal 12 of the stand terminal strip.
6. Connect the brown lead marked 11 to terminal 11 of the stand terminal strip.
7. Connect the orange lead 10 to terminal 10 of the stand terminal strip.
8. Connect the white lead 6 to terminal 6 of the stand terminal strip.
9. Connect the yellow lead 4 to terminal 4 of the stand terminal strip.
10. Connect the blue lead 3 to terminal 3 of the stand terminal strip.
11. Connect the red lead marked 2 to terminal 2 of the stand terminal strip.
12. Connect the black lead marked #1 to terminal #1 of the stand terminal strip.
13. The spare green lead is marked spare.

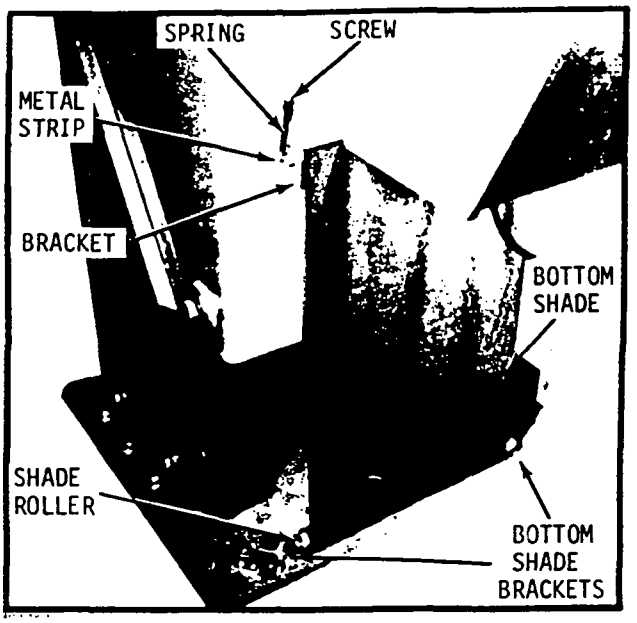
MOUNTING THE BACKGROUND SHADES

Top Shade

1. Position the top of the carriage approximately two feet below the top of the stand.
2. Install the two roll shade brackets to the top underside of the stand as shown in the photo. The holes are predrilled for mounting. Insert the roll shade in between these two brackets.
3. On the top front side of the carriage install the two brackets as shown in the photo. Place the two spacers between each bracket and the carriage. Insert the screws through the bracket holes and spacers and tighten.



TOP SHADE MOUNTING



BOTTOM SHADE MOUNTING

4. Pass the metal strip through the free end of the shade and each bracket as shown in the photo.

5. Attach a coil spring in each hole at the ends of this metal strip.

6. Insert the screws in the tapped holes below the brackets and attach the opposite end of both springs to these screws.

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NOTE

Springs are used to keep the shades self-aligning and wrinkle free.

7. Raise and lower the carriage making sure the shade moves freely without any binding.

Bottom Shade

The bottom shade is installed in the same manner as the top shade with the exception that the roll shade brackets are mounted to the bottom of the stand. Refer to photo.

Stand Trim Covers

The top, side, and bottom trim covers should not be installed on the stand until after the carriage checkout procedures in Section 3.

OPTIONAL DEVICES (INSTALLATION)

Accessory Attachment Post (3499E)

This is a rugged metal post that is attached to the Accessory Mounting Ring on the 3706A Collimator housing. The Post is required for mounting the Pin-and-Arc (3500C), and the Mechanical Back Pointer (3298C). The vertical position of the Post can be varied by turning a knurled knob on the side of the Post. Distance scales are field installed—for use of the Pin-and-Arc accessory.

To install this device release the lock clamps on each side of the post and insert the post into the two front slotted openings of the accessory ring. Position the post on the ring away from the slotted openings. Tighten the two clamps when the desired position is reached.

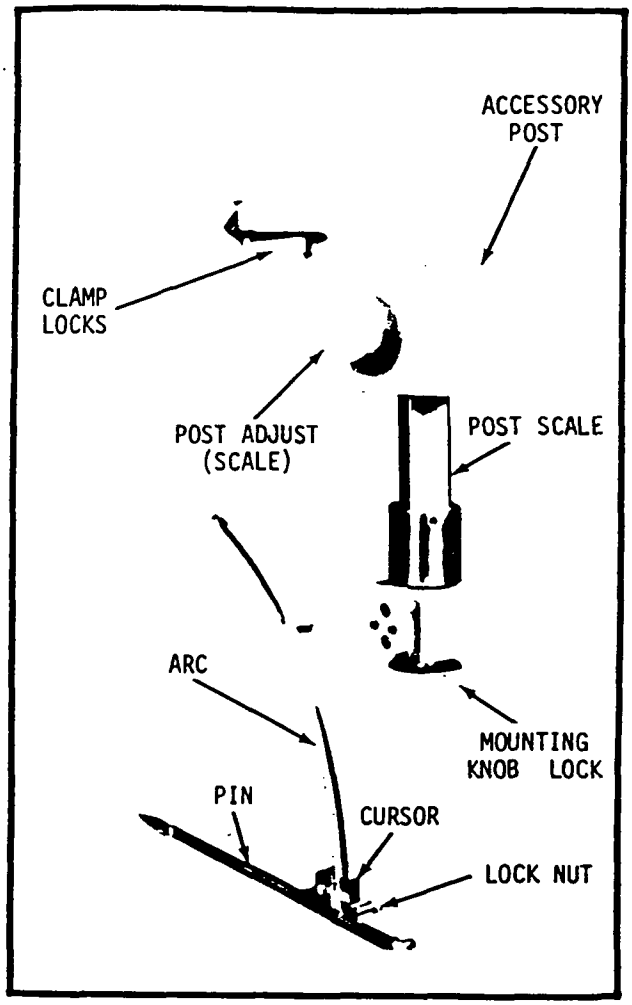
PIN-AND-ARC (3500C)

This beam directing device permits the user to quickly, conveniently, and accurately set the radiation beam at any desired angle and bring the patient to the proper treatment distance using a single reference point marked on the patient's skin.

The Pin-and-Arc can be easily attached to the Accessory Post by inserting the tapered adapter of the mounting bracket into the bottom of the Accessory Post. Turn the large knurled knob to tighten.

To properly install the scales on both the Attachment Post and the Pin-and-Arc the following procedure should be followed:

1. With this accessory mounted to the Post set the pin slider on the arc to the 90-degree position.
2. Reposition the Post to the 90-degree position on the accessory ring and secure with the clamp locks.
3. Turn on the collimator lamp. Place a sheet of white paper below the collimator on a table.
4. Turn on the Optical Distance Indicator and set it at 80cm.
5. Adjust the arc tilt set screws until the pin passes through the central ray of the collimator.
6. Set the pin so that the tip is on the central ray (on the cross hair of the paper).



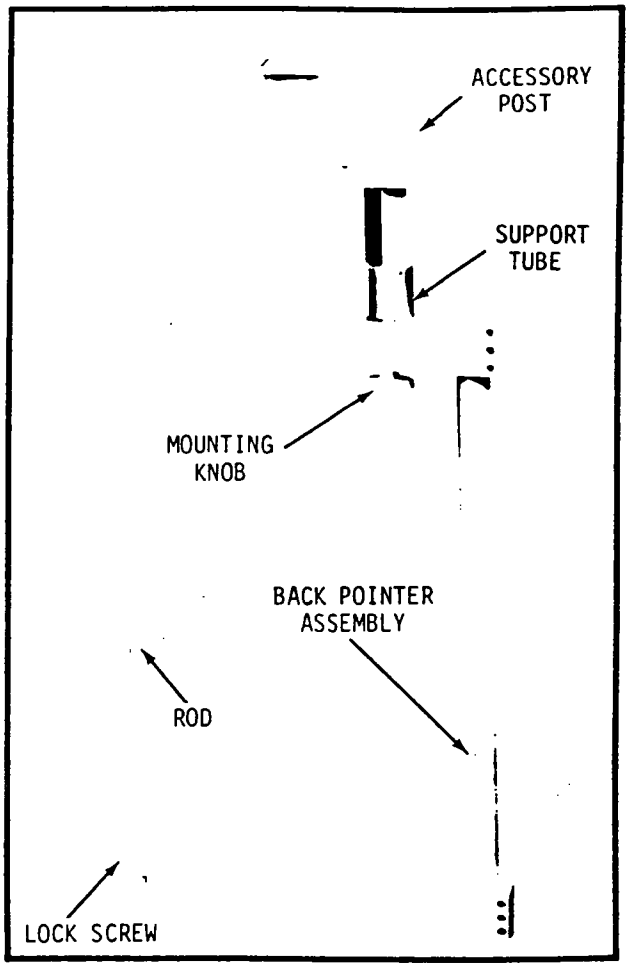
PIN AND ARC MOUNTING ACCESSORY POST

7. With the large knurled knob on the Attachment Post adjust until the pin tip is 80cm from the source as measured with the Optical Distance Indicator.
8. Glue the scale to the pin in such a position that it reads zero ("0").
9. Glue the scales to the Accessory Post in such a position that they read zero ("0").
10. Readjust the arc tilt set screws as required.
11. Check that the tip of the pin stays centered on the central ray as the pin slider is moved from one end of the arc to the other.
12. Turn out collimator lamp and Optical Distance Indicator and remove the device.

Mechanical Back Pointer Assembly (3298C)

This is a beam directing device which quickly locates the exit point of the radiation beam on the patient's skin. This device is rigidly mounted to the Accessory Post by inserting the tapered adapter of the mounting bracket into the bottom of the Post. A large knurled knob secures this device to the Post.

The Back Pointer consists of a "C" type assembly with adjustable backpointing rod accurately centered in the radiation beam.



MECHANICAL BACK POINTER

The following steps should be followed when installing the Back Pointer Assembly:

1. Install the mounting bracket to the support tube so the bracket surface and end of the support tube are flush.

2. Adjust the pointer arm so it is parallel to the mounting bracket. Secure all bolts.

3. Mount this assembly to the Accessory Post. Set the Post to zero ("0") on the scale.

4. Insert the pointer rod into the pointer arm and turn on the collimator lamp.

5. Adjust the height of the pointer rod so the tip of the rod is set at the central ray, then lock in place with the thumb screw.

NOTE

The mounting bracket may have to be repositioned (see step 1) to align the pin at collimator center.

6. Turn out collimator lamp and remove the Back Pointer Assembly.

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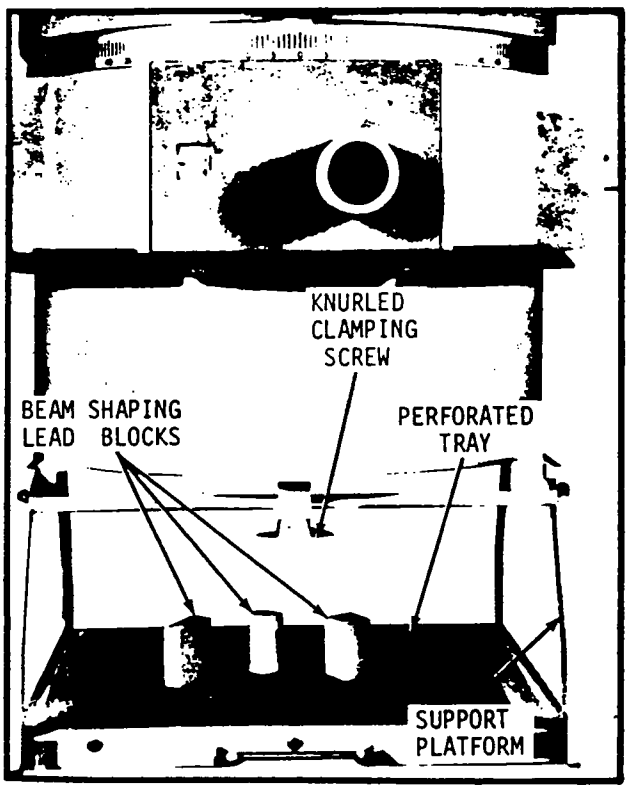
COLLIMATOR MOUNTED BEAM-SHAPING ASSEMBLY (3022)

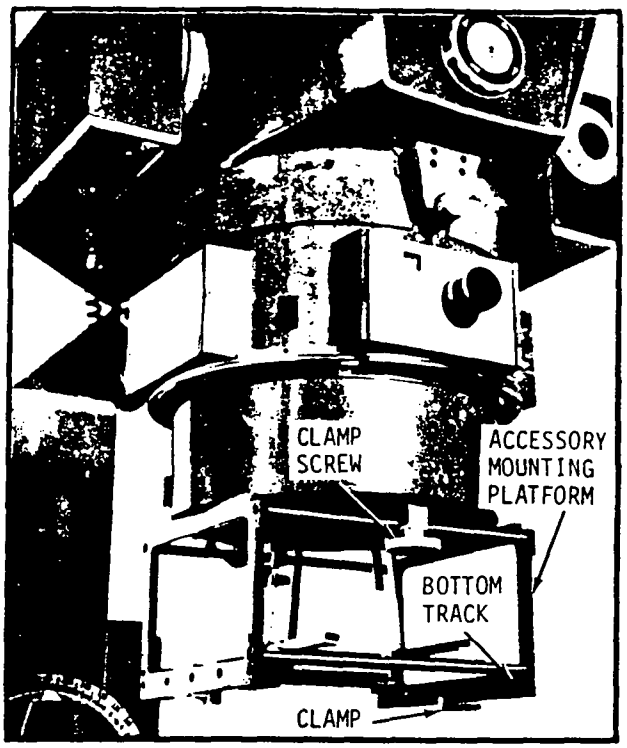
The above accessory permits the user to position lead blocks in the radiation beam to achieve irregularly shaped treatment fields and to shield predetermined areas of the patient.

This assembly consists of a beam-shaping support platform replaceable tray and beam-shaping lead blocks. The support platform is clamped to the bottom surface of the Collimator housing with a large knurled knob and stud located at the front of the support platform.

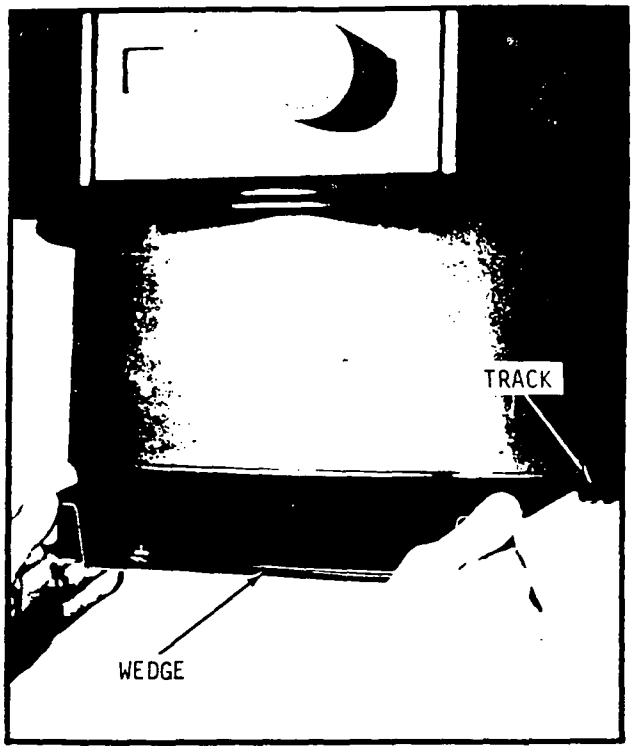
The perforated tray permits convenient visualization of position of lead shielding blocks (with collimator beam defining light field). Lead blocks are firmly clamped in any position on the perforated tray which can be removed from the support platform with the blocks clamped in position and stored so that the beam-shaping configurations can be quickly reproduced.



BEAM SHAPING ASSEMBLY



ACCESSORY MOUNTING PLATFORM



WEDGE MOUNTED TO COLLIMATOR

Accessory Mounting Platform (3754A)

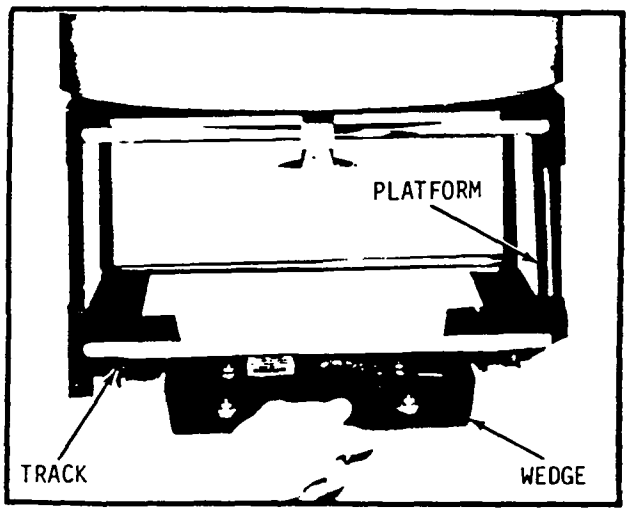
22 This platform is required when using the Wedge Filter (3021, 3021B), or the Oblique Brass Compensator (3021A).

The top of the platform mounts to the bottom tracks of the collimator. The large knurled knob and stud at the front of the platform secures this device to the threaded hole in the collimator.

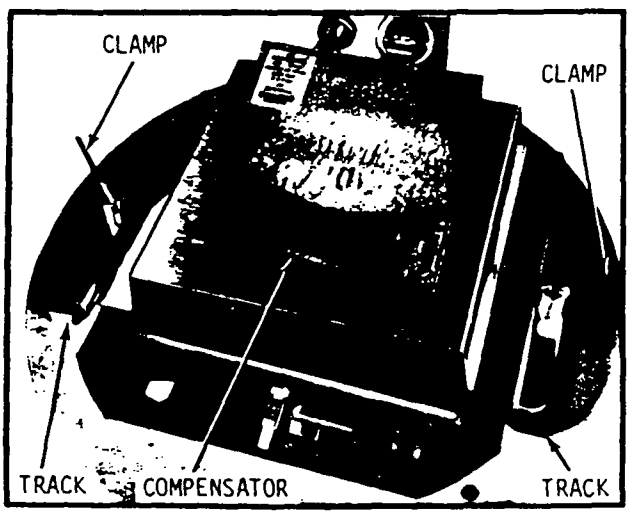
Wedge Filter (3021 and 3021B)

The Wedge Filter is made of lead and can be installed on the bottom tracks of the Collimator and locked in the desired position. The 3021 is a 45-degree wedge and the 3021B is a 60-degree type.

The Wedge can also be installed on the bottom tracks of the Mounting Platform (3754A).



WEDGE INSTALLED ON PLATFORM



COMPENSATOR MOUNTED TO COLLIMATOR (BOTTOM VIEW)

NOTE

Whenever a Wedge Filter is used with an Oblique Compensator the Wedge should always be mounted nearest the source.

Oblique Compensator (3021A)

The above can be used and installed in the same manner as the Wedge. The Oblique Compensator is made of brass. It must be mounted with the brass section away from the source.

The Oblique Compensator can be installed and locked on the bottom of the Collimator as shown in the photo.

THERAPY TABLE (3702A)

The 3702A is a traveling cantilevered table top which permits precise patient positioning prior to treatment with fixed or moving radiation beams. The table top longitudinal and transverse motions are manually controlled. The vertical elevation is motor-controlled. The entire table can be pivoted 180 degrees about the vertical beam axis.

Table top positioning locks and table floor brakes are normally applied to protect the patient and the therapist. In an emergency the table and patient can be instantly removed from the path of the radiation beam by a firm backward pull on the rear table handle.

DUAL LIGHT SOURCE (3595C)

The Dual Light Source consists of two individual light sources mounted on opposing treatment room walls that project a pencil thin coincident light beams that intersect at the cobalt machine isocenter. The lamp assembly in each unit can be adjusted to compensate for walls not parallel to the axis of the cobalt unit. Each wall unit can be operated from any 115 VAC wall outlet. Detailed instructions and drawings (A-T60A-487 and C-T60A-489) will accompany each unit. 23

Section 3

CHECKOUT AND ADJUSTMENT

Be sure to read thoroughly the Special Warning and initial operation as outlined in "WARNING TO SERVICE PERSONNEL" in the front of this manual.

Upon completion of the installation, the checkouts and adjustments should be made in the following sequence. All adjustments were made at PXM but since the unit was disassembled for shipment and reassembled at installation some adjustments may be necessary.

Use a survey meter at times until proper operation of unit has been established.

"V" BELT AND CAM FOLLOWERS

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Raise and lower the vertical carriage with the Pendant Switch. Check to see if the "V" belt shows any signs of slipping around the cable pulley. If this occurs, readjust the idlers for a greater tension against the belt.

Adjust the cam followers by tightening the set screws on both sides of the cam follower mounting blocks, until the Carriage rolls easily along the edges of the column channels. Be sure that the cam followers do not jam or bind during vertical motion of the Carriage.

Yoke and Head Leveling

1. Using the pendant switch, rotate the yoke assembly to its zero position on the rotational angular scale.

2. Hold a level across the bottom of the collimator (crosswise facing the unit). If not level, rotate the yoke slightly until it is level. A tolerance of ± 1/2 degree is acceptable.

3. The pointer on the angular scale should now be at zero degrees. If not, reposition the pointer to zero. Also check the gravity-operated angulation dial on the front of the yoke.

4. Hold the level lengthwise across the bottom of the collimator. If not level, tilt the head in the desired direction until it is level.

5. Check the tilt angular scales making sure it is set on zero.

Collimator Checkout

1. Place a Therapy Table (3702A or equivalent) below the collimator.

2. Check the field symmetry as follows:

a. Set the head and yoke at their 0° positions and rotate the collimator to either one of its 90° positions. Set the field size to about 10 x 10cm.

CAUTION

AT NO TIME SHOULD THE TRIMMER BARS BE RETRACTED OR EXTENDED BEYOND A 20 x 20CM PROJECTED LIGHT FIELD SIZE.

b. Mount a small pointer or dial indicator from the table top and adjust the height of the carriage so the pointer just touches the inside surface of one of the collimator vane bars.

CAUTION

DO NOT LEAN ON THE STRETCHER WHILE MAKING THIS CHECKOUT.

c. Manually rotate the collimator 180 degrees. The pointer should now touch the opposing vane bar. The error should not exceed 1/64-inch. If the vanes are off center; i.e., not symmetrically placed around the collimator axis, it will be necessary to adjust the positions of the two sets of cable pulleys (which hold the vane drive cables)—the ones nearest the end of the collimator. The pulleys must be moved in pairs so as to keep the cable between them taut. The pulley support locking screws should be loosened slightly, and the support blocks can then be moved by means of set screws which work against stops on the main frame casting.

When the adjustment is completed, the set screws which tighten the cable should be set to a torque of 4-1/2 inch-pounds.

d. Repeat for the other set of vanes.

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e. Turn on the field illumination light. Lay a white paper on the stretcher top, and tape it so that it won't move. Set the field size for a 10 x 10cm. The collimator should be at one of its 90° positions.

f. Using a ruler, draw a pencil line on the paper coincident with one edge of the field. Draw another line at 90 degrees to the above line for the other edge of the field. The two lines will resemble an "L". Rotate the collimator 180-degrees and check that the field edges line up with the pencil marks. If they don't, and if the previous steps have been carried out properly, then the mirror is bent or defective or somehow at the wrong angle. There is no adjustment—this is merely a check for shipping damage. Contact PXM if damage is evident.

3. Set the collimator field dials to 4 x 4cm at 80cm with the extenders "in"; i.e., retracted.

NOTE

The distance from the source to the bottom of the lowest trimmer bar of the collimator is 45cm with the vanes closed. The distance from the bottom of this trimmer bar to the paper should be 35cm (13-29/32 inches) for the 80cm setting.

4. Loosen the collimator locking knob on the front of the collimator and rotate the collimator to one of its 90-degree positions. Place a mark on the paper where the projected cross hairs intersect.

5. Rotate the collimator to a 180-degree position. The center cross hairs should remain at the center of the mark on the paper. If the center deviates away the cross hairs are not centered. The cross hair positions are adjustable at their mounting points and must be adjusted on exact center.

6. Rotate the collimator to its zero-degree position and tighten the collimator knob.

7. Reposition the alignment paper so it is at a 90-degree angle with the top of the book.

8. Rotate the yoke to the 90-degree clockwise position and observe the location of the cross hairs projection on the alignment paper. Mark accordingly.

9. Rotate the yoke to the 90-degree counterclockwise position off of the zero position and note the location of the cross hairs projection image in comparison with the 90-degree projection marking in step 8. The deviation should not exceed ± 2mm.

   If the deviation is greater than ± 2mm, rotate the yoke toward the center of rotation, splitting one-half the difference. Reset the alignment paper at the center of the cross hair projection. Recheck both steps 8 and 9.

CAUTION

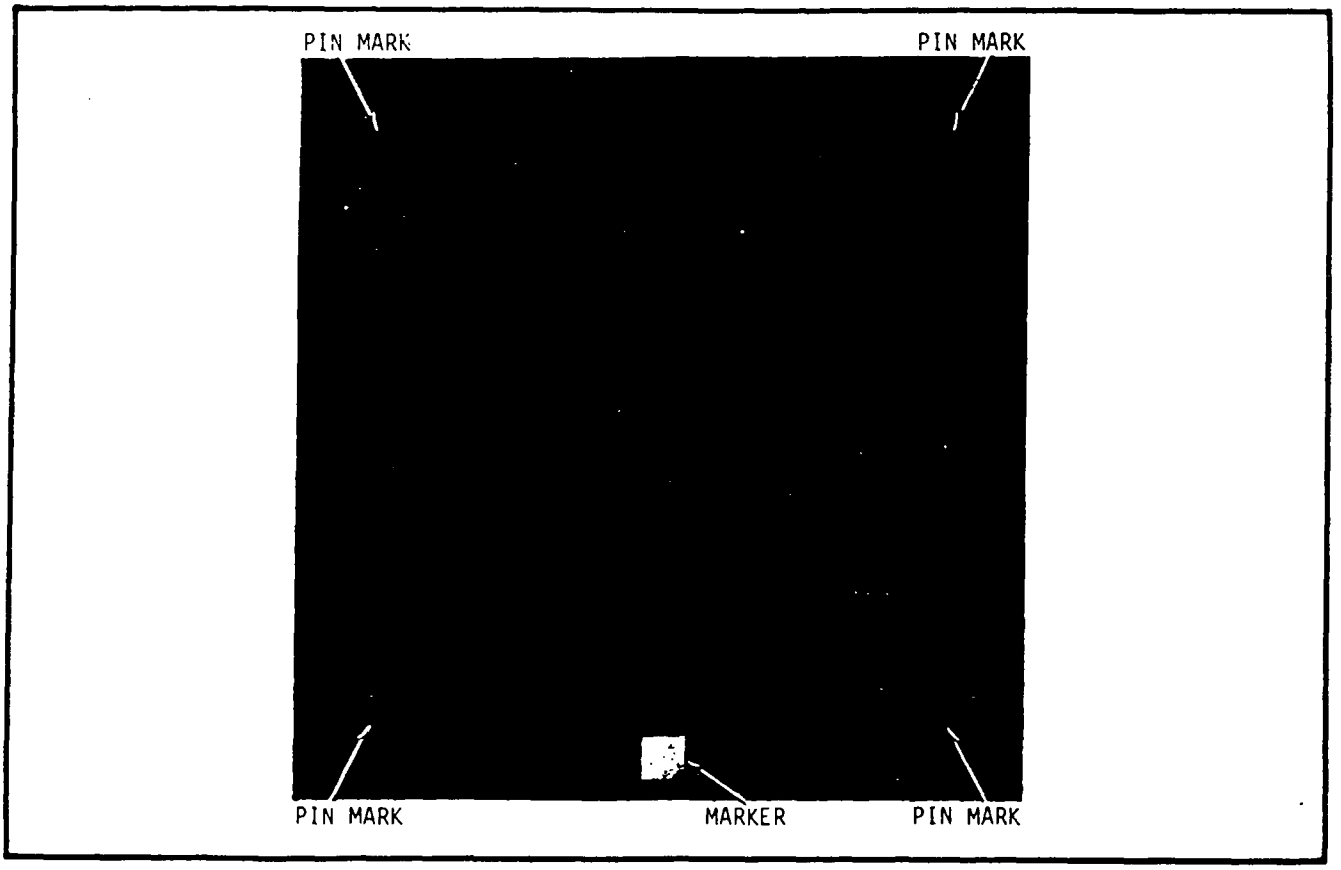
DO NOT MOVE THE STRETCHER OR THE ALIGNMENT FIXTURE.
LEAVE THEM IN PLACE FOR SUBSEQUENT TESTS.

COLLIMATOR FILM CHECK

This check should be made by a Physicist.

Using type "M" or type "R" film in a paper cassette, place this cassette at right angles to the collimator axis at 80cm from the source. Set the field size for a 10 x 10cm with the trimmers extended.

Turn on the field illumination light. Place pin marks as reference in the four corners of the illuminated field. Also place a marker in the middle of the field to identify the front (radiation input) side and to orient the film with respect to the collimator and machine. Expose to about 35 roentgens (type "M") or 70 roentgens (type "R"). The blackened part of the film should line up with the pin marks.

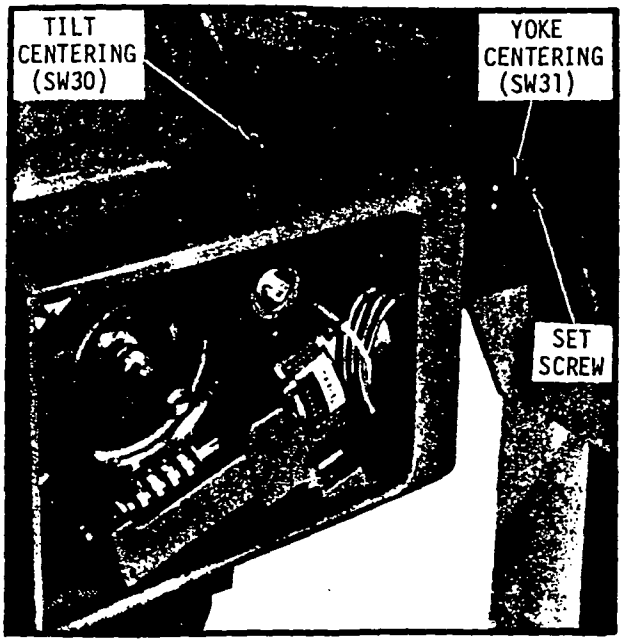


CORRECT FIELD ILLUMINATION PATTERN

Head Tilt Centering Switch (SW30)

Switch SW30 is located on the front center of the yoke and the switch actuator is mounted on the rear center of the Cobalt Head.

1. Place the Yoke Hanger at its zero-degree position and turn on the collimator light so the cross hairs project upon the alignment paper at a distance of 80cm. Mark the intersection of the projected cross hairs.



HEAD AND YOKE CENTERING SWITCHED

2. Since the head assembly has been previously adjusted to be on isocentric center and leveled "in" and "out," actuate the "in" and "out" buttons on the pendant switch to check that the cross hairs return to a position within ± 2mm of the centered position.

3. To adjust the switch the following procedure is recommended:

   a. Center the head for zero positioning of the cross hairs on the previously marked paper in step 2.

   b. Loosen the large chrome hex nut on the actuator box (on the back of the head) and move the switch actuator so it is in line with the centering switch roller (on the yoke hanger). Tighten the large hex nut.

   c. Position the actuator "in" or "out" so it will depress the centering switch on the yoke. A locking nut is used to accurately set this adjustment.

   d. Check these adjustments by tilting the head assembly "in" and "out" and observe the cross hair projections for centering accuracy.

Yoke Swivel Centering Switch (SW31)

The yoke swivel centering switch is located on the right rear surface of the yoke and is actuated by a pointed screw on the actuator bracket of the hanger.

1. Position the yoke with the pendant switch until the collimator cross hair projection is on the center of the alignment paper. The centering switch should be actuated at this point. If not, readjust as described in the following step.

2. The actuator bracket on the hanger contains a pointed Allen set screw that should depress the limit switch roller when the yoke is in the center position. By loosening the small Allen set screw on the bracket the large Allen set screw can be rotated until the switch roller "clicks." Tighten the small Allen set screw.

3. If the switch roller is not depressed loosen the two Philips head screws on the switch cover. Position the switch so the point of the actuator screw depresses the roller. Remount switch cover and tighten the two Philips head screws.

4. Check by rotating the yoke with pendant switch.

Optical Distance Indicator

1. Set the collimator field dials for 20 x 20cm with the trimmers retracted.

2. Place a piece of white paper at a distance of 35cm (13-29/32 inches) from the bottom edge of the trimmer bar. The paper is now 80cm from the source.

3. Turn on the collimator lamp switch which also controls the distance indicator.

4. An etched reticle in the distance indicator contains a graduated scale ranging from 55cm to 100cm. The 80cm mark on the projected indicator scale should fall exactly on the intersection of the collimator cross hairs.

5. To adjust distance indicator loosen the four screws that secure the lamp bracket to the collimator.

6. Adjust the three set screws in bracket until the 80cm graduation falls on the intersection of the cross hairs. No further adjustment of the distance indicator is necessary. Tighten the four bracket screws.

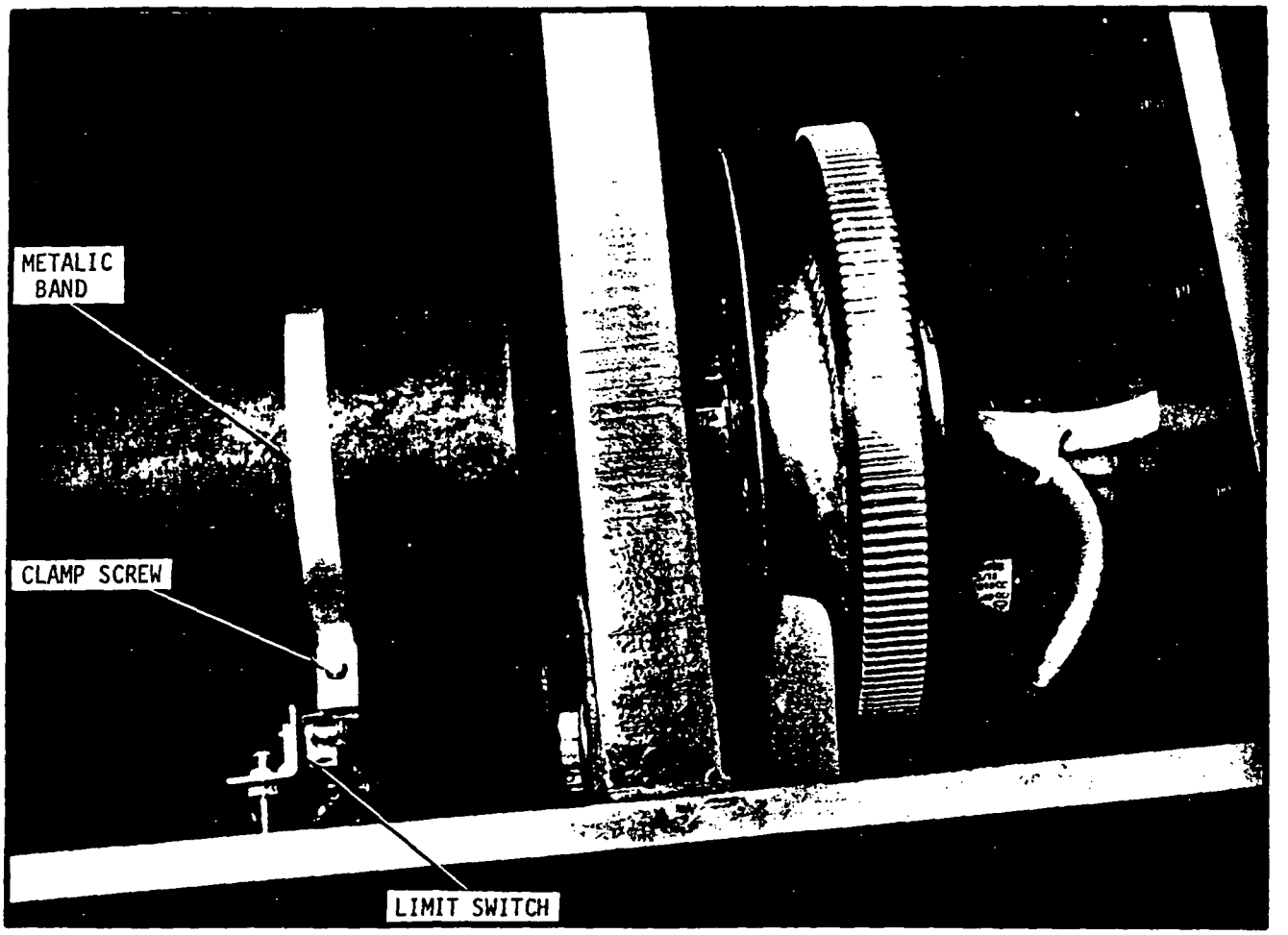
Yoke Rotation Limit Switches

The yoke rotation limit switches are located in the rear top of the hanger. These are adjusted to give the yoke a 175-degree clockwise and counterclockwise rotation from the zero or center position. To adjust these switches the following steps should be followed:

1. Set the yoke to its zero position as indicated on the yoke angular dial.

2. Remove the four screws and cover to expose the switches and actuator.

3. Rotate the yoke to the 175-degree clockwise position.



YOKE ROTATIONAL SWITCH ADJUSTMENT

4. The metallic band clamped around the yoke shaft with a screw and a nut should now actuate the clockwise rotation switch SW14.

5. If the tab on band does not depress SW14, loosen the screw and reposition the band until the tab actuates the switch.

6. Switch SW13, the counterclockwise limit switch, should now be actuated when the yoke is rotated to 175 degrees in the counterclockwise direction.

CAUTION

NEVER ROTATE THE YOKE IN A CONTINUOUS 360-DEGREE ROTATION OR THE ELECTRIC CABLES MAY TWIST AROUND EACH OTHER AND BREAK THE CONNECTIONS.

Source Head Tilt Limiting Switches

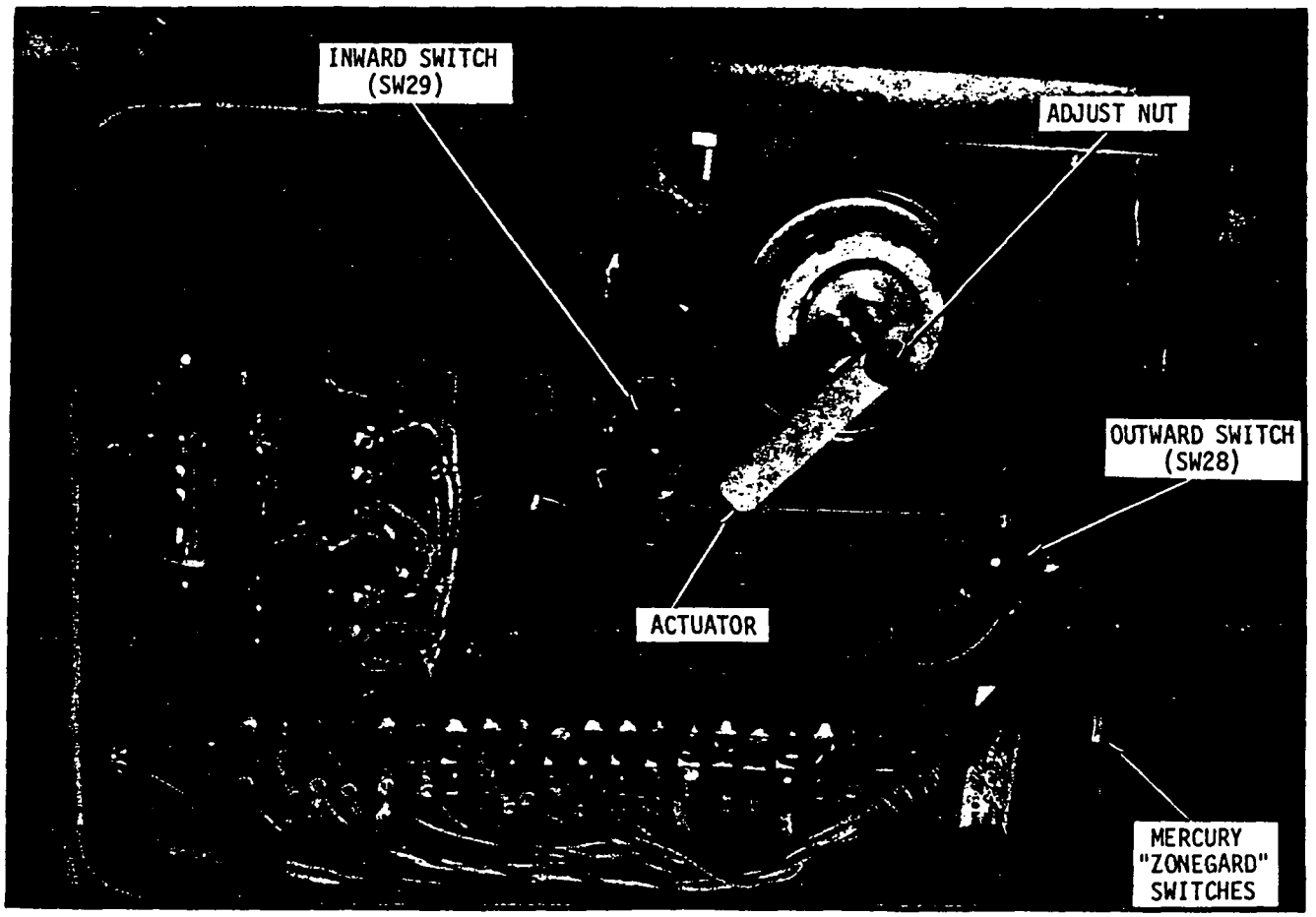
Switch SW28 limits the outward tilt up to an angle of 90 degrees, while SW29 limits the inward tilt to 20 degrees. Both switches are located in the left yoke.

Depress the Pendant Switch "OUT" tilt button and watch the Angular Tilt Dial. The head tilt should stop at 90 degrees. If not, the following procedure is recommended:

1. Position the head to the 90-degree position.

2. Loosen the nut on the actuator arm. (Refer to photo.)

3. Place the actuator arm directly over the switch SW28 making sure the switch arm is fully depressed. Tighten actuator arm.



LEFT SIDE OF YOKE

4. Depress the Pendant Switch "IN" tilt button.

CAUTION

MAKE SURE THE COLLIMATOR DOES NOT STRIKE THE YOKE.

5. At the 20-degree angle the actuator arm should depress the "IN" limit switch SW29 removing power from the tilt motor.

BRAKE ADJUSTMENT

The head tilt brake and the yoke brake are both adjusted in the same manner. (Refer to photos "Head Tilt Brake" and "Yoke Limit Switches, Brake, and Drive Motor".)

1. Turn the brake adjustment screw until the brake touches the disc.
2. Turn adjustment screw 3-1/2 turns in a clockwise direction.
3. Turn adjustment screw an additional 1/2-turn if a coast condition is evident.

REPLACING COLLIMATOR LAMP (Sylvania Type FCS or Picker Part No. T72-109)

1. Remove all power from the unit.
2. Remove the rear shroud cover.
3. Remove the two screws that secure the terminal block TB7 to the collimator casting.

CAUTION 31

ANY CONTACT WITH FINGERS, DIRT OR OIL WILL DRASTICALLY REDUCE THE LIFE OF THIS LAMP. USE WRAPPER FURNISHED WITH EACH LAMP.

4. Replace the lamp.

REPLACING OPTICAL DISTANCE INDICATOR LAMP (General Electric Part No. 1731 or Picker Part No. T72-111)

The Distance Indicator housing should not be removed from the mounting bracket to change the lamp. Merely unscrew the end of the lamp housing (the end where the cord enters) and the lamp is exposed for replacing.

It is not necessary to readjust the optical distance indicator assembly.

Section 4

REFERENCE DATA

ED-775	Decay Time in Months
ED-776	Decay Time in Days
C-T61A-557	WD/SD for VG-8D and VG-8E
E-T61B-363	Wiring Diagram for 1373D Stand
D-T61B-364	Schematic Diagram for V9
C-T61B-575	Head Wiring Diagram
D-T64-382	V9 Room Layout

ADDENDA "B"
TO
V9 COBALT 60 UNIT

Cat. No. 6268 Series

INSTALLATION INSTRUCTIONS

PH59:I3 (T55-571)

SUMMARY

1. This addenda supplements Installation Instructions PH59:I2 (T55-571) dated April 1970 and should be filed and used in conjunction with that manual.
2. This addenda supercedes addenda PH59:I2 dated September 1971 which is obsolete and may be discarded.
3. Make changes to the Installation Instructions (noted in item 1 above) as directed on pages ii and iii of this addenda.

PICKER CORPORATION
595 MINER ROAD, CLEVELAND, OHIO 44143

Aug '72

Printed in U.S.A.

ADDENDUM

VERTICAL MOTOR CIRCUIT V-9

PURPOSE:

On later models the electronics chassis includes a new relay chassis for controlling motor direction and speed. The following is the procedure for adjusting this new relay circuit.

THEORY OF OPERATION:

K1 and K2 are slow release relays. These relays allow the motor to stop before the direction can be electrically reversed. The release time is determined by C1 and C2 and is approximately 200 ms.

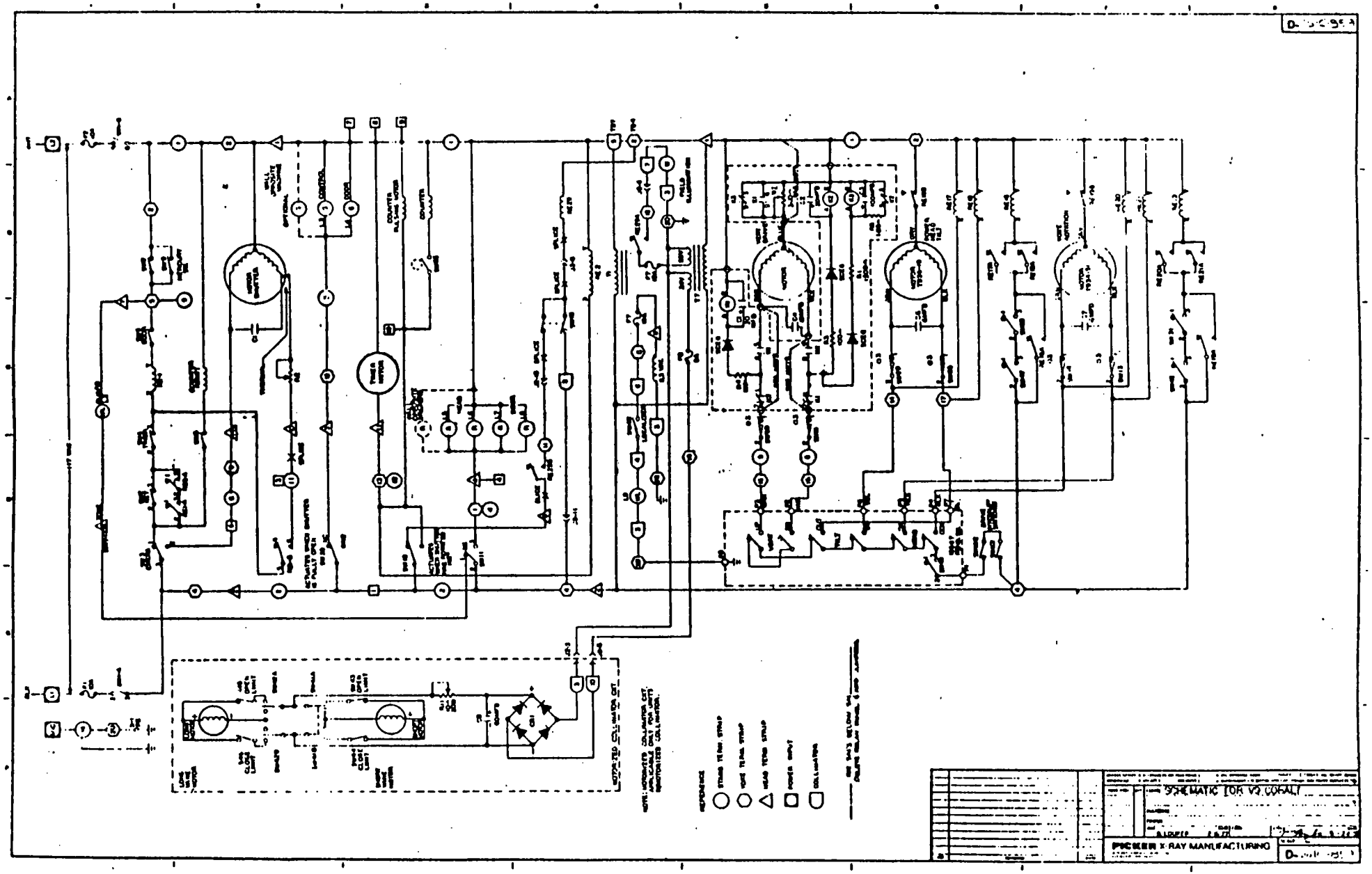
K3 is a slow energize relay that shorts out current limiting resistor R2 in downward direction for approximately 1 sec, during starting only. This permits the motor to have maximum starting torque which is in excess of 100 pounds. After approximately 1 sec K3 will pull in removing the short from R2. At this time the current is reduced in the motor, reducing running torque to approximately 50 pounds. The greater the value of R2, the less the torque. In the up drive condition K1 contacts short out R2 and the motor delivers maximum torque regardless of time.

ADJUSTMENT AND SETUP:
FACTORY AND INITIAL SETUP ONLY:

Loosen the motor so that the gears are free to move. With all normal shrouding, and minimum head attachments in place, determine that the head is balanced with the bucket and that the maximum torque needed to run is less than 50 pounds. To do this, use a scale and make at least 10 measurements in the downward direction. If the head needs more than 50 pounds, pull to move in any spot, determine the cause, and correct. After it has been determined that the unit is balanced (pull up is equal to pull down, and there is less than 50 pounds needed to pull down) retighten motor to gears.

FIELD ADJUSTMENT WITH NEW TORQUE LIMITING CIRCUIT:

The object is to produce as little torque in the downward direction as possible and still run from the upper to lower limit without stalling. To do this, adjust the R2 resistor for 200Ω. Starting from the upper limit run to the lower limit, if the unit stalls, reduce the resistor value by adjusting wiper. Decrease the value by 10% each time. After reducing the resistor value, test the run from the upper limit to the lower limit. Repeat the above procedure until the unit runs from the upper limit to the lower limit without stopping. Use a scale to determine the force required to stop the head after the motion has started. Do this in at least four places. The stopping force should be less than 50 pounds.


SCHEMATIC FOR V3 COBALT
PIONEER X-RAY MANUFACTURING

SUMMARY OF CHANGES

Page 3	Beam Collimator 3706A is changed to a 3706E. An optional motorized collimator 3706D can also be installed instead of the 3706E, the manually operated collimator. Refer to attached sheets on Collimators. Delete retractable trimmers. Add: The 3706D & E Collimators incorporate removable trimmers. See attached sheets.
Page 7, Step 1	Under heading of "Erecting the Stand" change layout drawing D-T64-318 to D-T64-382.
Page 11	Delete Head Tilt Mechanism Photo and see new photo in attached sheet.
Page 14, Step 10	Under "Installing the Main Housing Assembly" delete steps 4, 6, 7, and 8. Add: "Remove wires from switches (make note of wire location) and remount switches on shroud."
Page 15, Step 16	Delete Step 16. Under wiring - BL-2584A Cable, delete the last portion of the second sentence "the leads to TB7 on Collimator as shown below" and CHANGE "to the plastic connector".
Pages 15 & 16	Delete Wiring Procedure - BL-2584 Cable Add: "WIRING PROCEDURE - BL-2584A CABLE (3706D, E Collimators). This cable consists of eleven leads. One end in the yoke is factory connected to the yoke terminal board TB4. The opposite end of this cable is attached to plug J2. The J2 connector fits into the J2 receptacle located on the collimator. During shipment this cable and plug, along with the collimator cover, is taped to the yoke. For individual conections refer to C-T61B-914 and C-T61B-915 in the reference section."
Page 17	Under Pendant Switch, add sentence: "A switch SW49 is incorporated in the handle portion and must be depressed by the fingers before any of the control buttons on the pendant switch can be used." Delete Yoke Rotation photo and see new photo in attached sheet.
Page 19	Add: "VERTICAL TRAVEL LIMIT SWITCHES." See attached sheet for photos and description.
Page 21	Change Collimator Mounted Beam-Shaping Assembly to Cat. No. 3022A. See new photo in attached sheet.
Page 22	Change Accessory Mounting Platform to Wedge and Compensator Mounting Platform 3918. See photo in attached sheet.
	Change Wedge Filter Cat. No. to 3021M and 3021N. See photo in attached sheet.
Page 23	Change Oblique Compensator Cat. No. to 3021L. See photo in attached sheet.
	Change second paragraph to read, Oblique Compensator requires the 3918 Platform.
Page 26, Step 3	Change CAUTION at top of page to read "Do not install or remove Trimmers beyond a 20 x 20 cm field."
	Delete paragraphs B, C, & D.
	Change to read "with extenders removed."

RADIATION WARNING

X-Rays and Gamma-Rays are dangerous to both patient and operator unless established safe exposure procedures are strictly observed.

The useful beam can produce serious or fatal bodily injuries to any persons in the surrounding area if used by an unskilled operator. Adequate precautions must always be taken to avoid exposure to the useful beam, as well as to leakage radiation from within the source housing or to scattered radiation resulting from the passage of radiation through matter.

Those authorized to operate, participate in or supervise the operation of the equipment must be thoroughly familiar and comply completely with the currently established safe exposure factors and procedures described in the National Council on Radiation Protection and Measurements (NCRP) "Medical X-Ray and Gamma-Ray Protection for Energies up to 10 Mev — Equipment Design and Use" NCRP Report #33 as revised or replaced in the future.

Those responsible for the planning of X-Ray and Gamma-Ray equipment installations must be thoroughly familiar and comply completely with the structural shielding requirements outlined in NCRP #34 as revised or replaced in the future.

Failure to observe these warnings may cause serious or fatal bodily injuries to the operator, patient or those in attendance.

SUMMARY OF CHANGES Con't.

Page 27	Under Collimator Film Check, change the second sentence of paragraph 2 to read: "Set the field size for a 10 x 10 cm with the trimmers installed."
Page 28	Delete Head Tilt Centering Switch and Yoke Swivel Centering Switch and refer to the attached sheets for the adjustment procedure.
Page 29, Step 3	Under Optical Distance Indicator delete the first sentence. Change second sentence to read: "Turn on the distance indicator switch:"
Page 30	A latching relay R29 was added in the left yoke arm to the rear of the yoke terminal strip TB4. When the shutter reaches 142-degrees of rotation, switch SW10 is actuated turning off the collimator field lamp. Refer to attached sheet for photo.
Page 31	Add: "BRAKE ADJUSTMENTS - For Brake Procedure refer to C-9 Maintenance Manual H57:M Pages 6 and 7. The head tilt should be set at 60 to 80 pounds pull at the end of the collimator with the gear mesh disengaged. The yoke swivel set at 80 to 100 pounds pull at end of collimator with gear mesh disengaged (motor removed)."
Page 33	Reference Data

Add the attached revised schematics:

C-T61B-575	Head Wiring Diagram - 590E
D-T61B-717	Schematic Diagram for V9 Unit
E-T61B-722	Wiring Diagram of 1373E Stand
C-T61B-914	Wiring Diagram of 3706D Collimator
C-T61B-915	Wiring Diagram of 3706E Collimator

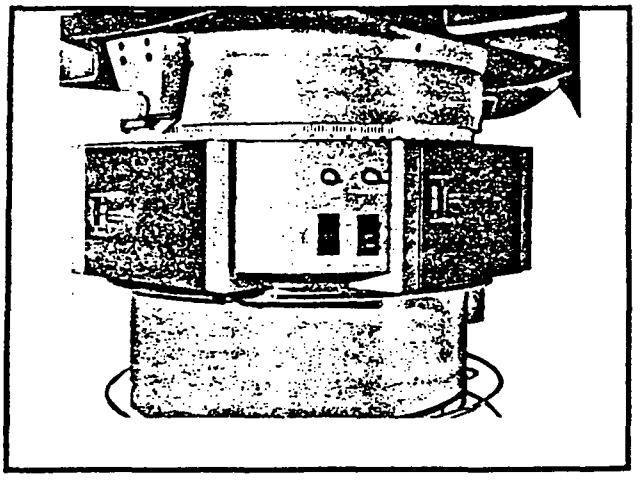
3706D COLLIMATOR

The 3706D is a Motorized Collimator which is an optional choice when purchasing the present V9 Cobalt Therapy Unit. Switches mounted on the side of the collimator, when depressed, set the desired field size. The field size dials are the same type used on the 3706E. The trimmer bars on both collimators are no longer built into the collimators but must be installed when required.

The field sizes are 3cm x 3cm (minimum) to 35cm x 35cm (maximum) at 80cm with the trimmers installed. With the trimmers removed the field sizes are 4cm x 4cm to 35cm x 35cm. Limit switches are installed for the minimum and maximum field sizes as shown in the photos.

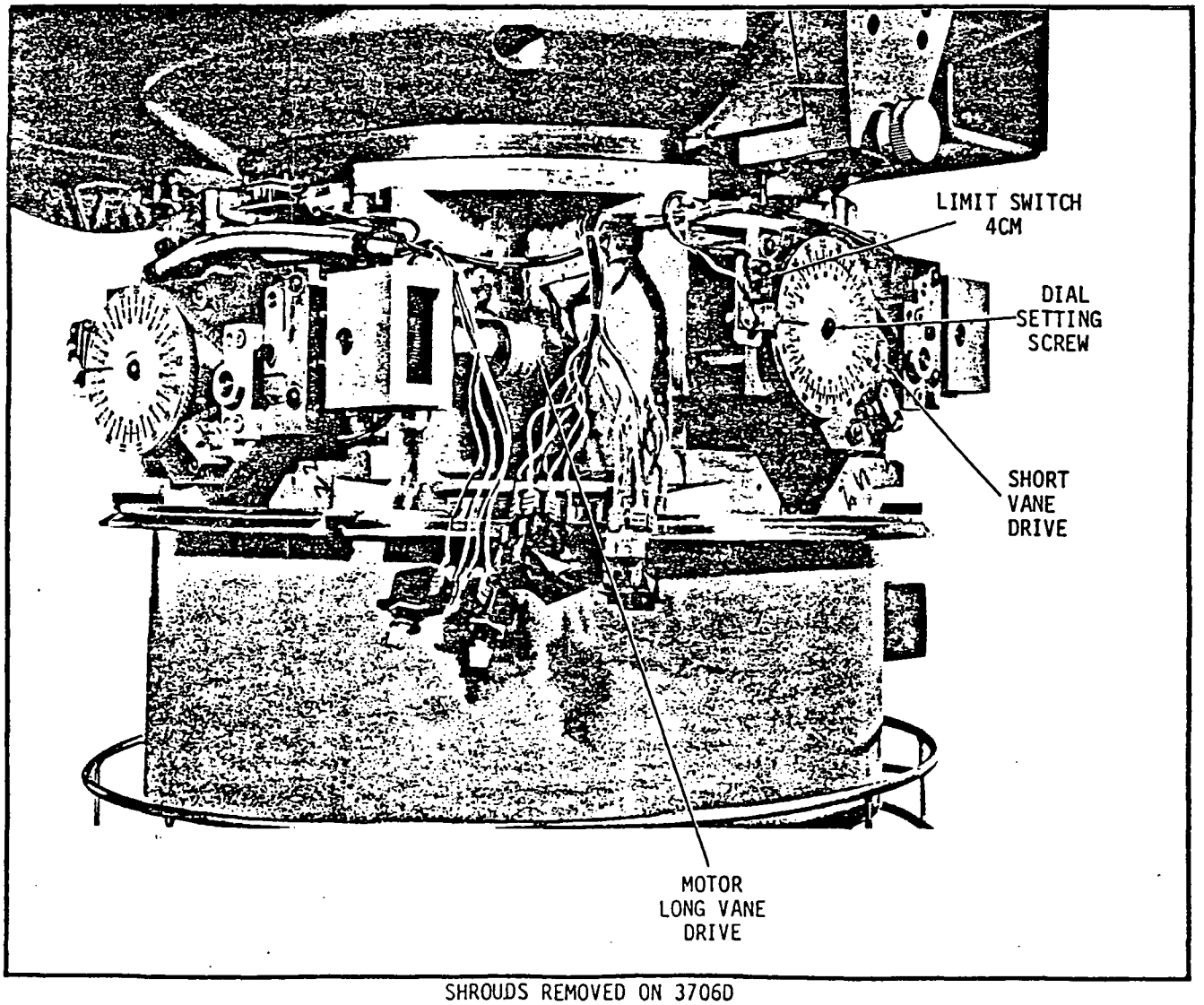
NOTE

The field size electrical limiting switches are only installed on the 3706D Collimator.

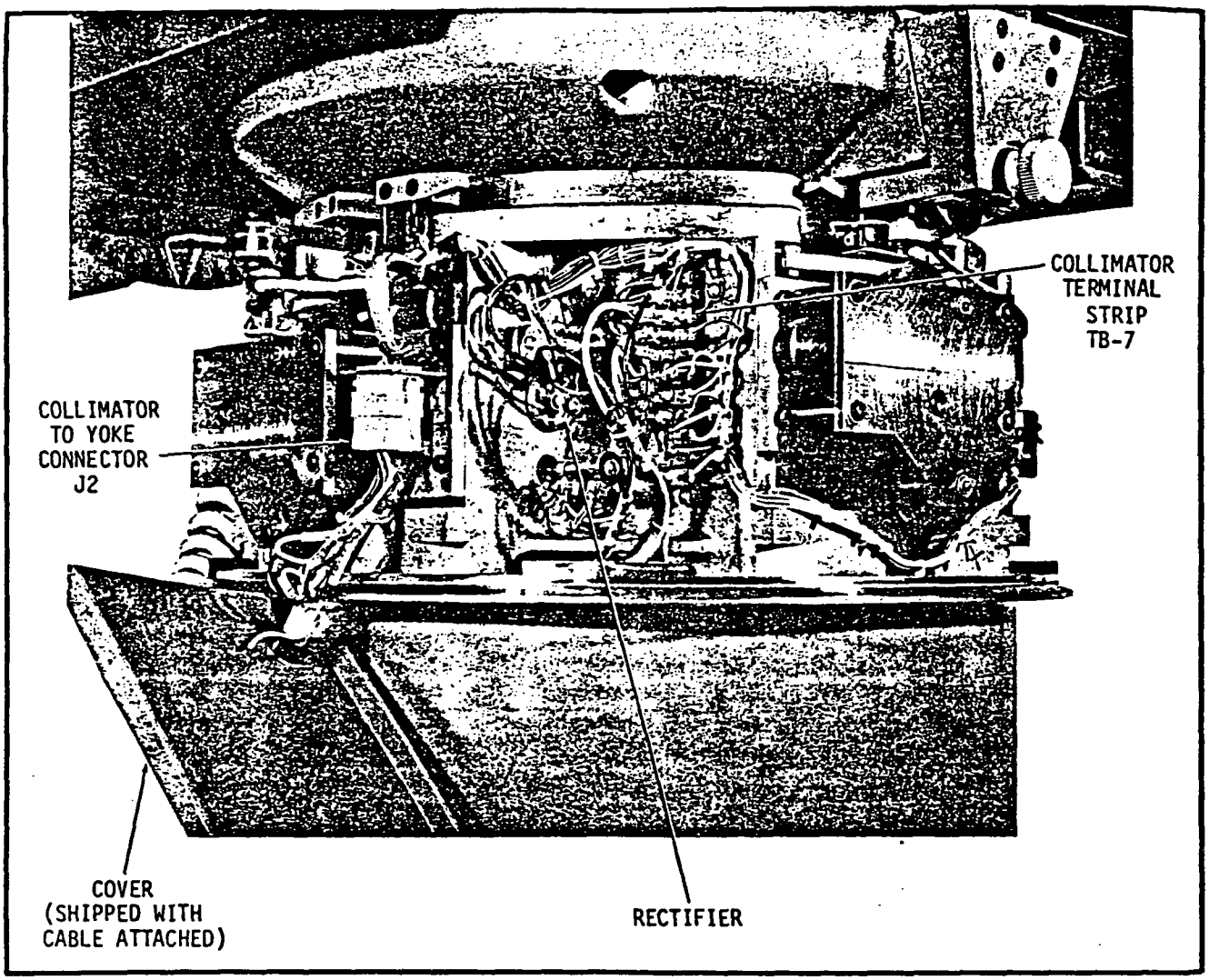


3706D MOTORIZED COLLIMATOR

The vane movement for field size is no longer controlled by cables. A new line shaft which is gear-coupled from the gear box of one vane to its opposite vane is now used for greater accuracy. Four gear boxes are now used instead of two. Adjustments can be made for each set of vanes.



SHROUDS REMOVED ON 3706D



3706D ELECTRICAL TERMINALS

The vanes are motivated by two 24 volt DC motors. A power supply mounted next to the collimator terminal strip consists of silicon rectifiers, a 60 mFD capacitor, and a semi-variable resistor, 10 ohms, 20 watts, to furnish 24 volts at 4 amps to the drive motors. Refer to photo.

ADJUSTMENT OF LIMIT SWITCHES

The limit switches can be adjusted by positioning the switch on its mounting. The cobalt head should be in a vertical position with the collimator facing downwards. A table should be placed below the Collimator to measure the field size. To adjust the following procedure is recommended:

1. Remove the extender shroud.
2. Set the field size dial without the extenders for 4cm x 4cm.
3. Measure the light field size on the table top. It should measure 4cm x 4cm.

NOTE

With the trimmers installed adjust dials for a 3cm x 3cm field.

4. Position the limit switches mounted alongside of each field size dial so the roller on the switch is open by the notch on the dial.
5. Open the field size with the motor switches to about 10cm x 10cm. Close the opening and see if the motors cut-off at 4cm on the dial.
6. To adjust the maximum (35cm x 35cm) field size switches remove the extender shroud.
7. Operate the field size switches until the dials read 35cm.

CAUTION

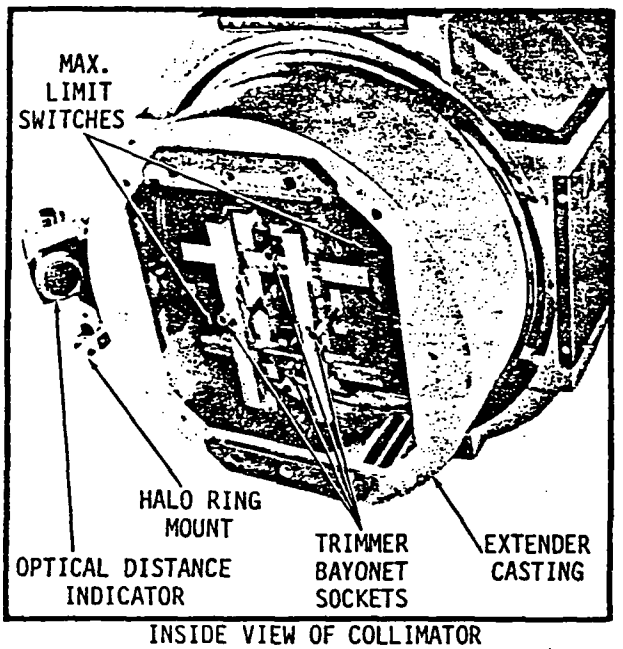
DO NOT TRY TO EXCEED THE 35 X 35cm MAXIMUM FIELD SIZE OR BEARING DAMAGE MAY RESULT.

8. The two field size limit switches should now be actuated to remove power from the field motors. If not, reposition the switches.

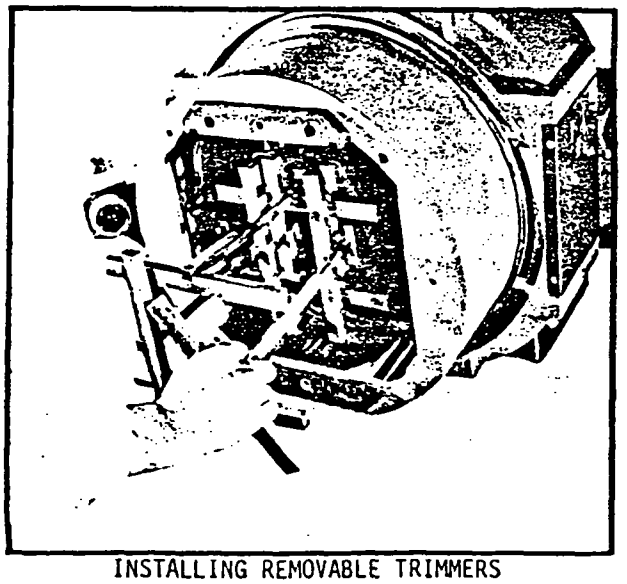
9. Operate the field size switches so the field decreases to about 25cm. Operate the field size switches to open and all movement of the vanes should stop when the 35cm field size is reached.

TRIMMERS

The trimmers can be removed and installed manually. To install, open the collimator vanes to a field size of 15 x 15cm and rotate the yoke to 90-degree position. The trimmers now bayonet into place at the ends of each of the four collimator vane assemblies. The trimmers are interchangeable--any one may be installed on any vane.



INSIDE VIEW OF COLLIMATOR


INSTALLING REMOVABLE TRIMMERS

BL-2584 CABLE

This is the coil cord that connects the yoke terminal board TB4 to the collimator connector (white plastic).

This cord is factory connected to TB4 and the opposite end terminates in a white plastic receptacle. Since this cord passes through a cable grip on the collimator shroud, the shroud and cord are taped to the yoke for shipment.

3706E COLLIMATOR

The 3706E is a manually-operated collimator which replaces the 3706C on the present C9 and V9 Cobalt Therapy Units. The 3706E is identical in all respects to the 3706D, with the one exception that the 3706D is motor-driven. No electrical field limit switches are installed on the 3706E. This collimator is of the line shaft type.

NOTE

Field conversion to motor operation is not possible.

YOKE SWIVEL CENTERING SWITCHES

V9 Cobalt units now shipped from the factory will incorporate a new yoke centering device. This device consists of two roller type switches (SW31 and SW48), and two adjustable actuators. This new type can be installed on any of the existing V9 units in the field by purchasing Kit No. 9974. Detailed instructions are furnished.

3

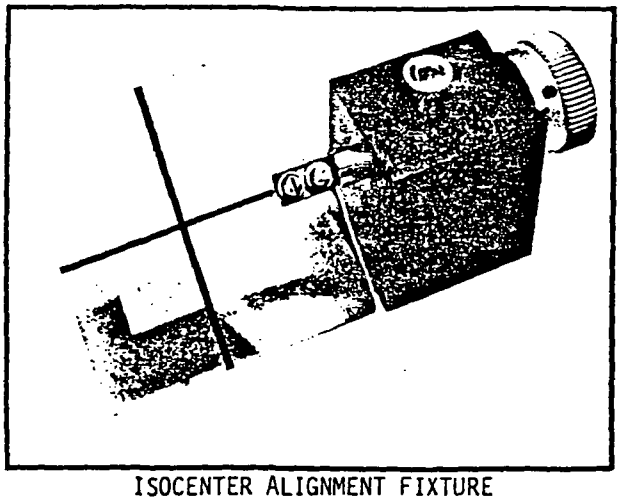
NOTE

Kit No. 9974 includes both the new yoke and head new type of centering switches and actuators.

To make the adjustment for the yoke centering, the following procedure is recommended:

1. Referring to Manual T55-571, use the techniques explained on pages 27 and 28 for proper centering. If an Isocenter Alignment Fixture, Cat. 181704, is available, this can be used as explained in the following steps.

2. Place the yoke to its zero-degree position and turn on the collimator field lamp. The cross hairs should project on the alignment paddle at a distance of 80cm. Remove the covers over the yoke centering switches and actuators.



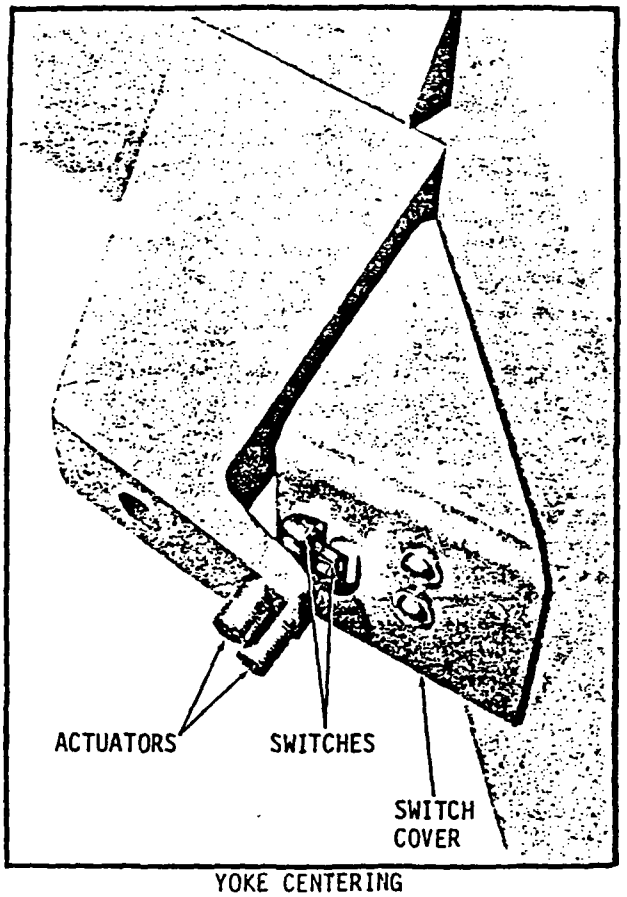
ISOCENTER ALIGNMENT FIXTURE

3. Center the yoke and head for zero positioning of the cross hairs on the alignment fixture by jogging the pendant switch.

4. Position the yoke centering switches so the roller actuators on the switches line up with the actuators on the yoke.

5. Loosen the lock set screws in the yoke actuator bracket. Turn the threaded actuators individually against the switch roller until a "click" is heard inside the switch. Both switches must be actuated at the same time.

4



YOKE CENTERING

CAUTION

BOTH SETS OF ACTUATORS MUST BE ADJUSTED SO THEY JUST TRIP THE SWITCHES WITHOUT USING ALL THE OVERTRAVEL.

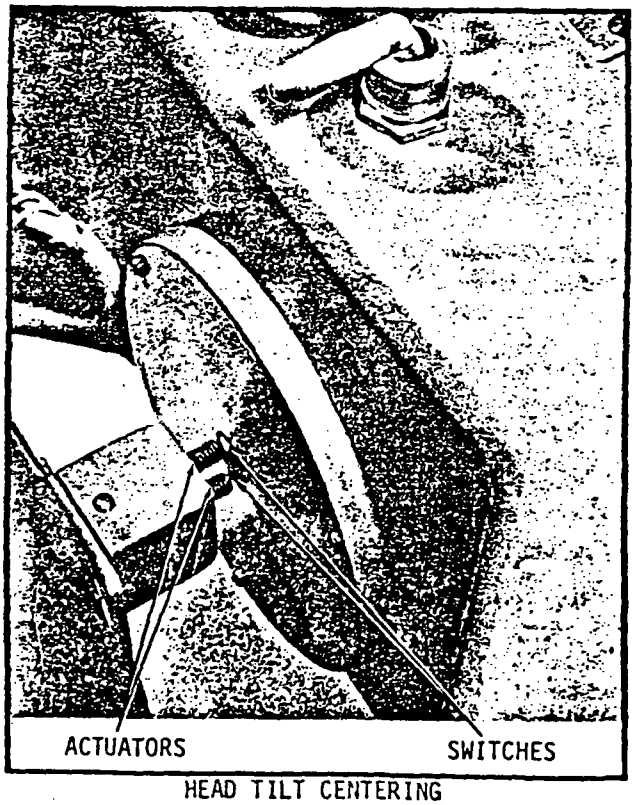
6. Electrically, rotate the yoke clockwise, then counterclockwise and observe the cross hair projection on the alignment fixture to check if centering is consistent in both directions. If not, recenter yoke and readjust the actuator screws.

7. If the yoke stops before center consistently from one direction and the actuator screws do not correct this condition, then loosen the switch bracket and slide the switch assembly in the direction of rotation and readjust the actuator screws.

8. Check centering again and when satisfactory, tighten all mounting screws and actuator set screws. Reinstall covers and make a final check.

HEAD TILT CENTERING SWITCH

To adjust the head tilt centering device the procedure is similar to the yoke centering. The head is tilted inwards and outwards and the actuators and switches are adjusted to automatically stop the head tilt movement when centered at zero-degrees.

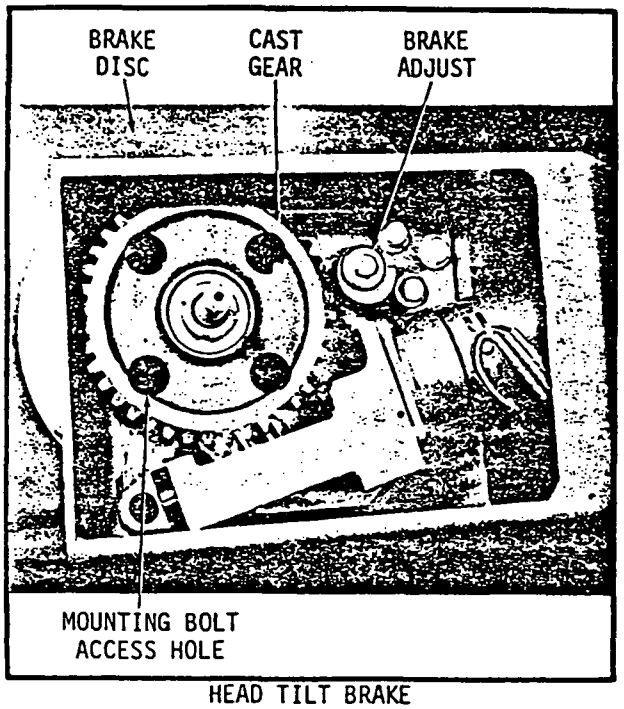


HEAD TILT CENTERING

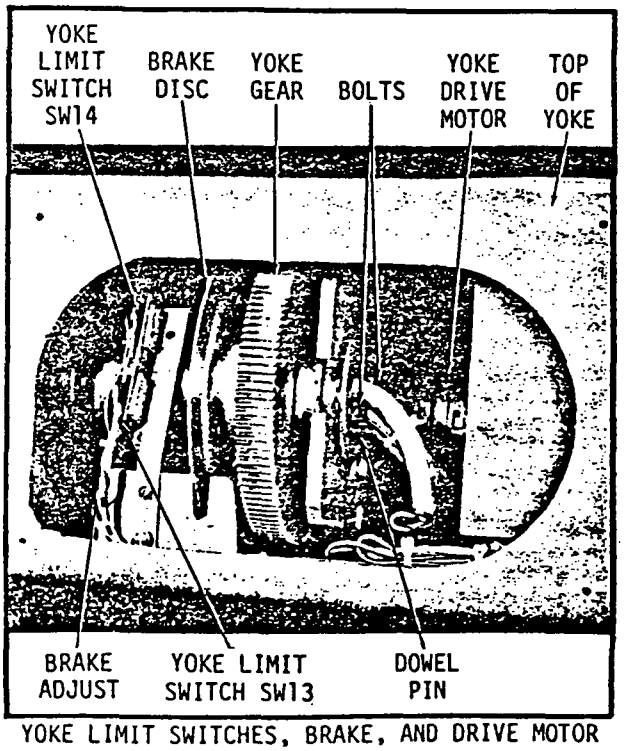
COLLIMATOR FIELD AND DISTANCE LOCALIZER LAMPS

The above lamps on the 3706D and E Collimators are turned "on" and "off" by separate switches mounted on the shroud.

The field lamp is turned off automatically when the shutter reaches 142-degrees of rotation. This was made possible by using the other portion of switch SW10 and installing a latching relay RE29 in the left arm of the yoke. To turn on the field lamps the manual switch must be used.



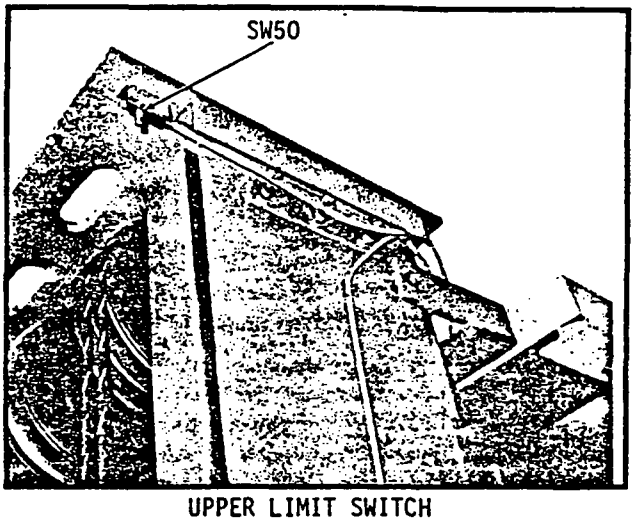
HEAD TILT BRAKE



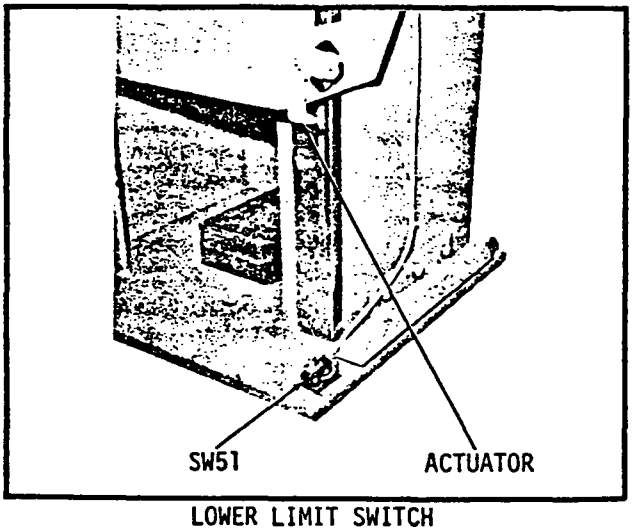
YOKE LIMIT SWITCHES, BRAKE, AND DRIVE MOTOR

UPPER AND LOWER VERTICAL TRAVEL LIMIT SWITCHES

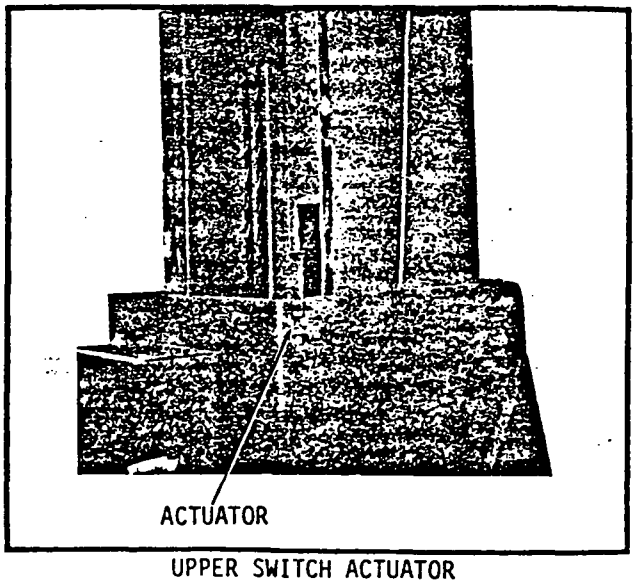
An upper limit switch (SW50) and a lower limit switch (SW51) are now installed to remove power from the main drive motor when the limits of travel are reached.



UPPER LIMIT SWITCH



LOWER LIMIT SWITCH



UPPER SWITCH ACTUATOR

5

Adjustable actuators are mounted on the top and bottom right side of the vertical carriage to actuate these switches when the limits are reached.

VERTICAL DRIVE REVISION

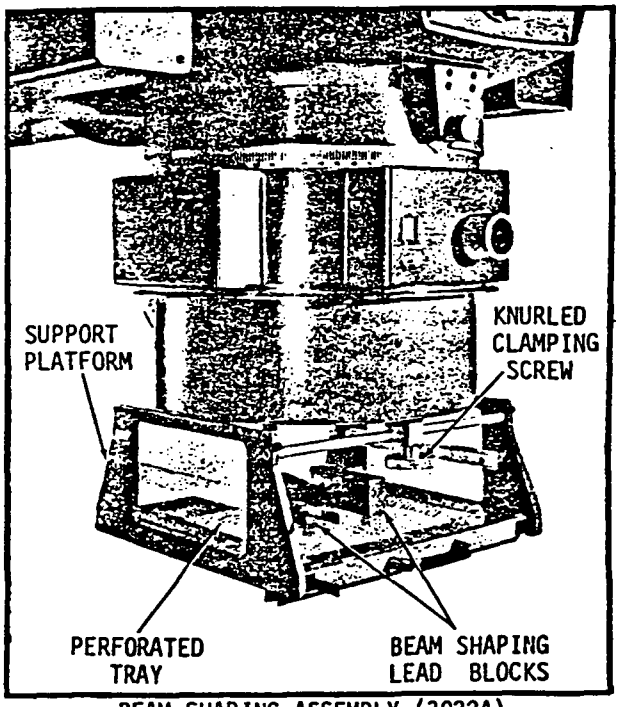
A direct drive is now incorporated which will now overcome up to 100-pounds maximum out-of-balance condition. This will overcome the various weights of accessories.

ACCESSORIES

Collimator Mounted Beam-Shaping Assembly, Cat. 3022A

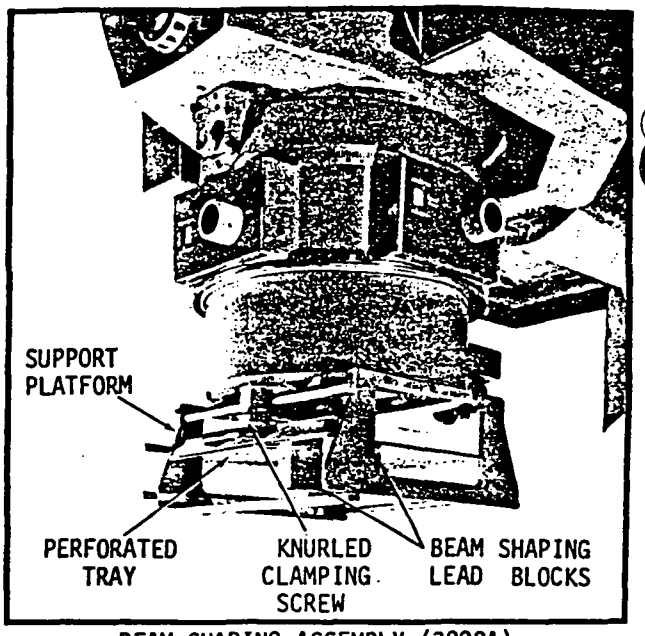
The above accessory permits the user to position lead blocks in the radiation beam to achieve irregularly shaped treatment fields and to shield predetermined areas of the patient.

This assembly consists of a beam-shaping support platform replaceable tray and beam-shaping lead blocks. The support platform is clamped to the bottom surface of the Collimator housing with a large knurled knob and stud located at the front of the support platform.



BEAM SHAPING ASSEMBLY (3022A)

The perforated tray permits convenient visualization of position of lead shielding blocks (with collimator beam defining light field). Lead blocks are firmly clamped in any position on the perforated tray which can be removed from the support platform with the blocks clamped in position and stored so that the beam-shaping configurations can be quickly reproduced.



BEAM SHAPING ASSEMBLY (3022A)

The tray can be moved closer to the source but the lead blocks must be mounted on the bottom as shown in photo.

The following steps should be followed when installing the Back Pointer Assembly:

1. Install the mounting bracket to the support tube so the bracket surface and end of the support tube are flush.
2. Adjust the pointer arm so it is parallel to the mounting bracket. Secure all bolts.
3. Mount this assembly to the accessory post. Set the post to zero (0) on the scale.
4. Insert the pointer rod into the pointer arm and turn on the collimator lamp.
5. Adjust the height of the pointer rod so the tip of the rod is set at the central ray, then lock in place with the thumb screw.

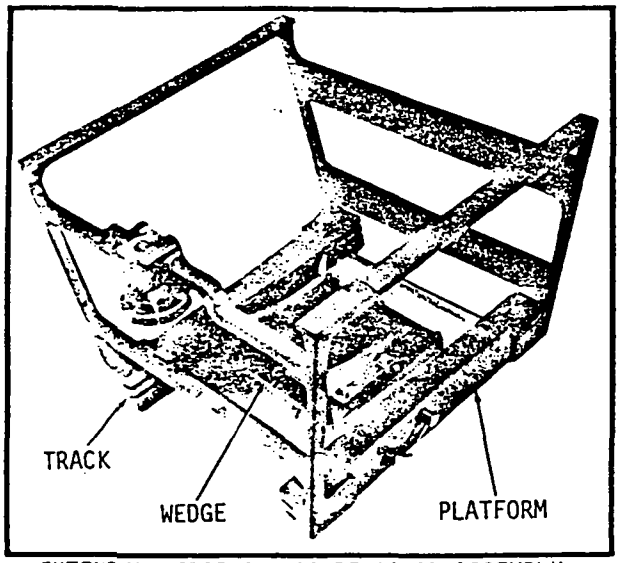
NOTE

The mounting bracket may have to be repositioned (see Step 1) to align the pin at collimator center.

6. Turn out collimator lamp and remove the Back Pointer Assembly.

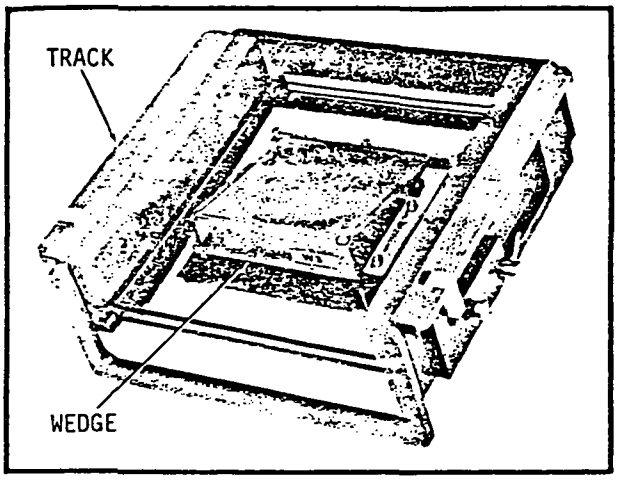
Accessory Mounting Platform, Cat. 3918

This platform is required when using the Wedge Filter (3021M, 3021N, or the Oblique Brass Compensator 3021L).

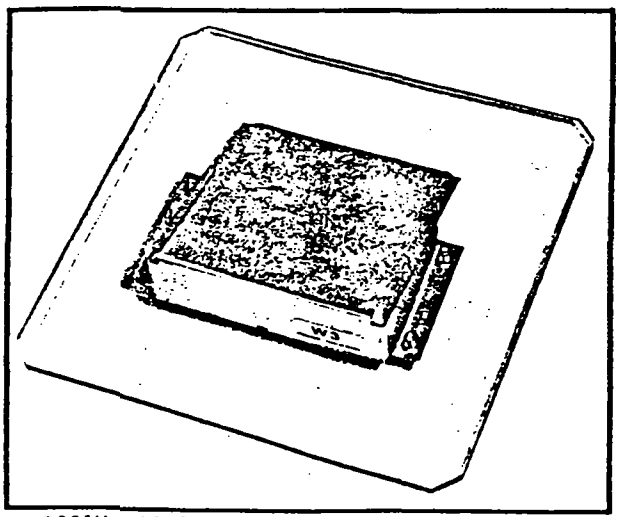


EXTENDED WEDGE AND COMPENSATOR ASSEMBLY

The top of the platform mounts to the bottom tracks of the collimator. The large knurled knob and stud at the front of the platform secures this device to the threaded hole in the collimator.



STANDARD MOUNTING BRACKET ASSEMBLY WITH WEDGE AND COMPENSATOR



3021M, 3021N LEAD WEDGE FILTER ASSEMBLY

Wedge Filter
(Cat. 3021M and Cat. 3021N)

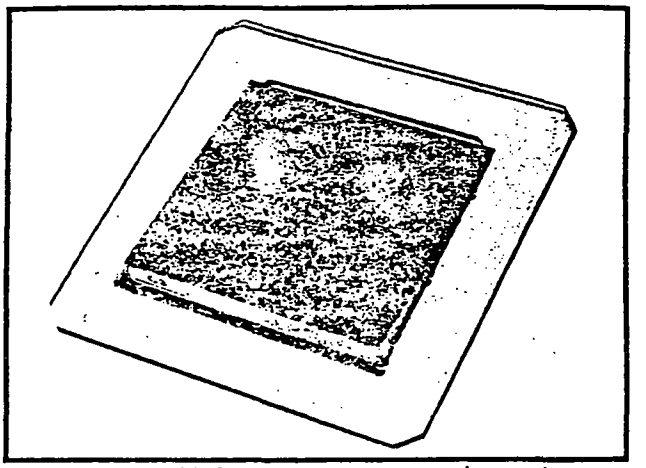
The Wedge Filter is made of lead and can be installed on the bottom tracks of the Collimator and locked in the desired position. The 3021M is a 45-degree wedge, and the 3021N is a 60-degree type.

NOTE

Whenever a Wedge Filter is used with an Oblique Compensator, the Wedge should always be mounted nearest the source.

Oblique Compensator, Cat. 3021L

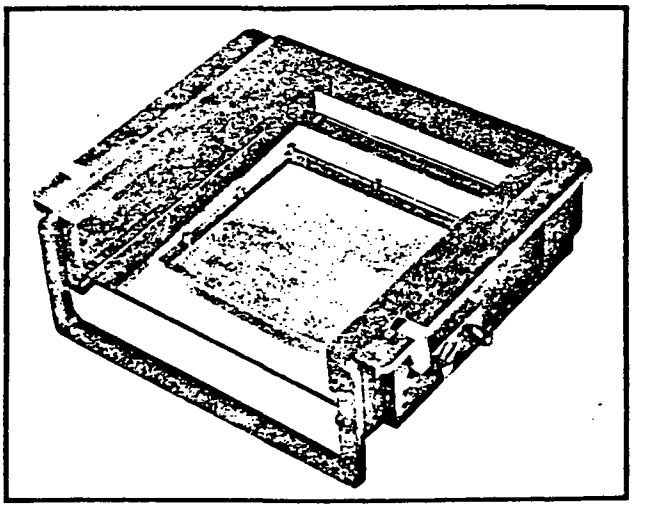
The Oblique Compensator can be used and installed in the same manner as the Wedge.



OBLIQUE COMPENSATOR ASSEMBLY (3021L)

The Oblique Compensator is made of brass. It must be mounted with the brass section away from the source.

The above compensator requires the 3918 mounting platform.



STANDARD MOUNTING BRACKET ASSEMBLY FOR WEDGE AND COMPENSATOR

C-T61B-575

FOR ROTATION BL1824-H

TB4 YOKE TERMINAL STRIP

TB5

BL-1824-G

B-1 BT93C-10

C-1 T45-22 4 M.F.D 600V

T868-8 T-1

L-5 T72-112 RED

L-2 T72-110 WHITE

L-6 T72-112 RED

SW-11 CLOSES WHEN SHUTTER STARTS TO OPEN T29A-16

SW-10 ACTUATES WHEN SHUTTER HAS ROTATED 142° T29A-16

SW-39 NC CLOSES WHEN SHUTTER IS FULLY OPENED T29A-16

SPLICE TO LEAD #34 OF BL-2347K

SPLICE LINE 9G, USING T36N-4 SPLICE, TO LINE 5D OF BL-1824B FOR C9; & SPLICE TO LINE 14A OF BL-1494D FOR V9 UNITS

SPLICE LINES 7G & 13G USING T36N-4 TO LEAD #28 OF BL-2347C

LTR	REVISION	BY	DATE
D	ADDED 32K DELETED 24K	MB	6/13/71
C	3 CHGS SEE ERO	MB	4-7-71
B	SEE ERO J.S.		3-20-70
A	WAS GEN/REL / J.S.		10-1-69

UNLESS NOTED ± TOLERANCES ON FRACTIONS ± DECIMALS ± ANGLES ± ALL BREAKING EDGES ____ INSIDE. BREAK ALL SHARP EDGES. DIMENSIONS ARE BEFORE APPLYING FINISH, ELECTRONIC SURFACES

NEXT ASSY	QTY.	NAME W/D C9/80 HEAD COBALT 60
590E	1	
		MATERIAL B/P
		FINISH

DSN. J.S. 1-14-69 CHKD. APPD. M.C. 1-16-69

PICKER X-RAY MANUFACTURING

A PICKER CORPORATION DIVISION CLEVELAND, OHIO 44117

SCALE NONE

C-T61B-575

D-TG1B-717

117 VAC

WHT

BLK

GRN

ZONE WL GUARD

SW11-1

SW2 KEY

SW4 TIMER

SW5 DOOR

SW8

SW9 MERCURY SW.

COUNTER RESET

THERMAL C1

R2

SPLICE

MOTOR SHUTTER

OPTIONAL (G) WALL OPPOSITE MACHINE

CONTROL

DOOR

TIMER MOTOR

COUNTER PULSING MOTOR

COUNTER SW25

WALL OPPOSITE MACHINE OPTIONAL

R5 HEAD

R7 DOOR CONTROL

SW39 NC NO

ACTUATES WHEN SHUTTER IS FULLY OPEN

SW10

ACTUATES WHEN SHUTTER HAS ROTATED 142°

SW11

X RAY RELAY T-1

RE29

J2-9

J2-10

J2-11

SW35

SW36

SW37

SW40 LOCALIZER

RE29A

RE29B

FIELD ILLUMINATION

6.3 VAC

2.4V

T-7

VERTICAL DRIVE BWD.

MOTOR

RAISE

LOWER

SW30

SW31

POWER HEAD TILT

SPLICE T18-64 (TYP.)

MOTOR T956-19

C6

SW29

SW28

MO. GRN

MO. BLK

MO. GRY

RE16B

RE17

RE18

RE16

RE17A

RE18A

SW30

SW47

RE16A

YOKE ROTATION

MOTOR T956A-51

C7

SW14

SW13

RE19B

SPLICE T18-64 (TYP.)

RE10

RE21

RE19

RE20A

RE21A

SW31

SW48

RE19A

P1 P2 P3 P4 P5 P6 P7 P8

16567 PEND. SW.

SW49

REFERENCE

STAND TERM. STRIP

YOKE TERM. STRIP

HEAD TERM. STRIP

POWER INPUT

COLLIMATOR

REVISIONS			
B	ADDED SW49 & SW50 SHEET	MJ	12-8-71
A	AS BUILT	MJ	11-2-71

UNLESS NOTED: • TOLERANCES ON FRACTIONS ± ___ • ALL REMAINING BARS ___ FINISH. ☐ EDGES ARE SHARP BREAK. OTHERWISE: • ANGLES ± ___ DECIMALS ± ___ • DIMENSIONS ARE BEFORE APPLYING FINISH, UNLESS INDICATED ◇

PART NUMBER	QTY	NAME
1373E	1	SCHEMATIC FOR V3 COBALT UNIT WITH 3706A

MATERIAL ~~~

FINISH ~~~

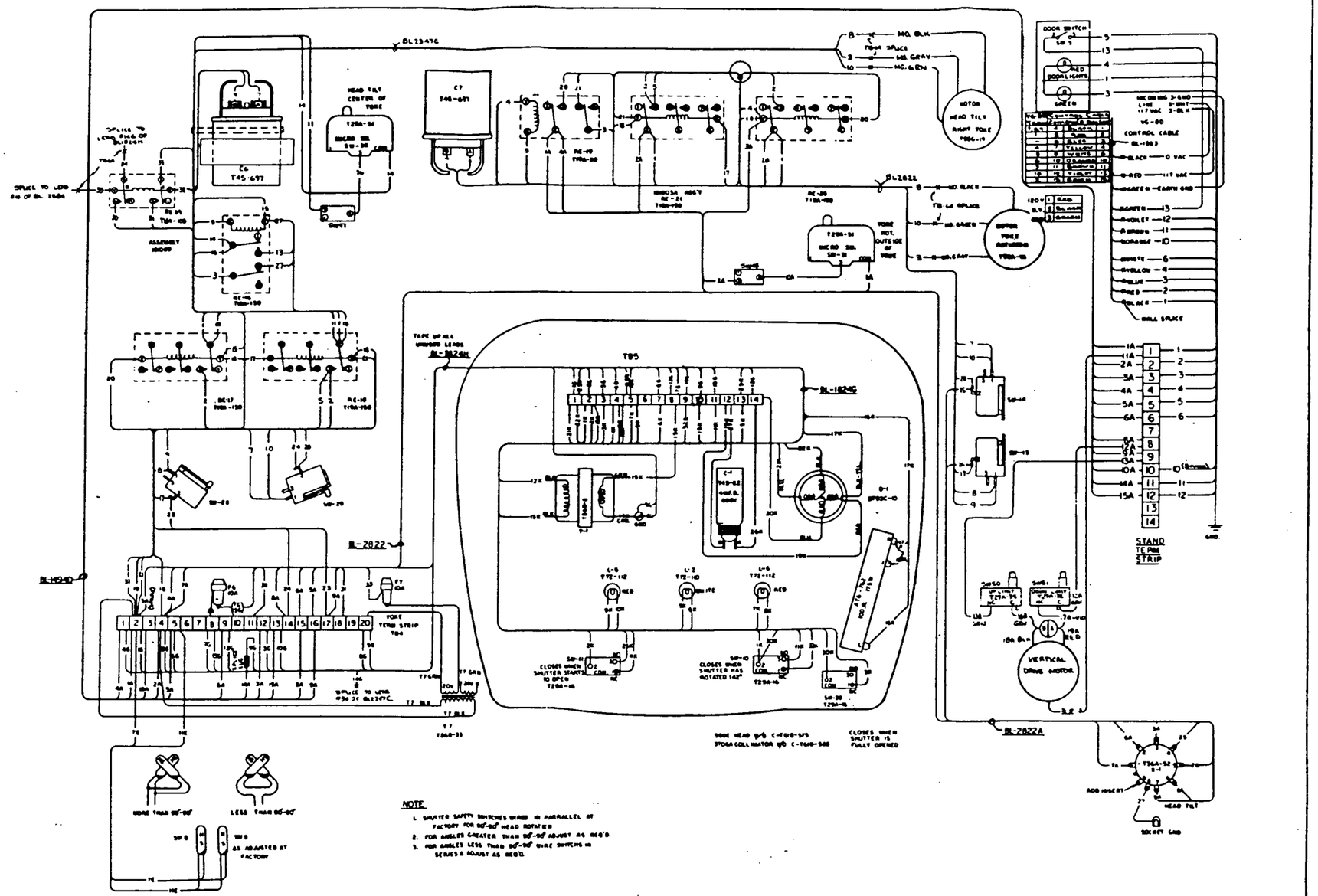
DRN. S.W. CHK. APVD. DATE

J. SIGNER 2-13-72

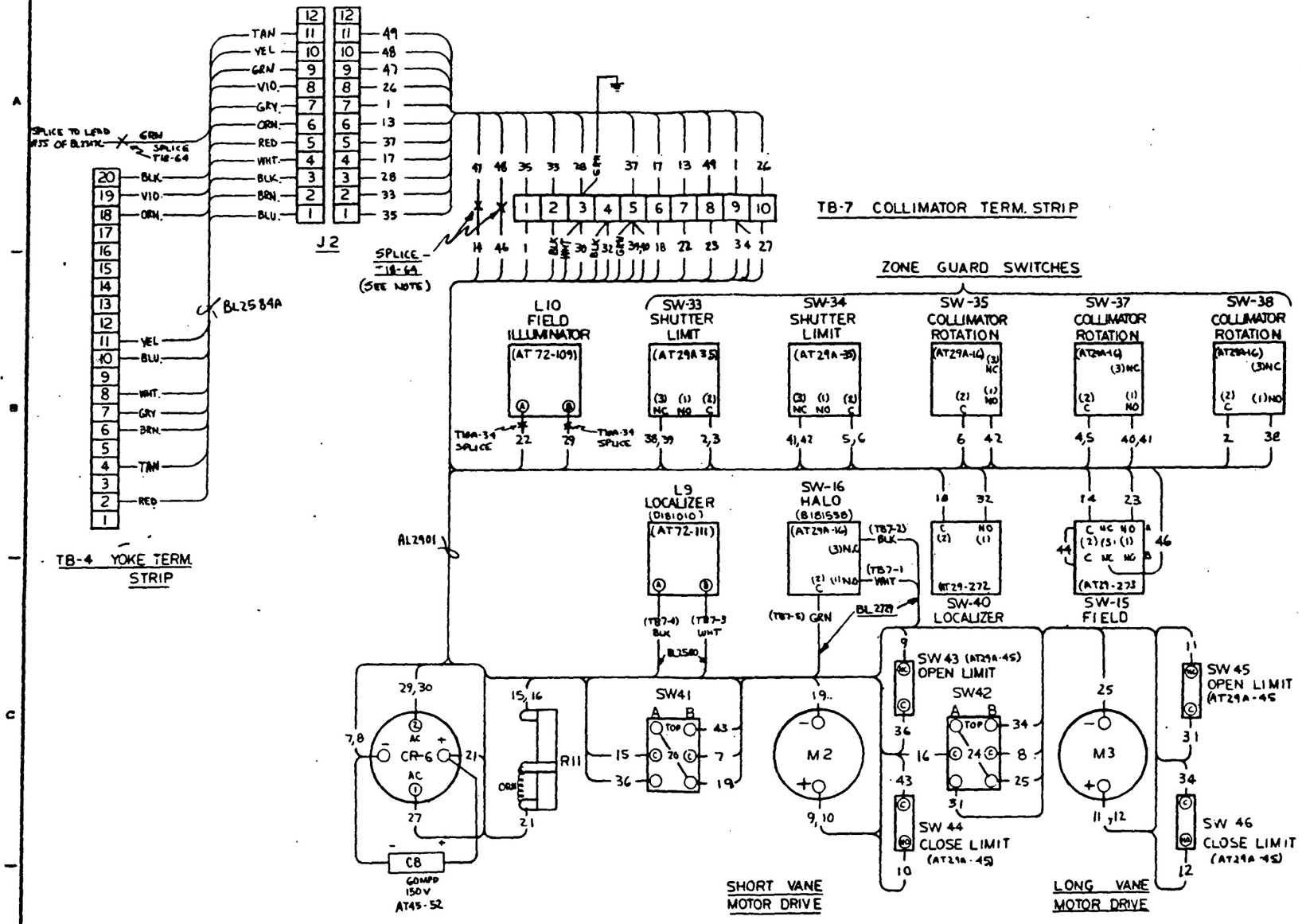
PICKER X-RAY MANUFACTURING

SCALE NONE

D-TG1B-717


BL-2822
BL-2822A
BL-2824L
BL-2824S
BL-1494D
TB5
TB4
STAND TERM STRIP
VERTICAL DRIVE MOTOR
HEAD TILT
NOTE
1. SHUTTER SAFETY SWITCHES WIRED IN PARALLEL AT FACTORY FOR 90°-90° HEAD ROTATION
2. FOR ANGLES GREATER THAN 90°-90° ADJUST AS REQ'D.
3. FOR ANGLES LESS THAN 90°-90° WIRE SWITCHES IN SERIES & ADJUST AS REQ'D.

C-T61B-914



NOTE:
COVER SPLICE WITH
3379E-17 & 20

UNLESS NOTED OTHERWISE:	○ TOLERANCES ON FRACTIONS ± DECIMALS ± ○ ANGLES ±	○ ALL BENDING RADII ____ INSIDE. ☐ BREAK ALL SHARP EDGES. ○ DIMENSIONS ARE BEFORE APPLYING FINISH, MACHINED SURFACES *▽	
NEXT ASSY	QTY.	NAME WIRING DIAGRAM 3706B COLLIMATOR	
3706B	REF.	(MOTOR DRIVEN)	
		MATERIAL ~	
		FINISH ~	
		DSN. MB ZNGA.E DATE 5-21-71 CHKD.	APPVD. DATE 6-1-71
A SEE ECO. 40356 M2		PICKER X-RAY MANUFACTURING	SCALE ~

NOTE: GREEN LEAD OF CABLE BL2584A SHOULD BE TAPED BACK NOT REQD. SPLICE VIOLET LEAD TO BL2347C LEAD #35

SPLICE TO LEAD #35 OF BL2347C (SEE NOTE)

GRN — NOT REQD, TAPE BACK (SEE NOTE)

TAN, YEL, VIO, GRY, ORN, RED, WHT, BLK, BRN, BLU

J2

BL 2584A

GRN — TAPE BACK NOT REQD (SEE NOTE)

TB-4 YOKE TERM STRIP

SPLICE T18-64 (4) SEE NOTE

TB-7 COLLIMATOR TERM. STRIP

AL2902

ZONE GUARD SWITCHES

L10 FIELD ILLUMINATOR (AT 72-109)

SW-33 SHUTTER LIMIT (AT29A-36)

SW-34 SHUTTER LIMIT (AT29A-35)

SW-35 COLLIMATOR ROTATION (AT29A 10)

SW-37 COLLIMATOR ROTATION (AT29A-14)

SW-38 COLLIMATOR ROTATION (AT29A-16)

L9 LOCALIZER (D181010) (AT72-111)

SW-16 HALO (B181558) (AT29A-44)

SW-40 LOCALIZER

SW-15 FIELD (AT29-273)

BL2580

BL2729

NOTE:
COVER SPLICE WITH 5379E-17 & -20

REVISION	DATE
D SEE ECO 2055622	5-27-72
E ADDED NOTE SEE ECO 1819	5-27-72
F [illegible] ECO	2-4-72
A ADDED WIRING SEE ECO	7/13/71

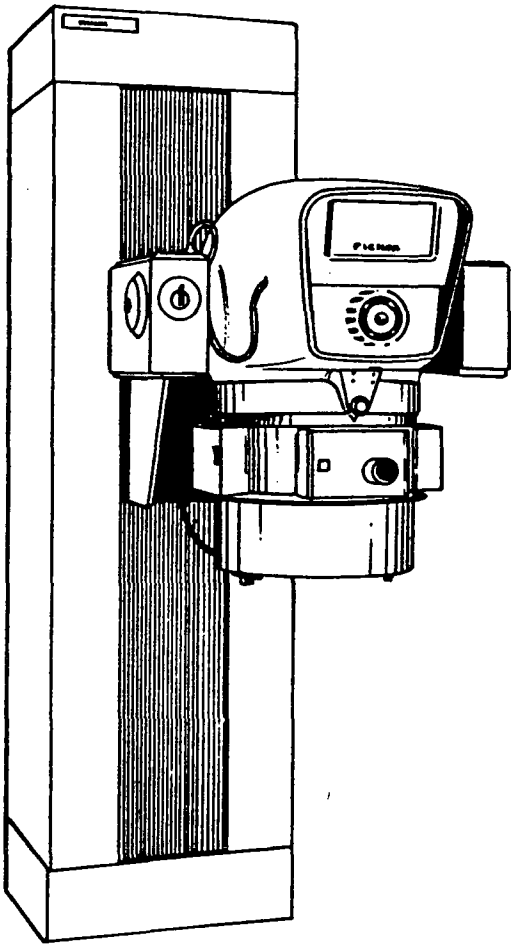
UNLESS NOTED OTHERWISE: ◇ TOLERANCES ON FRACTIONS ± ◇ ANGLES ± ◇ DECIMALS ± ◇ ALL BENDING RADII ___ INSIDE ☐ BREAK ALL SHARP EDGES ◇ DIMENSIONS ARE BEFORE APPLYING FINISH, MACHINED SURFACES

MFRT ASSY	QTY	NAME WIRING DIAGRAM 3706C COLLIMATOR
3706C	REF	(MANUAL)
		MATERIAL —
		FINISH —
		DRN MB DUGALE 5-21-71 CHKD APPD DATE

PICKER X-RAY MANUFACTURING

SCALE 2

C-T6B-915



6268 V9 COBALT THERAPY UNIT

APR'71

H59:P

PARTS LIST

V9 COBALT THERAPY UNIT
Cat. No.6268

CONTENTS

CONTENTS

INTRODUCTION

PURPOSE

This parts list was written with the intent of providing the user with a complete listing of all parts and components used in the assembly of this unit, with the exception of hardware items such as screws, nuts, bolts and washers. The contents of this manual has been so arranged as to offer maximum usability to all users. Suggestions on improving the format, and/or corrections to this manual are welcome and encouraged. Send all correspondence concerning this book to Picker Corporation, Medical Products Division, National Service Department, 595 Miner Road, Cleveland, Ohio 44143, attention Parts Listing.

USE OF PARTS LIST (See Fig. i)

This parts list incorporates the indenture or assembly, subassembly method of parts listing. With this method of listing indenture 1 is the primary assembly for the indicated figure, indenture 2 is either a direct part or subassembly of indenture 1, and indenture 3 is either a direct part or subassembly of indenture 2, which is a subassembly of indenture 1, etc. This system is also useful because the user knows what parts are a part of which assemblies. All indent 2 items are a part of indent 1 and will be found on the indent 1 Bill of Material. All indent 3 items are a part of the preceding indent 2 item and will be found on that indent 2 Bill of Material. All parts are identified once and only once and in their proper sequence.

DIFFERENCE DATA SHEET

The Difference Data Sheet (DDS) is a supplement to an existing parts list and is referenced to the existing list by Figure No.

The DDS does not list any parts which are common to both units, but only those parts which are different. If the word "delete" is used then that part is not used on the unit of the DDS but is used on the referenced unit. If an item number is found on the DDS and not on the referenced parts list then that part is found on the unit of the DDS but not on the referenced unit.

NOTE

All parts found on the parts list of the referenced unit apply to the unit of the DDS except those parts indicated on the DDS.

ORDERING

When ordering parts include the Parts List DRS No. and Date of Publication, Figure and Item No., and Part Description. If the part cannot be found in the parts list, include the Catalog Number of unit, Serial Number, and detailed description of part in question.

EXAMPLE:

FIGURE i

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
1 -	1348L	Mobile Chassis and Tubestand	1
- 1	13559	Cover, Back	1
- 2	T7D-117	Filter, 1/2 mm	2
- 3	11337A	Indexing Plate, Tube Arm, and Locking Assembly	1
- 4	27904	Nameplate	1
- 5	37797	Plug, Tube End	2
- 6	T5-204	Spring, Front Stop	1
- 7	T54-3	"O" Ring, 1 x 1-1/4"	2
- 8	40822	Bracket, Transport	1

MEDICAL PRICE BOOK REFERENCES

V/9 VERTICAL STAND UNITS

6268B	V/9 Cobalt-60 unit with motorized biplane sourcehead, automatic centering.
6268A	V/9 Cobalt-60 unit with motorized biplane sourcehead, automatic centering AND 3706B MOTORIZED COLLIMATOR.
NOTE:	V/9 units operate on 115 volts, single phase. For other supply voltages, a suitable transformer (about 1 kVA) is required and is to be furnished locally.

ACCESSORIES FOR V/9

3499E	Accessory attachment post (see ordering information #1).
3500C	Pin-and-arc beam directing device.
3298C	Back pointer beam directing device.
3755	Front pointer beam directing device.
3595C	Wall mounted positioning lights (set of 2).
3754A	Accessory mounting platform for wedge filter (see ordering information #2).
3021	Wedge filter set for 45° (set of 2); includes isodose curves.
3021B	Wedge filter set for 60° (set of 3); includes isodose curves.
3021A	Oblique incidence compensator set (set of 6).
3022	STANDARD Collimator mounted beam shaping platform with blocks and replaceable tray (see ordering information #4 for extra tray and blocks).
#17	RELIANCE treatment stretcher (V/9 only: see ordering information #3).
3759	Motor drive attachment for field modification of standard 3706A collimator. Converts 3706A collimator to 3706B for motorized operation.
3719	Cobalt rotational calculator.

ORDERING INFORMATION

1. A 3499E Accessory post must be ordered if any of the following is to be supplied:

   a. 3500C Pin-and-Arc,
   b. 3298C Back pointer,
   c. 3755 Front pointer,
   d. 3770 Cassette Holder.

2. A 3754A Accessory mounting platform must be ordered if any of the following is to be supplied:

   a. 3021 Wedge filter set,
   b. 3021B Wedge filter set,
   c. 3021A Oblique incidence compensator set.

3. Order #17 RELIANCE stretcher from F & K Koenigkramer Co., 96 Caldwell Drive, Cincinnati, Ohio.

4. Additional trays and blocks for 3022 standard collimator mounted beam shaping platform may be ordered as follows:

181763	Beam shaping block tray

Beam Shaping Blocks

181497	1-1/4 x 2-1/2 x 2"
181497A	(Set of 2) - 1-1/4 x 1-1/4 x 2"
181497B	(Set of 2) - 5/8 x 1-1/4 x 2"
181497C	1-1/4 x 5 x 2"
181497D	1-1/4 diameter x 2
181497E	(Set of 2) - 5/8 x 2-1/2 x 2"
181497F	(Set of 2) - 5/8 diameter x 2"

5. All accessories are shipped separately for installation in the field.

FIG. 1 - V9 COBALT UNIT
Part No. 6268

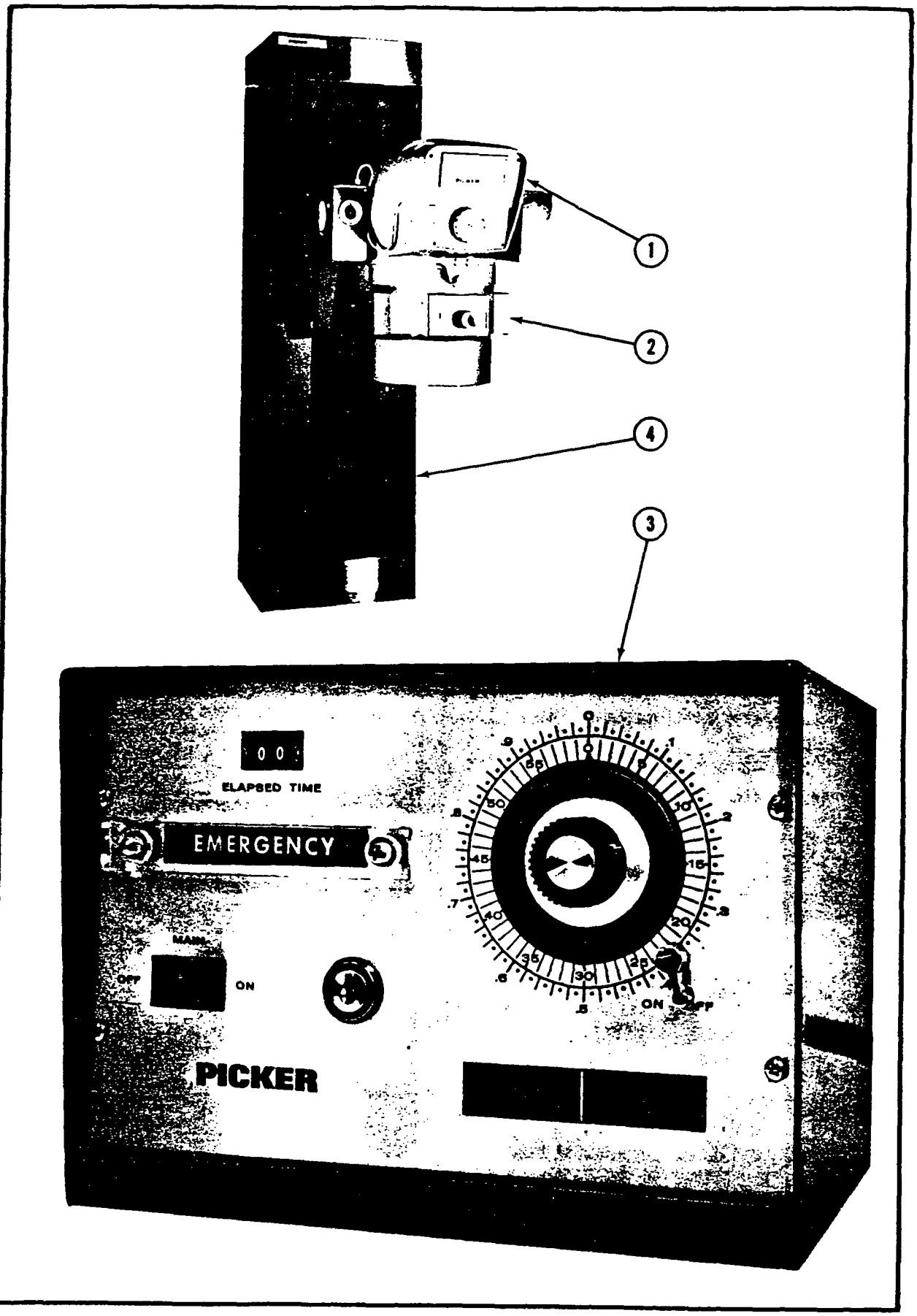


FIG. 1 - V9 COBALT UNIT
Part No. 6268

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
1 -	6268	V9 Cobalt-60 Therapy Unit	1
1	590E	Head, Cobalt (See Fig. 2)	1
2	3706A	Collimator (See Fig. 4)	1
2A	3706B	Collimator (See DDS 401) (Substitution Part)	1
3	VG8D	Control, Cobalt, 60 Hz (See Fig. 14)	1
3A	VG8E	Control, Cobalt, 50 Hz (See DDS 1401) (Substitution Part)	1
4	1373E	Stand, V9 Fixed (See Fig. 15)	1
		OPTIONAL EQUIPMENT	
5*	3499E	Post, Accessory Attachment (See Fig. 23)	1
6*	3022A	Support, Beam Blocks	1
7*	3298C	Back Pointer (See Fig. 24)	1
8*	3500C	Pin-and-Arc, Beam Direction (See Fig. 25)	1
9*	3021	Filter Assembly, Wedge 45°, (See Fig. 26, Item 1)	1
10*	3021A	Compensator Assembly, Oblique (See Fig. 26, Item 15)	1
11*	3021B	Filter Assembly, Wedge 60°, (See Fig. 26, Item 40)	1
12*	3595C	Lights, Wall-mounted Position (See Fig. 27)	1
13*	3755	Pointer Assembly, Front	1
14*	181560	Pointer Assembly, Front - Final (See Fig. 28)	1
15*	181564	Mounting Assembly, Scale Pointer (See Fig. 29)	1
16*	3913	Holder, Cassette	1
17*	14421E	Spare Parts	1
18*	3702A	Stretcher, Motorized Therapy (See Manual H72:P, "Motorized Therapy Stretcher" for Breakdown)	1
19*	3754A	Platform, Accessory Mounting (See Fig. 30)	1

*Not shown.

FIG. 2 - V9 COBALT HEAD
Part No. 590E

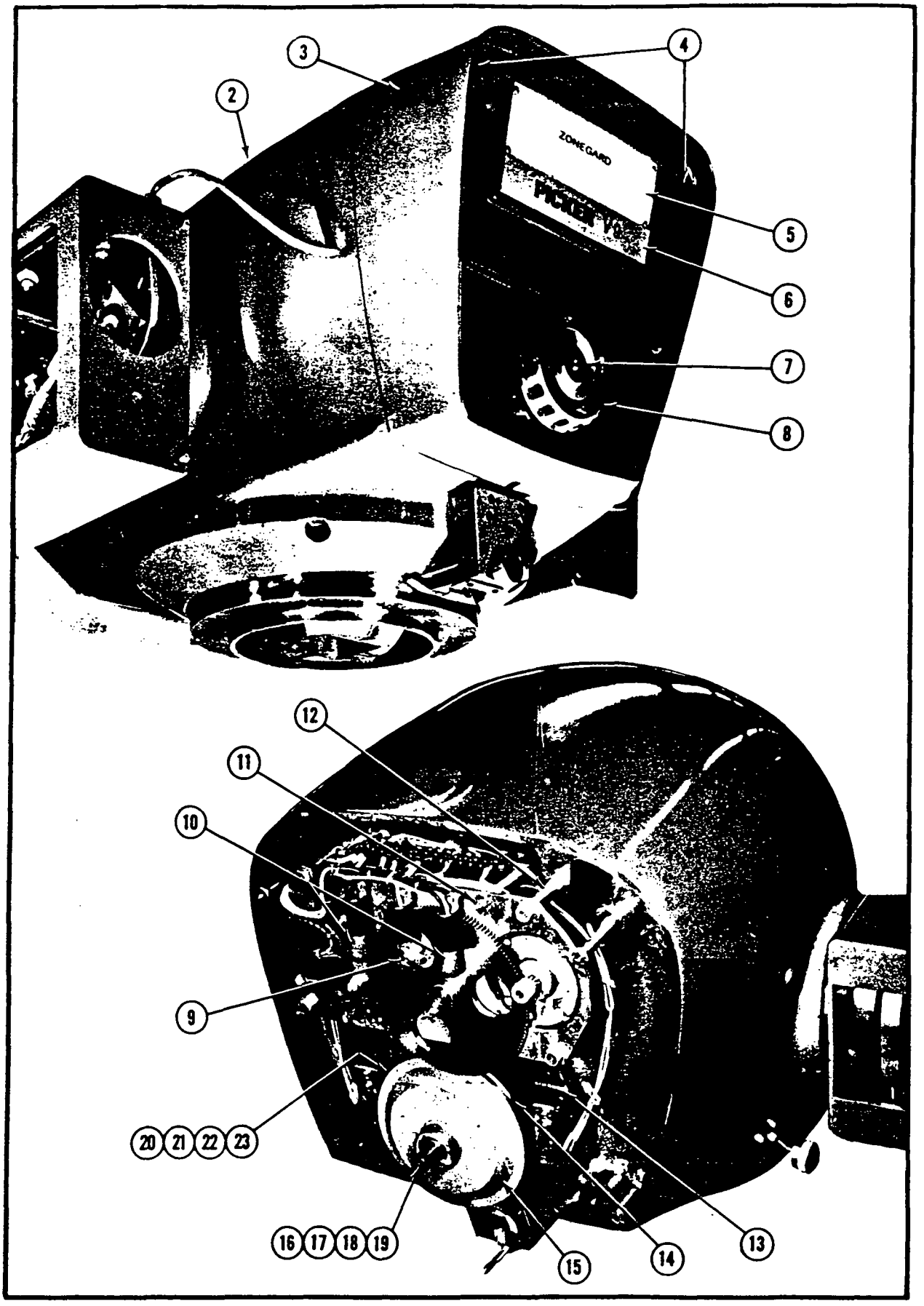


FIG. 2 - V9 COBALT HEAD
Part No. 590E

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
2 -	590E	Head, Cobalt (See Fig. 1, Item 1)	1
1	16568B	Head, Cobalt, Final Weldment	1
2	16568A	Head, Cobalt	1
3	46672	Cover, Front, Cobalt Head	1
4	T2F-185	Screw, Shutter Drive Plate Mounting	2
5	46717	Window, Head	1
6	T92-193	Nameplate, "Picker"	1
7	41582	Indicator, Shutter Position	1
8	40378B	Wheel, Hand	1
9	T72-110	Lamp, GE Cat. No. 6S6 DC, 120 V, clear or equivalent	1
10	T72-112	Lamp, GE Cat. No. 6S6 DC-R, 120 V, Red or equivalent	2
11	181856	Motor Assembly, Shutter Drive (See Fig. 3)	1
12	T10C-444	Spacer, Shutter Drive	4
13	16424E	Plug, Shutter Final Mach. Assembly	1
14	T26A-11	V-Belt, Shutter Drive	1
15	T84-21	Pulley, V-Belt	1
16	16423C	Rotor Assembly, Shutter	1
17†	14423B	Stop, Shutter Rotor	1
18†	181851	Stop, Shutter	1
19†	T14L-12	Pin	5
20	37137A	Spring, Shutter Power	1
21	37138	Cover, Shutter Power Spring	1
22	37138A	Cover, Shutter Spring	1
23	37144	Collar, Shutter Power Spring	1
24*	57408	Bushing	1
25*	56818	Stop, Shutter Rotor	1
26*	50234	Block, Shield	1
27*	T10C-260	Spacer, 13/32 x 17/64 x 1/4	1
28*	T14-911	Pin, Dowel, 1/4 x 1 (Brg. Plate)	2
29*	T14A-59	Pin, Groove 1/8 x 1-1/2	1
30*	T14A-117	Pin, Roll 3/16 x 1-1/4	1
31*	T14A-70	Pin, Roll 3/32 x 5/8	1
32*	T32-434	Decal, Radiation Warning	1
33*	T66A-5	Clamp, Cable	1
34*	T92-176	Nameplate, Rating	1
35*	T92-445	Plate, Shipping Spec.	1
36*	T92-78	Nameplate, Calibration	1
37*	T92-79	Emblem, Radiation Warning	1

*Not shown.

†Order next assembly.

5

FIG. 3 - SHUTTER DRIVE MOTOR ASSEMBLY
Part No. 181856

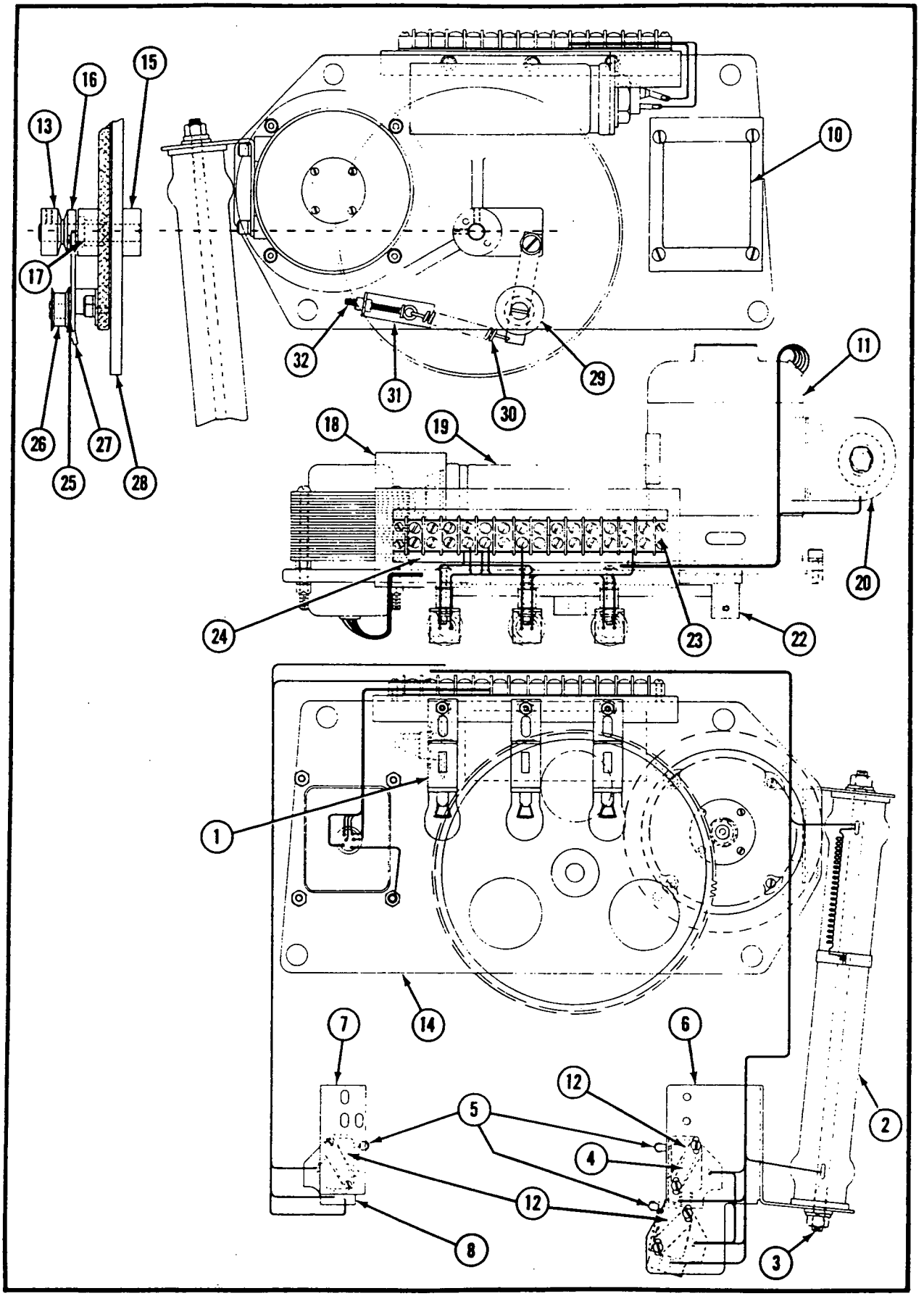


FIG. 3 - SHUTTER DRIVE MOTOR ASSEMBLY
Part No. 181856

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
3 -	181856	Motor Assembly, Shutter Drive (See Fig. 2, Item 11)	1
1	56148	Holder, Lamp - Bayonet Type	3
2	T6-762	Resistor, 100 Ohm, 175 W	1
3	T13A-80	Stud, 1/4 x 9-7/8	1
4	T4-248	Plate, Switch Retainer	3
5	35088	Actuator, Switch	3
6	56326	Bracket, Limit Switch Mounting	1
7	40548	Plate, Limit Switch Mounting	1
8	T9-74	Barrier, Microswitch	6
9*	L-1824G	Lead List, Head	1
10	T86B-8	Transformer	1
11	T93C-10	Motor	1
12	T29A-16	Switch, Micro	3
13	181845	Mounting Assembly, Shutter Drive	1
14	43153A	Mounting Assembly, Shutter Drive Motor	1
15	181826	Gear and Shaft Assembly, Shutter Drive	1
16	56582	Pulley, Shutter Wheel Drive	1
17	T12-447	Bearing, Shaft	2
18	43261A	Plate, Condenser Mounting	1
19	T45-22	Condenser	1
20	56668	Bracket, Resistor Mounting	1
21*	T14A-70	Pin, Roll, 3/32 x 5/8	1
22	T77-130	Gear, Shutter Drive	1
23	T81A-4	Strip, Terminal	1
24	T81B-4	Marker, Terminal Strip	1
25	T10C-10	Spacer, Bearing	4
26	T12-82	Bearing	1
27	43262	Strap, Idler Pulley	1
28	T77-130	Gear, Shutter Drive	1
29	T10B-370	Flange, Bearing	1
30	T5-170	Spring, Shutter	1
31	26521	Bracket, Support, Idler Pulley	1
32	T2-211	Eyebolt (Long)	1

*Not shown.

FIG. 4 - COBALT COLLIMATOR
Part No. 3706A

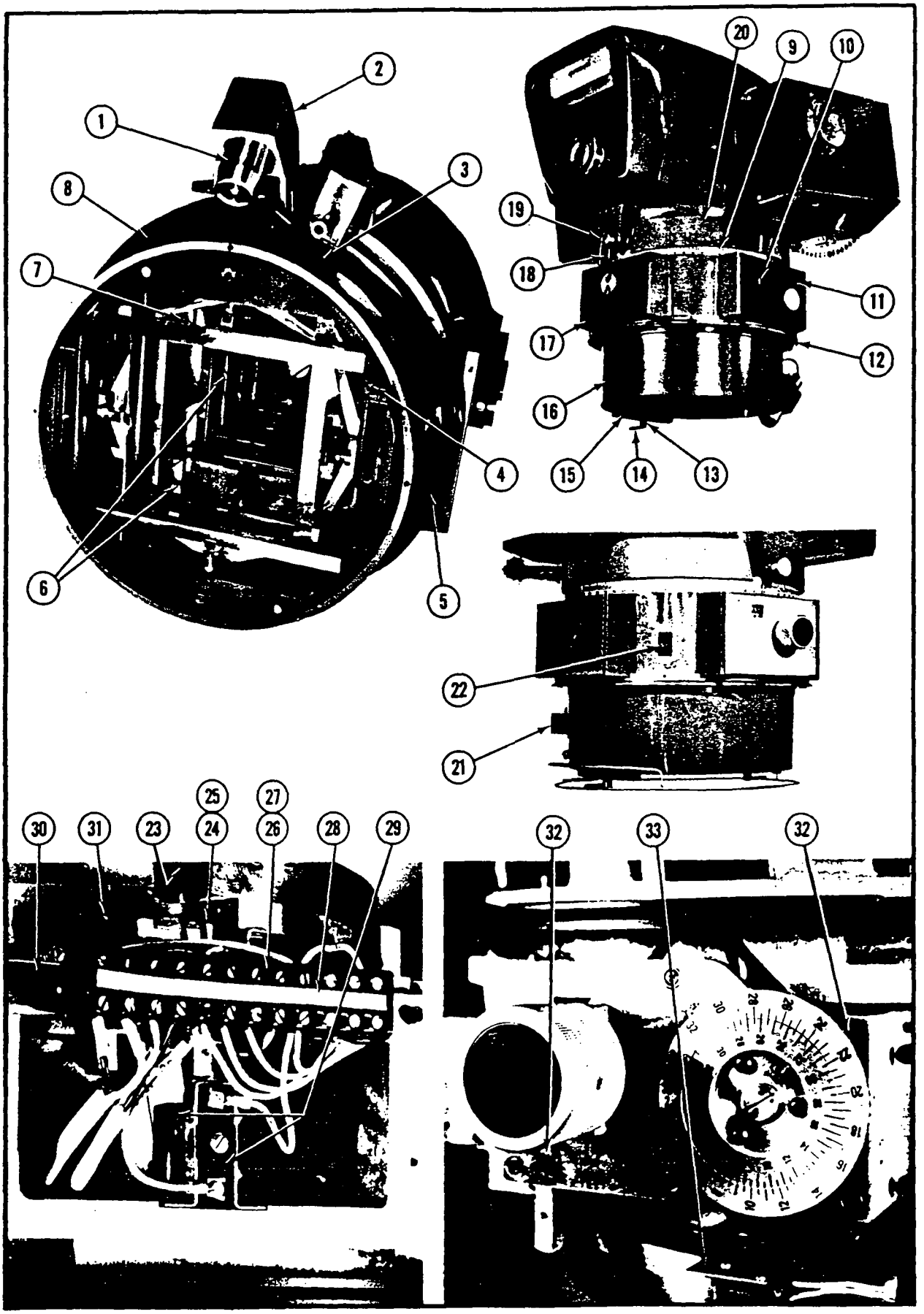


FIG. 4 - COBALT COLLIMATOR
Part No. 3706A

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
4 -	3706A	Collimator (See Fig. 1, Item 2)	1
1	181010	Indicator, Optical Distance (See Fig. 5)	1
2	55560A	Mounting, Localizer	1
3	T92-419	Nameplate, Serial and Patent Pending	1
4	55589A	Enclosure, Extender	1
5	55586A	Cover, Collimator Shroud	1
6	55595	Wire, Cross	2
7	55789	Bracket, Cross Wire Mounting	4
8	55586	Cover, Collimator Shroud	1
9	55976	Scale, Rotation, 90° - 0° - 90°	1
10	55847	Window, Dial Pointer	2
11	55584	Cover, Dial Upper Collimator	1
12	55575	Ring, Collimator Accessory Mounting	1
13	55648	Clamp, Screw Assembly	2
14	55649	Clamp, Handle Assembly	2
15	55652	Clamp, Nose Assembly	1
16	55583	Shroud, Lower	1
17	55585	Cover, Dial Lower Collimator	1
18	181474	Skirt Assembly, L.H. Adapter	1
19	181464	Brake Assembly, Rotational (See Fig. 13)	1
20	181473	Skirt Assembly, R.H. Adapter	1
21	55644	Plate, Halo Switch Cover	1
22	T29-246	Switch, Rocker	1
23	55977	Shield, Collimator Light	1
24	T36-388	Socket, Clamp	1
25	T72-109	Lamp, Sylvania Type ASA #FCS, 24 V, 150 W, 4500 Lumens, T4 Clear Quartz	1
26	T81A-73	Strip, Mounting Block Terminal	12
27	T81A-74	Block, End	1
28	T81B-48	Strip, Marker	1
29	T29J-11	Switch, Button	2
30	56116	Strip, Mounting Bracket Terminal	1
31	55590A	Bracket, Lamp Mounting	1
32	T14A-148	Pin, Dowel, 3/16 x 5/8	2
33	57339	Bracket, Switch Mounting	3
34*	181459	Ring Assembly, Bearing (See Fig. 6)	1
35*	181460	Cross Assembly, Main (See Fig. 8)	1
36*	181494	Feeler Assembly	1
37*	181507	Extender, Assembly (See Fig. 11)	4
38*	181558	Switch Assembly, Halo (See Fig. 12)	1
39*	181634	Shroud, Collimator	2
40*	181953	Actuator Assembly, Switch	2
41*	35088	Actuator, Roller	3
42*	55751	Actuator, Switch	2
43*	55954	Ring, Wear Strip Accessory Mounting (Short)	1
44*	55955	Ring, Wear Strip Accessory Mounting (Long)	1
45*	56786A	Barrier, Arc (Long)	3
46*	56785B	Barrier, Arc R.H.	2
47*	56785A	Barrier, Arc L.H.	2
48*	57355	Barrier, Arc	1
49*	T2-516	Plunger, Spring, 10-32 x 9/16	2
50*	T4-279	Plate, Nut	3
51*	T9-74	Barrier, Fiber	3
52*	T22-165	Truarc, Walds Cat. No. 5144	1
53*	T66-505	Collimator and Head	1

*Not shown.

DDS 401 - COBALT COLLIMATOR
Part No. 3706B

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
4 -	3706-B	Collimator, Therapy Cobalt (See Fig. 1, Item 2A)	1
19	Delete		
35	181460A	Cross Assembly, Main	1
39	181634-A	Shroud, Collimator	1
54	T29-256	Switch, Tippette	2
55	T92-442	Plate, Drive Switch Mounting	2

FIG. 5 - OPTICAL INDICATOR ASSEMBLY
Part No. 181010

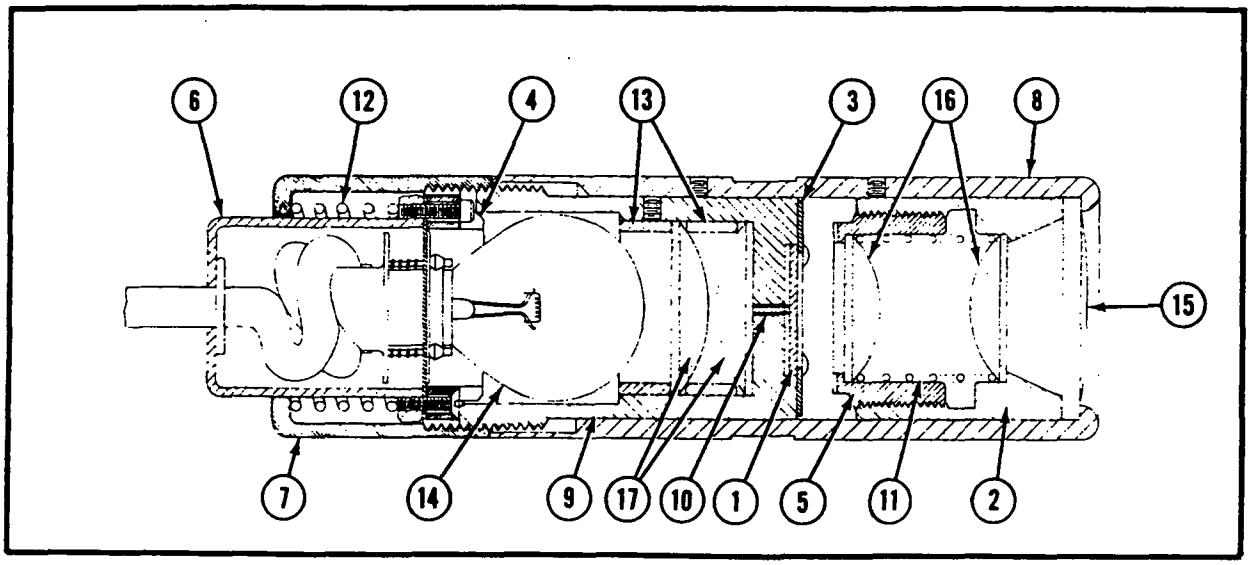


FIG. 5 - OPTICAL INDICATOR ASSEMBLY
Part No. 181010

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
5 -	181010	Indicator Assembly, Optical Distance (See Fig. 4, Item 1)	1
1	55546	Reticle	1
2	55829	Holder, Lens Front	1
3	55830	Mask	1
4	55831	Holder, Lamp Base	1
5	55832	Holder, Lens Rear	1
6	55833	Cover, Lamp Base	1
7	55834	Cap, End	1
8	55835	Housing	1
9	55836	Holder, Cond. Lens	1
10	T5A-271	Spring, Compression	2
11	T5A-272	Spring, Comp. Col. Lens	1
12	T5A-273	Spring, Lamp Base	1
13	T10C-584	Spacer, Condensing	2
14	T72-111	Lamp, GE Cat. No. 1731, 6.3 V, 50 CP	1
15	T87-128	Lens, Plano, 608mm	1
16	T87-129	Lens, Plano, 39.25mm	2
17	T87-130	Lens, Plano, 63.5mm	2

FIG. 6 - COBALT COLLIMATOR BEARING RING ASSEMBLY
Part No. 181459

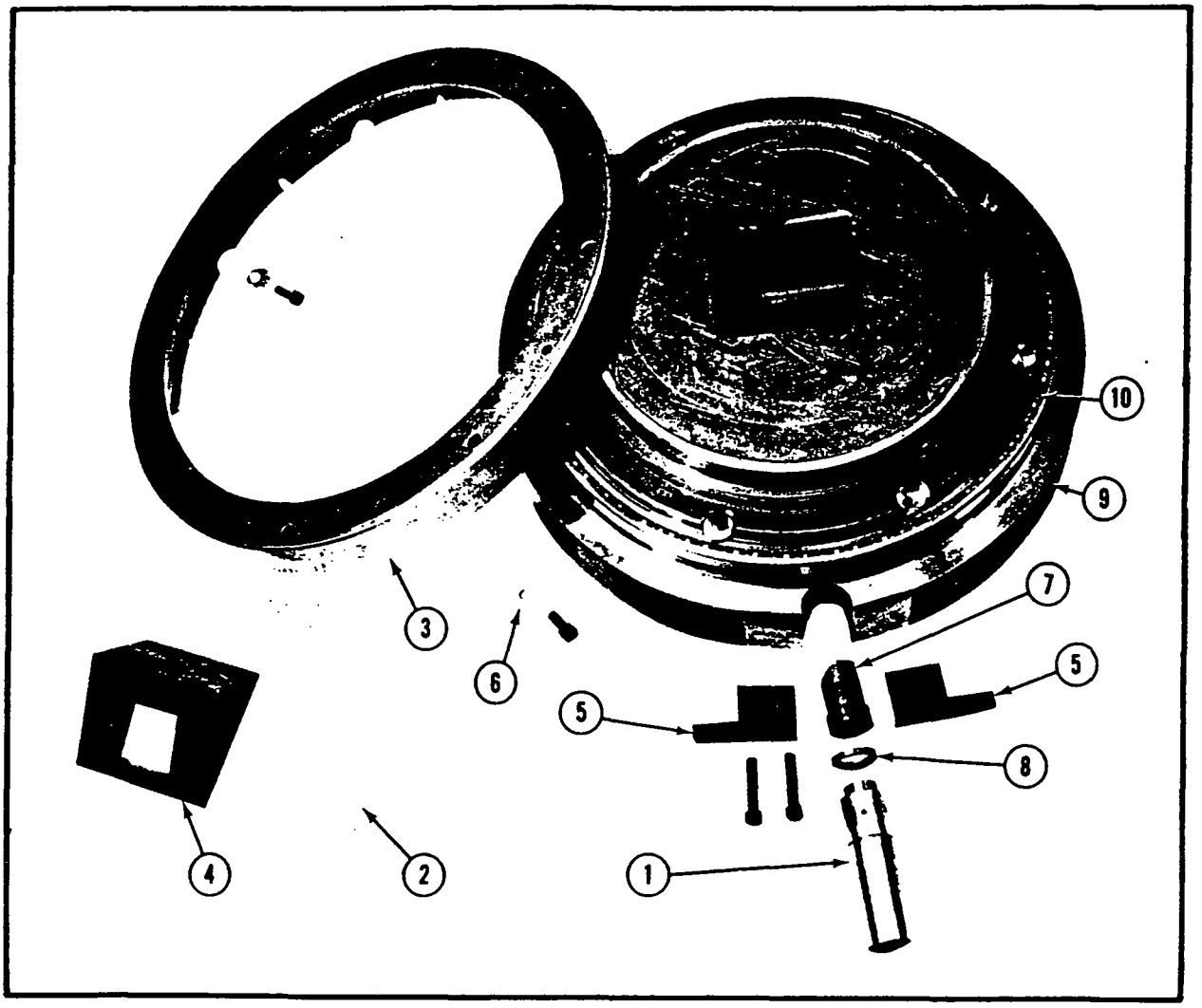


FIG. 6 - COBALT COLLIMATOR BEARING RING ASSEMBLY
Part No. 181459

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
6 -	181459	Ring Assembly, Bearing (See Fig. 4, Item 34)	Ref.
1	181461	Lens Assembly, Field Illuminator (See Fig. 7)	1
2	55432	Mirror, Collimator	1
3	55591	Adapter Ring, Bearing	1
4	55592	Retainer, Mirror	1
5	55748	Block, Rotation Stop	2
6	55593	Retainer, Bearing	16
7	55594	Aperture	1
8	56210	Spacer, Aperture	1
9	181389A	Ring Assembly, Bearing-Machined	1
10	T13-438	Bearing, Ball - 4 Point Contact	1

FIG. 7 - COBALT COLLIMATOR FIELD LENS ASSEMBLY
Part No. 181461

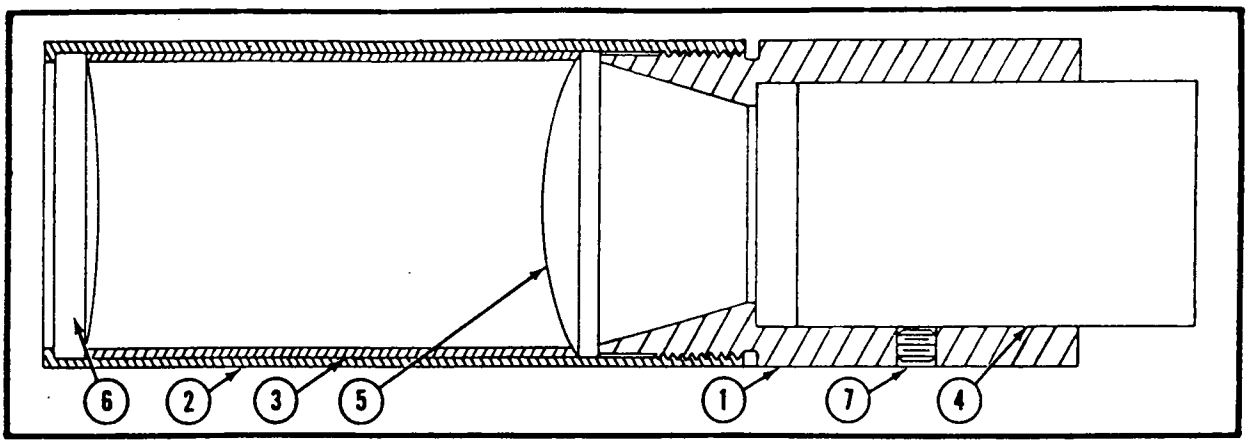
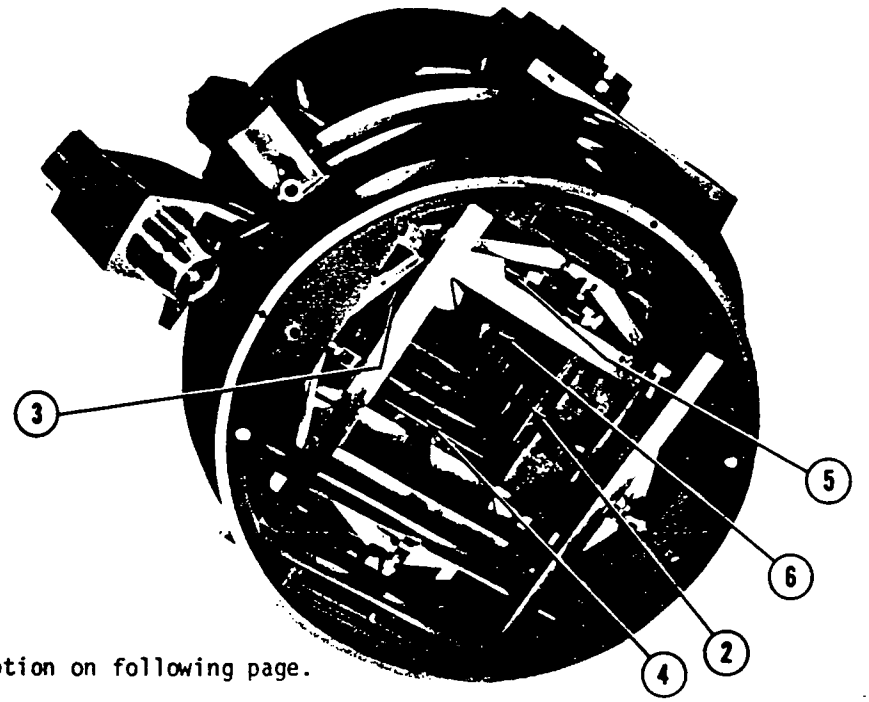


FIG. 7 - COBALT COLLIMATOR FIELD LENS ASSEMBLY
Part No. 181461

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
7 -	181461	Lens Assembly, Field Illuminator (See Fig. 6, Item 1)	Ref.
1	55826	Holder	1
2	55827	Sleeve	1
3	55825	Spacer	1
4	T87-127	Lens, Wide Angle Proj.	1
5	T87-126	Lens, Plano 56mm F.L.	1
6	T87-125	Lens, Plano 207.2mm F.L.	1
7	S33-98	Screw, Socket Set, #4-40 x 1/8	1

FIG. 8 - COBALT COLLIMATOR MAIN CROSS ASSEMBLY
Part No. 181460



NOTE: Parts Description on following page.

FIG. 8 - COBALT COLLIMATOR MAIN CROSS ASSEMBLY
Part No. 181460

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
8 -	181460	Cross Assembly, Main (See Fig. 4, Item 35)	Ref.
1*	181445	Pulley Assembly, Idle Side Take-up (See Fig. 9)	16
2	181467	Parallelogram Assembly, "X" Motion (with split nut)	1
3	181467A	Parallelogram Assembly, "X" Motion	1
4	181468	Parallelogram Assembly, "Y" Motion (with split nut)	1
5	181468A	Parallelogram Assembly, "Y" Motion	1
6	181469	Vane Assembly, Top	2
7*	181470	Drive Assembly, Gear (See Fig. 10)	1
8*	181470A	Drive Assembly, Gear - with special dials (See DDS 1001)	1
9*	55166A	Frame Casting, Main	1
10*	55597	Rod, Guide	4
11*	T10C-590	Spacer, Counterbalance Pivot	8
12*	T11P-251	Washer, Large O.D.	8
13*	T14D-182	Pin, Vane Pivot	8
14*	T82-96	Cable, Bottom Counterbalance	16

*Not shown.

FIG. 9 - COBALT COLLIMATOR MAIN CROSS PULLEY ASSEMBLY
Part No. 181445

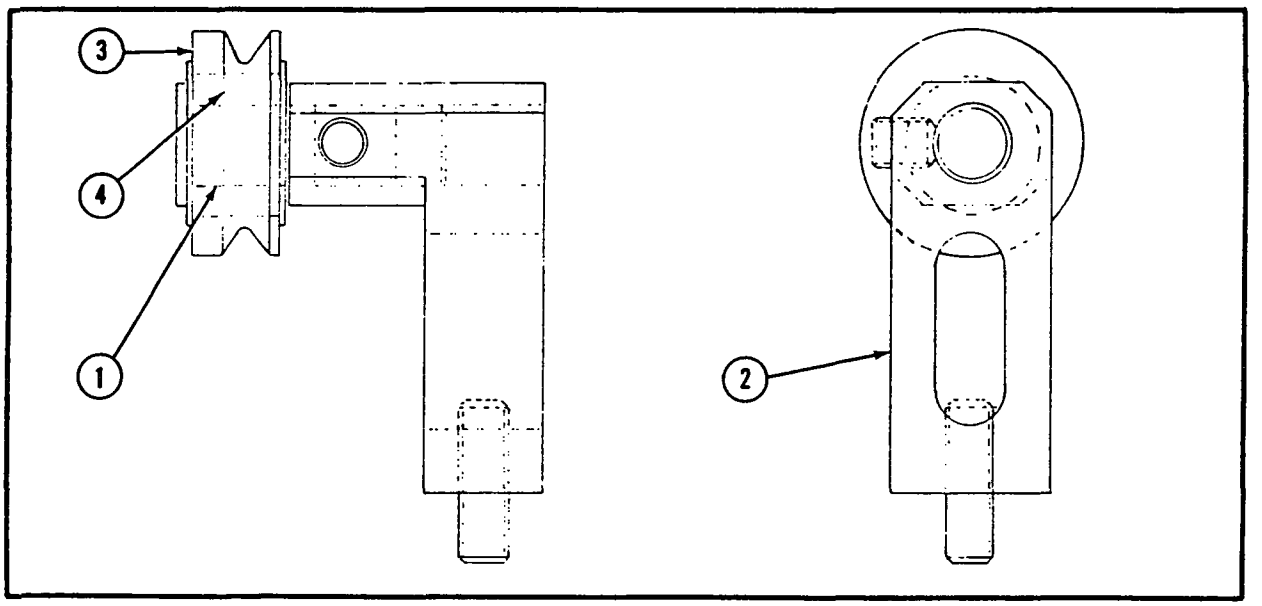


FIG. 9 - COBALT COLLIMATOR MAIN CROSS PULLEY ASSEMBLY
Part No. 181445

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
9 -	181445	Pulley Assembly (See Fig. 8, Item 1)	16
1	55600	Shaft, Pulley	1
2	55602	Block, Take-up	1
3	55599A	Pulley	1
4	T12-443	Bearing, Needle	1

FIG. 10 - COBALT COLLIMATOR MAIN CROSS HAND GEAR DRIVE ASSEMBLY
Part No. 181470
DDS 1001 - COBALT COLLIMATOR MAIN CROSS HAND GEAR DRIVE ASSEMBLY
Part No. 181470A

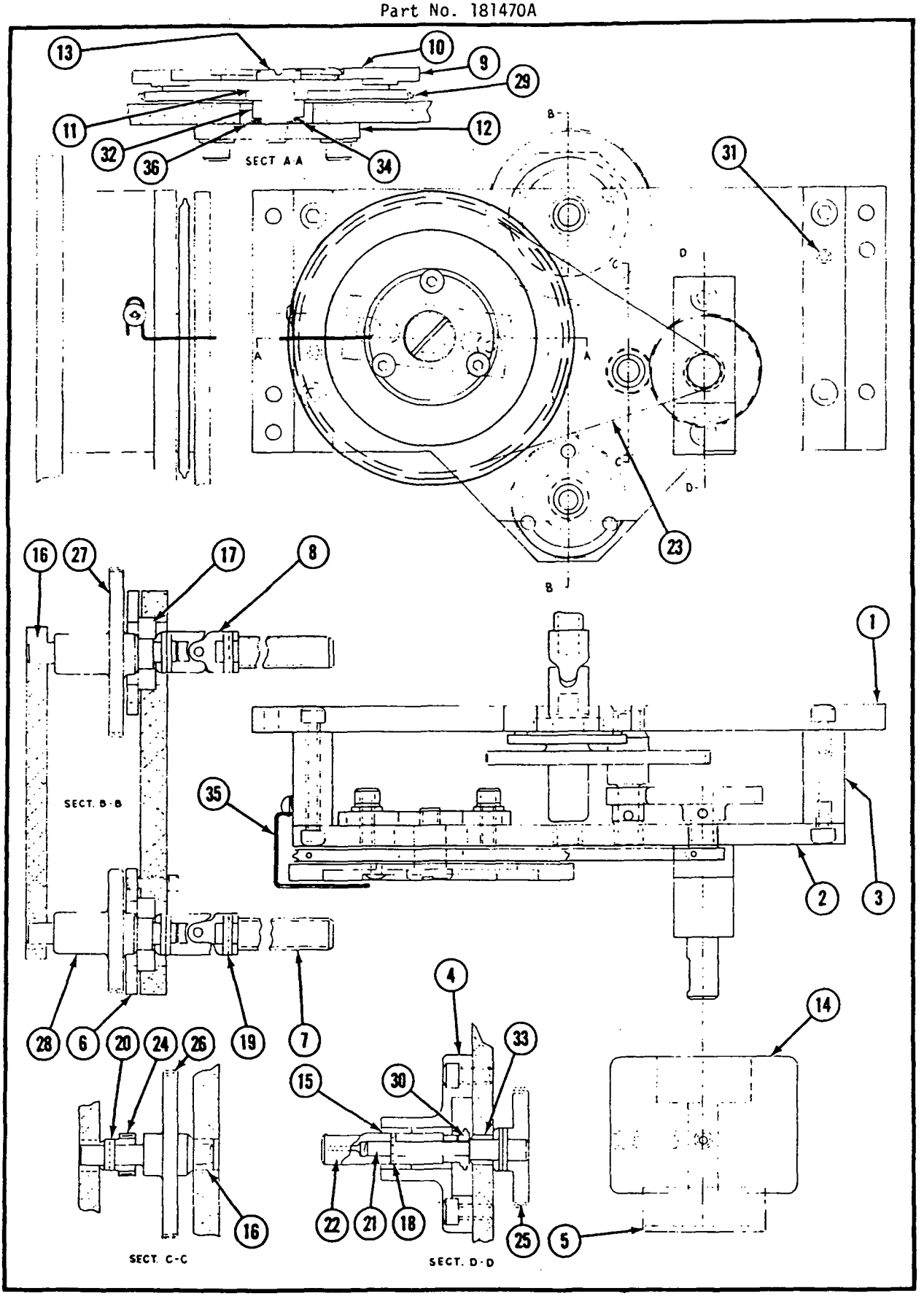


FIG. 10 - COBALT COLLIMATOR MAIN CROSS HAND GEAR DRIVE ASSEMBLY
Part No. 181470

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
10 -	181470	Gear Drive Assembly, Hand (See Fig. 8, Item 7)	1
1	55841	Plate, Rear	1
2	55842	Plate, Front	1
3	55843	Spacer, Plate	2
4	55844A	Support, Bearing	1
5	55845	Plug, Knob	1
6	55846	Retainer, Bearing	2
7	55848	Screw, Lead	2
8	55849	Joint, Universal	2
9	55850	Dial, Outer	1
10	55851	Dial, Inner	1
11	55852	Ring, Dial	1
12	55853	Plate, Adj.	1
13	T2-519	Screw, Shoulder	1
14	T3-166	Knob, Dial	1
15	T10F-85	Bushing	1
16	T10F-86	Bushing	4
17	T12-447	Bearing	2
18	T14A-110	Pin, Roll, 1/16 x 3/8	1
19	T14A-79	Pin, Roll, 1/8 x 1/2	5
20	T14A-84	Pin, Roll, 1/8 x 3/8	1
21	T14L-73	Shaft	1
22	T14L-74	Shaft, Adapter	1
23	T26-140	Chain, Roller	1
24	T77-326	Gear, 24 T., 48 D.P.	1
25	T77-327	Gear, 66 T., 48 D.P.	1
26	T77-328	Gear, 96 T., 48 D.P.	1
27	T77-329	Gear, 96 T., 48 D.P.	1
28	T77-330	Gear, 66 T., 48 D.P.	1
29	T77-38	Sprocket, 70 T.	1
30	T77-39	Sprocket, 10 T.	1
31	T14D-181	Pin, Dowel, 3/16 x 1/2	2
32	T10C-309	Bushing	1
33	56428	Bushing	1
34	T5-675	Washer, Spring	1
35	56637	Pointer, Dial	1
36	T11P-4	Shim	2

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DIFFERENCE DATA SHEET

DDS 1001 - COBALT COLLIMATOR MAIN CROSS HAND GEAR DRIVE ASSEMBLY
Part No. 181470A

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
10 -	181470A	Gear Drive Assembly, Head (See Fig. 8, Item 8)	1
9	55850A	Dial, Outer	1
10	55851A	Dial, Inner	1

FIG. 11 - COBALT COLLIMATOR EXTENDER ASSEMBLY
Part No. 181507

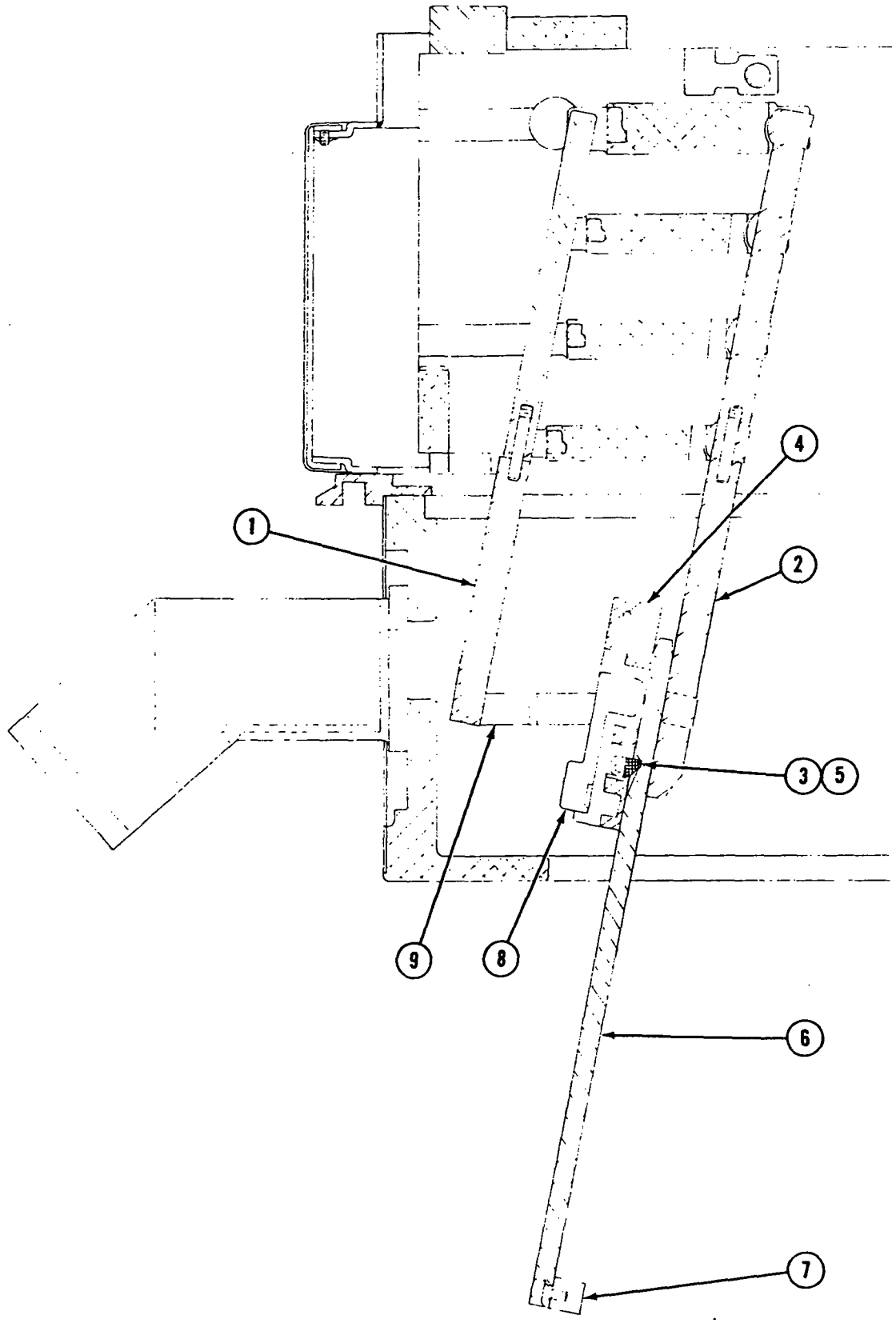

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FIG. 11 - COBALT COLLIMATOR EXTENDER ASSEMBLY
Part No. 181507

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
11 -	181507	Extender Assembly (See Fig. 4, Item 37)	Ref.
1	181462	Bar Assembly, Support	1
2	181463	Bar Assembly, Trimmer	1
3	56106	Stop, Extender	1
4	55576A	Guide, Extender	1
5	56107	Stop, Spring Extender	1
6	55578	Bar, Extender Mounting	1
7	55170	Extender	1
8	55580A	Lever	1
9	55581A	Yoke, Trimmer Bar Support	1
10*	56770	Lever, Keeper Plate	1
11*	T2-548	Screw, Cam Lever, Eccentric	1
12*	T5A-270	Spring, Compression	1
13*	T14F-35	Pin, 1/4 Diameter, Connecting	2
14*	T22-65	Retainer, Ring, Truarc	2
15*	T14D-189	Pin, 3/16 x 1"	1

*Not shown.

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FIG. 12 - COBALT COLLIMATOR HALO SWITCH
Part No. 181558

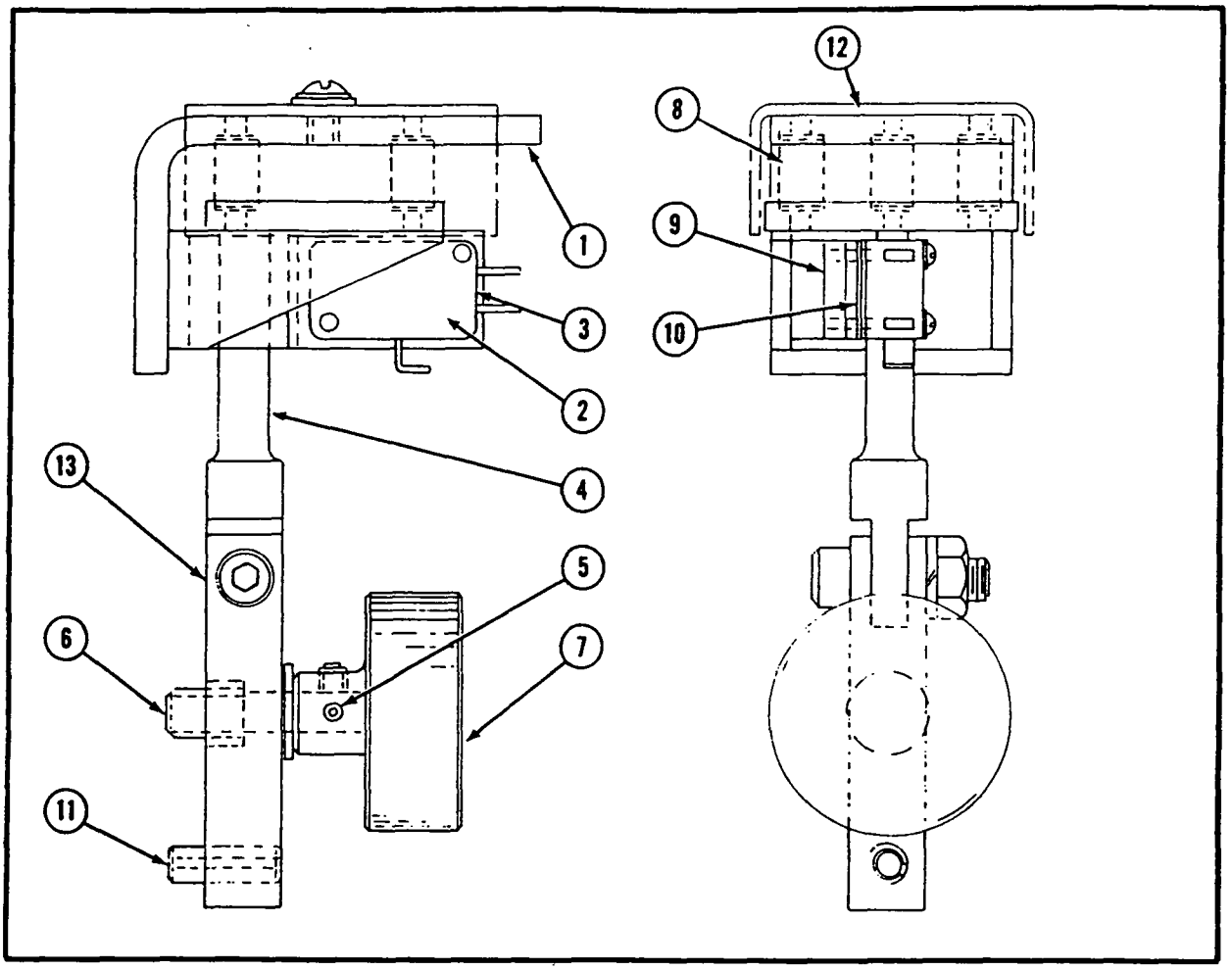

FIG. 12 - COBALT COLLIMATOR HALO SWITCH
Part No. 181558

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
12 -	181558	Switch Assembly, Halo (See Fig. 4, Item 38)	1
1	181562	Bracket, Angle	1
2	L-2729	Switch, With Leads	1
3	T29A-16	Switch	1
4	181563	Bracket, Mounting	1
5	T14A-76	Pin, Roll, 3/32 x 1/2	1
6	T14L-75	Stud	1
7	T3A-116	Knob	1
8	T5A-93	Spring, Compression	6
9	T4-165	Plate, Nut	1
10	T9-74	Barrier, Fibre	1
11	T14A-86	Pin, Roll, 1/4 x 3/4	1
12	55972	Plate, Guide Feeler	1
13	55971	Stem, Adjustable	1

FIG. 13 - COBALT COLLIMATOR ROTATIONAL BRAKE ASSEMBLY
Part No. 181464

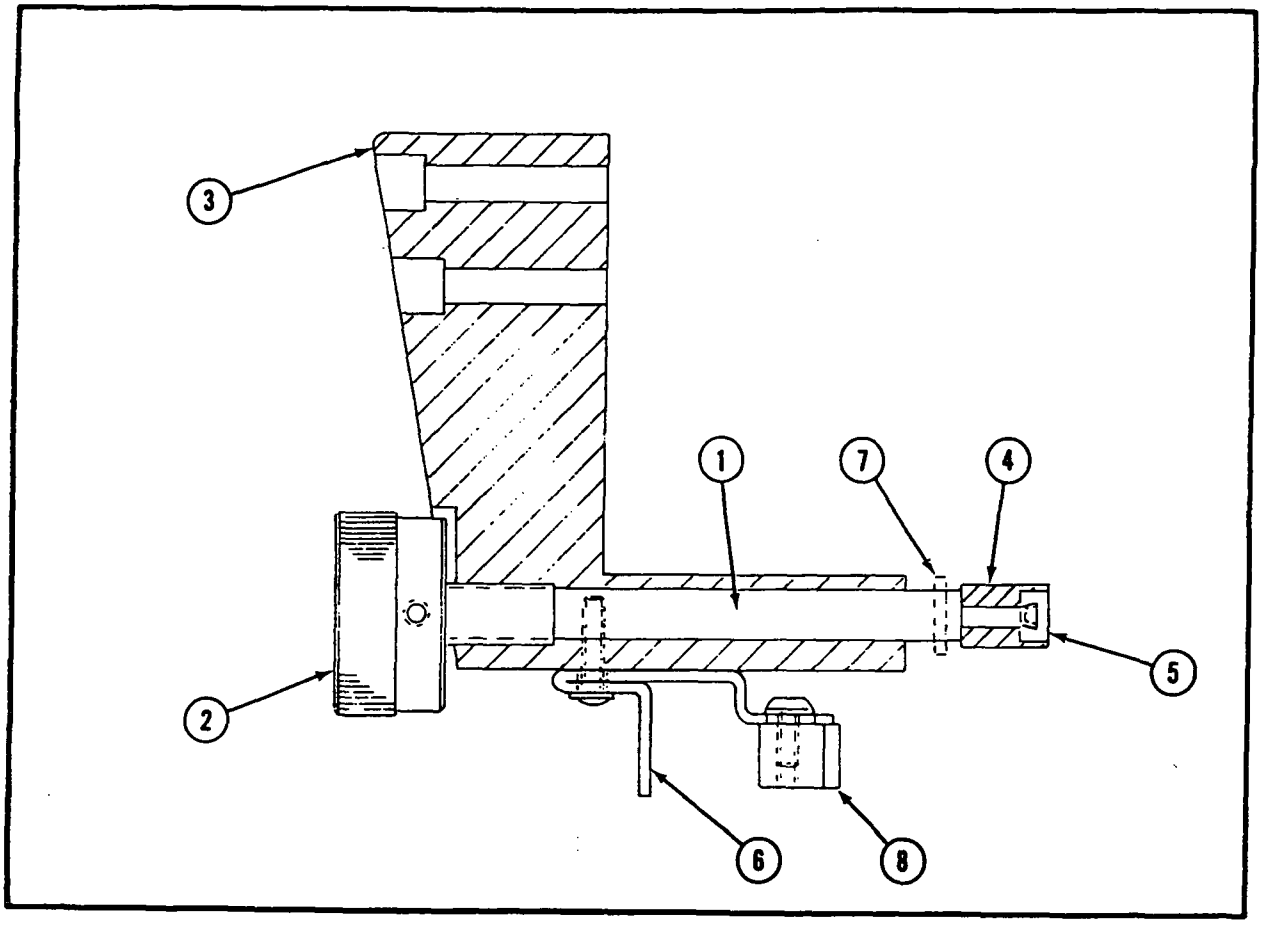

FIG. 13 - COBALT COLLIMATOR ROTATIONAL BRAKE ASSEMBLY
Part No. 181464

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
13 -	181464	Brake Assembly, Rotational (See Fig. 4, Item 19)	1
1	55657	Shaft, Brake	1
2	T3-61	Knob	1
3	55659A	Housing, Brake	1
4	55656	Shoe, Brake	1
5	55658	Lining, Brake Shoe	1
6	55655	Pointer	1
7	T14A-132	Pin, Roll, 1/16 x 1/2	1
8	56586	Actuator, Front Switch	1

FIG. 14 - V9 COBALT CONTROL
Part No. VG8D
DDS 1401 - V9 COBALT CONTROL
Part No. VG8E

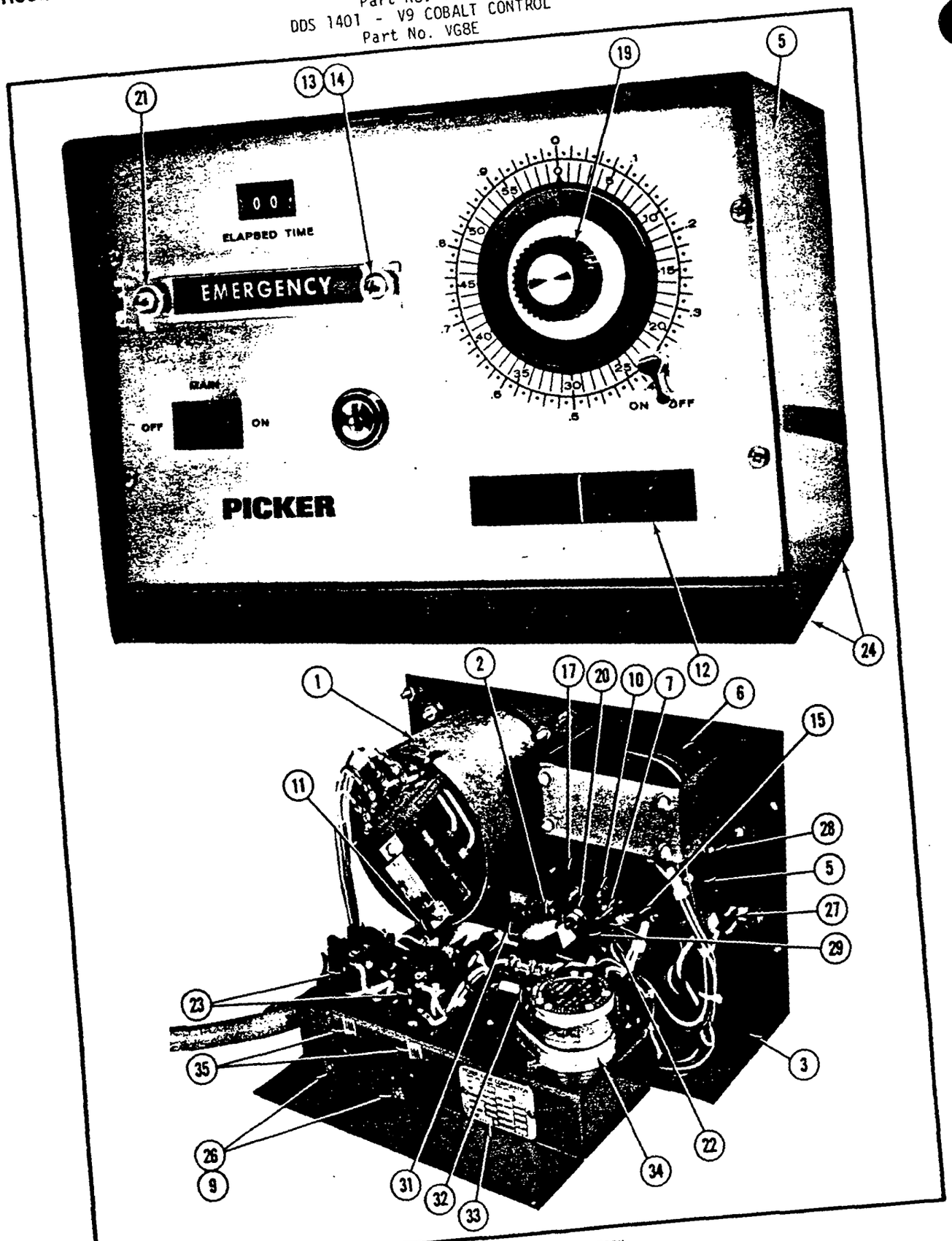

FIG. 14 - V9 COBALT CONTROL
Part No. VG8D

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
14 -	VG8D	Control, Cobalt, 60 Hz (See Fig. 1, Item 3)	1
1	945A	Timer, 60 Hz, L-F	1
2	14574	Bracket Assembly, Lamp	1
3	16463A	Chassis Assembly	1
4*	50314	Cabinet, Control	1
5	31358	Insulation (SW3)	1
6	34482	Timer, Back-up	1
7	34952	Actuator, Microswitch, Flat	2
8*	35088	Actuator, Microswitch, Roller	1
9	32062	Holder, Fuse	2
10	36759	Lock and Keys	1
11	37169	Sockets, Lamp	2
12	38759	Window, Shutter Indicator	1
13	38975	Bar, Exposure	1
14	38976	Strap, Cross	1
15	46536	Bracket, Key Switch	1
16*	46560	Cam, Timer	1
17	46562	Brackets, Timer	2
18*	46744A	Nameplate, Control	1
19	T3A-85	Knob	1
20	T5-433	Spring, Key Switch	1
21	T5A-185	Spring	2
22	T9-74	Spacer, Microswitch	3
23	T19A-108	Relay, D.P.D.T.	2
24	T21-140	Bumper, Rubber	4
25*	T21A-70	Grommet, Heyco	1
26	T27A-12	Fuse, 10 A, 125 Volt	2
27	T29-147	Switch, Rocker D.P.S.T.	1
28	T29A-15	Switch, Micro Snap	1
29	T29A-16	Switch, Micro S.P.D.T.	3
30*	T66A-10	Clamp, Cable	1
31	T72-8	Lamp, Mazda Bulb, 6 Watts, 120 Volts	2
32	T81A-21	Board, 10 PT. Terminal	1
33	T92-155	Plate, Rating	1
34	T93B-59	Motor, 60 Hz, 10 RPM, Syn.	1
35	T32B-8	Decal, 10 Amp	2

*Not shown.

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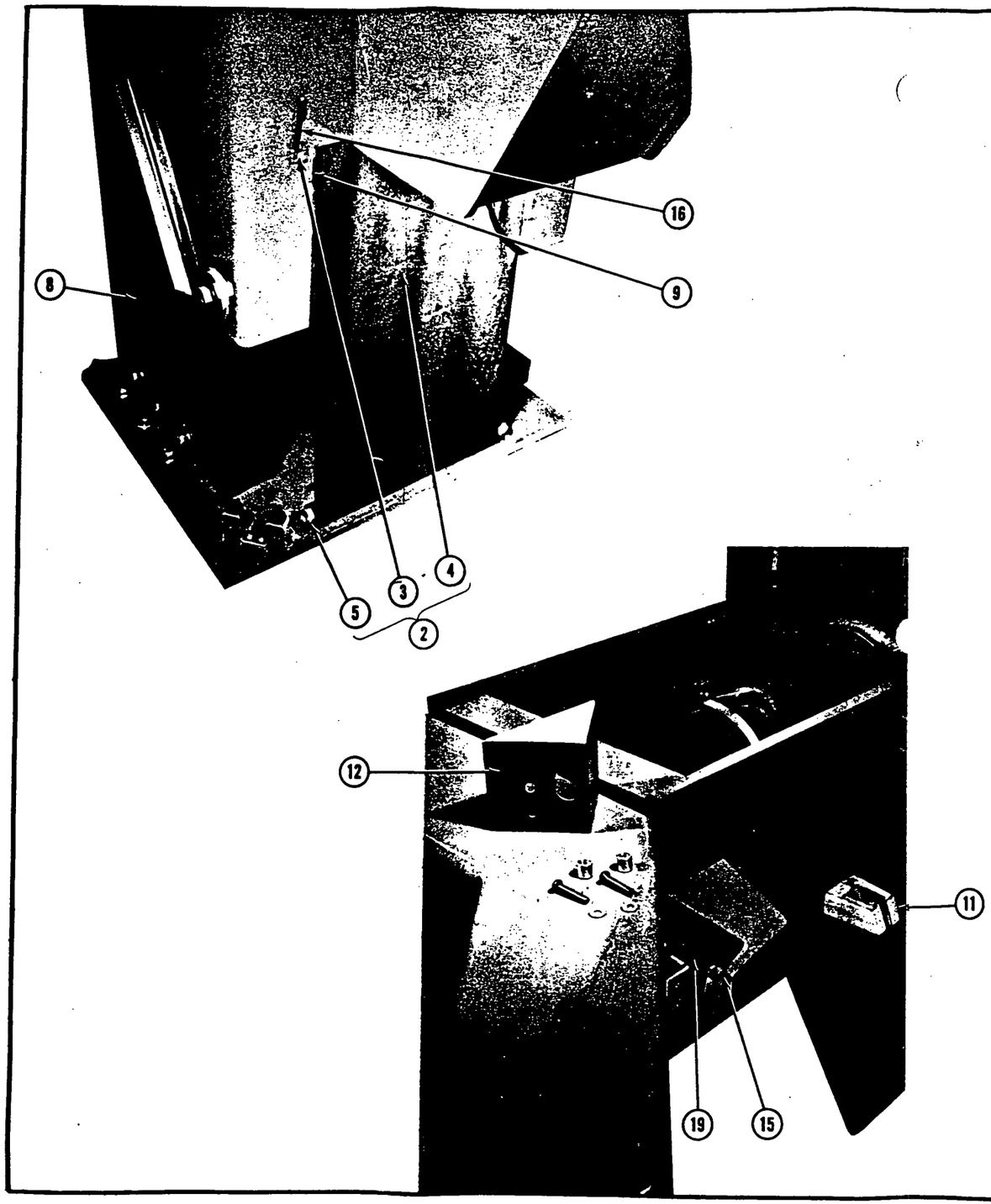
DIFFERENCE DATA SHEET

DDS 1401 - V9 COBALT CONTROL
Part No. VG8E

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
14 -	VG8E	Control, Cobalt, 50 Hz (See Fig. 1, Item 3A)	1
1	945C	Timer, 50 Hz L.F.	1
36	T93B-60	Motor, 50 Hz, 10 RPM, Syn.	1

FIG. 15 - V9 COBALT FIXED STAND
Part No. 1373E



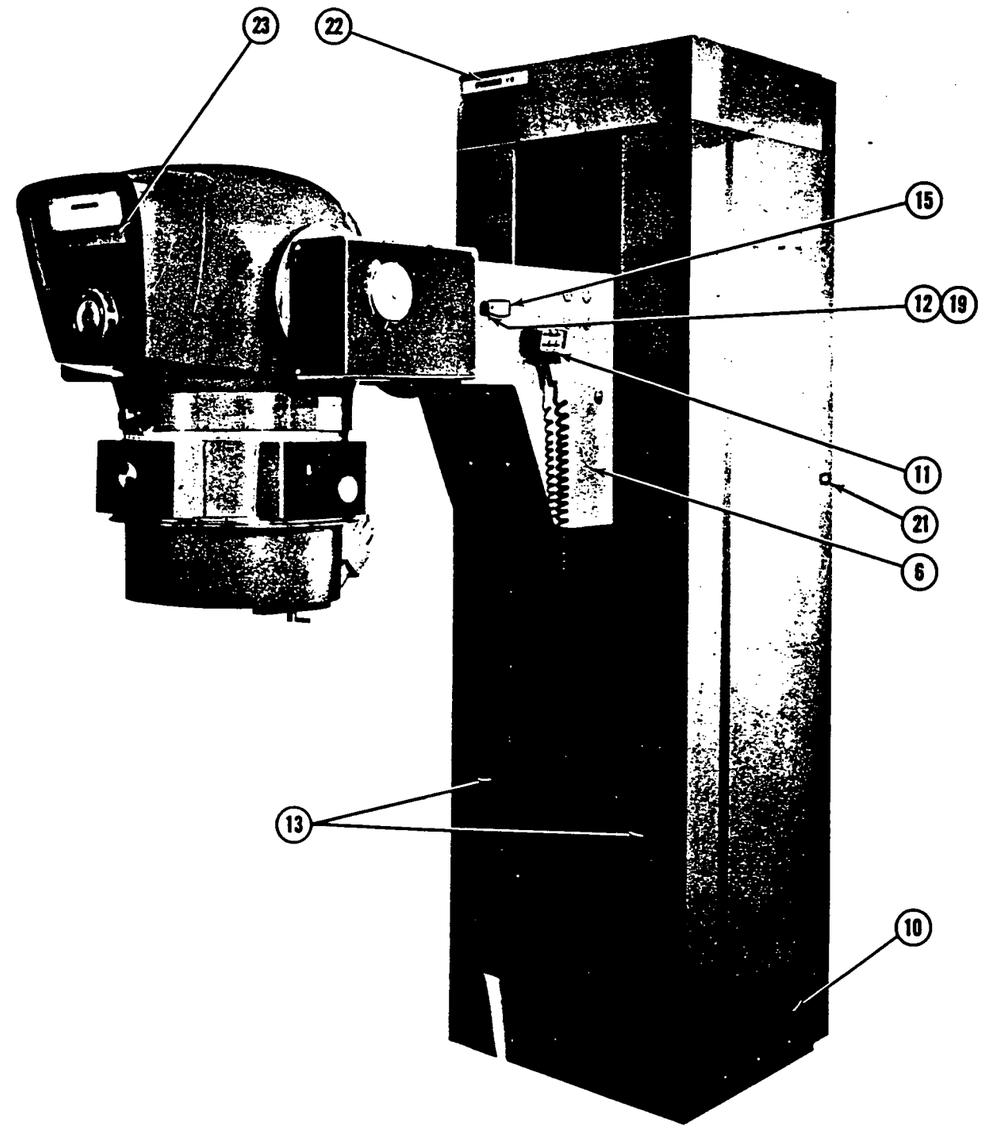


FIG. 15 - V9 COBALT FIXED STAND
Part No. 1373E

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
15 -	1373E	Stand, V9 Fixed (See Fig. 1, Item 4)	1
1*	3719	Calculator, Cobalt	1
2	15251A	Shade Assembly	2
3	42084	Slat, Vertical Shade	1
4	42074A	Shade	1
5	42080	Roller and Bracket, Shade	1
6	15956C	Carriage Assembly, Hanger and Roller (See Fig. 16)	1
7*	15958	Drive Assembly, Vertical (See Fig. 21)	1
8	15955B	Column Assembly (See Fig. 22)	1
9	31823	Stiffener, Contact	4
10	42076A	Moulding, Trim	2
11	50825	Caddy, Pendant Switch	1
12	54134	Cover, Yoke Centering Switch	1
13	42073A	Shroud	2
14*	42090	Ballast, 50 lb. Bag	8
15	T2-480	Screw, Switch Trip	1
16	T5-446	Spring, Shade	4
17*	T10C-197	Bushing	4
18*	T26A-12	V-Belt, Vertical Drive	1
19	T29A-51	Switch, Yoke Centering	1
20*	T14L-72	Rod, Threaded, Mounting Angulation Scale	1
21	T92-176	Nameplate, Rating	1
22	T92-193	Nameplate, Picker	1
23	T92-355	Nameplate, V9	1

*Not shown.

FIG. 16 - V9 COBALT CARRIAGE ASSEMBLY
Part No. 15956C

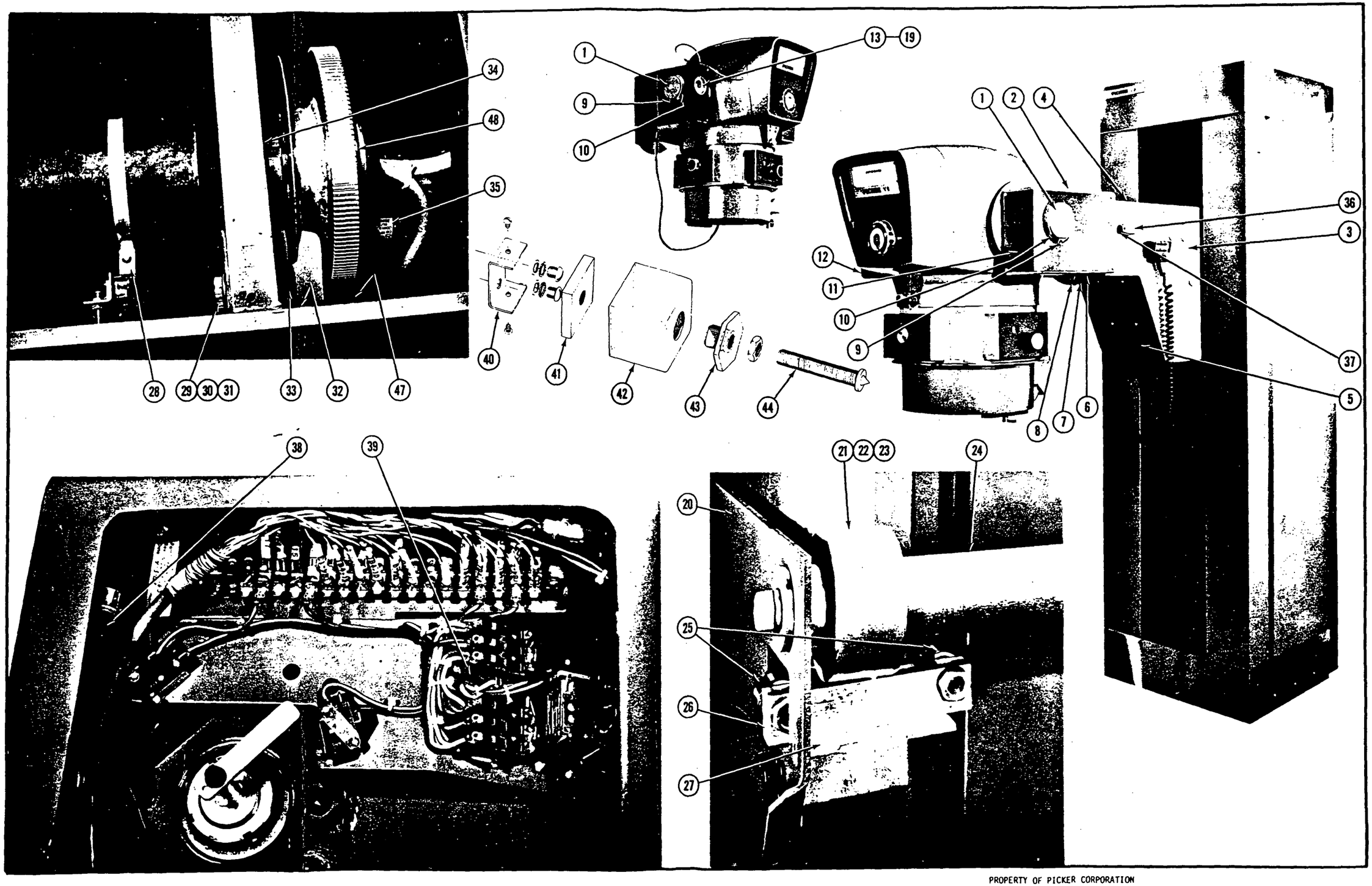


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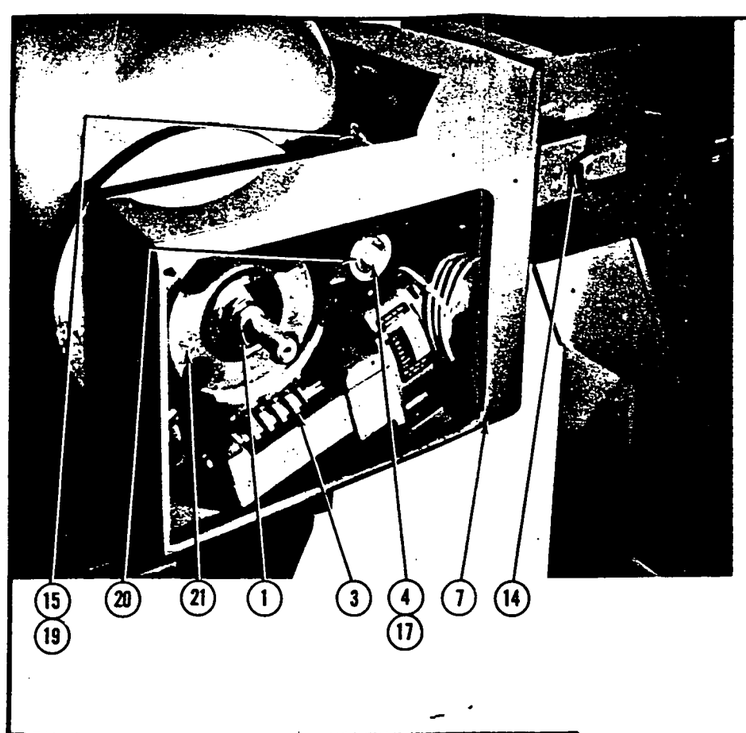
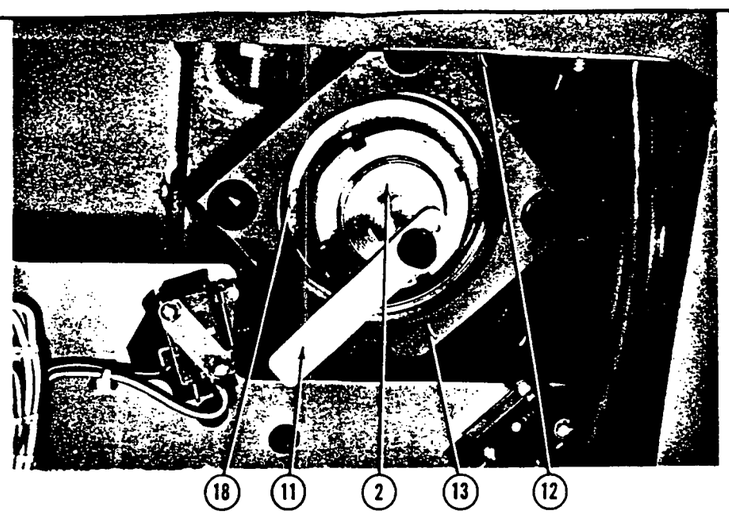
FIG. 16 - V9 COBALT CARRIAGE ASSEMBLY
Part No. 15956C

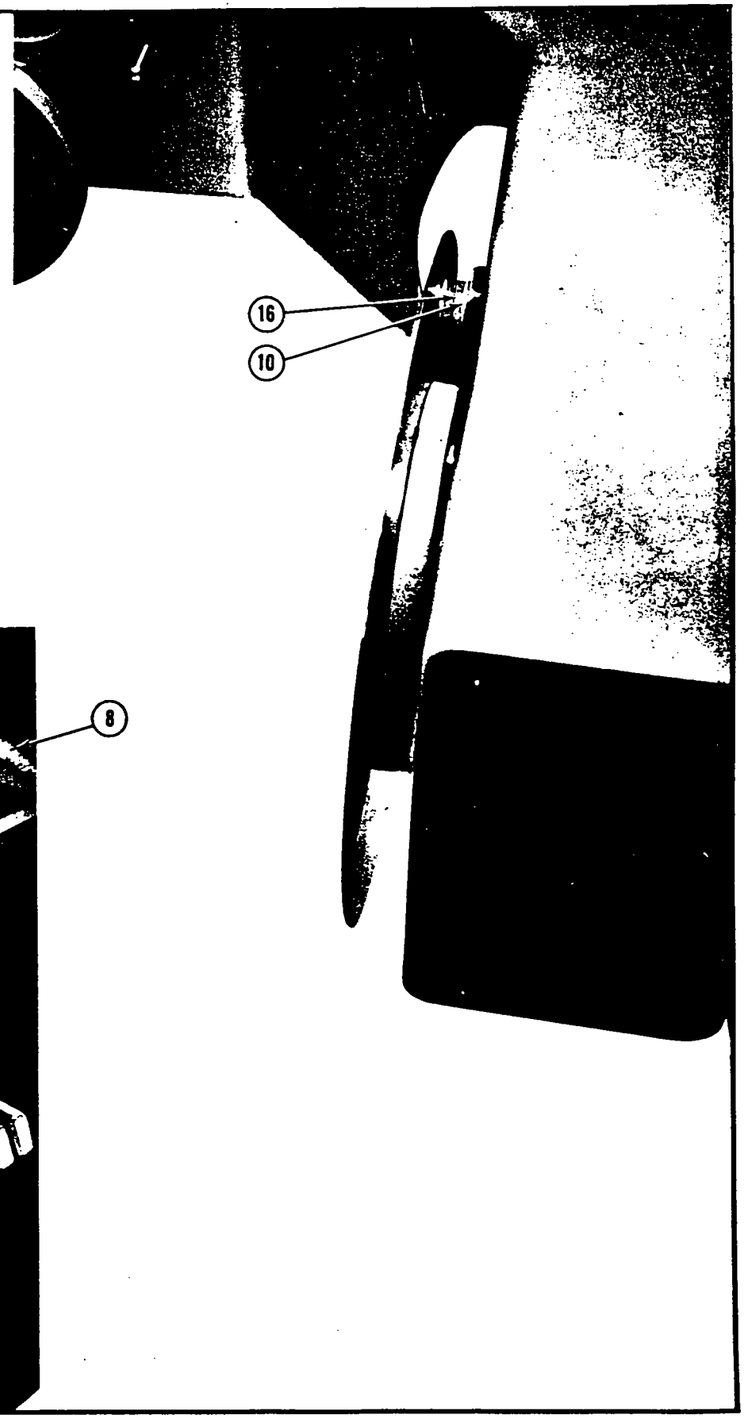
FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
16 -	15956C	Carriage Assembly, Hanger and Roller (See Fig. 15, Item 6)	1
1	13471C	Retainer Assembly, Angulation Scale (one on each side)	2
2	16833A	Yoke Assembly (See Fig. 17)	1
3	46855A	Support, Yoke	1
4	46856A	Plate, Yoke Support Top	1
5	46857A	Plate, Yoke Support Bottom	1
6	54135	Cover, Dust (between Yoke and Yoke Support	1
7	54150	Scale, Partial Yoke Tilt	1
8	54151	Pointer, Scale	1
9	45020	Pointer, Angulation Scale	2
10	35829A	Scale, Yoke Angulation	2
11	54015	Cover, Yoke Arm, Right	1
12	54015A	Cover, Yoke Arm, Left	1
13	13823E	Scale Assembly, Angulation	1
14	14953	Shaft and Counterweight Assembly	1
15	36060	Pointer	1
16	36083	Face, Dial	1
17	36934	Scale, Angulation	1
18	T12-205	Bearing, Ball	1
19	181601	Housing and Window Assembly (with Retainer)	1
20	42085B	Carriage, Roller	1
21	T22-53	Retainer, Ring	4
22	35910A	Wheel, Plain Carriage	4
23	T12-144	Bearing, Carriage Wheel	4
24	T14H-66	Shaft, Carriage Roller	2
25	T12-150	Roller, Back Floor	6
26	42072	Block, Roller Mounting	3
27	15247	Plate Weldment, Roller Bracket Mounting	3
28	54168	Trip, Limit Switch	1
29	53623	Pad, Brake	4
30	54152	Retainer, Spring	2
31	T5A-256	Spring, Compression	2
32	54165	Spacer, Yoke Brake	1
33	54155	Housing, Brake	1
34	T12-328	Bearing, Rear Yoke Tube	1
35	182120	Motor Assembly	1
36	54492A	Bracket, Yoke Switch Trip Mounting	1
37	T2-490	Screw, Switch Trip	1
38	T29-98	Switch, Mercury	2
39	181003	Control Assembly, Yoke Rotation (See Fig. 20)	1
40	54175	Bracket, Switch Mounting	1
41	T4-398	Nut Plate	1
42	181018	Bracket Assembly, Switch Trip	1
43	T11-249	Washer, Threaded	1
44	T2-480	Screw, Switch Trip	1
45*	55431	Plate, Motor Mounting	1
46*	T12-424	Bearing, Front	1
47*	T13A-235	Rod, Threaded	1
48	T22-150	Retainer, Ring	1
49*	T54-40	Ring, 2.725 Diameter	1
50*	T66B-12	Clamp, Angulation Scale	1

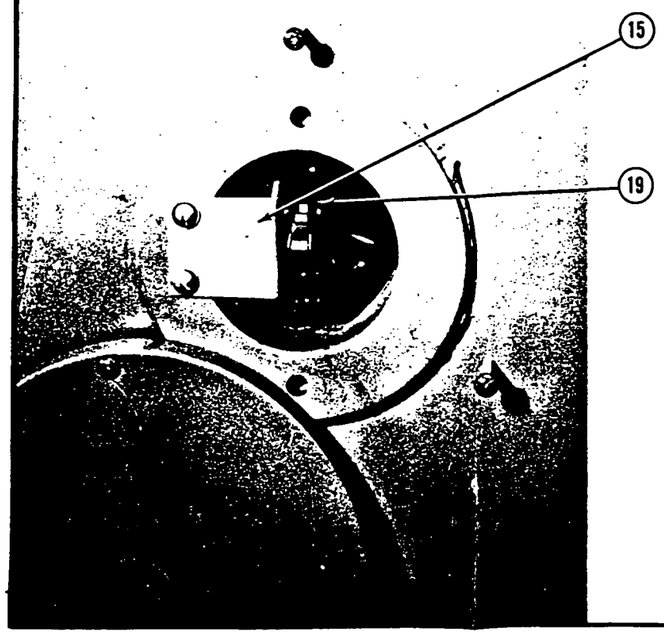
*Not shown.

FIG. 17 - COBALT TUBE ASSEMBLY
Part No. 16833A









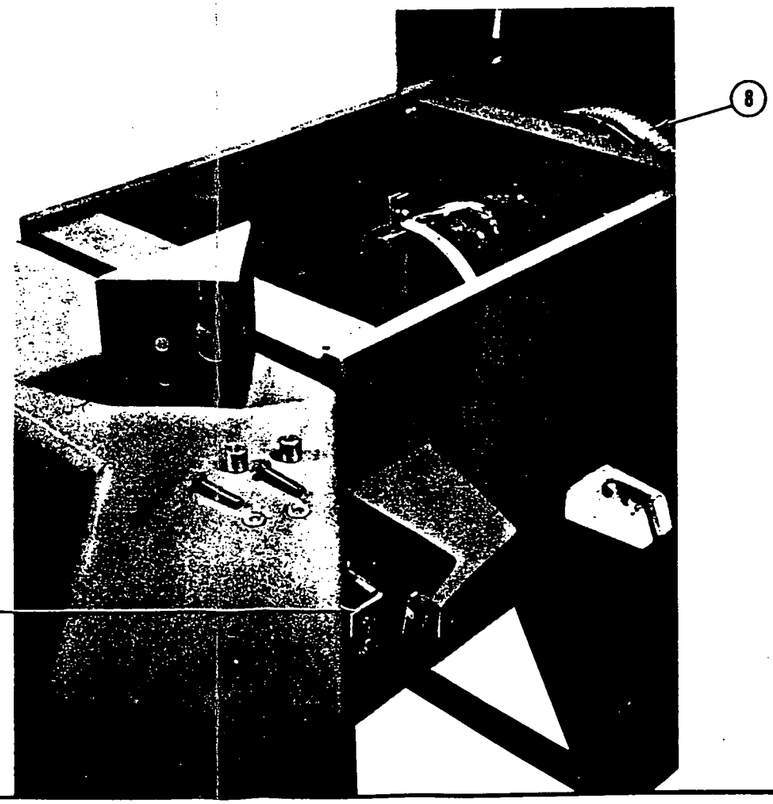


FIG. 17 - COBALT YOKE ASSEMBLY
Part No. 16833A

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
17 -	16833A	Yoke Assembly (See Fig. 16, Item 11)	1
1	180967	Trunnion Assembly, Cobalt Head (R.H.)	1
2	180968	Trunnion Assembly, Cobalt Head (L.H.)	1
3	180999	Drive Assembly, Worm (See Fig. 18)	1
4	181006	Plug Assembly, Spring Retaining	1
5*	181009	Control Assembly Head Tilt (See Fig. 19).	1
6*	181411A	Gear Assembly, Yoke and Drive	1
7	180997A	Yoke, Cobalt Head	1
8	181007A	Gear Assembly, Yoke Rotation	1
9*	53623	Pad, Brake	1
10	53628A	Disc, Brake	1
11	53677	Lever, Actuator, Limit Switch	1
12	38688	Weight, Balance	1
13	54131	Retainer, Bearing, Trunnion	2
14	54136	Bracket, Mounting, Yoke Centering Switch	1
15	54153	Bracket, Mounting, Head Centering Switch	1
16	55996	Pad, Brake (3/16" thick)	1
17	T5A-256	Spring, Compression	1
18	T12-260	Bearing, Trunnion	2
19	T29A-51	Switch, Head Centering	2
20*	T31-44	Key, Drive Gear (for Item 21 this figure)	1
21	T77C-33	Gear, Worm	1

*Not shown.

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FIG. 18 - COBALT HEAD WORM DRIVE ASSEMBLY
Part No. 180999

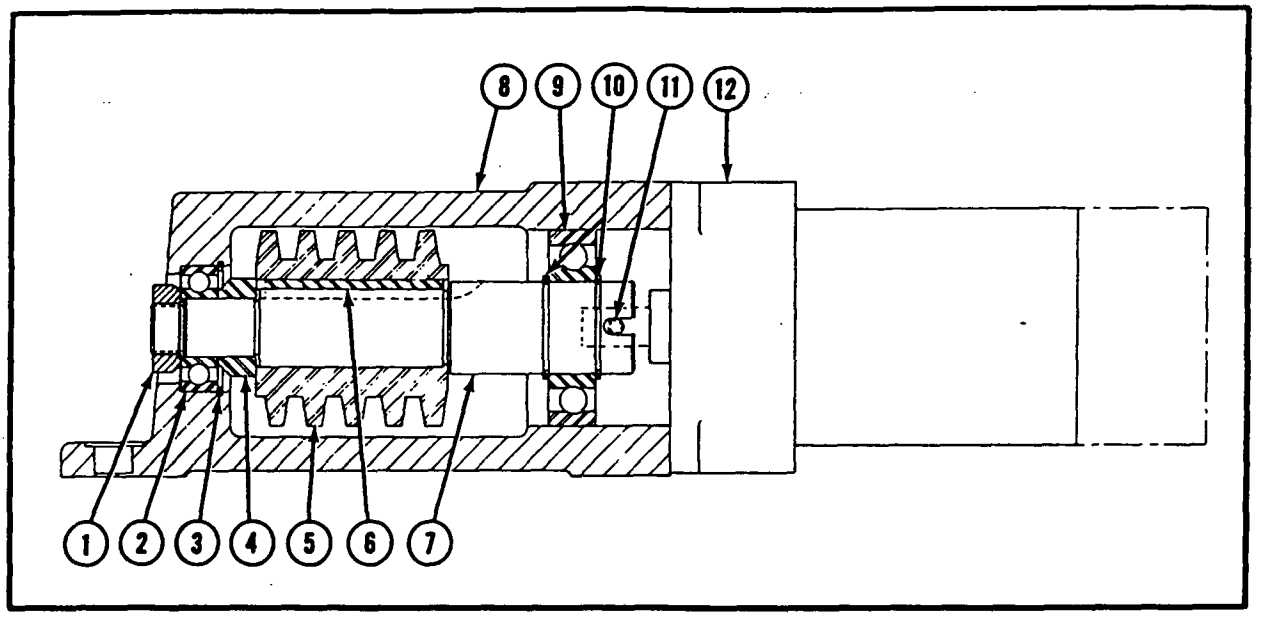

FIG. 18 - COBALT HEAD WORM DRIVE ASSEMBLY
Part No. 180999

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
18 -	180999	Drive Assembly, Worm (See Fig. 17, Item 3)	1
1	T4-146	Nut, Worm Shaft Lock	1
2	T12-245	Bearing, Ball	1
3	T22-144	Ring, Retaining	1
4	54144	Spacer, Worm Drive Shaft	1
5	T77B-34	Gear, Worm	1
6	T31-43	Key, Worm Drive	1
7	T14C-52	Shaft, Drive	1
8	53844	Housing, Bearing	1
9	T12-156	Bearing, Ball, Single Row Radial Double Shielded	1
10	T22-52	Truarc	2
11	T14A-62	Pin, Roll 3/16	1
12	T93G-15	Motor, Power Head Tilt and Yoke Rotation	1

FIG. 19 - COBALT HEAD TILT CONTROL ASSEMBLY
Part No. 181009

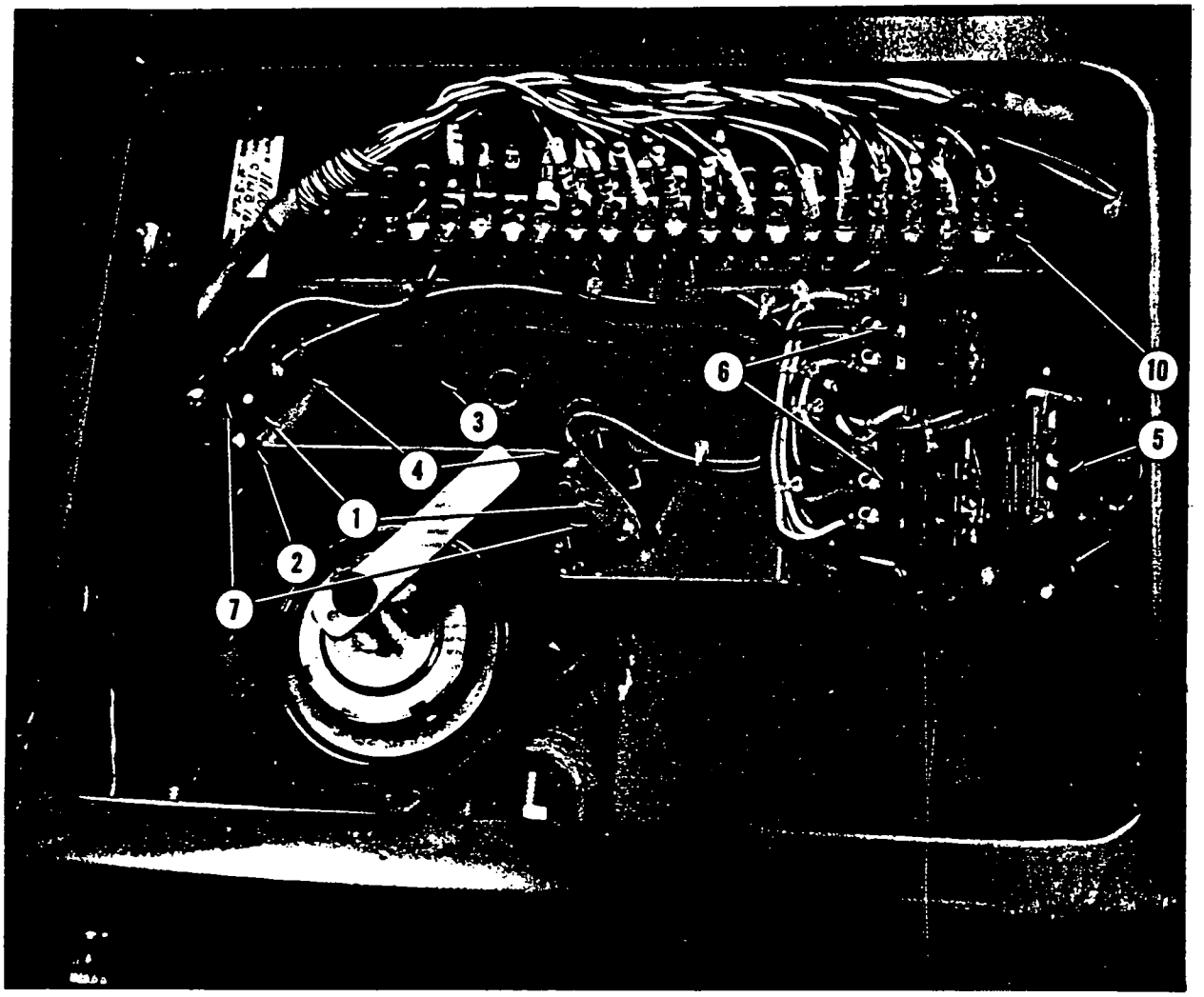

FIG. 19 - COBALT HEAD TILT CONTROL ASSEMBLY
Part No. 181009

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
19 -	181009	Control Assembly, Head Tilt (See Fig. 17, Item 5)	1
1	35088	Actuator, Switch	2
2	T4-165	Plate, Nut	2
3	56683	Bracket, Relay Panel Mounting	1
4	T9-74	Barrier, Switch	2
5	T19A-130	Relay, D.P.D.T., Latch	1
6	T19A-150	Relay, D.P.D.T.	2
7	T29A-16	Switch, Micro	2
8*	32062	Post, Fuse	2
9*	T45-464	Capacitor and Bracket, 4 MF, 136 VAC	1
10	T81A-67	Strip, Terminal, 20 Point	1
11*	T27A-12	Fuse, 10 A, 250 Volt	2
		*Not shown.	

FIG. 20 - V9 COBALT YOKE ROTATION CONTROL ASSEMBLY
Part No. 181003

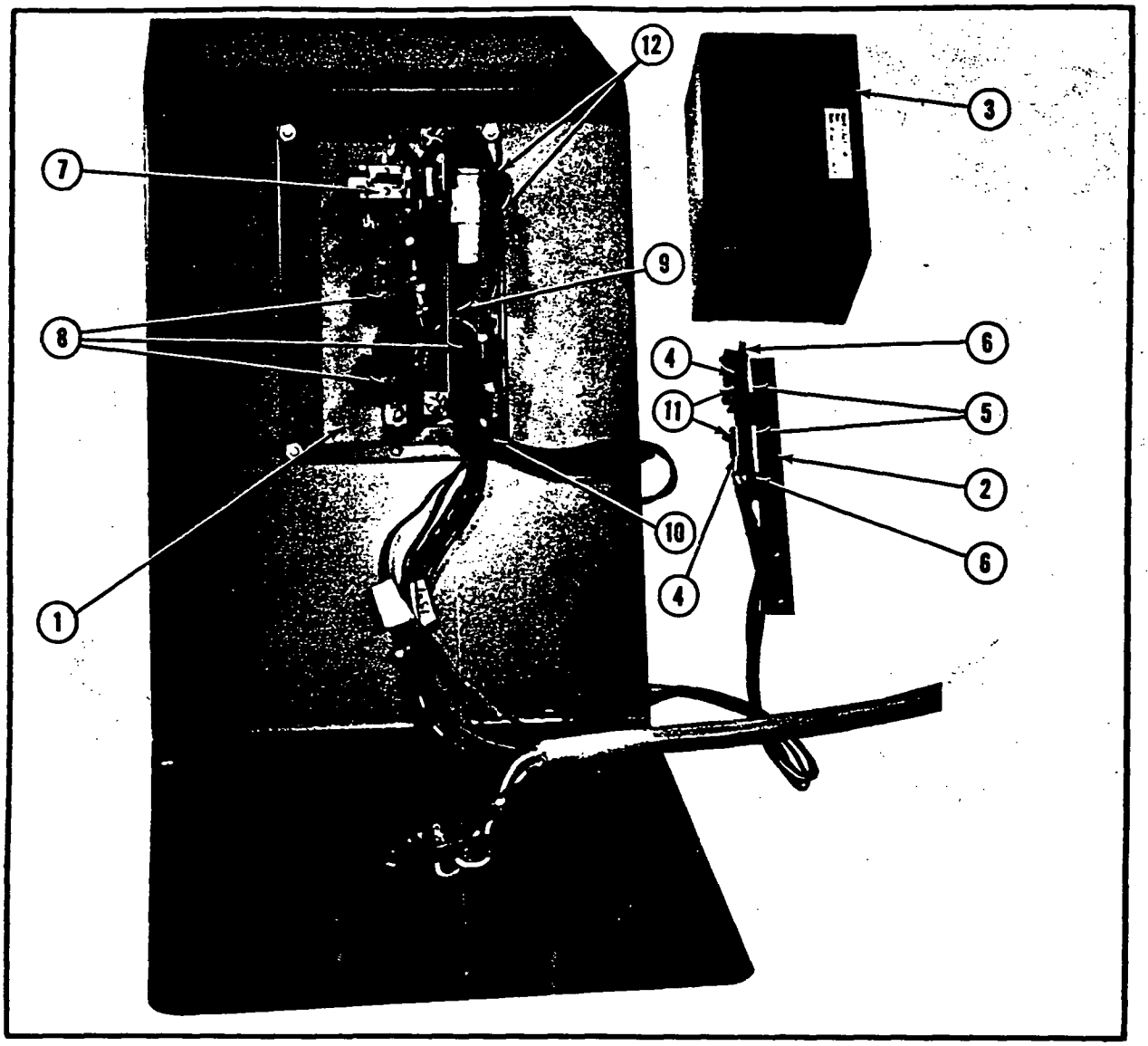

FIG. 20 - V9 COBALT YOKE ROTATION CONTROL ASSEMBLY
Part No. 181003

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
20 -	181003	Control Assembly, Yoke Rotation (See Fig. 16, Item 39)	1
1	181004	Panel Assembly	1
2	54143	Bracket, Limit Switch	1
3	54142	Cover, Relay	1
4	34952	Actuator, Switch	2
5	T4-165	Plate, Nut	2
6	T9-74	Barrier, Switch	2
7	T19A-130	Relay, D.P.D.T., Latch	1
8	T19A-150	Relay, D.P.D.T.	3
9	T21A-69	Bushing, Snap 1/2 I.D.	1
10	T21A-75	Grommet, Rubber 1/2 I.D.	1
11	T29A-16	Switch, Micro	2
12	T45-464	Capacitor and Bracket, 4 MFD, 236 VAC	1

FIG. 21 - V9 COBALT VERTICAL DRIVE ASSEMBLY
Part No. 15958

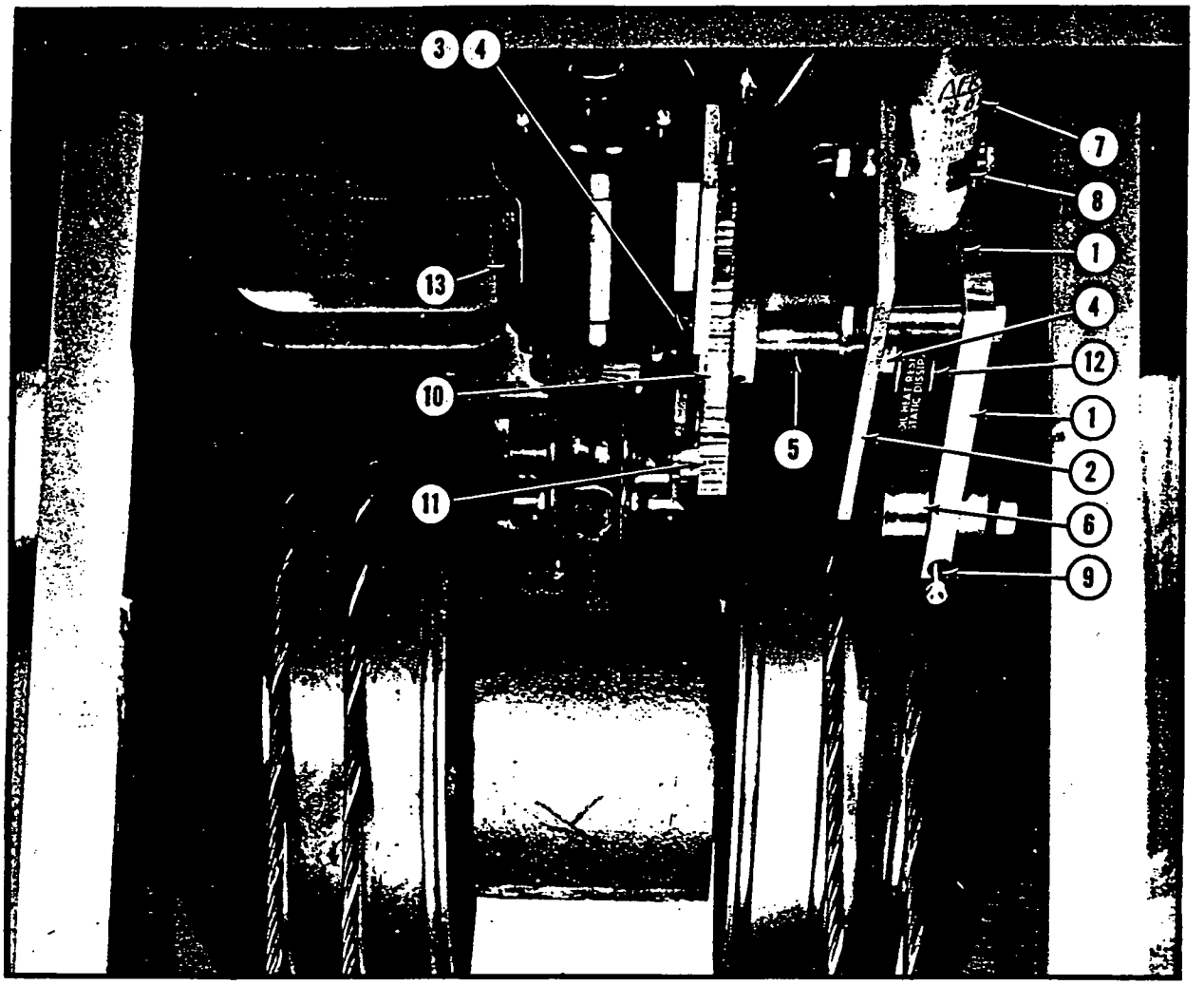

FIG. 21 - V9 COBALT VERTICAL DRIVE ASSEMBLY
Part No. 15958

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
21 -	15958	Drive Assembly, Vertical (See Fig. 15, Item 7)	1
1	50475	Bracket, Pulley, Idler	2
2	43397	Plate, Motor Mounting	1
3	T10B-308	Collar, Stop	1
4	T12-253	Flange, Bearing	2
5	T14H-85	Shaft, Drive	1
6	T12-150	Bearing	2
7	T45-45	Capacitor, 10 MFD	1
8	T66A-13	Clamp, Cable	1
9	T13A-116	Stud, Threaded	1
10	T77-103	Gear, Spur (Large)	1
11	T77-172	Gear, Spur (Small)	1
12	T84-22	Pulley	1
13	T93A-8	Motor, Horizontal Drive	1
		*Not shown.	

FIG. 21 - V9 COBALT VERTICAL DRIVE ASSEMBLY
Part No. 15958

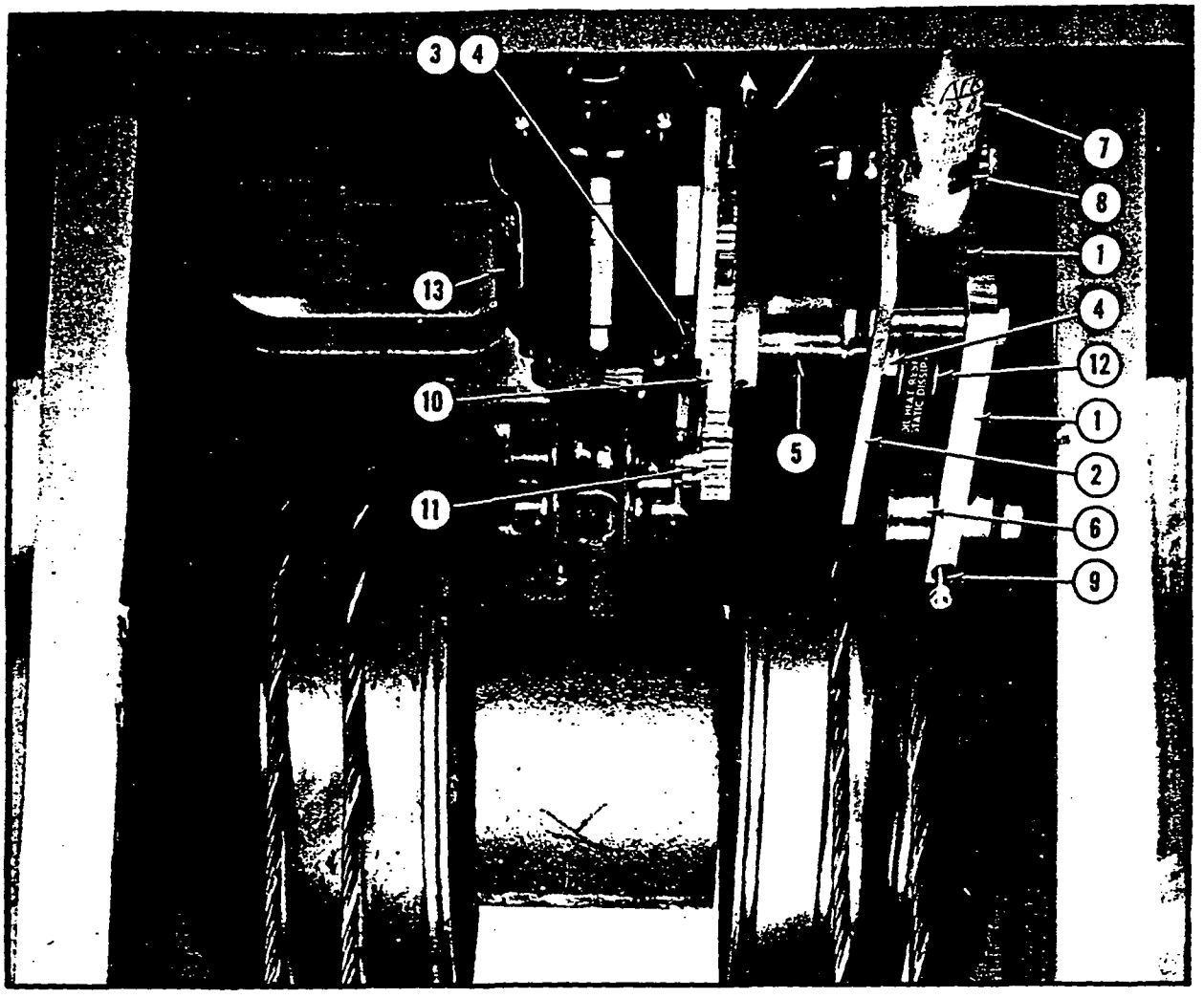

FIG. 21 - V9 COBALT VERTICAL DRIVE ASSEMBLY
Part No. 15958

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
21 -	15958	Drive Assembly, Vertical (See Fig. 15, Item 7)	1
1	50475	Bracket, Pulley, Idler	2
2	43397	Plate, Motor Mounting	1
3	T10B-308	Collar, Stop	1
4	T12-253	Flange, Bearing	2
5	T14H-85	Shaft, Drive	1
6	T12-150	Bearing	2
7	T45-45	Capacitor, 10 MFD	1
8	T66A-13	Clamp, Cable	1
9	T13A-116	Stud, Threaded	1
10	T77-103	Gear, Spur (Large)	1
11	T77-172	Gear, Spur (Small)	1
12	T84-22	Pulley	1
13	T93A-8	Motor, Horizontal Drive	1
		*Not shown.	

FIG. 22 - V9 COBALT COLUMN ASSEMBLY
Part No. 15955B

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
22 -	15955B	Column Assembly (See Fig. 15, Item 8)	1
1	15248	Strap Weldment, Support	1
2	15443B	Bucket Assembly, Counterweight	1
3*	34959	Cushion, Rubber	1
4	42059	Sleeve, Cable	2
5	42060	Channel, Left Hand Support	1
6	42061	Plate, Lower Bearing	1
7	42062A	Plate, Upper Bearing	1
8	42067	Housing, Bearing Casting	1
9	42068	Angle, Channel Mounting	4
10	42069A	Bracket, Shroud Mounting	4
11	42078	Bracket, Carriage Stop	1
12	42086	Channel, Right Hand Support	1
13*	T9B-105	Marker, Trim Strip, 14-Post	1
14	T12-234	Bearing, Main Support	2
15*	T14A-85	Pin, Roll, 3/8 x 1-3/4	2
16	T14H-67	Shaft, Main Bearing	1
17	T21-14	Bumper	2
18*	T81A-13	Strip, Terminal, 14-Post	1
19	T82-91	Support, Cable	4

*Not shown.

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FIG. 23 - COBALT, ACCESSORY ATTACHMENT POST ASSEMBLY
Part No. 3499E

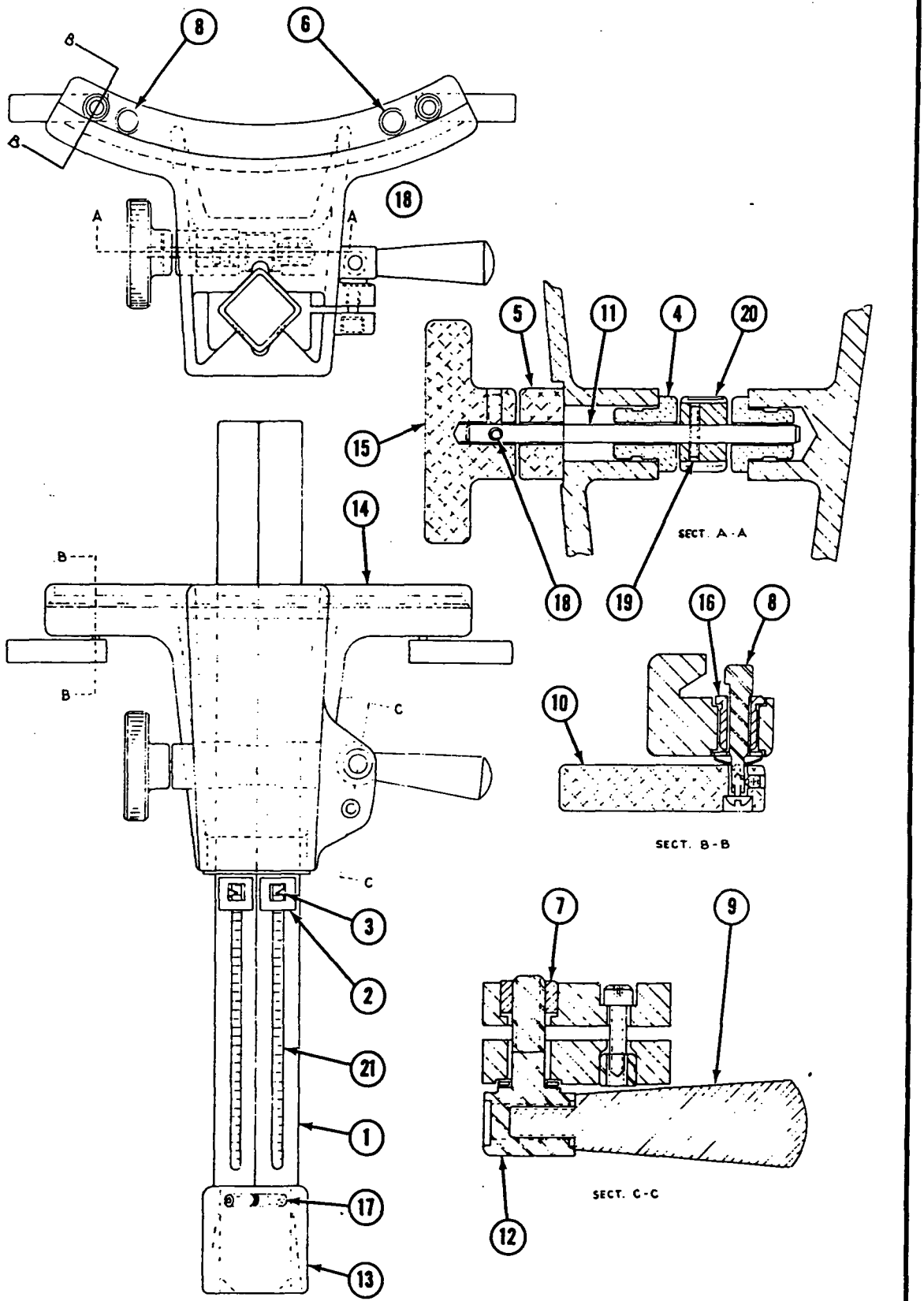

FIG. 23 - COBALT, ACCESSORY ATTACHMENT POST ASSEMBLY
Part No. 3499E

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
23 -	3499E	Post Assembly, Accessory Attachment (See Fig. 1, Item 5)	1
1	181481	Tube Assembly, Drive	1
2	181478	Bracket Assembly, Pointer	1
3	20816	Pointer	2
4	55663	Bushing, Eccentric	2
5	55664	Spacer, Drive Knob	1
6	55665	Pad, Nylon	2
7	55667	Clamp, Knurled Insert	1
8	55668	Clamp, Eccentric	2
9	55670	Handle, Clamp	1
10	55671	Handle, Clamp, Eccentric	2
11	55672	Shaft, Drive Wheel	1
12	55673	Bolt, Clamp	1
13	55674	Collar, Tapered	1
14	55360A	Post, Accessory Mounting	1
15	T3-62	Knob, Clamp	1
16	T10B-574	Bushing	2
17	T14A-86	Pin, Roll, 1/4 x 3/4	2
18	T14A-122	Pin, Roll, 1/8 x 1	1
19	T14A-113	Pin, Roll, 1/8 x 3/8	1
20	T77-323	Gear, Drive	1
21	T32-489	Scale,"0"CM to 20CM	2

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FIG. 24 - COBALT, BACKPOINTER ASSEMBLY
Part No. 3298C

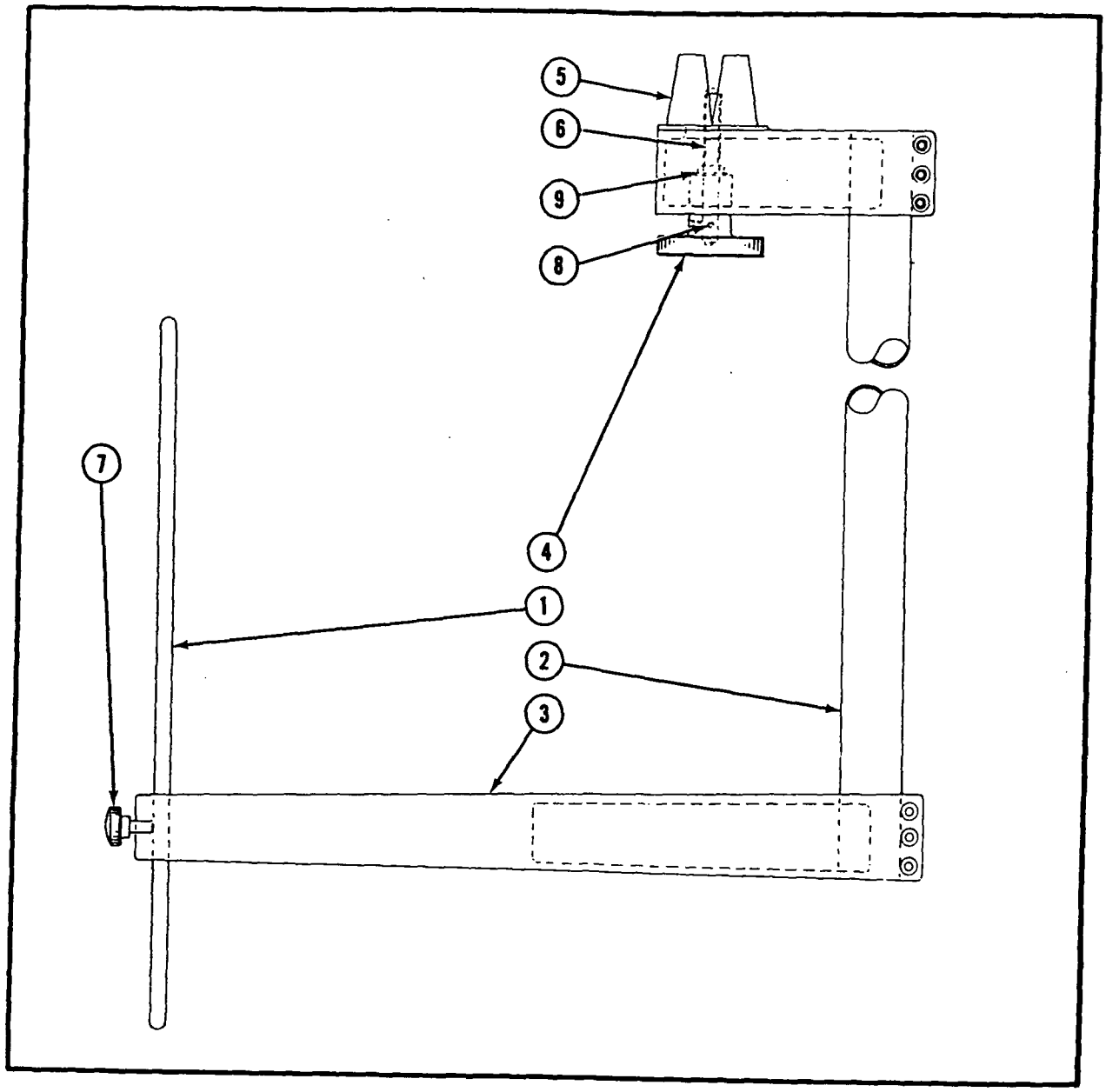

FIG. 24 - COBALT, BACKPOINTER ASSEMBLY
Part No. 3298C

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
24 -	3298C	Backpointer Assembly (See Fig. 1, Item 7)	1
1	39057	Rod, Pointer	1
2	50623	Support, Tube	1
3	55545A	Arm, Backpointer	1
4	T3-155	Knob, Clamp	1
5	55542A	Backpointer, Upper Arm	1
6	T13-395	Shaft, Clamp Knob	1
7	T2J-66	Screw, Thumb	1
8	T14A-122	Pin, Roll, 1/8 x 1	1
9	T22-22	Ring, Retaining, Truarc, 3/8 Shaft	1

FIG. 25 - COBALT, BEAM DIRECTING PIN-AND-ARC ASSEMBLY
Part No. 3500C

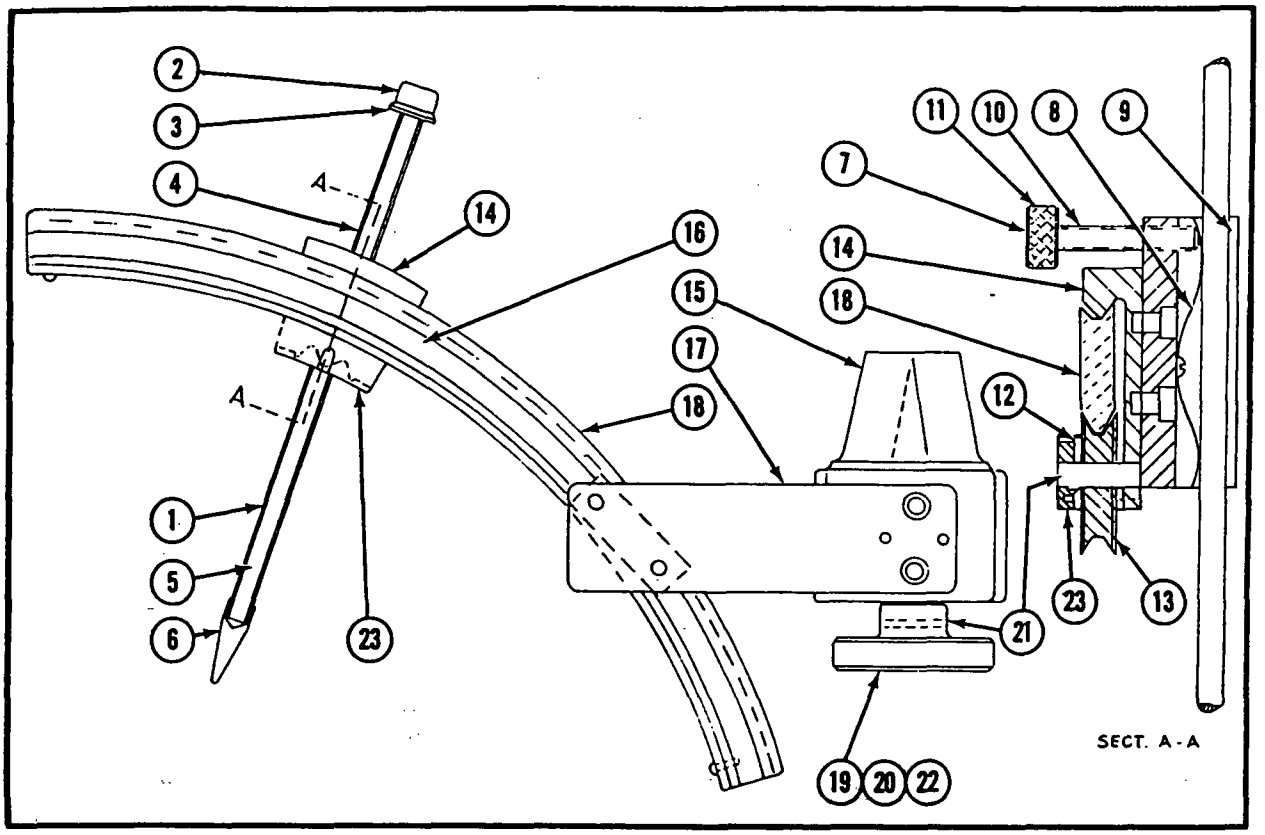

FIG. 25 - COBALT, BEAM DIRECTING PIN-AND-ARC ASSEMBLY
Part No. 3500C

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
25 -	3500C	Pin-and-Arc, Beam Directing (See Fig. 1, Item 8)	1
1	14361A	Pin Assembly	1
2	39055	Level, Circular	1
3	39081	Flange, Level Mounting	1
4	55680	Pin	1
5	55894	Scale	1
6	39627	Cap, Pointer	1
7	14396	Bushing Assembly, Pin	1
8	T5-455	Spring, Pin Bushing	1
9	38942	Bushing, Pin	1
10	T10C-389	Spacer	1
11	T2J-37	Screw, Thumb	1
12	20816	Pointer, Index	1
13	39088	Wheel, Thumb	1
14	39090	Arc, Cursor	1
15	55543A	Block, Mounting	1
16	55666	Scale, Arc	1
17	56494	Plate, Arc Mounting	1
18	56729A	Arc	1
19	T3-155	Knob, Clamp	1
20	T13-395	Shaft, Clamp Knob	1
21	T14-927	Pin, 3/16 x 5/8	1
22	T14A-122	Pin, Roll 1/8 x 1	1
23	T5-453	Spring, Pressure	1

FIG. 26 - COBALT, WEDGES AND COMPENSATOR ASSEMBLIES

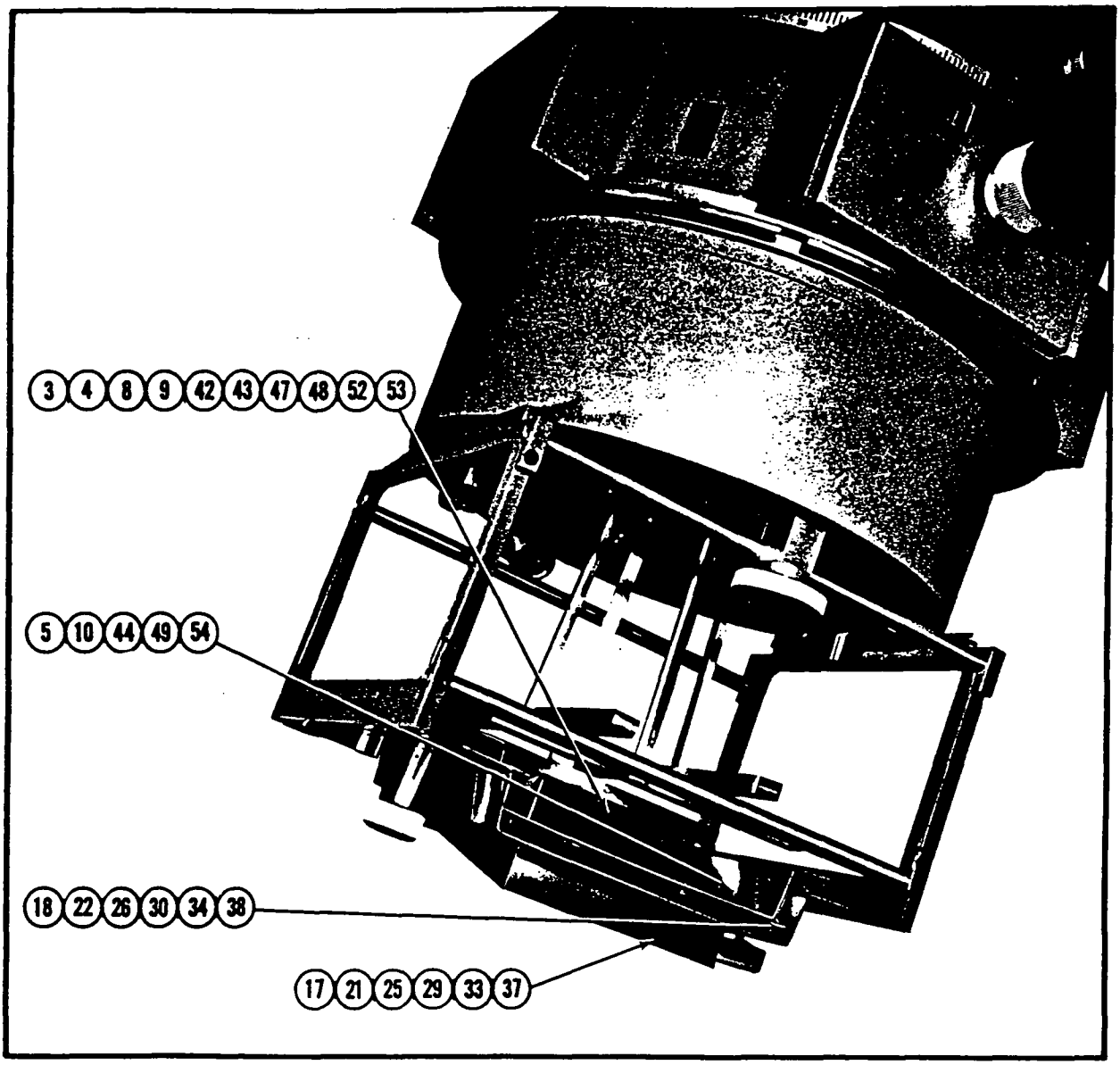

FIG. 26 - COBALT, WEDGES AND COMPENSATOR ASSEMBLIES

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
26 -	---	Wedges and Compensator Assemblies (See Fig. 1, Items 9, 10 and 11)	
1*	3021	Filter, Lead Wedge (45°) (See Fig. 1, Item 9)	1
2*	181651	Wedge Assembly, Lead (45°) 8°-14'	1
3	55614	Wedge, 8°-14', Lead (stamped "W1")	1
4	55624	Cover, Wedge	1
5	55611	Plate, Wedge Mounting	1
6*	T32-476	Decal	1
		*Not shown.	

FIG. 26 - COBALT, WEDGES AND COMPENSATOR ASSEMBLIES
(continued)

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
26 -	---	(continued)	
7*	181651C	Wedge Assembly, Lead (45°) 6°-41'	1
8	55617	Wedge (45°), 6°-41' (stamped "W4")	1
9	55620	Cover, Wedge	1
10	55612	Plate, Wedge Mounting	1
11*	T32-479	Decal	1
12*	181858	Curve Set, Wedge Filter (45°)	1
13*	181858B	Curve Set, Wedge Filter (45°)	1
14*	181858E	Curve Set, Wedge Filter (45°)	1
15*	3021A	Compensator Assembly, Oblique (See Fig. 1, Item 10)	1
16*	181652	Compensator Assembly, Brass (45°)	1
17	55628	Compensator (45°)10°-11' (stamped "C1")	1
18	55626	Plate, Compensator Mounting	1
19*	T32-481	Decal	1
20*	181652A	Compensator Assembly, Brass (45°)	1
21	55629	Compensator (45°) 8°-38' (stamped "C2")	1
22	55626	Plate, Compensator Mounting	1
23*	T32-482	Decal	1
24*	181652B	Compensator Assembly, Brass (30°)	1
25	55630	Compensator (30°) 6°-8' (stamped "C3")	1
26	55626	Plate, Compensator Mounting	1
27*	T32-483	Decal	1
28*	181652C	Compensator Assembly, Brass (30°)	1
29	55631	Compensator (30°) 5°-12' (stamped "C4")	1
30	55626	Plate, Compensator Mounting	1
31*	T32-484	Decal	1
32*	181652D	Compensator Assembly, Brass (30°)	1
33	55632	Compensator (30°) 4°-12' (stamped "C5")	1
34	55627	Plate, Compensator Mounting	1
35*	T32-485	Decal	1
36*	181652E	Compensator Assembly, Brass (45°)	1
37	55633	Compensator (45°) 7°-18' (stamped "C6")	1
38	55627	Plate, Compensator Mounting	1
39*	T32-486	Decal	1
40*	3021B	Filter, Lead Wedge (60°) (See Fig. 1, Item 11)	1
41*	181651A	Wedge Assembly, Lead (60°) 13°-58'	1
42	55615	Wedge, (60°) 13°-58' (stamped "W2")	1
43	55623	Cover, Wedge	1
44	55611	Plate, Wedge Mounting	1
45*	T32-477	Decal	1
46*	181651B	Wedge Assembly, Lead (60°) 15°-28'	1
47	55616	Wedge, (60°) 15°-28' (stamped "W3")	1
48	55620	Cover, Wedge	1
49	55611	Plate, Wedge Mounting	1
50*	T32-478	Decal	1
51*	181651D	Wedge Assembly, Lead (60°) 11°-32'	1
52	55618	Wedge (60°) 11°-32' (stamped "W5")	1
53	55622	Cover, Wedge	1
54	55612	Plate, Wedge Mounting	1
55*	T32-480	Decal	1

*Not Shown

FIG. 27 - COBALT, WALL MOUNTED LIGHTS
Part No. 3595C

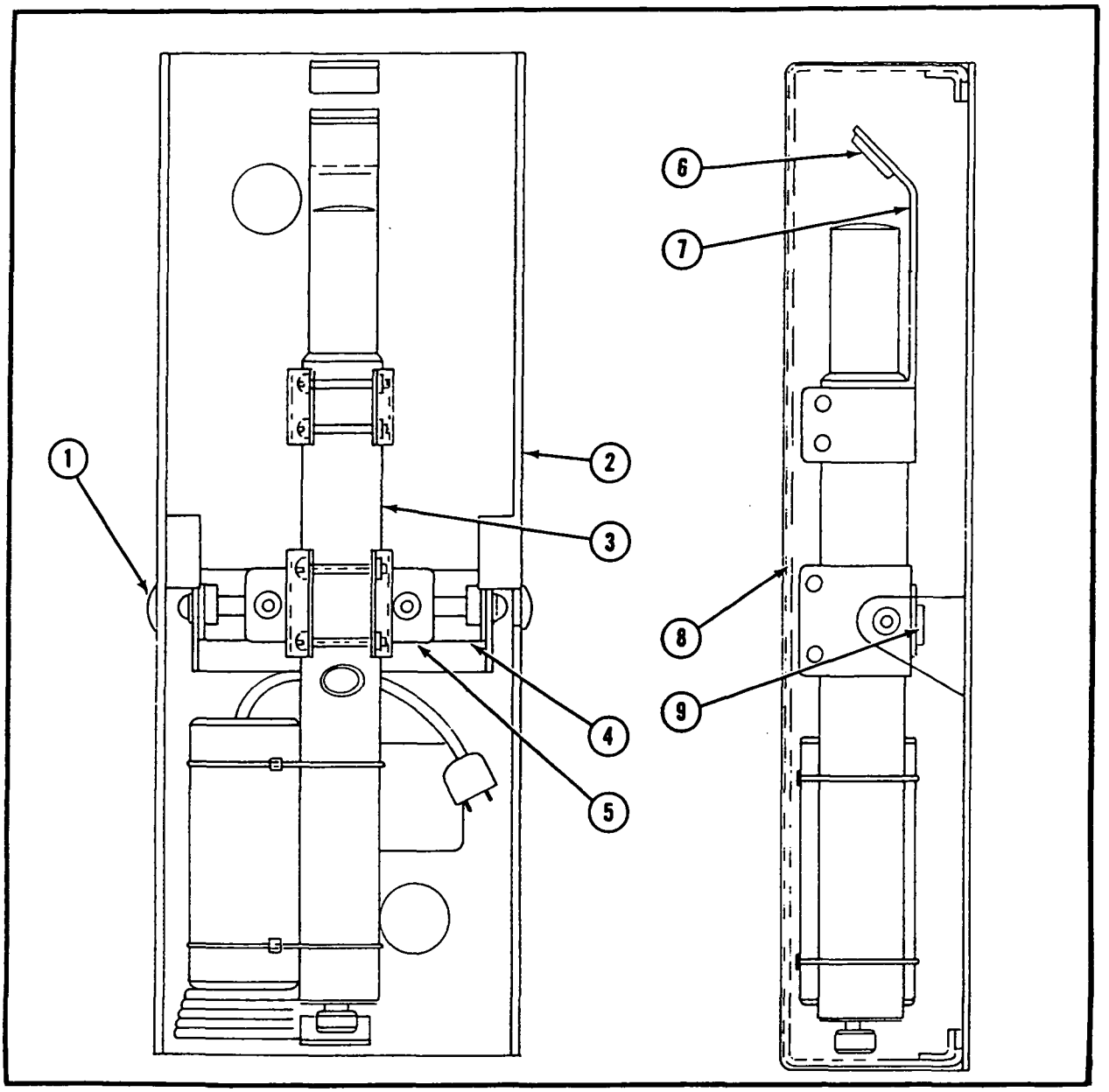

FIG. 27 - COBALT, WALL MOUNTED LIGHTS
Part No. 3595C

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
27 -	3595C	Lights, Wall Mounted Position (See Fig. 1, Item 12)	Ref.
1	T30-140	Button, Plug	2
2	181637	Container, Light	1
3	44557	Pointer, Spot Light	1
4	181636	Bracket, Adj.	1
5	181635	Bracket, Mounting	1
6	T87A-20	Mirror	1
7	46874	Support, Mirror	1
8	56100	Cover, Box	1
9	56096	Plate, Nut	1

FIG. 28 - COBALT, FRONT-FINAL POINTER ASSEMBLY
Part No. 181560

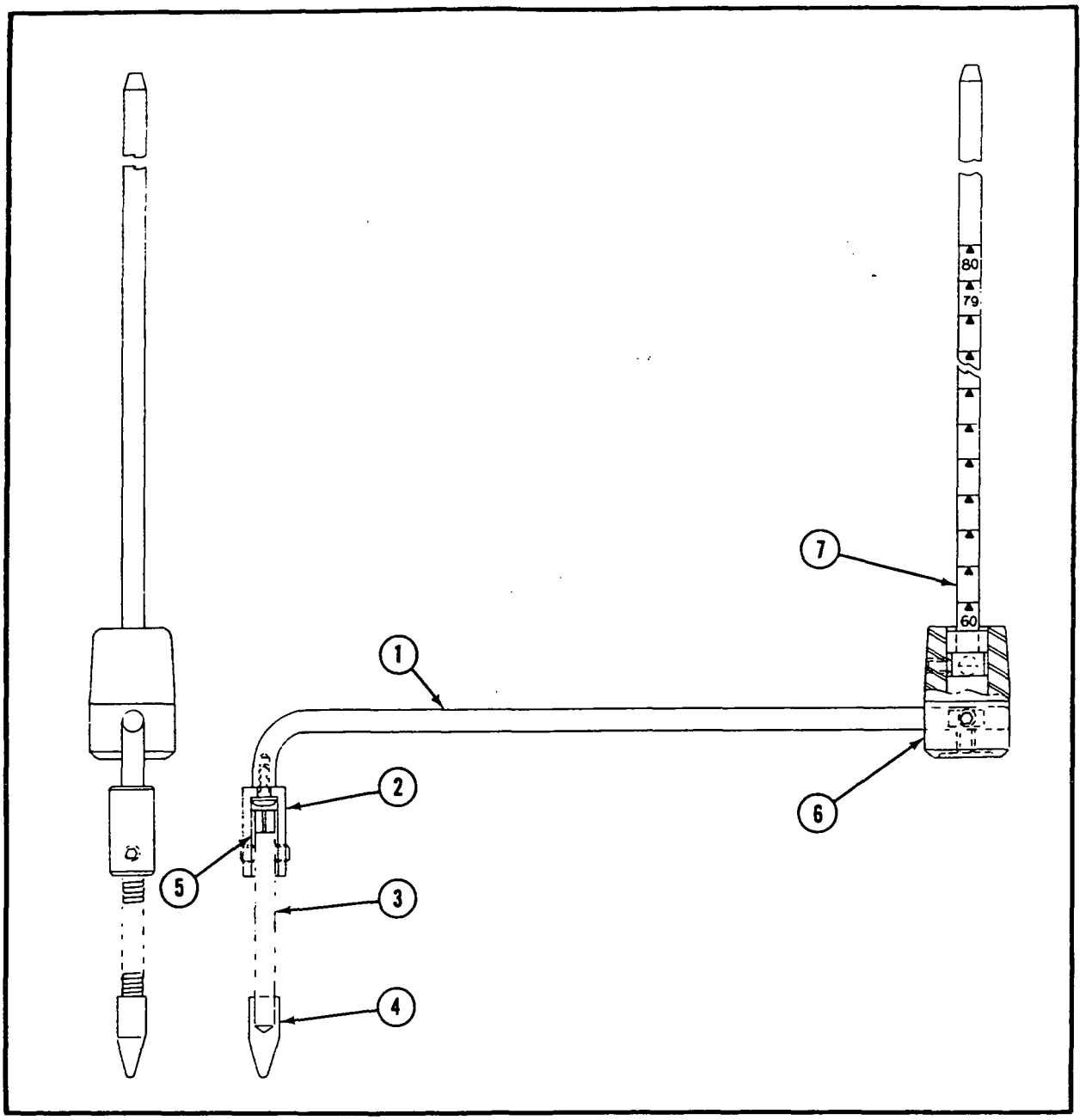

FIG. 28 - COBALT, FRONT-FINAL POINTER ASSEMBLY
Part No. 181560

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
28 -	181560	Pointer Assembly, Front-Final (See Fig. 1, Item 14)	Ref.
1	55925	Arm, Pointer	1
2	55926	Bushing, Adapter	1
3	T5-664	Spring	1
4	55927	Tip, Pointer	1
5	55928	Bushing, Split	1
6	55962	Adapter, Arm-to-Pointer	1
7	181586	Arm Assembly, Scale	1

FIG. 29 - COBALT, SCALE POINTER MOUNTING ASSEMBLY
Part No. 181564

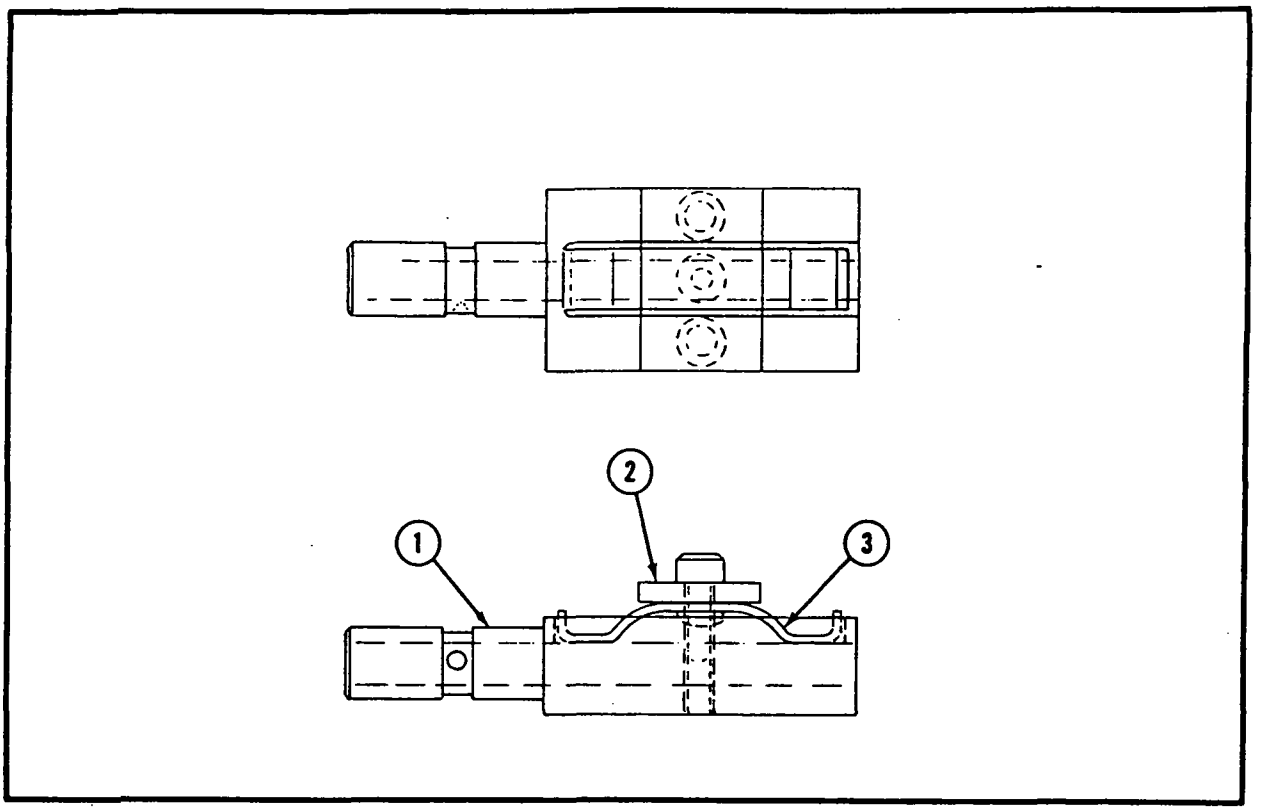

FIG. 29 - COBALT, SCALE POINTER MOUNTING ASSEMBLY
Part No. 181564

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
29 -	181564	Mounting Assembly, Scale Pointer (See Fig. 1, Item 15)	1
1	181764	Pointer Assembly, Sleeve	1
2	T4-426	Nut Plate	1
3	T5-665	Spring, Pressure	1

FIG. 30 - COBALT, ACCESSORY MOUNTING PLATFORM ASSEMBLY
Part No. 3754A

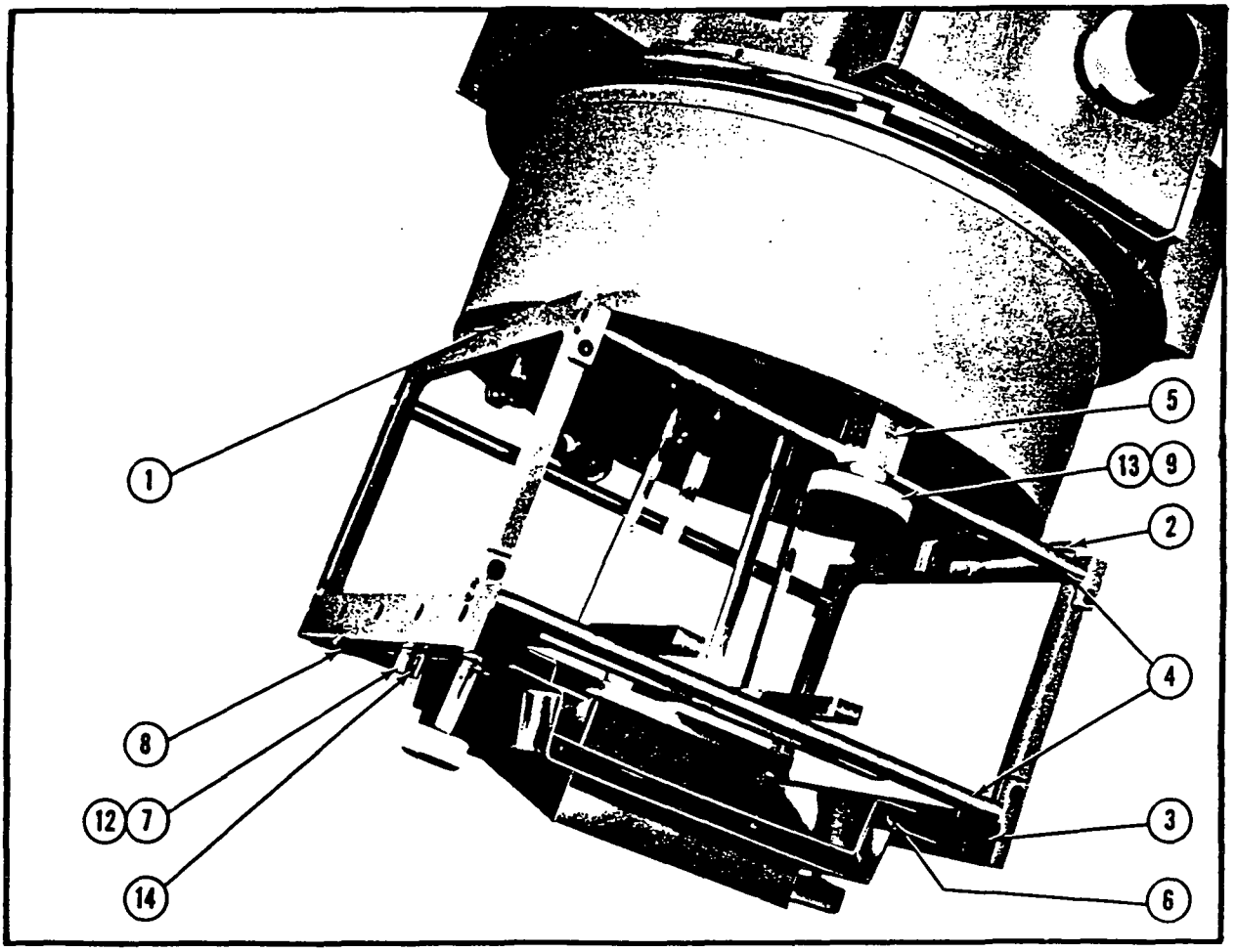

FIG. 30 - COBALT, ACCESSORY MOUNTING PLATFORM ASSEMBLY
Part No. 3754A

FIG & ITEM	PART NO.	1 2 3 4 5 DESCRIPTION	QTY
30 -	3754A	Platform Assembly, Accessory Mounting (See Fig. 1, Item 19)	Ref.
1	55654	Side Plate, Platform	1
2	55654A	Side Plate, Platform	1
3	55653	End Plate, Platform	2
4	55650	Bar, Connecting	4
5	55651	Block, Tie-Down	1
6	55652	Nose, Accessory Clamp	2
7	55648	Screw, Accessory Clamp	2
8	55649	Handle, Accessory Clamp	2
9	T13-396	Stud, Clamp	1
10*	T22-165	Truarc, 1/4" Shaft	2
11*	T14A-122	Pin, Roll, 1/8 x 1	2
12	T2-516	Plunger, Spring 10-32 x 9/16	2
13	T3-155	Knob, Clamp	1
14	T14A-148	Pin, Dowel (3/16 x 5/8)	2
		*Not shown.	

ADVANCED MEDICAL SYSTEMS OPERATING PROCEDURE

SOURCE INSTALLATION AND EXCHANGE PROCEDURES USING CATALOG 3320-3320 AR LOADING AND EXCHANGE CONTAINERS AT AUTHORIZED THIRD PARTY FACILITIES

ISP-18 Rev. 1/95

1.0 PURPOSE: To provide a procedure for the safe transfer or exchange of high output Cobalt 60 sealed sources at authorized third party facilities.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 This procedure is applicable to source transfers or exchanges performed at customer sites on a variety of Picker and AMS manufactured teletherapy/radiography equipment.

2.2 This procedure requires two (2) individuals, a Class 1 Service Engineer and an assistant. The Class 1 Service Engineer has been specifically approved by the NRC to perform this procedure. The person assisting must be agreeable to the task and have received Part 19.12 training for this procedure.

2.3 Sources should be exchanged only by, or in the physical presence of, persons specifically licensed by the NRC or an agreement state to perform these operations.

2.4 An individual licensed to perform source exchanges may perform only those operations described in the procedures.

Prepared by: Robert Meschter

Approved by: R Meschter

Date: 1-24-95

2.5 The person making the exchange is obligated to refuse to make an exchange should any condition or action present a situation wherein the exchange cannot be made within the limitations of these procedures.

2.6 Prior to the commencement of the operations outlined in this procedure, the licensee for whom the exchange is being performed will relinquish control over the use of, and the keys for, the equipment and its Controlled Areas to the licensed person performing the exchange. At such time as the source has been exchanged, and it has been determined by the licensed person performing the exchange that the equipment is in safe operating condition, control of the equipment and Controlled Areas will be returned to the licensee.

2.7 At certain times during this procedure (specifically during the actual source transfer), the Class 1 Service Engineer will be alone in the room. During these periods, it is important that communication between the engineer and assistant be maintained.

a. Visual communication may be possible by utilizing the closed circuit television equipment that is often installed in the room.

b. Audio communication may be possible by utilizing an intercom system.

3.0 INSTRUCTIONS:

3.1 Equipment Required

3.1.1 The following equipment is either shipped with the 3320/3320AR exchange container or hand carried to the job site:

1 - Audible Detector
1 - Victoreen 491 (or equivalent) survey meter
1 - Nuclear Associates Minimonitor II (or equivalent) survey meter
2 - 200mR Pocket Dosimeters
2 - 5R Pocket Dosimeters
1 - Dosimeter Charger
1 - Drawer "T" Handle
2 - Pair Disposable Gloves
1 - Pushrod Extension
1 - Swivel for Pushrod Extension
1 - Spring Loaded Pushrod Support

1 - Brass Head to Container Adapter
1 - Service Manual for specific unit
1 - Cable hoist, hand ratchet type (1/2 ton capacity minimum)
1 - Sling
Generous supply of paper towels, plastic bags and masking tape
Hand tools, as required
Hardware, as required
Shipping tags, labels and placards, as required

3.1.2 The following additional equipment is shipped only as needed:

1 - Hanger pull
1 - Collimator Lifting Fixture, service tools
1 - Head Tilting Wrench
1 - Head Bearing Locking Screws
1 - 1/2" Impact Wrench

3.2 Inspection and Source Exchange Container

NOTE: This procedure is to be followed once the source exchange container (SEC) has been removed from the shipping overpack.

3.2.1 Check the container for any signs of mishandling or damage.

a. If any damage is noted, immediately check for radiation leakage and contamination as outlined in Step 3.2.2.

b. If determined to be safe, take whatever action is necessary to repair the damage.

c. If the damage presents a safety hazard, call the Chairman of the Isotope Committee or the Radiation Safety Officer (RSO) for advice or assistance.

3.2.2 Perform a radiation survey of the container to determine if any point reads more than ten (10) mR/hr at one (1) meter.

a. If any point exceeds 10mR/hr at 1 meter, something is wrong.

b. Proceed carefully to find the cause, avoiding exposure to high radiation levels.

c. If the radiation level on the surface of the container is more than one (1) R/hr at any point, do not, under any circumstances, proceed without consulting with the Chairman of the Isotope Committee and/or the RSO.

3.2.3 Remove the bottom plate, the drawer cover plate and the top cover plate. Next, lift out the plug in the top cavity, wet smear the plug and replace the plug.

CAUTION: Keep away from the open top cavity as a highly collimated beam of radiation (10-100R/hr) is emitted when the plug is removed.

3.2.4 If any wet smear, after drying, indicates greater than 200 cpm above background, notify the RSO before proceeding.

3.2.5 Verify that the container is level and the bottom most part of the skid is between 11-3/4 inches and 12 inches above the floor.

3.3 Preparation of Unit for Source Exchange

3.3.1 Over the years, Picker and AMS have manufactured a variety of equipment involving various designs of source heads, collimators and stands, making available a large number of combinations. Refer to the appropriate manual for the unit being worked on. This procedure will deal with the handling of individual components.

3.3.2 Lock source shutter mechanism (shutter wheel) in the "beam off" position. See appropriate unit manual for locking instructions.

3.3.3 Remove the collimator (performing wet smear checks as indicated).

CAUTION: Removing a collimator creates an imbalance in the unit. Take precautions as outlined in the appropriate unit manual.

a. 3313 Series

This collimator weighs about 500 pounds. It should be maneuvered onto a soft pad on the floor or onto a "dolly" capable of handling the weight. The dust shield is part of the machine head, so no preliminary contamination check is necessary before removing.

b. 3347 Series

Take a wet smear of the periphery of the collimator bearing ring before removing. This collimator can be installed or removed in either one piece (200 lbs.) or in two pieces (100 lbs. each).

c. 3706 Series and 183435 Collimator

The collimator (but not the collimator bearing ring) may be removed before contamination check is made.

Perform a wet smear contamination check of the periphery of the collimator bearing ring before removing.

3.4 Prepare Machine Heads

3.4.1 Model #581, #581A, #581B Heads.

a. After collimator removal, pierce a small hole in the port dust shield through which a cotton swab stick can pass.

b. Take a wet smear contamination check.

c. Remove the dust shield and lead port block.

d. Insert the proper "head to source exchange container" adapter.

3.4.2 Model #583, #583A, #583B, #590, #590A and #590B Heads.

a. Remove "saddle" (where applicable) and take a wet smear of the exposed surface of the source wheel.

b. Place the appropriate "head to container" adapter on the container.

3.4.3 Model #590C, D, E, F, G and 182972A Heads.

CAUTION: Radiation leakage may be several R/hr on the bottom surface of the head when the collimator bearing ring is removed.

a. Insert the brass head-to-container adapter into the doughnut, align the center hole and secure together.

b. Immediately after the removal of the collimator and bearing ring, mount the doughnut to the bottom of the head. This will reduce the radiation leakage greatly and help to offset the imbalance condition.

3.5 Maneuver Head to Mate with Source Exchange Container

3.5.1 Model C-5000 and V-2000 Vertical-Spring Counterbalance Units.

a. Lock the yoke and head tilt movements. The stand will operate electrically and manually in the unbalanced condition.

b. Maneuver exchange container under head and lower head electrically until it is close to mating. Manually lower head until mated.

3.5.2 Model V-3000, V-4, V-8, V-9, V-10,000 - Vertical Weight Counterbalanced Units.

a. These units are delicately balanced and the head will rapidly rise to its upper limit if the collimator is removed without a restraining device. To prevent this rise, attach a cable hoist to the right side of the unit.

b. Remove the shrouds from the stand and then remove one of the 1/2-13 bolts holding the side columns to the base plate.

c. Using a longer 1/2-13 bolt, bolt the special sling provided in the kit to the column with the bolt through both loops in the ends of the sling.

d. Electrically lower the head as far as it will go.

e. Connect a cable hoist on the right hand side (viewing from the front) of the column between the sling and the top edge of the head support hanger.

f. Pull up on the hoist until it is snug.

g. The collimator may now be removed.

h. The head may be raised and lowered to mate with the container by using the cable hoist.

3.5.3 Model C-1000, C-2000, C-3000 Rotational - Magnetic Clutch Drive Units.

a. The magnetic clutch on the C-arm drive on these units will safely hold the C-arm in the vertical position after the collimator has been removed.

b. Engage the magnetic clutch.

c. Have assistant lend his weight to balance C-arm. Momentarily releasing magnetic clutch, rotate the C-arm so that the head is in the 12 o'clock position. Re-engage clutch.

d. Attach the appropriate "Head Tilting Wrench".

e. Remove the shroud from the left foot of the unit and attach cable hoist between left foot and C-arm behind head.

f. Have assistant maintain head tilting wrench horizontal. Unlock head bearing ring or yoke brake, drive or lock.

g. Take up on cable hoist lowering head to about 9 o'clock position. Maneuver container under head, insert proper adapter and mate.

3.5.4 Model C-4, C-8, C-9, C-10,000 and C-12 Rotational Chain or gear Driven Units.

a. These units can be maneuvered electrically after the collimator has been removed. Move unit in short arcs, adjusting head each time to keep bottom surface of head horizontal. Care must be taken not to damage yoke motor during mating operation. Move slowly.

b. Secure the head to the container.

3.5.5 Model C-10,000 Rotational - Chain or Gear Driven - Fixed Yoke.

a. The head must be removed from this unit to mate it with the container.

b. With the head at the 6 o'clock position, secure the yoke to hinge brackets on each side of the bed frame with chains or cable hoist. This is to keep the unit in "O" position. Using the special collimator lifting fixture and a gantry, remove the collimator and set aside on a soft pad.

c. Take a wet smear.

d. Mount special head lifting fixture to flat surface of head. Attach gantry hoist.

e. Remove head mounting bolts and index pins.

f. Lift head out of yoke and set on floor.

g. Attach lifting ears. Remove lifting fixture. Rotate head 180 degrees so that flat side is down.

h. Fix ears so head will not rotate. Lift head, insert proper adapter, and mate to container.

3.5.6 Cyclops Hydraulic Mobile and Jib Crane Stands.

a. These units can be maneuvered electrically in the unbalanced (collimator off) condition.

b. Mate head to container using proper head to container adapter.

c. Secure the head to the container.

3.5.7 Fixed Head Rotational Magnetic Clutch Drive.

a. Remove the stand covers from one side. The head will be at 5 o'clock or 7 o'clock during this operation. If at 5 o'clock, remove left hand covers. If at 7 o'clock, remove the right hand covers.

b. Check the stand to floor mounting bolts for tightness. If they are not tight, the unit could tip over during this procedure.

c. Remove shutter motor access cover from above and behind the head.

d. Remove the transformer and the cover and disconnect it from the terminal board.

e. Remove all the wires coming up from the slip rings to the terminal board.

f. Remove the stainless trim covers from the back of the head and disconnect the wires from the mercury switches and distance localizer assembly.

g. Construct a wood cradle to hold the head.

h. Swing the head around to the 5 o'clock position and position the head in the cradle (using padding to protect paint). Set the wheels of the dolly so that it can be pulled straight out away from the stand after the head is unbolted.

i. Place a 4,000 lb. come-along hook into the top of the C-arm access hole. The other hook of the come-along is fastened to the outside of the left toe. If the 7 o'clock position of the head allows more room for this procedure, the come-along is fastened to the right toe.

j. Take up on the come-along until the head rests firmly in the cradle. The come-along will prevent the barrier from swinging down once the head is removed.

k. Remove the allen screws holding the head to the ring to separate the head from the stand. When loosening the last two bolts, watch to see if the come-along tension is right. This is done by watching to see that the C-arm barrier are rigid and that the head is snug in the cradle.

l. In addition to the bolts that hold the head to the C-arm, there are two 3/8 inch centering pins holding the head. Use two screwdrivers to separate the head and C-arm.

m. The head is now pulled away from the C-arm. Pull from the dolly and not from the head or cradle. Pull the dolly straight out, or the motor assembly will be damaged. Move to an area out of the swing of the C-arm and barrier.

n. Replace the fixed head mounting ring with the rotating head mounting bearing ring and remount head. The unit can now be treated as a standard C-2000 unit with rotating head.

o. After the source exchange is completed, reverse the procedure, and remount the fixed head mounting ring.

3.6 Source Exchange Procedure Using Model 3320 AR Exchange Container

3.6.1 Perform and record a radiation leakage measurement on the surface of the top of the head. Mark the location for future reference.

3.6.2 Remove the 1/4-20 screw and square brass insert holding the bottom end of the pushrod in position. Install the pushrod extension onto the lower end of the pushrod by using a 10-32 x 1" socket head cap screw. Test for free movement of the pushrod by turning. If any binding is noticed, the screw holding the pushrod extension to pushrod is either not in far enough or is too long. The pushrod should have about 2" free vertical movement.

3.6.3 Insert the shaft of the "T" handle into the coil spring and screw this assembly all the way into the plunger, then back it out two (2) full turns. Mark the lower side of the drawer. When exchange is complete, this mark should be uppermost.

CAUTION: Do not loosen the drawer stop and pull out the drawer at this time, as this will greatly increase the radiation leakage above the container.

3.6.4 Place a Minimonitor II gamma survey meter (or equivalent) on the floor within easy view, about two (2) feet from the container. Set to X10 scale (full scale 100mR/hr). Place an audible detector at this same position.

3.6.5 Remove the shutter lock.

3.6.6 At this point, give the shutter operating key to the assistant and have him and all non-assisting personnel leave the room. The assistant should take a survey meter with him in case an emergency entrance is necessary.

NOTE: The following operations to be performed by the Source Engineer should be done from the supine position with the body kept as close to the casters of the exchange container as is possible. At no time should any part of the body, except the hands and the forearms, be raised above the bottom edge of the source drawer.

3.6.7 Loosen drawer stop screw.

CAUTION: Do not remove entirely.

3.6.8 Pull the drawer out to scribed line (approximately 1/4 inch beyond the indexing groove). Twist drawer slightly to verify that the safety bolt is in place in the drawer groove.

CAUTION: If safety bolt is not in proper place, the drawer could be inadvertently removed and the source exposed.

3.6.9 Gently push the "T" handle in as far as it will go.

3.6.10 Raise the pushrod gently until it can be felt that the source is up against the plunger tongue. Maintain this raised position and tighten the "T" handle until it stops. The spring tension of the "T" handle will hold the source in the plunger tongue. Lower pushrod.

3.6.11 Reach up with both hands and gently pull drawer out until it stops.

CAUTION: If drawer does not stop before 4-1/2 inch withdrawal, something is wrong and the drawer must be pushed back in.

3.6.12 Call to assistant to electrically open the shutter of the therapy head. The timer must be set at 30 minutes or more so that the shutter will not close during the exchange.

3.6.13 Gently raise the pushrod as far as it will travel, rotate it until its pins seat in the holes of the source capsule. (The swivel may be used for this.)

NOTE: If the pushrod will not engage the source, the shutter wheel is not in proper alignment. In this event, lower the pushrod and have the assistant close the shutter. Verify that room radiation levels are safe. Have the assistant come into the room, with the control key, and position himself above the therapy head. From this position, as directed by the source exchanger, he can manually open the shutter and adjust the stop when the pushrod engages the source.

CAUTION: The assistant should be warned to keep all portions of his body above the head to container junction.

3.6.14 Keeping a firm upward pressure on the pushrod, unscrew the old source.

a. If the old source is tight and will not unscrew with one hand pressure, place the spring loaded pushrod holder and the swivel between the pushrod and the floor.

b. Adjust spring pressure so that it takes both hands to lift it off the floor when in place under the pushrod and swivel. This frees both hands for loosening the old source.

c. If the source is still unmovable, a pipe wrench may be used on the pushrod.

NOTE: An impact wrench may also be utilized to break the source free. However, it should not be used to unscrew the source from the shutter.

3.6.15 After the source has been loosened, remove the pushrod holder again hold in place by hand. Unscrew source at least five (5) complete turns.

3.6.16 Turning the pushrod slightly, gently lower the pushrod to its bottom most position.

a. If the source is completely loose and follows the pushrod down into the container, a noticeable flash of radiation will be detected by watching the gamma survey meter as the source passes the joint between the head and the container.

b. In addition, an audible signal will be heard from the audible detector.

c. If no "flash" is noticed, the source did not follow the pushrod down, and the operation of unscrewing and lowering should be repeated until successfully completed.

3.6.17 With two hands, gently push the drawer in until the scribe line is just visible.

a. Unscrew the "T" handle two (2) full turns and release the new source from the plunger.

b. Lower pushrod to bottom most position (approximately 2" protruding from container).

3.6.18 Gently push the drawer into the innermost position. If necessary to close drawer, remove the pushrod extension.

NOTE: If pushrod pins are no longer in old source pinholes, the drawer will not close. Rotate pushrod to correct.

a. Slip the drawer stop over the end of the drawer and tighten the screw holding it in place.

b. Both sources are now safely stored in the exchange container and the radiation background should not be more than 20mR/hr at one (1) meter from the surface. Verify this with the survey meter.

3.6.19 Have the assistant close the shutter. Take possession of the shutter key.

3.6.20 Verify that the source has been removed from the head by surveying the top of the head.

3.6.21 If a Five Year Inspection and Preventive Maintenance is to be performed, proceed to perform the head and shutter related items at this time.

3.6.22 Once the head is reassembled, verify that the shutter mechanism is operating properly, then proceed to install the source.

3.6.23 Place a Minimonitor II gamma survey meter (or equivalent) on the floor within easy view about two (2) feet from the container. Set to X10 scale (full scale 100mR/hr). Place an audible detector on this same position.

3.6.24 At this point, give the shutter operating key to the assistant and have him and all non-assisting personnel leave the room. The assistant should take a survey meter with him in case an emergency entrance is necessary.

NOTE: The following operations to be performed by the Source Engineer should be done from the supine position with the body kept as close to the casters of the exchange container as is possible. At no time should any part of the body, except the hands and the forearms, be raised above the bottom edge of the source drawer.

3.6.25 Loosen drawer stop screw.

CAUTION: Do not remove entirely.

3.6.26 Pull the drawer out to scribed line (approximately 1/4 inch beyond the indexing groove). Twist drawer slightly to verify that the safety bolt is in place in the drawer groove.

CAUTION: If safety bolt is not in proper place, the drawer could be inadvertently removed and the source exposed.

3.6.27 Gently push the "T" handle in as far as it will go.

3.6.28 Re-install pushrod extension and raise the gently until it can be felt that the new source is up against the plunger tongue. Maintain this raised position and tighten the "T" handle until it stops. The spring tension of the "T" handle will hold the source in the plunger tongue. Lower the pushrod and old source.

3.6.29 Reach up with both hands and gently pull drawer out until it stops.

CAUTION: If drawer does not stop before 4-1/2 inch withdrawal, something is wrong and the drawer must be pushed back in.

3.6.30 Rotate drawer 180 degrees in whichever direction it will turn (it will only turn in one direction). This puts the new source in the upper position.

3.6.31 Reach up with both hands and gently push drawer in until the scribed line is just visible.

3.6.32 Loosen "T" handle two (2) complete turns.

3.6.33 Raise the pushrod gently until it can be felt that the old source is up against the plunger tongue. Maintain this position and tighten the "T" handle until it stops. The spring tension of the "T" handle will hold the source in the plunger tongue. At this point, both the old and new sources are in the drawer plunger tongue.

3.6.34 Reach up with both hands and gently pull drawer out until it stops.

CAUTION: If drawer does not stop before 4-1/2 inch withdrawal, something is wrong and the drawer must be pushed back in.

3.6.35 Rotate drawer 180 degrees in whichever direction it will turn (it will only turn in one direction). This returns the new source to the bottom position.

3.6.36 Again reach up with both hands and gently push drawer in until the scribed line is just visible. This places the new source over the pushrod so that it may now be removed from the drawer plunger tongue. At this point, the mark that was put on the drawer when the exchange was started should again be in the original position.

3.6.37 Raise the pushrod gently until it touches the source in the drawer tongue. Rotate pushrod until the pins seat.

a. While holding the pushrod in this position, loosen the "T" handle two (2) complete turns. The source will then be released and will follow the pushrod down when it is lowered.

b. Lower the pushrod. Again tighten the "T" handle to the limit. The new source is now resting on the pushrod.

3.6.38 Reach up with both hands and gently pull drawer out until it stops. Do not rotate drawer 180 degrees.

CAUTION: If drawer does not stop before 4-1/2 inch withdrawal, something is wrong and the drawer must be pushed back in.

3.6.39 Have assistant open the shutter.

3.6.40 The path to the shutter wheel is now clear for the new source. Gently raise the pushrod until the new source touches the shutter wheel. A flash of radiation will again be noticed on the meter as the source passes the joint between the head and the container. Maintaining a firm upward pressure, turn the pushrod in a tightening direction until the source has turned at least three and a half turns and becomes as tight as possible using one hand on the pushrod cross handle. Now lower the pushrod to the bottom most position. There should be no flash of radiation noticeable on the meter if the source is threaded in the shutter wheel.

3.6.41 Have assistant close the shutter. The radiation level showing on the survey meter should drop considerably when the shutter is closed.

3.6.42 Reach up with both hands and gently rotate the drawer 180 degrees in whichever direction it will turn. This puts the old source in the bottom position. Now push the drawer inward until the scribe line is just visible.

3.6.43 Lift the pushrod gently until it touches the source in the drawer tongue.

a. While holding the pushrod in this position, loosen the "T" handle two (2) complete turns. The source will then be released and will follow the pushrod down when it is lowered.

b. Lower the pushrod.

3.6.44 Gently push the drawer into its innermost position. Slip the drawer stop over the end of the drawer and tighten the screw holding it in place.

3.6.45 Remove the 10-32 x 1" cap head screw holding the pushrod extension to the pushrod. Raise the pushrod and insert 1/4-20 hex head screw and brass block. This secures the pushrod in its shipping position.

3.6.46 Attach the shutter locking bar.

3.6.47 Take possession of shutter operating key.

3.6.48 Perform a radiation leakage survey at the top surface of the head as previously marked. If the sources have been properly exchanged, this reading should be higher than the original reading.

3.6.49 Unmate the head from the container.

CAUTION: Keep body as far as possible from the open top cavity. The radiation levels in this area may be 10 to 100R/hr.

3.6.50 Remove adapter and insert plug into the container cavity.

3.6.51 Reinstall collimator to head.

3.6.52 Perform Beam Off Head Leakage Survey using appropriate data sheet. The average leakage shall not be greater than 2mR/hr at one (1) meter from the source, with no single spot exceeding 10mR/hr.

3.6.53 Complete the Five Year Inspection and PM.

3.7 Source Exchange Procedure for 3320 and 3320B Containers

NOTE: The Model 3320 container has only one source cavity and can be used only for loading and unloading a source.

The Model 3320B container is to be used for removing or loading a single Cesium source only.

The Picker Model 3320 and 3320 AR containers are easily converted to Model 3320B containers by replacing the Cobalt pushrod with a Cesium pushrod.

3.7.1 Inspect shipping container as per Step 3.2.

3.7.2 Prepare Model 592 machine head for source transfer.

a. Remove beam defining device (cone) per instructions in Section 8 of Picker Manual T55-226.

b. Perform a wet smear contamination check of the inner most diaphragm of the "cone" holder.

c. Lock the head in the upright position by using the lever on the right hand trunnion (see Figure 3, Manual T55-226).

d. Remove the decorative covers.

e. Remove cone holder (see Figure 8, Manual T55-266).

CAUTION: When cone holder is removed, the radiation leakage will increase in this area to as much as 300mR/hr. Do not stand or place hands unnecessarily close to this area.

f. Perform a wet smear contamination check of exposed section of shutter wheel.

g. Install head to container adapter.

3.7.3 Remove the shipping container top cavity plug.

3.7.4 Move the shipping container under the head.

3.7.5 Lower the head, maneuvering the container so that the head to container adapter enters the container top cavity. Lower until firmly seated. Secure machine head to exchange container.

3.7.6 Evacuate the room and turn source to "ON" position to make sure shutter works electrically. Close shutter.

3.7.7 Source Removal.

a. Place a Minimonitor II gamma survey meter (or equivalent) on the floor within easy view, about two (2) feet from the container. Set to X10 scale (full scale 100mR/hr). Place an audible detector at this same position.

b. Remove the shutter lock.

c. At this point, give the shutter operating key to the assistant and have him and all non-assisting personnel leave the room. The assistant should take a survey meter with him in case an emergency entrance is necessary.

NOTE: The following operations to be performed by the Source Engineer should be done from the supine position with the body kept as close to the casters of the exchange container as is possible. At no time should any part of the body, except the hands and the forearms, be raised above the bottom edge of the source drawer.

d. Loosen drawer stop screw.

CAUTION: Do not remove entirely.

e. Pull the drawer out to scribed line (approximately 1/4 inch beyond the indexing groove). Twist drawer slightly to verify that the safety bolt is in place in the drawer groove.

CAUTION: If safety bolt is not in proper place, the drawer could be inadvertently removed and the source exposed.

f. Raise pushrod until it touches shutter wheel, then lower about 1/2 inch.

g. Have assistant open the shutter and note the meter reading.

h. Raise pushrod until it touches the source.

i. Rotate until it engages the source.

j. Keeping firm upward pressure, rotate the pushrod to unscrew right hand threaded source, three and a half turns (3-1/2) or more.

k. If the old source is tight and will not unscrew with one hand pressure, place the spring loaded pushrod holder and the swivel between the pushrod and the floor.

l. Adjust spring pressure so that it takes both hands to lift it off the floor when in place under the pushrod and swivel. This frees both hands for loosening the old source.

m. If the source is still unmovable, a pipe wrench may be used on the pushrod.

NOTE: An impact wrench may also be utilized to break the source free. However, it should not be used to unscrew the source from the shutter.

n. Lower pushrod and source, noting the flash of radiation, indicated by the meter, as the source passes the point between the head and the container. When the source lowers into the container, the radiation level will drop significantly. If the level does not drop, it means the source has not been removed and lowered into the container. The removal sequence should be continued until the source is in the safe position in the container.

o. Push the drawer into the container and secure drawer stop. Check the area with a survey meter to ensure all is safe.

p. Unmate the machine head and container and insert lead plug into the container top cavity.

q. Check the source cavity in head for contamination.

r. Move the container a safe distance from the work area and proceed with repairs or maintenance on the head.

3.7.8 Source installation.

a. Remate head and container.

b. Place a Minimonitor II gamma survey meter (or equivalent) on the floor within easy view, about two (2) feet from the container. Set to X10 scale (full scale 100mR/hr). Place an audible detector at this same position.

c. Remove the shutter lock.

d. At this point, give the shutter operating key to the assistant and have him and all non-assisting personnel leave the room. The assistant should take a survey meter with him in case an emergency entrance is necessary.

NOTE: The following operations to be performed by the Source Engineer should be done from the supine position with the body kept as close to the casters of the exchange container as is possible. At no time should any part of the body, except the hands and the forearms, be raised above the bottom edge of the source drawer.

e. Loosen drawer stop screw.

CAUTION: Do not remove entirely.

f. Pull the drawer out to scribed line (approximately 1/4 inch beyond the indexing groove). Twist drawer slightly to verify that the safety bolt is in place in the drawer groove.

CAUTION: If safety bolt is not in proper place, the drawer could be inadvertently removed and the source exposed.

g. Have assistant open the shutter.

NOTE: The path to the shutter wheel is now clear for the new source. Gently raise the pushrod until the new source touches the shutter wheel. A flash of radiation will again be noticed on the meter as the source passes the joint between the head and the container. Maintaining a firm upward pressure, turn the pushrod in a tightening direction until the source has turned at least three and a half turns and becomes as tight as possible using one hand on the pushrod cross handle. Now lower the pushrod to the bottom most position. There should be no flash of radiation noticeable on the meter if the source is threaded in the shutter wheel.

h. Have assistant close the shutter. The radiation level showing on the survey meter should drop considerably when the shutter is closed.

i. Gently push the drawer into its inner most position.

j. Slip the drawer stop over the end of the drawer and tighten the screw holding it in place.

k. Unmate the head from the container.

CAUTION: Keep body as far as possible from the open top cavity. The radiation levels in this area may be 10 to 100R/hr.

l. Remove adapter.

m. Reinstall cone assembly head.

n. Perform Beam Off Head Leakage Survey using appropriate data sheet. The average leakage shall not be greater than 2mR/hr at one (1) meter from the source, with no single spot exceeding 10mR/hr.

o. Complete the Five Year Inspection and PM.

ADVANCED MEDICAL SYSTEMS
OPERATING PROCEDURE

RADIATION WORK PERMITS

ISP-29 Rev. 01/95

1.0 PURPOSE: To provide instructions to personnel needed to prepare and use Radiation Work Permits (RWP). Radiation Work Permits are an integral part of AMS ALARA Program.

2.0 PRECAUTIONS AND LIMITATIONS:

2.1 Radiation Work Permits are written to inform workers of the radiological conditions and controls associated with work within Restricted Areas.

2.2 Each individual is responsible for following the RWP and keeping track of thier dose.

2.3 The RSO or designee is resposible for ensuring that all Radiation Work Permits are prepared in accordance with this procedure.

3.0 INSTRUCTIONS:

3.1 Types of RWPs

3.1.1 Job Specific RWP - This type RWP is to be used for all entries into Radiation Areas, Contamination Areas and for all work in Controlled Areas that involves radioactive materials. These RWPs will be prepared for each job and will be terminated immediately following the completion of the work.

Prepared by: Robert Meschter Approved by: R Meschter

Date: 1-24-95

3.1.2 Extended RWP - This type RWP is to be used for all entries into Restricted Areas that do not require a job specific RWP. This type RWP may also be used for repetitive jobs such as routine surveys, training, etc. These RWPs will be terminated at one (1) year intervals or sooner if radiological conditions change such that additional controls are needed.

3.2 Initiating a Radiation Work Permit

3.2.1 Any employee wishing to enter a Restricted Area of the facility should ensure that the entry is covered by a current RWP. If not, the employee can initiate an RWP by completing the Description and Location of Work section of the RWP, Form ISP-29B, and submit the RWP to the RSO or designee for completion and possible approval.

3.2.2 The RSO or designee will complete the RWP, including the ALARA review, and activate the permit by signing and dating the form. Each RWP will be consecutively numbered and entered in the RWP Tracking Log, Form ISP-29A.

3.2.3 Each person who enters an area under an RWP must read and sign the RWP Sign In Sheet, Form ISP-29C. Each person signing this sheet acknowledges that they have read and understand the RWP requirements and precautions.

3.3 Use of a Radiation Work Permit

3.3.1 Prior to entering the area, workers shall:

a. Read and understand the RWP.

b. When appropriate, receive a prejob briefing from the RSO or designee.

c. Obtain radiation safety job coverage, if required.

d. Ensure sufficient exposure is available for the job.

e. Ensure they have met all the necessary precautions and have obtained the needed protective clothing and devices for the job.

3.3.2 During work, workers should:

a. Periodically read their self reading pocket dosimeter unless exposure is being tracked by timekeeping methods.

b. Wear protective clothing and devices properly.

c. Maintain exposures ALARA.

d. Stop work and exit the area if radiological conditions change significantly from those outlined in the RWP.

3.3.3 When exiting the area/job site, workers should:

a. Leave the area in a clean and unlittered condition by removing all tools and materials from the job site.

b. Use proper techniques to minimize the spread of contamination, including proper removal of protective clothing and proper use of step-off pads.

c. Perform a whole body frisk for personal contamination, paying particular attention to those areas of the body that could most likely become contaminated (hands, feet, face, knees, etc.).

d. Report any personal contamination or unusual exposures to the RSO or designee.

3.4 RWP Termination

3.4.1 RWPs will be terminated by the RSO or designee:

a. Upon completion of work.

b. Upon expiration of the RWP.

c. If the scope of work has significantly changed.

d. If the radiological conditions have significantly changed.

RADIATION WORK PERMIT TRACKING LOG

ISP-29A

RWP NO.	DESCRIPTION OF WORK	AUTH DATE	TERM DATE

REVIEWED BY RSO: _____ DATE: _____

RADIATION WORK PERMIT

ISP-29B

PERMIT NO.: _____
EXPIRATION DATE: _____ JOB SPECIFIC - EXTENDED (CIRCLE)

DESCRIPTION AND LOCATION OF WORK: _____
_____
_____
_____
_____

SURVEY INFORMATION

GENERAL AREA DOSE RATES (mR/HR): _____
MAXIMUM ACCESSIBLE DOSE RATES (mR/HR): _____
REMOVABLE CONTAMINATION LEVELS (DPM/100CM^2): _____

ALARA REVIEW

ESTIMATED TOTAL DOSE: _____ ACTUAL TOTAL DOSE: _____
___PREJOB BRIEFING ___POSTJOB BRIEFING PERFORMED BY: _____
DOSE REDUCTION TECHNIQUES TO BE EMPLOYED: _____
_____
_____
_____

DOSIMETRY REQUIREMENTS

___TLD/FILM BADGE ___FINGER RING ___SRPD(200MR) ___SRPD(1R) ___SRPD(5R)
___OTHER-SPECIFY: _____

PROTECTIVE EQUIPMENT

___COVERALLS ___LABCOAT ___HOOD ___RUBBER GLOVES ___BOOTIES ___RUBBERS
___RESPIRATOR ___TAPED SEAMS ___RADIATION SAFETY COVERAGE ___AIR SAMPLE
OTHER PRECAUTIONS AND SPECIAL INSTRUCTIONS: _____
_____
_____
_____
_____
_____

AUTHORIZED BY: _____

TERMINATED BY: _____

RWP SIGN IN SHEET

ISP-29C

RWP NUMBER: _____

Signing this document means that the worker has read and understands this Radiation Work Permit.

PRINTED NAME	SIGNATURE	REQ. DOS.	VER. BY	DOSE IN	DOSE OUT	DOSE
TOTAL DOSE THIS RWP SIGN-IN SHEET						

REVIEWED BY RSO: _____ DATE: _____

DOCUMENT 6

Telefacsimile to John A. Grobe, Chief, Nuclear Materials Inspection, Section 2, U.S. Nuclear Regulatory Commission from David Cesar, Treasurer, Advanced Medical Systems, Inc., Re: W.H.U.T. Room report, March 6, 1995.

FAX FORM

ADVANCED MEDICAL SYSTEMS, INC.

121 North Eagle Street
Geneva, OH 44041
Phone: (216) 466-4671
FAX: (216) 466-0186

TO: JOHN A. GROBE, CHIEF
NUCLEAR MATERIALS INSPECTION
SECTION II - USNRC, REGION III

FROM: DAVID CESAR
TREASURER

FAX NO.: /515-1259

DATE: MARCH 6, 1995 PAGE 1 OF 1

I have received assurance from S.E.G. that the W.H.U.T. Room report will be overnighted to me on Tuesday, March 7, 1995. I should receive it on Wednesday, March 8. I will then overnight the report to you. You should receive it by Thursday, March 9.

DC/cs

DOCUMENT 7

Letter to John A. Grobe, Chief, Nuclear Materials Inspection, Section 2, U.S. Nuclear Regulatory Commission from David Cesar, Treasurer, Advanced Medical Systems, Inc., Re: enclosing two copies of W.H.U.T. Room Survey, with enclosed Survey, March 8, 1995.

Advanced Medical Systems, Inc.

121 North Eagle Street • Geneva, Ohio 44041
(216) 466-4671 FAX (216) 466-0186

R2

97891

March 8, 1995

Mr. John A. Grobe, Chief
Nuclear Materials Inspection
Section II
U.S. Nuclear Regulatory Commission
Region III
801 Warrenville Road
Lisle, Illinois 60532-4351

Dear Mr. Grobe:

Enclosed, please find two (2) copies of Advanced Medical Systems, Inc.'s W.H.U.T. Room Survey which is a part of our License Renewal.

If you have any questions, please contact me.

Sincerely,

DAVID CESAR
Treasurer

DC/cs
Enclosures

Advanced Medical Systems, Inc.

Waste Hold-Up Tank Room Survey

March 1995

Revision 1

SCIENTIFIC ECOLOGY GROUP, INC.

Radiological Engineering & Decommissioning Services

SCIENTIFIC ECOLOGY GROUP, INC.

WASTE HOLD-UP TANK ROOM SURVEY

for

DEWIGHT A. MILLER, ATTORNEY AT LAW

for

ADVANCED MEDICAL SYSTEMS, INC.

Reviewed by: _____ Date 3-7-95
for Rick Grisham
Radiological Engineer

Reviewed by: _____ Date 3-7-95
David M. Hall
Manager
Decommissioning Contract Services

Approved by: _____ Date 3-7-95
Donald R. Neely
Vice President
Radiological Engineering and
Decommissioning Services

Prepared By:

The SCIENTIFIC ECOLOGY GROUP, INC.
1560 Bear Creek Road
Oak Ridge, Tennessee 37831

REVISION 0
MARCH 1995

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1.0 INTRODUCTION

This survey report has been prepared by Scientific Ecology Group, Inc., (SEG) for Dewight A. Miller, Attorney at Law for the Advanced Medical Systems, Inc. (AMS), Geneva, OHIO, to confirm and document the results of the Waste Hold-Up Tank (WHUT) room integrity verification analysis.

The WHUT room integrity survey consisted of two separate tasks. The first task to be performed was to sample the soil and the groundwater around the perimeter of the WHUT room foundation. This required the collection of three soil samples and three water samples through the floor slab. The second task to be performed was an inspection of the interior of the WHUT room. This required access through four penetrations, two in the west WHUT room wall and third access point through the south wall for visual inspection of the interior of the WHUT room and the fourth in the south labyrinth wall for a waist level visual inspection of the tanks and ion exchange columns.

Background information related to the project is contained in Section 2.0, Background. Section 3.0, Methodology, discusses the general approach to performing the project tasks, and Section 4.0, Findings, summarizes the results of the sampling, visual inspection, and the radiological surveys. Included as part of this report are photographs taken from the videotape of the WHUT room inspection and the videotape itself.

2.0 BACKGROUND

2.1 History

Advanced Medical Systems, is located in an industrial/residential neighborhood on the east side of Cleveland, Ohio (Figure 1). The facility is located in the northeastern end of a large warehouse/manufacturing building, formerly owned by the Picker Corporation. Figure 2 shows a plot plan of the property. The main floor (Figures 3 and 4) includes an office area, an isotope area, a hot cell, a shielded work room, a storage area, and several unoccupied areas. The second floor (Figure 5) includes additional unoccupied office space, mechanical equipment room, and the exhaust ventilation room. The basement (Figure 6) includes a former dry waste storage area, a liquid waste handling room, and a former liquid waste storage tank room.

The hot cell and supporting structures were added, by Picker Corporation, to their London Road facility in 1958 which is now owned and operated by AMS and licensed by the Nuclear Regulatory Commission (NRC).

The WHUT room, located in the basement of the London Road facility, collected waste from the hot cell via a floor drain. In 1989, a survey of the WHUT room indicated radiation levels exceeding 1000 R/hr. The NRC granted permission for AMS to seal the WHUT room until activity decay would permit remediation of the room.

2.2 Facility Description

The facility consists of a hot cell, a laboratory, a controlled ventilation system and a controlled liquid waste system. The "isotope area" is a small part of the building located on London Road. The cell and its two (2) support rooms are stacked with the cell located on top of the WHUT room and the ventilation room on the top of the cell. These three (3) rooms are structurally interconnected and support the remainder of the building. The waste generated from the facility is exclusively CO-60 oxide.

The basement area consists of 3 main areas (Figure 6), area east (air sampling room, isodose curve room, stairwell), area west (dry waste storage room) with the WHUT room located between the two. The controlled liquid waste system has been removed. A door and small hall exist between the area east and west while the north wall abuts undisturbed soil. Stairs in areas east and west supply entry and exit points to the basement.

The WHUT room is located directly beneath the Hot Cell. The WHUT room was designed to hold radioactive liquid wastes generated from the Hot Cell and the isotope area. A 100 gallon tank received waste water from a cell sink and floor drain and a 500 gallon tank was designed to receive overflow from the smaller tank and liquid waste from the showers, sinks and drains in the laboratory. Located in the room is a 2 column ion exchange system. There is no drain in the room. All surfaces are poured concrete unpainted and a small dike is located in the entrance to prevent the migration of liquid to other areas of the basement the event of a spill. Various pipes and conduit that penetrated the walls have been removed and sealed with lead rope, lead wool, concrete and silicone. No light or power exists in the room and the room is ventilated by an exhaust duct with the tank vents connected to the controlled ventilation system.

2.3 Radiological Conditions

The radiological condition of the WHUT room is provided by data from a 1989 radiological survey. The survey records indicated dose rates in the excess of 1000 R/hr. The floor had approximately 1-inch of sediment uniformly distributed through out the room that had a talcum powder consistency. A major spill had occurred sometime prior to 1988. Ambient dose rates at the entrance way were expected to be 5 R/hr and increasing to 300 R/hr within 3-4 ft. into the room. Dose rates were postulated to increase toward the ceiling area of the room. Dose rates outside the WHUT room were reported to be from 0.5mR/hr to 170 mR/hr general area. Loose contamination levels were estimated to be 5000dpm/100cm^2 outside the WHUT room mRad smearable inside the WHUT room.

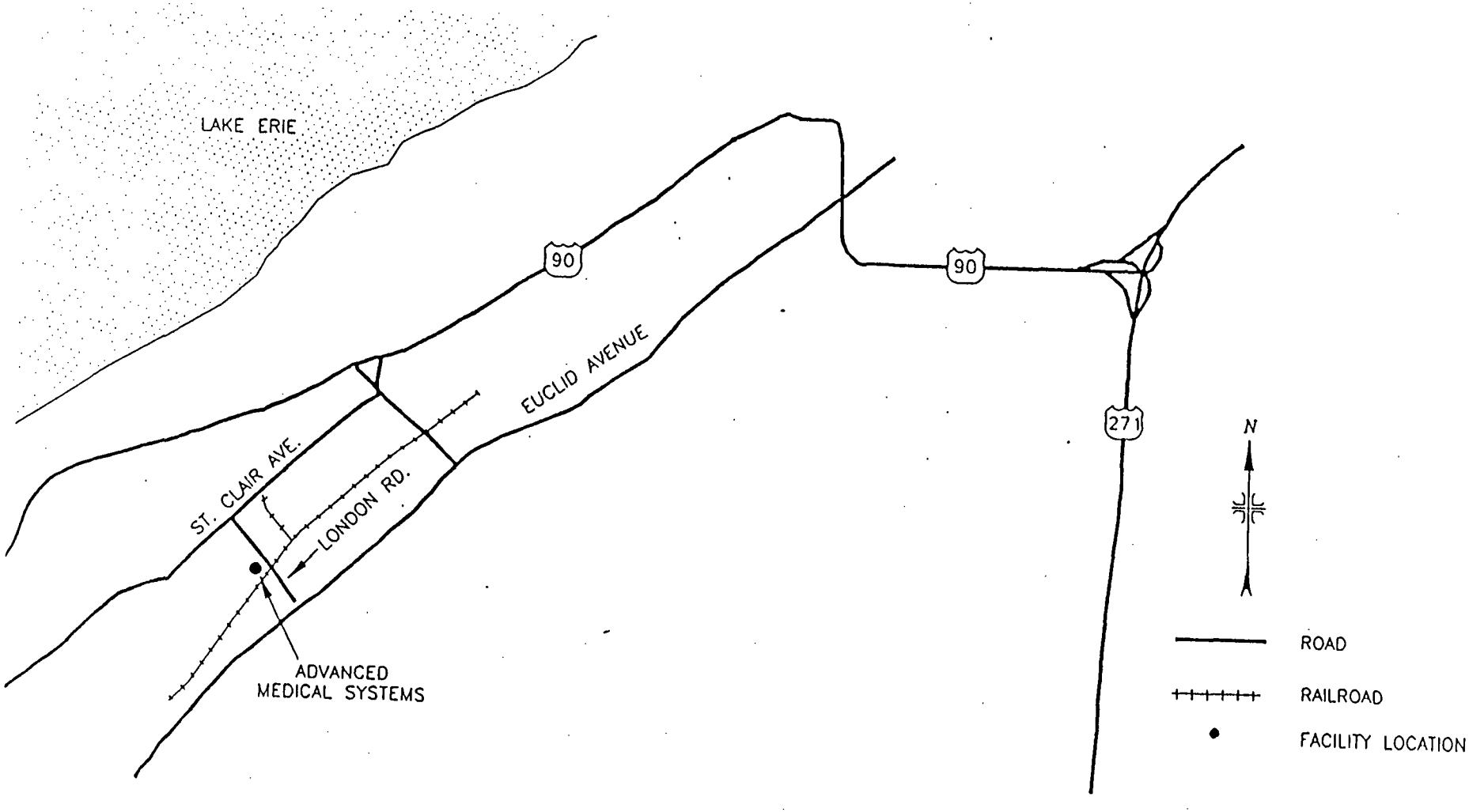


FIGURE 2-1
AREA INDICATING THE LOCATION OF THE AMS FACILITY

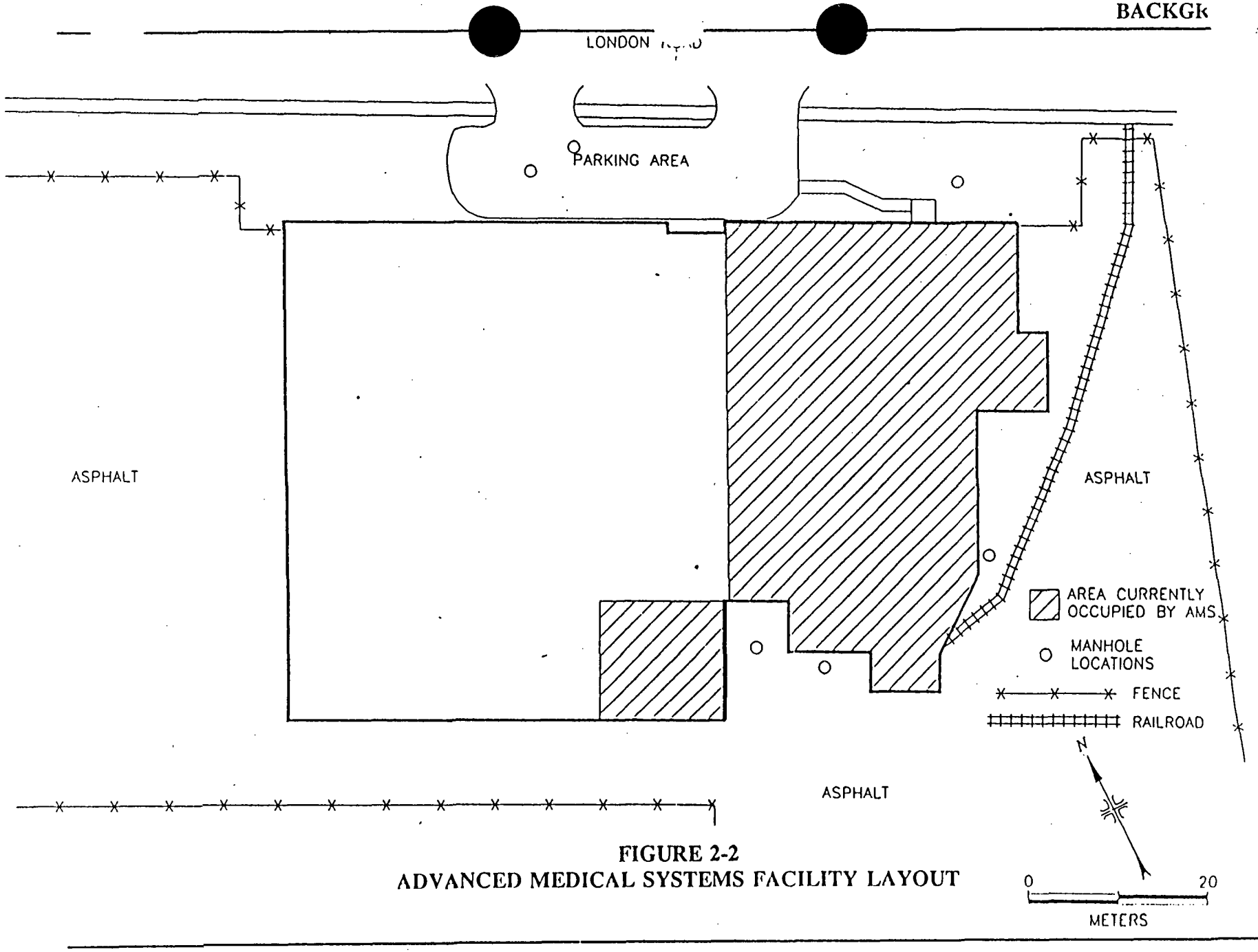


FIGURE 2-2
ADVANCED MEDICAL SYSTEMS FACILITY LAYOUT

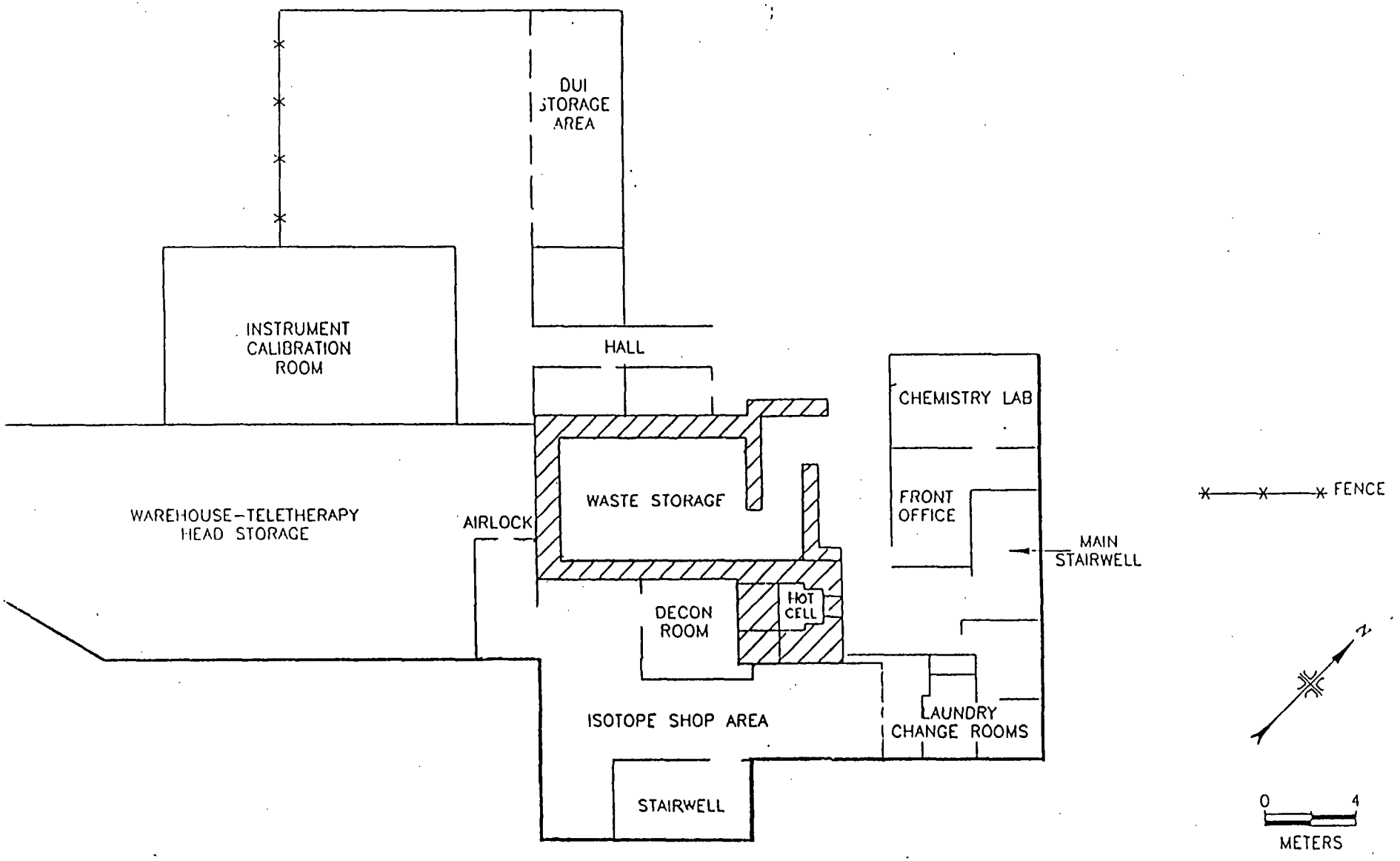


FIGURE 2-3
PARTIAL FLOOR PLAN OF THE AMS OCCUPIED AREA ON THE FIRST FLOOR

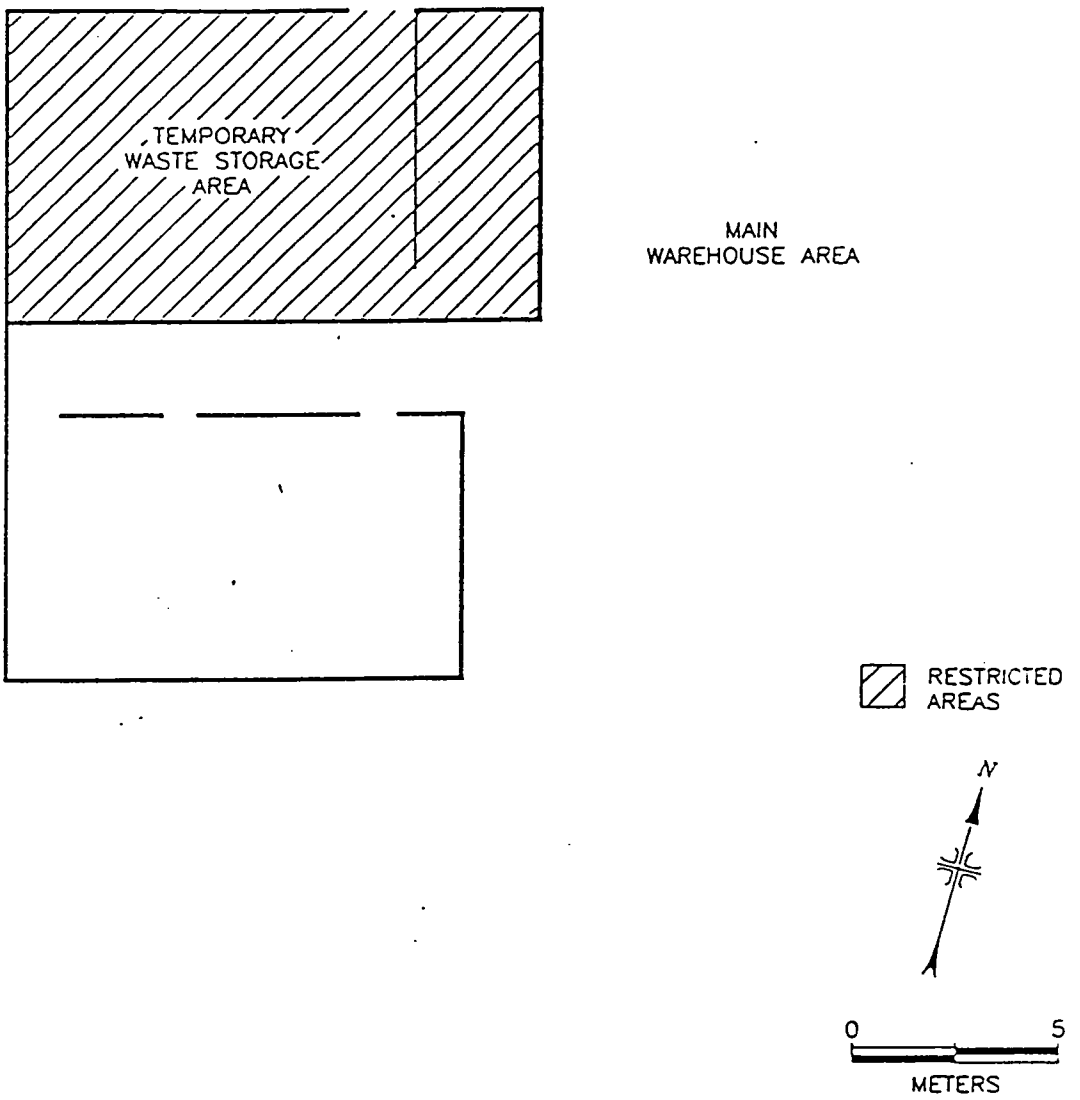


FIGURE 2-4
PARTIAL FLOOR PLAN OF THE AMS OCCUPIED AREA ON THE FIRST FLOOR

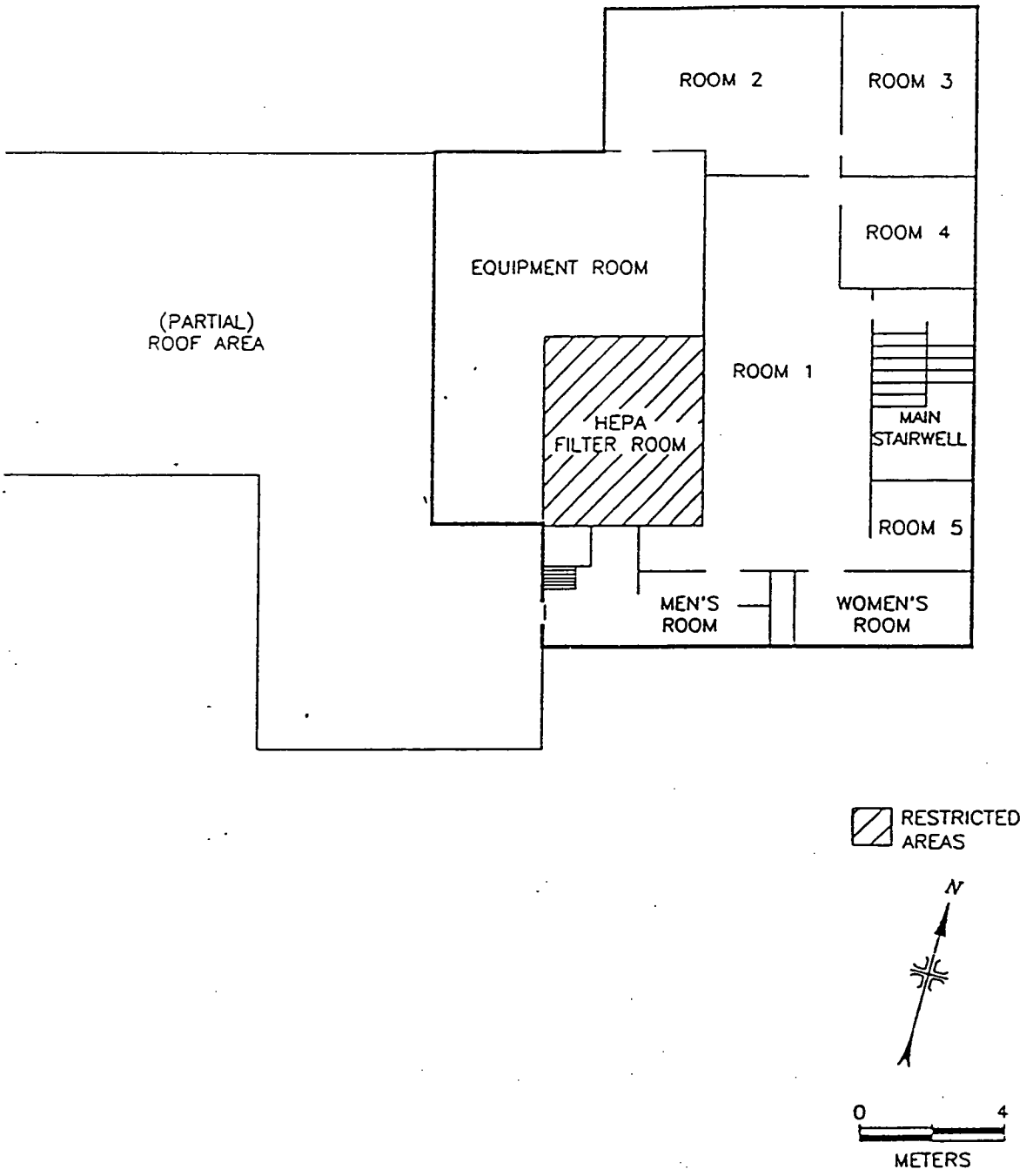


FIGURE 2-5
FLOOR PLAN OF THE AMS OCCUPIED AREA ON THE SECOND FLOOR

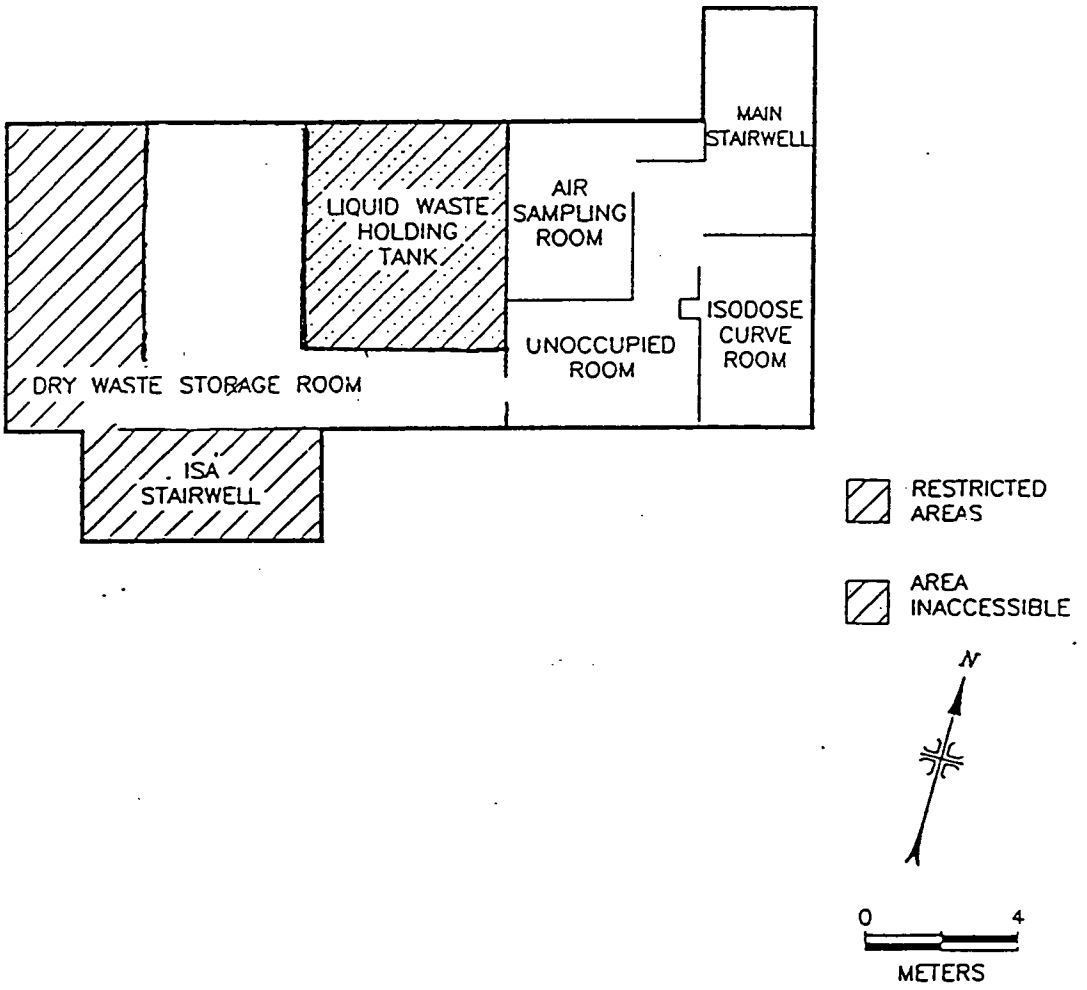


FIGURE 2-6
FLOOR PLAN OF THE AMS OCCUPIED AREA ON THE BASEMENT FLOOR

3.0 METHODOLOGY

Dewight A. Miller, Attorney at Law for Advanced Medical Systems, Inc. contracted with Scientific Ecology Group, Inc. to evaluate the integrity of the WHUT room through the sampling and analysis of soils below the perimeter of the WHUT room and a visual inspection of the room.

SEG provided a Work Plan for the integrity verification survey. The objectives of the plan were to:

- Comply with federal regulations and AMS license conditions.
- Keep exposure to As Low As Reasonable Achievable (ALARA).
- Evaluate WHUT room integrity by sampling subsurface soils and groundwater, performing a visual inspection of the room, and performing a limited radiological survey of the room.
- Prepare a report to document the results of the evaluation.

3.1 Preparation

To plan the WHUT room integrity verification survey, SEG developed a work plan to coordinate SEG activities and meet the AMS license and procedure requirements. The work plan was based upon characterization data and cell operational history provided by AMS.

3.1.1 Work Plan

The work plan (AMS-WP-00, Waste Hold-up Tank Integrity Verification Analysis) identifies the responsibilities, safety precautions, equipment needed, prerequisites and technical approach for each of the tasks, soil sampling, visual inspection and radiological survey. The work plan is included as Appendix A.

3.1.2 Staffing

The SEG on-site staff included Radiological Engineer and Senior Health Physics Technician. Off-site assistance was provided by a Radiological Engineer and technical staff at the SEG Oak Ridge facility.

3.1.3 Equipment

Equipment required for the project was provided by and shipped from SEG's Oak Ridge facility. This included instrumentation, one RO-7 radiation meter and one RO-2 for radiological for recording survey data.

A 2000 cfm HEPA unit was prepared for a backup ventilation system in the event a sealed enclosure would be needed to complete specific sampling activities and a possible failure of the WHUT room ventilation system during inspection.

Soil sampling equipment, auger, sample tube and attachments were utilized to collect the necessary samples needed for analysis.

A 2-inch x 2-inch x 6-inch Water Pic camera with audio visual screen was chosen for the visual inspection because of its unique design. The camera was small enough to slide through the existing penetrations and eliminating unnecessary core boring through the 3 ft. thick WHUT room walls.

3.1.4 Procedures

SEG provided procedures to support the project. Procedure topics included: instrumentation, sample analysis, decontamination, etc. Appendix B contains a list of SEG procedures used during the project.

3.1.5 Training

AMS staff provided the training to SEG personnel to meet AMS site access.

3.2 Soil Sampling

A strippable coating was applied to the east and west floor areas of the basement to control loose contamination and lowering airborne concentrations. Herculite in high traffic areas was used to provide further protection over highly contaminated concrete floors, and to prevent contamination migration.

Sampling locations (Attachment 1) were selected in areas of the basement where radiation levels were both ALARA and which would provide data relevant to determining if radioactivity was migrating from the WHUT room into the subsurface soils or groundwater. A roto-hammer with a 4-inch bit was used for boring the basement floor. This method allowed for a 6-inch deep dry cut through the concrete floor, which was beneficial in preventing cross contamination of soil samples. Pre-selected hold points were established to collect survey data to ensure cross contamination to underlying soil was prevented. One inch of soil from each hole was removed from the top of each sample for cross contamination concerns. Attachment 2 shows the results of smear samples taken during the sampling to verify that cross contamination did not take place. A three inch split spoon sampler was used to collect the soil samples. Collected soil samples were sealed and relinquished to AMS. All samples were shipped by AMS personnel to SEG in Oak Ridge for processing and analysis.

After twenty four hours water had filled all of the sample holes. Ground water samples were collected, sealed and relinquished to AMS and shipped to the SEG lab.

Each sample hole was filled with crushed rock and pumice. The middle 3 to 5 inches were filled with a mixture of "Top and Bond" adhesive cement and rock. The next 3 to 4 inches above the mixture was filled solely with "Top and Bond". After curing about 24 hours, a 1 inch cap of concrete was used to bring the hole flush with the basement floor.

3.3 WHUT Room Inspection

The visual inspection of the WHUT room was to be performed using a remote camera inserted through four penetrations into the room. Areas of the WHUT room of concern were the 100 gallon tank, the 500 gallon overflow tank, and the ion exchange columns.

Historical data provided by AMS lead to the identification of the penetrations that would be selected for the radiological survey and visual inspections. Penetrations identified are listed in Attachment 3, WHUT Room Penetrations. The list represents penetrations seen during evaluation. No attempt was made to map all penetrations. Two penetrations (B1 and B2) were chosen on the west wall in order to survey and perform a visual of the 500 gallon tank. A third penetration (S1) was opened by SEG personnel to provide for a visual inspection and radiological survey on the 100 gallon tank and ion exchange column. A fourth penetration was cut by SEG, through the 1 ft. thick labyrinth wall to provide a waist level visual of the room. A graphical representation of the penetrations chosen are seen in Attachment 4, WHUT Room Diagram.

3.3.1 Visual Inspection

The visual inspection was performed through penetrations B1, B2, S1, and S2 labyrinth. The visual inspection was complicated by the three foot thick WHUT room walls which limited camera movement. The camera was not equipped with pan and tilt ability. The camera was removed and relocated at different angles on the extension pole to complete the full visual inspection of the room. Several minutes of video were recorded and are included in this report.

3.3.2 Radiological Survey

The radiological survey was performed using a high range meter (RO-7). A high range probe was mounted to a 18-foot extension pole and inserted through penetrations and radiation readings were recorded in 1-foot increments across the room, west to east in penetrations B1 and B2, and south to north in penetration S1. Attachment 4 provides a graphical representation of the collected survey data in relationship to the internal WHUT room components.

4.0 FINDINGS

4.1 Soil and Groundwater Sampling

Soil and groundwater samples were analyzed by SEG using gamma spectroscopy. The results of the analysis are summarized in Table 4-1.

The Hole "C" groundwater sample was analyzed by Oak Ridge Analytical Laboratory. The laboratory analyst stated there is a large uncertainty in the sample results, with a bias toward high results, due to the non-homogeneous nature and small size of the sample. The laboratory comment are included in Appendix C.

TABLE 4-1
HOLE SAMPLE RESULTS

	Soil (pCi/g)	Groundwater (μCi/ml)
Hole "A"		
0 to 6 inches	0.348 ± 5.87%	
6 to 10 inches	0.102 ± 20.93%	4.97E-8 μCi/ml ± 15.7%
Hole "B"		
0 to 12 inches	<0.179	<7.2E-8 μCi/ml
Hole "C"		
0 to 6 inches	1.640 ± 4.10%	
6 to 12 inches	<0.133	2.5E-6 μCi/ml

Soil sample Co-60 limit for environmental remediation: 8 pCi/gram*
10CFR20, Table 2, Column 2, Limit for Co-60 in effluent water: 3 × 10-6 μCi/ml
*USNRC Report published in the Federal Register, Volume 57, No. 34, Page 6, 136 dated Thursday, February 20, 1992.

4.2 Visual Inspection

The visual inspection indicates that a spill took place at one point during past operations of the cell. Heavy corrosion on the existing equipment and discoloration on the walls indicate water levels ranged from 8-inches to 24-inches in depth. There is a sludge like material unevenly distributed on the floor which at the present time is covered with about 1/2-inch of water. Both the 100 and 500 gallon tanks have brown discolorations around the inlet flanges and fan out along the external tank surfaces. There is a 6-inch stalactite hanging from the ion exchanger piping under the 100 gallon tank and it could not be determined whether the 45 degree connection with a union is opened or closed. Large debris (barrels, boxes, pipes, sheets of plastic, etc.) cover the floor area in the room. A video tape was made of the room

and included as Appendix E. Still photographs from the video are included in Attachment 5.

4.3 Radiological Survey

The inlet pipe and loop seal to the 100 gallon tank appear to be the highest radiation source term in the WHUT room. The radiation levels are estimated to be higher than 750 R/hr. The rest of the main drain header and the 100 gallon tank also have significant radiation source terms. The drain header surveys may not be accurate due to other source terms in the area. Dose rates 2 feet from the 100 gallon tank are 10 to 30 R/hr higher than other areas in the room. This would suggest the 100 gallon tank may have contact dose rates greater than the 70 R/hr measured in the survey. The floor appears to contribute from 2 to 20 R/hr to the room dose rates. This is difficult to determine since a portion of the source term is under water and dose rates due to the floor source term will be significantly higher when dry. Dose rates near the 500 gallon tank and the ion exchanger do not appear to be significant in comparison to other contributors in the room. Estimated source term size from largest to smallest would be:

- The 100 gallon tank
- Floor debris
- The drain header and associated piping
- The 500 gallon tank
- The ion exchanger

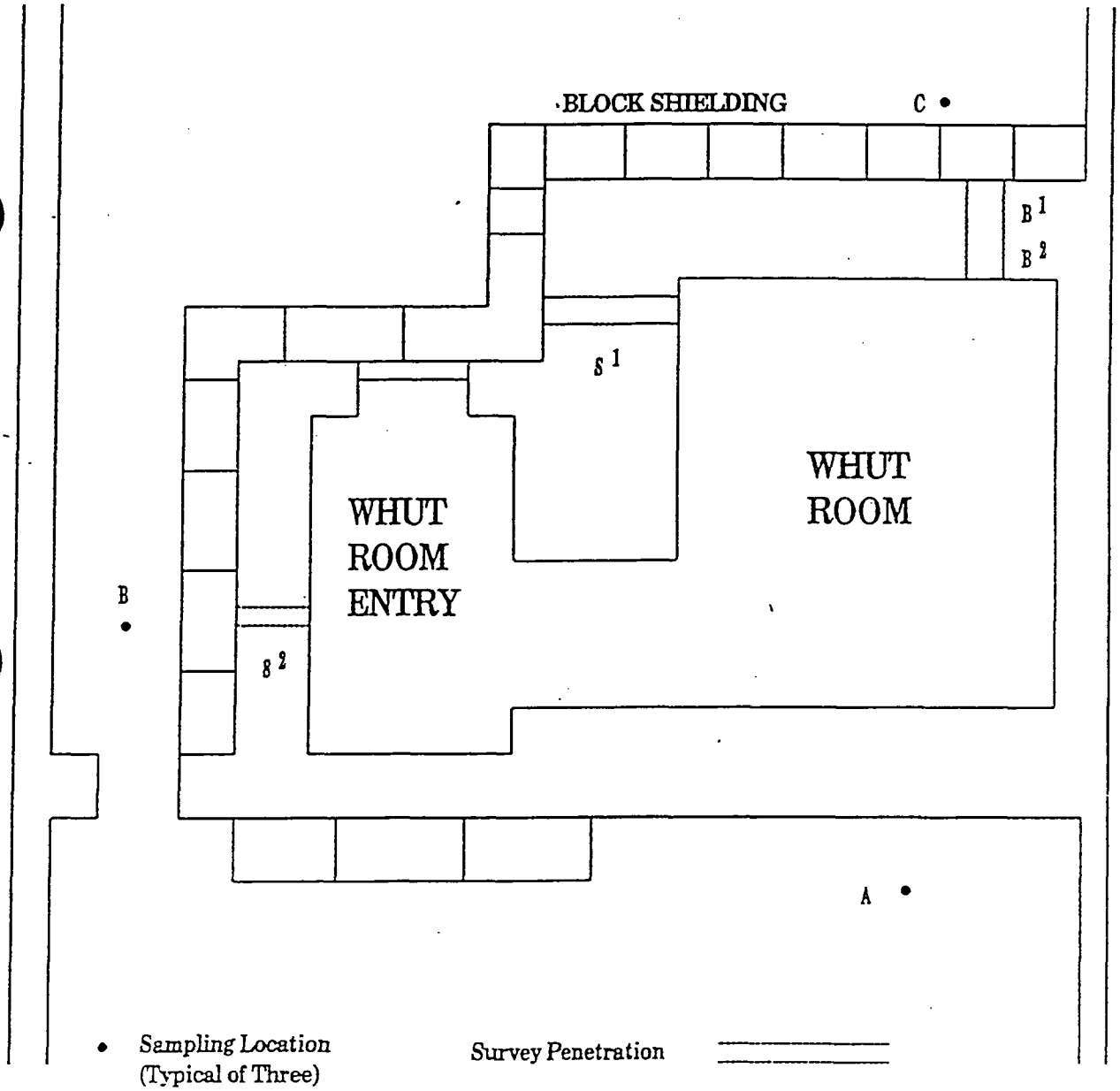
Attachment 4 is a diagram of the WHUT room with dose rate data identified.

ATTACHMENT 1

SAMPLE AND PENETRATION LOCATIONS

ATTACHMENT 1

SAMPLE AND PENETRATION LOCATIONS



ATTACHMENT 2

CORING INFORMATION

ATTACHMENT 2
CORING INFORMATION

Smears During Coring (dpm/100 cm²)						
Sample Hole	A		B		C	
Smear Location	Floor	Bit	Floor	Bit	Floor	Bit
Under stripable coating - PC	ND-100	ND	N/A	N/A	20-1030	ND
After decon under coating - PC	N/A	N/A	N/A	N/A	450	N/A
After 4" core - DC	ND-50	30	ND-80	210	50-930	50
After 6" core - DC	N/A	N/A	ND-70	20	30-130	40
After 8" core - DC	N/A	N/A	ND-80	70	ND-40	10
After breaking through fill - AC	20-120	20	ND-70	40	ND-30	40
After first sample - AC	ND-60	ND	ND-40	ND	ND	260

Smear Analyzer: AMS well counter # 04896, Calibration Due: 1-8-95.

Normal LLD values for the well counter were: 170 to 210 dpm/100 cm².

PC - Prior to Coring
DC - During Coring
AC - After Coring
N/A - Not Applicable
ND - Count rate was less than or equal to background count rate

Core Data		
	Top of Core	Rest of Core
A	400 CCPM	100 CCPM
B	3000 CCPM	1000 CCPM
C	1.5 mR/hr, 2 mRad/hr	N/A

Top of core readings were taken on the side of the core which was formerly the basement floor. CCPM readings were taken with a calibrated Ludlum Model 177 frisker and a standard G-M pancake probe. Dose rate readings were taken with RO-2 # 6087, Calibration Due 1-18-95.

ATTACHMENT 3

WHUT ROOM PENETRATIONS

ATTACHMENT 3
WHUT ROOM PENETRATIONS

Wall Location	Type	Condition	Number	Estimated Size	Contact Reading (mR/hr)	
East	Isoshop Drain Line	Pipe	F1	5 inch diameter	20 open	1.2 closed
South	Unknown	Empty	S1	4 inch diameter		25 closed
West	Ventilation	Duct	None	6 x 18 inches		50 closed
West	Empty	Empty	B1	10 inch diameter	200 open	30 closed
West	Empty	Empty	B2	10 inch diameter	200 open	35 closed
West	Empty	Empty	None	10 inch diameter		N/A
West	500 gal. tank vent	Pipe	None	5 inch diameter		N/A
West	Unknown	*	None	1 inch diameter		500 closed
West	100 gal. tank vent	Pipe	None	5 inch diameter		N/A
West	Drain Header	Pipe	None	5 inch diameter		32000 closed

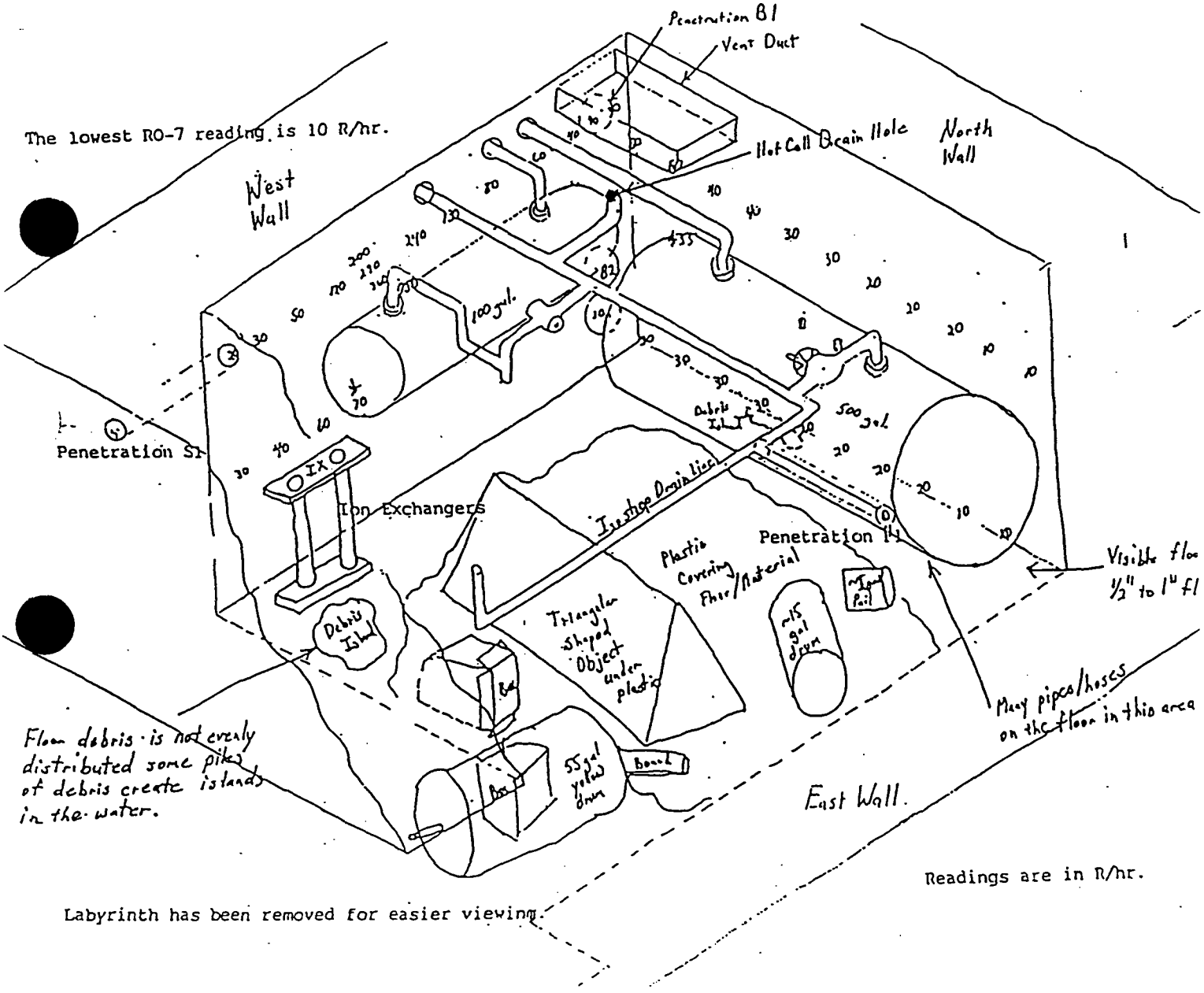
* No external indication of plugging. Located about three feet below the 100 gal. tank vent penetration.

ATTACHMENT 4

WHUT ROOM DIAGRAM
RADIATION DOSE RATES

ATTACHMENT 4

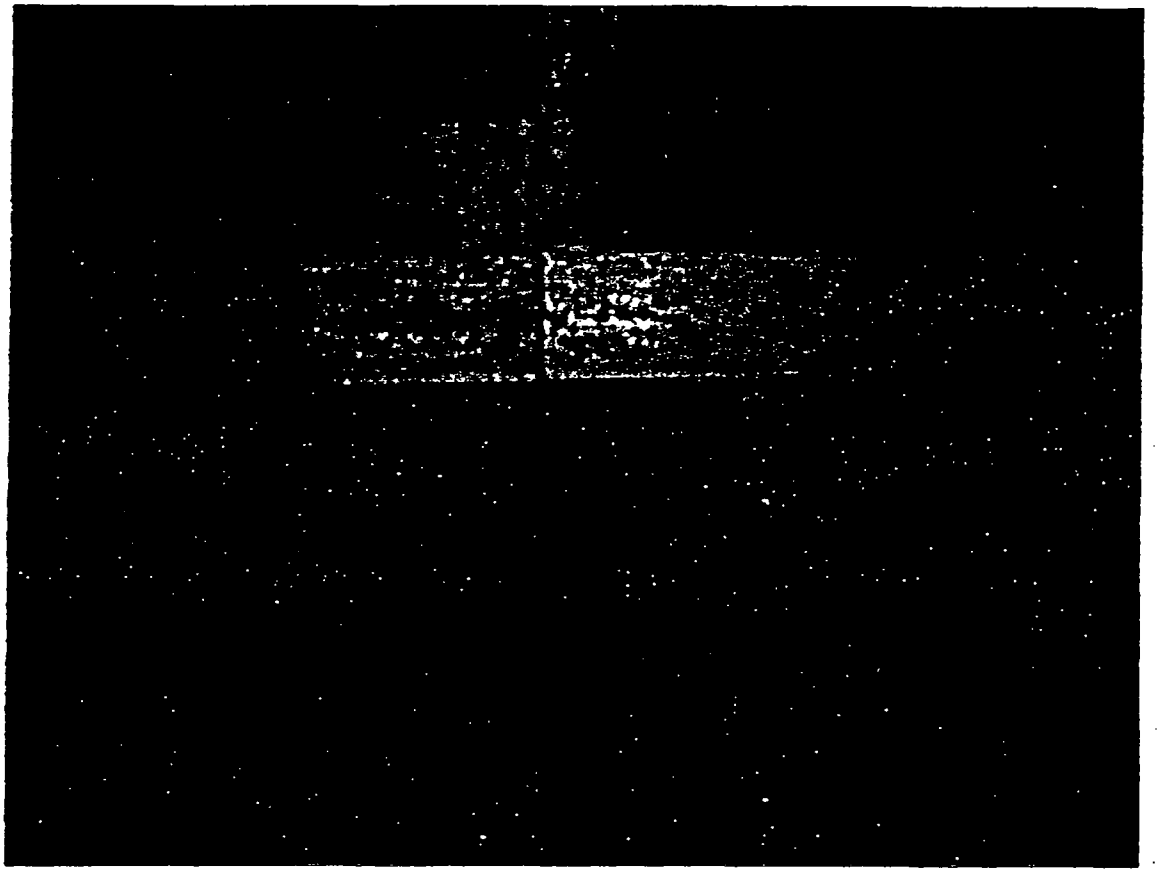
WHUT ROOM DIAGRAM



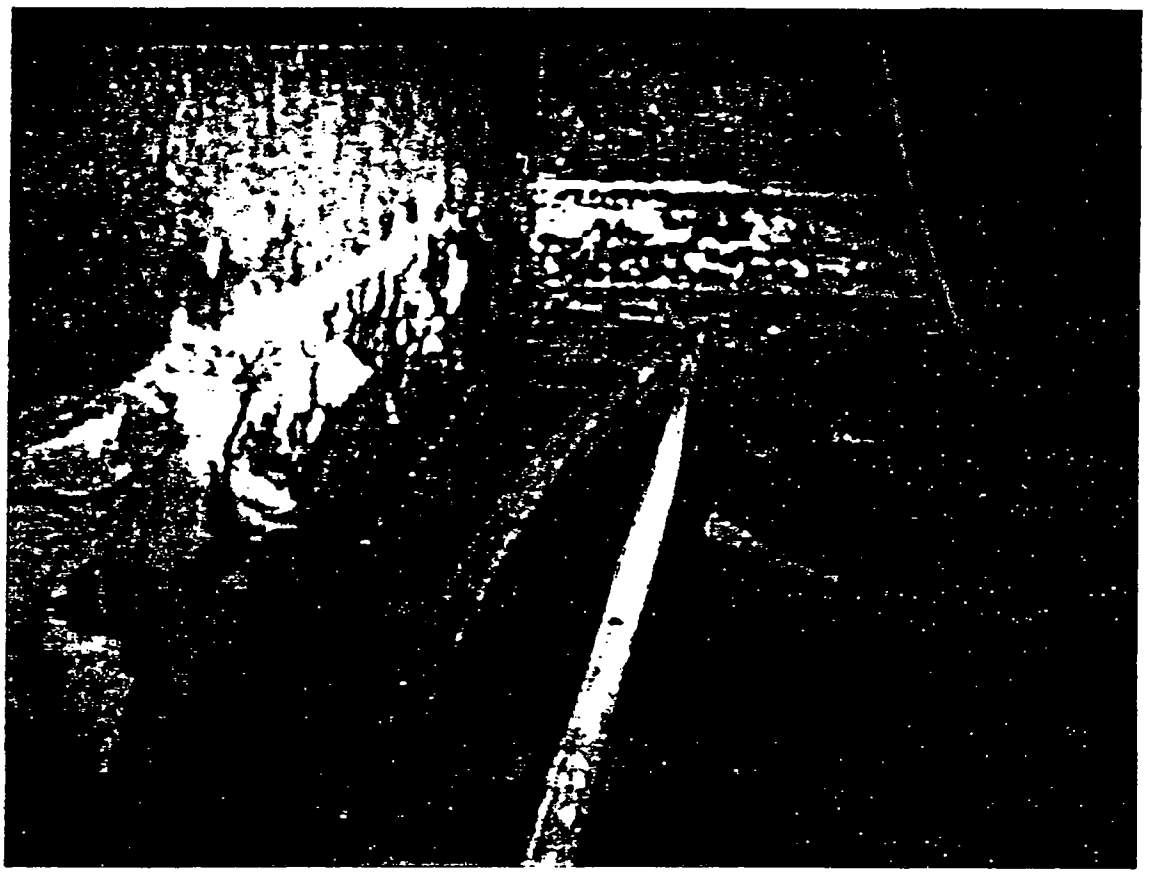
ATTACHMENT 5

PHOTOGRAPHS

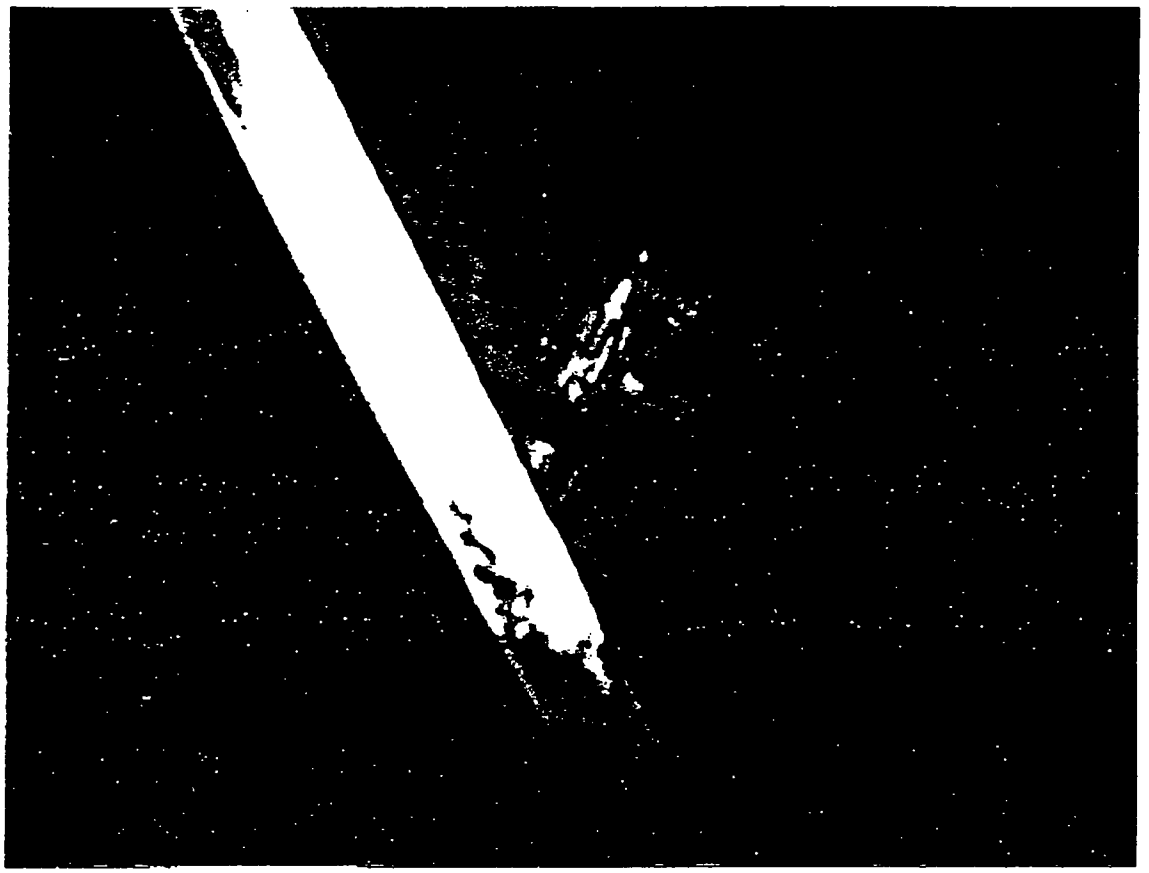
VIEW UNDER 100 GALLON STORAGE TANK EXHIBITING 6" STALACTITE FROM TANK DRAIN LEAKAGE. LOOKING NORTH FROM PENETRATION S2.



VIEW OF BERM AT THE ENTRANCE OF THE WHUT ROOM DOOR PENETRATION S2 INDICATING WATER DISTRIBUTION ON FLOOR.



VIEW OF THE FLOOR AND 500 GALLON TANK SUPPORT FROM PENETRATION B2.



VIEW OF THE 2 COLUMN ION EXCHANGE SYSTEM FROM PENETRATION S2 DISPLAYING 45° CONNECTION AND UNION.

SOIL SAMPLE FROM ADVANCED MEDICAL SYSTEMS, INC., BASEMENT AREA
EAST CORE BORE "A".

APPENDIX A

WASTE HOLD-UP TANK
INTEGRITY VERIFICATION ANALYSIS

SCIENTIFIC ECOLOGY GROUP, INC.

ADVANCED MEDICAL SYSTEM

WORK PLAN

AMS-WP-00

REVISION 0

WASTE HOLD-UP TANK INTEGRITY VERIFICATION ANALYSIS

REVIEWED BY: Richard D. Fuiksma — Project Manager — 11/15/94 — Date

APPROVED BY: D L Cesar — AMS Representative — 11-18-94 — Date

SEG
SCIENTIFIC ECOLOGY GROUP, INC.

ADVANCED MEDICAL SYSTEM

WORK PLAN

AMS-WP-00

REVISION 0

WASTE HOLD-UP TANK INTEGRITY VERIFICATION ANALYSIS

REVIEWED BY: Richard D. Smithson
Project Manager

11/15/94
Date

APPROVED BY: _____
AMS Representative

_____
Date

ADVANCED MEDICAL SYSTEMS, REV. 4
January 18, 1995

This package of procedures has been prepared for the Advanced Medical Systems project. Please use procedure REDS-PDC-104, *Acknowledgement of Document Understanding*, to record the briefing of all necessary personnel on these procedures. The procedures included in this package are as follows (changes or additions are shaded):

	PROC. NO.	TITLE	REVISION
1.	REDS-CHM-101	Sample Identification and Chain-of-Custody	2
2.	REDS-CHR-106	Surface Soil Sampling	0
3.	REDS-CHR-107	Subsurface Soil Sampling	0
4.	REDS-CHR-108	Surface Soil Surveys and the Collection of Water, Sediment, Vegetation and Surface Soil Samples	2
5.	REDS-DEC-301	Decontamination of Tools, Area and Equipment	0
6.	REDS-DEC-302	Control and Use of Radiological Containments	1
7.	REDS-DEC-303	Decontamination Techniques - Selection and Precautions	1
8.	REDS-INST-100	Radiation Protection Instrumentation Program	2
9.	REDS-INST-101	Issue, Control and Accountability of Radiation Protection Instrumentation	1
10.	REDS-INST-104	Calibration and Test Requirements for Radiation Protection Instrumentation	0
11.	REDS-INST-204	Operation of Eberline RO-7 High Range Ion Chamber	0
12.	REDS-INST-207	Operation of Eberline Ion Chamber Model RO-2/RO-2A	1
13.	REDS-INST-216	Operation of F&J LV-1 and HV-1 Air Samplers	0
14.	REDS-OPS-201	Radiation Work Permits	1
15.	REDS-OPS-304	Analysis and Evaluation of Air Samples	2
16.	REDS-PDC-104	Acknowledgement of Document Understanding	0
17.	REDS-RSP-103	HEPA Ventilation Operation	0

There may be references to procedures not included in this package. If review of these references is required, they are available at the SEG RE&DS home office, Oak Ridge, TN. Please contact Dave Hall, Manager, Decommissioning Contract Services.

APPENDIX C

SAMPLING RESULTS

APPENDIX C

SAMPLING RESULTS

le No: 94058543

Environmental Soil / SEG / AMS-A-000-006
11/28/94 833.2 grams (KW)

nalysis Information:

Start time 28-NOV-94 10:39:16
Live time 1800
Dead time .25%
EG&G Ortec Model: GMX-33195P SN: 29-TN10256
500 ml Marinelli Beaker on Detector End Cap
Main analysis library: SEG.LIB
Peak rejection level 30.000%
Activity scaling factor 2.7050E+01/ 8.3320E+02 = 3.2465E-02
Decay correct to date NO

u[redacted]e Summary:

UCLIDE		ACTIVITY pCi/gram	COUNTING
G-110M	<	4.12E-02	
M-241	<	5.29E-02	
[redacted]41	<	4.06E-02	
[redacted]4	<	1.95E-01	
[redacted]7	<	1.71E-02	
O-58	<	3.62E-02	
O-60		3.4848E-01	5.87%
R-51	<	2.52E-01	
S-134	<	3.03E-02	
S-137	<	3.79E-02	
E[redacted]	<	5.58E-02	
[redacted]	<	2.60E-02	
-40		1.1819E+01	4.58%
N-54	<	3.93E-02	
B-94	<	3.88E-02	
B-95	<	4.23E-02	
N-220		7.2911E-01	4.84%
N-222		6.6660E-01	5.90%
U-103	<	1.53E-02	
U-106	<	3.00E-01	
B-125	<	1.17E-01	
N-113	<	4.20E-02	
H-232		7.2282E-01	7.86%
-235		6.2095E-02	23.64%
-238		1.1677E+00	15.90%
N-65	<	1.13E-01	
R-95	<	1.29E-01	

ACTIVITY 1.5515750E+01 pCi/gram

echnician: K. Holman Date: 11-28-94

Scientific Ecology Group, Inc. Oak Ridge, TN

EG&G ORTEC OMNIGAM (143) I3.02.15 28-NOV-94 10:43:56 Page 1

le No: 94058544

Enviromental Soil / SEG / AMS-A-006-010
11-21-94 (k Wright) 843.9 gr

Analysis Information:

Start time 28-NOV-94 10:06:43
Live time 1800
Dead time .28%
EG&G Ortec Model: GMX-33195P SN: 29-TN10256
500 ml Marinelli Beaker on Detector End Cap
Main analysis library: SEG.LIB
Peak rejection level 30.000%
Activity scaling factor 2.7050E+01/ 8.4390E+02 = 3.2054E-02
Decay correct to date NO

Nu[redacted]de Summary:

NUCLIDE		ACTIVITY pCi/gram	COUNTING
AG-110M	<	5.19E-02	
AM-241	<	6.48E-02	
[illegible]41	<	5.00E-02	
[illegible]4	<	2.39E-01	
[illegible]7	<	2.44E-02	
CO-58	<	4.68E-02	
CO-60		1.0195E-01	20.93%
CR-51	<	2.37E-01	
CS-134	<	3.91E-02	
CS-137	<	4.73E-02	
FE[redacted]	<	9.01E-02	
I[redacted]	<	4.43E-02	
K-40		2.0455E+01	3.51%
MN-54	<	4.66E-02	
NB-94	<	4.07E-02	
NB-95	<	4.38E-02	
RN-220		1.2203E+00	3.67%
RN-222		6.1268E-01	4.97%
RU-103	<	2.24E-02	
RU-106	<	4.57E-01	
SB-125	<	9.71E-02	
SN-113	<	4.28E-02	
TH-232		1.1291E+00	7.33%
U-235	#	1.0943E-01	16.84%
U-238		1.1278E+00	18.65%
ZN-65	<	8.72E-02	
ZR-95	<	1.57E-01	

\# All peaks for activity calculation had bad shape.

[illegible] ACTIVITY 2.4756440E+01 pCi/gram

Technician: [signature] Date: 11/28/94

Scientific Ecology Group, Inc. Oak Ridge, TN

EG&G ORTEC OMNIGAM (143) I3.02.15 28-NOV-94 10:41:26 Page 1

le No: 94058545

Enviromental Soil / SEG / AMS-B-000-012
11-22-94 713.4 gr (K.Wright)

nalysis Information:

Start time 28-NOV-94 10:06:40
Live time 1800
Dead time .28%
Oxford Model: CNVDS30-15190 SN: 7976
500 ml Marinelli Beaker on Detector End Cap
Main analysis library: SEG.LIB
Peak rejection level 30.000%
Activity scaling factor 2.7050E+01/ 7.1340E+02 = 3.7917E-02
Decay correct to date NO

[redacted]de Summary:

UCLIDE		ACTIVITY pCi/gram	COUNTING
G-110M	<	1.06E-01	
M-241	<	1.69E-01	
41	<	1.19E-01	
44	<	2.43E-01	
O-57	<	2.96E-02	
O-58	<	8.42E-02	
O-60	<	1.79E-01	
R-51	<	6.37E-01	
S-134	<	1.70E-01	
S-137	<	1.00E-01	
E[redacted]	<	1.60E-01	
[redacted]	<	8.10E-02	
-40		3.1190E+01	3.85%
N-54	<	1.15E-01	
B-94	<	1.05E-01	
B-95	<	9.83E-02	
N-220		1.4372E+00	4.98%
N-222		8.8725E-01	5.99%
U-103	<	5.99E-02	
U-106	<	7.64E-01	
B-125	<	1.52E-01	
N-113	<	5.05E-02	
H-232		1.5321E+00	10.45%
-235	<	1.15E-01	
-238	<	1.66E+00	
N-65	<	2.72E-01	
R-95	<	3.05E-01	

, ACTIVITY 3.5047040E+01 pCi/gram

echnician: [signature] Date: 11/28/94

Scientific Ecology Group, Inc. Oak Ridge, TN

EG&G ORTEC OMNIGAM (143) I3.02.15 28-NOV-94 14:55:18 Page 1

le No: 94058546

Environmental Soil / SEG / AMS-C-000-006
11/28/94 689.8 grams (KW)

Analysis Information:

Start time 28-NOV-94 10:39:15
Live time 1800
Dead time .25%
Oxford Model: CNVDS30-15190 SN: 7976
500 ml Marinelli Beaker on Detector End Cap
Main analysis library: SEG.LIB
Peak rejection level 30.000%
Activity scaling factor 2.7050E+01/ 6.8980E+02 = 3.9214E-02
Decay correct to date NO

Nuclide Summary:

NUCLIDE		ACTIVITY pCi/gram	COUNTING
G-110M	<	1.07E-01	
M-241	<	1.68E-01	
11	<	1.07E-01	
14	<	5.03E-01	
O-57	<	3.15E-02	
O-58	<	1.31E-01	
O-60		1.6396E+00	4.10%
R-51	<	4.47E-01	
S-134	<	1.81E-01	
S-137	<	1.16E-01	
E-	<	3.28E-01	
-	<	9.88E-02	
-40	<	4.78E+00	
N-54	<	1.03E-01	
B-94	<	1.39E-01	
B-95	<	1.03E-01	
N-220		1.3910E+00	5.88%
N-222		8.6964E-01	6.65%
U-103	<	9.30E-02	
U-106	<	6.68E-01	
B-125	<	1.32E-01	
N-113	<	6.35E-02	
H-232	<	8.48E-01	
-235		1.5930E-01	24.72%
-238	<	1.77E+00	
N-65	<	2.71E-01	
R-95	<	3.38E-01	

ACTIVITY 4.0595890E+00 pCi/gram

Technician: K. Holman Date: 11-28-94

* U-238 peaks present; But not Id'd.

Scientific Ecology Group, Inc. Oak Ridge, TN

EG&G ORTEC OMNIGAM (143) I3.02.15 28-NOV-94 14:54:26 Page 1

ple No: 94058547

Environmental Soil / SEG / AMS-C-000-012
11/28/94 655.3 grams (KW)

nalysis Information:

Start time 28-NOV-94 11:21:04
Live time 1800
Dead time .17%
Oxford Model: CNVDS30-15190 SN: 7976
500 ml Marinelli Beaker on Detector End Cap
Main analysis library: SEG.LIB
Peak rejection level 30.000%
Activity scaling factor 2.7050E+01/ 6.5530E+02 = 4.1279E-02
Decay correct to date NO

u[redacted]e Summary:

UCLIDE		ACTIVITY pCi/gram	COUNTING
G-110M	<	8.59E-02	
M-241	<	2.39E-01	
[redacted]41	<	1.17E-01	
[redacted]44	<	2.71E-01	
D-57	<	3.85E-02	
D-58	<	1.05E-01	
D-60	<	1.90E-01	
R-51	<	7.52E-01	
S-134	<	1.78E-01	
S-137	<	2.02E-01	
E[redacted]	<	7.97E-02	
[redacted]-40		3.3778E+01	3.86%
N-54	<	1.37E-01	
B-94	<	8.23E-02	
B-95	<	9.31E-02	
N-220		1.5730E+00	5.03%
N-222		8.7181E-01	6.84%
U-103	<	4.35E-02	
U-106	<	7.49E-01	
B-125	<	1.51E-01	
I-113	<	7.49E-02	
H-232		1.4689E+00	8.86%
-235		1.5593E-01	24.08%
-238	<	2.01E+00	
I-65	<	2.09E-01	
I-95	<	3.36E-01	

ACTIVITY 3.7847520E+01 pCi/gram

chnician: K. Hohman Date: 11-28-94

* U-238 peaks present but not idled.

Scientific Ecology Group, Inc. Oak Ridge, TN

EG&G ORTEC OMNIGAM (143) I3.02.15 28-NOV-94 13:24:19 Page 1

Sample No: 94058548

Environmental Water / SEG / AMS-B-LIQ-012
11-22-94 (K. Wright) 20 ml (KOJ)

Analysis Information:

Start time 28-NOV-94 09:32:43
Live time 1800
Dead time .12%
Oxford Model: CNVDS30-15190 SN: 7976
2" Planchet Placed on Center of Detector End Cap
Main analysis library: SEG.LIB
Peak rejection level 30.000%
Activity scaling factor 2.7050E-05/ 2.0000E+01 = 1.3525E-06
Decay correct to date NO

Nuclide Summary:

NUCLIDE		ACTIVITY uCi/ml	COUNTING
G-110M	<	7.46E-07	
M-241	<	1.11E-06	
41	<	7.75E-07	
44	<	2.64E-06	
O-57	<	2.50E-07	
O-58	<	6.42E-07	
O-60	<	1.45E-06	
R-51	<	4.13E-06	
S-134	<	7.11E-07	
S-137	<	6.29E-07	
E[redacted]	<	1.14E-06	
-[redacted]	<	3.99E-07	
-40	<	2.35E-05	
N-54	<	5.22E-07	
B-94	<	4.98E-07	
B-95	<	7.97E-07	
N-220	<	9.84E-07	
N-222	<	1.72E-06	
U-103	<	7.31E-07	
U-106	<	4.49E-06	
B-125	<	1.61E-06	
N-113	<	8.67E-07	
H-232	<	4.08E-06	
-235	<	9.38E-07	
-238	<	6.76E-06	
N-65	<	1.30E-06	
R-95	<	1.66E-06	

ACTIVITY 0.0000000E+00 uCi/ml

Technician: Keith O. Jeter Date: 11/28/94

Scientific Ecology Group, Inc. Oak Ridge, TN

EG&G ORTEC OMNIGAM (143) I3.02.15 01-DEC-94 22:03:14 Page 1

Sample No: 94059585

Liquid sample / AMS-A-LIQ-010/CUS/Hole A
12-1-94 500 ml PH=8 (KW)

Analysis Information:

Start time 01-DEC-94 20:06:01
Live time 1800
Dead time .30%
EG&G Ortec Model: GMX-33195P SN: 29-TN10256
500 ml Marinelli Beaker on Detector End Cap
Main analysis library: SEG.LIB
Peak rejection level 30.000%
Activity scaling factor 2.7050E-05/ 5.0000E+02 = 5.4100E-08
Decay correct to date NO

Nuclide Summary:

NUCLIDE		ACTIVITY uCi/ml	COUNTING
AG-110M	<	4.34E-08	
AM-241	<	2.75E-08	
CE-141	<	2.73E-08	
[illegible]144	<	1.23E-07	
[illegible]57	<	1.24E-08	
CO-58	<	3.06E-08	
CO-60		7.9908E-08	13.30%
CR-51	<	1.42E-07	
CS-134	<	3.29E-08	
CS-137	<	4.41E-08	
FE-59	<	9.56E-08	
[illegible]131	<	1.39E-08	
[illegible]	<	5.43E-07	
[illegible]54	<	4.90E-08	
NB-94	<	2.44E-08	
NB-95	<	4.62E-08	
RN-220	<	5.02E-08	
RN-222	<	5.14E-08	
RU-103	<	1.82E-08	
RU-106	<	2.00E-07	
SB-125	<	5.29E-08	
SN-113	<	3.52E-08	
TH-232	<	1.68E-07	
U-235	<	3.80E-08	
U-238	<	5.03E-07	
ZN-65	<	6.55E-08	
ZR-95	<	7.15E-08	

TOTAL ACTIVITY 7.9908010E-08 uCi/ml

[illegible]chnician: Paul Ernest Date: 12-1-94

Scientific Ecology Group, Inc. Oak Ridge, TN

EG&G ORTEC OMNIGAM (143) I3.02.15 30-JAN-95 14:38:04 Page 1

ple No: 94059585

Liquid Sample / AMS-A-LIQ-010/CUS/Hole "A"
1-30-95 PH =6

Analysis Information:

Start time 30-JAN-95 12:39:02
Live time 7200
Dead time 1.15%
Oxford Model: CPVDS30-29195 SN: 2443
500 ml Marinelli Beaker on Detector End Cap
Main analysis library: SEG1.LIB
Peak rejection level 30.000%
Activity scaling factor 2.7050E-05/ 5.0000E+02 = 5.4100E-08
Decay correct to date NO

Nuclide Summary:

NUCLIDE		ACTIVITY uCi/ml	COUNTING
AG-110M	<	1.98E-08	
AM-241	<	1.64E-07	
[illegible]41	<	1.90E-08	
[illegible]44	<	5.46E-08	
CO-57	<	1.03E-08	
CO-58	<	7.24E-09	
CO-60		4.9713E-08	15.72%
CR-51	<	9.77E-08	
CS-134	<	1.58E-08	
CS-137	<	1.85E-08	
[illegible]	<	2.70E-08	
[illegible]	<	2.57E-07	
MN-54	<	8.06E-09	
NB-94	<	1.56E-08	
NB-95	<	1.48E-08	
RN-220	<	3.36E-08	
RN-222	<	3.81E-08	
RU-103	<	1.47E-08	
RU-106	<	1.83E-07	
SB-125	<	4.17E-08	
SN-113	<	1.49E-08	
TH-232	<	7.62E-08	
U-238	<	1.04E-06	
ZN-65	<	2.61E-08	
ZR-95	<	1.98E-08	

TOTAL ACTIVITY 4.9712860E-08 uCi/ml

Technician: K. Harris Date: Jan. 30, 1995

Scientific Ecology Group, Inc. Oak Ridge, TN

&G ORTEC OMNIGAM (143) I3.02.15 01-DEC-94 22:00:48 Page 1

Sample No: 94059586

Liquid Sample / AMS-B-LIQ-012/CUS/Hole B
12-1-94 500 ml PH=6 (KW)

Analysis Information:

Start time 01-DEC-94 20:06:00
Live time 1800
Dead time .30%
Oxford Model: CNVDS30-15190 SN: 7976
500 ml Marinelli Beaker on Detector End Cap
Main analysis library: SEG.LIB
Peak rejection level 30.000%
Activity scaling factor 2.7050E-05/ 5.0000E+02 = 5.4100E-08
Decay correct to date NO

[redacted]ide Summary:

NUCLIDE		ACTIVITY uCi/ml	COUNTING
AG-110M	<	6.41E-08	
AM-241	<	1.94E-07	
[redacted]-141	<	1.08E-07	
[redacted]144	<	4.41E-07	
[redacted]-57	<	6.69E-08	
CO-58	<	5.35E-08	
CO-60	<	1.22E-07	
CR-51	<	2.75E-07	
CS-134	<	4.72E-08	
CS-137	<	8.56E-08	
FE-59	<	1.16E-07	
[redacted]1	<	7.48E-08	
[redacted]	<	1.33E-06	
MN-54	<	5.48E-08	
NB-94	<	4.90E-08	
NB-95	<	4.54E-08	
RN-220	<	1.21E-07	
RN-222	<	1.68E-07	
RU-103	<	3.66E-08	
RU-106	<	6.06E-07	
SB-125	<	1.92E-07	
SN-113	<	9.59E-08	
TH-232	<	2.27E-07	
U-235	<	9.15E-08	
U-238	<	1.83E-06	
ZN-65	<	1.31E-07	
ZR-95	<	1.25E-07	

TOTAL ACTIVITY 0.0000000E+00 uCi/ml

Technician: Paul Ernest Date: 12-1-94

Scientific Ecology Group, Inc. Oak Ridge, TN

EG&G ORTEC OMNIGAM (143) I3.02.15 01-DEC-94 22:05:31 Page 1

ple No: 94059587

Liquid sample /AMS-C-LIQ-012/CUS/Hole C
12-1-94 25.77 ml PH=5.5 (KW)

Analysis Information:

Start time 01-DEC-94 20:51:36
Live time 1800
Dead time .29%
EG&G Ortec Model: GMX-33195P SN: 29-TN10256
2" Planchet Placed on Center of Detector End Cap
Main analysis library: SEG.LIB
Peak rejection level 30.000%
Activity scaling factor 2.7050E-05/ 2.5770E+01 = 1.0497E-06
Decay correct to date NO

Nuclide Summary:

NUCLIDE		ACTIVITY uCi/ml	COUNTING
AG-110M	<	5.13E-07	
AM-241	<	3.80E-07	
41	<	2.42E-07	
44	<	1.25E-06	
CO-57	<	1.23E-07	
CO-58	<	3.83E-07	
CO-60	<	8.84E-07	
CR-51	<	1.41E-06	
CS-134	<	4.59E-07	
CS-137	<	4.65E-07	
E[redacted]	<	6.74E-07	
[redacted]	<	2.63E-07	
-40	<	6.88E-06	
MN-54	<	4.12E-07	
NB-94	<	4.30E-07	
NB-95	<	4.43E-07	
PB-220	<	5.77E-07	
PB-222	<	5.19E-07	
RU-103	<	2.18E-07	
RU-106	<	4.22E-06	
SB-125	<	1.22E-06	
SN-113	<	4.31E-07	
TH-232	<	1.22E-06	
U-235	<	4.10E-07	
U-238	<	4.15E-06	
ZN-65	<	1.04E-06	
ZR-95	<	1.09E-06	

ACTIVITY 0.0000000E+00 uCi/ml

Technician: Paul Ernst Date: 12-1-94

OAK RIDGE
ANALYTICAL SERVICES, INC.

739 Emory Valley Road, Oak Ridge, TN 37830-7017
Voice: (615) 482-1010 • Fax: 481-0454

Report of Analysis for Scientific Ecology Group

Purchase Order Number TN90304TTW

Sample ID	Isotope	Activity (pCi/L)	Uncertainty (pCi/L)	MDA (pCi/L)
95005119	Co-60	2.511E+03	1.088E+03	2.386E+02

Reported By

AMS-C-LIQ-012 /CUS/ HOLE "C" REANALYSED

95005119.TXT

VMS Nuclide Identification Report V2.9 Generated 1-FEB-1995 10:31:06

Configuration : SYS$SYSDEVICE:[GAMMA.SCUSR.ARCHIVE]SMP_95005119_GAMMA1_GLASS
Analyses by : PEAK V16.4,PEAKEFF V2.2,ENEACK V1.5,NID V3.1,MINACT V2.5
Sample date : 5-JAN-1995 00:00:00 Acquisition date : 29-JAN-1995 20:46:44
Sample ID : 95005119 Sample quantity : 3.50000E-02 L
Detector name : GAMMA1 Detector geometry: GLASS JAR
Elapsed live time: 1 00:00:00.00 Elapsed real time: 1 00:00:23.77 0.0%
Peak Width (FWHM): 3.00 Confidence level : 5.00 %
Energy tolerance : 2.00 keV Half life ratio : 8.00
Errors propagated: Yes Systematic Error : 0.00 %
Efficiency type : Empirical Efficiencies at : Library Energy
Abundance limit : 75.00 WIM error limit : 3.00

Combined Activity-MDA Report

---- Identified Nuclides ----

Nuclide	Activity (pCi/L)	Act error	MDA (pCi/L)	MDA error	Act/MDA
K-40	8.549E+03	4.483E+03	1.568E+03	2.462E+02	5.451
CO-60	2.511E+03	1.088E+03	2.386E+02	4.732E+01	10.526
CE-141	1.211E+03	8.826E+02	7.830E+02	4.031E+02	1.547
BI-212	5.356E+03	4.296E+03	4.402E+03	2.089E+03	1.217

---- Non-Identified Nuclides ----

Nuclide	Key-Line Activity (pCi/L)	K.L. Ided	Act error	MDA (pCi/L)	MDA error	Act/MDA
BE-7	1.074E+03		1.777E+03	3.022E+03	1.208E+03	0.355
CR-51	1.231E+03		2.228E+03	3.873E+03	5.720E+02	0.318
MN-54	-1.641E+02		2.989E+02	3.626E+02	4.498E+02	-0.453
CO-57	4.650E+00		1.731E+02	2.800E+02	1.610E+02	0.017
CO-58	-1.937E+02		2.694E+02	4.052E+02	2.355E+02	-0.478
FE-59	5.670E+01		5.001E+02	8.355E+02	2.060E+02	0.068
ZN-65	3.340E+02		4.680E+02	7.563E+02	4.372E+02	0.442
GE-68	-4.698E+03		7.042E+03	1.025E+04	7.151E+03	-0.458
NB-94	1.299E+02		2.043E+02	3.349E+02	1.865E+02	0.388
NB-95	-2.968E+01		3.188E+02	5.440E+02	1.764E+02	-0.055
ZR-95	1.519E+01		6.263E+02	7.838E+02	2.835E+02	0.019
RU-103	1.774E+02		2.506E+02	4.218E+02	1.712E+02	0.421
RU-106	-9.364E+02		1.775E+03	2.884E+03	1.425E+03	-0.325
AG110M	6.725E+01		1.978E+02	3.351E+02	2.195E+02	0.201
SB-125	-4.246E+02		4.683E+02	7.344E+02	2.820E+02	-0.578
BA-133	-2.749E+02		2.028E+02	3.331E+02	3.752E+01	-0.825
CS-134	-1.665E+02		2.015E+02	3.139E+02	1.331E+02	-0.530
CS-137	6.002E+00		2.043E+02	3.506E+02	2.359E+02	0.017
CE-144	3.195E+02		1.384E+03	2.228E+03	1.209E+03	0.143
TL-208	2.540E+03		1.233E+03	1.158E+03	4.896E+02	2.193

95005119.TXT

BI-211	2.706E+03	1.028E+03	1.783E+03	2.098E+02	1.518
PB-211	-1.636E+02	6.846E+03	1.783E+03	2.098E+02	-0.092
PB-212	1.892E+03	7.317E+02	5.969E+02	2.080E+02	3.171
BI-214	8.437E+02	3.549E+02	6.179E+02	7.217E+01	1.365
PB-214	1.190E+03	6.717E+02	7.692E+02	3.403E+02	1.547
RN-219	1.570E+02	1.097E+03	1.895E+03	5.552E+02	0.083

Combined Activity-MDA Report (continued) Page : 2
Sample ID : 95005119 Acquisition date : 29-JAN-1995 20:46:44

---- Non-Identified Nuclides ----

Nuclide	Key-Line Activity (pCi/L)	K.L. Ided	Act error	MDA (pCi/L)	MDA error	Act/MDA
RN-220	-5.417E+04		1.437E+05	2.409E+05	1.007E+05	-0.225
RA-223	6.399E+02		8.614E+02	1.472E+03	4.358E+02	0.435
RA-224	-1.225E+04		5.453E+03	5.566E+03	1.918E+03	-2.202
RA-226	2.086E+04		1.013E+04	7.753E+03	3.384E+03	2.690
TH-227	-5.496E+03		2.257E+03	1.820E+03	6.422E+02	-3.020
AC-228	3.741E+03	+	4.434E+03	1.668E+03	1.881E+03	2.243
PA-231	-1.865E+03		5.132E+03	8.742E+03	1.430E+03	-0.213
PA-234	-4.543E+03		3.403E+03	9.356E+02	6.365E+02	-4.856
TH-234	4.945E+04		3.633E+04	1.197E+04	8.687E+03	4.132
U-234	3.202E+05		4.871E+05	7.007E+05	2.578E+05	0.457
U-235	1.232E+03		6.025E+02	4.700E+02	2.056E+02	2.621
AM-241	-1.207E+03		1.060E+03	1.430E+03	3.416E+02	-0.844

OAK RIDGE
ANALYTICAL SERVICES, INC.

739 Emory Valley Road, Oak Ridge, TN 37830-7017
Voice: (615) 482-1010 • Fax: 481-0454

February 28, 1995

Mr. Rick Grisham
Science and Ecology Group
FAX 376-6247

Dear Mr. Grisham:

I have reviewed the results and am forwarding the following:

1. Glass jar geometry is the most appropriate geometry.
2. Only .0351 was provided for the analysis and this has created some problems.
3. The uncertainties are very large as well and this is an artifact of the sample size.
4. As I recall, the sample not only was small but was not homogeneous. If the "activity" is located in the sediment this compiled with a small sample size could cause anomalous readings.
5. Any inhomogenity in a small sample will "magnify" the results.

If I can provide any additional information please let me know.

Sincerely,

Larry A. Burchfield, Ph. D.

LAB/lat

Scientific Ecology Group, Inc. Oak Ridge, TN

EG&G ORTEC OMNIGAM (143) I3.02.15 01-DEC-94 22:01:51 Page 1

ple No: 94059588

Liquid Sample / AMBWA0010/CUS/Hole B Split
12-1-94 500 ml PH=6 (KW)

nalysis Information:

Start time 01-DEC-94 20:05:58
Live time 1800
Dead time .30%
Oxford Model: CPVDS30-29195 SN: 2443
500 ml Marinelli Beaker on Detector End Cap
Main analysis library: SEG.LIB
Peak rejection level 30.000%
Activity scaling factor 2.7050E-05/ 5.0000E+02 = 5.4100E-08
Decay correct to date NO

[redacted]e Summary:

UCLIDE		ACTIVITY uCi/ml	COUNTING
G-110M	<	6.15E-08	
M-241	<	4.14E-07	
41	<	4.51E-08	
44	<	1.21E-07	
O-57	<	2.70E-08	
O-58	<	3.40E-08	
O-60	<	8.56E-08	
R-51	<	2.20E-07	
S-134	<	2.52E-08	
S-137	<	5.73E-08	
E[redacted]	<	1.08E-07	
[redacted]	<	3.23E-08	
-40	<	4.91E-07	
N-54	<	4.31E-08	
B-94	<	3.06E-08	
B-95	<	2.69E-08	
N-220	<	7.10E-08	
N-222	<	9.39E-08	
U-103	<	3.44E-08	
U-106	<	2.97E-07	
B-125	<	7.44E-08	
N-113	<	5.21E-08	
H-232	<	1.18E-07	
-235	<	4.87E-08	
-238	<	3.34E-06	
N-65	<	8.77E-08	
R-95	<	1.06E-07	

ACTIVITY 0.0000000E+00 uCi/ml

echnician: Paul Ernst Date: 12-1-94

ATTACHMENT 6.1
CHAIN OF CUSTODY RECORD
(example)

Collected by: Kevin Wright **for:** Advanced Medical Systems

Site Contact: Bob Meschter or Kevin Wright
Phone: 216-692-3270

Address: 1020 London Rd.
Cleveland, Ohio 44110

Sample Number	Sample Location	Collection Date	Collection Time	Remarks
058543 AMS-A-000-006	Soil sample Hole 'A' 0"-6"	11-21-94	N/A	See below
058544 AMS-A-006-010	Soil sample Hole 'A' 6"-10"	11-21-94	N/A	for correlation
058545 AMS-B-000-012	Soil sample Hole 'B' 0"-12"	11-22-94	N/A	between the
[redacted] AMS-C-000-006	Soil sample Hole 'C' 0"-6"	11-22-94	N/A	assigned AMS
058547 AMS-C-006-012	Soil sample Hole 'C' 6"-12"	11-22-94	N/A	number and
058548 AMS-B-LIQ-012	Liquid from Hole 'B' 6-12"	11-22-94	N/A	the SEG number.
AMS #	SEG #			
AMS-A-000-006	AMOSL0001			
AMS-A-006-010	AMOSL0002			
AMS-B-000-012	AMOSL0003			
AMS-C-000-006	AMOSL0004			
AMS-C-006-012	AMOSL0005			
AMS-B-LIQ-012	AMOWA0001			

Need Hpge Analysis.

CUSTODY LOG

Name	Date/Time	Name	Date/Time
Collected by K. Wright	11-21-94/N/A	Relinquished by K. Wright Sent by UPS to SEG	11-22-94 1600
Accepted by Keith Oetter	11/28/94 0830	Relinquished by	
Accepted by		Relinquished by	
Accepted by		Relinquished by	
Accepted by		Relinquished by	

ATTACHMENT 6.1
CHAIN OF CUSTODY RECORD
(example)

Collected by: Kevin Wright for: Advanced Medical Systems

Site Contact: Bob Meschter or Kevin Wright
Phone: 216-692-3270

Address: 1020 London Rd.
Cleveland, Ohio 44110

Sample Number	Sample Location	Collection Date	Collection Time	Remarks
9585 AMS-A-LIQ-010	Hole 'A' Liquid Sample	11-29-94	N/A	HpGe analysis
9586 AMS-B-LIQ-012	Hole 'B' Liquid Sample	11-29-94	N/A	required.
9[redacted] AMS-C-LIQ-012	Hole 'C' Liquid Sample	11-29-94	N/A	
9[redacted] AMBWA0010	Hole 'B' Split Sample for QC	11-30-94	N/A	
Sample #	Cross Reference			
AMS #	SEG #			
AMS-A-LIQ-010	AMBWA 0007			
AMS-B-LIQ-012	AMBWA 0008			
AMS-C-LIQ-012	AMBWA 0009			

CUSTODY LOG

Name	Date/Time	Name	Date/Time
Collected by Kevin Wright	11-29-94 1630	Relinquished by	
Accepted by Kristie Ogilvie	12/1/94 1430	Relinquished by Kristie Ogilvie	12/2/94 1310
Accepted by		Relinquished by	
Accepted by		Relinquished by	
Accepted by		Relinquished by	

APPENDIX D

SURVEY RESULTS

BASEMENT

Post-painting, pre-cutting survey

e 11-19-94

Inst. RO-2/LM-177 S/N 6087/47703

cal. date 1-18-95 / 4-18-95

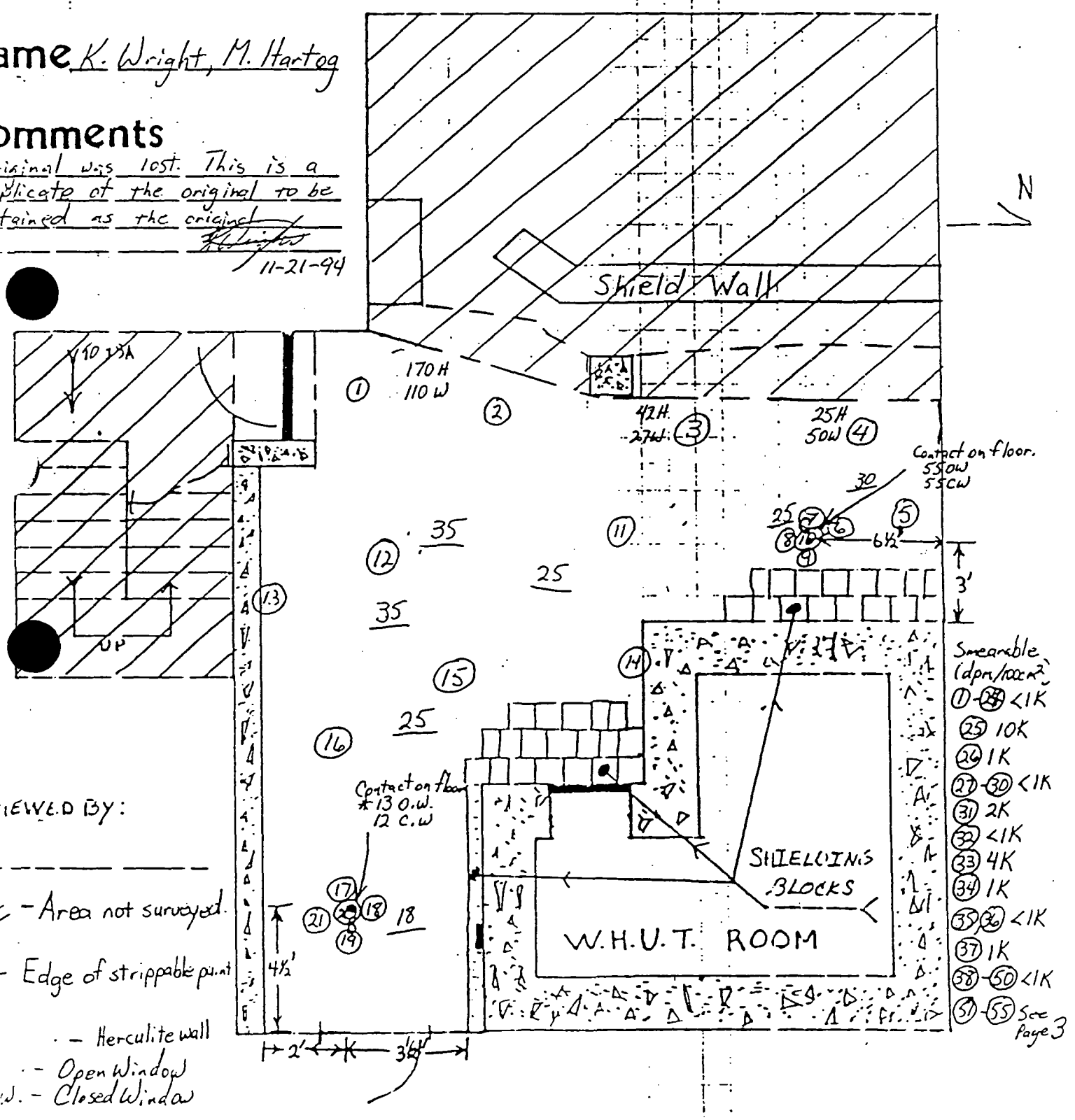
ime 1400

ame K. Wright, M. Hartog

omments

Original was lost. This is a duplicate of the original to be retained as the original

11-21-94



VIEWED BY:

- Area not surveyed.

- Edge of strippable paint

. . - Herculite wall

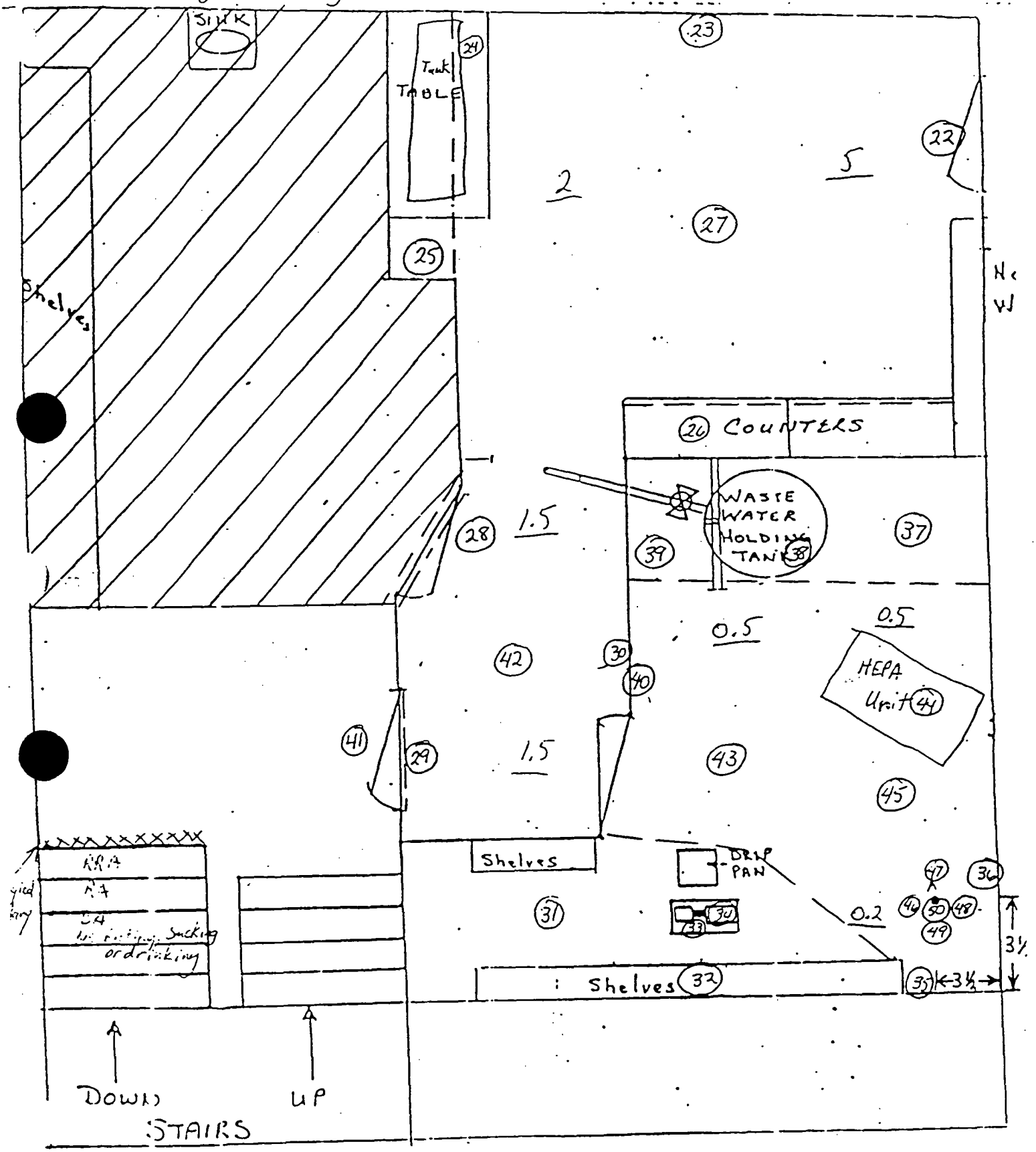
- - Open Window

W. - Closed Window

Date _____ Type of survey Pre-painting, pre-cutting

TIME 1730 Inst RO-2 / LH-177 Comments _____

TECH K. Wright, M. Hartog S/N 6087/47703 Reviewed by _____



Post-painting, pre-cutting survey

LOOSE SURFACE CONTAMINATION SURVEY

1/19/94 INST.: Well Counter S/N: 04896 BKG. 22 CPM

: 1430 CAL. DATE: 1/8/95 C_{eff} .10 %

: V. Rocco AREA/ITEM SURVEYED Hole 'A' Front Basement - Tank Room

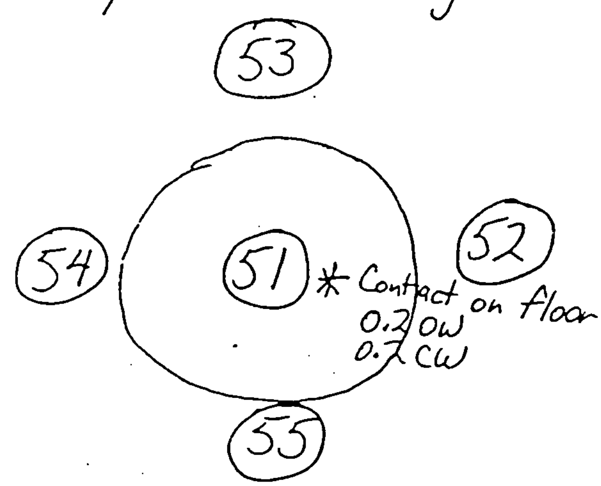
Avg. smear area 100 cm^2

o.	G_{cpm}	C_{cpm}	DPM
1	26	4	40
2	18	ND	ND
3	24	2	20
4	18	ND	ND
5	21	ND	ND

N/A

DRAWING

Hole 'A' location after strippable coating was cut away for cement coring.



$LLD = 2.71 + 3.3\sqrt{\frac{Cb}{Ts} + \frac{Cb}{Tb}}$

LLD = 18.57 cpm or 185.7 dpm

omments Pre-cut survey of floor prior to coring for soil samples.

Reviewed by ______

Time; 1600

Name; M. Hartog

Inst; RO2/LM-177

S/N; 6087/41296 Cal.Date; Due 7-18-95 / 4-18-95

Comments; All smears taken are 100cm² area

All dose rates taken are contact on wall

or ~~4ft~~ not 11-29-94 floor @ wall unless otherwise noted.

Legend; ● contact dose

x= general area waist level

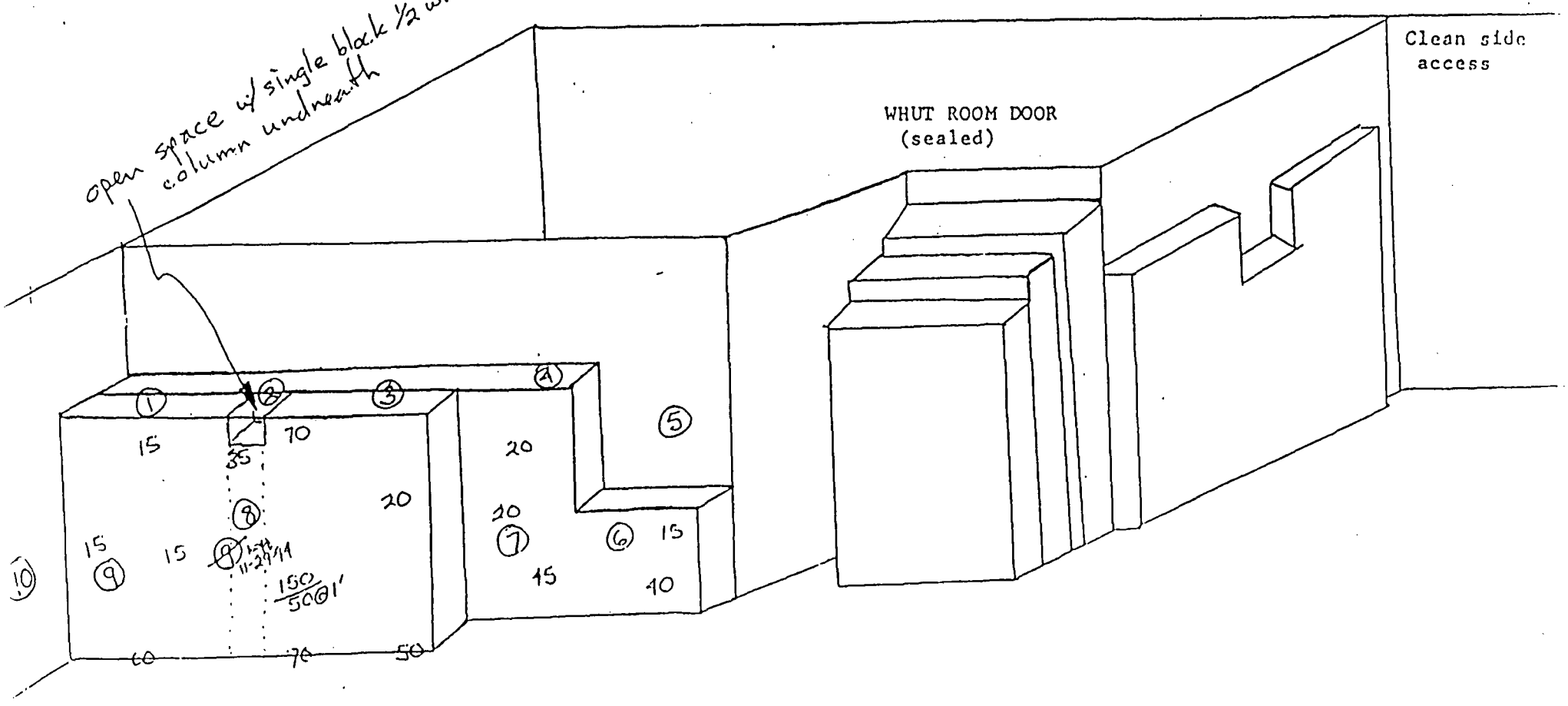
x̲ = general area @ 6' high

Q

Reviewed By; Robert Marcellus

Smears:

1	7K	6	1K
2	20K	7	<1K
3	1K	8	2K
4	1K	9	1.5K
5	1K	10	1.5K



WHUT ROOM SHIELDING/EXPANSION SU [illegible] FORM

Date; 11 -94

Time; 1500

Name; M. Hartog / north

Inst; RO-2

S/N; 6087 Cal.Date; Due 1-18-95

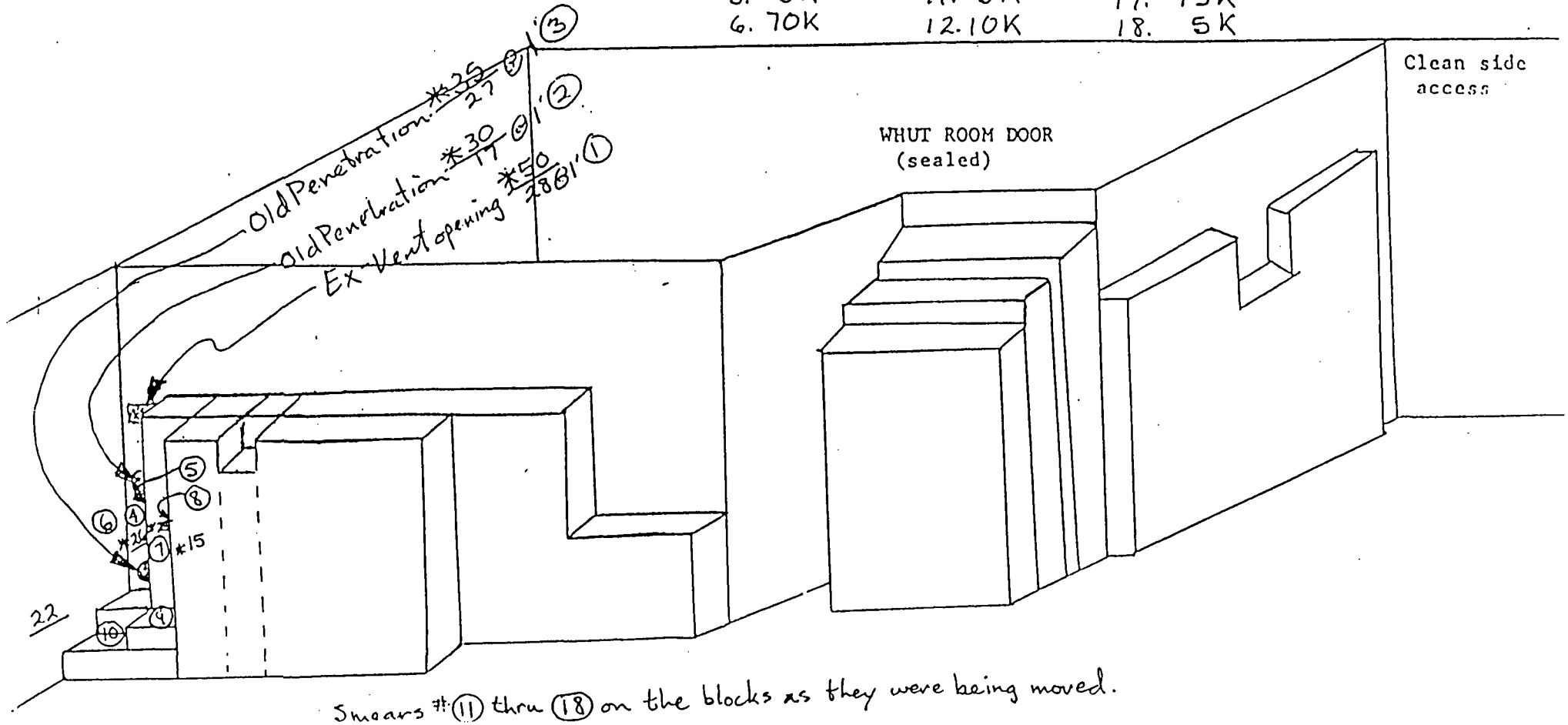
Comments; Penetrations & Vent opening plugged w/ Pb & grouted closed. Area over old penetrations on wall & blocks covered w/ herculite, w holes cut to expose old penetrations

Legend; * = contact dose
x = general area waist level
x = general area @ 6' high

Reviewed By; R Meredith

Contamination Levels (K = X1000) Lvls in dpm/100cm²

1. 3K	7. 5K	13. 100K
2. 1K	8. 10K	14. 50K
3. 2K	9. 10K	15. 100K
4. 20K	10. 100K	16. 10K
5. 5K	11. 5K	17. 15K
6. 70K	12. 10K	18. 5K



Smears #(11) thru (18) on the blocks as they were being moved.

Date; 12-14

Resealing WHUT [redacted] Penetrations.

Time; 1200

Name; Kevin Wright

Inst; RO-2

S/N; 6087, 41296 Cal.Date; 1-18-95, 4-18-95

Legend; *[redacted]/# = Contact dose rate/1' Dose Rate/. Rate.
x= general area waist level
x = general area @ 6' high
@ Dose Rates are in mR/hr

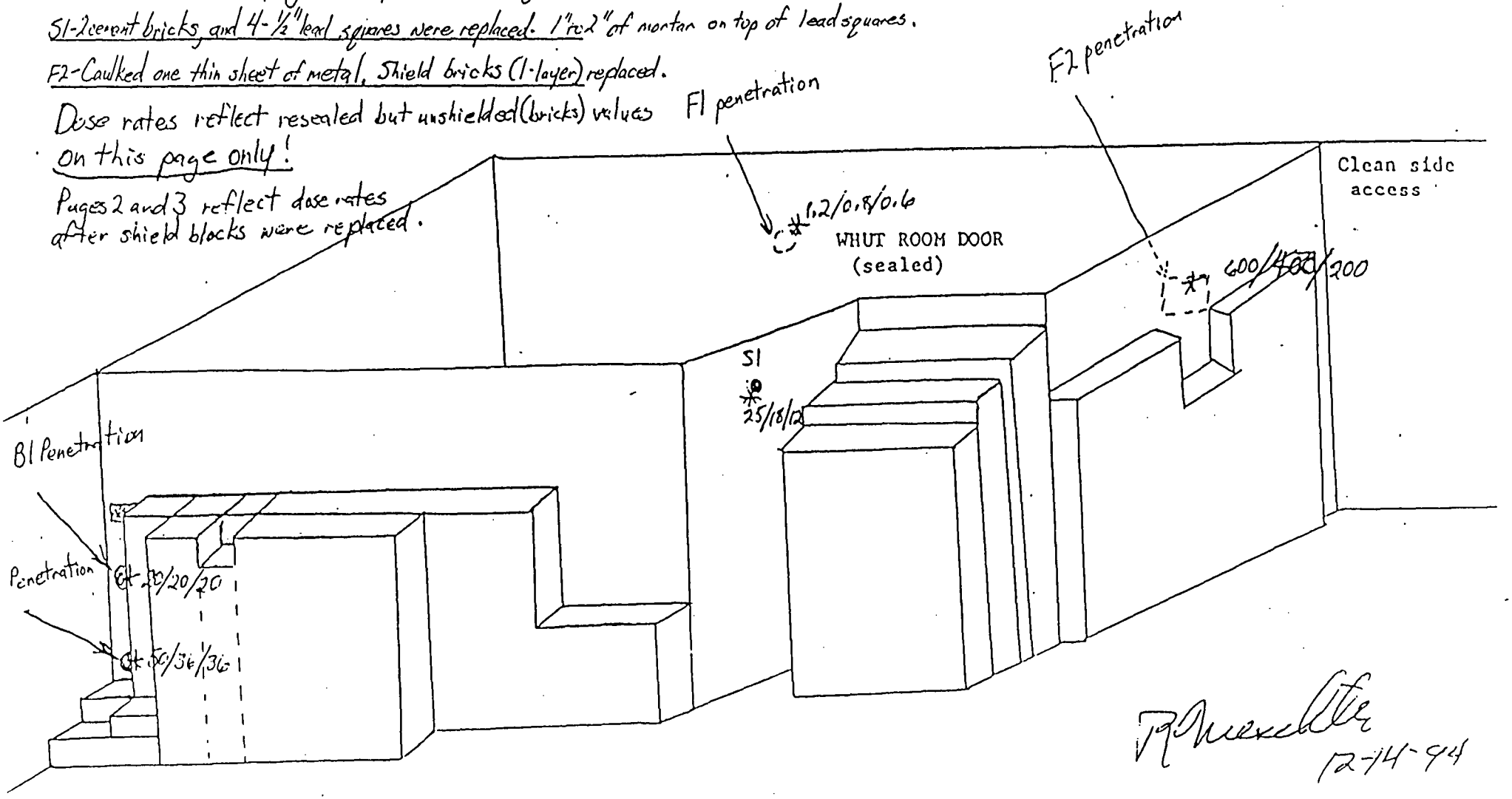
Comments; F1 - Pipe restuffed with lead wool. Mortar placed around pipe. Reviewed By: _____

B1+B2 - Former cement plug (6" to 8") replaced in hole. Edges have lead rope/caulk. Two to 3" of mortar seal the front of the plug. Shield bricks were replaced (2-layers). S1-2 cement bricks, and 4-½" lead squares were replaced. 1"x2" of mortar on top of lead squares.

F2 - Caulked one thin sheet of metal, Shield bricks (1-layer) replaced.

Dose rates reflect resealed but unshielded (bricks) values on this page only!

Pages 2 and 3 reflect dose rates after shield blocks were replaced.



12-14-94

BASEMENT

Date 12-14-94

Inst. RO-2, L-177 S/N 6087, 41296

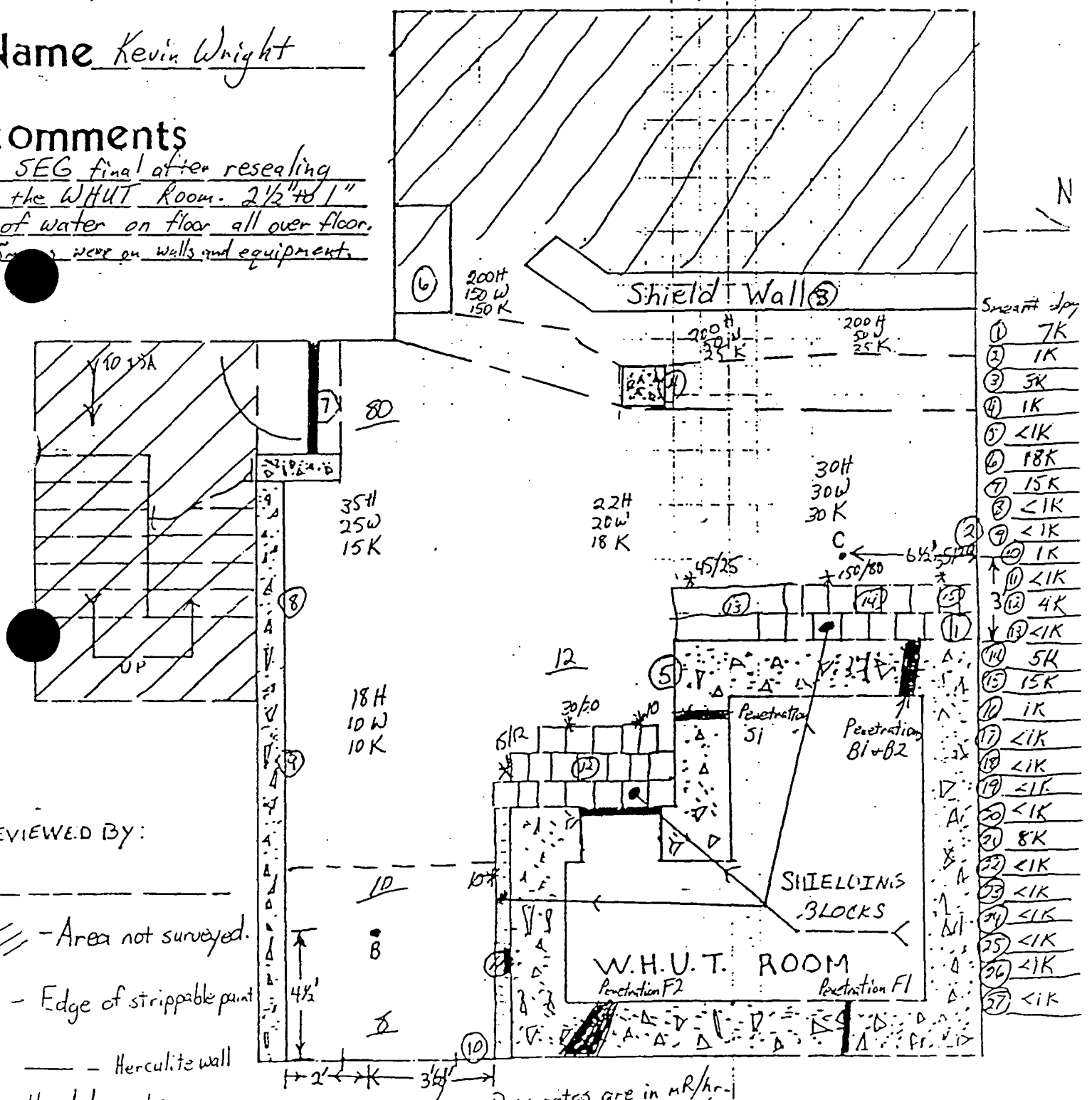
cal. date 4-18-95, 4-18-95

Time 1200

Name Kevin Wright

comments

SEG final after resealing the WHUT Room. 2½" to 1" of water on floor all over floor. Smears were on walls and equipment.



Smear # dpm

1	7K
2	1K
3	5K
4	1K
5	<1K
6	18K
7	15K
8	<1K
9	<1K
10	1K
11	<1K
12	4K
13	<1K
14	5K
15	15K
16	1K
17	<1K
18	<1K
19	<1K
20	<1K
21	8K
22	<1K
23	<1K
24	<1K
25	<1K
26	<1K
27	<1K

REVIEWED BY:

// - Area not surveyed.

\- Edge of strippable paint

____ - Herculite wall

1 - Head dose rate
- Waist dose rate
- Knee dose rate

Dose rates are in mR/hr

*#/#/# - Contact dose rate / 1' Dose rate / 3' Dose rate

Date 12-14-94

TIME 1200

TECH Kevin Wright

Type of survey SEG final after resealing WHUT floor

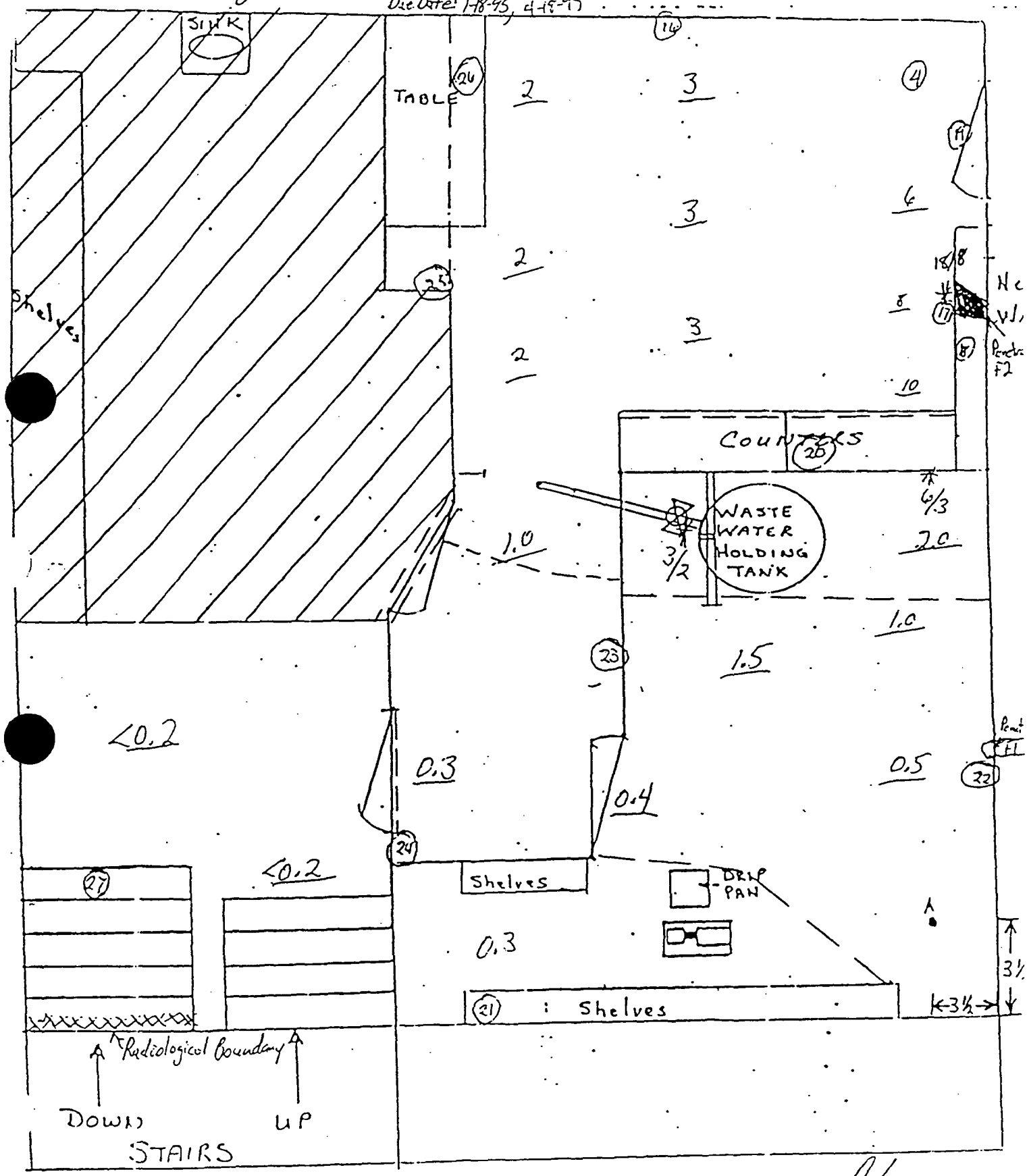
Inst Ko-2, 4177

S/N 6087, 41296

Comments See Page 2

Reviewed by

Due Date: 1-18-95, 4-19-95



R Meschter
12-14-94

APPENDIX E

VIDEO TAPE

DOCUMENT 8

Letter to Advanced Medical Systems, Inc., Attn: David Cesar, Treasurer from John A. Grobe, Chief, Nuclear Materials Inspection Section 2, Re: Review of Decommission Funding Plan, March 13, 1995.

Grote

March 13, 1995

Advanced Medical Systems, Inc.
ATTN: David Cesar
Treasurer
121 North Eagle Street
Geneva, OH 44041

Dear Mr. Cesar:

We have completed our review of your Decommissioning Funding Plan submitted with your application for renewal of NRC License No. 34-19089-01, and find that we will need additional information as noted below:

1. **Revise Exhibit A to the Standby Trust Agreement to Reflect All Costs Assured (*Regulatory Guide 3.66*, page 4-26)**

   Exhibit A to your standby trust agreement has not been revised to reflect the increase in the amount of financial assurance from $750,000 to $1,800,000. As a result, the standby trust allows the trustee to make payments of only $750,000, rather than $1,800,000, towards the decommissioning of the facility. *Regulatory Guide 3.66* "Standard Format and Content of Financial Assurance Mechanisms Required for Decommissioning Under 10 CFR Parts 30, 40, 70, and 72" (June 1990), page 4-26, recommends that Schedule A (which corresponds to the submitted Exhibit A) list the amount of financial assurance demonstrated by the standby trust agreement. To ensure that the standby trust provides adequate financial assurance to NRC, revise Exhibit A to reflect the full amount of the current cost estimate.

2. **Revise the Standby Trust Agreement as Needed to Correctly Identify the Address of the Licensed Facility**

   Section 2 of the revised standby trust agreement states that the agreement pertains to the costs "... for the facility identified on Exhibits 'A' and 'A-1.'" The two exhibits appear to reference different facilities, however. Exhibit A identifies the address of the licensee as 1020 London Road, whereas Exhibit A-1 defines the facility as the plant located at 1120 London Road. To ensure that the trustee has the information needed to administer the standby trust, revise the standby trust agreement as needed to correctly identify the address of the licensed facility.

(3) **Submit Evidence Indicating that the Party Signing the Standby Trust Agreement for the Licensee is Authorized to Represent the Company *(Regulatory Guide 3.66*, page 3-14)**

The submission does not provide any evidence indicating that the party signing the mechanism is authorized to enter into a standby trust agreement for the licensee, as recommended in *Regulatory Guide 3.66*, page 3-14. Evidence of authority to represent the licensee is necessary to ensure the validity and enforceability of the mechanism. Submit a copy of the corporate by-laws or other evidence indicating that the party signing the standby trust agreement is authorized to do so.

We also have some concerns regarding your cost estimate for decommissioning your facility. However, these issues will be discussed in another deficiency letter which will address the technical issues of your application for renewal.

We will continue our review of your application upon receipt of this information. Please reply in duplicate, within 15 days, and refer to Control Number 00209.

If you have any questions or require clarification on any of the information stated above, you may contact us at (708) 829-9887.

Sincerely,

Original Signed by John A. Grobe

John A. Grobe, Chief
Nuclear Materials Inspection Section 2

Enclosure: Regulatory Guide 3.66

See Attached Distribution

DOCUMENT NAME: G:\LTRS2LIC\MTLS\030\953016055.L16

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DATE	03/13/95		03/13/95		03/13/95					

OFFICIAL RECORD COPY

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Radiation Safety Officer
Advanced Medical Systems, Inc.
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Geneva, OH 44041

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DOCUMENT 9

Materials License No. 34-19089-01, as amended, March 17, 1995.

MATERIALS LICENSE

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter I, Parts 30, 31, 32, 33, 34, 35, 36, 39, 40, and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations, and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

Licensee	In accordance with letter dated March 1, 1995,
1. Advanced Medical Systems, Inc.	3. License Number 34-19089-01 is amended in its entirety to read as follows: 39849
2. 1020 London Road Cleveland, OH 44110	4. Expiration Date December 31, 1994
	5. Docket or Reference No. 030-16055/040-08764/030-17154

6. Byproduct, Source, and/or Special Nuclear Material	7. Chemical and/or Physical Form	8. Maximum Amount that Licensee May Possess at Any One Time Under This License
A. Cobalt-60	A. Solid Metal	A. 150,000 curies
B. Cobalt-60	B. Sealed sources (teletherapy/ radiography sealed sources which have been evaluated and approved for commercial distribution by the NRC or an Agreement State)	B. 135,000 curies (no single source to exceed 13,700 curies)
C. Cesium-137	C. Sealed sources (teletherapy/ radiography sealed sources which have been evaluated and approved for commercial distribution by the NRC or an Agreement State)	C. 40,000 curies (no single source to exceed 2,200 curies)
D. Depleted Uranium	D. Nickel Plated	D. 4,040 kilograms
E. Cobalt-60	E. Sealed Sources	E. 15,000 curies

COPY

3

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License Number
34-19089-01

Docket or Reference Number
030-16055/040-08764/030-17154

Amendment No. 32

6. Byproduct, source, and/or special nuclear material	7. Chemical and/or physical form	8. Maximum amount that licensee may possess at any one time under this license
F. Cobalt-60	F. Sealed Sources (any sealed source approved by the NRC or an Agreement State)	F. 15 millicuries

9. Authorized Use:

A. For storage only incident to waste disposal or transfer to an authorized recipient. This license does not authorize the manufacture of sealed sources.

B. For installation, maintenance of, dismantling and servicing of Picker Corporation and Advanced Medical Systems, Inc. teletherapy units and Picker Model 6145 radiography units possessed by licensees authorized to possess the radioactive material pursuant to a specific license issued by the Commission or an Agreement State. For installation and removal of sealed sources into Picker Corporation, Advanced Medical Systems, Inc. and Keleket Barnes teletherapy units of licensees authorized to possess the radioactive material pursuant to a specific license issued by the Commission or an Agreement State. For training Hospital or Clinic personnel for in-house service operations on teletherapy equipment, on unit model per course, in accordance with letter dated August 15, 1988 and September 29, 1988.

C. For installation, maintenance, dismantling and servicing of Picker Corporation and Advanced Medical Systems radiography and teletherapy units of licensees authorized to possess the radioactive material pursuant to a specific license issued by the Commission or an Agreement State.

D. Shielding material in Picker Corporation and Advanced Medical System, Inc., radiography and teletherapy devices.

E. For storage only, those non-NRC approved sources in the possession of the licensee prior to the issuance of this amendment.

F. For use in devices (including Tech OP Model 571 Calibrator described in application dated November 12, 1984) approved by the Nuclear Regulatory Commission or an Agreement State to calibrate radiation survey instruments.

CONDITIONS

10. Licensed material in Items 6.A., 6.E. and 6.F. shall be used only at the licensee's facility at 1020 London Road, Cleveland, Ohio. Licensed material in Items 6.B. and 6.C. shall be used only at 1020 London Road, Cleveland, Ohio and at facilities of customers who possess a specific license from the NRC authorizing possession of the licensed material. Licensed material in Item 6.D. shall be used only at the licensee's facilities at 1020 London Road, Cleveland, Ohio or 121 North Eagle Street, Geneva, Ohio, and at facilities of customers who possess a specific license from the NRC authorizing possession of the licensed material.

11. A. The Radiation Protection Officer for service operations described in Subitems 9.B. and 9.C. and routine health physics activities is Robert Meschter.

The licensee shall not perform service operations described in Subitems 9.B. and 9.C. until Robert Meschter has completed the required training.

B. Licensed material shall be used by, or under the supervision of and in the physical presence of users listed in the table below. The users are only authorized to perform the indicated services on the teletherapy or radiography units specified in the table below:

AMS/PICKER TELETHERAPY/RADIOGRAPHY UNITS MODELS

	CS 600	C 1000	C 2000	C 3000	C 5000	C 10,000	C4	C8	C9	C12	Cyclops
USER											
Curtis Perry				3	1,2	1,2	1,2	1,2	1,2		1,2
Haddock	5	5	5	5	5	5	5	5	5	5	5

AMS/PICKER TELETHERAPY/RADIOGRAPHY UNITS MODELS

	V 1000	V 2000	V 3000	V 10,000	C V4	C V9					
USER											
Curtis Perry		1,2	1,2	1,2	1,2	1,2					
Haddock	5	5	5	5	5	5					

11. (Continued)

1. Authorizes the servicing of AMS/Picker units, excluding source exchange.
2. Authorizes sealed source exchange.
3. Authorizes removal of unit and head from customer sites only.
4. Authorizes the training of AMS personnel in the manufacture of AMS/Picker sealed sources.
5. Authorizes the handling of sealed sources only.

12. A. (1) Each sealed source acquired from another person and containing licensed material, other than hydrogen-3, with a half-life greater than 30 days and in any form other than gas shall be tested for contamination and/or leakage before use. In the absence of a certificate from a transfer or indicating that a test has been made within 6 months before the transfer, a sealed source received from another person shall not be put into use until tested.

(2) Notwithstanding the periodic leak test required by this condition, any licensed sealed source is exempt from such leak tests when the source contains 100 microcuries of less of beta and/or gamma emitting materials or 10 microcuries or less of alpha emitting material.

(3) Except for alpha sources, the periodic leak test required by this condition does not apply to sealed sources that are stored and not being used. The sources excepted from this test shall be tested for leakage before any use or transfer to another person unless they have been leak tested within 6 months before the date of use or transfer.

B. Each sealed source fabricated by the licensee shall be inspected and tested for construction defects, leakage, and contamination prior to use or transfer as a sealed source. If the inspection or test reveals any construction defects or 0.005 microcurie or greater of contamination, the source shall not be used or transferred as a sealed source until it has been repaired, decontaminated and retested.

C. Each sealed source containing licensed material, other than hydrogen-3, with a half-life greater than 30 days and in any form other than gas shall be tested for leakage and/or contamination at intervals not to exceed 6 months except that each source designated for the purpose of emitting alpha particles shall be tested at intervals not to exceed 3 months.

D. The test shall be capable of detecting the presence of 0.005 microcurie of radioactive material on the test sample. The test sample shall be taken from the sealed source or from the surfaces of the device in what the sealed source is permanently or semi-permanently mounted or stored on which one might expect contamination to accumulate. Records o leak test results shall be kept in units of microcuries and maintained for inspection by the Commission. Records may be disposed of following Commission inspection.

12. (Continued)

E. If the test required by Subsection A. or C. of this condition reveals the presence of 0.005 microcurie or more of removable contamination, the licensee shall immediately withdraw the sealed source from use and shall cause it to be decontaminated and repaired or to be disposed of in accordance with Commission regulations. A report shall be filed within 5 days of the date the leak test result is known with the U.S. Nuclear Regulatory Commission, Region III, 801 Warrenville Road, Lisle, Illinois 60532-4351, ATTN: Chief, Nuclear Materials Safety Branch, describing the equipment involved, the test results, and the corrective action.

13. The licensee may transport licensed material in accordance with the provisions of 10 CFR Part 71, "Packaging and Transportation of Radioactive Material."

14. Inventory Requirements:

A. An inventory system will be established that accounts for the receipt, movement, transfer and disposal of all radioactive material possessed under this license. Records of inventories will be maintained for 10 years from the date of each inventory.

B. A complete examination of records will be completed every six months to confirm the location of all radioactive material and ensure that possession is within the limits specified in this license.

C. A physical inventory of all radioactive material possessed under this license will be conducted on or before June 1, 1993. Thereafter, a physical inventory of all radioactive material possessed under this license will be completed within 60 months of the previous physical inventory.

15. The licensee's field service audits (as described in the ATC Medical Group Management Plan, revised April 1, 1989, and submitted with letter dated April 17, 1989) shall be performed unannounced by the Radiation Protection Officer (i.e., Radiation Safety Officer).

16. The licensee shall follow the recommend survey frequencies outlined in Regulatory Guide 8.21, Revision 1, October 1979, in work areas where radioactive materials are handled or used.

17. The licensee shall maintain records of information important to safe and effective decommissioning at 1020 London Road, Cleveland, Ohio per the provisions of 10 CFR 30.35(g) until this license is terminated by the Commission.

18. The licensee shall maintain and execute the response measure of their Emergency Plan dated October 25, 1991 and revised January 1992, May 27, 1992 and April 26, 1993. The licensee shall make no change in the emergency plan submitted pursuant to 10 CFR [30.32(i), 40.31(j), 70.22(i)] that would decrease the effectiveness of the plan without prior Commission approval. The licensee may make changes to its Emergency Plan without prior Commission approval if the changes do not decrease the effectiveness of the plan. The licensee shall maintain records of changes that are made to the plan without prior approval for a period of three years from the date of the changes and shall furnish the Chief, Medical, Academic, and Commercial Use Safety Branch, Division of Industrial and Medical Nuclear Safety, NMSS, U.S. Nuclear Regulatory Commission, Washington, DC 20555, and the appropriate NRC Regional Office specified in Appendix D of 10 CFR 20, a report, within six months after the change is made, containing a description of each change.

19. The licensee is authorized to begin the following activities no sooner than March 17, 1995, and must complete them within 90 days after March 17, 1995 in accordance with letters dated January 27, February 2, 10, and 14, and March 1, 3, 8, and 10, 1995, wherein the licensee proposed and clarified its plans and schedules for: (1) dealing with the accumulation of ground water in and around its facility basement; (2) immobilizing and/or remediating contamination that has collected in below ground sewer piping and manholes; and (3) processing future ground water that builds up around the facility. These plans and schedules address the following actions the licensee will take.

    A. Process water that is currently stored outside its facility in above-ground tanks.

        i. Tanked water will be processed in-situ using a submersible water treatment system that includes filtration and ion-exchange demineralization as described in letters dated March 1, 3, 8, and 10, 1995.

        ii. Water will be treated until it contains no detectable non-soluble cobalt-60 and less than 200 pCi/l of soluble cobalt-60 as determined by a contract analytical laboratory. The treated water will subsequently be pumped to 25,000 gallon storage containers located in the facility warehouse, as described in letters dated March 3, 8 and 10, 1995.

    B. Simultaneously pump and process water currently residing in the sewer manhole and lateral, building sump pit and basement.

        i. Pumping will be sequenced as described in letter dated March 1, 1995, to ensure a positive hydrostatic pressure is maintained from outside to inside the facility's basement.

        ii. Water in the sewer manhole, lateral, building sump pit, and basement will be pumped to a radiologically controlled area of the facility and processed using a skid mounted, multi-stage filtration and ion-exchange system as described in letters dated March 1, 3, 8 and 10, 1995. Spill procedures and radiological controls will be implemented as described in letter dated February 14, 1995, and Attachment 2 to letter dated March 1, 1995.

19. (Continued)

iii. Water removed from the sewer manhole, lateral, building sump pit, and basement will be treated to contain no detectable non-soluble cobalt-60 and less than 200 pCi/l soluble cobalt-60 as determined by a contract analytical laboratory. The treated water will subsequently be pumped to 25,000 gallon storage containers located in the facility warehouse, as described in letters dated March 3, 8, and 10, 1995.

C. Water sampling and analytical protocols will be as described in letter dated February 2, 1995, as clarified in letters dated February 14, and March 3, 1995. Solubility of cobalt-60 in samples containing detectable activity will be demonstrated in accordance with the reference in Supplement 2 to letter dated March 3, 1995. All solid radwaste generated from the water processing activities, including filter and demineralizer resin wastes, will be collected and stored at the London Road facility pending its ultimate disposal as radioactive waste.

D. Excavate areas around the facility to allow: (i) access to the radioactively contaminated four-inch waste discharge line; and (ii) the radiological evaluation of the facility's underdrain system and surrounding soils.

i. Excavate the soil in the vicinity of the building's four-inch waste discharge line and underdrains and disconnect these drains as described in letter dated March 1, 1995. Evaluate the radiological contamination status of the underdrain system and remediate or replace the system. Reconnect the underdrain system to the building sump pit and pump, test and process the underdrain system waters as described in letter dated March 1, 1995. The testing and processing of water pumped from the underdrain system will continue until sampling of the water consistently reveals no detectable non-soluble cobalt-60 and less than 200 pCi/l soluble cobalt-60.

ii. Evaluate the radiological status of the soil in the vicinity of the underdrain system and building sump pit as described in the letter dated March 1, 1995.

E. Immobilize the radioactive contamination present in the sewer manhole, lateral and four-inch discharge line.

i. Completely grout-in the radioactively contaminated four-inch sewer discharge line and the manhole and lateral up to the sewer interceptor as described in "Issue 4" of letter dated January 27 and letter dated March 1, 1995. The grouting will render the existing sewer discharge piping system inoperable and immobilize (fix) the radioactive contamination that resides in the system.

ii. Develop and implement a sub-surface radiological monitoring program to assess contamination migration as described in letter dated February 10, 1995. The program must be submitted in writing and approved by the NRC.

F. Remediate the London Road interceptor in the vicinity of the abandoned lateral, as described in letter dated January 27, 1995. The remediation activities will be coordinated with the Northeast Ohio Regional Sewer District.

20. Except as specifically provided otherwise in this license, the licensee shall conduct its program in accordance with the statements, representations, and procedures contained in the documents including any enclosures, listed below. The Nuclear Regulatory Commission's regulations shall govern unless the statements, representations and procedures in the licensee's application and correspondence are more restrictive than the regulations.

A. Application dated November 12, 1984;

B. Letters dated November 12, 1984 (excluding Item 4), February 12, 1985, June 7, 1985 (excluding letter Item 4), September 6, 1985 (excluding change to Page 29 of ISP-1 manual);

C. Letters dated May 29, 1986 (Response to Enclosure A, Significant Licensing Deficiencies of NRC letter dated March 7, 1986);

D. Letter dated July 23, 1986 (Response to Enclosure B, Additional Licensing Issues for Renewal Applications of NRC letter dated March 7, 1986) excluding approval of the licensee's in-house training program;

E. Letters dated August 22, 1986, October 28, 1986, November 13, 1986, November 14, 1986 and December 4, 1986 (with Revised ISP-1 Manual, Appendices A and B attached), May 7, 1987, August 3, 1987, December 31, 1987, January 15, 1988 (Item V only), August 15, 1988 (with attached course manual), September 29, 1988 (with attachments) and November 21, 1988; and

F. Letters dated March 29, 1989 (except Section 3.4 "Hot Cell Entry and Action Levels"), April 7, 1989, August 25, 1989 (except Item B(4)), July 23, 1990 (except Sections 3.0 and 5.0 of ISP-14 procedure), March 1, 1991 (with attachments), March 27, 1991 (with attachments), May 9, 1991, May 14, 1991, February 27, 1992, February 28, 1992, March 2, 1992, and March 5, 1992.

G. Letters dated April 16, 1992 (with enclosures), June 15, 1992 (with attachments), August 10, 1992, September 18, 1992, December 29, 1992 (with enclosures), January 20, 1993, March 30, 1993, March 31, 1994 (with enclosure), April 11, 1994, and September 21, 1994.

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License Number
34-19089-01

Docket or Reference Number
030-16055/040-08764/030-17154

Amendment No. 32

20. (Continued)

H. Letters with attachments dated January 27, 1995, February 2, 10, and 14, 1995, and March 1, 3, 8, and 10, 1995.

Notwithstanding any reference to the specific activities in the above listed letters, the following activities are not addressed by this license.

i. The evaporation of treated water or its discharge to the sanitary sewer system.

ii. Installation of a composite sampler and flow gage.

iii. Conventional disposal of excavated soils exhibiting cobalt-60 concentrations greater than 8 pCi/g.

iv. Re-connection of the foundation underdrain system to the proposed new manhole and lateral.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Date March 17, 1995

By Joseph F. Pierson
Materials Licensing Section, Region III

DOCUMENT 10

Letter to Advanced Medical Systems, Inc., Attn: David Cesar, Treasurer from John A. Grobe, Chief, Nuclear Materials Inspection Section 2, Re: Cost Estimate for Decommissioning, March 30, 1995.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
801 WARRENVILLE ROAD
LISLE, ILLINOIS 60532-4351

March 30, 1995

Advanced Medical Systems
ATTN: David Cesar
Treasurer
121 North Eagle Street
Geneva, OH 44041

Dear Mr. Cesar:

We have completed our review of your cost estimate for decommissioning the London Road site and are concerned that your estimate of 1,795,612 dollars may not reflect the actual cost to decommission the facility. Overall, our concerns can be summarized as follows: (1) the cost estimate is based on the assumption that the soil under the building is not contaminated, (2) the cost for disposal of solid radioactive waste is based on a cost of $181 per cubic foot, (3) the decommissioning plan does not anticipate demolition of the building, and (4) the decommissioning plan contemplated that the W.H.U.T. Room will not require remote decontamination techniques.

Based on recent water problems at the facility, three additional issues may significantly impact the cost of decommissioning the London Road site. The three issues are: (1) the water may have structurally damaged some parts of the building which would need to be considered in the decommissioning plan, (2) the basement floor slab including the W.H.U.T Room floor, may have to be removed due to further intrusion of contamination into the concrete, and (3) the contaminated water may have migrated causing soil contamination. Based on past experience, the impact of having to remove and dispose of contaminated concrete and soil may cause the cost estimate for the London Road site to be greater than the initial estimate.

Section 4.1 of your submittal entitled "Cost Modifying Factors", states that the cost of radwaste processing, shipping, and disposal account for about 20 percent of the total decommissioning cost. This is based on a disposal cost of $181 per cubic foot. Based on current data from other regional compacts, a more realistic disposal cost would be $400 to $450 per cubic foot, resulting in an increase of 20 to 25 percent over your current estimate. Due to the fact that the Midwest Compact disposal site has not been selected in Ohio, the $400 to $450 cost range per cubic foot may be a reasonable estimate.

In order for the NRC to have a reasonable level of confidence in your cost estimate, please submit a detailed structural evaluation of the existing building, and perform a more detailed characterization of the extent of any concrete and soil contamination. Also, include in your estimate any special remote decontamination techniques that will be utilized to clean the W.H.U.T. room. Finally, please re-evaluate your estimate for the cost of disposal of radioactive waste.

Please submit your response within 30 days of the date of this letter. If you have any questions or require clarification on any of the information stated above, please do not hesitate to contact Kevin Null of my staff at (708) 829-9854.

Sincerely,

John A. Grobe
Nuclear Materials Inspection
Section 2

License No.: 34-19089-01
Docket No.: 030-16055

DOCUMENT 11

Letter to Advanced Medical Systems, Inc., Attn: David Cesar, Treasurer from John A. Grobe, Chief, Nuclear Materials Inspection Section 2, Re: Emergency Plan and Notice of Violation, March 31, 1995.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
801 WARRENVILLE ROAD
LISLE, ILLINOIS 60532-4351

March 31, 1995

Advanced Medical Systems, Inc.
ATTN: David Cesar
Treasurer
121 North Eagle Street
Geneva, OH 44041

Dear Mr. Cesar:

This refers to the March 29, 1995 telephone conversation between you, me, Messrs. Wayne Slawinski and Kevin Ramsey of the NRC staff, regarding your Emergency Plan (Plan) for responding to a release of radioactive material. The Plan was submitted with your revised application for license renewal on January 26, 1995.

The conversation disclosed that Advanced Medical Systems, Inc. had not allowed offsite response organizations the opportunity to comment on the revised Plan prior to its submission to the NRC. Your failure to provide the Plan to offsite response organizations before submitting it to the NRC is a violation of NRC requirements, as described in the enclosed Notice.

Based on our conversation, we understand that you will submit the Plan to the following organizations by April 1, 1995, and solicit their comments:

- Ohio Emergency Response Commission
- Ohio Emergency Management Agency
- Cuyahoga County Local Emergency Planning Commission
- Cleveland Police and Fire Departments
- Cleveland Emergency Medical Services
- Local Hospital(s)

The above listed organizations will be allowed 60 days to comment on the Plan and their comments will be provided to the NRC as required by 10 CFR 30.32(i)(4). Further, you indicated that the letters for those organizations would be sent registered mail with a copy to NRC Region III.

Since you committed to take appropriate action to correct this problem, no written reply to the violation is required and we have no further questions regarding this matter at this time.

In accordance with 10 CFR 2.790 of the Commission's regulations, a copy of this letter and the enclosure will be placed in the NRC Public Document Room.

We will gladly discuss any questions you have concerning this matter.

Sincerely,

J. A. Grobe, Chief
Nuclear Materials Inspection
Section 2

License No.: 34-19089-01
Docket No.: 030-16055

Enclosure: Notice of Violation

cc w/encl: T. Ploski, RIII

NOTICE OF VIOLATION

Advanced Medical Systems, Inc.
Geneva, Ohio

License No. 34-19089-01
Docket No. 030-16055

During an NRC review of your license renewal application, a violation of NRC requirements was identified. In accordance with the "General Statement of Policy and Procedure for NRC Enforcement Actions," 10 CFR Part 2, Appendix C (1995), the violation is listed below:

10 CFR Part 30.32(i)(4) requires that the licensee allow the offsite response organizations expected to respond in case of an accident 60 days to comment on the licensee's emergency plan, prepared pursuant to paragraph 30.32(i)(1), before submitting it to the NRC. The licensee shall provide any comments received within the 60-days to the NRC with the emergency plan.

Contrary to the above, the licensee failed to allow offsite response organizations expected to respond in case of an accident 60 days to comment on the licensee's emergency plan, which was submitted to the NRC along with your revised application for license renewal on January 26, 1995.

This is a Severity Level IV violation (Supplement VI).

The inspection showed that steps had been taken to correct the identified violation(s) and to prevent recurrence. Consequently, no reply to the violation(s) is required and we have no further questions regarding this matter.

Dated at Lisle, Illinois
this 31 day of March 1995

DOCUMENT 12

Letter to Distribution List from David Cesar, Treasurer, Advanced Medical Systems, Inc., Re: Enclosing copies of AMS' Emergency Plan, March 31, 1995.

Zobler

Advanced Medical Systems, Inc.

121 North Eagle Street • Geneva, Ohio 44041
(216) 466-4671 FAX (216) 466-0186

March 31, 1995

VIA: USPS CERTIFIED MAIL

DISTRIBUTION: PLEASE SEE ATTACHED LIST

To Whom it May Concern:

Enclosed please find a copy of Advanced Medical Systems, Inc.'s Emergency Plan which includes a hazardous assessment for our facility at 1020 London Road, Cleveland, Ohio. Please review this plan and respond to me by May 31, 1995.

If you have any questions, please do not hesitate to contact me.

Sincerely,

DC/cs

DAVID CESAR
Treasurer

DC/cs
Enclosures

cc: John A. Grobe, USNRC Region III
w/o enclosure

Emer Plan in Previous letter to NRC

APR 4 1995

Advanced Medical Systems, Inc.

121 North Eagle Street • Geneva, Ohio 44041
(216) 466-4671 FAX (216) 466-0186

DISTRIBUTION LIST FOR ADVANCED MEDICAL SYSTEMS, INC.'S EMERGENCY PLAN:

Cuyahoga Emergency Management Assistance Center
1255 Euclid Avenue
Cleveland, Ohio 44115-1807
ATTN: Mr. Michael S. Kalstrom, Secretary
Cuyahoga County Local Emergency Planning Committee

University Hospital of Cleveland
11100 Euclid Avenue
Cleveland, Ohio 44106
ATTN: Dr. Rao

ATTN: Mr. Lloyd T. Root, Chief
Fire Marshal
City of Cleveland
1645 Superior Avenue
Cleveland, Ohio 44114

Cleveland City Police Department
601 Lakeside Road
Room 230
Cleveland, Ohio 44114
ATTN: Commander Robert Cermak

Ohio Emergency Management Agency, Inc.
ATTN: Mr. James Williams
Radiological Branch Chief
2825 West Dublin-Granville Road
Columbus, Ohio 43235-2206

DC/cs
03/31/95

DOCUMENT 13

Letter to Mr. John A. Grobe, Chief, Nuclear Materials Inspection, Section II, U.S. Nuclear Regulatory Commission From David Cesar, Treasurer, Advanced Medical Systems, Inc., Re: Modified and Restated Decommissioning Trust, March 31, 1995 (with enclosures).

Advanced Medical Systems, Inc.

121 North Eagle Street • Geneva, Ohio 44041
(216) 466-4671 FAX (216) 466-0186

March 31, 1995

Mr. John A. Grobe, Chief
Nuclear Materials Inspection
Section II
U.S. Nuclear Regulatory Commission
Region III
801 Warrenville Road
Lisle, Illinois 60532-4351

RE: Advanced Medical Systems, Inc.'s Decommissioning Trust

Dear Mr. Grobe:

Enclosed please find the modified and restated Decommissioning Trust along with the Corporate Resolution empowering me to sign.

If you should have any questions, please do not hesitate to contact me.

Sincerely,

David Cesar/cs

DAVID CESAR
Treasurer

DC/cs
Enclosures

CERTIFIED RESOLUTION
OF
ADVANCED MEDICAL SYSTEMS, INC.

RESOLVED, that the Treasurer of the Corporation is hereby authorized, on behalf of the Corporation, to execute the Standby Trust Agreement (As Modified and Restated) between the Corporation and Bank One Ohio Trust Company N.A., as Trustee.

RESOLVED FURTHER, that a copy of the aforesaid Standby Trust Agreement (As Modified and Restated) of the 30 day of March 1995 be kept in the corporate file.

CERTIFICATE OF SECRETARY

C. ANTHONY STAVOLE, Secretary of Advanced Medical Systems, Inc., hereby certifies that the foregoing is a true and accurate copy of Resolution duly adopted by the Board of Directors of the Corporation, as of the 23rd day of March, 1995, in which all members consented; and that said Resolutions remain in effect, unchanged to the present date.

C. Anthony Stavole

C. ANTHONY STAVOLE, Secretary

AMSTRUST/032394

STANDBY TRUST AGREEMENT

(AS MODIFIED AND RESTATED)

THIS INSTRUMENT, of the ___ day of _____, 1995, is to evidence that:

WHEREAS, ADVANCED MEDICAL SYSTEMS, INC. ("AMS"), a Florida corporation (hereinafter referred to as the "Grantor"), entered into a Trust Agreement with SOCIETY BANK OF EASTERN OHIO, N.A., hereinafter referred to as "Trustee", under date of the 11th day of March, 1988, and as modified and restated on the 24th day of October, 1991;

WHEREAS, AMS did enter into a modified and restated Standby Trust Agreement on the 8th day of July 1994 with Bank One Ohio Trust Company N.A., as successor Trustee;

WHEREAS, Grantor desires to modify the Trust Agreement of July 8, 1994 and in the interests of clarity and convenience to restate in its entirety the trusts upon which

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and the uses and purposes for which the property now held or hereafter acquired by the Trustee shall be held, managed, and controlled;

WHEREAS, the Nuclear Regulatory Commission ("NRC"), an agency of the United States Government, has established certain regulations applicable to the Grantor, requiring that an owner or operator of a hot-cell facility shall provide assurance that funds will be available when needed for decommissioning the facility;

WHEREAS, the Grantor has elected to establish a standby trust with a letter of credit to provide all or part of such financial assurance for the facilities identified herein;

WHEREAS, when payment is made under a letter of credit, this standby trust shall be used for the receipt of such payment; and

WHEREAS, the Grantor, acting through its duly authorized officers, has selected the Trustee to be the Trustee under this Agreement, and the Trustee is willing to act as Trustee.

NOW, THEREFORE, pursuant to the rights of modification reserved to Advanced Medical Systems, Inc. in said Trust Agreement, Advanced Medical Systems, Inc. does now hereby provide that the property now held in said Trust shall be disbursed to the Grantor and that any funds hereafter acquired by Bank One Ohio Trust Company, N.A., as successor Trustee, under the terms of this Modified Standby Trust Agreement, or its successor, as Trustee, shall be held, managed, and disposed of by the Trustee as follows:

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SECTION 1

DEFINITIONS

As used in this Agreement:

(a) The term "Grantor" means the owner or operator who enters into this Agreement and any successors or assigns of the Grantor.

(b) The term "Trustee" means the Trustee who enters into this Agreement and any successor Trustee.

SECTION 2

IDENTIFICATION OF FACILITIES

This Agreement pertains to the facility identified on attached Exhibits "A" and "A-1".

SECTION 3

ESTABLISHMENT OF FUND

The Grantor and the Trustee hereby establish a standby trust fund (the "Fund") for the purpose of decommissioning the facility. The Grantor and the Trustee intend that no third party have access to the Fund except as herein provided. Payments made to the Trustee for the Fund shall consist of cash, securities or other liquid assets acceptable to the Trustee. The Fund is established initially as consisting of the assets, which are acceptable to the Trustee, described in Exhibit "B" attached hereto. Such assets together with any other assets subsequently transferred to the Trustee is referred

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to as the Fund, together with all earnings and profits thereon, less any payments or distributions made by the Trustee pursuant to this Agreement. The Fund will be held by the Trustee, in trust, as hereinafter provided. The Trustee shall not be responsible nor shall it undertake any responsibility for the amount or adequacy of, nor any duty to collect from the Grantor, any payments necessary to discharge any liabilities of the Grantor established by the NRC.

SECTION 4

PAYMENT FOR DECOMMISSIONING EXPENSES

The Trustee will make such payments from the Fund as the Grantor will direct, in writing, to provide for the payment of the costs of decommissioning the facilities covered by this Agreement. The Fund is established initially as consisting of property which is acceptable to Trustee in the form and amounts set forth on Exhibit B. The Trustee will reimburse the Grantor or other persons as specified by the Grantor from the Fund for decommissioning expenditures in such amounts as the Grantor will direct, in writing. In addition, the Trustee will distribute to the Grantor such amounts as the Grantor specifies in writing. The Trustee shall make payments from the Fund to the Grantor upon presentation to the Trustee of the following:

(a) A certificate duly executed by the Secretary of the depositor attesting to the occurrence of the events, and in the form set forth in attached Exhibits D and E.

(b) A certificate attesting to the following conditions:

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(1) that decommissioning is proceeding pursuant to an NRC-approved plan;

(2) that the funds withdrawn will be expended for activities undertaken pursuant to that plan; and

(3) that the NRC has been given thirty (30) days' prior notice of Advanced Medical System's intent to withdraw funds from the escrow fund.

Upon distribution, such funds will no longer constitute part of the Fund as defined herein. No withdrawal from the Fund can exceed ten percent (10%) of the outstanding balance of the Fund unless NRC written approval is attached.

SECTION 5

TRUSTEE'S POWERS OF ADMINISTRATION

In addition to and not in limitation of the powers given by law, the Trustee shall have full power:

(a) to invest and reinvest any money whether the income or principal at any time in said trust in such bonds, stocks, notes, or other securities, including securities, deposits with, and repurchase agreements issued or accepted by the Corporate fiduciary or its subsidiary, affiliate or parent corporation, or in a common trust fund, as said Trustee shall deem wise, without being limited by any statute or rule of law of the State of Ohio regarding investments by trustees now or hereafter in effect, excluding forever securities or other obligations issued by the Grantor or any of its affiliates; to invest in

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mutual funds, including those for which the Trustee or an affiliate member of Banc One Corporation serves as investment advisor and receives a fee as advisor;

(b) to borrow money and mortgage or pledge any property, at any time constituting a portion of said trust upon such terms and conditions as said Trustee shall deem wise;

(c) to cause any security or other property which may at any time constitute a portion of said trust to be issued, held, or registered in the name of a nominee or in such form that title will pass by delivery;

(d) to vote by proxy or in person, and exercise all other rights in relation to all stocks and securities contained in said trust;

(e) to enter into option or voting trust agreements and to consent to the reorganization, consolidation, liquidation, readjustment of the financial structure or sale of the assets of any corporation or other organization, the securities of which constitute a portion of said trust, and to take any action with reference to such securities which in the opinion of the Trustee is necessary to obtain the benefit of any such reorganization, consolidation, readjustment, or sale; to exercise any conversion privilege or subscription right given to it as the owner of any security constituting a portion of said trust; to accept and hold as a portion of said trust the securities resulting from any such reorganization, consolidation, readjustment, sale, conversion, or subscription;

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(f) to employ such attorneys, agents, and consultants as it may deem necessary in the administration of this Trust and to pay to them from this Trust reasonable compensation for services rendered by them;

(g) notwithstanding the provisions of the within Section 5 of this Agreement, Grantor reserves to itself the right to determine the types of investment vehicles to be utilized in investing the funds, and may, but shall not be required, to give written instructions to the Trustee concerning the choice of investments to be made concerning the funds; except that securities or other obligations of the Grantor, or any other owner or operator of the facilities, or any of their affiliates as defined in the Investment Company Act of 1940, as amended (15 U.S.C. 80a-2(a)), shall not be acquired or held, unless they are securities or other obligations of the Federal or a State government.

(h) notwithstanding the foregoing, written instructions of Grantor are valid so long as the Fund covers the decommissioning cost estimate.

SECTION 6

TAXES AND EXPENSES

All taxes of any kind that may be assessed or levied against or in respect of the Fund and all brokerage commissions incurred by the Fund will be paid from the Fund. All other expenses incurred by the Trustee in connection with the administration of this Trust, including fees for legal services rendered to the Trustee, the compensation of the Trustee to the extent not paid directly by the Grantor, and all other proper charges and

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disbursements of the Trustee will be paid from the Fund; provided, however, that before Trustee incurs charges and disbursements, including but not limited to, fees for legal services, such charges and disbursements will be presented to the Grantor in writing, and Grantor will be given a reasonable period, not to exceed thirty (30) days, to assume and furnish said expenses on its own account.

SECTION 7

ANNUAL VALUATION

After payment has been made into this standby trust fund, the Trustee shall annually, at least thirty (30) days before the anniversary date of receipt of payment into the standby trust fund, furnish to the Grantor and to the NRC a statement confirming the value of the Trust. Any securities in the Fund shall be valued at market value as of no more than sixty (60) days before the anniversary date of the establishment of the Fund. The failure of the Grantor to object in writing to the Trustee within ninety (90) days after the statement has been furnished to the Grantor and the NRC, or State agency, shall constitute a conclusively binding assent by the Grantor, barring the Grantor from asserting any claim or liability against the Trustee with respect to the matters disclosed in the statement.

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SECTION 8

ADVICE OF COUNSEL

The Trustee may, from time to time, consult with counsel, who shall be counsel to the Grantor, with respect to any question arising as to the construction of this Agreement or any action to be taken hereunder. The Trustee will be fully protected, to the extent permitted by law, in acting upon the advice of counsel.

The Trustee may consult with independent counsel in the event of a conflict of interest on the part of Grantor's attorney (See Section 5(f)).

SECTION 9

TRUSTEE COMPENSATION

For its services as Trustee, Bank One Ohio Trust Company, N.A., or its successor, shall receive the compensation stipulated in its regularly published schedules of compensation in effect and applicable at the time such compensation shall become payable. A copy of the current fee schedule is attached hereto and marked Exhibit "F".

SECTION 10

SUCCESSOR TRUSTEE

The Trustee may resign or the Grantor may replace the Trustee, but such resignation or replacement shall not be effective until the Grantor has appointed a successor trustee and the successor accepts the appointment. The successor trustee will have the same powers and duties as those conferred upon the Trustee hereunder. Upon

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the successor trustee's acceptance of the appointment, the Trustee will assign, transfer and pay over to the successor trustee the funds and properties then constituting the Fund. In the event of the resignation of the Trustee, the Grantor shall have a period of sixty (60) days from the date of receipt of said resignation to appoint a successor trustee. If for any reason the Grantor cannot or does not act within the aforementioned sixty (60)-day period, the Trustee may apply to a court of competent jurisdiction for the appointment of a successor trustee or for instructions. The successor trustee shall specify the date on which it assumes administration of the Trust in a writing sent to the Grantor and the present Trustee by certified mail, ten (10) days before such change becomes effective. Any expenses incurred by the Trustee as a result of any of the acts contemplated by this Section will be paid as provided hereinbefore.

SECTION 11

INSTRUCTIONS TO THE TRUSTEE

All orders, requests and instructions by the Grantor to the Trustee will be in writing, signed by such persons as are designated in the attached Schedule "C" or such other designees as the Grantor may designate by amendment to Schedule "C". The Trustee will be fully protected in acting without inquiry in accordance with the Grantor's orders, requests and instructions. The Trustee will have the right to assume, in the absence of written notice to the contrary, that no event constituting a change or a termination of the authority of any person to act on behalf of the Grantor hereunder has

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occurred. The Trustee will have no duty to act in the absence of such orders, requests and instructions from the Grantor except as provided for herein.

SECTION 12

AMENDMENT OF AGREEMENT

This Agreement may be amended by an instrument in writing executed by the Grantor and the Trustee. All amendments shall meet regulatory requirements of the NRC.

SECTION 13

IRREVOCABILITY AND TERMINATION

Subject to the right of the parties to amend this Agreement as provided in Section 12, this Trust shall be irrevocable and shall continue until terminated at the written agreement of the Grantor, the Trustee and the NRC or state agency, or by the Trustee and the NRC or state agency, if the Grantor ceases to exist. Upon termination of the Trust, all remaining trust property, less final Trust administration expenses, shall be delivered to the Grantor, or its successor.

SECTION 14

IMMUNITY AND INDEMNIFICATION

The Trustee will not incur liability of any nature in connection with any act or omission, made in good faith, in the administration of this Trust, or in carrying out any directions by the Grantor issued in accordance with this Agreement. The Trustee will

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be indemnified and saved harmless by the Grantor or from the Trust Fund, or both, from and against any separate liability to which the Trustee may be subjected by reason of any act or conduct in its official capacity, including all expenses reasonably incurred in its defense in the event the Grantor fails to provide such defense.

In the event this Trust is or becomes subject to specific regulatory requirements of any governmental or quasi-governmental agency relating to hot cell operation or decommissioning, funding, administration, distribution of funds, or termination of this Trust, the Grantor accepts full responsibility for compliance with such rules, regulations or requirements.

SECTION 15

CHOICE OF LAW

This Agreement will be administered, construed and enforced according to the laws of the State of Ohio.

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SECTION 16

INTERPRETATION

As used in this Agreement, words in the singular include the plural and words in the plural include the singular. The descriptive headings for each Section in this Agreement will not affect the interpretation or the legal efficiency of this Agreement.

IN WITNESS WHEREOF, the parties have caused this Agreement to be executed by their respective officers duly authorized.

Witnesses:

"GRANTOR"

ADVANCED MEDICAL SYSTEMS, INC.

By: _____

Its: Treasurer

"TRUSTEE"

BANK ONE OHIO TRUST COMPANY, N.A.

By: _____

Its: _____

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STATE OF OHIO)
) SS:
COUNTY OF CUYAHOGA)

On this 30TH day of MARCH, 1995, before me a Notary Public in and for said County and State, personally appeared PHILIP ROSPLOCH, and he did depose and say that he is the VICE PRESIDENT of Bank One Ohio Trust Company, N.A., Trustee, which executed the above instrument and that the same is his free act and deed.

In testimony whereof, I have hereunto set my hand and official seal at CLEVELAND, Ohio, this 30TH day of MARCH, 1995.

William T. Spitzer, Jr.
NOTARY PUBLIC
William T. Spitzer, Jr.
Notary Public, State of Ohio
My Commission Expires Feb. 20, 1997
(Recorded in Cuyahoga County)

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EXHIBIT A

This Agreement demonstrates financial assurance for the following cost estimates for the following licensed activities:

U.S. NUCLEAR REGULATORY COMMISSION LICENSE NUMBER	NAME AND ADDRESS OF LICENSEE	ADDRESS OF LICENSED ACTIVITY	COST ESTIMATES FOR REGULATORY ASSURANCES DEMONSTRATED THIS AGREEMENT
34-19089-01	Advanced Medical Systems, Inc. 1020 London Road Cleveland, OH 44110	Same	$1,800,000.00

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EXHIBIT A-1

This facility shall be defined as the plant located at:

1020 London Road
Cleveland, Ohio

Parcel No. 1

Situated in the City of Cleveland, County of Cuyahoga and State of Ohio, and known as being part of Sub-lots Numbers 235, 237 and 253, and all of Sub-lots Numbers 254 to 256, both inclusive, in the Wolfe-Sill Realty Company's St. Clair London Road Subdivision of part of Original Euclid Township Lots Numbers 9 and 42, Tract Number 10, as shown by the recorded plat in Volume 54 of Maps, Page 24 of Cuyahoga County Records, and also a part of Original Euclid Township Lot Number 9, Tract Number 10, and together forming a parcel of land, bounded and described as follows: Beginning on the Southeasterly side of Mandalay Avenue N.E., at the most Northerly corner of land conveyed to Great Lakes Warehouses, Inc., by deed dated February 15, 1973, and recorded in Volume 73183, Page 967 of Cuyahoga County Records; thence Northeast 52 degrees 19' 40" East, 210 feet along the Southeasterly side of Mandalay Avenue, N.E. to the Southwesterly side of London Road N.E.; thence South 40 degrees 47' 10" East, 400.34 feet along the Southwesterly side of London Road N>E>, to the most Northerly corner of a parcel of land conveyed to the New York, Chicago and St. Louis Railroad Company, by deed dated April 13, 1948, and recorded in Volume 6477, Page 19 of Cuyahoga County Records; thence South 16 degrees 08' 00" West, 207.53 feet along the Northwesterly line of land so conveyed to the Northwesterly line of the 232nd parcel of land conveyed to the New York, Chicago and St. Louis Railway Company, by deed dated October 27, 1883, and recorded in Volume 361, Page 11 of Cuyahoga County Records; thence South 52 degrees 41' 20" West, 969.19 feet along the Northwesterly line of the 232nd parcel so conveyed and along the Northwesterly line of land conveyed to the New York, Chicago and St. Louis Railway Company, by deed dated November 10, 1910, and recorded in Volume 1108, Page 447 of Cuyahoga County Records and along the Northwesterly line of land conveyed to the New York, Chicago and St. Louis Railroad Company, by deed of land conveyed to the New York, Chicago and St. Louis Railroad Company, by deed dated February 29, 1924, and recorded in Volume 3112, Page 124 of Cuyahoga County to the most Southerly corner of Parcel No. 1 of land conveyed to the City of Cleveland, by deed dated December 29, 1953, and recorded in Volume 8005, Page 465 of Cuyahoga County Records; thence North 37 degrees 16' 43" West, 40.00 feet along the Southwesterly line of the first parcel of land so conveyed to the City of Cleveland to a point; thence North 52 degrees 41' 20" East, 189.63 feet parallel with the Southeasterly line of land so conveyed to the City of Cleveland to the most Southerly corner of Parcel No. 1, 370 feet to the Southeasterly side of Mandalay Avenue N.E.; thence North 52 degrees 19' 40" East along said Southeasterly side, 17.25 feet to

the most Westerly corner of land conveyed to Great Lakes Warehouses, Inc., as aforesaid; thence South 37i 20' 20" East along the Southwesterly line of said land, 225.80 feet to the most Southerly corner thereof; thence North 52 degrees 20' 40" East along the Southeasterly line of land so conveyed to Great Lakes Warehouses, Inc. 623.79 feet to the most Easterly corner thereof; thence North 37 degrees 20' 20" West along the Northeasterly line of said land, about 226 feet to the place of beginning, be the same more or less, but subject to all legal highways.

Parcel No. 2.

Situated in the City of Cleveland, County of Cuyahoga and State of Ohio, and known as being part of Original Euclid Township Lot No. 9, Tract No. 10, bounded and described as follows: Beginning on the Southwesterly line of Parcel No. 1 of land conveyed to the City of Cleveland, by deed dated December 29, 1953, and recorded in Volume 6005, Page 469 of Cuyahoga County Records, at the most Easterly corner of Parcel No. 2 of land conveyed to the City of Cleveland, by deed dated May 14, 1958, and recorded in Volume 9095, Page 335 of Cuyahoga County Records; thence South 37 15' 43" East, along said Southwesterly line of Parcel No. 1 so conveyed to the City of Cleveland and its Southeasterly prolongation to a point distant South 37 15' 43" East, 25.80 feet from the Northwesterly line of a parcel of land conveyed to the New York, Chicago and St. Louis Railroad Company, by deed dated February 29, 1924, and recorded in Volume 3112, Page 124 of Cuyahoga County Records; thence 52 41' 20" East, 416.21 feet parallel to said Northwesterly line of land so conveyed to the New York, Chicago and St. Louis Railroad Company to a point; thence South 36 09' 35" West, 200.56 feet to the most Southerly corner of Parcel No. 2 of land conveyed to the City of Cleveland, by deed dated May 14, 1958, and recorded in Volume 9095, Page 335 of Cuyahoga County Records; thence North 52 41' 20" East, 37.78 feet to the place of beginning, be the same more or less, but subject to all legal highways.

Parcel No. 175-33-001, 004

EXHIBIT B

Standby Letter of Credit number SB300980 dated January 27, 1995 in the amount of $1,800,000.00.

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EXHIBIT C

The designated representatives of the Grantor are:

Treasurer
Radiation Safety Officer

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EXHIBIT D

CERTIFICATE OF EVENTS

Bank One Ohio Trust Company, N.A.
600 Superior Avenue
Cleveland, Ohio 44114

Attention: Trust Division

Gentlemen:

In accordance with the terms of the Agreement with you dated _____, I _____, Secretary of Advanced Medical Systems, Inc. hereby certify that the following events have occurred:

1. Advanced Medical Systems, Inc. is required to commence the decommissioning of its facility located at Cleveland, Ohio (hereinafter called the decommissioning).

2. The plans and procedures for the commencement and conduct of the decommissioning have been approved by the United States Nuclear Regulatory Commission, or its successor, on _____ (copy of approval attached).

3. The Board of Directors of Advanced Medical Systems, Inc. has adopted the attached resolution authorizing the commencement of the decommissioning.

_____
Secretary of Advanced Medical Systems, Inc.

_____
Date

EXHIBIT E

CERTIFICATE OF RESOLUTION

I, _____, do hereby certify that I am Secretary of Advanced Medical Systems, Inc., a Florida corporation, and that the resolution listed below was duly adopted at a meeting of this Corporation's Board of Directors on _____, 19___.

IN WITNESS WHEREOF, I have hereunto signed my name and affixed the seal of this Corporation this _____ day of _____, 19___.

_____
Secretary

RESOLVED, that this Board of Directors hereby authorizes the President, or such other employee of the Company as he may designate to commence decommissioning activities at Advanced Medical Systems, Inc. in accordance with the terms and conditions described to this Board of Directors at this meeting and with such other terms and conditions as the President shall approve with you upon the advice of Counsel.

EXHIBIT F

TRUST DEPARTMENT FEE SCHEDULE

Annual fees are based on the market value of assets.

Administrative Fee
.6% of the first $750,000 invested
.3% of assets above $750.000

Investment Management Fee
.6% of the first $1,000,000 invested
.3% of assets above $1,000,000

PLUS

Fees will be charged to income unless otherwise provided.

At the time of distribution of principal to anyone other than the Grantor, a deferred charge is made equal to 1% of the fair value of the trust assets distributed.

Appropriate additional compensation may be charged for services rendered which exceed the normal scope of account activities.

Minimum Fee: $750.00 annually

Base Fee for Grantor Trusts: $600.00 annually

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