ABBOTT

~~Graces~~
RSS

Paul Ward
Health Physicist
Employee Health Department

Abbott Laboratories
14th & Sheridan Road
North Chicago, Illinois 60064

17 August, 1988

Log	Sept-3-11
Remitter	
Check No.	610095
Amount	$230
Fee Category	3G
Type of Fee	Amd
Date Check Rec'd.	9/9/88
Date Completed	9/12/88
By:	[signature]

88 SEP -9 P2 RECEIVED

Earl G. Wright
U.S. Nuclear Regulatory Commission, Region II
Nuclear Materials Safety Section
101 Marietta St.
Suite 2900
Atlanta, GA 30323

Dear Mr. Wright,

This letter is in reference to U.S. Nuclear Regulatory Commission License No. 52-24994-01, which is issued to Abbott Hospitals, Inc. for our Radiation Sterilization Facility at Vega Alta, Puerto Rico.

I would like to request an amendment of condition 11.B. of that license to include the following persons as Site Radiation Safety Officers (RSO's):

1. Jose Carrasquillo
2. Edward Hopkins
3. Frank Reboyras
4. Angel Rojas

These individuals have had their training and experience reviewed. I certify them as having fulfilled the requirements outlined in section 9 of our license application, and have approved them as fully qualified Irradiator Operators. Additionally, they have successfully completed the Radiation Safety Officers Course given by Atomic Energy of Canada, Ltd. from 30 May to 3 June, 1988 at the Canadian Irradiation Center in Montreal, Canada. Their individual training and experience resumes are attached.

I would also like to request a change to condition 16 of the license, which states:

> ". . ., a radiation survey shall be conducted to determine radiation levels around, above, and below the irradiator with the sources in the shielded position and in the exposed position . . ."

I request that the requirement to survey below the irradiator be deleted since the design of the irradiator cell precludes access below the pool.

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Additionally, I would like to request changes to several pages of the license application supplemental information submitted April 27, 1988.

Page 4-33, item 4.7.10 has been changes to reflect the current AECL practice of setting the in-cell temperature sensor to actuate if the temperature exceeds 160° F (71° C).

Page 8-12, item 8.2.5 has been revised to replace the reference to the former Isomedix license 29-15364-01 with the current Abbott license 52-24994-01.

Page 8-15, Section I has been revised to update the medical contact and provide up-to-date telephone numbers.

Page 10-1, item 10.1 has been revised to include the Abbott license number and to define the duration of the consulting agreement with the former owner, Isomedix.

Pages 10-3, 10-4, 10-5, 10-6 and 10-7, item 10.2 (Training and Experience Resumes for Isomedix Personnel) should be deleted and replaced with those for the Abbott personnel listed earlier.

Copies of the revised pages are attached. I have enclosed a check in the amount of $230.00 as payment for the requested amendments. Any questions regarding these requests should be addressed to me at the address above, or by telephone at (312) 937-5276.

Sincerely,

Paul Ward

Paul Ward
Corporate Radiation Safety Officer
Manager of Health Physics

4.7.6 START-UP TIMER

A 90 second timer which must be started with the MACHINE key is located at the far end of the irradiation room so that the operator ensures that the conveyors are correctly loaded and that no one remains in the room. If the start-up procedure if not completed within the time limit or any emergency device is actuated the start-up procedure must be repeated. The green MACHINE READY light is illuminated only after the maze door is closed. A warning bell rings during the timing period, and a light flashes in the irradiator.

4.7.7 SOURCE MOVING ALARM

When the source is either DOWN or UP its position is annunciated by console lights while it is in transit a source moving alarm bell replaces those light signals. A "Radiation Warning" light adjacent to the maze door is illuminated when the source is not in its "safe" position.

4.7.8 SOURCE RACK GUIDE CABLE

If the source rack should jam, the tension on the guide cables can be relieved from outside the irradiation cell to permit the rack to be set free.

4.7.9 POOL WATER LEVEL

The water level in the pool is automatically maintained within pre-set levels by a switch controlling a water make-up line. The cell monitor will detect an increase in background radiation if the water level drops significantly while the source is in the down position.

A raw water meter measures and records the amount of make-up water being automatically introduced into the pool.

4.7.10 IN CELL TEMPERATURE SENSOR

A temperature sensor located in the radiation room will actuate if the temperature rises above 160°F (71°C). Actuation of this sensor will cause the source to be lowered into the fully shielded (safe) position, stop the product pass system and shut down the room ventilation system.

GENERAL DESCRIPTION OF PROCEDURE

(Note: The following procedure is currently being followed under Abbott License 52-24994-01.)

Wipe testing of the source in the pool is conducted as follows:

1. Attach a styrofoam, gauze or equivalent pad to the end of an underwater tool.
2. Rub the pad along the source, and on the accessible ends of the sources in a source module.
3. Remove the pad from the pool and check for radiation with a RATO/F or equivalent meter. Meter should read below 1mr/hr. If not, call RPO.
4. If reading in (3) is below lmr/hr, remove pad from tool, and allow to dry.
5. Repeat for several source modules
6. Send pads to Corporate Radiation Protection Officer, Abbott Park or Isomedix, Whippany, New Jersey for counting
7. Shipment of pads to be performed in accordance with the applicable regulations of U.S. Department of Transportation..

PROCEDURE FOR COUNTING SMEARS AND DETERMINING CONTAMINATION LEVELS

Swipes are counted using at least a 5 cm x 5 cm NaI Well Detector. Results are compared to counts from a NBS tracable standard cobalt-60 source. Removable NBS tracable activity, in microcuries, is calculated as follows:

1. Take background count (BC).
2. Count Leak Test Swab (LTS).
3. Then LTS-BC = Test Swab Count.
4. Then:

$$\frac{\text{Test Swab Count}}{\text{Detection System Efficiency}}$$

5. Removable contamination should be less than

1×10^{-5} microcuries.

Radiation Overexposure

I. Extreme Overexposure - Victim Unconscious

A. If a person is unconscious from an overexposure, immediately call the ambulance and tell the driver to take him to the Manati Doctor's Center. Call the Center (854-1795), explain the problem, and request that the Abbott Medical Director, Dr. Arnaldo Ocasio be notified, and that he be requested to come to the center. Dr. Ocasio can be reached at 846-3500 or 846-6900 or 793-8585 (unit 1902).

B. Escort the victim to the center either in the ambulance or in your own car.

C. Following the above, immediately call one of the following:

Mr. Paul Ward	312-937-5276	312-336-3079
Mr. George Dietz	201-876-9588	201-887-4700
Mr. John Masefield	201-234-2396	201-887-4700
Mr. Jonathan Young	201-895-2137	201-887-4700

D. The person notified above in item C will contact the NRC, Region II (404-331-4503), and explain the circumstances with a view toward obtaining the services of either Dr. Neil Ward or Dr. Thoma, or another expert in overexposure available to NRC on a consulting basis.

The NRC Emergency number after duty hours in our area: 301-951-0550.

II. Moderate or Suspected Overexposure - Victim Conscious

A. Immediately call on of the following:

Mr. Paul Ward, Dietz, Masefield or J. Young (same as in item I (c) above); if none of the above can be reached on the first try, call the Manati Doctor's Center and take the victim there, and proceed as in I (A).

B. Take the actions directed from your contact of the above mentioned people. Actions may include the following:

1. Taking the victim to the center (Manati Doctor's) in your own car.

2. Calling for the ambulance.

3. Notifying Manati Doctor's Center, and telling them to expect the victim, and to alert emergency.

C. If for some reason the above personnel cannot be reached immediately and other action is taken, be sure to continue to try to contact either Mr. Ward, Dietz, Masefield or Young until at least one has been notified.

PART 1 - TRAINING AND EXPERIENCE IN RADIATION SAFETY

10-1 <u>OPERATIONAL PLAN</u>

The Vega Alta irradiator was operated by Isomedix, Inc. beginning 1982 under its License No. 52-23041-01. Abbott purchased the facility February 26, 1988 and will continue irradiation operations under its License No. 52-24994-01.

Abbott has hired the Isomedix Plant Manager, Mr. Arnaldo Rosado, who has approximately four years of operational experience at the subject irradiator. Abbott also hired the Plant Engineer, QA person and one of the previous Isomedix qualified operators so as to maintain a smooth operational transition at the irradiator.

In addition, Abbott has entered into a 12 month consulting agreement with Isomedix, Inc. to assist Abbott in assuring that the highest standards of radiation safety and adherence to license conditions are maintained.

10.2 Training and Experience Resumes

These are on the following pages.

Type of Training	Where Trained	Duration of Training	On the Job	Formal Course
a. Principles of Radiation Protection.	AHI-Vega Alta & AECL-Canada	5 months	5 months	Yes
b. Radioactive measurement standardization, monitoring techniques and instrumentation.	AHI-Vega Alta & AECL-Canada	5 months	5 months	Yes
c. Mathematical basics to the use and measurement of radioactivity.	AHI-Vega Alta & AECL-Canada	5 months	5 months	Yes
d. Biological effects of radiation.	AHI-Vega Alta & AECL-Canada	5 months	5 months	Yes

EXPERIENCE WITH RADIATION

Isotope	Max. Amount	Where Experience Was Gained	Duration	Type of Use
Co-60	300,000	Abbott Hospitals, Inc., Vega Alta Puerto Rico	5 months	Sterilization of medical devices.

Mr. José L. Carrasquillo, through Mr. Arnaldo Rosado, RPO and Radiation Facility Mgr. for Abbott Hospitals, Inc., in Vega Alta, P.R., received on-the-job training in the use of shielding, time and distance relations for reduced radiation exposure, in the emergency procedures for personal and environmental protection, in routine safety and maintenance procedures of the Vega Alta Irradiation facility and in the operational aspects of radiation monitoring and surveying instruments. The on-the-job training was complemented and correlated with two formal courses: one 40-hour course on the Principles of Radiation Protection offered by a practicing RPO from the Center for Energy Environment Research of the University of Puerto Rico: Ms. Nimia Irizarry. A second 40-hour course for RPO's was approved at the Atomic Energy of Canada Ltd. irradiation training facilites in Montreal, Canada. Contents of both training programs are outlined separately.

Mr. Carrasquillo received continued on-the-job training at the 300,000 Ci unit for five months and successfully completed the Operator's Training Program during July, 1988.

Previously, Mr. Carrasquillo was Safety & Security Mgr. for a 400 employees Chemical plant (1974-1977) and was the supervisor of the safety and industrial hygiene officer at Abbott Hospitals, Inc. Barceloneta plant (1984-1986).

Formal Education	-	High School Graduate	- 1968
		BS Industrial Engineering	- 1973
		MS-Industrial Management	- 1979

EDWARD J. HOPKINS
QUALITY ASSURANCE ENGINEERING MANAGER
ABBOTT HOSPITALS, INC.
BARCELONETA, PUERTO RICO 00617

EDUCATION

B.S. Chemistry, 1977 Interamerican University, San German Puerto Rico

TRAINING

40 Hours — Center for Environmental and Energy Research, U.S. Department of Energy, University of Puerto Rico, Mayaguez Regional.

Principles of radiation safety, radioactivity, commercial uses, radiation measurement and protection procedures. Equipment and practice for measurement of radiation.

Commercial measurement and calculation of source load, shielding, time distance exposure calculations.

40 Hours — Radiation safety officer course (Industrial Irradiator). Atomic Energy of Canada, LTD. & Canadian Irradition Center, Laval Canada.

Radiation units, basic mathematics, physics of radiation, radioactive process, interaction of radiation with matter.

Biological effects of radiation - high and low doses, radiation protection, radiation shielding, and types of instruments.

Calibration of instruments, instrument limitations, cobalt-60, industrial irradiator design and safety systems, computerized irradiator monitoring system.

Radiation survey techniques, use of radiation monitoring equipment, dosimetry for Industrial Irradiators.

Administrative controls, emergency procedures, United States Nuclear Regulatory Commission Regulations, AECB, AEC Regulations and duties of the radiation safety officer.

Page 2

EXPERIENCE WITH RADIATION

Abbott Hospitals, Inc., Vega Alta, Puerto Rico Medical Device Manufacturer including sterilization by irradiation.

7 Months On job training - principles and practice of sterilization by irradiation.
On job training - radiation safety of personnel, environment & product
On job training - source load/product exposure calculations.
On job training - use and maintenance of radiation measurement equipment.
On job training - writing and implementation of operating procedures.
On job training - biclogical effects of radiation.

7 Months On job training - writing and implementation of operating procedures.
On job training - irradiator operations
On job training - radiation survey
On job training - emergency procedure review
On job training - USNRC regulations

Facility loading consists of 300,000 curies of cobalt-60.

APPLICATION FOR RADIOACTIVE
MATERIAL LICENSE

FRANK REBOYRAS

TYPE OF TRAINING	WHERE TRAINED	DURATION OF TRAINING	ON THE JOB	FORMAL COURSE
a. Principles and practices of radiation protection.	Isomedix	3 months	2 1/2 years	Yes
b. Radioactive measurement standardization and monotoring techniques, and instrumentation.	Isomedix	3 months	2 1/2 years	Yes
c. Math and calculations basic to the use and measurement of radioactivity.	Isomedix	3 months	2 1/2 years	Yes
d Biological effects of radiation.	Isomedix	3 months	2 1/2 years	Yes
e. Basic Course on Radiation Safety	Abbott Hospitals, Inc.	40 hours	2 months	Yes
f. Radiation Safety Officer Course	Atomic Energy of Canada, Limited	40 hours	5 months	Yes

EXPERIENCE WITH RADIATION

Isotopes	Max. Amount	Where Experience Was Gained	Duration	Type of Use
Co-60	1,700,000 ci	Isomedix Puerto Rico, Inc. Facility Engineer	2 1/2 years	General processing e.g. sterilization
Co-60	300,000 ci	Abbott Hospitals, Inc. (Puerto Rico) Facility Engineer	5 months	General processing e.g. sterilization

Mr. Reboyras, through Mr. Arnaldo Rosado, RPO, received on-the-job training in the use of shielding and time-distance relations in reducing radiation exposure; the use, maintenance and limitations of monitoring and surveying instruments; and protective, routine, and emergency procedures in effect at the Abbott Hospitals, Inc. Vega Alta, Puerto Rico facility. The on-the-job training was correlated with a formal course given by Arnaldo Rosado contents of this training program are outlined elsewhere.

Mr. Reboyras was a licensed operator of the 1.7 million curie Isomedix (Puerto Rico), Inc. facility 2 1/2 years, and a licensed operator for the Abbott Hospitals, Inc. Irradiator for the five (5) months the plant has been operating.

Mr. Reboyras was hired by Abbott Hospitals, Inc. (Puerto Rico) (a large, totally automated, AECL medical products irradiator in Puerto Rico) as Maintenance Engineer and licensed irradiator operator. From October 1985 until February 28, 1988, Mr. Reboyras was the Facility Engineer for Isomedix (Puerto Rico), Inc. He was also a licensed irradiator operator in this plant.

Formal Education - High School Graduate - 1966

APPLICATION FOR RADIOACTIVE
MATERIAL LICENSE

ANGEL ROJAS

TYPE OF TRAINING	WHERE TRAINED	DURATION OF TRAINING	ON THE JOB	FORMAL COURSE
a. Principles and practices of radiation protection.	Abbott Hospitals, Inc.	3 months	4 months	Yes
b. Radioactive measurement standardization and monotoring techniques, and instrumentation.	Abbott Hospitals, Inc.	3 months	4 months	Yes
c. Math and calculations basic to the use and measurement of radioactivity.	Abbott Hospitals, Inc.	3 months	4 months	Yes
d Biological effects of radiation.	Abbott Hospitals, Inc.	3 months	4 months	Yes
e. Basic Course on Radiation Safety	Abbott Hospitals, Inc.	40 hours	4 months	Yes
f. Radiation Safety Officer Course	Atomic Energy of Canada, Limited	40 hours	4 months	Yes

EXPERIENCE WITH RADIATION

Isotopes	Max. Amount	Where Experience Was Gained	Duration	Type of Use
Co-60	300,000 ci	Irradiator Operator Group Leader	5 months	General processing e.g. sterilization

Mr. R[illegible] through Mr. Arnaldo Rosado, RPO, received on-the-job traini[illegible] the use of shielding and time-distance relations in reducing radiation exposure; the use, maintenance and limitations of monitoring and surveying instruments; and protective, routine, and emergency procedures in effect at the Abbott Hospitals, Inc. Vega Alta, Puerto Rico facility. The on-the-job training was correlated with a formal course given by Mr. Arnaldo Rosado (RSO), contents of this training program are outlined elsewhere.

Mr. Rojas is a Licensed Irradiator Operator and Group Leader for the Abbott Hospitals, Inc. Vega Alta, Puerto Rico facility, (a large, totally automated, AECL medical products irradiator). He was hired on March 28, 1988 by Abbott Hospitals, Inc.

Formal Education - High School Graduate - 1978

- Inter American University
  San Juan, PR - 1983 BS Chemistry
  BS Biology

SUPPLEMENTAL INFORMATION

Application for Byproduct Material License

Vega Alta, Puerto Rico

APRIL 27, 1988
Date

ABBOTT LABORATORIES, INC.

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APPENDIXES

PART 1 - IRRADIATOR DESCRIPTION

1.1. Introduction

THE IR-107 Irradiator as described herein is a standard model of medical supply irradiator, fabricated by Atomic Energy of Canada Limited. It consists of a large concrete biological shield which houses the cobalt-60 and a shuffle mechanism which transports product carriers past the source in a particular pattern. The unit is totally automated. Product is loaded into carriers in an outside unrestricted area, and carriers are then automatically sequenced into and out of the unit. The general layout of the facility is as shown on Drawing B110701 002G. (See Appendix A).

It is the intent of this presentation to describe the unit with special emphasis on the safety-related system and its operation. This will include detailed procedures applicable to the operation of the facility; however, it is not the intent to discuss the detailed operating procedures of the mechanical mechanism.

1.2 Use

The irradiator will be utilized for the sterilization of medical devices, and/or the processing of other materials except those of an explosive or hazardous nature.

1.3 - General Facility Operation

Drawing No. A-3 in Appendix B shows the general layout of the irradiator in relation to an associated 17, 460 sq. ft. warehouse area which will support pre- and post- irradiation product storage and handling.

A conveying system located outside of the unit is available for the loading and storage of carriers scheduled for irradiation processing. The carriers are fed one at a time through a maze into the irradiation chamber. A tandem trolley system is utilized to take the carrier from the maze into the internal conveyor system. The tandem system will pick up a finished carrier, transport it out of the inner conveyor system and put it onto the second part of the tandem carrier for transport back through the maze to the exit side of the carrier system. The exit side is physically blocked by one carrier. As the next exit carrier moves into position, it forces the previous carrier out of position onto the post-irradiation external storage mechanism. After the existing carrier has moved into position the tandem system moves a new carrier into the inner conveyor system from the entrance side of the conveyor storage system. In addition to the carriers acting as physical barriers, the inlet and outlet passages to the maze are obstructed by barriers when no product carriers are in the opening. The barriers are operated by pneumatic cylinders, and sequence their opening and closing with the passage of carriers into or out of the irradiator.

The schematic on page 1-3 shows the overall layout and operation of the irradiator as described above.

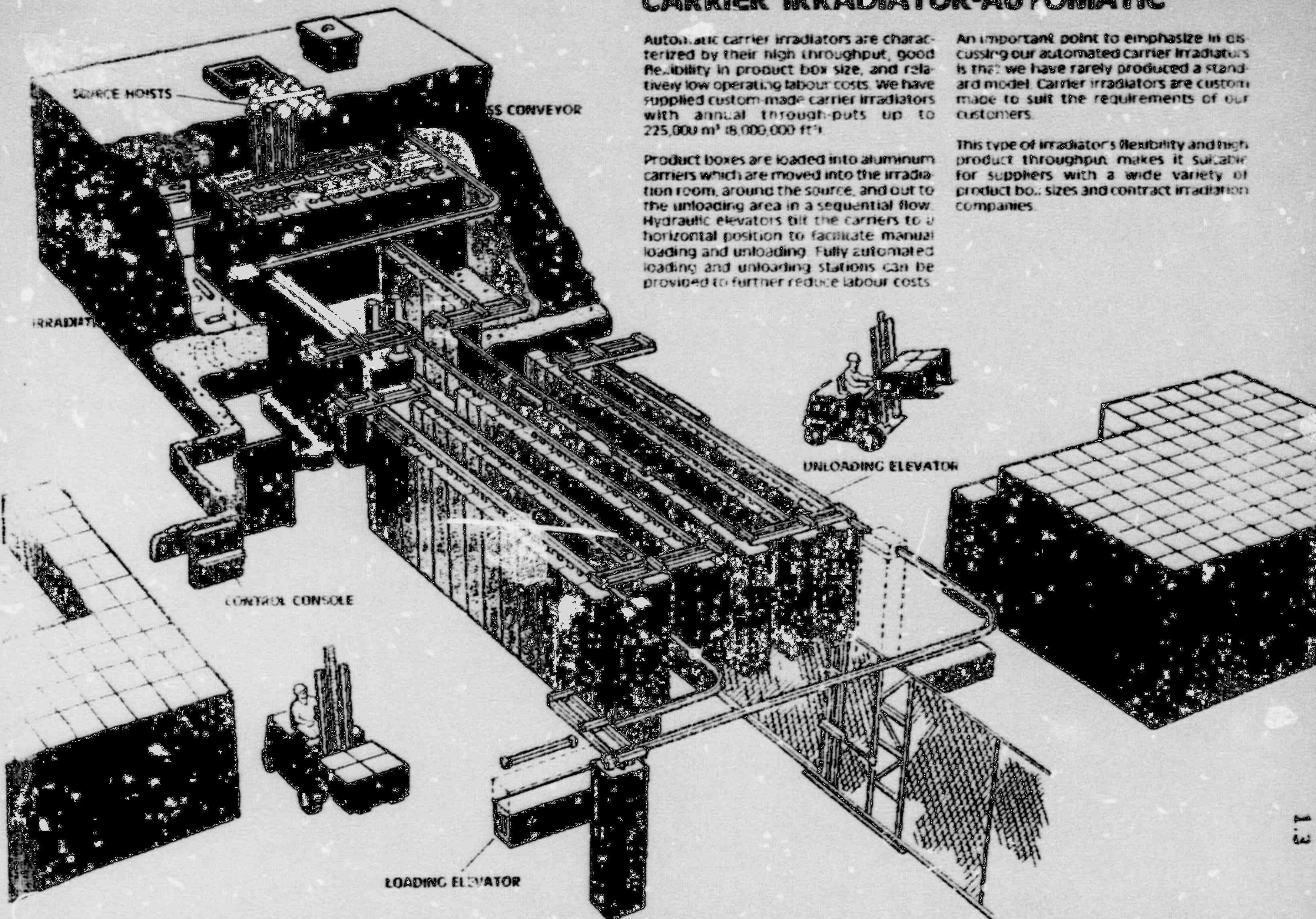
CARRIER IRRADIATOR-AUTOMATIC

Automatic carrier irradiators are characterized by their high throughput, good flexibility in product box size, and relatively low operating labour costs. We have supplied custom-made carrier irradiators with annual through-puts up to 225,000 m³ (8,000,000 ft³).

Product boxes are loaded into aluminum carriers which are moved into the irradiation room, around the source, and out to the unloading area in a sequential flow. Hydraulic elevators tilt the carriers to a horizontal position to facilitate manual loading and unloading. Fully automated loading and unloading stations can be provided to further reduce labour costs.

An important point to emphasize in discussing our automated carrier irradiators is that we have rarely produced a standard model. Carrier irradiators are custom made to suit the requirements of our customers.

This type of irradiator's flexibility and high product throughput makes it suitable for suppliers with a wide variety of product box sizes and contract irradiation companies.



1.4 Licensed Material

Line (1)

A Cobalt-60

B Radioactive Cobalt-60 metal

C Manufactured by Atomic Energy of Canada Limited - Commercial Products. The cobalt-60 Model C-188 Type 1, 2, 3 or 4 are double encapsulated in 316 stainless steel. They are designated as acceptable for licensing in the U.S.A.

D Maximum activity per C-188 source is 14,250 curies of cobalt-60. Maximum cobalt-60 source loading is 4,000,000 curies in 1344 positions. The activity supplied in these sources will range from 6,000 to 12,000 curies of cobalt-60 per source.

E Commercial sterilization or processing of packaged medical products and other items, except those of an explosive or hazardous nature.

Line (2)

A Cesium 137

B Anhydrous Cesium Chloride

C Nuclear Associates Incorporated, Westbury, New York Catalog Number 62-103

D Maximum activity per individual source is ten microcuries of Cesium 137. This is an exempt quantity.

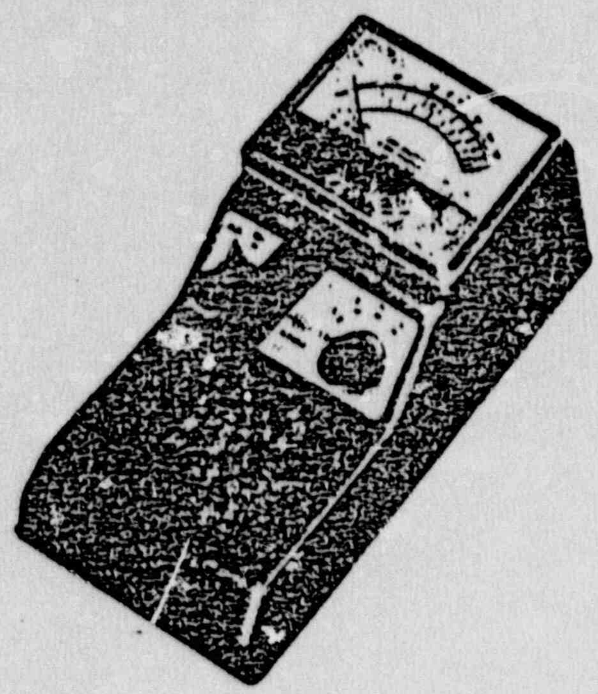
E Instrument check source.

PART 2 - RADIATION DETECTION INSTRUMENTS

2.1 Both portable and fixed monitors as described on the following pages will be utilized.

RATO/F or Eberline E-130G will be utilized as handheld units. Both are acceptable units.

They are described on pages 2-2 through 2-6.



Highly sensitive small instrument for measuring dose rates of γ- and β-radiation as well as for detection of α-radiation.

Differentiation between γ- and β-radiation by adjustment of a built-in slide

Lowest value indicated	10 μr/h	
Highest value indicated	10 r/h	
Measuring ranges and time constants	0– 1 mr/h	10 s (RC values)
	0– 10 mr/h	10 s
	0–100 mr/h	1 s
	0– 1 r/h	1 s
	0– 10 r/h	1 s

Acoustical indication

In the lowest two measuring ranges, there is an additional acoustical indication as every pulse causes a click in the built-in loudspeaker.

Scale division

The scale is quasi-logarithmic whereby 1 % of the full deflection is still readable.

Since this quasi-logarithmic dial curve is produced by resistances and condensers only, high accuracy which is constant from one instrument to the next, is guaranteed.

As a further difference from the purely logarithmic division, the intensity value "0" is also indicated, and a high accuracy is obtained at small intensities combined with high zero-point-stability.

Energy dependence

± 20 % in the range between 0.1 and 1.5 MeV γ-radiation.

Calibration

with γ-radiation of radium (0.5 mm Pt-filter).

Calibration accuracy ± 10 %

Recalibration

Recalibration by a control source is not necessary in this instrument since high voltage as well as pulse size are stabilised, and since, furthermore, the counter tubes operate in the pulse mode.

Functional control is, moreover, provided by the acoustical and optical indication of background.

However, for demonstration and training purposes, a weak Cs^{137} source, which is not subject to authorization, can be delivered.

Counter tubes

The instrument contains two counter tubes:

a) an end window halogen counter tube with a window of 63.5 mm² area, thickness 2–3 mg/cm². This counter tube is built into the base of the instrument. This arrangement facilitates the measurement of surface contaminations since the instrument can be held like a flat-iron.

b) a miniature halogen counter tube for the range of 0–10 r/h

Power supply

The instrument has two built-in DEAC cells, type 500 DKZ. The working time with fully charged cells is 12 hours in continuous operation. A charging unit for connection to 220 volts A.C. (other voltages on request) is supplied for recharging the built-in cells. Charging time: 10 hours. If timely recharging was neglected, the instrument can also be powered by an external battery or, provisionally, from the mains by way of the charging unit. The stabilisation of the instrument is such that any type of battery between 1.25 and 3 volts can be used.

The voltage can be checked on the measuring instrument by turning the operation switch to the corresponding position.

Temperature range

− 30 ° to + 50 ° C

Resistance against overload

A dose rate of 1000 R/h does not cause a return of the pointer from full deflection in any measuring range.

Stability against shocks and jolts

approximately 10 g

Case

The instrument is incorporated in a plastic case which is insensitive to shocks and blows. It is splash-water-proof.

Dimensions and weight

190 x 90 x 80 mm 800 g

Carrying case

A carrying case of genuine cowhide is supplied with the instrument. The charging unit is also housed in this case.

Other radiation protection measuring instruments

For highly sensitive contamination measurements of α, β- and γ-radiation, the contamination measuring instrument LB 1200 is recommended which, in addition to the built-in counter tube, makes the connection of numerous external probes possible (even for liquids and gases).

For wave-length-independent dose rate measurements of X-rays and gamma radiation, from 10 keV on, the portable apparatus TOL/E with a gas amplification chamber of plastic material is used (most sensitive range 0–300 μr/h, readable 10 μr/h).

Taking into operation

Turn left hand switch to "Ein" ("on").
Adjust the right hand switch to the range desired.

Measuring gamma-radiation

Push the slide at the reverse side of the instrument over the counter tube window.

Measuring beta-radiation

Push the slide in opposite direction to the counter tube window.

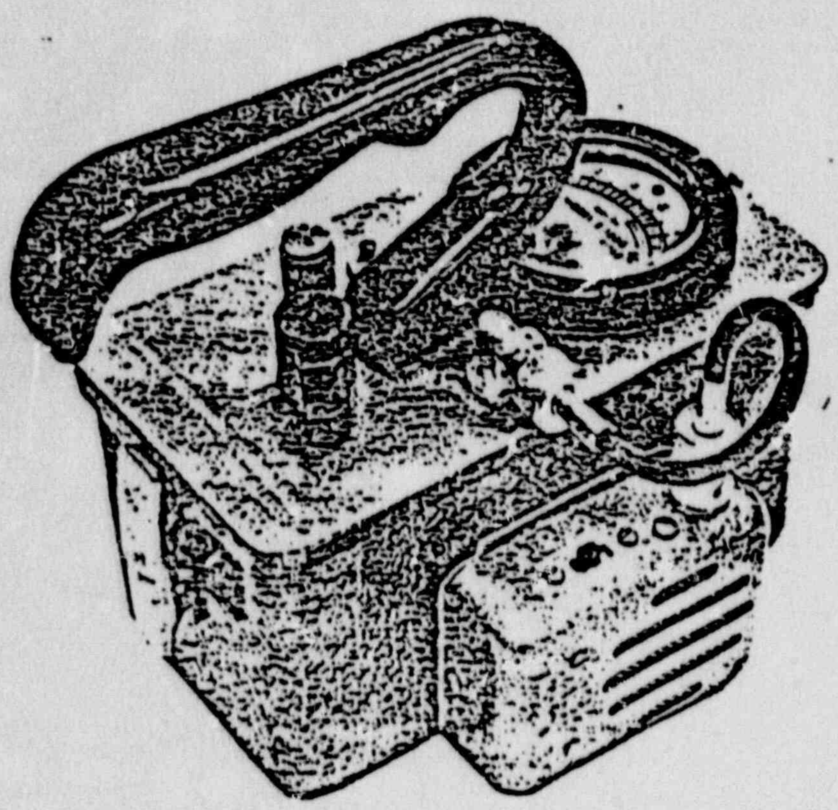
Voltage control

Turn the left hand switch to K". The indication should now rise above the marking "K" in the upper scale. If it is below the marking "K", the DEAC cells in the instrument have to be recharged. For this purpose the plug of the charger is put into the socket at the side of the instrument and the charging instrument in the Schuko-socket. The charging time is about 3 - 15 hours. During that time the instrument must not be switched on.

PORTABLE GAMMA RADIOGRAPHIC SURVEY METER
MODEL E-130C

MEETS U.S. AEC REGULATIONS
(10 CFR PART 34, PARA. 34.24)
FOR USE IN RADIOGRAPHIC INSTALLATIONS

- UTILIZES INTEGRATED CIRCUITS
- SMALL SIZE - LIGHT WEIGHT
- LONG LIFE WITH TWO D-CELLS
- STABLE OVER WIDE TEMPERATURES
- EXCELLENT LINEARITY AND STABILITY
- VARIABLE METER RESPONSE TIME
- BATTERY CONDITION CHECK
- 3 RANGES - TO 1000 mR/hr
- RUGGEDIZED METER
- ENGRAVED SWITCH MARKING



SHOWN WITH SK-1 SPEAKER

MODEL E-130G

GENERAL DESCRIPTION

The Model E-130G Portable Gamma Survey Meter combines the proven reliability of geiger detectors with new electronic circuits to provide an instrument with outstanding operational characteristics in a small, lightweight package at an economical price. The ruggedized meter provides exceptional linearity with continuously variable response time. Calibration stability results from temperature compensation and battery voltage regulation. High efficiency circuits extend the life-time of the two D-cell batteries. A rotary switch combines the functions of power switch, battery check and selection of one of three sensitivity ranges. The amplifier-driven phone output may be used with headset, speaker assembly, or external pulse counter.

Design features include: voltage amplifier, monolithic integrated circuit trigger, meter driver with variable response time, phone driver, regulated and feedback controlled high voltage supply and individual calibration controls for each range. A single etched board holds and interconnects all components resulting in a minimum number of solder joints which enhances reliability. The etched board connects to the die cast aluminum cover, forming a completely operational instrument with controls and test points exposed for ease of calibration or maintenance. An aluminum can covers the assembly, sealing against an O-ring, forming a rugged, weather-proof housing.

Standard factory calibration is to mR/hr from ^{137}Cs sources having calibration traceable to the National Bureau of Standards. A cadmium shield surrounding the detector tube provides compensation for low energy gamma radiation. The instrument is furnished complete with C-Zn batteries, Calibration Certification, manual and carrying strap. Available accessories include headset and speaker assembly (SK-1).

SPECIFICATIONS

I. READOUT
RANGES: 3 Linear Ranges, switch controlled; 10, 100, 1000 mR/hr ^{137}Cs full scale.
SCALE LENGTH: 1.76 inches (4.5 cm).
LINEARITY: Within ±5% of full scale, ±2% typical.
RESPONSE TIME: Variable by panel control from 10 sec. to 2 sec. to 90% of final value.
PHONE: One pulse for each event counted. Negative pulse approximately 2.5 volts amplitude, length determined by range switch.
SATURATION LEVEL: Exceeds 1000 R/hr.
VOLTAGE COEFFICIENT: Reading changes less than 10% with battery voltage from 3.0 to 2.0 volts (New batteries to end point.

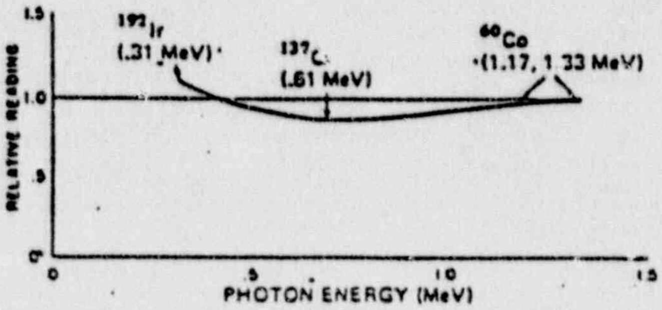
II. BATTERIES
Two "D" size cells held by internal captive holders.
VOLTAGE REQUIREMENT: 1.6 max. to 1.0 min. volts per cell.
LIFE: Variable depending on cell type, age, temperature, etc. Nominal life with new cells at room temperature for each type is:

Carbon-Zinc	300 hours
Alkaline	500 hours
Mercury	700 hours
Nickel-Cadmium (Single Charge)	200 hours

III. DETECTOR
GM TUBE: Small, rugged, halogen quenched.
Cadmium shield surrounding tube for low energy compensation.
SENSITIVITY: Approximately 100 CPM per mR/hr for ^{137}Cs.

IV. MECHANICAL
DIMENSIONS: Approximately 6-3/4" L x 3-3/8" W x 3-5/8" + 2-3/8" handle H (17.1 x 8.6 x 9.2 + 6.0 cm).
WEIGHT: 3 lb. (1.4 Kg) with C-Zn batteries.

V. ENVIRONMENTAL
TEMPERATURE: Typical temperature coefficient of reading is -.15% per °F from -40° to +140°F (-.27% per °C from -40°C to +60°C). Maximum is -25% per °F (-.45% per °C).



TYPICAL ENERGY RESPONSE OF E-130G

EBERLINE INSTRUMENT CORPORATION
P.O. BOX 2108 SANTA FE, NEW MEXICO 87501
PHONE: (505) 471-3232 TWX: 910-985-0678

FIXED RADIATION MONITORS

Three fixed monitors are provided. A Model L118 Wall Mounted Monitor is located adjacent to, and interlocked with the Personnel Access Door to the maze. The sensor is in the last leg of the maze leading to the irradiation room so that it prevents opening of the door unless the source is safely stored in the pool and there is no excessive radiation in the room.

A Model D/L2 No. L119 is mounted above the product exit barrier. One additional D/L2 No. L119 monitor is mounted on the deionizer unit. These continuously operating monitors are on separate circuits. They are individually interlocked with the machine operation. Should the radiation at the maze door or resin bed exceed a preset level, the product pass mechanism and conveyors will automatically shut down. These monitors are described in Appendix C.

RELIABILITY UNDER SERVICE CONDITIONS

Response of Monitors in High Radiaton Fields

a. Blank out of Model L118 monitor does not present a hazard. Interlocks prevent the Personnel Access door from being opened until monitor response has been tested each time the door is to be opened.

b. The D/L2 monitors or the Model L118 monitor will alarm well before radiation fields sufficiently high to cause blank out can occur.

MONITOR SETTINGS

a. The monitor on the water treatment system is set to alarm at approximately 0.5 mrad/hr, and that on the exit maze at approximately 0.5 mr/hr. Lower settings may cause spurious momentary alarms not related to a problem area, causing an unnecessary shutdown of the mechanism. The alarm settings are set using the check source.

b. The L118 unit automatically blanks out in a high radiation field, breaking the circuit to the door interlock. It can only be reset when the unit is tested, and when the actual readings are below the preset alarm level. The preset alarm level is approximately 0.5 mrad per hour.

2.2 CALIBRATION OF INSTRUMENTS

2.2.1 RATO/F and Eberline

These units will be calibrated at least semi-annually. Units sent for repair will be calibrated as part of the repair procedure.

2.2.2 Model L118

This unit will be checked for proper functioning at quarterly intervals. The calibration procedure is outlined on Page C-12 of Appendix C.

2.2.3 Model L119

This unit will be tested for proper functioning once a month. The test procedure is outlined on Page C-27 of Appendix C.

PART 3 - PERSONNEL MONITORING

3.1 FILM BADGES AND POCKET DOSIMETERS

All employees who enter the irradiator chamber or who work in or around the irradiator will wear film badges and pocket dosimeters.

Visitors with temporary restricted area access authorization will wear film badges and pocket dosimeters in the irradiation chamber. Badges are exchanged at intervals not exceeding one month and their issue and maintenance are supervised by the Radiation Protection Officer. Film badges and dosimeters are left in the facility in a rack near the entrance to the irradiator.

3.2 PROCEDURAL RESTRICTIONS

At the labyrinth entrance to the irradiator, there is a sign posted to inform personnel that certain radiation monitoring devices are required to be worn in the restricted area. Visitors will be accompanied by the Facility Manager or an authorized operator designated by the Facility Manager. Frequent visits to restricted areas by the Radiation Protection Officer and authorized users ensures that these procedures are followed. The procedures follow.

a. Obtain a film badge and pocket dosimeter from the film badge storage rack before entering any restricted area. Unless the monitoring devices are permanently assigned to individuals with regular restricted access, the name of the wearer must be identified with the identification number of the device, the date and time of issue and return, and the dosimeter reading.

b. Wear the monitoring device(s) at all times while in the restricted area.

c. Return the monitoring device(s) to the designated location upon leaving the restricted area or upon leaving the facility for the day. The time of return must be entered on the form provided.

d. Film badges are collected monthly and sent to the supplier for processing. Quartz-fiber dosimeters are read daily and the results recorded in a log. Film badge results are reported in record form and are transferred quarterly to Forms AEC-5 or equivalent.

e. The issuing, wearing and recording of film badges and dosimeters to employees or visitors is supervised by the Radiation Protection Officer or his designee.

3.3 SUPPLIERS

Pocket dosimeters will be supplied by Dosimeter Corporation of America, or an equivalent supplier. The readable range of the pocket dosimeters will be 0-200 milliroentgens.

TLD personnel badges are currently provided by Teledyne-Isotopes Co., and this service will be continued. An acceptable alternate is R.S. Landauer Co. which provides personnel film badges.

PART 4 - FACILITIES AND EQUIPMENT

4.1 SITE LOCATION AND DESCRIPTION

4.1.1. GENERAL INFORMATION

The Company's plant is located at:

Abbott Hospitals Inc.

Lot Number 3

Macco Industrial Park

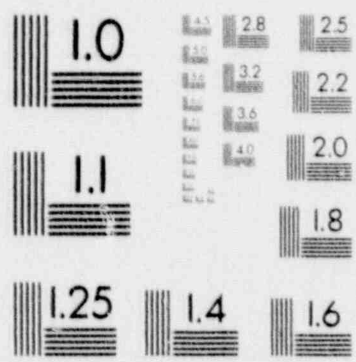
State Road 690 km. 1.7

Barrio Sabana Hoyos

Vega Alta, Puerto Rico 00762

1

IMAGE EVALUATION TEST TARGET (MT-3)



150mm

6"

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IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6″

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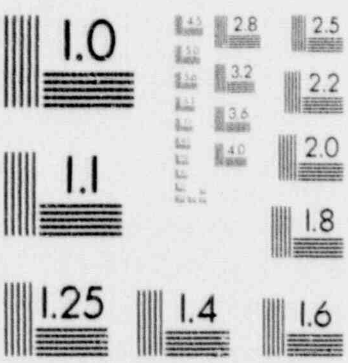
IMAGE EVALUATION TEST TARGET (MT-3)



150mm

6″

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IMAGE EVALUATION
TEST TARGET (MT-3)

150mm

6″

4.1.2 PLANT SITE

The plant is on the left front corner of the Park and adjacent to Route 690. The land area is of a rectangular shape with 4.54 acres of total area, (see map, Page 4-4).

At present, the plant is part of the Macco Industrial Park Development, in conformity with the conditions and recommendations outlined by the approved resolution of the Planning Board of the Commonwealth of Puerto Rico dated June 13, 1980.

The total land area of Lot Number 3 is occupied as follows:

> Buildings, including warehouse and manufacturing areas, offices, equipment and maintenance room, employees' lounge and restrooms, occupy approximately 21,000 square feet. The parking lot and trailer yard utilize 27,000 square feet and the landscaping and unoccupied area takes the remaining portion.

Topography

The topography of the lot is about 90% flat with an average elevation of 49.50 meters.

The adjacent areas follow the same pattern along the west and south side of the lot. The access road of the Park and Route 690 is located to the north and east sides of the lot, respectively.

Flora - Fauna

The vegetation of the area is one of minor fruit trees such as Avocado (Persea Americana), Mango (Mangifera Indica), Breadfruit (Artocarpus Altilis), Lime (Citrus Aurantifolia), Grape fruit (Citrus Paradisi) and Orange (Citrus Sinensis). There are some common ornamental plants, such as Hibiscus, Anthurium and Allamanda Cathortica (Canario). A house and a garage were located on the central area of the Lot but the structures were demolished during the clearing and grading of the development and construction of the Park.

<u>Geological Characteristics - Soil Quality</u>

Seventy-five percent of the soils of the Park area are of the Bayamon Rock Outcrop and the rest is of the Tanama Rock Outcrop types.

<u>Natural - Artificial Systems</u>

There are no natural or artificial systems in the Park area.

<u>Surrounding Terrains - Description and Usage</u>

The Park area is part of a small valley surrounded by low promontories (mogotes), which are very common along the northern coastal slope zone. The promontories are located to the north, west, and south areas of the Park and the terrains are not suitable of agriculture due to the difficulty to work them.

To the east, across State Road 690, is the Owens Illinois Industrial Glass Plant and the El Morro Corrugated Box Corporation. The nearest housing or community is located about 600 meters northeast of the Park and is known as Regadera Community.

There are three houses south of the Park, but they will be relocated to another area due to the widening of the road (Route 690), which is presently under construction.

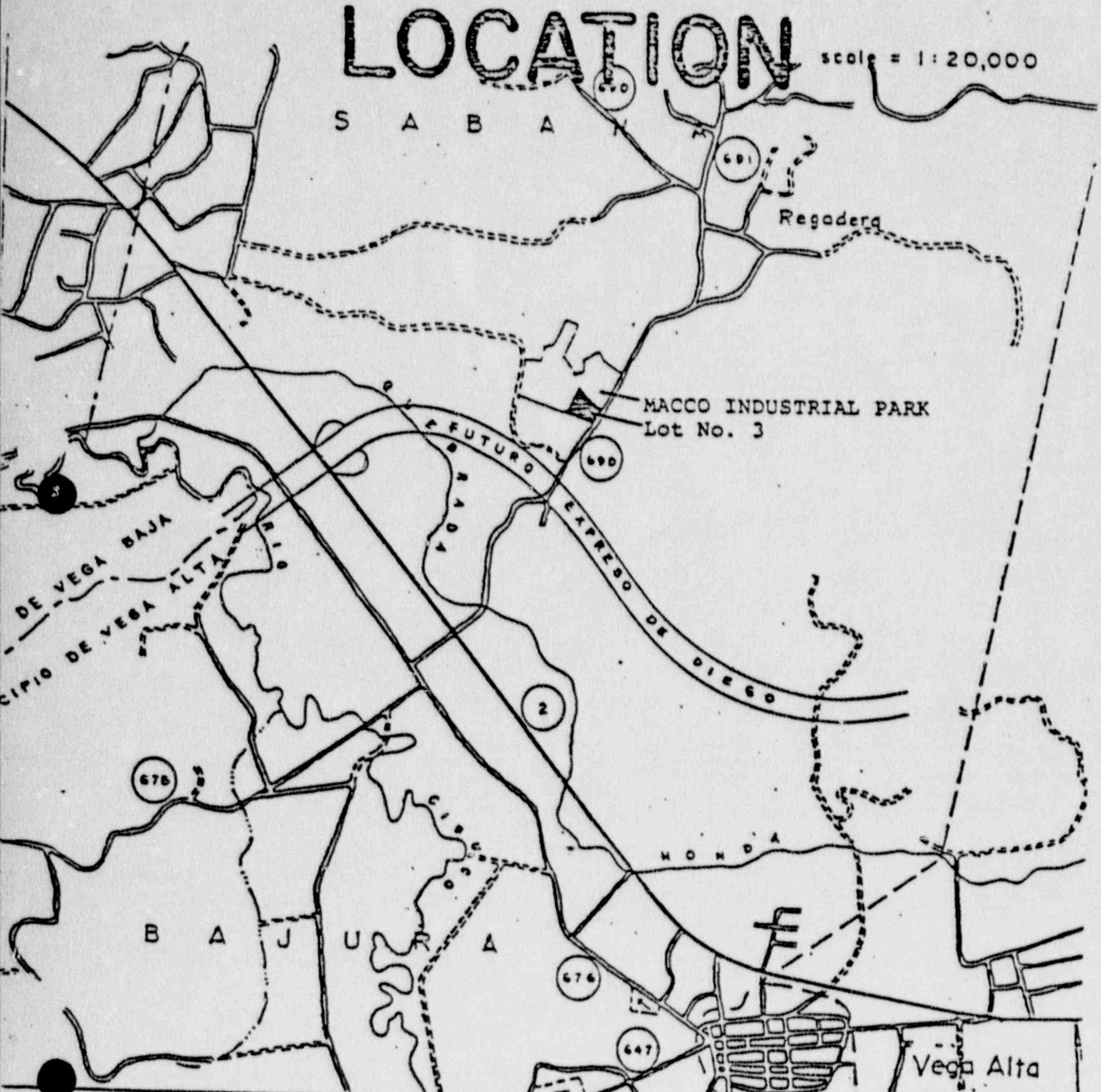
<u>Meteorology and Climatology</u>

The prevailing climate is tropical and the temperature variations are minimum. The average annual rainfall for the area is about 60 inches. The winds are mostly from the east - northeast to the southeast with an average velocity of 12 to 14 miles per hour.

<u>Present Planning Board Zonification</u>

The present zoning of the Macco Industrial Park is IL - 1 as per Resolution of the Planning Board dated June 13, 1980.

4.1.3 MAP OF AREA



4.1.4 SEISMIC HISTORY OF PUERTO RICO

(Source: U.S. Coast & Geodetic Survey)

The seismic history of Puerto Rico places it in the Zone 2 category, using the same criteria employed in the Uniform Building 2 Code, in designating seismic risk in the United States. This means that while a large part of the island may experience intensity VII and VIII earthquake disturbances (Modified Mercalli Intensity Scale of 1931), intensity IX, indicating major damage, is experienced at such infrequent intervals and over such limited areas that they modify the evaluation of risk over a long period of time. In recent years there has been a tendency to raise the MM intensities associated with the Uniform Building Code zones by one grade.

The maximum earthquake damage ever reported from Puerto Rico occurred on October 11, 1913, from a submarine earthquake (magnitude 7.5) in Mona Passage not far from the northwestern corner of Puerto Rico. In the nearby coastal area there was major damage from ground vibrations and additional damage from seismic sea waves. This shock struck closer to the shores of Puerto Rico than any other strong shock in its history.

The western half of Puerto Rico may expect moderate damage at relatively frequent intervals from submarine shocks which follow approximately the 67.10 meridian in the areas west and northwest of the island. Seismographic data reveal shocks of the following magnitude in the last 50 years in this area: 6.2, 6.5, 6.5, 6.8, 7.0, 7.5, and 7.8. They originated from 10 to 60 miles offshore.

In the eastern area a submarine shock in 1867 estimated of magnitude 7.5, appears to have originated within the triangle formed by the islands of St. Thomas, St. Croix, and Vieques. Although 75 miles off the eastern coast of Puerto Rico, damage was reported from all parts of the island, especially the eastern portion. Instrumental results indicate a smaller number of strong shocks in the eastern waters of Puerto Rico than in the waters to the west and northwest. No shocks of high magnitude have been recorded in the eastern area in the last 50 years.

Six or eight nondestructive shocks originating within historic time on the island itself have shaken areas seldom exceeding 25 miles in radius. They apparently all centered in the mountainous area halfway between San Juan and Ponce.

Possible Fault Line

Maps indicate that there is a possible fault line approximately 35-40 miles long, which generally parallels the north central cost of the island approximately 1-2 miles inland. The proposed facility will be located some 3-5 miles east and south of the eastern extremity of the possible fault.

Discussion

The structural portion of the facility has been designed to accommodate earth movements of the magnitudes indicated by past recorded experience.

The pool itself is constructed as an integral unit separate from the floor of the irradiator building and the foundation walls. The pool is free to move relative to the interior building, thus minimizing the stresses applied to walls and floor of the pool during any earth movement.

4.2 BUILDING LAYOUT

See Appendix B

4.3 MECHANISM OPERATION

4.3.1 Description

Refer to Drawing B- 110701-002 in appendix A. Each source is raised from the fully shielded (safe) position in the pool to the "irradiation position" by one stainless steel cable attached to the source rack. These cables run through the ceiling to a pneumatic hoist system. Return to the fully shielded (safe) position is by gravity when the air supply is shut off and the pneumatic hoists are vented. Each source rack is guided by two taut stainless steel cables extending from the floor of the pool through the ceiling to the roof. The cables run through guides at each end of the source rack. The correct "irradiate" position of the source rack is sensed by the end of the rack activating a microswitch mounted on one of the guide cables. Each hoist cable passes over two sets of sheaves. One set of sheaves is fixed, the other is moved by the pneumatic cylinder so as to increase the separation between the two sets of sheaves thereby hoisting the rack. The hoisting distance is a function of the preset piston stroke and the number of sheaves in each set. The "irradiate" position of the source rack is adjusted to the full stroke of the pneumatic hoist.

Removing the air supply and venting the pneumatic hoists permits the weight of the source and rack to force the two sets of sheaves together. This extends the cable, lowering the source to the fully shielded (safe) position in the pool. The rate at which the source is lowered is governed by the rate at which air is allowed to exhaust from the pneumatic hoists. This normally takes about 25 seconds.

The hoists are located on the roof of the irradiation room where they can be serviced at any time. The only components of the source system within the radiation room are the source in its rack, guide cables, hoist cables and one microswitch. The rack, guide and hoist cables are not subject to radiation damage. Failure of the microswitch will return the source to the fully shielded (safe) position.

Each hoist cable is 3/16 inch (4.76mm) diameter preformed and prestressed stainless steel wire rope. The construction is 7 strands of 19 wires each and the breaking strength is rated at 3,700 pounds (1,678 kg). The weight of each of the two fully loaded source racks is approximately 600 lb (272 kg).

Separate guide cables for the rack are 5/16 inch (7.94 mm) diameter preformed and prestressed stainless steel wire rope.

A two-position keyswitch on the control console allows only one source rack hoist cylinder to be activated, and one source rack will be raised to the irradiate position. In the second key position, both racks are raised.

The bottom of each guide cable is attached to a hook located at the end of an anchor assembly made from 2 stainless steel angles. This assembly is attached to the pool floor by threaded anchors embedded in the concrete. The tops of the guide cables pass through tubes installed in the concrete ceiling where they are held taut by tensioning devices on the roof. The source hoist and guide cables are visually inspected by AECL-CP at the time of each source replenishment and by the operator once a month during the routine preventive maintenance. If any broken strands or signs of wear are apparent, the source modules are removed from the rack by qualified AECL-CP personnel and stored at the bottom of the pool. The empty source rack is then raised and cables closely examined. If necessary, the damaged cable is replaced.

The guide cables can be removed from or replaced on the hooks on the anchor by use of underwater tools handled in areas above the pool surface where the radiation levels are low. There is no need to empty the pool for cable inspection or change.

4.3.2 Source Movement Procedure

To raise the source and start the machine, the operator must first rectify any faults indicated by the console lights. He must then use the MACHINE key to activate a time delay at the far end of the radiation room. This allows him to make a last inspection and ensures that no one is in the room. He then has a period of 90 seconds in which to engage the source hoist air interlock and close the maze door. The irradiation will start when the MACHINE key is turned to the START position. If the time delay runs out before he completes this sequence he must repeat the entire sequence.

The source hoist is controlled by fail-safe interlocks to prevent the source being raised if correct procedures are not followed or faults are indicated by safety devices. During the machine operation, the source will automatically return to the fully shielded (safe) position in the event of a power failure, a loss of air pressure or the actuation of a safety device.

A power failure when the source is up will de-energize all relays causing the air to exhaust from the source hoist system and lower the source. To prevent unnecessary shutdowns due to power failures of short duration, a pneumatic timer will restart the machine and raise the source if the power is off for less then ten seconds. Since the access door cannot be opened when the power is off, this feature does not present a radiation hazard to personnel. (Note: This is a future design change. At present, the control panel must be manually reset, and the unit activated in the normal startup sequence).

The following unusual occurrences have been considered and the consequences are shown to not represent a radiation hazard. These are to be rectified by qualified AECL-CP personnel.

a. Source cable breaks. The rack would drop to the bottom of the pool under its own weight. The resistance of the water would prevent the rack from reaching sufficient speed to damage the source elements.

The rack in the fully up irradiate position actuates a microswitch secured to the guide cable. The microswitch must be actuated to indicate that the source is in the correct irradiate position. If the microswitch is de-actuated, the source moving alarm will sound. The air is exhausted from the hoist cylinder allowing the rack to return to the fully shielded (safe) position and the machine is shut down.

If the hoist cable breaks, the machine would shut down because of the de-actuation of the microswitch. The absence of weight pulling on the hoist would prevent the source down limit switch from being actuated. The source moving alarm will continue to sound, warning the operator of an abnormal occurrence.

To replace the hoist cable qualified AECL-CP personnel would remove the source modules from the rack. The modules and source pencils would be inspected underwater for any damage and stored at the bottom of the pool if no damage is apparent. The empty rack would then be lifted out of the water and inspected for any damage. The hoist cable would be replaced and the source modules would be reloaded into the rack.

b) Hoist cable jams in hoist. The hoist is located on the roof outside the radiation room and is readily accessible. It can be dismantled and the cable freed without any personnel exposure.

c) Source rack sticks on guide cable. The guide cable can be detached from the tensioning devices on the roof and lowered to the bottom of the pool.

d) Obstruction prevents source rack from lowering. Product is prevented from jamming against or under the rack by the metal carriers which are guided at the top and bottom.

e) Obstruction above the source rack. The lift capacity of the hoist is limited by controlling the air supply to it. An obstruction would prevent the rack from reaching the irradiate position within the preset time, causing it to automatically return to the fully stored safe position. The irradiator would be shut down.

Electrical Circuitry

All electrical circuits within the radiation room are low voltage, typically 24V, which is too low to result in an electrical shock hazard in the event of radiation damage to insulation or other components. The wiring is installed so that only the final 18 inches (45 cm) connecting to the pneumatic cylinders is ever flexed. Electrical malfunctions due to failed insulation will blow fuses and shut the plant down without creating a radiation hazard.

Personnel barriers at the product entry and exit openings are automatically controlled by the product. Product boxes which obstruct the openings must be present before the barrier doors open.

4.3.3 SPREAD OF RADIOACTIVITY DUE TO FORESEEABLE ACCIDENTS

Airborne Radioactivity

Tests have indicated that in the event of rupture of a source pencil containing cobalt-60, there will be no airborne release of radioactive material. As a precaution, a 97% absolute filter is placed in the ventilation system. There are no radioactive gases present.

In Source Storage Pool

The pool is a closed system so there will be no release of radioactivity from it to the environment.

It is assumed that a leaking source pencil could result in 10^{-5} uCi/ml in the pool. This has been discussed in "Radiation Levels Due to Foreseeable Accident" part (C) Leaking Source Capsule (below). The disintegration of a source element is not considered possible. The lining of the pool is such that it can be cleaned by wiping and vacuuming without hazard if conducted by qualified personnel.

Source Movement Displays

Closing the maze door, after the interlocks within the radiation room have been properly made, lights a green MACHINE READY light on the control console.

Turning the MACHINE keyswitch to START causes the key, when released, to return to the ON position and yellow MACHINE ON indicator to light. The green SOURCEDOWN light is extinguished and the source travel alarm rings. When the source is fully raised, as signalled by the microswitch on the guide cable, the red source UP indicator lights and the source travel alarm stops ringing. Automatic operation of the conveyor system begins.

4.3.4 RADIATION LEVELS DUE TO FORESEEABLE ACCIDENTS

a) Source Activity Transported on a Product Carrier

The carriers will be stopped by the alarming of the D/L2 monitor when exterior radiation levels reach approximately 0.5 mr/h. The maximum activities which can escape undetected are:

i) activity detectable leaving product exit door =7.0 mCi cobalt-60.

ii) activity detectable 10 feet (3.05m) before reaching end of maze = 80.0 mCi cobalt 60.

b) The Source Rack Sticks or Jams

There will be no external radiation field greater than that in normal operation.

c) Leaking Source Capsule

A maximum concentration of 10^{-5} uCi/ml is expected. This will deposit on the filter and resin bed of the water treatment plant and could accumulate to 0.5 mCi in a month. The radiation field at 1 metre from the treatment plant would therefore not exceed 0.6 mR/h. In any event the D/L2 monitors would alarm and shut down the irradiation facility when the preset alarm level or 0.5 mR/h is reached.

4.4 SHIELDING AND CALCULATIONS

4.4.1 RADIATION ROOM SHIELDING

Permissible Radiation Levels

The shield is designed to attenuate radiation from the design capacity source to the level recommended by the International Commission on Radiological Protection. Shielding thicknesses are calculated so that under normal working conditions no person in the vicinity of the irradiator will receive more than 10 mrem/week or a maximum of 500 mrem/year.

The occupancy factor for areas adjacent to the irradiator shield is assumed to be 40 h/week.

Material Specifications

Concrete density = 2.35 g/cm^3 (147 lb/ft^3)

Lead = 11.35 g/cm^3

Shield Penetration

The ventilation duct from the radiation room passes below the floor and terminates in the equipment room at the filter assembly.

Piping serving the water treatment plant and the pool cooler, exits from the shielded area in a trench below the floor. Lead wool is used in the trench to reduce the radiation field to an acceptable level.

The source hoist and guide cables pass through the concrete ceiling in pipes which are just large enough to accommodate them. The pipes are located in the concrete with lead shot packing. In surveys of previous installations, the leakage along each of these paths has been acceptably low.

In any event, a complete survey of radiation fields in all accessible areas around the facility must be carried out when the source is first raised. Any deficiencies in shielding must be corrected before the plant is considered operational.

4.4.2 SHIELDING CALCULATIONS

Radiation Levels

The shield for the IR107 irradiator is shown on Drawing B110701-002 in appendix A. The shield is designed to attenuate the radiation from a 4,000,000 curie cobalt-60 plaque source to sufficiently low levels so that under normal working conditions no person in the vicinity of the irradiator receives more than an average of 10 mrem per week or a maximum of 500 mrem per year. This is the exposure level recommended by the International Commission on Radiological Protection (1) for individual members of the public.

To allow full occupancy of 40 hours per week in all areas adjacent to the irradiator, the shield is designed to reduce the average exposure rate with a capacity source to less than 0.25 mR/h. Radiation levels up to 2.0 mR/h are allowed in small areas adjacent to the shield provided that these do not contribute significantly to the personnel dose. Some of the areas where exposure rates between 0.25 mR/h and 2.0 mR/h may be expected are at the edges of the personnel door, at the product opening, at the floor trench, at the edges of the roof plug and outside the primary shield at the source centerline.

When the source is in the fully shielded (safe) position, the average exposure rate inside the radiation room will be less than 0.25 mR/h.

Primary Shielding

The transmission of cobalt-60 gamma radiation in concrete is shown in Figures 5.1A ad 5.1B, Pages 4-17 and 4-18. The exposure rate from a 1 curie point source of cobalt-60 is 1.3 x 10^3 mR/h at 1 metre and varies inversely with the square of the distance. Concrete thickness of the primary shielding was determined by calculating the maximum exposure rate outside the shielding wall for a point source and correcting for source geometry and absorption within the source plaque. Some sample calculations are given below:

a) Maximum field outside external wall parallel to source plaque.

   Concrete thickness = 74 inches (1.88 m)

   Transmission = 1.4 x 10^{-9}

   Distance from source center to exterior surface of wall = 16 feet 8 inches (5.08 m)

Exposure rate due to point source of 4,000,000 curies of cobalt-60 =

$$1.3 \times 10^3 \times 4.0 \times 10^6 \times \left(\frac{1}{5.08}\right)^2 \times 1.4 \times 10^{-9} = 0.28 \text{ mR/h}$$

Self absorption factor and geometry factor for transforming point source calculation to that for 13 foot (3.96m) high plaque source = 0.7

Maximum exposure rate = 0.20 mR/h

This is within the design average radiation level of 0.25 mR/h

b) Maximum field outside wall at end of source plaque.

Concrete thickness = 71 inches (1.80m).

Transmission = 3.3×10^{-9}

Assume point source at center of source plaque.

Distance from source center to exterior surface of wall = 21 feet, (6.40m).

Exposure rate due to point source of 4,000,000 curies of cobalt-60

$$1.3 \times 10^3 \times 4.0 \times 10^6 \times \left(\frac{1}{6.40}\right)^2 \times 3.3 \times 10^{-9} = 0.42 \text{ mR/h}$$

Self absorption and geometry factor at end of source plaque = 0.3

Maximum exposure rate = 0.13 mR/h

This is below the design average radiation level of 0.25 mR/h. Additional attenuation provided by oblique transmission through concrete will reduce the average radiation levels in the areas adjacent to the primary shielding to less than 0.25 mR/h with a capacity source of 4,000,000 curies of cobalt-60.

Maze Design

Accurate calculations of the exposure rate and energy spectrum at points along a concrete maze are difficult to perform. At present detailed calculations of the exposure rate attenuation in concrete mazes have been confined to two-legged concrete ducts (2). The amount of work required for detailed calculations for mazes with more than one right-angle bend becomes prohibitive and maze designers must either rely on measurements to determine exposure rates at the entrance of a maze with several legs or must make order of magnitude estimates using purely empirical formulae.

Maze entrances for industrial irradiators designed by AECL-CP are based on both calculations and measurements. The radiation incident upon the maze walls due to singly-scattered radiation is calculated by dividing the scattering areas into small segments and calculating the amount of singly-scattered radiation from each segment. The exposure rate from the small scattering area A (Figure 5.2, Page 4-19) is given by:

$$D = \frac{D_o\, \partial\, (E_o, \theta_o, \theta, \phi)\, A \cos \theta}{r_1^{\,2} \qquad r_2^{\,2}}$$

Where,

$\partial(E_o, \theta_o, \theta, \phi)$ is the differential exposure albedo,

A is the area of the scattering surface,

D_o is the exposure rate at one unit length from the source.

E_o is the initial energy of the gamma rays from the source.

Values of the differential exposure albedo,

$\partial(E_o, \theta_o\, \theta, \phi)$ have been calculated by Raso [3] using the Monte Carlo method. Using the Raso data, Chilton and Huddleston[4] developed the following semi-empirical equation for the differential exposure albedo,

$$\partial(E_o, \theta_o, \theta, \phi) = \frac{C(E_o)\, K(\theta_s)\, 10^{26} + C'\, (E_o)}{1 + \cos \theta_o / \cos \theta}$$

Where $C(E_o)$ and $C'(E_o)$ are constants for a given energy
$K(\theta_s)$ is the Klein-Nishina differential energy scattering coefficient.
θ_s is the angle through which the radiation is scattered and is given by:

$$\cos \theta_s = \sin \theta_o \sin \theta \cos \phi - \cos \theta_o \cos \theta$$

For cobalt-60 gamma rays, E_o = 1.25 MeV

C(1.25 MeV) = 0.0665

C'(1.25 MeV) = 0.107

The calculated values of the differential exposure albedo for cobalt-60 gamma rays have been verified by measurements at AECL-CP.

The energy of the single-scattered radiation is given by:

$$E = \frac{E_o}{1 + \frac{E_o}{0.511}(1-\cos\theta_s)}$$

The required thickness of the maze walls required to attenuate the single-scattered radiation of energy, E, to below the design levels are calculated and corrections for lower energy multiply-scattered radiation are made using information obtained from measurements of the radiation fields in and around mazes built by AECL-CP.

For the maze walls where no single-scattered radiation is incident and the maximum radiation energy is due to doubly-scattered radiation, an estimate of the incident doubly-scattered exposure rate is obtained by calculating the scatter from one wall surface to another surface and then to the maze wall. The energy of the gamma rays impinging on the second area is assumed to be the energy of a gamma ray having one Compton scatter at the center of the first area and going to the center of the second area. For the second scatter, the parameters"

$C(E_o)$ and $C'(E_o)$ are approximated by

$C(E_o) = 0.0561\ E_o^{\ 0.574}$ and $C'(E_o) = 0.0122\ E_o^{\ -0.683}$

Again, corrections for lower energy multiply-scattered radiation are made from measurement data.

Detailed measurements of radiation fields inside mazes have been performed by AECL-CP for two shielded room facilities in Ottawa, the irradiator at St. Hilaire, Quebec, and the Ethicon Medical Products Sterilizing Irradiator in Somerville, New Jersey. In addition, surveys of the exterior radiation fields are performed on every industrial irradiator built by AECL-CP. These extensive measurements confirm that the recommended maze shielding provides adequate protection.

References

1. "Recommendations of the International Commission on Radiological Protection", (adopted September 17, 1965), ICRP Publication 9, London; Pergammon Press 1966.

2. J.M. Chapman and C.M. Huddleston, "Dose Attenuation in Two-Legged Concrete Ducts for Various Gamma-Ray Energies", Nuclear Science and Engineering, 25, 66 (1966).

3. D.J. Raso, "Monte Carlo Calculations on the Reflection and Transmission of Scattered Gamma Rays", Nuclear Science and Engineering, 17, 411 (1963).

4. A.B. Chilton and C.M. Huddleston, "A Semi-Empirical Formula for Gamma Rays on Concrete", Nuclear Science and Engineering, 17, 419 (1963).

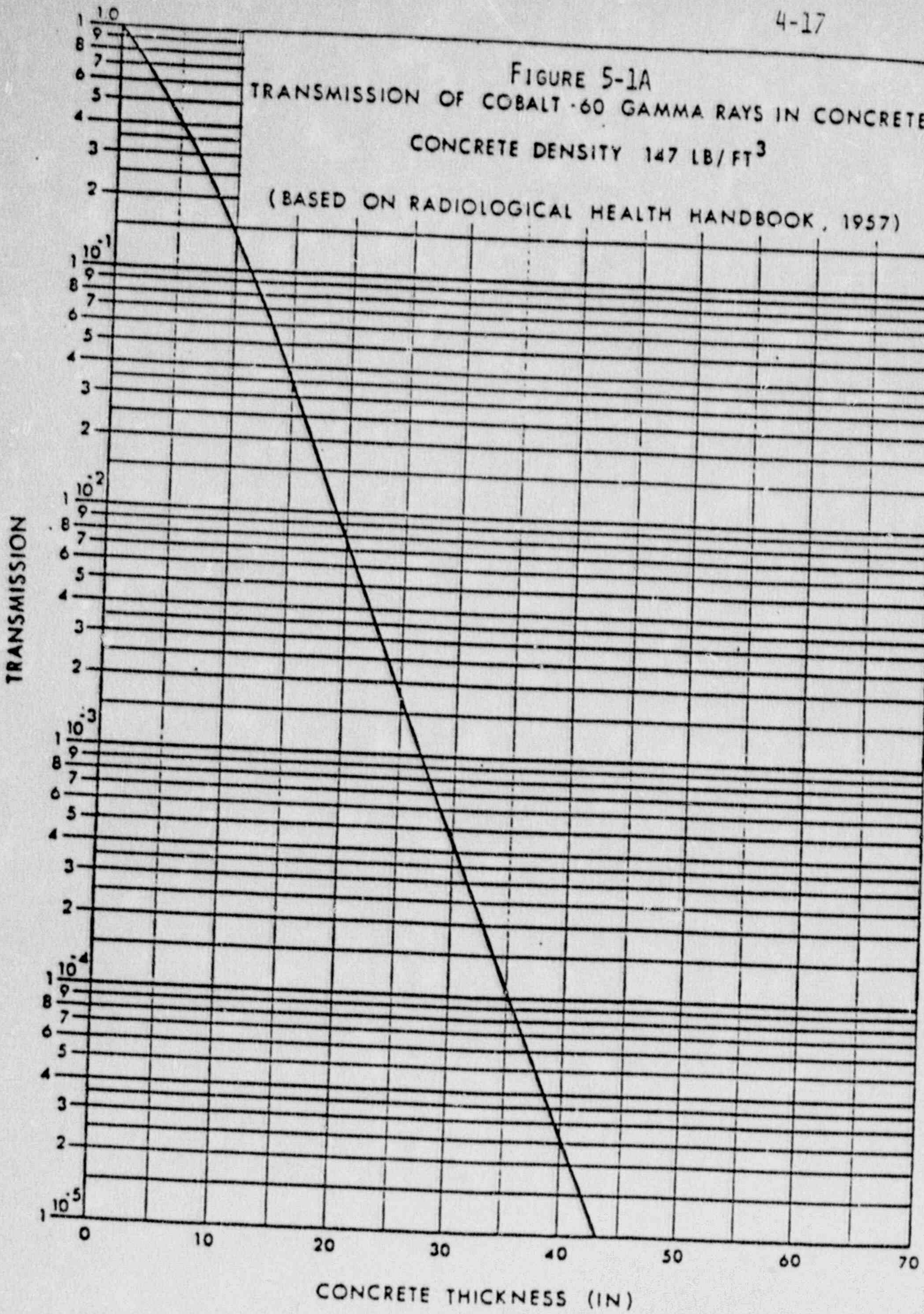


FIGURE 5-1A
TRANSMISSION OF COBALT-60 GAMMA RAYS IN CONCRETE
CONCRETE DENSITY 147 LB/FT3
(BASED ON RADIOLOGICAL HEALTH HANDBOOK, 1957)
TRANSMISSION
1.0
10-1
10-2
10-3
10-4
10-5
0
10
20
30
40
50
60
70
CONCRETE THICKNESS (IN)

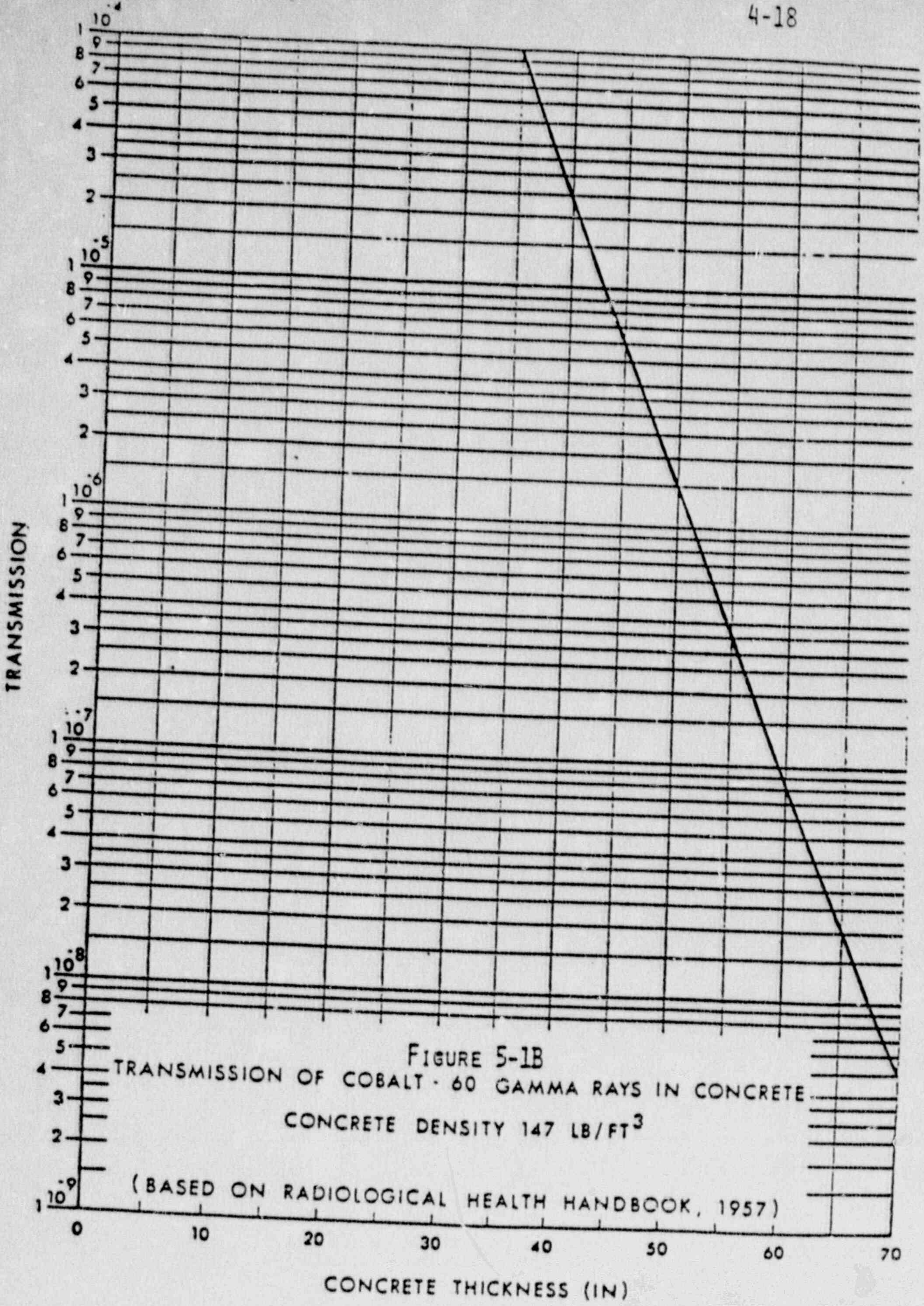


FIGURE 5-1B

TRANSMISSION OF COBALT - 60 GAMMA RAYS IN CONCRETE

CONCRETE DENSITY 147 LB/FT^3

(BASED ON RADIOLOGICAL HEALTH HANDBOOK, 1957)

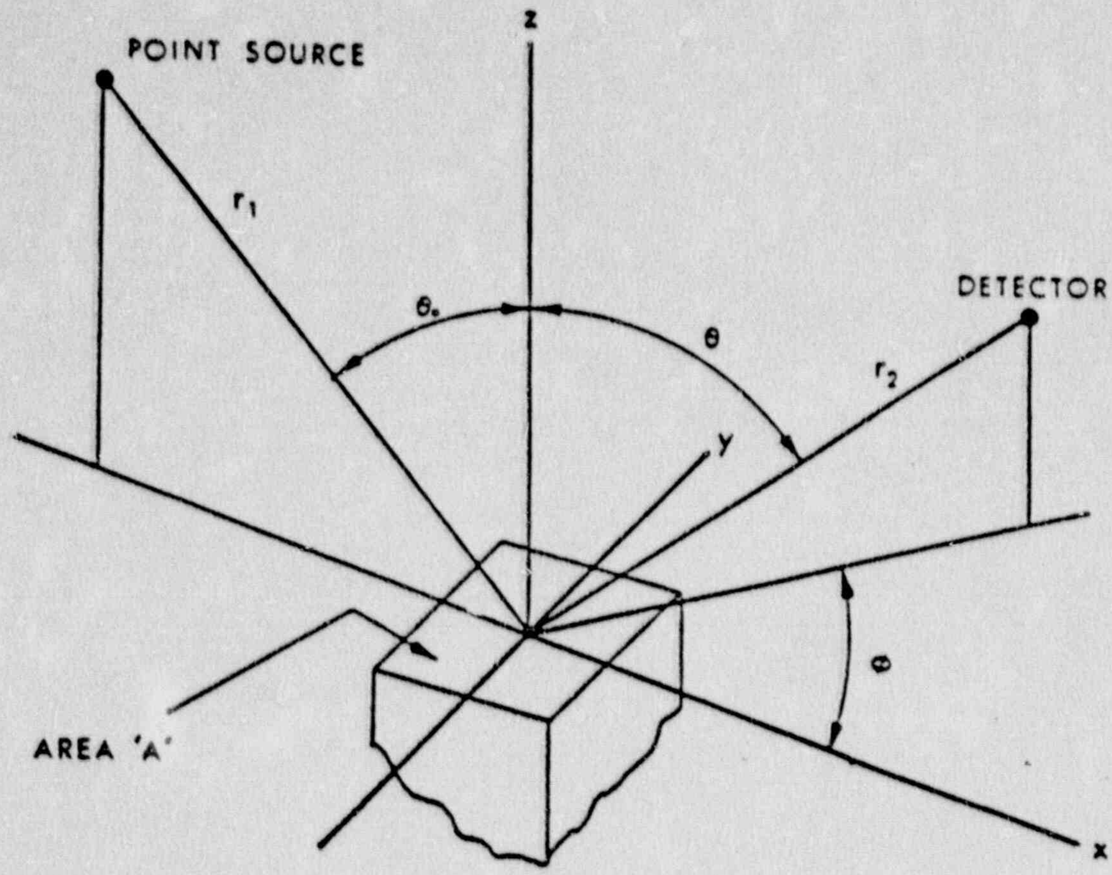
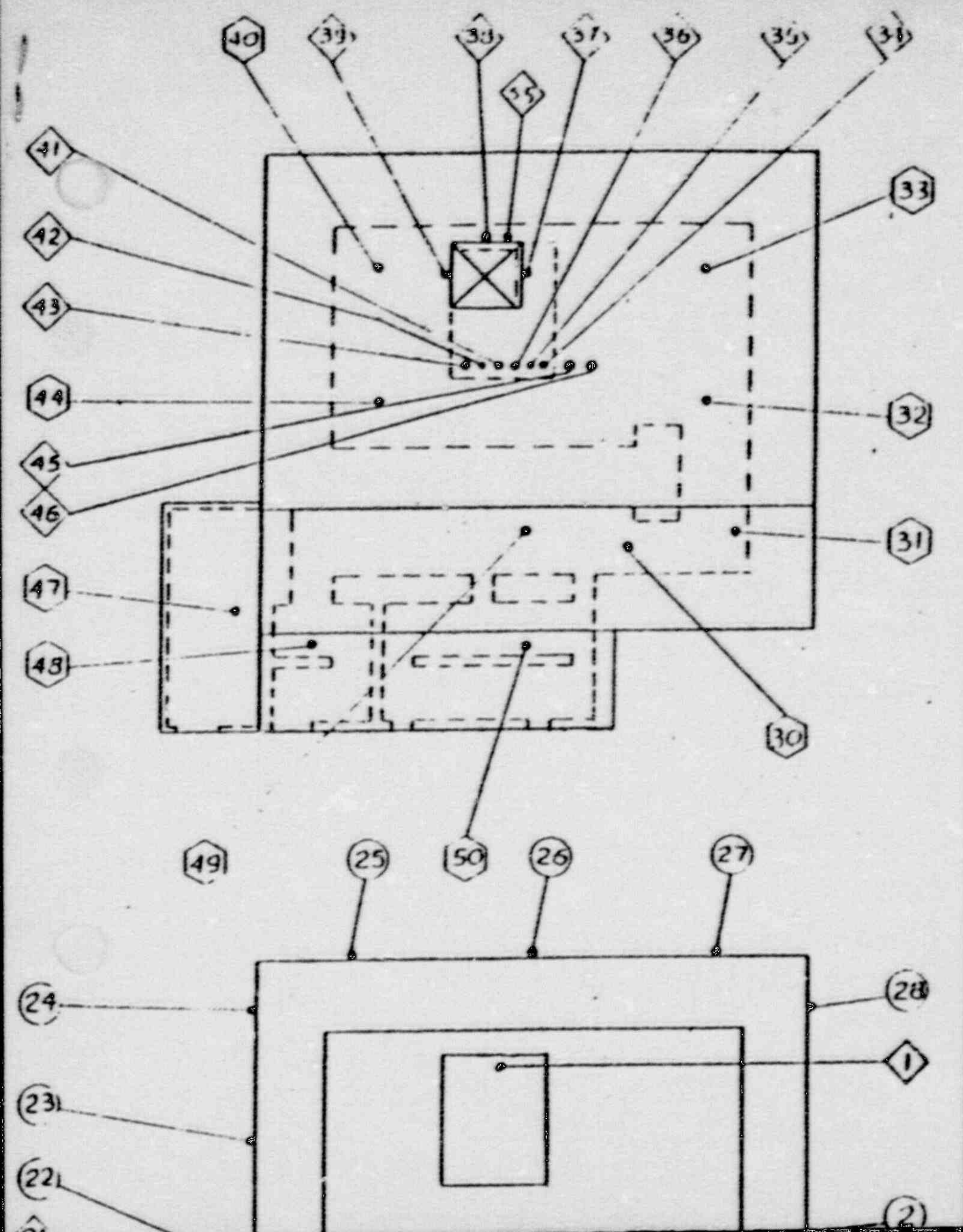


FIGURE 5-2
SCATTERING OF GAMMA RAYS
FROM SURFACE

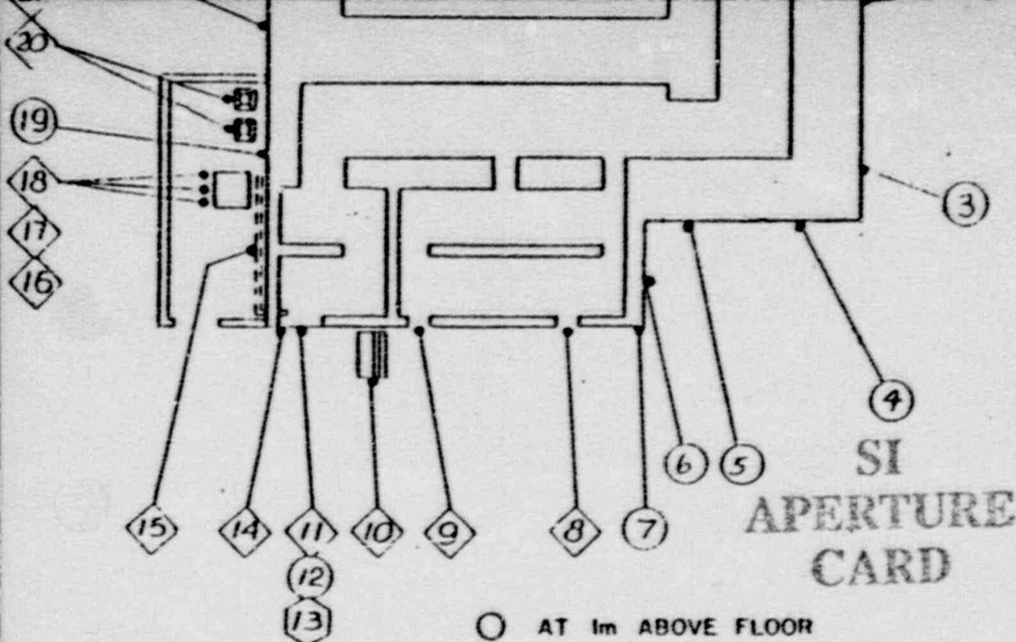
4.4.3 Radiation Survey

A radiation survey, taken 1-29-86, is on the following page, and represents measured dose rates at critical areas with 1,700,000 curies of installed cobalt-60. The survey indicates safe working radiation levels.



ALL READINGS IN mrem/h
READINGS LESS THAN 0.03 mrem/h
SHOWN THUS *

NO	READING	REMARKS
1	.06	POOL SURFACE
2	*	
3	*	
4	*	
5	*	
6	*	
7	*	
8	.3	CONVEYOR OUTLET
9	.1	CONVEYOR INLET
10	.08	CONTROL CONSOLE
11	.2	TOP OF DOOR
12	.2	
13	.35	
14	.35	DOOR CRACK
15	.2	FLOOR TRENCH
16	*	DEIONIZER
17	*	DEIONIZER
18	*	DEIONIZER
19	*	
20	*	AIR FILTER
21	*	AIR FILTER
22	*	
23	*	
24	*	
25	*	
26	*	
27	*	
28	*	
29		N/A
30	*	
31	*	
32	*	
33	*	
34	*	GUIDE CABLE
35	*	HOIST CABLE
36	*	GUIDE CABLE
37	.25	ROOF PLUG
38	.05	ROOF PLUG
39	*	ROOF PLUG



40	*	
41	*	GUIDE CABLE
42	*	HOIST CABLE
43	*	GUIDE CABLE
44	*	
45	.2	AIR SUPPLY LINE
46	.1	AIR SUPPLY LINE
47	*	
48	*	
49	*	
50	*	
51		
52		
53		
54		
55	1.5	BASE OF PLUG
56		
57		
58		
59		
60		

○ AT 1m ABOVE FLOOR

⬡ AT FLOOR OR ON ROOF

◇ ON NAMED FEATURE (SURVEYOR TO ADD AS NECESSARY)

ALL READINGS WITH SOURCE IN NORMAL IRRADIATION POSITION, EXCEPT FOR POOL SURFACE ** (SOURCE DOWN)

SURVEY TO USNRC

8911290369-01

MAXIMUM RADIATION DESIGN LEAKAGE SO THAT NO ONE SHALL RECEIVE MORE THAN 10 mrem IN A 40 HOUR WORK WEEK WITH CURIES OF COBALT-60 INSTALLED.

OCCUPANCY HRS/WEEK	DOSE RATE IN mrem/h IN AREA	
	MAXIMUM	AVERAGE
40	2.0	0.25

SURVEY PERFORMED BY J. VARAKLIS
DATE JAN. 29/86

SURVEY INSTRUMENT MODEL RATO / F
SERIAL NO. 2064 CALIBRATION DATE 85-10-29
SOURCE CONTENT 1,717,932 CURIES
ON DATE JAN. 1st 1986

ATOMIC ENERGY OF CANADA LIMITED
OTTAWA COMMERCIAL PRODUCTS CANADA

RADIATION SURVEY REPORT
AFTER SOURCE INSTALLATION NO. 5
IN IR 107 ISOMEDIX
PUERTO RICO

4.5 POOL AND WATER TREATMENT SYSTEM

4.5.1 DETAILS OF POOL CONSTRUCTION

Pools used for the wet storage of source pencils in AECL-CP industrial irradiators are constructed of reinforced concrete water-proofed by a continuous 4-ply membrane waterproofing applied to the exterior surface of the walls and floor. The specifications for membrane waterproofing and for Flintkote "Yellow Jacket" glass fibre membrane material are given in para. 4.5.2. The pool walls and floor are tested for leakage after the application of the membrane waterproofing and prior to backfilling.

The pool is constructed as an integral unit separate from the floor of the irradiator building and the foundation walls. The pool is free to move relative to the irradiator building, thus minimizing the stresses applied to walls and floor of the pool during any earth movement.

In the unlikely event that a crack should develop through the poolwalls, the rate of water loss from the pool would be dependent on such factors as the permeability of the backfill and subsoil, and the distance above the water table. Water could be supplied at a rate greater than the rate of water loss by running hoses into the maze. The water level in the pool would be maintained at a sufficiently high level to permit underwater source handling operations. The source modules could then be removed from the source rack and the source pencils transferred from the source modules into shipping containers lowered to the bottom of the pool. The pool could then be drained and repaired.

The only foreseen condition that would require draining the pool and placing the sources into temporary storage is to repair a crack in the pool. All other operations including decontamination can be performed without emptying the pool. If it is ever necessary to drain the pool, sufficient shipping containers to temporarily store the entire source can be shipped from AECL-CP at short notice. For a source of 1,000,000 curies of Cobalt 60, three type F-168 source shipping containers, each capable of storing 400,000 curies of Cobalt 60 would be required. There is no personnel safety hazard during the period between the development of a crack in the pool and its repair. Depending on the rate of water loss, the irradiator can be shut down and personnel prevented from entering the radiation room or the water in the pool can be maintained at the proper level by installing temporary auxiliary supplies and irradiator operations can be continued until repairs are made.

The interior walls and bottom of the pool are lined with stainless steel which is corrosion resistant, impermeable to water and easily decontaminated.

MONITORING

The carbon filter and resin beds are continuously monitored for radioactive contamination. Once a month the radiation levels are checked with the hand-held Berthold RATO/F or equivalent and the results recorded. Any indication of a change in the amount of radiation present should be reported in accordance with the "Operating Regulations" to be supplied.

4.5.2 POOL WATERPROOFING SPECIFICATIONS

A. EXAMINATION

1. Before the work of membrane waterproofing is commenced, the sub-contractor is to examine all walls and other surface to satisfy himself that all materials and finishes are in a proper condition for him to work over, and that all the proper waterproofing sleeves and flanges if any are installed for integration into the membrane, where pipes or ducts pass through.

2. All honeycombing, construction joints, form ties, etc. on the surfaces to be waterproofed shall be cut out to a depth of at least 1" and shall be patched with "Embeco".

3. The waterproofing sub-contractor will be held responsible for the final water-tightness unless he notifies the General Contractor and the engineer in writing of defects, before commencing his work. Should this trade start the work without such notification, it shall be construed as an acceptance by him of all proceeding and connecting work and as a waiver of all claims or questions as to the suitability of such work for receiving his membrane water proofing.

4. Concrete to receive waterproofing to have a maximum water content of 20% as ascertained by Inspector.

B. MATERIALS

1. Asphalt primer - of the penetrating type meeting CGSB37-GP-9.

2. Glass Fibre Membrane - shall be an inorganic asphalt impregnated interwoven glass fibre cloth weighting not less than 1.8 oz. per square yard. Weave shall be 20 x 10 mesh or, shall be asphalt saturated cotton fabric weighting not less than 10 oz. per square yard and meeting C.S.A. Specification A123.15-1953.

3. Asphalt - types 1, 2 and 3 - C.S.A. A123.7.

4. Protective Board - 7/16" asphalt impregnated fibreboard.

5. Butyl Rubber - Mark II M.D.N. ASTM-D-412-61-T.

6. Butyl Rubber Adhesive - M.B.N. Asphalt or No. 90 M.B.N.

7. Joint Sealer - 'gas Joint Sealer manufactured by Sika Chemical Corporation - or equal approved.

C. PROTECTION

1. Where 1" - 0" widths or projecting membrane are exposed for lapping purposes at further application, the following protection will apply:

   After the projecting lap membranes have been laid and before any other traffic uses these areas, lay a complete temporary covering of building paper lapped 6" at joints, followed by a complete temporary covering of plywood or other non-flexible material. These shall only be removed just prior to the further application of the wall membrane.

2. 7/16" asphalt impregnated particle board shall be applied as per manufacturer's written specifications over all exposed membrane where waterproofing comes in contact with backfill to avoid damage to the finished membrane.

D. APPLICATION

1. This work includes the furnishing of all labor, materials, tools, scaffolding, ladders, plant and other equipment required to complete the following hot process membrane waterproofing.

2. Surfaces over which waterproofing is to be applied shall be smooth and free from loose materials, grease, oil or any foreign matter. Wash off surface with water hose to assure freedom from deleterious substances, and allow surfaces to dry.

3. All concrete surfaces to be waterproofed shall be primed with <u>undiluted</u> Asphalt Primer at a rate of one gallon per square foot.

4. The application of all waterproofing membrane shall be a full mopping of each ply, three or more plies as specified of membrane, to the primed concrete surfaces, using not less than 20 pounds of hot asphalt per mopping per 100 square feet, plus top mopping. In no place shall dry membrane touch dry membrane. All membrane shall be applied without wrinkles or buckles, making provision for ample lapping etc., as herein after specified, or indicated on the drawings.

5. A 3 Ply glass fibre membrane to be applied to exterior faces of all concrete pool walls.

6. At sump pits and other depressions below the floors, the membrane shall be 4 ply on walls and under slab, in accordance with above specifications, excepting that one additional ply of glass fibre and one additional mopping of hot asphalt shall be applied.

7. At all edges and angles, apply two extra plies of membrane in two additional moppings of hot asphalt. Additional plies of membrane shall be lapped not less than 6" all around.

8. Where vertical laps are left to be connected, they shall be temporarily protected with a 1/2" layer of cement mortar or treated wood plank. When connections with laps are made, laps shall be carefully cleaned and dried before proceeding with the work.

9. Provide extra plies carefully cut and fitted, and lapped onto pipe sleeves that pass through basement walls, trenches, sumps or pits. All gaps between pipes and sleeves shall be carefully caulked and made watertight.

10. Lay 1-1/2" insulation over waterproofing under arcade walk according to manufacturer's instructions of this type of application.

E. DEFECTIVE WORK

Work which has been applied poorly or has become defective before backfilling or other covering, is to be ether removed or is to have additional layers of material applied until acceptable.

4.5.3 WATER TREATMENT PLANT SPECIFICATIONS

TYPICAL RAW WATER ANALYSIS

Alkalinity as $CaCo_3$	Less than 100 ppm
Ion as FE	Less than 1 ppm
Calcium as $CaCo_3$	Less than 120 ppm
Free Chlorine as $C1_2$	Less than 1 ppm
Total Hardness as $CaCo_3$	Less than 50 pm
Turbidity	Less than 10 ppm
Dissolved Organic Material	Less than 1 ppm
Color	Less than 15 ppm
Total Solids	Less than 150 ppm
Ph Factor	6.5 to 8.0

NOTE:

To determine the capacity of the water treatment plant, two (2) one-half pint water samples in clean containers should be sent to AECL for analysis.

WATER TREATMENT PLANT CHARACTERISTICS

1. Carbon Filter Bed - approximately 12 inches diameter.

2. Two Bed Demineralizer - exchange capacity greater than 1,000,000 milligrams as $CaCo_3$.

   Quality of effluent using raw water better than 10 micromhos/cm. Beds approximately 12 inches diameter.

3. Flow rate - maximum 26 1pm (7.0 U.S. gpm).*

4. Working Pressure - 3.5 Kg/cm^2 (50 psig)
   Maximum Pressure - 5/6 Kg/cm^2 (80 psig)

WATER TREATMENT PLANT DESCRIPTION

1. Plant approximate dimensions are 1.1 m wide x 0.5 m deep x 1.5 m high (42 inches W x 19 inches D x 60 inches H).

2. Complete plant is skid mounted and completely assembled with all necessary water controls and flow meter. The raw water supply line, drain line, pool discharge line, recirculation line and all electrical wiring may be hooked up directly to the plant services. The drain system must be of acid resistant construction.

3. All valves and controls are located and accessible at the front of the plant.

4. An electrical control box containing a control relay, transformer, shut off switch and fuses is supplied and installed by AECL.

5. A pump motor starter is supplied and installed by AECL.

CARBON AND RESIN SPECIFICATIONS

1. Carbon Bed - 2 cubic feet of high density large grain activated carbon.

2. Cation Resin - 2 cubic feet of DOWEX 50-8-W or equal.

3. Anion Resin - 2 cubic feet of DOWEX 21-K or equal.

4.6 'ENTILATION SYSTEM

4.6.1 DESIGN BASIS

The system must:

a) maintain humidity at a low level,

b) prevent ozone from escaping down the maze,

c) maintain the ozone concentration within the radiation room low enough that the operator can safely enter the room as soon as the source has reached the fully shielded (safe) position.

The intakes, ducting and exhaust are laid out as described in Dwg. B110701-002. The location and height of the exhaust stack is such that the discharged air cannot be drawn into nearby ventilation intakes.

The air flow through the ventilation unit is adjusted by setting the damper to give an exhaust rate of 2200 ft^3/minute (62.3 m^3/minute). This corresponds to a linear velocity of 2800 ft/minute (854 m/minute).

The ventilation system is itself interlocked to a temperature sensor so that a high temperature condition in the radiation room will stop the ventilation system.

No auxiliary ventilation system is included.

4.6.2 NOXIOUS GAS PRODUCTION AND CONTROL

Allowable Concentration Versus Expected Production

GAS	ALLOWABLE/WORKING DAY	EXPECTED WHEN SOURCE IS UP
Ozone	0.1 ppm*	0.6 ppm
NO_2	5. ppm**	60 ppb
H_2	<4% ***	zero

* American Conference of Governmental Industrial Hygienists

** US OSHA

*** Lower Limit of flammability

The production of ozone is 1.2×10^{-3} standard m^3/h per million curies of cobalt-60. Radiation room air is exhausted at 2200 $feet^3$/min for approximately 4.6 minutes per complete air change. The concentration of ozone will therefore be adequately low by the time the operator can enter the radiation room.

The recombination rate of radiolytically produced H_2 is high enough that essentially no H_2 escapes from the water. The production of NO_2 is less than 60 ppb which does not represent a hazard.

4.6.3 CONTROL BY VENTILATION AND LOWERING OF SOURCE

Ozone and NO_2 production takes place when the source is exposed. As shown in preceding page, their levels will be controlled by operation of the ventilation system. In the event of this system failing the source is automatically lowered to fully shielded (safe) storage in the pool.

4.7 SAFETY DEVICES - SUMMARY

(Refer to Drawing B110701-002G in appendix A)

The control system contains interlocks which will prevent start-up if correct procedure is not followed. Existing faults are annunciated at the control console. They must be rectified before start-up can take place. Similarly, faults which develop during operation, will automatically return the source to the SOURCE DOWN position and stop all conveyors. The problem may be diagnosed from the displays on the console.

4.7.1 MACHINE KEY

One key is used to operate all circuits as follows:

a) the POWER keyswitch

b) the MACHINE keyswitch

c) the MAINTENANCE keyswitch

d) the START-UP timer keyswitch

This key also unlocks the personnel door to the maze.

IMPORTANT - Only one key should be used. This key must be attached permanently to a handheld radiation monitor. Duplicate keys must be kept by the supervisor for emergency use only.

4.7.2 MAZE DOOR LOCK

The maze door can be opened from the outside only;

a) with the MACHINE key

b) after POWER has been turned ON

c) when the source rack is in the "safe" position

d) when the cell monitor has been shown by test to be operating properly and no abnormal radiation field is present in the irradiation room.

This door may be opened from the inside at any time.

4.7.3 SOURCE HOIST VALVE

A safety chain across the maze just inside the door is mechanically interlocked with the source hoist air valve. Unless this chain is in place air can not be supplied to the source hoist to raise the source.

4.7.4 EMERGENCY STOP CABLE AND BUTTON

A pull-cable runs along the maze and three walls of the irradiation room. If pulled, all conveyors will stop and the source will be lowered automatically. An emergency STOP button on the console performs the same safety functions.

4.7.5 FIXED RADIATION MONITORS

A Model L118 Radiation Monitor is located alongside the Maze Door. Its radiation sensor is located in the irradiation room to sense radiation fields in the room when the source is down. The monitor circuit must be tested, by increasing the sensitivity to cause an alarm condition every time the door is to be opened. The monitor interlock prevents the door from being opened and sounds an alarm horn if there are abnormal radiation fields. There is an indicator light.

A Model D/L2 No. 119 monitor is mounted at the product exit door. Its sensor is located so as to monitor the radiation inside the maze door. Its purpose is to confine any radioactive material within the biological shield by stopping the conveyor. The source will also be lowered and a high pitched alarm sounded.

The carbon filter and resin beds are continuously monitored for radioactive contamination. Once a month the radiation levels are checked with the handheld Berthold RATO/F or equivalent and the results recorded. Any indication of a change in the amount of radiation present should be reported in accordance with the "Operating Regulations" to be supplied.

4.7.6 START-UP TIMER

A 90 second timer which must be started with the MACHINE key is located at the far end of the irradiation room so that the operator ensures that the conveyors are correctly loaded and that no one remains in the room. If the start-up procedure if not completed within the time limit or any emergency device is actuated the start-up procedure must be repeated. The green MACHINE READY light is illuminated only after the maze door is closed. A warning bell rings during the timing period, and a light flashes in the irradiator.

4.7.7 SOURCE MOVING ALARM

When the source is either DOWN or UP its position is annunciated by console lights while it is in transit a source moving alarm bell replaces those light signals. A "Radiation Warning" light adjacent to the maze door is illuminated when the source is not in its "safe" position.

4.7.8 SOURCE RACK GUIDE CABLE

If the source rack should jam, the tension on the guide cables can be relieved from outside the irradiation cell to permit the rack to be set free.

4.7.9 POOL WATER LEVEL

The water level in the pool is automatically maintained within pre-set levels by a switch controlling a water make-up line. The cell monitor will detect an increase in background radiation if the water level drops significantly while the source is in the down position.

A raw water meter measures and records the amount of make-up water being automatically introduced into the pool.

4.7.10 IN CELL TEMPERATURE SENSOR

A temperature sensor located in the radiation room will actuate if a rise in temperature of 40°F (22°C) above ambient occurs. Actuation of this sensor will cause the source to be lowered into the fully shielded (safe) position, stop the product pass system and shut down the room ventilation system.

The radiation room walls, ceiling and floor are constructed of concrete as shown on the drawing. The equipment inside the radiation room is mainly metal with a small amount of organic material such as insulation on wires, etc. This organic material will not sustain combustion when the ignition source is removed.

4.7.11 SECURITY SYSTEM

The irradiator system has been designed for total automation and hence unattended operation. The input accumulator conveyor can hold some 18 loaded carriers, ready for processing. These are fed into the irradiator in a controlled sequence, and completed carriers are directed into the output accumulator. Any malfunction--inside or outside of the irradiator--will automatically cause the source to return to the storage position.

A trained operator will be present and available whenever the irradiator is in use.

The security system includes the following:

(1) The property is surrounded by a 6' high chain-link mesh fence, topped with 1-foot high barbed wire (three strands, off-set).

(2) All doors and windows which give access to the warehouse area, which houses the irradiator, are interlocked with a burglar alarm system. Any violation of the system automatically triggers a telephone system to call the Radiation Facility manager or the licensed operator who is designated to be on standby and respond to abnormal operations for that period. The system also ties into the local police station, giving them notification of a possible unauthorized entry.

If unauthorized access is made into the warehouse, the security system relating to the irradiator itself will prevent entry into the unit while the source is exposed.

4.7.12 ROOF PLUG INTERLOCK

An interlock on the roof plug senses when the plug is in the fully seated position. The source cannot be raised unless the plug is in its fully seated position.

4.7.13 FIRE PROTECTION IN RADIATION CELL:

An automatic sprinkler system with fusible heads is installed in the irradiator over the source plaque. An in-cell fire will melt the heads, causing water to sprinkle on the fire.

A manual cut-off valve to this portion of the sprinkler system is located outside of the radiation chamber.

4.7.14 IN-CELL SMOKE DETECTOR

A Model CA-4 Pyrotronics Smoke Detector is incorporated into the control system. A probe continually draws air from the ceiling of the radiation cell and passes it through the monitor, which is located outside of the chamber. Detection of smoke will cause audio and visual alarms to display, and send the source into the storage position. The alarm has UL864 approval.

4.7.15 IN-CELL STARTUP ALARM

When the operator activates the in-cell key-activated, 90 second keyswitch, a horn sounds and lights flash inside the irradiator to warn of an irradiator startup.

4.7.16 POWER FAILURE

In the event of power failure, tho source returns to the storage position. The cell cannot be entered until power is restored to the in-cell radiation monitor.

4.7.17 HAND-HELD MONITORS

Initial entries into the irradiator, following source return from the irradiate position, are made by a qualified operator, utilizing a hand-held monitor with both audio and visual alarms. The monitor is checked for operability with a test source prior to each use.

PART 5 - WASTE DISPOSAL

5.1 COLLECTION, STORAGE AND DISPOSAL OF RADIOACTIVE WASTES

Contaminated Pool Water

This will be cleaned by passing it through a specially designed treatment plant. The radio-activity will accumulate in the filter and resin bed.

Contaminated Solid Wastes

These will consist of filters and resins contaminated during the cleaning up of any spill. Other contaminated waste expected would be rags and styrofoam pads used for removing contamination from pool walls, source rack and other irradiator components.

These contaminated wastes would be stored in steel drums or shielded containers and disposed of as authorized by the U.S. NRC.

All radioactive source material to be returned to Atomic Energy of Canada Limited - Commerical Products, for disposal.

COMMENT - normal operation of the plant produces no radioactively contaminated wastes.

PART 6 - RADIATION PROTECTION PROGRAM

6.1 INTRODUCTION

It will be our philosophy to keep radiation exposure of employees and the public as low as reasonably achievable (ALARA). This philosophy is implemented in the following ways:

a) Design of operating procedures to minimize radiation safety hazards.

b) Continuous radiological surveillance of operational activities.

c) Establishment of effective administrative procedures, including emergency actions.

d) Utilization of competent, well-trained personnel.

e) Use of well-tested and reliable equipment.

f) Use of outside experts in the areas of radiation safety as backup to our own staff.

Abbott will continue as was previously done by Isomedix, Inc. to utilize the staff and services of Atomic Energy of Canada Limited (AECL) in radiation safety issues.

Abbott has also contracted with Isomedix, Inc. for assistance during the first year of operation in monitoring its radiation safety program, for helping to assure that license conditions are met, and for certain other operationally related functions. This assistance will be provided by Isomedix through its Corporate Radiation Safety Committee (J. Masefield, G. Dietz, J. Young -- whose resumes are included in Part 10).

Specific tasks will include:

a) Periodical visits to the site for on-site inspection of records and adherence to the designated safety program.

b) Review and approval of personnel recommended by the Radiation Facility manager for operator status.

c) Assistance in licensing matters.

d) On-call assistance in routine or non-routine radiation safety and operational matters.

e) Counting of smears and wipe tests, with appropriate certification of results.

6.2 ORGANIZATION

6.2.1 Operations

The chief operating officer of the facility is the Radiation Facility Manager. He is responsible for the safe and continuous functioning of all aspects of the company's operations, including Radiation Safety. He reports to the AHI Production Manager.

6.2.2 Radiation Protection

The on-site Radiation Protection Officer (RPO), if other than the Radiation Facility Manager, reports to the Radiation Facility Manager on operational issues and to the Division or Corporate RPO on safety issues and as such, has direct authority to regulate operations when necessary to achieve adequate radiation protection control. If there is a conflict, radiation safety will take precedence over operational issues.

The responsibilities of the on-site Radiation Protection Officer include:

a) Development of the radiation protection program.

b) Surveillance of conditions affecting radiation protection, including source inventory and control, facility radiation monitoring, and personnel monitoring.

c) Training employees and the public in radiation protection principles and practices.

d) Coordination of emergency actions.

e) Maintenance of radiation protection records.

f) Licensing actions and liaison with the federal regulatory authorities. Periodic inspections of the Radiation Protection Officer's files and records will be made by the Corporate Radiation Protection Officer, to assure compliance with license requirements and company standards.

6.2.3 Maintenance of Safe Working Conditions

6.2.3.1 Source Inventory and Control

6.2.3.2 Procurement

Each purchase order for radioactive material is approved by the Corporate Radiation Protection Officer to aid in determining that possession limits are not exceeded.

6.2.3.3 Inventory

Upon receipt or shipment of radioactive material, a copy of the receiving, shipping or transfer ticket is sent to the Corporate Radiation Protection Officer who enters the material into or removes it from inventory.

6.2.4 Contamination Detection Procedures

6.2.4.1 Source Wipe Testing

In the absence of a certificate from a transferror indicating that a test for leakage and/or contamination has been made within six months prior to a transfer to the facility, each source is leak tested upon arrival at the facility. Also, prior to removal or shipment, and in any case, at intervals not to exceed six months, sources are wipe tested. (Procedures are detailed in Section 8.2.5, p. 8-13).

6.2.4.2 Irradiator Wipe Test

Wipe testing of walls in the irradiator is accomplished on a monthly basis as follows:

a) Using a clean, dry, cotton swab or filter disc, thoroughly wipe several representative accessible surfaces of the irradiator and exhaust filter.

b) Place the sample in a clean plastic vial or envelope and remove from the irradiator.

c. Measure with a RATO/F or equivalent meter. If reading is over one millirad per hour, notify R.P.O. If below one millirad per hour, wrap and send samples to R.P.O. Abbott Park or New Jersey for counting and determination of activity.

d) Procedure for counting is outlined in Section 8.2.5.

6.2.4.3 Routine Checks

In addition to the constant checks of the safety devices and systems made by operations personnel and the continuous display of area radiation monitoring, the Radiation Protection Officer makes the following checks;

a) Visual Inspection

Although inspections of the irradiator and discussions with operations personnel are made daily on an informal basis, regular inspections are conducted. These inspections consist of discussions with operation personnel about current and future work, observation of ventilation, monitoring, water and other controls, checking of the condition of irradiator equipment and confirmation that posted operating procedures are being followed.

b) Daily Operation Check

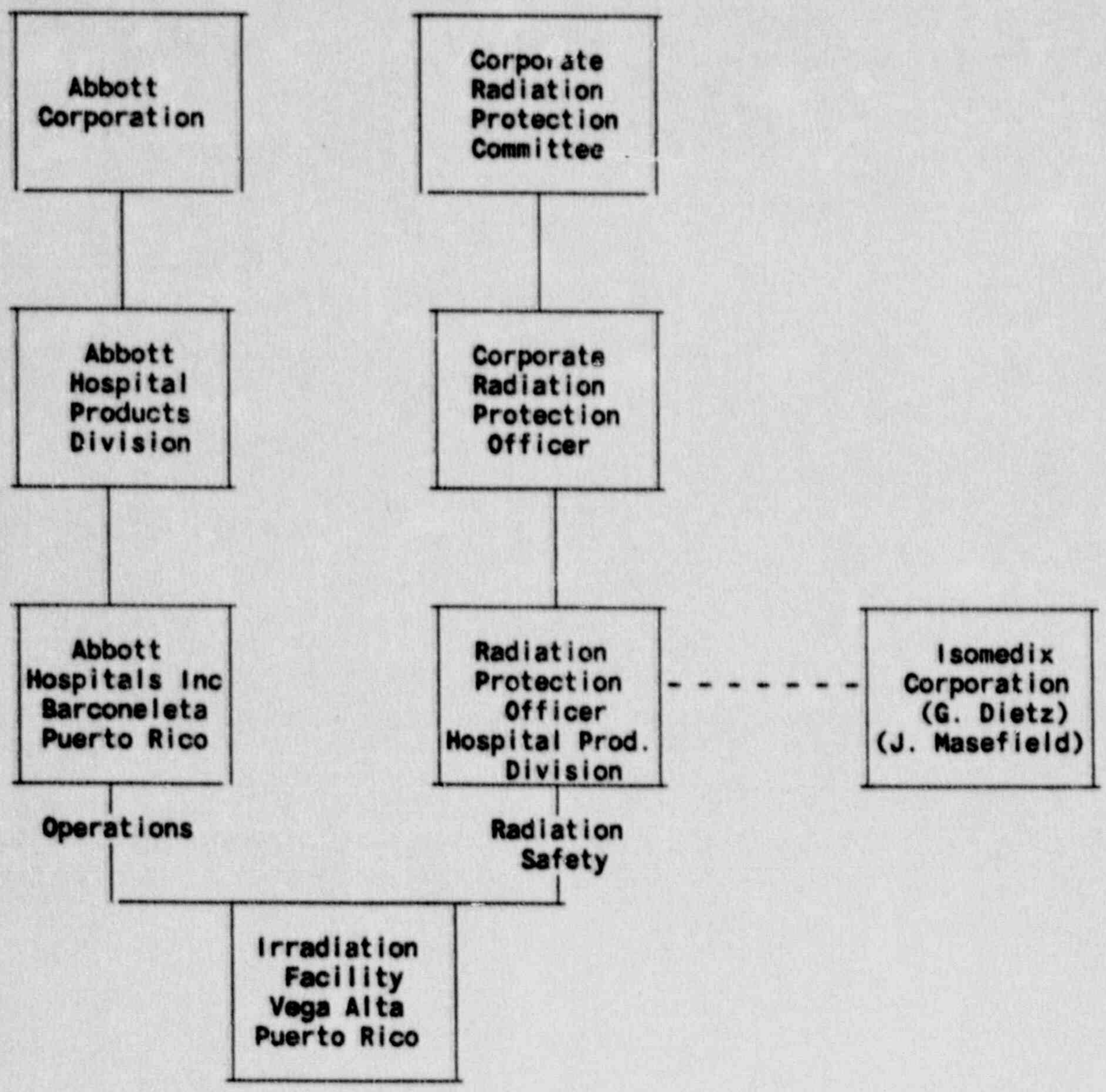
1. Visual checks by Operator to assure indicator lights are not burned out.

2. Determination that major systems are functioning during normal operations.

c) Other Periodic Inspections

Weekly, monthly, quarterly, semi-annual and annual checklists have also been developed to assure safe and uninterrupted operation of the irradiator.

Section 7 outlines the daily, weekly, monthly, and quarterly radiation safety checks. Semi-annual and annual checks, which pertain to mechanical operation, have been omitted.



Abbott Corporation
Corporate Radiation Protection Committee
Abbott Hospital Products Division
Corporate Radiation Protection Officer
Abbott Hospitals Inc Barconeleta Puerto Rico
Radiation Protection Officer Hospital Prod. Division
Isomedix Corporation (G. Dietz) (J. Masefield)
Operations
Radiation Safety
Irradiation Facility Vega Alta Puerto Rico

PART 7 - OPERATIONAL AND SAFETY CHECKS

7.1 IRRADIATION ENTRY

Prior to each initial entry into the irradiator, the operator will complete the following "Irradiator Entry Safety Check".

When the safety check is completed, the operator may enter the irradiator, carrying the hand-held meter.

IRRADIATOR ENTRY SAFETY CHECK LOG

(To be performed prior to each entry into irradiator)

1. Control console "Source Down" light shall be illuminated.
2. Flashing "Source Up' light shall be off.
3. "Source Down" light shall be lit and alarm shall be silent.
4. In-cell probe will indicate a radiation field of normal background only.
5. In-cell probe shall be tested to confirm it is operational.
6. The portable survey instrument shall be turned on and tested with the check source to be sure it is functional.
7. After opening the personnel entry door, the air coupling shall be disconnected to cut off air supply to the source hoist mechanism.

When these safety checks are made and the safety system is determined to be functional, the irradiator may be entered using the approved irradiator entry procedure.

DATE	TIME	SYSTEM FUNCTIONAL (Yes or No w/Comment)	OPERATOR

7.2 SAFETY AND MAINTENANCE RELATED CHECKS

It is self-evident that preventive maintenance on both the safety and mechanical systems of the irradiator will greatly assist in unit operation in the safest and most economical manner.

The following formalized weekly, Monthly and Quarterly Operation Check-lists do not obviate the requirement that the operator exercise a continuous daily observance of operations and systems, and cause their repair or replacement on an as-needed basis.

The checklists may be modified as required to enhance their effectiveness.

7.2.1 WEEKLY SAFETY/MAINTENANCE CHECK

DATE ____________________

INSPECTOR____________________

ITEM	COMMENT (OK OR OTHER)
1. Visually inspect control panel All lights and indicators shall be working correctly.	____________
2. Attempt to open personnel door with key, with source up. Door should not open.	____________
3. Source-up light will be on.	____________
4. Press Emergency Stop Button. Source moving bell should alarm, "source up" light should extinguish, and "source moving" light will illuminate.	____________
5. After source travel (approximately 30 seconds)"source moving" light will extinguish and "source down" light will illuminate. The "source up" light will extinguish.	____________
6. Attempt to open door without performing the radiation monitor check. Door should not unlock.	____________
7. Perform monitor check and open door. Disconnect source hoist air line and inspect for damage, wear, etc.	____________
8. Enter cell in approved manner with monitor. Check radiation level over pool. Record reading at pool surface ____________ .	____________
9. Depress pool water level control switch. Audible and visual alarms will sound at the control panel, the pump shall stop, and makeup water shall flow into the pool.	____________
10. Inspect skimmer and remove debris as required.	____________

WEEKLY SAFETY/MAINTENANCE CHECK

ITEM		COMMENT (OK OR OTHER)
11.	Generally inspect the pool, source and mechanism for obvious faults.	________
12.	With the key, activate the startup delay timer. An audible alarm should sound, and the warning light will begin to flash.	________
13.	Exit the irradiator, hook up the air hose, and close the door. Allow the delay timer to time out and attempt to raise source. Source shall not raise.	________
14.	Reenter the irradiator and start the delay timer. Exit, hook up the air hose, leave the door open and activate the "source up" switch. Source shall not raise.	________
15.	Close door and activate source. Observe control panel lights for correct operation. Source moving alarm shall sound.	________
16.	Inspect carrier gate operation. They will sequence open and closed with carrier movement.	________
17.	Inspect air compressor for correct oil level in crankcase. Check for leaks. Clean air filter. Check V-belt for wear and tension.	________
18.	Check water treatment plant. Record incoming _______ and outgoing _______ water conductivity. Check for correct flow rate, no leaks, and general correct operation.	
19.	Check air line lubricators and filters. Refill if necessary. Check for air and oil leaks.	________
20.	Visually inspect product carriers, storage conveyors and cylinders, and load/unload stations, for normal or routine operations.	________

7.2.2 MONTHLY SAFETY/MAINTENANCE CHECK

DATE ______________

INSPECTOR ______________

ITEM		COMMENT (OK OR OTHER)
1. Use the portable survey meter and check air filter banks and water filter and resin beds. Record readings.	AIR BANK	______________
	WATER BANK	______________
2. Lower source and enter irradiator. Pull the emergency cable. Safety stop fault indicator light shall illuminate. reset emergency cable.		______________
3. Check source guide cables for broken strands, fraying or signs of wear. (Report defects immediately.)		______________
4. Check that the limit switch on the outlet conveyor shuts down the machine for a "fully loaded" condition.		______________
5. With the source down, expose the irradiation room monitor to the test source. The alarm will sound. Close personnel door. Door will not be able to be opened from the outside.		______________
6. Expose the irradiation room monitor to the test source. An alarm will sound.		______________
7. Expose the exit barrier monitor to the test source. An alarm will sound.		______________
8. Expose the deionizer monitor to the test source. An alarm will sound.		______________
9. Check ventilation system. change air filters.		______________

MONTHLY SAFETY/MAINTENANCE CHECK

10. Check the Monorail Drive Unit motor for overheating. Inspect V-Belt for wear and slipping. Check clutch for slipping. ________________

11. Inspect source hoist and windup cables for wear or broken strands. ________________

12. Take one smear of following area: (6 month Source Wipe test for June and December):

    a. Top of source rack
    b. Middle of source rack
    c. Bottom of source rack
    d. Cesium 137 ________________

7.2.3 QUARTERLY SAFETY CHECK

Date ______________

Inspector ______________

1. **Smoke Detectors**

   Blow smoke into the intake vent. The console warning light shall display, and the ventilation system will turn off. ______________

2. **Pool Water Chlorine Test**

   Test the Pool water with the ph test kit. Record results. Ph Reading: ______________

3. **Temperature Probe**

   Use a heat source. Place under temperature probe. The console warning light will display, and the ventilation system will turn off. ______________

PART 8 - OPERATING PROCEDURES

8.1 NORMAL OPERATION

8.1.1 Normal Start-up

Normal start-up is defined as the commencement of operations not dictated by faulty or abnormal conditions.

To start the machine, the operator should proceed as follows:

In the Equipment Room

Turn on the main power supply to the control power transformer.

At the Control Console

1. Using the MACHINE key, turn the POWER keyswitch to the "RESET" position and release. The RESET/POWER TRIP indicator will briefly illuminate.

NOTE: The radiation alarm may signal for a short period until the irradiation room monitor capacitors have fully charged.

2. Check the FAULT INDICATORS:

   a) Source Pass/Overdose Timers

   b) Source Rack/Maze Monitor

   c) Low Air/Safety Stop

   d) High Temp/Exhaust Fan

   e) Safety Timer/Intern Conv

   f) Load-Unload/Deionizer Monitor

   If any of these indicators are illuminated, a fault exists and must be rectified before proceeding (refer to "AUTOMATIC FAULT SHUT-DOWN").

3. Check that the irradiation room monitor, located at the maze door, is functioning as indicated by the flashing of the lamp and that the indicated radiation level is normal. If the radiation level is not normal, or if an alarm condition is indicated, leave the facility immediately (refer to "CONTAMINATION DETECTION PROCEDURES" in this manual).

4. Check that the digits on the MASTER CONTROL are set to their correct positions. If the setting is incorrect, alter the time cycle accordingly.

5. Set the OVERDOSE CONTROL to a duration approximately 20% longer than that set on the MASTER CONTROL. Use the TIMER key for this purpose.

6. Check that carriers are available on the inlet conveyor and that the outlet conveyor is clear.

7. Proceed as outlined in Figure 3.1 "ENTRY PROCEDURE".

NOTE: The maze door can not be opened if,

a) the monitor has not been tested, or

b) the radiation alarm is signaling, or

c) the source is not in the fully down position.

IMPORTANT

When entering the maze:

If a noticeable increase in the audio output of the portable monitor is evident, leave and close the maze door, and notify the Radiation Protection Officer immediately. The Radiation Protection Officer will check the radiation levels with the survey meter and will notify Atomic Energy of Canada Limited - Commercial Products of unusual conditions or incidents and/or take appropriate safety actions.

Do not enter the irradiation room.

POST IN A PROMINENT POSITION CLOSE TO THE CONTROL CONSOLE AND AT THE MAZE ENTRANCE DOOR

IMPORTANT

DO NOT ENTER THE IRRADIATION CELL WITHOUT AN AUTHORIZED OPERATOR

EMERGENCY CONDITIONS

IF RADIATION MONITOR ALARM SIGNALS (LOUD CLAXON)
OR SOURCE MOVEMENT BELL SOUNDS
TAKE THE FOLLOWING ACTION

(A) PERSONNEL IN MAZE OR IRRADIATION CELL

PULL SAFETY CABLE ON WALL AND LEAVE FACILITY IMMEDIATELY.
CLOSE MAZE DOOR BEHIND YOU.

(B) PERSONNEL IN THE CONTROL AREA

PUSH THE RED EMERGENCY STOP BUTTON ON THE CONTROL CONSOLE PANEL.

FOR EMERGENCY SERVICE, CONTACT

ATOMIC ENERGY OF CANADA LIMITED, COMMERCIAL PRODUCTS, OTTAWA, CANADA.
CABLE: NEMOTA TELEPHONE: (613) 592-2790 TELEX 053-4162

COBALT 60 IRRADIATOR

In the Irradiation Room

1. Ensure that the pneumatic cylinders are in their normal start-up positions as indicated by green lights in the console display.

2. Ensure that the maze conveyor is in the start-up position.

3. Under normal conditions, there should be no personnel in the irradiation room. However, a check must be made to ensure that the room has been vacated.

   NOTE: The operator must lead all visitors when they are entering the cell and follow behind when they are leaving.

4. Actuate the SAFETY TIMER keyswitch using the MACHINE key. This will start the 90 second safety timer. An audible device will operate while the timer is running.

5. Leave the room (at a normal walking pace) making certain to engage the source hoist air interlock and to close the maze door on the way out. Closing the maze door will illuminate the MACHINE READY indicator on the control console provided the safety timer is still running.

   NOTE: If the safety timer runs out before the machine is started, the start-up procedure will have to be repeated.

Starting the Irradiator

1. Check that all green indicators are illuminated and that all red FAULT INDICATORS are extinguished. If either condition does not exist, the fault must be rectified before proceeding.

2. Turn the MACHINE keyswitch to the "Start" position and release. The key will return to the "On" position and the MACHINE ON indicator will illuminate.

The source will begin to rise as indicated by the ringing of the source travel alarm and the extinguishing of the SOURCE DOWN indicator. When the source is in the fully up position, the red SOURCE UP indicator will illuminate and the source travel alarm will stop ringing. Automatic operation of the machine will begin.

3. Make a complete entry in the Log Book. Entries should include the date, time of start-up, cycle time, box number, and other information required on log sheet.

8.1.2 Normal Shut-Down

Normal shut-down is defined as the termination of operations not dictated by faulty or abnormal conditions.

To shut-down the machine, the operator must:

1. Turn the MACHINE keyswitch to the "Off" position when the machine has reached the end of a cycle. The MASTER CONTROL timer will reach zero and the source will begin to lower (the SOURCE UP indicator will extinguish) and the source travel alarm will signal.

2. When the source is in the fully down position (after the green SOURCE DOWN light illuminates and the source travel alarm stops ringing), remove the MACHINE key from the MACHINE keyswitch. The POWER keyswitch should be kept "On" at all times in order to keep the irradiation room monitor operating.

8.1.3 Emergency Shut-Down

a) Press the emergency STOP button on the control console, or

b) Turn "Off" the MAINTENANCE keyswitch (if being used), or

c) Turn "Off" the POWER keyswitch.

d) Pull the emergency PULL cable.

8.1.4 Automatic Fault Shut-Down

During operation, a number of fault conditions or abnormal occurrences may cause the irradiator to automatically shut-down. In this event, the cause will be indicated by the illumination of one or more of the FAULT INDICATORS on the control console.

<u>IMPORTANT</u>

In the event of either a "Source Rack" or a "Monitor" shut-down, the operator must notify the Radiation Protection Officer (RPO) immediately.

In the case of a "Monitor" shut-down, the Radiation Protection Officer (RPO) will check the radiation levels with a survey meter and will notify Atomic Energy of Canada Limited-Commercial Products of unusual conditions or incidents.

For either shut-down, the resumption of normal operations is subject to the Radiation Protection Officer's (RPO) approval.

The indicator(s) will remain illuminated until the fault is rectified and the POWER keyswitch is turned to the "Reset" position and released.

If the irradiation room must be entered in order to rectify the fault, make certain that the "ENTRY PROCEDURE", Figure 3.1 is adhered to.

To correct the problem:

1. Rectify the fault.
2. "Reset" the POWER keyswitch.
3. Turn the MACHINE keyswitch to the "Start" position and release.

   The machine will resume normal operation.

CELL ENTRY PROCEDURE FIGURE 3-1

8.2 - PROCEDURE FOR OTHER OPERATIONS

8.2.1 Check Out Procedure Prior To Cobalt-60 Installation

As each facility component is installed it is checked for correct operation before proceeding with the next stage of assembly. These component checks include:

1. A full operation check out of the source rack (unloaded). Limit switch settings are adjusted to provide smooth operation and the rack is cycled at least 20 times.

2. The ventilation fan is checked for satisfactory operation and filters are installed.

3. Standby compressor operation. (If installed)

4. Water level float switch and water filtration unit.

5. The complete conveying system (using dummy product boxes) for smooth operation.

6. Interlock procedure and safety switches. The start-up procedures are simulated and machine functions are checked for satisfactory operation. All safety interlocks, emergency stops and alarms, are actuated to check for correct operation.

7. The monitor is checked using the test source.

8.2.2 Check Out Procedure After Initial Cobalt-60 Installation

1. The operating area is monitored with an appropriate survey meter during and after source replenishment. The source pencils and associated components are wipe tested "in situ."

2. The first time that the radiation source is raised from the pool the following items must be checked:

   a) The correct interlock procedure is carried out and authorized persons only are in attendance during the test.

   b) The source is raised with the "Source" keyswitch (without conveyor operation). The survey meter is checked for radiation readings.

   c) A complete radiation survey of the building is conducted with the source in the raised position.

3. The source rack is then lowered. The monitor is rechecked using the test source.

4. Final test of complete machine.

8.2.3 Roceipt of Radioactive Material in Casks

Cask unloading will require the physical presence of the RPO to supervise operations. Pocket dosimeters and film badges will be worn by participating personnel.

1. Survey the exterior of the cask while on the vehicle with a survey meter (RATO/F or equivalent generic survey instrument). Radiation level should not exceed 10 millirad at one meter from the cask's surface. If this rate is exceeded, the shipper will be notified to determine possible causes and courses of action.

2. Smear the cask surface and truck bed in five or more locations. Count with RATO/F or equivalent survey instrument.

3. If smears read more than 0.1 mrem source shipper will be notified to determine courses of action including rejection of shipment. Truck driver will be held until the problem is resolved.

4. If removable contamination limits (Item 3) and radiation levels (Item 2) are acceptable, unlash the cask. An overhead crane or mobile crane will be used as appropriate.

5. Move cask into designated area. If reading at cask surface is less than 2 millirad per hour, cask may be placed in unrestricted storage. Place radioactive sign on cask. If surface dose rate is between 2 and 10 millirad per hour a rope barrier will be established at the 2 millirad distance and a radioactive sign will be hung from it.

6. If source loading/unloading is to be accomplished by a qualified AECL team of at least two persons, the physical presence of the on-site RPO is not mandatory requirement.

8.2.4 Placing The Cask in the Pool Irradiator and Unloading Source Basket

This operation will require the physical presence of the RPO to supervise operations. RPO will use RATO/F meter or equivalent to continually monitor radiation levels at pool surface.

1. Lower underwater light into pool or use high intensity dry lamp on surface.

2. Remove any conveying equipment on the irradiator floor directly beneath the stepped roof plug to permit easy access by the cask into the source storage pool.

3. Remove any obstructions from where cask will be placed in bottom of pool.

4. Utilizing a mobile crane, remove the roof plug from the irradiator roof.

5. Utilizing the mobile crane, lift the cask above the roof level, position it over the opening in the irradiator roof and from the roof of the building direct the crane operator as the cask is being lowered.

6. Cask is lowered to approximately floor level of the irradiation room.

7. From inside of the irradiator remove bolts securing the cask lid while cask is still suspended from the mobile crane.

8. Lower cask to bottom of pool

9. Using long handled tools, disengage the crane hooks from the cask and secure them in the lifting lugs on the cask lid.

10. Advise crane operator to raise cask lid and set it to one side of the cask on the pool floor. Using long handled underwater tools, disengage crane hooks from cask lid.

11. Raise crane cables out of working area.

12. Using long handled tools, remove the basket holding the irradiation sources from the shipping cask. CAUTION: DO NOT RAISE THE HANDLING TOOL ABOVE THE POINT WHERE THE RED LINE AT THE 8' MARK IS LEVEL WITH THE SURFACE OF THE WATER.

13. Place the sources (in their basket) on the floor of the pool, well away from the shipping cask.

14. Advise crane operator to lower crane. Using long handled tools, hook the crane to the lid.

15. Replace lid on cask.

16. Using long handled tools, disengage crane hooks from lid and secure them in the lifting lugs on the source cask.

17. Guide the crane operator in removing the shipping cask from the pool, and through the roof. Monitor cask as it is raised.

18. Advise crane operator to place empty shipping cask on parking lot.

19. Replace stepped plug on top of irradiator.

If this function is to be performed by a qualified two-man AECL team, the physical presence of the RPO is not mandatory.

8.2.5 Sealed Source Leak Test Procedures

General: In the absence of a certificate from a transfer, or indication that a test for leakage and/or contamination has been made within six months prior to a transfer to Abbott, each source will be leak tested upon arrival at Abbott. After source receipt, leak tests will be performed on the source plaque at intervals not exceeding six months.

Specific Information

Name and Address of Individual Performing Leak Test

Site Radiation Protection Officer A. Rosado, or designee, to take smears; Abbott Hospitals Inc; Macco Industrial Park; State Road 690 Km 1.7; Vega Alta, Puerto Rico 00762.

Paul Ward or designee to perform monitoring tests at Abbott Laboratories, Abbott Park, IL 60064 or alternatively:

G. Dietz or designee to perform monitoring tests at Isomedix Inc., 11 Apollo Drive, Whippany, New Jersey 07981.

Type of Test

Wipe.

Leak Test Experience of Individuals

Abbott

Eighteen years experience doing similiar procedures.

Isomedix

Fourteen years experience doing identical procedure for up to 11 Isomedix facilities.

Radiation Detection Instruments Used

CANBERRA Series 20 multichannel analyzer with sodium iodid well detector (or equivalent).

RATO/F (or equivalent)
Baird-Atomic Spectrometer, Model 530, with deep well counter (or equivalent), or single pulse height analyzer (Eberline or Ludlum)

GENERAL DESCRIPTION OF PROCEDURE

(Note: The following procedure is currently being followed under Isomedix License 29-15364-01 in New Jersey.)

Wipe testing of the source in the pool is conducted as follows:

1. Attach a styrofoam, gauze or equivalent pad to the end of an underwater tool.
2. Rub the pad along the source, and on the accessible ends of the sources in a source module.
3. Remove the pad from the pool and check for radiation with a RATO/F or equivalent meter. Meter should read below 1mr/hr. If not, call RPO.
4. If reading in (3) is below lmr/hr, remove pad from tool, and allow to dry.
5. Repeat for several source modules
6. Send pads to Corporate Radiation Protection Officer, Abbott Park or Isomedix, Whippany, New Jersey for counting
7. Shipment of pads to be performed in accordance with the applicable regulations of U.S. Department of Transportation..

PROCEDURE FOR COUNTING SMEARS AND DETERMINING CONTAMINATION LEVELS

Swipes are counted using at least a 5 cm x 5 cm NaI Well Detector. Results are compared to counts from a NBS tracable standard cobalt-60 source. Removable NBS tracable activity, in microcuries, is calculated as follows:

1. Take background count (BC).

2. Count Leak Test Swab (LTS).

3. Then LTS-BC = Test Swab Count.

4. Then:

$$\frac{\text{Test Swab Count}}{\text{Detection System Efficiency}}$$

5. Removable contamination should be less than

   1×10^{-5} microcuries.

8.3 - Emergency Procedures

8.3.1 General

Although plant facilities and equipment are designed to minimize radiation hazards and to facilitate their control, the possibility of an unforeseen accident cannot be overlooked. Radiation monitoring systems, through their meters and alarm features, provide warning and measurement of abnormal conditions to employees and the Radiation Protection Officer. Warning of a condition requiring emergency action might also come from an operator in his observation of such a condition. However, in virtually every conceivable instance, the radiation monitoring system would respond to the condition also.

8.3.2 Radiation Alarm

If any unexplained audible alarm sounds, immediately lower source to bottom of pool. Call Radiation Protection Officer. RPO will monitor surrounding area with a meter and attempt to determine the cause of the alarm.

If the alarm sounds and the cause can be immediately ascertained and controlled by the operator, he can first control the cause and then reset the alarm system. He will then notify the RPO or his designee of the situation and circumstances surrounding the incident.

If the alarm sounds and the cause cannot be immediately ascertained and controlled, personnel will proceed to their designated area. The RPO or his designee, determines the appropriate action based on a review of the monitoring system, ratemeters, and other available information. Appropriate action by a designee would be to evacuate the area while calling for further assistance.

Emergency actions selected are based on limiting radiation exposures to employees with regular restricted area access authorization to 2.5 rem and other employees to .25 rem during the course of the emergency and its aftermath. Actions that are considered include: relocation of sources, erection of temporary barriers or shielding, area or building evacuation.

8.3.3 Radiation Overexposure

Copies of this procedure will be conspicuously posted near the irradiator entrance door, in the office area, or in any other conspicuous location determined by the Facility Manager.

The procedure was developed after consultation with the personnel, doctors and hospital listed.

The procedure is on the following page.

Radiation Overexposure

I. Extreme Overexposure - Victim Unconscious

A. If a person is uncnnscious from an overexposure, immediately call the ambulance and tell the driver to take him to the Bayamon Regional Hospital. Call the Bayamon Hospital, explain the problem, and request that Dr. Manuel Martinez be notified, and that he be requested to come to the hospital. Dr. Martinez can be reached at 787-5151.

B. Escort the victim to the hospital either in the ambulance or in your own car.

C. Following the above, immediately call one of the following:

Mr. Paul Ward - 312-937-5276 - 312-336-3079
Mr. George Dietz - 201-876-9588 - 201-887-4700
Mr. John Masefield - 201-234-2396 - 201-887-4700
Mr. Jonathan Young - 201-895-2137 - 201-887-4700

D. The person notified above in item C will contact the NRC, Region II (404-331-4503), and explain the circumstances with a view toward obtaining the services of either Dr. Neil Ward or Dr. Thoma, both experts in overexposure, and both available to NRC on a consulting basis.

The NRC Emergency number after duty hours in our area: 301-951-0550.

II. Moderate or Suspected Overexposure - Victim Conscious

A. Immediately call on of the following:

Mr. Paul Ward, Dietz, Masefield or J. Young (same as in item I (c) above); if none of the above can be reached on the first try, call the Bayamon Regional Hospital and take the victim there, and proceed as in I (A).

B. Take the actions directed from your contact of the above mentioned people. Actions may include the following:

1. Taking the victim to the hospital (Bayamon Regional) in your own car.

2. Calling for the ambulance.

3. Notifying Bayamon Regional Hospital, and telling them to expect the victim, and to alert emergency.

C. If for some reason the above personnel cannot be reached immediately and other action is taken, be sure to continue to try to contact either Mr. Ward, Dietz, Masefield or Young until at least one has been notified.

8.3.4 Emergency Procedures for Malfunctions in Automated Irradiator

For any malfunction in the interior of the irradiator, personnel safety is maintained as long as personnel do not enter the chamber. In the event of product or carrier blockage of the source and the source cannot be returned to its normal storage position, the following corrective procedures can be conducted depending on the situation and source location, under the direction of the RPO. However, before other action is undertaken, the on-site RPO will take the following action:

1. Notify P. Ward and G. Dietz, J. Masefield or J. Young.

2. Notify AECL.

The following action may be authorized, but most likely will not be allowed until AECL representatives arrive on-site:

1. If source will not lower, raise source to the fully exposed position.
2. Attempt to lower source again in the normal manner.

3. If it is determined that a product is blocking the source from returning to its storage position, enter the irradiator roof and slacken the source rack guide cable tensioners located at the top of the irradiator roof which in turn will permit the source rack to float within the constraints of the slackened cables.

5. Return to the control console and attempt to lower the source in the normal manner.

6. If this cannot be done, a less desirable procedure can also be followed. This involves drilling one or more access holes through the roof, and the use of closed circuit TV and special tools to return the source to the storage position. This procedure, undertaken previously by AECL on other facilities, is to be performed <u>only</u> by AECL personnel.

8.3.5 Notification of Incidents

The Radiation Facility Manager or his authorized representative shall immediately notify:

a. The Abbott Corporate RPO.

b. NRC Region II

c. Atomic Energy of Canada Limited, Ottawa, Ontario, Canada

by telephone or telegraph, of any incident involving any source of radiation possessed by him and which may have or threatens to cause a radiation hazard. In the event of an incident which endangers or threatens to endanger Plant Personnel or the Public, the licensing authority may take any steps necessary to remove the danger. Any further action to decontaminate the plant and return it to operating condition will be taken by AECL.

If for any reason AECL personnel cannot reach the plant in a reasonable time, further action may be taken by the licensee at the specific request of AECL.

8.3.6 Decontamination Procedures

In the event of any indication of contamination by any of the monitors or from routine wipe tests, the licensee will immediately close down the facility, restrict entrance, and quarantine all products in the suspected area, and will notify Atomic Energy of Canada Limited by phone. The licensee will immediately advise the pertinent licensing authority that an incident is suspected and will effect the safety control measures as listed below:

1. No immediate attempt shall be made to clean up the contamination.

2. All windows shall be closed; fans, water filtration plant and air conditioners shall be shut off, and everyone shall leave the facility.

3. All doors shall be closed and locked.

4. All personnel who may have been contaminated shall be thoroughly tested for contamination and immediate steps taken to remove any radioactive contamination.

5. Entrance to the facility (or contaminated area) shall be prohibited except to authorized personnel requiring access in the performance of their special duties.

6. Under no circumstances shall any unauthorized or untrained persons attempt to examine or clean up any "spilled" radioactive material.

Fans or ventilating apparatus shall not be used in an attempt to disperse the radioactive material or its decay products. Such a maneuver will only disseminate the radioactive contamination throughout the area.

Atomic Energy of Canada Limited will dispatch qualified personnel to the site to assess the situation and confirm or deny the presence of contamination, and will report their findings to the pertinent licensing authority.

Atomic Energy of Canada Limited, or their Agent, have available, and will provide if necessary, emergency equipment as listed later in this manual.

If it is confirmed that contamination has been detected, Atomic Energy of Canada Limited will dispatch a Senior Radiation Protection Officer together with qualified personnel to institute corrective action.

8.3.7 Emergency Equipment

Atomic Energy of Canada Limited, or their Agent, have available and will provide if necessary, the emergency equipment listed hereunder:

1. Personnel protective clothing, including plastic suits, special footwear, plastic hoods, gloves, etc.

2. Respiratory equipment, including demand air packs (MSA), canister type respirators, and supplied air respirators.

3. Decontamination supplies, including polyethelene sheeting, disposal bags and containers.

4. Approved radiation monitoring devices and personnel exposure dosimeters for all personnel involved.

5. Instruments of adequate sensitivity for the measurement of low level beta-gamma contamination.

6. Area radiation monitors with alarm.

7. General safety protective equipment, such as safety helmets, gloves, shoes, etc.

PART 9 - OPERATOR DESIGNATION AND TRAINING

9.1 General

It is proposed that Abbott be authorized to appoint qualified personnel as operators. Such an appointment would be authorized when the trainee has:

a. Completed the required formal training.

b. Passed the written test with a minimum score of 80%.

c. Completed a minimum of 90 days of on-the-job training.

d. Been recommended for operator status by the Radiation Facility Manager to the Abbott Corporate RPO, wherein the trainee's qualifications are reviewed.

e. Been approved by the Abbott Corporate RPO.

The contents of the training program, together with the written test (and answers) follow. Test questions may be changed from time to time.

The Abbott policy for training of all personnel (including but not limited to irradiator operations) is shown beginning on Page 9-12.

9.2 Contents of Radiation Training Program

	Hours
1. The Hazards of Radiation Unavoidable low level exposure Hazard evaluation	2
2. The Effects of External Radiation a. Effects on the body. b. Units of measurement. c. Levels of injury. d. Long term exposures. e. The banking concept.	3

3. Protection from External Radiation
   a. Time — 3
   b. Distance
   c. Shielding materials
   d. Define curies and half value layers, dose rate curves in the irradiator.

4. Radiation Physics
   The nucleus-isotopes-radioactive decay — 3

5. Internal Radiation Problems — 2
   a. How radioactive material enters the body. — 2
   b. Effects on the body.

6. Contamination
   a. Hazards associated with contamination — 4
   b. Prevention of spread.
   c. Decontamination procedures

7. Instruments and Dosimetry
   a. Geiger counters — 7
   b. Ionization chambers
   c. Scintillation counter
   d. Film badges
   e. Pocket Electroscopes
   f. Practical instrument use

8. Irradiator Safety System and Procedures
   a. Source interlock systems — 10
   b. Operating procedures-routine irradiation
   c. Operating procedures for irradiator operations

9. Instruction in Survey Techniques
   Instrument Survey Techniques — 2
   Wipe Test Methods

10. General Discussion and Summary — 2

11. Written Test — 2

TOTAL — 40 hrs

The NRC publication, "Living with Radiation" is used as a basis for this training, together with the facility operating manual.

9.3 Examination for Operator Qualification

1. Name the three common types of radioactive decay emissions.

2. Of the three emissions from Question 1 above, cobalt-60 emits the highly penetrating.

   ____

3. Cobalt-60 emits energy which (circle correct answer(s):)

   (a) Can make other materials radioactive.
   (b) Can damage living tissues.
   (c) Can penetrate only the human skin.
   (d) Is identical to X rays, except for the mechanism by which they are "born".

4. Regulatory agencies allow limits of exposure for licensed, badged personnel working in radiation areas. The acceptable yearly level, if radiation history is unknown, is:

   (a) 12 rem.
   (b) 5 rem.
   (c) 25 rem.
   (d) 500 rem.

5. True or False (circle)

   It is far more detrimental to the body to receive a 3 rem dose over a two-hour period as opposed to over a three-year period.

6. The normally accepted dose of whole body radiation, over a short period, at which about 50% of the population would die, is_______rem. Below_______ rem, there are no physical detectable effects.

7. A 30-year old worker joins the staff as an authorized worker around radiation. In his past work, he has received a total whole body exposure of 2 rem. Under the "banking" concept, how many rems should remain to his credit? _______

8. Can this worker use up all of his "credit" within the next three years" Yes _______ No _______

9. Define the term "rad".

10. High personnel exposures could cause genetic effects. What are genetic effects?

11. What are the three best means of protection from external exposure?

12. The dose rate at one foot from a source is 160,000 rads per hour. What is the dose rate at 4 feet?

13. How often should you zero your pocket dosimeter?

14. When are the pocket dosimeter and film badge worn?

15. You are on duty at night and the source automatically drops during the cycle. However, the access door to the irradiator will not open because the alert radiation light is lit. Perhaps the light has malfunctioned. Your correct course of action is to:

    (a) Unscrew the light and enter the cell normally.
    (b) Wait until the next shift arrives.
    (c) Call the Radiation Protection Officer.
    (d) Try to bypass the alarm and enter the chamber very carefully with a hand-held meter.

16. It is necessary to enter the irradiation chamber. You make a test check of the hand-held monitor, and find that you get no reading response. What action do you take?

17. A group of important looking visitors arrives unexpectedly at night and would like to go into the irradiation chamber to see the mechanism. The Radiation Protection Officer is temporarily absent and is expected to return in three hours. What do you do?

18. While you are working in the control room, you hear strange scraping sounds coming from the irradiation chamber. What is your first action?

19. Irradiation causes a toxic gas to be formed inside the irradiation chamber. What is it called?

If you enter the irradiator and the odor is very noticeable, what is your action?

20. In _any_ type of actual or suspected radiation emergency, what is your first action?

21. If a source were to leak or rupture, airborne or waterborne contamination could occur. Name at least two procedures which could give early warning of trouble.

22. In an actual personnel overexposure, where you are quite sure a person has received an overdose, who are the three persons or agencies to contact immediately?

23. An overexposed person will show physical signs which might give a clue to the doe he received. Match the following doses and symptoms:

25 rem	Nausea, fatigue
100 rem	Unconscious, shock
1000 rem	No detectable effect

24. Can cobalt-60 irradiation of a person make him radioactive for a short time?

25. The irradiator is a production unit which is expected to operate on a continuous basis. Its primary function is to process. Only one consideration is more important. What is it?

For questions 26-30: an electrical storm hits and power is knocked out. Under these conditions,

26. True False The irradiator will continue to process until the air supply is exhausted.

27. True False The emergency generator will kick in immediately, allowing the cycle to continue.

28. True False If the source descends, you should enter the cell to make sure there is no damage.

29. If you answered False to 28, state why?

30. What is your action when power is restored?

31. If you pull the emergency cable in the irradiator, what will happen?

32. What happens when you activate the key activated timer in the cell?

33. Approximately how long do you have after activating the delay timer, to complete lockup and raise the source?

34. What happens if the allowed time is exceeded?

35. If the allowed time is exceeded, what is your action?

36. What is the purpose of the chain across the personnel entry door?

37. When would it be safe to step over the chain and enter the irradiator, without disconnecting it?

38. When is power to the personnel door lock turned on?

39. Does the "source moving" alarm sound when the source is moving up, or down, or both? (circle answer)

40. You are in the control room, and the source begins to descend. Name 5 possibilities or reasons it might be lowering.

41. Is your film badge or pocket dosimeter more reliable as an indicator of small radiation doses to which you might be exposed? (circle one)

42. During a source loading, the surface of a shipping cask might read as high as 30 mrem/hr.
True or False?

43. If you touch open wires in the irradiator, will you receive a bad shock? Why?

44. Where is the shut-off valve to the in-cell sprinkler system?

45. True/False: The pool water is normally contaminated with cobalt-60?

46. All of our sources are doubly encapsulated. What does this mean?

For questions 47 - 49

You are in the control room and the source begins to descend.

47. You see the "low air" light on. What is your action?

48. You see "smoke alarm" light on. What ;is your action?

49. You see "low water" light on. What is your action?

50. When are we authorized to operate the unit with no operator present in the building?

a. Weekends only

b. When doing non-flammable items

c. When no product is in chamber

d. None of the above

9.4 Answers to Sample Examination for Operator Qualification

1. Alpha, Beta, Gamma

2. Gamma

3. b. and d.

4. b.

5. True

6. 500 and 25 respectively

7 58

8 No

9 The absorption of 100 ergs per gram of energy.

10. Effects on future generations (such as mutations) which may be caused during or after conception, until birth.

11. Time, distance and shielding

12. 10,000 rad/hr.

13. Whenever the reading exceeds 15 mrem at the beginning of the work tour.

14. At all times when and on duty.

15. c.

16. Any of the following:

a. Call Radiation Protection Officer.
   Do nothing until he advises.
b. Take the spare meter.
c. Replace batteries in the first meter;
   made sure it responds; then proceed.

17. Politely refuse entry of the visitors past the office/reception area.

18. Lower the source.

19. Ozone. Leave the cell for 2-3 minutes, then re-enter.

20. Call the Radiation Protection Officer.

Answers to sample examination for Operator qualification - continued

21. Source wipe test.
    Monitoring of water treatment system.
    Smearing walls, floor, vent, in cell.

22. a. Hospital or emergency squad
    b. Radiation Protection Officer
    c. Nuclear Regulatory Commission

23. 25 rem No detectable effect
    100 rem Nausea, fatigue
    1000 rem Unconscious, shock

24. No

25. Safety

26. False

27. False

28. False

29. No power to door lock. Cannot enter.

30. Enter cell normally, restart irradiator.

31. Unit will shut down, source descends to bottom, warning light appears on console.

32. 90 seconds to complete lockup, lights flash, bell sounds.

33. 90 seconds.

34. Timer times out. Sequence has to be started over.

35. Return into cell, begin sequence again.

36. Shuts off air to cylinders that raise sources.

Answers to sample examination for Operator qualification - continued

37. Never

38. After the in-cell monitor is tested and shows no abnormal radiation.

39. Both

40. End of cycle, carrier movement not completed in prescribed time, low air, no power, smoke alarm, high temperature alarm, emergency stop activated.

41. Film badge

42. True

43. No. 24 volt system

44. As appropriate

45. False

46. Cobalt is totally enclosed in a stainless steel cylinder, which in turn is again encased in a second sealed stainless steel cylinder.

47. Check air compressor and its circuit breakers. Reset or call maintenance.

48. Enter cell normally to assess situation. Call appropriate personnel.

49. Enter cell normally to assess situation. Call appropriate personnel.

50. D.

9.5 Personnel Training Policy

AHI RADIATION FACILITY POLICIES AND PROCEDURES

Distribution: Radiation Facility Manager
Subject: Personnel Training Policy
Effective Date: March 15, 1988
Approved By:

This policy covers the general training requirements applicable to warehouse personnel, operators, supervisors and production control managers, and Radiation Facility managers. The program shall consist of both formal training requirements and on-the job training administered by personnel deemed qualified by the Division Office and the AHI Plant Manager.

A. Basic Training, All Personnel

1. Scope of activities of Abbott in Vega Alta.
2. Description of radiation operations.
3. Operational policies and procedures.
4. Need for general cleanliness and care in the handling and processing of medical devices and drugs.
5. General requirements of regulatory bodies, including the Nuclear Regulatory Commission and the Food and Drug Administration.
6. General requirements of FDA Good Manufacturing Practice guidelines.
7. NRC license requirements as they relate to the use and operation of cobalt-60 irradiators.
8. Other items which may be designated from time to time.

B. Operators, Supervisors, Production Control Managers, Radiation Facility Managers

In addition to (A) above, this category of personnel will receive additional training as follows:

1. Formal training course for qualification as Irradiator Operator (course as defined in NRC license).

2. General procedures for inspection and acceptance and/or rejection of good housekeeping conditions, including, but not limited to:

B. <u>Operators, Supervisors, Production Control Managers, Radiation Facility Managers</u> - continued

a. Warehouse cleanliness.
b. Mechanism appearance/cleanliness.
c. Inspection of outgoing trailers for cleanliness, holes in body, dirt, strange odors, or other odd factors which might be sensitive to the shipment of finished medical devices.
d. General insect and rodent control on premises.

3. Irradiator operation and maintenance.
4. Processing procedures.
5. Dosimetry procedures and training.
6. Shipping/receiving procedures.

C. <u>Supervisors, Production Control Managers, Radiation Facility Managers</u>

This category of personnel shall, in addition to (A) and (B) above, receive additional training as follows:

1. Personnel administration.
2. Production control, including factors related to scheduling, processing and administrative requirements related to processing.
3. Full indoctrination and training of all Abbott policies and procedures as they relate to processing.
4. Other subjects as determined by the Radiation Facility Manager or Corporate Staff.

D. <u>Radiation Facility Managers</u>

In addition to all of the above, the Radiation Facility Manager shall receive additional training as determined appropriate by Corporate Staff, including administration, budgeting, personnel and quality control. The Radiation Facility Manager is also specifically charged with adherence to GMP procedures, and is responsible for quality control of his facility. Among other QC responsibilities the Radiation Facility Manger, in terms of his Quality Assurance Program, will assure himself that he is capable of:

1. Identifying quality assurance problems.
2. Solving quality assurance problems.
3. Verifying implementation of solutions.
4. Determining that procedures are performed correctly.

This basic policy may be amended or added to from time to time either formally or informally as additional training requirements become obvious.

Refresher training, either on a formal or informal basis, should be conducted semiannually or earlier as the need arises.

9.6 Radiation Protection Officer Responsibilities

AHI RADIATION FACILITY POLICIES AND PROCEDURES

Distribution: Radiation Facility Manager
Subject: Radiation Protection Officer Responsibilities
Effective Date: March 15, 1988
Approved by:

This policy covers the responsibilities of the site Radiation Protection Officer (RPO).

The responsibility and authority of the RPO includes:

a. Maintain on-site Nuclear Regulatory Commission (NRC) license conditions.

b. React in an emergency to safeguard worker and public health and safety.

c. Correct minor machine malfunctions.

d. Prompt notification to Division or Corporate RSO of any unusual situation which may be or threatens to be an unusual or potentially hazardous situation.

e. Allow no corrective action to be taken for major malfunctions or potentially hazardous situations without guidance and approval of the Division or Corporate RSO.

f. The site Radiation Protection Officer has complete site authority for all situations which threaten worker or public health and safety. He is reportable only to the Division or Corporate RPO in these situations. Radiation safety considerations will take precedence over operational issues if there is a conflict.

PART 1 - TRAINING AND EXPERIENCE IN RADIATION SAFETY

10-1 OPERATIONAL PLAN

The Vega Alta irradiator was operated by Isomedix, Inc. beginning 1982 under its License No. 52-23041-01. Abbott purchased the facility February 26, 1988 and will continue irradiation operations.

Abbott has hired the Isomedix Plant Manager, Mr. Arnaldo Rosado, who has approximately four years of operational experience at the subject irradiator. Abbott is in the process of interviewing and hiring other Isomedix qualified operators so as to maintain a smooth operational transition at the irradiator.

In addition, Abbott has entered into a consulting agreement with Isomedix, Inc. to assist Abbott in assuring that the highest standards of radiation safety and adherence to license conditions are maintained.

10.2 Training and Experience Resumes

These are on the following pages.

APPLICATION FOR RADIOACTIVE
MATERIAL LICENSE -

ARNALDO ROSADO

Type of Training	Where Trained	Duration Training	On the Job	Formal Course
a. Principles and practices of radiation protection	Isomedix	3 months	2 years	Yes
b. Radioactive measurement standardization, monitoring techniques, and instrumentation.	Isomedix	3 months	2 years	Yes
c. Math and calculations basic to the use and measurement of radioactivity.	Isomedix	3 months	2 years	Yes
d. Biological effects of radiation.	Isomedix	3 months	2 years	Yes

EXPERIENCE WITH RADIATION

Isotope	Max. Amount	Where Experience Was Gained	Duration	Type of Use
Co-60	1,7000,000 ci	Isomedix, Inc. Vega Alta, PR	2 years	General Processing e.g., sterilization of medical devices

Mr. Rosado, through Mr. George B. Baker, Assistant Corporate RPO, received on-the-job training in the use of shielding and time-distance relations in reducing radiation exposure; the use, maintenance and limitations of monitoring and surveying instruments; and protective, routine, and emergency procedures in effect at the Vega Alta facility. The on-the-job training was correlated with a formal course given by Mr. Baker. Contents of this training program are outlined elsewhere.

Mr. Rosado has been a licensed operator of the 1.7 million curie unit for two years, having successfully completed the Operator Training Course October 26, 1984. Mr. Rosado currently holds the position of Radiation Facility Manager. He administers the radiation safety program at Vega Alta.

Formal Education - High School Graduate - 1970
AAS - Civil Engineer - 1975
BA - Industrial Engineering 1987

APPLICATION FOR RADIOACTIVE MATERIAL LICENSE

GEORGE R. DIETZ

Type of Training	Where Trained	Duration of Training	On the Job	Formal Course
a. Principles and practices of radiation protection	Georgia Institute of Technology	2 years	NO	Yes
	U.S. Army Natick, Mass. Radiation Lab	4 years	Yes	No
	Brookhaven National Lab	1 month	Yes	Yes
	Radiation International (Asst RSO)	1-1/2 years	Yes	No
b. Radioactive measurement standardization and monitoring techniques, and instrumentation.	Same as above			
c. Math and calculations basic to the use and measurement of radio-activity.	Same as above			
d. Biological effects of radiation.	Same as above			

EXPERIENCE WITH RADIATION

Isotope	Max. Amount	Where Experience Was Gained	Duration	Type of Use
Co 60	500,000 curies	Brookhaven National Lab.	1 month	Training
Co-60	600,000 curies	Radiation Machinery	1-3/4 yrs.	Irradiation Services
Co-60	350,000 curies	Radiation International	2 years	Irradiation Services
Cs-137	250,000	Isomedix	9 years	Self-Contained Irradiators
Co-60	1,500,000 curies	Isomedix, N.J.	9 years	Irradiation Services

George R. Dietz (continued)

Mr. George R. Dietz is Executive Vice President, and Radiation Protection Officer, of Isomedix, Inc.

In addition to handling the Isomedix Corporate Radiation Protection functions (RPO) of Isomedix, he is a licensed operator for all of Isomedix eleven plants, the earliest of which dates to 1972.

Mr. Dietz is the Chairman of the Isomedix Corporate Radiation Safety Committee.

APPLICATION FOR RADIOACTIVE MATERIAL LICENSE

JOHN MASEFIELD

Type of Training	Where Trained	Duration of Training	On the Job	Formal Course
a. Principles and practices of radiation protection.	Atomic Energy of Canada Limited.	7 years	Yes	Yes
	Radiation Int'l.	2 years	Yes	Yes
	Isomedix, Ltd	4 years	Yes	No
b. Radioactive measurement standardization and monitoring techniques, and instrumentation.	Isomedix, Inc.	8 years	Yes	Yes
	Same as above			
c. Math and calculation basic to the use and measurement of radioactivity.	Same as above			
d. Biological effects of	Same as above			

EXPERIENCE WITH RADIATION

Isotope	Max. Amount	Where Experience Was Gained	Duration	Type of Use
Co-60	1,000,000 ci	AECL	7 years	General processing, self-contained irradiators.
Co-60	300,000 ci	Radiation Int'l	2 years	General processing.
Co-60	300,000 ci	Isomedix, Ltd.	4 years	General Processing
Co-60	500,000 ci	Isomedix, Inc.	8 years	General Processing
Co-60	100,000 ci	Newfield Products, Ltd.	2 years	General Processing
Co-60	1,500,000 ci	Isomedix, Inc.	8 years	General Processing

During his seven years with AECL, Mr. Masefield was Head of Irradiator Design. In addition to supervising design and construction of self-contained irradiators, he supervised design and commissioning of large production irradiators, including the Ethicon units in Somerville, New Jersey, and San Angelo, Texas, as well as a production facility in Peterborough, Canada.

He was a licensed operator and RSO of the Newfield Products, Ltd. irradiator in Canada for two years. Mr. Masefield is a licensed operator for Isomedix' 2,000,000 ci service irradiator in New Jersey.

Mr. John Masefield is Chairman of the Board of the Isomedix Companies.

APPLICATION FOR RADIOACTIVE MATERIAL LICENSE

JONATHAN YOUNG

TYPE OF TRAINING	Where Trained	Duration of Training	On the Job	Formal Course
a. Principles and practices of radiation protection.	Isomedix	6 months	8 years	Yes
b. Radioactive measurement standardization and monitoring techniques, and instrumentation.	Isomedix	6 months	8 years	Yes
c. Math and calculations basic to the use and measurement of radio-activity.	Isomedix	6 months	8 years	Yes
c. Biological effects of radiation.	Isomedix	6 months	7 months	Yes

EXPERIENCE WITH RADIATION

Isotope	Max. Amount	Where Experience Was Gained	Duration	Type of Use
Co-60	1,500,000 ci	Isomedix Inc. Production Mgr. and OJT	3 years	General processing, e.g. sterilization
Co-60	200,000 ci	Isomedix	1-1/2 yrs.	Hot Cell Operations
Co-60	3,000,000 ci	Isomedix (South Carolina)	6 years	General Processing
Co-60	2,000,000 ci	Isomedix (Whippany)	3 years	General Processing

Mr. Young, through Mr. George R. Dietz, RPO, received on-the-job training in the use of shielding and time-distance relations in reducing radiation exposure; the use, maintenance and limitations of monitoring and surveying instruments; and protective, routine, and emergency procedures in effect at the Isomedix New Jersey facility. The on-the-job training was correlated with a formal course given by Mr. Dietz. contents of this training program are outlined elsewhere.

Mr. Young was a licensed operator of the 1.5 million curie Parsippany unit for 3 years, and a licensed operator for Isomedix Hot Cell Irradiators for nearly 2 years.

Jonathan Young (continued)

Mr. Young was transferred to the Isomedix South Carolina facility (a large, totally automated, AECL medical products irradiator) where, as Production Manager, he was also a licensed operator. From February 1982, until July 1, 1984, Mr. Young was the Plant Manager, and on-site RPO at that facility, being licensed as such by the State of South Carolina. He was also a licensed operator in this plant for 6 years, until his transfer to New Jersey as Plant Manager to both the Whippany and Parsippany irradiators.

Mr. Young joined Isomedix in 1976.

Formal Education - High School Graduate - 1972
College - 3 years

APPLICATION FOR RADIOACTIVE
MATERIAL LICENSE - Items 8 and 9

PAUL WARD

Type of Training	Where Trained	Duration Training	On the Job	Formal Course
Principles and practices of radiation protection, radioactive measurement standardization, monitoring techniques and instrumentation, biological effects of radiation, calculations basic to the use and measurement of radioactivity.	Michigan State Univ.	1 semester	5 years	Yes
	Univ. of Michigan	3 years	2 years	Yes
	Abbott Labs		5 years	No

EXPERIENCE WITH RADIATION

Nuclide	Amount	Where	Duration	Type of Use
Cf-252	5 Ci	U of M	2 years	Instrument and dosimeter cal
Pu-239	40 mCi			
Tl-204	100 mCi			
Pm-147	100 mCi			
Cs-137	100 Ci			
I-125	5 Ci	Abbott Labs	5 years	Waste Disposal
Kr-85	50 kCi	TMI-2	6 months	Containment air contamination
Zn-65	unknown	MSU	5 years	Activated Cyclotron parts
Co-60	17 kCi	Abbott Labs	5 years	Sterilization Research
Na-21	unknown	MSU	5 years	Activated coolant samples
Misc. mixed fission	unknown	TMI-2	6 months	Post accident reactor primary coolant samples

Other Radiation Sources

100 kVp X-ray crystalography machine	U of M	2 years	Dosimeter cal
300 kVp X-ray therapy machine			

Paul Ward (continued)

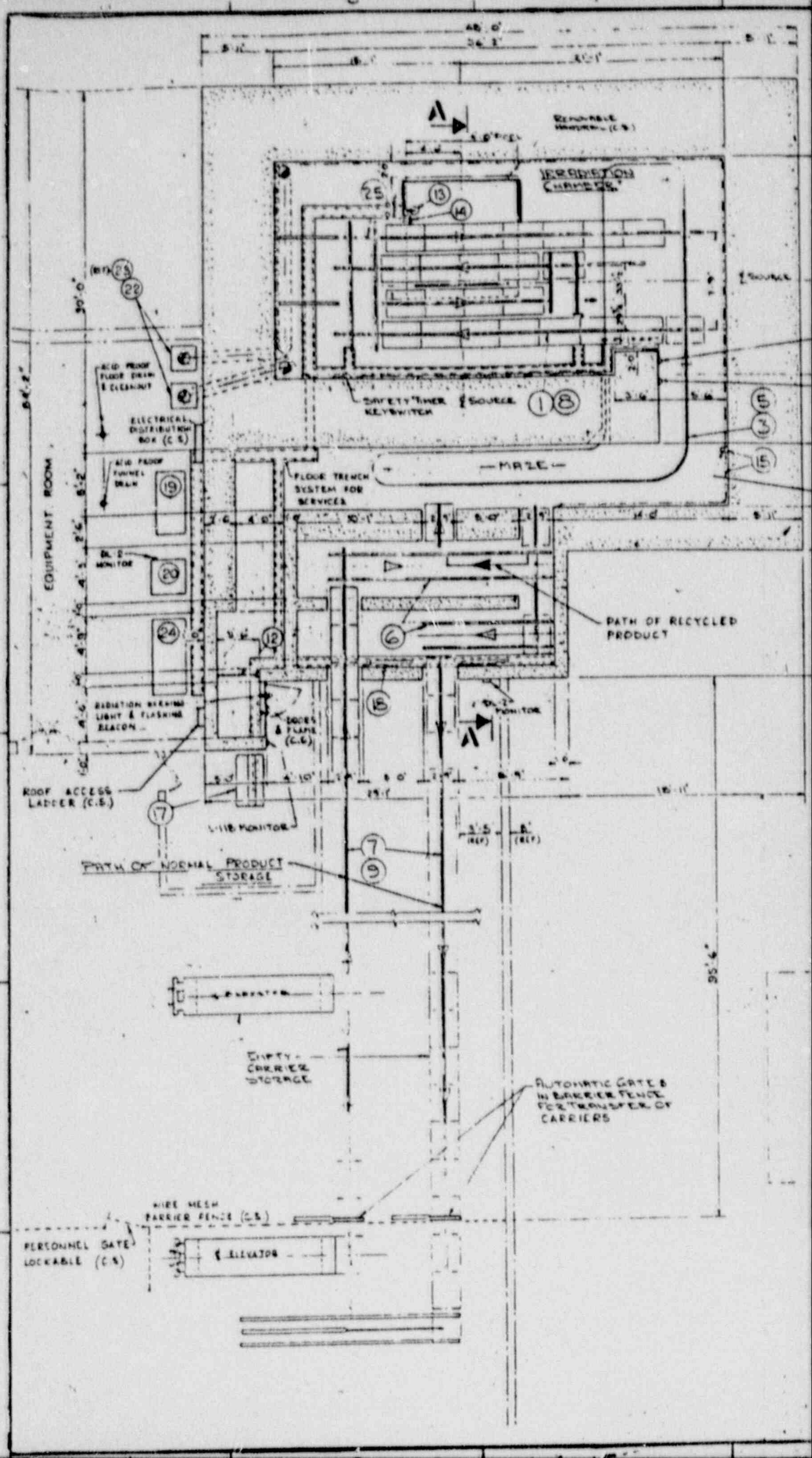
<u>Formal Education</u>	High School	1969	
	Michigan State University, Lyman Briggs' College	1976	B.S. Biology & Physics
	The University of Michigan, School of Public Health	1982	M.S.Radiological Health

Mr. Ward was cyclotron technician at Michigan State University Cyclotron Laboratory from 1973 to 1979. He received his B.S. Degree from Lyman Briggs' College in biology and physics in 1976. He attended the University of Michigan School of Public Health from 1979 to 1982, and received a Master of Science in Environmental Health Sciences. During his tenure with the university, he conducted applied research into dosimetry of mixed beta, gamma and neutron radiation. This research was directed by Dr. Phillip Plato and Dr. C. Glen Hudson. He was a dosimetry consultant to GPU Nuclear in 1980, during the containment venting and initial containment re-entry at Three Mile Island Nuclear Station, Unit 2, in Middletown, Pennsylvania.

Since 1982, Mr. Ward has been employed at Abbott Laboratories in North Chicago, Illinois. He joined the company as a Health Physics Supervisor in charge of operational health physics for Abbott Diagnostics Division. In 1986, he was promoted to Manager of Health Physics and Corporate Radiation Safety Officer. He is a member of the Health Physics Society and is active in the Midwest Chapter, serving as chapter secretary during 1986-87. He has passed Part I of the American Board of Health Physics comprehensive Certification Examination, will be eligible to take Part II in 1988.

APPENDIX A

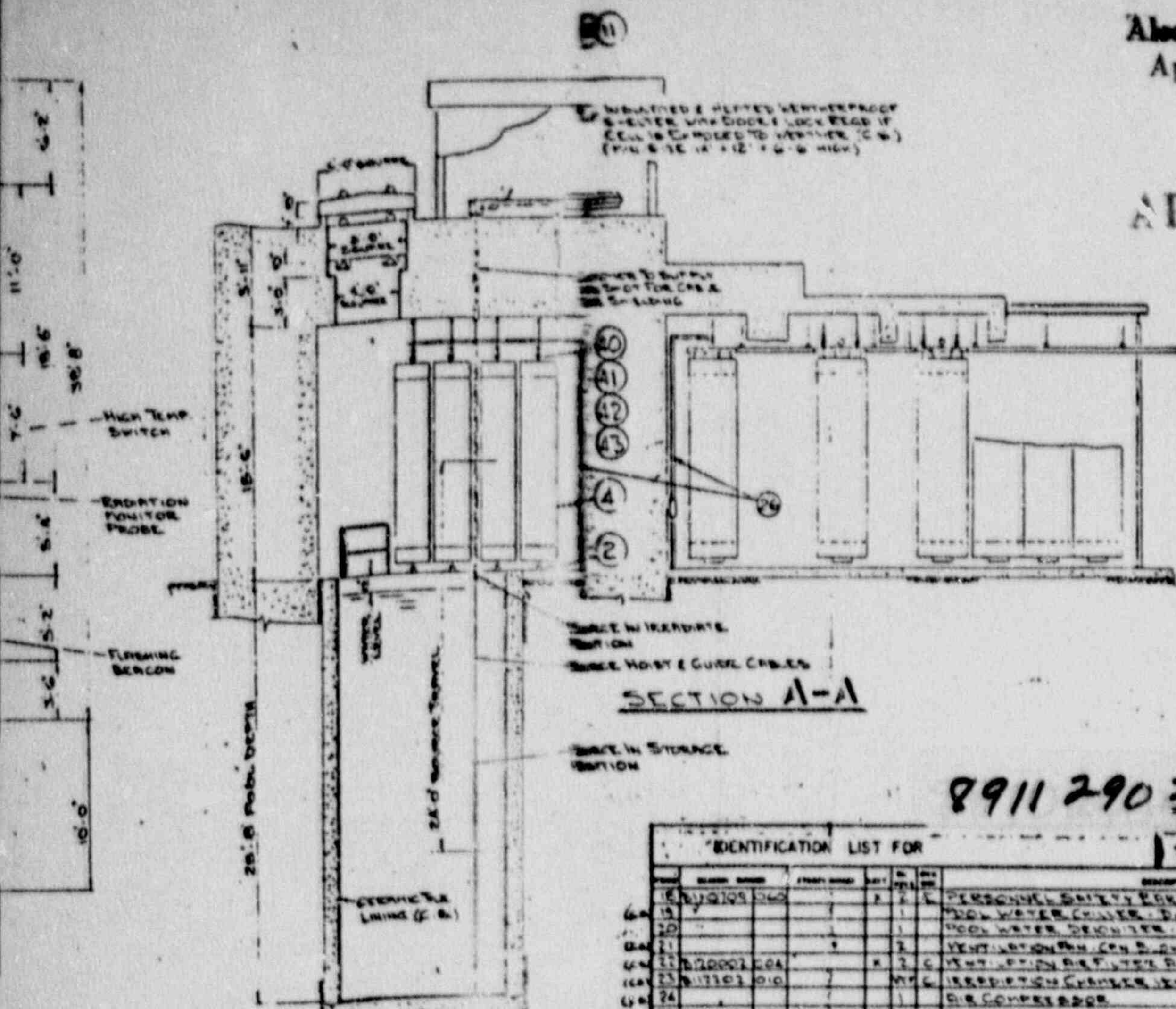
DRAWING B110701 002 G



IRRADIATION CHAMBER
REMOVABLE HATCH (C.S.)
SAFETY TIMER KEYSWITCH
MAZE
FLOOR TRENCH SYSTEM FOR SERVICES
EQUIPMENT ROOM
ACID PROOF FLOOR DRAIN & CLEANOUT
ELECTRICAL DISTRIBUTION BOX (C.S.)
ACID PROOF FUNNEL DRAIN
RADIATION WARNING LIGHT & FLASHING BEACON
DOORS & FRAME (C.S.)
ROOF ACCESS LADDER (C.S.)
PATH OF RECYCLED PRODUCT
PATH OF NORMAL PRODUCT
STORAGE
EMPTY CARRIER STORAGE
AUTOMATIC GATES IN BARRIER FENCE FOR TRANSFER OF CARRIERS
WIRE MESH BARRIER FENCE (C.S.)
PERSONNEL GATE LOCKABLE (C.S.)
ELEVATOR
MONITOR

Also Available On Aperture Card

SI APERTURE CARD



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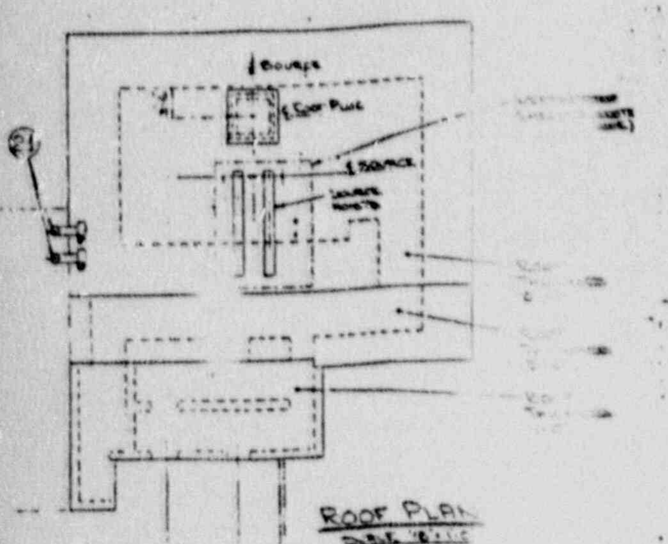
IDENTIFICATION LIST FOR — 2 — B110791 002 G

18	B110709	060		x	2	E	PERSONNEL SAFETY CARRIER ASSY.
19					1		POOL WATER CHILLER · DUNHAM BUSH "PC0108"
20					1		POOL WATER DEIONIZER · WATER REFINING "C0DM 12"
21					2		VENTILATION FAN [illegible]
22	B120002	004		x	2	C	VENTILATION AIR FILTER ASSEMBLY
23	B117707	010				C	IRRADIATION CHAMBER VENTILATION SYSTEM
24					1		AIR COMPRESSOR
25	B110709	035		x	1	C	TEMPORARY RAIL FOR SOURCE REPLENISHMENT
26	B110707	008		X	1	D	LAY-IN DUCTWORK
27							
28							
29							
30							
31							
32							
33	B120005	001	NOT SHOWN		1		RADIATION METER PACKAGE
34	B110701	002	NOT SHOWN			D	SPARES LIST
35	B110707	101	NOT SHOWN				ELEMENTARY WIRING
36							
37							
38							
39							
40	B109709	012		x	22	C	CARRIER WHEEL BRACKET
41					212		HALF TROLLEY "PL 754 (3¾" DROP)" "MONOVEYOR" DEGREASED
42			33073802		201		3/8"-16 x 1¼" LG. HEX HD CAPSCREW
43			34040091		201		3/8"-16 LOCKNUT · ESTS. HAUS · HN-127
44							

IDENTIFICATION LIST FOR — B110791 002 G

1	B110709	001		x	1	E	SOURCE PASS MECHANISM ASSEMBLY
2	B110709	002		x	1	E	CARRIER KEEL TRANSFER MECHANISM
3	B110709	003		x	1	E	MAZE CONVEYOR ASSEMBLY
4	B110709	004		x	44	E	PRODUCT CARRIER ASSEMBLY
5	B110709	036		x	1	D	MAZE KEEL GUIDE SYSTEM
6	B110709	040		x	1	E	INTERIM TRANSFER AREA ASSEMBLY
7	B110709	101		x	1	E	STORAGE AREA CONVEYOR ARRANGEMENT
8	B110707	001		x	1	E	PNEUMATIC SCHEMATIC · SOURCE PASS MECH.
9	B110707	201		x	1	D	PNEUMATIC SCHEMATIC · STORAGE AREA
10	B110704	001		x	1	E	SOURCE MECHANISM ASSEMBLY
11	B108906	001	NOT SHOWN	x	1	D	SOURCE HANDLING TOOL KIT
12	B120007	006		x	1	D	SOURCE HOIST SAFETY VALVE ASSEMBLY
13	A05868		AD58836	x	1	C	POOL SKIMMER ASSEMBLY.
14	A05843		AD58431	x	2	C	WATER LEVEL SWITCH ASSEMBLY
15	B110707	010		x	1	C	EMERGENCY STOP CABLE ASSEMBLY
16	B104207	017	A06896	x	1	D	MAZE ENTRANCE DOOR ASSEMBLY.
17	B110707	119			1		CONTROL CONSOLE ASSEMBLY



NOTES:

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible] B110702/001, 002, 002, 002, 004, 005 [illegible]

G	[illegible]	
F	ITEMS 5 & 12 [illegible]	
E	[illegible] WORDS & DELIMITER	
D	[illegible]	
C	ITEM 26 ADDED	
B	[illegible]	
A	[illegible]	

ATOMIC ENERGY OF CANADA LIMITED

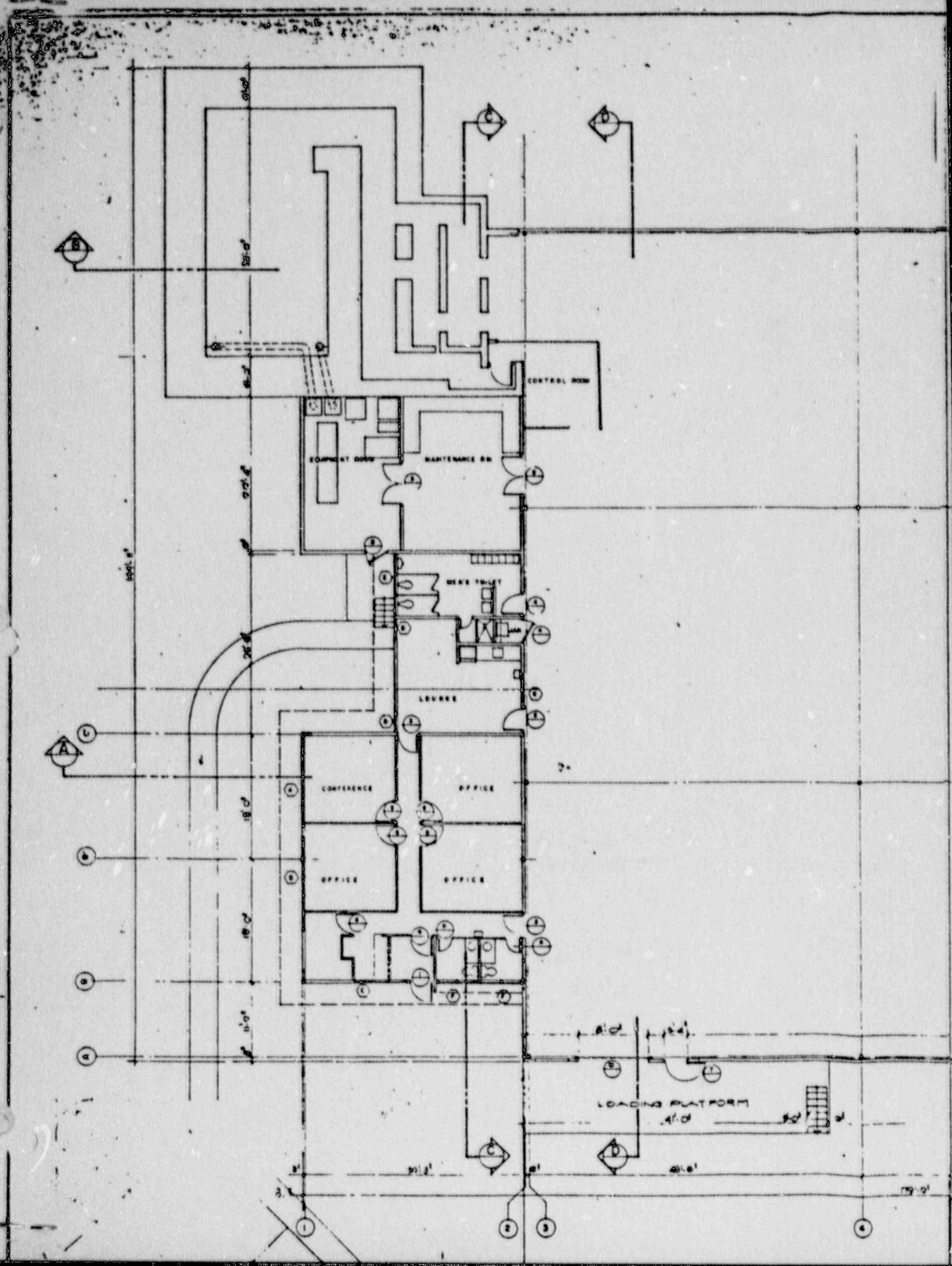
CARRIER TYPE IRRADIATOR (MONUBRIX (PUERTO R[illegible]

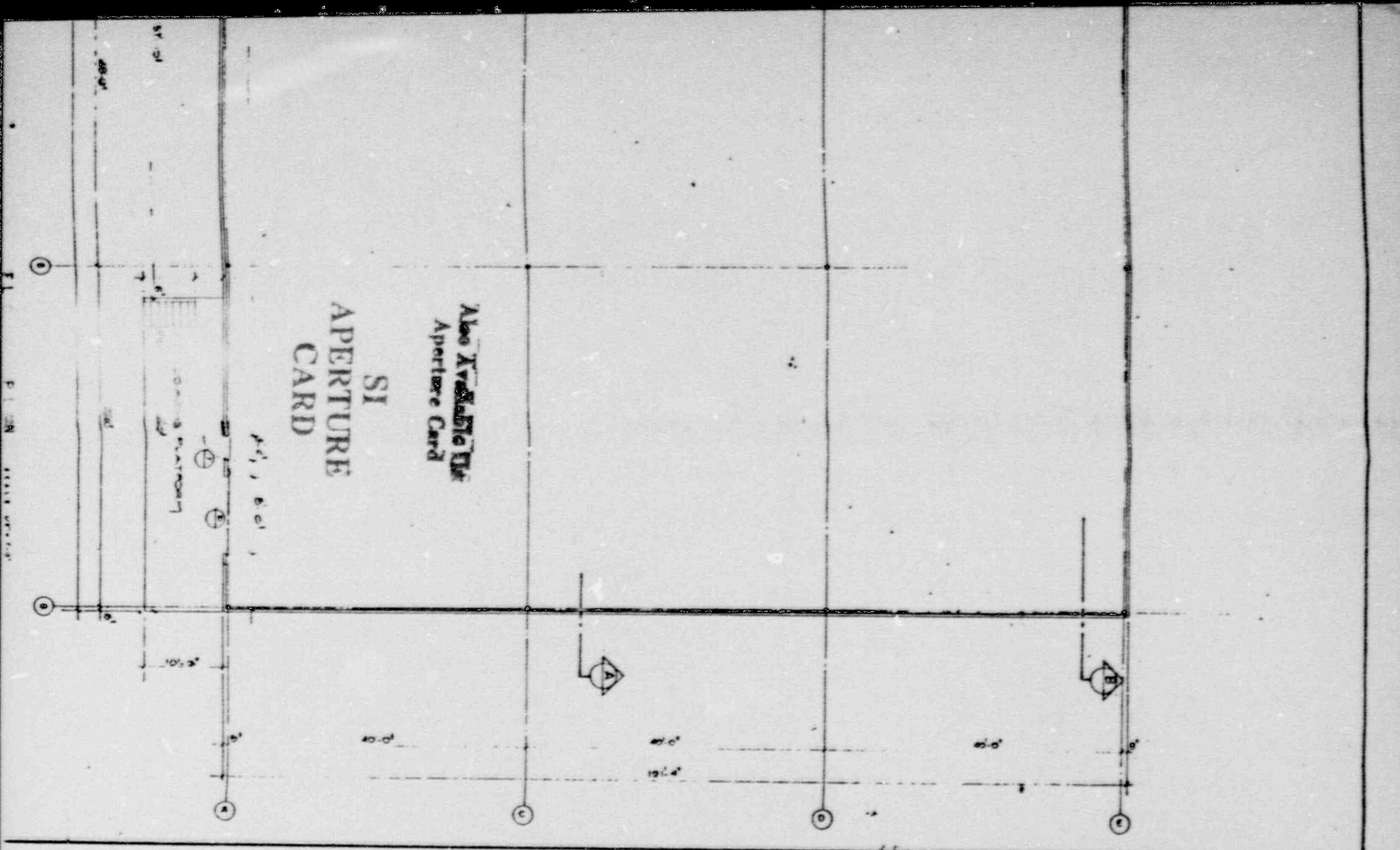
B110791 002 G

APPENDIX B

DRAWING A-3

General Layout of Building


CONTROL ROOM
MAINTENANCE RM
MEN'S TOILET
LOUNGE
CONFERENCE
OFFICE
OFFICE
OFFICE
LOADING PLATFORM



A-3

DE P.R.

VEGA ALTA, PUERTO RICO

CERTIFICADO
ARQUITECTO
GRADUADO
PUERTO RICO

jose g barat-masri
arquitecto

8911290369-03

APPENDIX C

DESCRIPTIONS OF FIXED MONITORS

OPERATING INSTRUCTIONS

SINGLE PROBE

WALL MOUNTED MONITOR

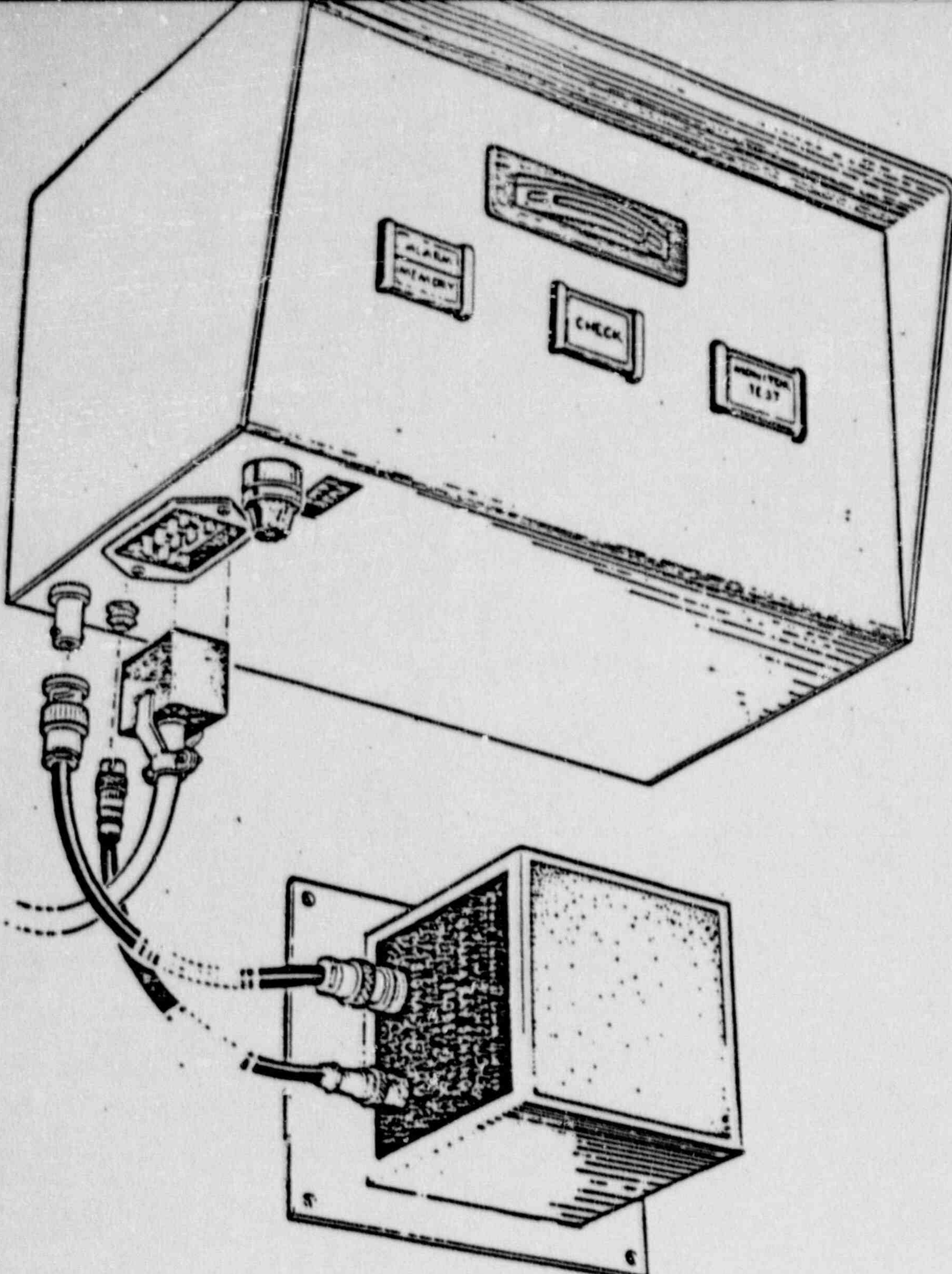
CATALOGUE NO. L118

Edition No. 3, July 1975

Atomic Energy of Canada Limited,
Commercial Products,
Ottawa, Canada

DESCRIPTION

LIST OF ILLUSTRATIONS



RII H100312-007

WALL MOUNTED SINGLE PROBE
MONITOR SYSTEM

L118

FIGURE 1

DESCRIPTION

Introduction

The wall mounted monitor system is designed to warn and indicate that gamma radiation is present, and to monitor the radiation facility.

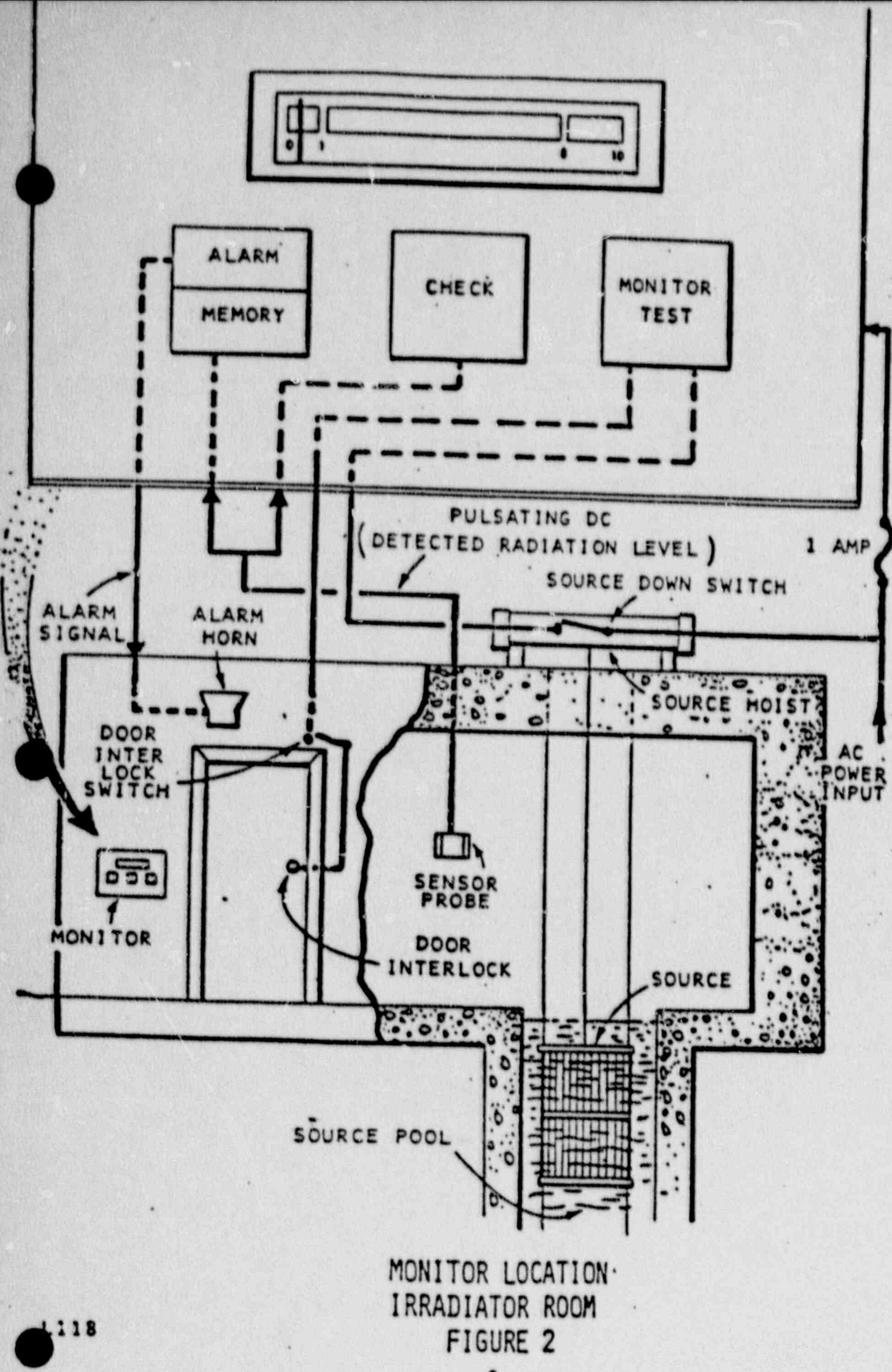
A Gamma Ray sensing probe is used with the radiation monitor system and is installed in the area to be monitored, and the detected radiation signal is then transmitted to the electronic assembly unit.

The electronic assembly will then transmit the detected signal to a visual and audio warning system. A visual indicator will also monitor the radiation level sensed by the probe.

General (Ref. Figure 1)

The Single Probe Monitor system consists of two assemblies. Reference AECL Drawing A12986.

a) A probe which contains the electronic radiation detectors.
b) The Ratemeter, Power Supply, associated relay and indicator circuits which are contained in the Monitor console. A radiation alarm horn is also an integral part of the system, which is mounted in the most advantageous position.



MONITOR LOCATION
IRRADIATOR ROOM
FIGURE 2

1118

c) The Monitor System can be used with the following signal inputs:

i) With an input from the Sensing Probe only; or

ii) A Sensing Probe signal input and an Interlock system.

Monitor Control Console (Ref. Figure 2)

The Monitor Control Console shall be located in a room where the electronic components are not exposed to a high radiation field.

The monitor console includes the following controls and indicators:

1. Check Lamp - a flashing neon lamp which indicates that the ratemeter circuit is functioning properly.

2. Monitor Test - an illuminated switch that is used in a safety interlock system and will simulate an alarm condition which will check that the Monitor system is functioning properly.

3. Alarm and Memory - a split lens push switch; the alarm lens will illuminate in an alarm condition; the memory lens will remain ON after an alarm condition.

4. Ratemeter - a linear scale meter which indicates the level of radiation as sensed by the probe.

Alarm Horn

The horn will sound under an alarm condition.

Sensing Probe

When the detector in the sensing probe is exposed to a radiation field, it will generate a series of voltage pulses. The frequency of voltage pulses will be proportional to the radiation field strength, and is transmitted to the monitor ratemeter circuit for a visual indication of radiation level being sensed.

The Gama Ray sensing probes contain Geiger-Meuller gas filled tubes, and are used with the radiation monitor system.

The sensing probe is installed in the location to be monitored, and is selected for use with a monitor system for a particular monitoring application.

The three types available are:

(a) Type L110A - Reference AECL Drawing A03364
(b) Type L110B - Reference AECL Drawing A03367
(c) Type L110C - Reference AECL Drawing A03366

Circuit Protection

The Monitor System ha a 1 AMP fuse in the 115 VAC line side of the system.

MONITOR CALIBRATION

Ratemeters

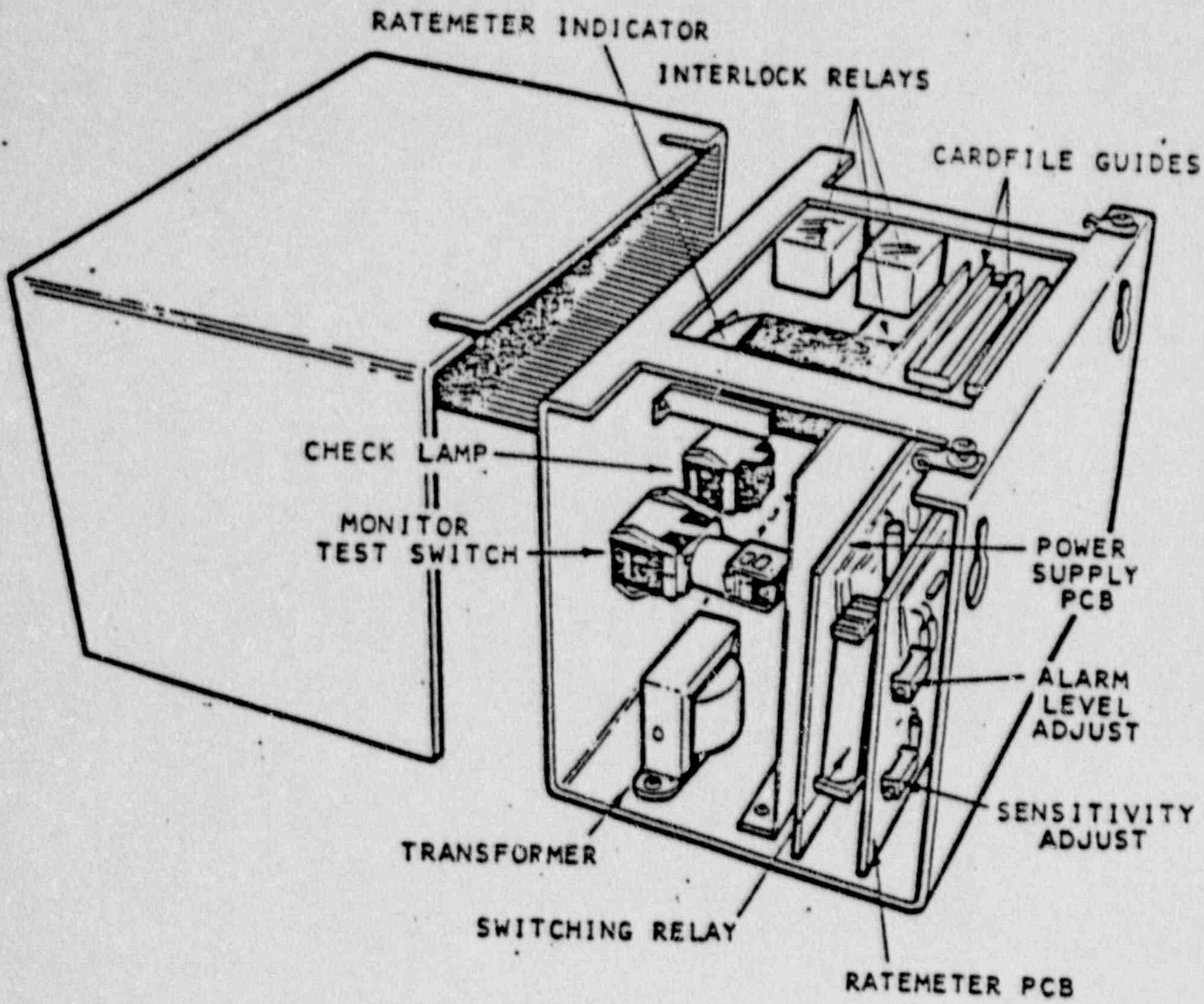
With the geiger probe located in a field of background strength, the sensitivity of the ratemeter can be adjusted by means of a trimpot mounted on the ratemeter board so that the meter registers at 10% of full scale (0-1 reading). The check lamp should be flashing in time with the pulses.

Alarm Circuits

The critical level of the alarm circuit is adjustable by means of a trimpot located on the ratemeter board. This level should normally be set at 80% of the full scale meter deflection (a scale reading of 8).

The proper functioning of the alarm indicators, visual and audible, should be checked every 3 months by moving a calibration source close to the geiger probe. When the calibrator approaches the probe the irradiation system should sound the alarm horn and the "Alarm" and "Memory Alarm" lamps should illuminate.

Normal operating and alarm levels should be checked with the aid of a calibration source provided and adjusted every 6 months.



COMPONENT LOCATION
FIGURE 3

Calibration Procedure

(a) In areas "other than cell location", the calibration is conducted with the source in the raised or "On" position.

1. Using the signals from the Geiger Muller probe, preset the "Sensitivity Adjustment" settings on the ratemeter board for a scale reading of one (1).

2. Adjust the "Alarm Level" trimpot on the ratemeter board until the alarm signals. The ratemeter should give a scale reading of eight (8).

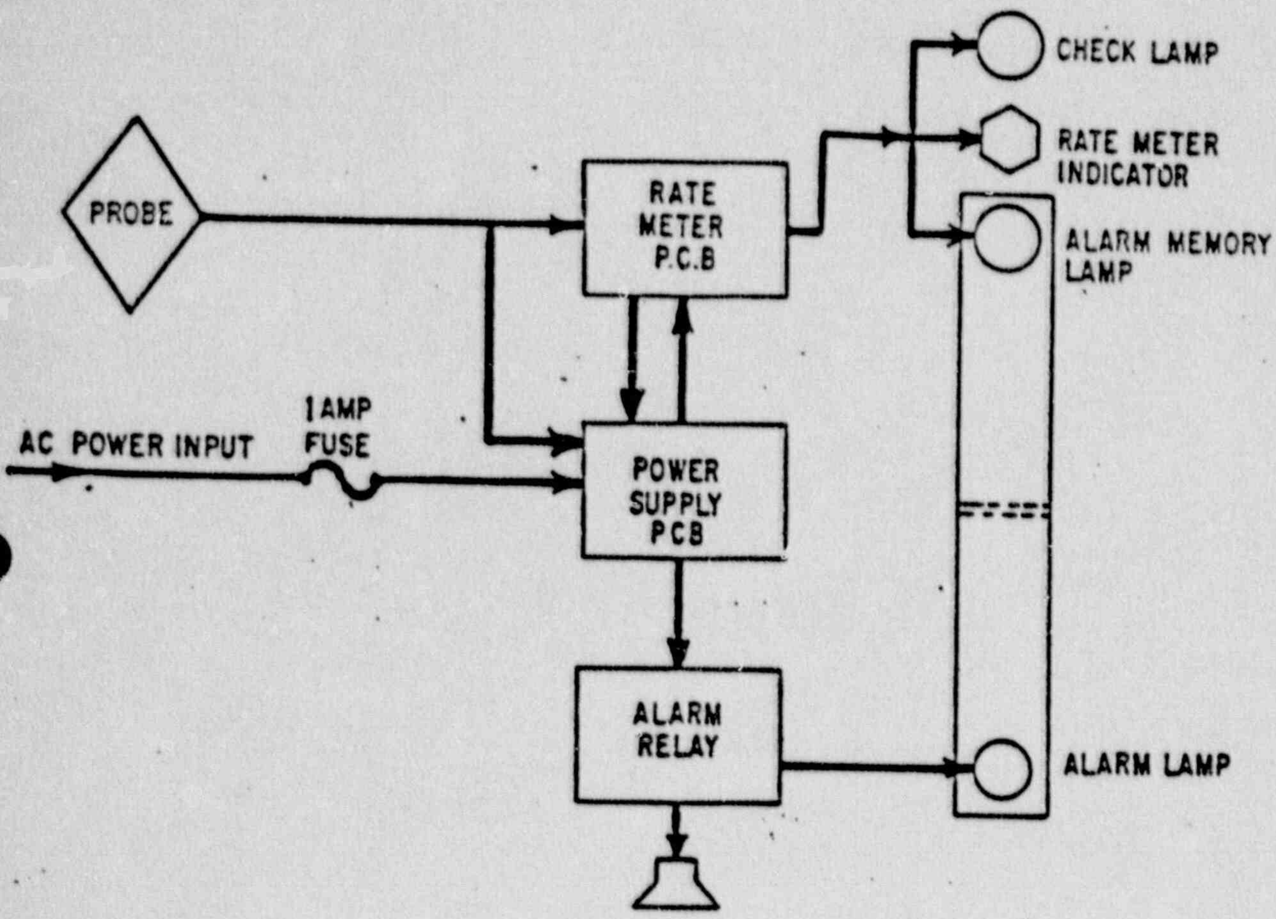
3. Reset the monitoring system at the "Alarm Memory" push button on the Monitor Control Panel.

4. If necessary, repeat step 1 and adjust the "Alarm Level Adjustment" until the alarm signal occurs within ± 10% of a scale reading of eight (8).

5 Reset the monitor system as in step 3. Note that the scale reading should decrease to one (1).

(b) In "cell locations", calibration is conducted with the source in the lowered or "Safe" position.

1. Repeat steps (a) 1 to 5 inclusive.



DATA FLOW DIAGRAM
CONTROL ROOM OPERATION
FIGURE 4

L118

USE AND OPERATION

Use

The L118 wall mounted monitor system is designed to indicate the radiation level in an irradiation room when the source is in the "Safe" (stored) position.

It may also be used as a radiation detector in the control room.

Control Room Operation (Ref. Figure 4)

Normal Operation

The sensing probe is located in the control room area where background radiation levels will be detected.

Voltage pulses proportional to the radiation field will be generated by the GM detector tube, and applied to the power supply and ratemeter printed circuit boards.

The signal to the power supply board is felt at the open contacts of the switching relay with no further circuit effect.

The monitor transformer which will be continuously operating applies 115 VAC through a rectifier, to the switching relay coil keeping it energized. With the transformer operating, 650 VDC from a rectifier circuit is also applied to the sensor probe necessary for system operation.

The detected signal is also applied to the ratemeter printed circuit board. The first stage to accept the signal is an emitter follower. From the follower, to a one-shot multi-vibrator which has an adjustable potentiometer is its integrator circuit. The potentiometer is used to adjust the pulse width of the signal pulses received. This determines the sensitivity of the meter indicator as described in the calibration procedures.

The one-shot output is fed to a driver, and the driver output is then fed to the check lamp and meter indicator.

The check lamp and meter will give a proportional indication of radiation detection.

The driver output signal is also felt at the next stage, the emitter follower.

The background radiation pulse has no further circuit effect as its frequency is below alarm level.

Alarm Operation

The circuit action to the meter indicator and check lamps will be as described in "Normal" operation.

However, the check lamps will flash at an increased rate at a frequency proportional to the radiation field, and the indicator meter needle will move into the alarm area as previously calibrated.

The alarm signal will now overcome the bias as set by the alarm level potentiometer, and the level detector stage will conduct.

The detector output is felt a the Schmitt trigger circuit, and its output will switch from a low to a high voltage level to the final emitter follower stage.

The final emitter stage of the ratemeter circuit will send an alarm signal to the trigger transistor. This high input is felt as a low at the SCR which will stop conducting. The alarm relay normally energized, will now de-energize.

The de-energized alarm relay will permit a DC Voltage to be felt at the "Alarm" lamp which will illuminate.

An AC Voltage will also be felt through the closed alarm relay contact which will sound the alarm horn.

ALARM CONDITION CEASES

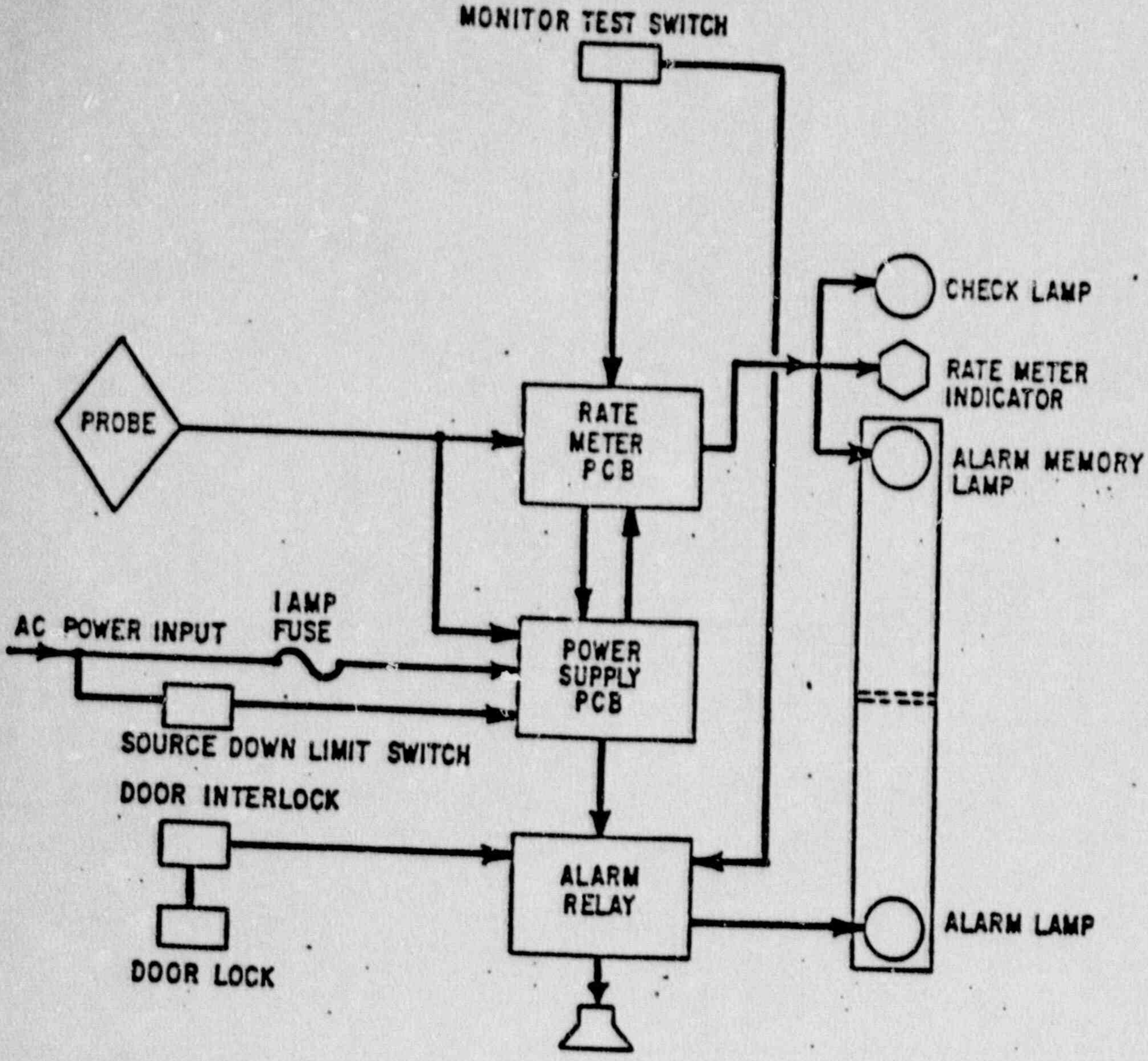
Alarm Circuit

When the alarm condition ceases the red "Alarm" light will extinguish as the alarm relay will energize as in normal operation, breaking the 12.5 VDC circuit to the "Alarm" lamp.

The "Alarm Horn" will be silent as the 115 VAC line will be broken by the open contacts of the energized alarm relay.

Memory Circuit

The "Memory Alarm" light will remain illuminated, as the SCR is still conducting, until the "Alarm Memory" lamp switch is depressed. Depressing the switch will cause the SCR to stop conducting, and open the circuit to the "Memory" lamp which will extinguish.



DATA FLOW DIAGRAM
IRRADIATOR ROOM OPERATION
FIGURE 5

L118

IRRADIATION ROOM OPERATION (Ref. Figure 5)

The sensor probe is installed in the irradiation room where background radiation levels will be detected.

Feature

The following ancilliary circuits are used in an irradiation room operation:

(a) Electrical Interlock Circuit - This system has a microswitch which is actuated by the irradiation room door. The circuit is used as a "Safety" Interlock in the Irradiation room door lock mechanism, and will prevent the door from being inadvertently opened while the source is in the exposed position.

(b) Electrical Source Safe/Exposed Circuit - This system will apply a high DC voltage to the sensor probe with the source in the "Safe" position; the DC voltage will be removed from the sensor probe with the source in the exposed position.

(c) Monitor Test Circuit - This system will test the monitor for correct operation before the operator enters the irradiation room. By depressing the "Monitor Test" switch two capacitors are paralleled which has the effect of increasing the alarm voltage level necessary for alarm operation. This will simulate an alarm condition in the monitor system.

Operation - Source Down

The sensing probe is located in the irradiation room. It will detect gamma ray radiation above the preset ambient level with the source in the "Safe" (stored) position. The sensor will not detect the radiation level when the source is in the "Exposed" position.

The Source Down Limit switch will close, making a high DC voltage available to the sensor probe for its operation. It also energizes a switching relay removing the ground from the signal line.

The monitor operation will be as previously described in CONTROL ROOM OPERATION in Normal, Alarm and Alarm Condition Ceases.

Ancilliary Circuits

The following will describe the function and use of the ancilliary circuits:

Monitor Test Switch

The switch is used by the operator to establish that the irradiation room monitor is functioning properly. The "Source" must be in the "Down" (stored) position. This check is performed preparatory to entering the irradiation room.

(a) Depress the Monitor Test switch and hold until the monitor indicates an alarm condition. The alarm relay will de-energize,

115 VAC will actuate the alarm horn and the meter indicator needle will move to full scale deflection.

The Interlock relays will energize and 115 VAC will be fed to the contacts of the door interlock switch, when alarm condition ceases. The monitor test light, alarm and memory lights will illuminate.

(b) Release the monitor test switch, the alarm relay will energize and open its contacts to the alarm light which will extinguish.

The monitor test light and the memory light will remain "On".

(c) Press the memory switch to clear the circuit which will extinguish the memory lamp.

(d) The irradiation room door may now be unlocked, as the door key is turned it will complete the circuit to the door lock solenoid.

(e) Opening the door will now open the door switch and the interlock relay will de-energize extinguishing the monitor test lamp.

Operation - Source Up

The source down limit switch will open as the source rack begins to rise. This will remove the high DC voltage necessary for the sensor probe operation and grounds out the signal line.

DETECTION OF MONITOR MALFUNCTIONS

With each L118 monitor, the following replacement parts are supplied:

1. Gamma Sensing Probe (Figure 1).
2. Power Supply PCB (figure 3).
3. Ratemeter PCB (figure 3).
4. Ratemeter indicator (figure 3).
5. Set of HV Test and Signal Cables (figure 1).
6. Lamps, Fuses, etcetera (figure 1).

In the event of a malfunction originating within the L118 Monitor System, proceed as follows:

1. Remove the monitor probe from the cell.
2. Using the supplied HV test cables, replace each component, one at a time, for which a replacement part has been provided, and using the test source located in the maze door keyswitch box, test the operation of the monitor.
3. When the fault has been located, replace the faulty component with its appropriate replacement part.

NOTE:

Remember to immediately re-order any component which has been replaced.

OPERATING AND INSTALLATION INSTRUCTIONS

D/L 2 MONITOR

CATALOGUE NO. L119

Edition No. 2, August 1975

STORES CODE 2M002426

Atomic Energy of Canada Limited,
Commercial Products,
Ottawa, Canada

DESIGN CHANGE - Effective July 1976

D/L 2 MONITOR - OPERATING AND INSTALLATION INSTRUCTIONS

Page 11 - SCHEMATIC	Zener Diode CR8, BZY88 changed to SZ6.8A, 1 WATT

INDEX

LIST OF ILLUSTRATIONS

GENERAL DESCRIPTION

The D/L 2 Monitor System is designed to warn and indicate that gamma radiation is present. A typical use is as an area monitor for an irradiator facility.

A clear light-emitting diode (LED) indicates that the detector is ON and a red LED "flickers" under normal background radiation.

If the gamma radiation reaches an unsafe level then an audible alarm signal is activated and the red LED will remain illuminated. The D/L 2 Monitor also contains an auxiliary relay that closes a set of contacts when the audible alarm sounds. This facility can be used to control an associated system such as "shutting down" the irradiator facility.

SPECIFICATIONS

1. Detection Sensitivity - indicates background radiation below 0.05 mR/h.

2. Alarm Level - can be set for 0.5 mR/h and higher.

3. Power Requirements - 100-130 VAC, 50/60 Hz.

NOTE: A 1/4 AMP line fuse must be externally installed.

4. Case Dimensions - 8-1/2 in. long x 5-1/2 in. wide x 4 in. diameter, overall.

5. Auxiliary relay contacts - 15 watts capacity.

COMPONENTS Refer to figure 1

TRANSFORMER

1. Provides a 12 VAC supply.
2. Provides isolation from the 115 VAC line.

POWER LAMP

Indicates that the D/L 2 Monitor is ON.

ALARM LAMP

Provides a visual indication of gamma radiation.

GEIGER-MEULLER TUBE

Monitors the gamma radiation and produces output pulses at a frequency that is proportional to the radiation level.

ALARM HORN

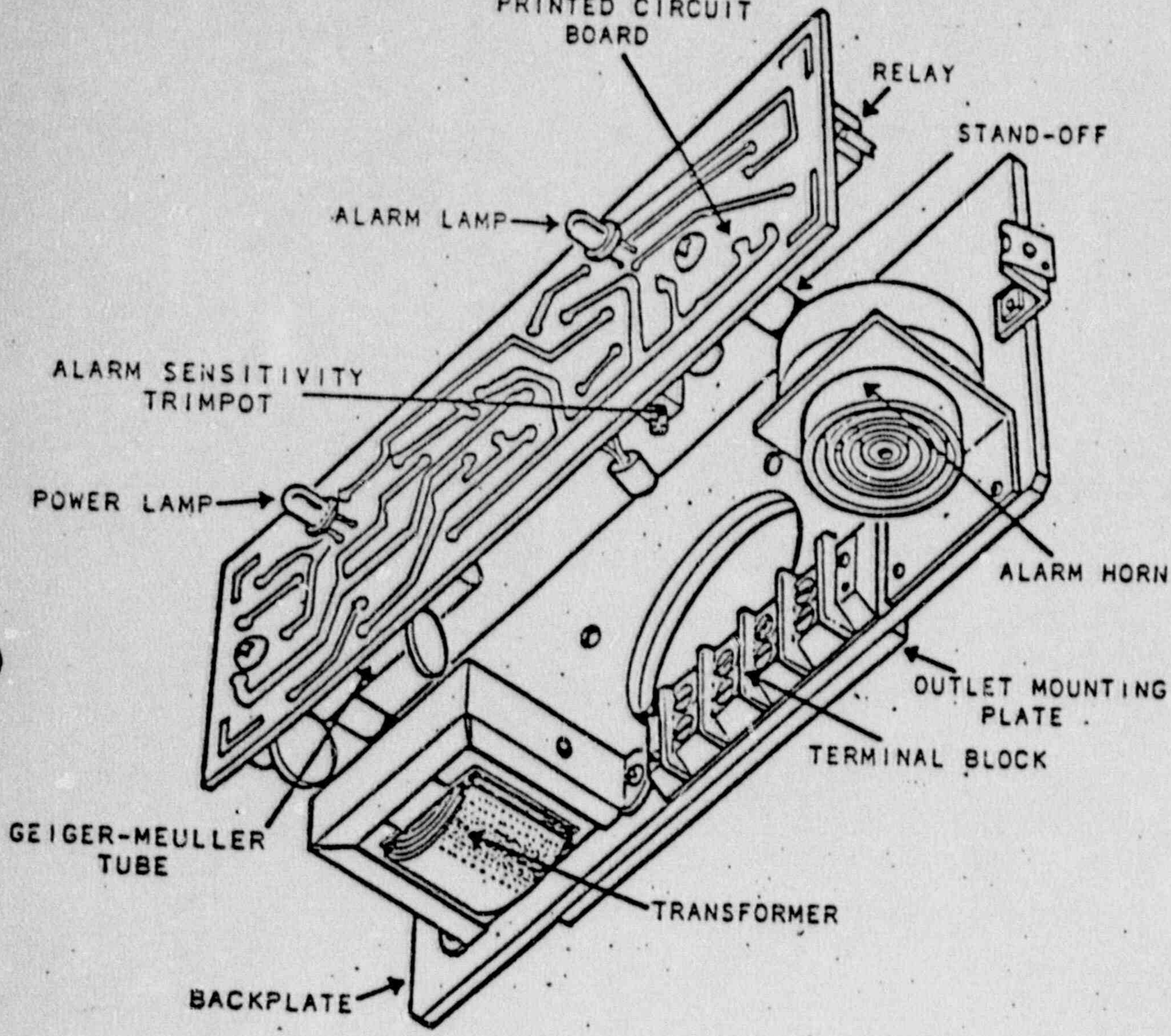
Produces a high-frequency "shrill" sound in the advent of unsafe gamma radiation.

RELAY

The relay contacts close in an alarm condition.

ALARM SENSITIVITY TRIMPOT

Provides a means of adjusting the sensitivity of the MONITOR to gamma radiation.



REF B105207-024/A

COMPONENT LOCATION

FIGURE 1

TERMINAL BLOCK

1. Provides for easy connection to 115 VAC.
2. Auxiliary relay contacts are also available at this terminal block.

THEORY OF OPERATION Refer to AECL Drawing A14233

The radiation level is monitored by a Geiger-Meuller tube which produces output pulses at a frequency proportional to the radiation lever. These pulses are then processed by a Transducer Detector to produce a non-symmetrical square-wave output having an "on-time" proportional to the frequency of the pulses from the Geiger-Meuller tube.

The output of the transducer detector drives the red ALARM lamp (LED). This output also feeds an R-C integrator having a relatively "long" time constant. Therefore, the DC output voltage from the R-C integrator is consequently proportional to the radiation lever.

The output of this R-C integrator goes to a COMPARATOR whose reference voltage is set by the ALARM SENSITIVITY trimpot.

If the radiation should increase to an unsafe lever, then the COMPARATOR (along with transistor Q1) will "actuate" the audible alarm and thus de-energize the relay coil causing the relay contacts to close.

SENSITIVITY ADJUSTMENT

The sensitivity of the D/L 2 Monitor should be adjusted with Maximum background radiation (with the source in the raised or "ON" position).

1. Adjust the alarm sensitivity trimpot (Figure 1) until the alarm horn sounds.
2. With the alarm horn sounding, adjust the sensitivity until the horn just turns OFF. The SENSITIVITY is now set.

TESTING THE SENSITIVITY OF THE MONITOR

With the source in the raised position (this provides maximum background radiation) bring a calibration source towards the D/L 2 Monitor until the alarm horn sounds.

If the alarm does not sound, then the SENSITIVITY should be re-adjusted as described above.

PERIODIC CHECKING OF THE MONITOR

The D/L 2 Monitor should be checked once a month (minimum).

CHECKING PROCEDURES

1. the POWER lamp should be ON (this can easily be inspected each day).
2. The red ALARM lamp should "flicker" for normal background radiation.
3. Check the SENSITIVITY as described above.
4. Check the operation of the relay contacts (perhaps the relay is used to turn on a light at a master control panel).

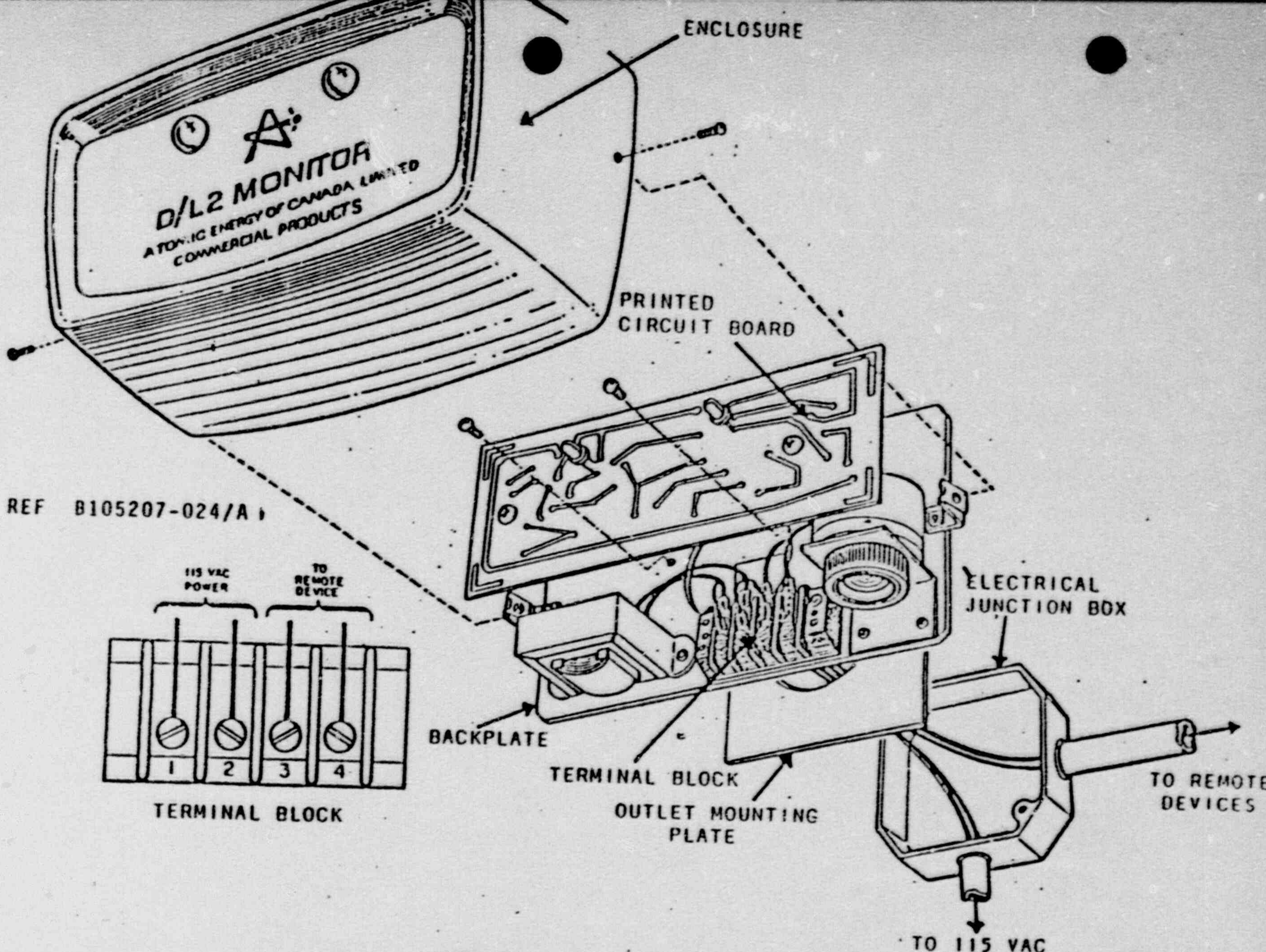
NOTE: If the relay contacts are not used to control an associated system then there is no need to check these contacts since they, in no way affect the operation of the D/L 2 Monitor.

INSTALLATION INSTRUCTIONS Refer to Figure 2

The D/L 2 Monitor is designed for wall mounting and should only be located where the background radiation is relatively "low" otherwise the electronic components could be damaged.

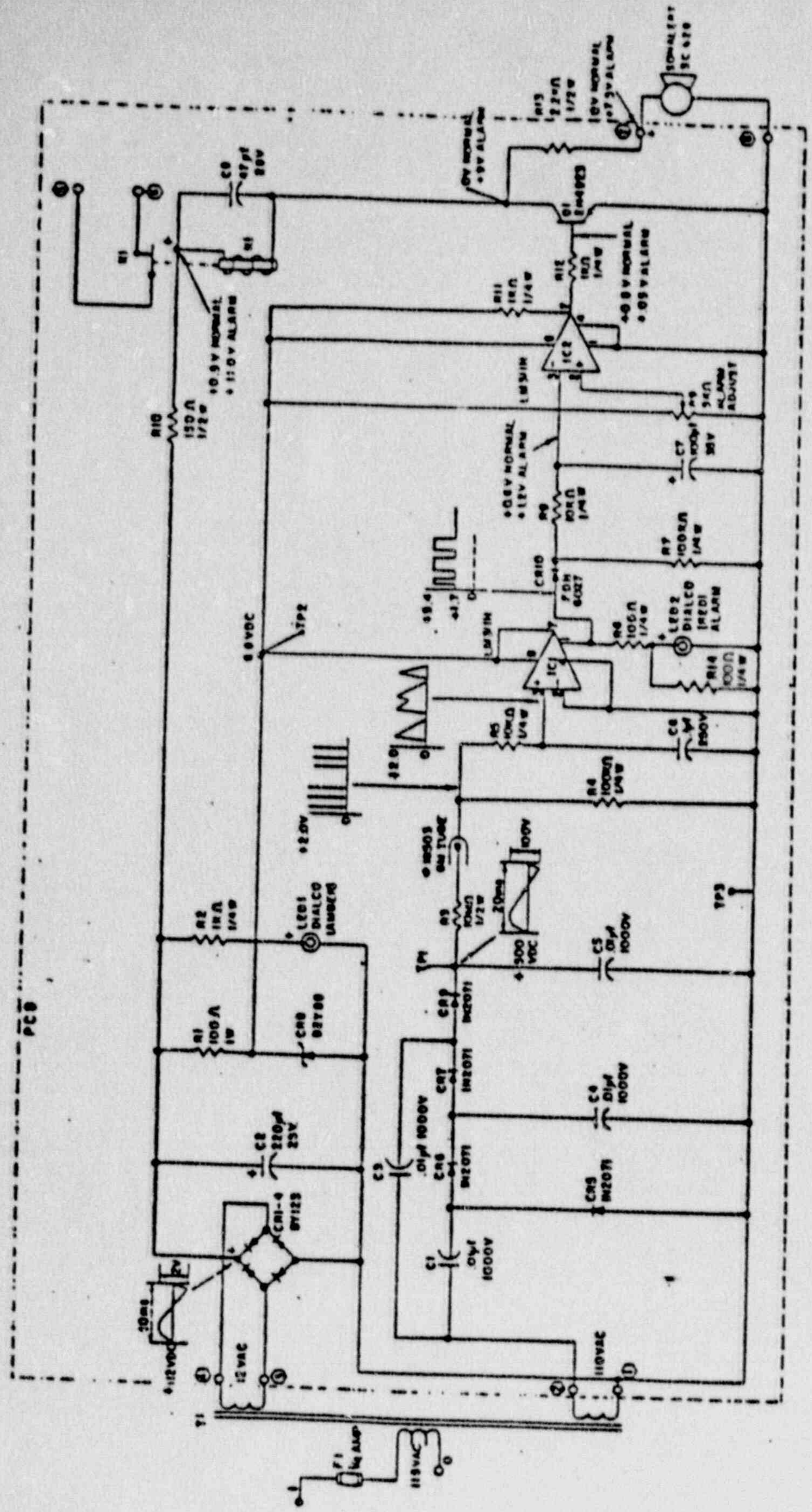
MOUNTING

1. Remove enclosure from backplate.
2. Remove printed circuit board from stand-offs.
3. Remove outlet mounting plate.
4. Drill holes in the outlet mounting plate to align with mounting holes in the electrical junction box.
5. Bring wires through the access hole in the outlet mounting plate.
6. Mount the outlet mounting plate to the junction box.
7. Bring wires through the access hole in the backplate.
8. Mount backplate to outlet mounting plate.
9. Mount printed circuit board to the stand-offs.
10. Connect wires to terminal block (as shown in Figure 2).
11. Adjust the alarm sensitivity as described earlier in this section.
12. Mount enclosure to backplate.



MOUNTING DETAILS

FIGURE 2



D/L 2 MONITOR SCHEMATIC

FIGURE 3