Atomic Energy of Canada Limited
L'Énergie Atomique du Canada, Limitée

Commercial Products
Produits Commerciaux

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Tel. (613) 592-2790
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File

1963

1963

File: F92108
80-PE-870

1980 September 4

Mr. Paul R. Guinn,
License Management Branch,
Division of Fuel Cycle and
Material Safety,
U.S. Nuclear Regulatory Commission,
Washington, D.C.
U.S.A. 20555

Dear Mr. Guinn:

Subject: Radiation Survey Report as per Condition 16 of USNRC Lic. No. 54-00300-9 Category IV Irradiator

Please find enclosed a copy of a Radiation Survey performed August 14, 1980 as follows:

Site: Becton-Dickinson
Division of Becton, Dickinson & Company
Route 7 and Gracewa/
Canaan, Connecticut 06018

Type of Work: Source Loading - Addition of 466,388 curies Cobalt-60 1980 August 1
Category IV Irradiator
Serial No. IR21

Total Activity: 1,499,140 curies Cobalt-60 1980 August 1

Authorized Technician: Mr. R. Chu

Yours very truly,

Rod Chu, Senior Radiation Physicist,
Industrial Engineering & Service

/cpg
Encl.

cc: Dr. John Glen, Region 1, USNRC
Office of Inspection & Enforcement
631 Park Avenue
King of Prussia, Penn. 19406, U.S.A.

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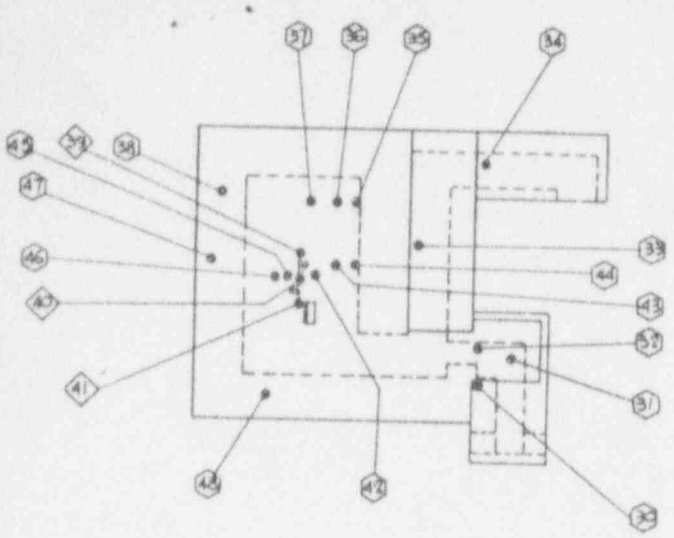
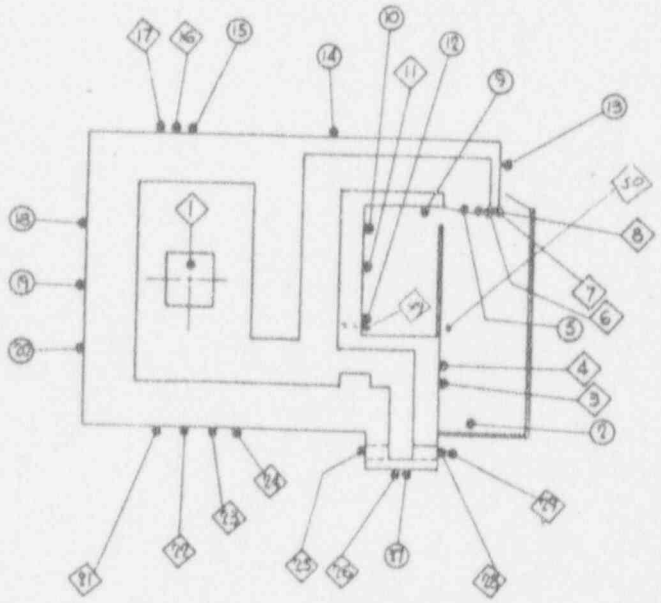
A-1





ALL READINGS IN mrem/h
READINGS LESS THAN 0.03 mrem/h
SHOWN THUS 1963

NO	READING	REMARKS
1	*	POOL SURFACE
2	0.03	CONSOLE
3	0.3	LOCAL SPOT
4	0.4	LOCAL SPOT
5	0.1	THROUGH DOOR
6	0.65	CRACK OVER DOO
7	1.0	CRACK UNDER DO
8	1.0	DOOR SIDE CRACK
9	0.05	
10	0.2	D.S.
11	0.5	NEAR TOP OF WALL
12	0.75	
13	0.15	
14	0.12	
15	0.2	
16	2.6	BEAM CYLINDER
17	2.2	BEAM CYLINDER
18	0.15	
19	0.30	
20	0.15	
21	0.05	
22	0.07	
23	0.05	
24	0.04	
25	0.05	MAX AT DISCHARG
26	2.0	PORT AT CONVEY
27	0.12	
28	0.15	MAX AT ENTRY
29	0.9	PNEUM. CYLINDE
30	*	
31	0.2	
32	0.14	
33	0.25	
34	0.04	
35	0.05	
36	0.12	
37	0.15	
38	0.05	
39	3.0	GUIDE CABLE
40	5.0	HOIST CABLE
41	2.2	GUIDE CABLE
42	5.5	
43	1.4	
44	0.2	
45	6.0	
46	1.5	
47	0.05	
48	0.05	
49	2.8	TRENCH
50	0.05	FREEZER LAB ABOVE
51		CONTROL ROOM
52		
53		
54		
55		
56		
57		
58		
59		
60		

○ AT 1m ABOVE FLOOR
⬡ AT FLOOR OR ON ROOF
◇ ON NAMED FEATURE
(SURVEYOR TO ADD AS NECESSARY)

NOTE:
ROOF (POSITIONS 30-48) IS A RESTRICTED AREA.

MAXIMUM RADIATION DESIGN LEAKAGE SO THAT NO ONE SHALL RECEIVE MORE THAN 10 mrem IN A 40 HOUR WORK WEEK WITH 1.5×10^6 CURIES OF COBALT-60 INSTALLED.

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

SURVEY PERFORMED BY [illegible]
DATE Aug. 14/80

SURVEY INSTRUMENT MODEL Eberline RO-1C
SERIAL NO. 373502 CALIBRATION DATE July 22/80
SOURCE CONTENT 1491.40 CURIES
ON DATE -

ATOMIC ENERGY OF CANADA LIMITED
OTTAWA COMMERCIAL PRODUCTS CANADA

RADIATION SURVEY REPORT
AFTER SOURCE INSTALLATION NO. 5
IN IR 21 BECTON - DICKINSON
CANAAN

Enclosure 3

UR Claim

Atomic Energy of Canada Limited
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Ottawa, Canada
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Tel. (613) 592-2790
Telex. 053-4162

File: B-1
80-PE-934

1980 December 15

RECEIVED
DEC 24 [illegible]
CANAAN PLANT

Becton-Dickinson,
Rt. #7, Grace Way,
Canaan, Connecticut,
U.S.A. 06018.

Gentlemen:

SERVICE BULLETIN - RADIATION STERILIZATION FACILITIES

As a result of a recent engineering survey of several irradiator installations and a recent field incident, we have noted two critical situations which can cause damage to an irradiator and/or your product. We feel it our duty to warn you about these situations and to recommend remedial action.

1) In every irradiator, regardless of model or design, the product, during irradiation, passes by the source rack with minimal clearance in order to maximize irradiation efficiency. The minimal clearance between product and source rack approximates 2 inches (5.1 cms). Because of this clearance, it is mandatory that no damaged product cartons, tote boxes, or carriers (depending on your particular irradiator model) be allowed to enter the irradiator. Damaged cartons, totes or carriers increase the probability of interference with the source rack with potential jamming or damage to the source system occurring.

   Totes and carriers must be routinely inspected at the unload station of your irradiator. If damaged, they must be immediately removed from service and repaired. Inspection of totes or carriers must be implemented as a mandatory continuing function for your operators.

A-2

...2

2) With higher source activities now being placed in service, we inform you that there can be a risk of fire in your product if, for any reason, movement of product through the irradiator is stopped for an extended period while the source remains in the exposed position. Experience indicates that a source of one million curies Cobalt-60 can cause stationary combustible product to smolder or ignite after approximately 9 hours continuous exposure to the source.

If you have not already installed a fire extinguishing system in your irradiator, we urge that you do so without delay to minimize potential damage to your product and the irradiator equipment in the event of fire. A water sprinkler system controlled by a heat detector probe having a manual override is the recommended system for most irradiators.

We highly recommend the above matter(s) be attended to with minimum delay. If you have questions about your facility, contact me personally for engineering assistance.

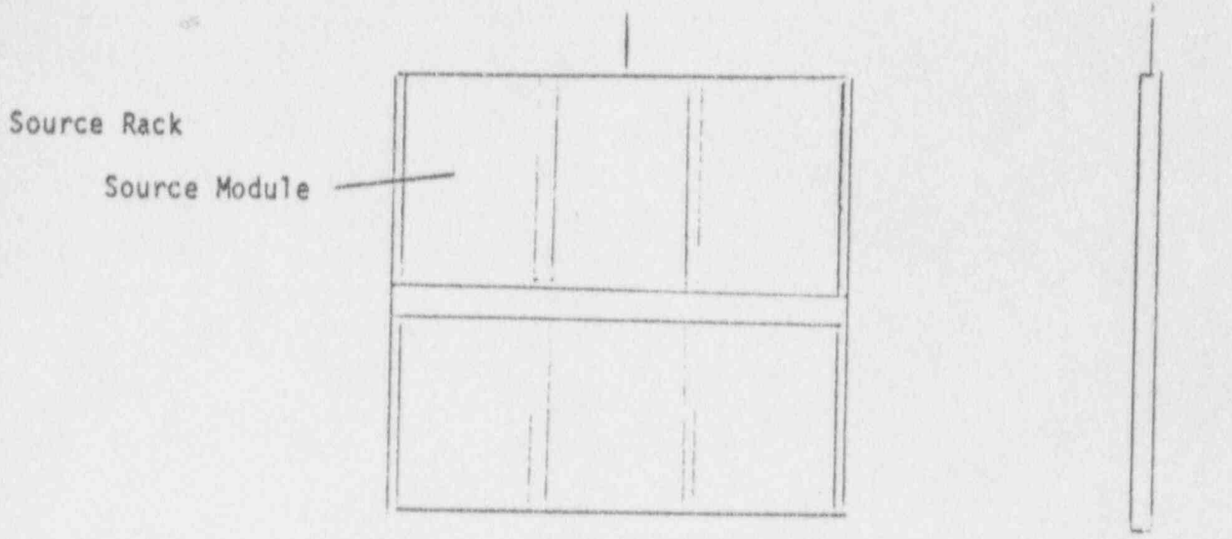
Sincerely,

R.G. McKinnon, Manager,
Industrial Engineering & Service.

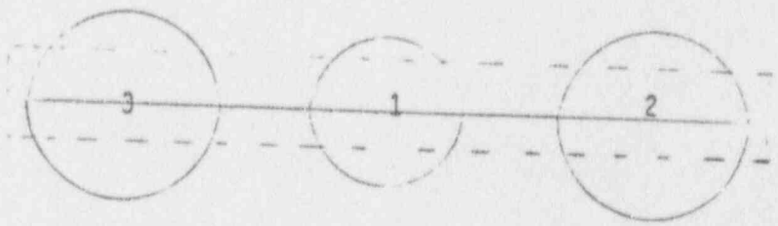
Enclosure 4

Front View

Side View



Arrangement of Drilled Holes over Normal Position
of Source Module Rack



PART 1

DESCRIPTION

The general layout of the facility is shown on A.E.C.L. drawing A02687 or A04708. The type J-6000 and J-6500 Irradiator is a self-contained unit surrounded by a ventilated concrete biological shield. The J-6000 machine is designed to sterilize by irradiation medical products in fibreboard product boxes 18.0 in. (45.7 cm.) wide, 36.0 in. (91.4 cm.) high, and 18.0 in. (45.7 cm.) in length. Maximum box weight is 65.0 lb. (29.5 kg) assuming a product density of 0.30 gm/cc, and the minimum box weight is 10.0 lb. (4.5 kg) assuming a product density of 0.05 gm/cc. The tolerance on box outside dimensions is plus or minus 0.12 in. (3.17 mm). Under no circumstances should a box be processed in the irradiator which exceeds this tolerance.

The J-6500 machine is designed to sterilize by irradiation medical products in fibreboard product boxes 19.0 in. (43.3 cm.) wide, 36.0 in. (91.4 cm.) high and from 16.0 in. (40.6 cm.) to 23.0 in. (58.5 cm.) in length. The tolerance on the maximum box dimensions are plus or minus 0.12 in. (3.17 mm). Maximum product density is 0.30 gm/cc, and minimum product density of 0.05 gm/cc. In selecting product box sizes, consideration must be given to the stability of a moving unit on conveyors. The boxes in the irradiator must be of one size only.

IRRADIATOR BUILDING

The irradiator building comprises that area deliniated on A.E.C.L. drawing A02687 or A04708. E-1 The building is constructed above ground from standard density concrete (2.36 g/cc.) and is attached to the main plant. The reinforced concrete biological shield is designed to reduce radiation levels to not more than 0.25 m.r.h. on all accessible surfaces when a ~~1,000,000~~ 1,500,000 curie Cobalt 60 radiation source is utilized.

The building is served by the main plant heating (and/or air conditioning), electrical power, compressed air, water, drainage and sprinkler facilities.

BIOLOGICAL SHIELD

The biological shield is designed such that either no personnel receive more than 10 m.r. during any 40 hour week, or that the maximum dose rate does not exceed 0.25 mr/hr.

With the source in the irradiating position the shield provides shielding in all proximate areas as indicated on A.E.C.L. Drawing No. A02687 or A04708. The following areas have been taken into consideration.

a) Control Area — the average radiation field inside the control area does not exceed 0.25 m.r.h. The maximum field in any small area does not exceed 2.5 m.r.h.

b) Roof — this is a restricted area.

c) Equipment Room — this is a restricted area.

d) External Areas.

VENTILATING REQUIREMENTS

The irradiation room requires ventilation facilities capable of providing 20 air changes per hour.

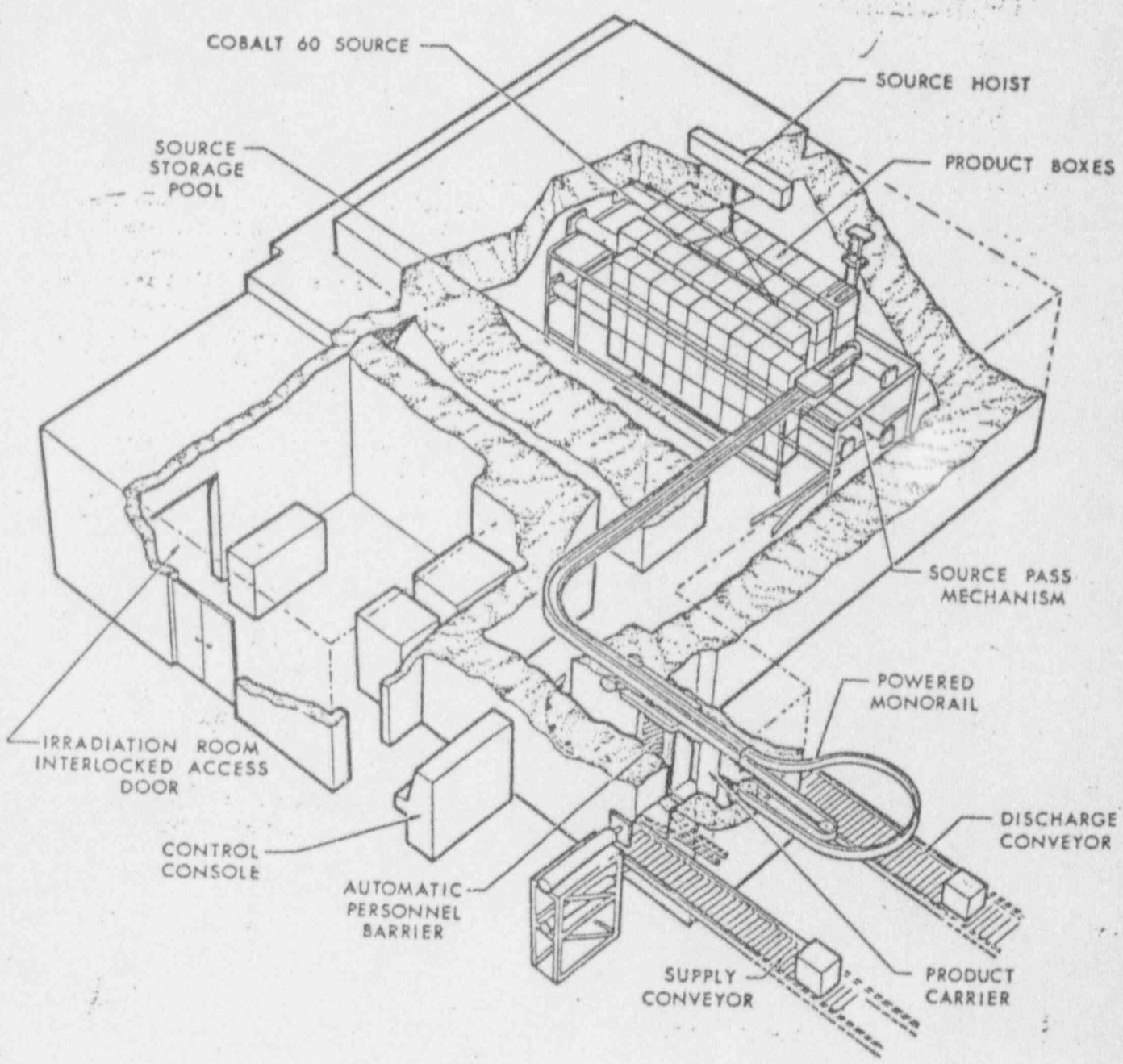


FIGURE 1

J6000-J6500

PNEUMATIC REQUIREMENTS

The irradiator requires pneumatic facilities with a minimum capacity of 35.4 cubic feet per minute free volume of air based on free air at 7.0 atmospheres. A 7.5 HP compressor with a reservoir of 20 cubic feet capacity is recommended.

ELECTRICAL REQUIREMENTS

The irradiator requires a 220 volt, 3 phase and 110 volt, 1 phase, 50 or 60 cycle supply with a minimum capacity of 5.0 K.V.A. Transformers will be supplied to reduce local voltages available to the above.

STORAGE POOL

A water filled pool is provided in the floor of the irradiation room for storage and replenishment of the Cobalt 60 source pencils. When the source is in the storage position radiation fields inside the irradiation room will not exceed 0.25 m.r.h.

The water in the pool is continuously circulated through a mixed resin bed demineralizer and activated carbon purifier. Pool walls are constructed with poured concrete of minimum density 147 lb. cubic foot (2.36 gm/cc.).

To prevent seepage of pool water into the surounding earth a waterproof membrane is provided on the exterior pool walls with an industrial tile lining on the interior.

PRODUCT BOXES

Medical products are transported through the irradiator IN ALUMINUM CARRIERS. ~~in corrugated fiberboard containers (boxes). Two boxes are taped together for irradiation operations.~~ The strength and rigidity of the box must be comparable to that stipulated in Rule 41 of the Uniform Freight Classification for the following minimum grade of material to ensure trouble free operation of the product conveying systems:

J-6000 PRODUCT BOX SPECIFICATIONS

a) External Dimensions — fixed product box sizes are; 18.0 in. (45.7 cm.) wide, 36.0 in. (91.4 cm.) in height, Box length 18.0 in. (45.7 cm.).

b) Weight — 65.0 lb. (29.5 Kg) assuming a product density of 0.30 gm/cc. or a minimum of 10.0 lb. (4.5 Kg) assuming a product density of 0.05 gm/cc.

c) Box Design Criteria — a single box unit of typical dimension 18.0 in. (45.7 cm.) x 18.0 in. (45.7 cm.) x 36 in. (91.4 cm.) must be capable of withstanding a uniform and centrally located side load of 400 lb. (182 Kg) without causing deflection, distortion or other damage to the box unit; side load to be applied via a flat metal surface over an area of 18 in. (45.7 cm.) x 18 in. (45.7 cm.).

d) Box Tolerance — external dimensions maintained to within plus or minus 0.12 in. 3.18 mm.).

J-6500 PRODUCT BOX SPECIFICATIONS

a) External Dimensions — variable product box sizes are; 19.0 in. (43.3 cm.) wide, 36.0 in. (91.4 cm.) in height, and from 16.0 in. (40.6 cm.) to 23.0 in. (58.5 cm.) in length.

b) Product Density — maximum density of 0.30 gm/cc. and minimum density of 0.05 gm/cc.

c) Box Design Criteria — a single box unit of typical dimension 18.0 in. (45.7 cm.) x 18.0 in. (45.7 cm.) x 36.0 in. (91.4 cm.) must be capable of withstanding a uniform and centrally located side load of 400 lb. (182 Kg) without causing deflection, distortion or other damage to the box unit; side load to be applied via a flat metal surface over an area of 18 in. (45.7 cm.) x 18 in. (45.7 cm.).

d) Box Tolerance — external dimensions maintained to within plus or minus 0.12 in. 3.18 mm.).

PRODUCT CONVEYOR SYSTEM

The product conveyor system automatically transports the boxes into and out of the irradiation chamber. The unirradiated product is stored on the accumulating input storage conveyor which is adjacent to the load-unload station. The input conveyor is 15.0 feet (4.57 m.) in length and has a storage capacity for 10 product boxes.

On a signal from the master timer, ~~a double box unit (two boxes stacked and taped together one on top of the other) is~~ A ALUMINUM CARRIER IS fed onto the top level of the source pass conveyor. A product box pair is then ejected from the bottom layer of the source pass conveyor into the lower shelf on the maze carrier.

The source pass conveyor consists of two layers of box support beds, pneumatic "pushers" and end transfers, and an elevator mechanism. The incoming product is discharged onto the upper layer support bed and irradiated product is discharged onto the lower shelf of the maze carrier.

The carrier returns through the maze to discharge irradiated products to the accumulating output storage conveyor. This conveyor is 15.0 feet (4.57 m.) in length.

The product boxes are conveyed about the vertical plaque source by means of the pneumatic pushers and end transfer devices. Box movement is intermittent with the cycle time determined by the master timer.

SOURCE PASS MECHANISM

When a product box reaches the end of the first pass by the source it is transferred to the inner passage on the same layer and its direction is reversed. On completion of the second pass the product box is transferred to the opposite side of the source plaque on the same layer and its direction is again reversed. On completing the third pass the product box is transferred to the fourth pass and its direction is again reversed.

When the product reaches the end of the fourth pass the box is lowered on a pneumatic elevator to the lower source pass mechanism layer where it is transferred onto the fifth pass. The product continues to move intermittently through the sixth, seventh and eighth passes on the lower level. On completing the eighth pass the product box is discharged into the maze carrier for transport out to the discharge storage conveyor.

CONTROL OF ACCESS

ROOF OF IRRADIATION BUILDING

The roof is accessible only by ladder. There is a steel ladder secured to the main building wall up to the roof of the maze. A radiation hazard sign will also be displayed in this area. Use of the ladder is restricted by a ~~fixed chain~~ DOOR THAT SWINGS OPEN. DOOR IS FULL LENGTH OF LADDER AND IS LOCKED AT THE TOP OF THE LADDER.

COBALT 60 SOURCE

Each source "pencil" is made up of 16 Cobalt 60 "slugs" each 0.63 cm. dia. by 2.54 cm. long, doubly encapsulated and heliarc welded in type 316 ELC stainless steel tubing. Overall pencil dimensions are 17.78 in. (45.16 cm.) long with a body diameter of 0.38 in. (0.96 cm.) and solid stainless steel end caps 0.437 in. (1.11 cm.). (Refer A.E.C.L. Specifications C110, C177 and C188).

Source pencils are housed in modular frames to form a plaque source. The plaque frame contains 6 modules with each module handling up to 42 pencils; a maximum plaque capacity for 252 pencils.

CONTROL CONSOLE

A two sectioned control console is provided. The console is located in the control area close to the control area door, ~~and viewing window~~.

The left hand section (or panel) includes the following controls and indicators:

1. Monitor "Meter" — an edge mounted ratemeter to indicate radiation levels inside the irradiation room with the source in the down (or safe) position.

2. Monitor "Alarm" and "Memory" — a split pilot light to indicate a) when radiation levels inside the irradiation room exceed the permissible limit and b) after an alarm condition has ceased or been rectified the "Memory" pilot light will remain illuminated until the "Reset" button has been actuated.

   An alarm horn, which is wired in parallel with the "Alarm" pilot light, will emit a loud piercing signal if an alarm condition occurs. The critical level in the alarm circuit will normally be set at 80% of the full scale ratemeter deflection, about 8 times the normal background level.

3. Monitor "Check" — a pilot light to indicate a steady "on" or "off" condition as well as momentary (normal) pulsing. The "Check" light will pulse to show that the ratemeter circuits are functioning.

4. Monitor "Test" — an illuminated push button switch. When the switch is actuated an alarm condition is induced into the ratemeter circuit to verify that the meter circuit is functioning correctly.

5. "Reset" — an illuminated push button switch to reset the monitor after an alarm condition.

6. "Power" — a three position keyswitch with an "off", "on", and a spring loaded "reset" position to control the power supply to the unit.

7. "Control" — a three position keyswitch with an off, on, and a spring loaded "start" position. This switch controls both the source hoist and conveyors for automatic machine operation.

8. "Machine On" — a pilot light to indicate that the machine is running automatically.

9. "Machine Ready" — a pilot light to indicate that the safety delay timer in the irradiation room has not "timed out" and the machine is ready for operation.

10. "Carrier in Position No. 1" — a pilot light to indicate that the product box carrier is in the correct position to commence machine operation.

11. "Box On Conveyor" — a pilot light to indicate that a product box is available on the supply conveyor.

12. Master "Timer" — a key operated timer to control the machine cycle period.

13. "Exhaust Fan" — a pilot light to indicate that the exhaust fan is functioning.

14. "Water Regenerate and Filtration Pump" — a split pilot light to indicate a) that the deionizer plant requires regeneration and b) the filtration pump is functioning.

15. "Water Level" — a pilot light to indicate that the water in the pool is being replenished.

16. "Safety" — a pilot light to indicate that either a) the emergency cable has been pulled, b) the emergency button at the load/unload station has been actuated, c) the emergency push button on the control console has been actuated, or d) the door interlock circuit has been tripped. e) safety timer

17. "Internal Conveyor" — a red pilot light to indicate that the source pass conveyor has malfunctioned.

18. "High Temperature" — a red pilot light to indicate that the temperature sensing probe inside the irradiation room has detected a significant rise in temperature.

19. "Low Air Pressure" — a red pilot light to provide a visual indication that air pressure in the system has dropped below the required level.

20. "Source Rack" — a red pilot light to indicate that source rack operation is faulty.

21. "Source" — a three position keyswitch with an "off", "on" and spring loaded "start" position. This switch controls the source hoist mechanism without machine conveyor operation.

22. "Source Down" — a green pilot light to indicate that the source is in the fully down (or safe) position.

23. "Source Up" — a split red pilot light to indicate that the source rack is in the irradiate position and that the plaque is horizontal.

Note:

With reference to items 22 and 23 above it should be noted that both the red "Source Up" and the green "Source Down" pilot lights will be simultaneously illuminated for any intermediate source position. Individual red or green lights will indicate that the source is fully up or down.

24. "Emergency Stop" – a red push button switch is located on the left control panel. Use of this switch will cause the product conveying mechanisms to automatically shut down and the source will be lowered immediately.

25. "Box Counter" – an impulse counter is located on the left control panel to record twice the number of completed source pass mechanism cycles. During normal (automatic) operations an irradiated double product box is discharged and an unirradiated double box enters the facility on completion of one full cycle. For record purposes, Serial No. of each box may be arranged to correspond with the box counter.

The right hand section (or panel) includes the following pneumatic cylinder position indicators and conveyor controls:

1. "P. 101, Receive" – a pilot light to indicate that cylinder P. 101, at the load/unload station, is in the receive position.

2. "P. 102, Receive" – a pilot light to indicate that pneumatic cylinder P. 102, at the load/unload station, is in the receive position.

3. "P. 101, Discharge" – a pilot light to indicate that pneumatic cylinder P. 101, at the load/unload station, is in the discharge position.

4. "P. 102, Discharge" – a pilot light to indicate that pneumatic cylinder P. 102, at the load/unload station, is in the discharge position.

5. "Carrier In" – a pilot light to indicate the direction of carrier movement on the monorail between the load/unload and source pass mechanisms. The "in" direction is towards the source pass mechanism. It becomes a push button switch used to move the carrier towards the internal mechanism during "manual" conveyor key switch operation.

6. "Carrier Out" – a pilot light to indicate the direction of carrier movement on the monorail between the source pass and load/unload mechanisms. The "out" direction is away from the source pass mechanism. It becomes a push button switch used to move the carrier away from the internal mechanisms during "manual" conveyor key switch operation.

Note:

Reference items 5 and 6; only one of the specified pilot lights will be illuminated at any one time. "Manual" operation by the keyswitch and pushbutton will not affect the cycling of the "in" or "out" pilot lights. The lights will only indicate carrier movements during automatic operations. It should be noted that the pilot lights do not indicate the actual position of the carrier but only the position that the carrier must assume for automatic operations.

7. "Conveyors" – a three position keyswitch with and "off", "manual", and spring loaded "automatic" position. This switch controls conveyor operations, without source elevation, during machine maintenance procedures.

8. "P. 1 to P. 15 (inclusive) Receive" – fifteen illuminated push button switches. These switches are used during maintenance operations to move the designated source pass mechanism cylinders from the discharge into the receive position. Actuated only when the conveyor keyswitch is in the "manual" position.

9. "P. 1 to P. 15 (inclusive) Discharge" – fifteen illuminated push button switches. These switches are used during maintenance operations to move the designated source pass mechanism cylinders from the receive position into the discharge position. Actuated only when the conveyor keyswitch is in the "manual" position.

EMERGENCY AND SAFETY DEVICES

Emergency Stop Controls

An emergency control cable is positioned along two walls in the irradiation room and extends throughout the maze. Emergency push buttons are also located at the load/unload station and on the control console. If either of these controls is actuated the conveyors will stop and the source will be lowered.

Power Failure

In the event of a power failure the source rack will be lowered automatically at a rapid but controlled rate. This will prevent overexposure of the product. If the failure is of a momentary (up to 30 seconds) duration the source will return to the exposed position on resumption of the power supply. The machine will then continue to operate normally.

Maze Door Interlock

A door interlock is provided on the maze door which prevents access into the irradiation room during irradiator operations. The interlock solenoid is of the normally engaged type and continuously rated. The solenoid must be energized with the "Maze Door" keyswitch before the room is accessible. A mechanical interlock release is provided inside the maze to permit personnel to leave if the door shuts accidentally.

A microswitch mounted in the door latch ensures that the unit is only operable when the door is closed and locked. Overall control of the door interlock is maintained with the "Power" keyswitch on the control console.

Source Storage Rack

A storage rack, with a capacity to store all the source modules, is provided for use in the pool. This permits the source rack itself to be periodically raised for examination as required.

Source Rack Guide Cable

If the source rack should jam, the tension on the guide cable can be relieved from outside the irradiation room to permit the rack to be freed.

Temperature Sensing Device

A temperature sensing and control unit, mounted with its probe inside the irradiation room, will detect a significant rise in temperature, lower the source, and stop the machine.

Conveying System

If the conveying system does not complete its cycle within a present time interval of 135 seconds (approx.) the machine will automatically shut down.

Pool Water Level

The water in the pool is automatically maintained within preset levels by a switch controlling a water make-up line. If the level drops below the lower limit a caution light illuminates on the control console. The "Water Level" caution light advises the operator that water replenishment is required. A raw water meter measures the amount of make-up water being automatically introduced into the storage pool.

Source Hoist

If the source plaque does not complete the transition source "off" position/source "on" position within 60 seconds (approx.) the machine will shut down automatically.

Source Alarm

While the source is in motion an audible alarm will signal continuously. Pilot lights on the control console will indicate the position of the source.

Air Pressure

Failure of the compressed air system will shut down the conveyor system and lower the source. A pilot light on the control console will provide a visual indication of pneumatic failure.

Start-up Safety Delay Timer

A 90 second timer controlled by the "Safety" delay keyswitch installed inside the irradiation room, must be actuated with the "Power" key before irradiation operations can commence. This ensures that the operator enters the room and checks for

the presence of personnel and eliminates the possibility of personnel being inadvertently shut inside the irradiator.

Source Interlock

The source interlock will drop out 90 seconds after the "Safety" keyswitch is actuated. If any emergency device is actuated while the source interlock procedure is being carried out, the operator must return to the control console and reset the machine before repeating the start-up procedure. The operator cannot open the maze door from the outside unless the source is fully down (or safe) and there is a positive safe reading indicated by the irradiation room monitor.

SHIELDING CALCULATIONS

The biological shield for the Type J-6000 and J-6500 Irradiator is shown on Drawing A02687 and A04708. The shield is designed to attentuate the radiation from a 300,000 and a 1,000,000 curie Cobalt 60 plaque source within the design levels shown in Table 1. The radiation leakage levels were selected on the basis that under normal working conditions no person in the vicinity of the irradiator receives more than an average of 10.0 mrem per week or a maximum of 500.0 mrem per year. This is the exposure level recommended by the International Commission on Radiological Protection (1) for members of the public. Atomic energy workers (operators or control technicians) may receive 10 times this amount (5.0 mrem per year).

PRIMARY SHIELDING

The transmission of Cobalt 60 gamma radiation in concrete is shown in Figure 1. The dose rate from 1 curie point source of Cobalt 60 is 1.3×10^3 mr/hr and varies inversely with the square of the distance. Concrete thickness for the primary shielding were determined by calculating the max. dose 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.

1. Maximum field outside external wall parallel to source plaque:

   Concrete thickness = 57.0 in. (144.8 cm.)
   Transmission = 1.13×10^{-6}
   Distance from source plane to exterior surface of wall = 139.0 in. (353.1 cm.)
   Dose rate due to point source of 1,000,000 curies of Cobalt 60 =
   $1.3 \times 10^3 \times 1.0 \times 10^4 \times \left(\frac{39.37}{139}\right)^2 \times 1.13 \times 10^{-6}$
   = 1.18 mrh

   Self absorption factor and geometry factor for transforming point source calculation to that for a 36.0 in. (3.14 cm.) x 60.0 in. (152.4 cm.) plaque source = 0.65
   Maximum dose rate = 0.77 mrh
   This is below the design level of 2.0 mrh maximum.

2. Maximum field on roof:

   Concrete thickness = 57.0 in. (144.8 cm.)
   Transmission = 1.93×10^{-7}

Assume point source at centre of source plaque
Distance from source to roof = 119.0 in. (302.3 cm.)
Dose rate due to point source of 1,000,000 curies of Cobalt 60

$$= 1.3 \times 10^3 \times 1.0 \times 10^4 \times \left(\frac{29.37}{119}\right)^2 \times 1.93 \times 10^{-7}$$

= 27.4 mr/hr

Self absorption and geometry factor for vertical source plaque = 0.20
Maximum dose rate = 5.5 mrh
This is below the design level of 15.0 mrh maximum.

MAZE DESIGN

Accurate calculations of the dose rate and energy spectrum at points along a concrete maze are difficult to perform. At present detailed calculations of the dose 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 dose 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 A.E.C.L. 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 dose rate from the small scattering area A (Figure 2) is given by:

$$D = \frac{D_o \; a(E_o, \Theta_o, \Theta, \phi) \; A \cos\Theta}{r_1^2 \; r_2^2}$$

where

$a(E_o, \Theta_o, \Theta, \phi)$ is the differential dose albedo,

A is the area of the scattering surface,

D_o is the dose 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 dose albedo, $a(E_o, \Theta_o, \Theta, \phi)$ have been calculated by Roso (3) using the Monte Carlo method. Using the Roso data, Chilton and Huddleston (4) developed the following semi-empirical equation for the differential dose albedo

$$a(E_o, \Theta_o, \Theta, \phi,) = \frac{C(E_o) \, K(\Theta_s) \, 10^{2s} + C^1(E_o)}{1 + \cos(\Theta_o / \cos\Theta)}$$

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
$C(1.25 \text{ Mev}) = 0.0665$
$C'(1.25 \text{ Mev}) = 0.107$

The calculated values of the differential dose albedo for Cobalt 60 gamma rays have been verified by measurements at A.E.C.L. The energy of the singly-scatered radiation is given by

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

The required thicknesses of the maze walls required to attentuate the singly-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 A.E.C.L.

For maze walls where no singly-scattered radiation is incident and the maximum radiation energy is due to doubly-scattered radiation, an estimate of the incident doubly-scattered dose rate is obtained by calculating the scatter from one 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 centre of the first area and going to the centre of

the second area. For the second scatter the parameters $C(E_o)$ and $C'(E_o)$ are approximated by $C(E_o) \simeq 0.0561\ E_o^{0.574}$ and $C'(E_o) \simeq 0.0122\ E_o^{-0.683}$. Again, corrections for lower energy multiply-scattered radiation are made from measurement data.

Detailed measurements of radiation fields inside mazes have been performed by A.E.C.L. 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 were performed on numerous other industrial irradiators built by A.E.C.L. 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.

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(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).

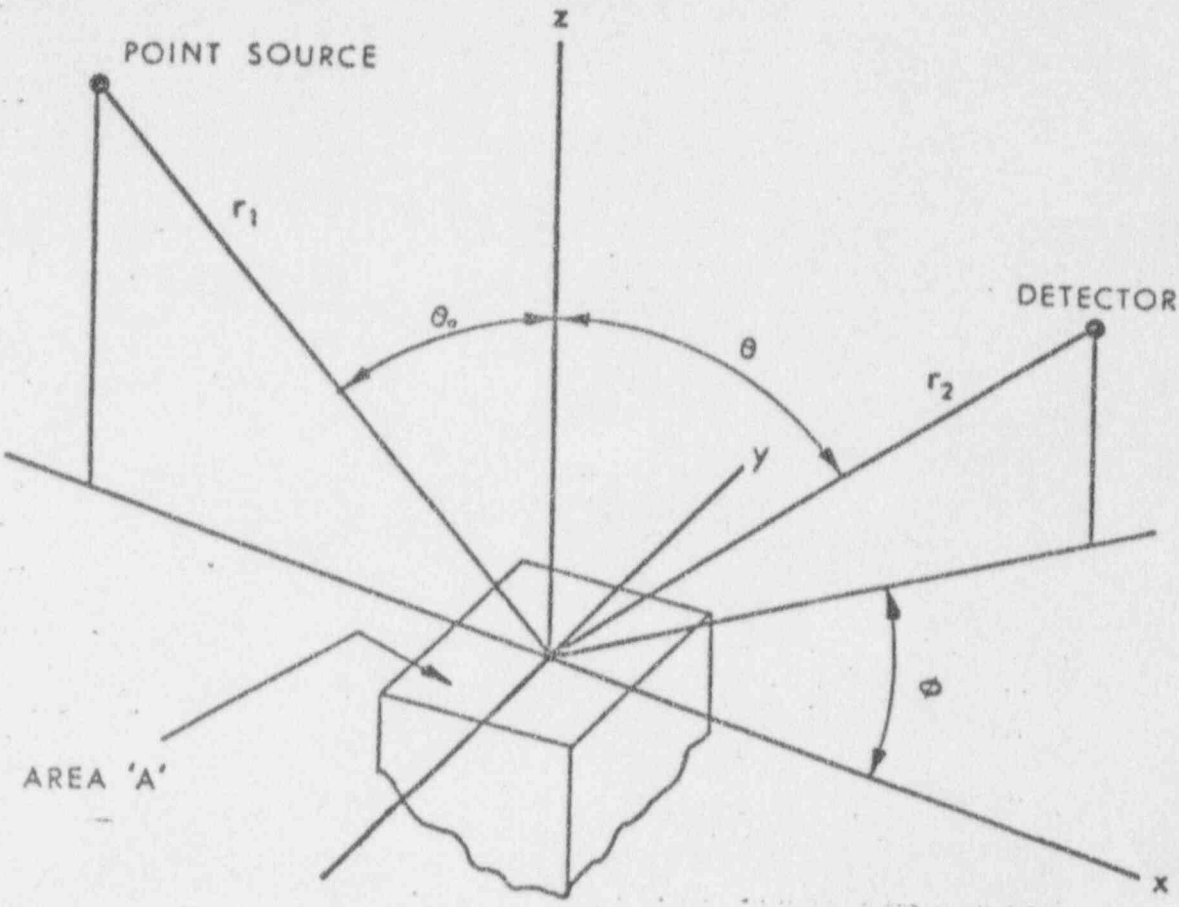


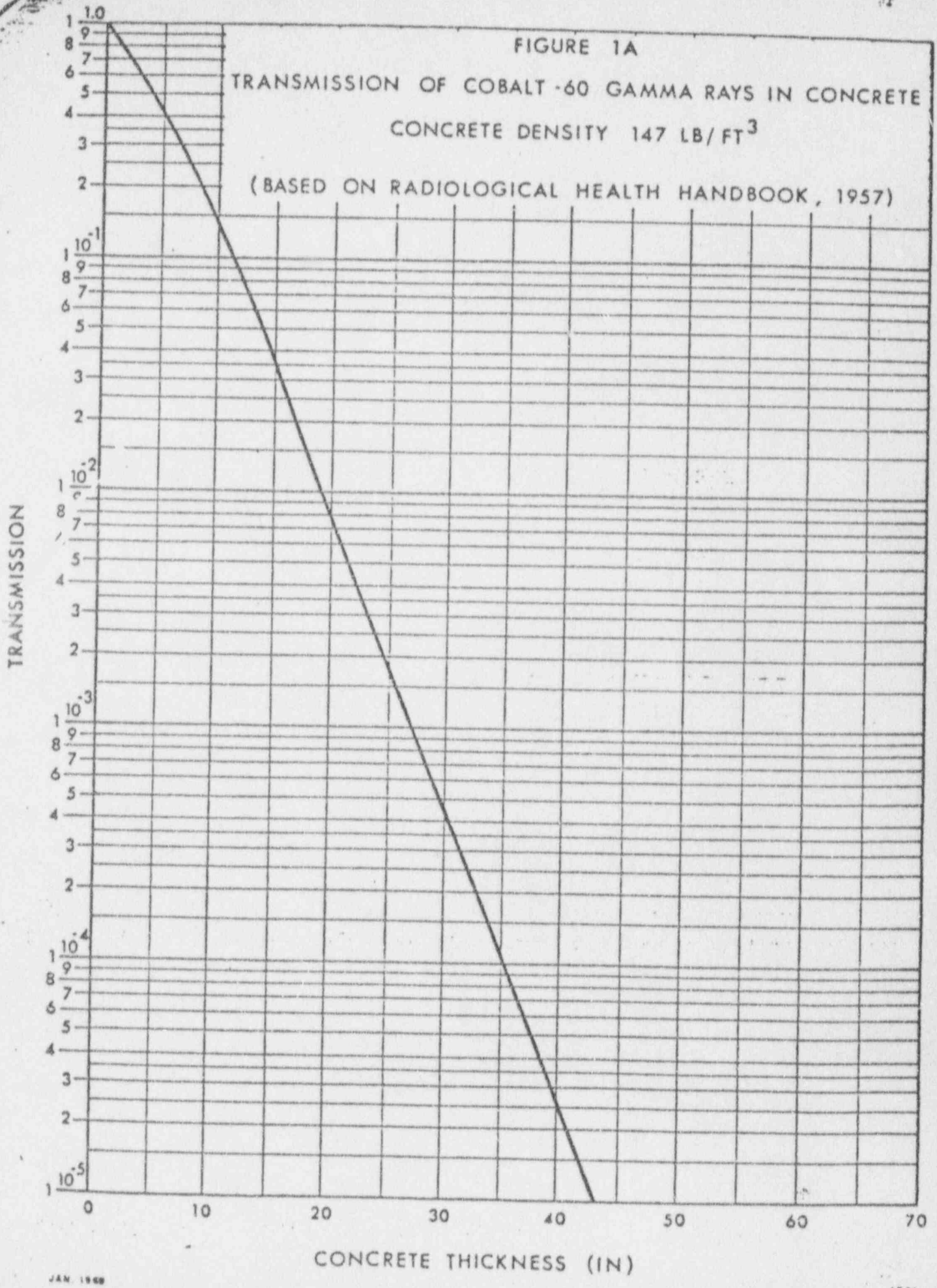
FIGURE 2
SCATTERING OF GAMMA RAYS
FROM SURFACE

FIGURE 1A

TRANSMISSION OF COBALT-60 GAMMA RAYS IN CONCRETE

CONCRETE DENSITY 147 LB/FT^3

(BASED ON RADIOLOGICAL HEALTH HANDBOOK, 1957)



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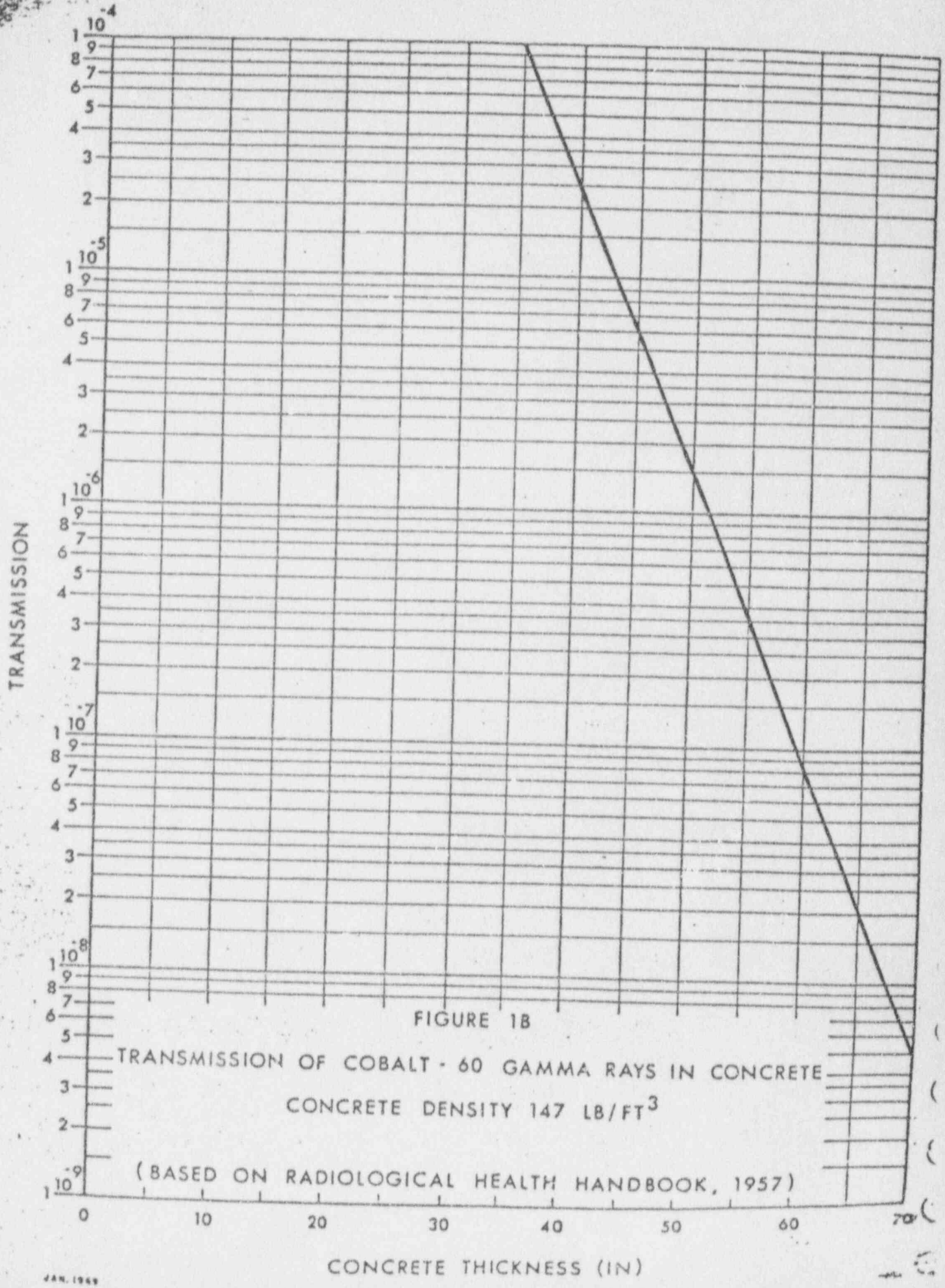

FIGURE 1B

TRANSMISSION OF COBALT - 60 GAMMA RAYS IN CONCRETE

CONCRETE DENSITY 147 LB/FT^3

(BASED ON RADIOLOGICAL HEALTH HANDBOOK, 1957)

JAN. 1969

EMERGENCY SHUT-DOWN PROCEDURE

In an emergency the machine can be immediately shut down as follows:

1. At the Load/Unload Station, Control Console or Maze — depress the emergency stop button or pull the emergency cable at these locations. The radiation source will be lowered and the conveyor system will stop immediately, irrespective of the stage attained in the machine cycle, and the "Safety" pilot light on the control console will illuminate.

   When the radiation source is in the "safe" position, check that the irradiation room monitor is back in operation. If the radiation level is normal, press the "Monitor Test" button and hold until the monitor alarms. The alarm signal will continue until shortly after the button is released. The "Monitor Test" pilot light will remain illuminated until the maze door is opened. All emergency procedures must be entered in the Log Book which is provided with this manual.

Note:

a) The irradiation room monitor is automatically cut out when the source is in the "on" (or irradiate) position.

b) The maze door can only be opened by the

operator when the source is fully down and no alarm condition exists.

c) The first time each day that the operator is required to open the maze door, the portable monitor must be checked against the test source to ascertain that the audible alarm is functioning.

2. After an emergency shutdown, the irradiator should be started up as per "start-up after emergency or inadvertent shut-down".

INADVERTENT SHUT-DOWN

During operation a number of conditions or occurrences may cause irradiator shut-down at any stage. In this event the cause will be indicated by a red shut-down pilot light on the control console. In order to restart the machine it will be necessary for the operator to rectify the fault and then proceed as per "start-up after emergency or inadvertent shut-down".

The red shut-down pilot light will remain illuminated until the fault is rectified and the "Power" key is turned to the "reset" position in the "Power" keyswitch and released.

The following is a list of typical shut-down conditions with their associated rectification procedures.

TO OPEN MAZE DOOR

1. At the Control Console — check that the source is in the safe position. This will be indicated by the "Source Down" pilot light.

2. At the Control Console — Insert the "Power" key in the "Power" key switch and turn through the "On" position to the "Reset" position and release.

3. At the Control Console — check that the monitor "Read-out" on the console is functioning and that the indicated radiation level is normal. The monitor "Check" pilot light should be flashing at all times. If the reading is not normal or an alarm is indicated, leave the facility as described in this manual under Contamination Detection.

4. At the Control Console — Press the "Monitor Test" button and hold until the monitor alarms.

   Note: The "Monitor Test" pilot light will remain illuminated until the maze door is opened.

5. At the Control Console — remove the "Power" key from the key switch taking care not to turn the machine off.

6. At the back of the Control Console — check the portable hand monitor against the test source to ascertain that the audible alarm is functioning correctly.

7. At the Maze Door — insert the "Power" key into the "Maze Door" key switch and open the door.

8. In the Maze — if a noticeable increase in monitor crackle rate is evident on entering, leave the room and notify the department supervisor immediately. The supervisor will check the radiation levels with a survey instrument and will notify Atomic Energy of Canada Limited, or their Agent, of unusual conditions or incidents. If conditions are normal proceed as required.

HAND OPERATION OF UNIT

(Maintenance or Inspection Purposes)

1. At the Maze Door — proceed as detailed under heading To Open Maze Door.

2. At the Control Console—check that the "Power" key switch is in the "On" position.

3. At the Control Console — insert the "Power" key into the "Conveyor" key switch and turn into the "Manual" position.

   IMPORTANT: DO NOT TURN THE KEY SWITCH INTO THE "AUTOMATIC" POSITION.

4. At the Control Console — Operate the pneumatic cylinders as desired by pressing the appropriate push buttons.

Cylinders can be timed with a stop watch by checking the appropriate pilot lights on the control panel during cylinder operation. For example: With cylinder P. 1 in the receive position, press the "P. 1 Discharge" push button. As the cylinder begins to move from receive to discharge the receive light will extinguish. Both receive and discharge pilot lights will remain extinguished until the cylinder assumes the discharge position. When the cylinder has assumed the discharge position the discharge pilot light will illuminate. Cylinder stroke time can thus be determined from cylinder pilot light operation. Care must be exercised during hand cylinder operation to ensure that the cylinders are free to move without obstruction from product boxes.

CARRIER MOVEMENT

Carrier movement under hand control can be conducted by merely depressing the "Conveyor In" or "Conveyor Out" switches. Unlike cylinder operation the switches must be held in position during carrier movement.

Caution: Do not operate cylinder P. 1 unless the carrier is fully in Position 1 or completely clear of Position 1. Conversely the carrier must be fully in the load/unload position before cylinders P. 101 or P. 102 are operated. These cylinders can of course be operated if the carrier is completely clear of the load/unload station. It will be obvious that the carrier could be damaged by moving cylinders if this precaution were not taken.

AUTOMATIC OPERATION OF MACHINE

(Maintenance or Inspection Purposes)

1. At the Maze Door — Proceed as detailed under heading "To Open Maze Door".
2. At the Load/Unload Station or Source Pass Mechanism — To operate the machine with product boxes it is necessary to check that all boxes either in the load/unload station or at the source pass mechanism are in their proper positions.
3. At the Control Console — Check that the "Power" key switch is in the "On" position.
4. At the Control Console — Insert the "Power" key in the "Conveyor" key switch and turn the key into the "Manual" operation position.
5. At the Control Console — Check that all pilot lights on the maintenance control panel are green.
6. At the Control Console — Check that the green "Pos. No. 1" pilot light is illuminated. If the carrier is not at its correct position at the internal conveyor, turn the "control" key switch to the "on" position only and the carrier will automatically go to it's correct position, including going through a "load/unload" operation if required. Remove the key from the "control" keyswitch.

   Caution: It is extremely important that the operator must not start the machine for automatic maintenance operation with the carrier in a position other than the one indicated by the green "Pos. No. 1" pilot light on the control console. The white "conveyor in" and "conveyor out" pilot lights indicate the direction the CARRIER SHOULD MOVE for automatic operation and NOT NECESSARILY WHERE THE CARRIER ACTUALLY IS.

   Serious damage could occur if automatic operation were attempted while the carrier was at the load/unload position, when the control panel "conveyor in" pilot light indicates that the carrier should be at the internal conveyor Position No. 1 for start-up.

   In this case the machine would be out of sequence, the load/unload station would commence to discharge and receive boxes from the carrier as the carrier attempts to correct its position by returning to internal conveyor Position No. 1. This would cause serious interference between the carrier and the cylinders.
7. At the Control Console — Turn the "Power" key in the "Conveyor" key switch through the

"manual" position into the "Automatic" position and release. The machine will now assume automatic operation. For operation of the machine without product boxes the switch at the load/unload station which indicates that there is a box on the conveyor must be actuated manually for each machine cycle.

START UP AFTER EMERGENCY OR INADVERTENT SHUT-DOWN

"Safety"

An emergency shut-down has occurred via the emergency button at the load/unload or the emergency cable located inside the maze and irradiation room or an attempt has been made to gain access into the irradiation room by force.

1. At the Control Console — Reset the machine controls by turning the "power" key into the "reset" position on the "power" key switch. The key will return to the "on" position. Resetting the machine will clear all the inadvertent shut-down condition pilot lights on the control panel and these lights will now be extinguished.
2. At the Control Console — Remove the "power" key from the "power" key switch taking care to leave the switch in the "on" position.
3. At the Maze Door — Proceed as detailed under heading "To Open Maze Door".
4. Ascertain the cause of the emergency condition and rectify the fault.

   Important: Do not attempt to alter the position of machine components before restarting.
5. In the Irradiation Room — Actuate the "Safety-Delay" switch with the "Power" key. This will start the 90 second safety delay timer.
6. In the Irradiation Room — Leave the room (at a normal walking pace) closing the maze door on the way out.
7. At the Control Console — Insert the "Power" key into the "Machine" key switch and turn the key clockwise to the "on" position. Leave in this position until the carrier arrives at "Pos. No. 1". Now turn the key through the "On" position to the "Start" position. Release the key and it will return to the "On" position and the "Machine On" pilot light should now be illuminated. The source alarm bell will signal until the source reaches the irradiate position and the "Source Up" pilot light will illuminate. The product conveying systems will then resume operations automatically.
8. At the Control Console — Make a complete entry in the Log Book.

"HIGH TEMPERATURE"

A machine shut-down has been caused by the detection of temperatures above normal in the irradiation room.

1. For the resumption of operations proceed as detailed under heading "Safety".

"LOW AIR PRESSURE"

A machine shut-down has been caused by a failure in the pneumatic system.

1. For the resumption of operations proceed as detailed under heading "Safety".

"SOURCE RACK"

A machine shut-down has been caused by a malfunction in source rack operation; the source rack has not assumed the fully exposed position in the preset time period.

1. Before resuming operations the operator must notify the facility supervisor of the conditions existing at the unit. Subject to supervisor approval the operator can then proceed as detailed under heading "Safety".

"INTERNAL CONVEYOR"

A machine shut-down has occurred due to a malfunction in the internal conveyor system or maze

conveyor system or the machine has "timed out" because of no box being available on the load/unload station. See the following procedures which are detailed under headings "Internal Conveyor Malfunction" and "Internal Conveyor Timed Out" before resuming operations.

INTERNAL CONVEYOR MALFUNCTION OR MAZE CONVEYOR MALFUNCTION

In the event of an internal conveyor malfunction or maze conveyor malfunction which would indicate a box jam, or limit switch malfunction, the following procedure for the resumption of operations should be adopted:

1. At the Maze Door — Proceed as detailed under heading "To Open Maze Door".
2. Ascertain the cause of machine shut-down.
3. Should it be necessary to actuate a cylinder in order to rectify the malfunction, it is important to make sure that the various cylinder positions are not changed from those they assumed at machine shut-down. It is important for the operator to familiarize himself with the operating sequence of the source pass mechanism cylinders as described in Part 3 of this manual under heading "Pneumatic Cylinder Operating Sequence").

   Each cylinder operation is dependent upon the completion of preceding cylinder movements. For example, cylinders P. 1 and P. 15 actuate simultaneously when discharging and loading the maze carrier. If either of these cylinders does not complete its' stroke and actuate their respective discharge position limit switch the cycling sequence will stop. The succeeding cylinders in the operating sequence require actuation and completion of preceding cylinder movements before they can function. Therefore, if a given cylinder does not complete its' stroke and actuate its' respective discharge or receive limit switch (whether this is caused by a faulty switch or a box jam) the cylinder operation sequence will stop, the timer will run out and the machine will shut down. In rectifying the problem (by clearing the jam and allowing the cylinder to complete its' stroke, or by adjusting or replacing the respective limit switch), the operator must not change the position of the cylinder pushers from that in which they were found when the unit shut down. It may be necessary to actuate a given cylinder employing the hand operation method to rectify the problem but the operator must return the cylinder pusher to the position which it had attained or was attempting to attain when the shut down occurred.
4. After rectifying the malfunction, operation can be resumed by proceeding as detailed under heading "Safety".

SUPPLY CONVEYOR EMPTY OR DISCHARGE CONVEYOR FULL

1. At the Maze Door — Proceed as detailed under heading "To Open Maze Door".

   Note: On entering the maze the carrier will be found at the load/unload station. The internal conveyor will have completed its' cycle and all cylinder indicating lights P. 1 through P. 15 will be green. The "Box On" "Position No. 1", "Machine Ready" and "Machine On" pilot lights will not be illuminated. The clock timer will be at 0 time.
2. After rectifying the storage conveyor shut-down, operation can be resumed by proceeding as detailed under heading "Safety".

"SOURCE" KEY

The "Source" key which is provided by Atomic Energy of Canada must be kept in a safe place under lock and key at the site for the use of A.E.C.L. personnel only. At no time will the operating personnel be permitted the use of this key.

PRODUCT BOX LOADING PROCEDURES

1. At the Maze Door — Porceed as detailed under heading "To Open Maze Door".

2. At the Storage Conveyor — Load the storage conveyor with a minimum of ten (10) dummy product box units.

3. Obtain the "Timer" key from the plant supervisor.

4. At the Control Console — Insert the "Timer" key into the "Timer" key switch and turn the key counter-clockwise to the desired timer setting.

   Note: The minimum timer setting on this timer is six minutes. In other words, the black hand of the timer must be in the black portion of the timer setting scale.

5. At the Control Console — Insert the "Power" key into the "Power" key switch and turn to the "Reset" position and release.

6. At the Control Console — Cylinders P. 1 through P. 15 pilot lights must be green.

7. Remove "Power" key from the "Power" key switch making sure that the key switch is in the "On" position.

8. At the Control Console — Insert the "Power" key in the "Conveyor" key switch and turn the key into the "Manual" operation position.

9. At the Control Console — Using hand operation move the carrier into the "Pos. No. 1" position at the internal conveyor.

10. At the Control Console — Turn the "Power" key to the "Off" position in the "Conveyor" key switch. Then turn the key into the "Automatic" position and release. The machine will now assume automatic operation.

11. At the Control Console — When the mechanism is completely loaded with dummy boxes turn off the machine by turning the "Power" key to the "Off" position in the "Conveyor" key switch.

12. At the Inlet Storage Conveyor — Load inlet storage conveyor with product to be irradiated.

13. At the Control Console — Start up machine as as per paragraph "Normal Start-up Procedures".

TO UNLOAD UNIT

1. At the Inlet Storage Conveyor — Load inlet storage conveyor with a minimum of ten (10) dummy product box units and allow the machine to run under normal conditions with the source up until the first dummy box is discharged onto the discharge storage conveyor. At this time the internal conveyor will be full of dummy box units.

2. At the Control Console—Shut down the machine as per paragraph "Normal Shut Down Procedures".

   Note: It may be necessary to clear the internal conveyor mechanism of product boxes for maintenance work. The operator must open the maze door as detailed under heading "To Open Maze Door" and manually remove the dummy product boxes from the source pass conveyor.

POST IN A PROMINENT POSITION CLOSE TO THE CONTROL STATION

IMPORTANT

COBALT 60 IRRADIATOR TYPE J-6000 J-6500

EMERGENCY CONDITIONS

NOTE: BEFORE ENTERING THE IRRADIATION ROOM CHECK THAT THE CELL MONITOR IS FUNCTIONING

A. PERSONNEL IN MAZE OR IRRADIATION ROOM AT START-UP

1) PULL EMERGENCY CABLE ON THE WALL AND/OR

2) PUSH EMERGENCY STOP BUTTON AT THE LOAD/UNLOAD STATION OR CONTROL CONSOLE.

3) VACATE THE IRRADIATION ROOM

B. MONITOR ALARM SIGNALS

1) SHUT DOWN MACHINE

2) DETERMINE CAUSE

3) NOTIFY ATOMIC ENERGY OF CANADA LIMITED IF OTHER THAN MECHANICAL OR ELECTRICAL FAILURE

C. MOMENTARY POWER FAILURE

1) TURN OFF MACHINE

2) TURN POWER KEY IN POWER KEYSWITCH TO RESET WHEN POWER IS RESTORED

D. PROLONGED POWER FAILURE

1) TURN OFF MACHINE

2) WHEN POWER IS RESTORED RESTART THE MACHINE

E. SAFETY PILOT LIGHT ILLUMINATES

1) TURN OFF MACHINE

2) INVESTIGATE AND RECTIFY FAULT

F. INTERNAL CONVEYOR PILOT LIGHT ILLUMINATES

1) TURN OFF MACHINE

2) CHECK FOR CAUSE OF TROUBLE

G. AIR PRESSURE LIGHT ILLUMINATES

1) TURN OFF MACHINE

2) RECTIFY FAULT

H. BOX ON CONVEYOR PILOT LIGHT EXTINGUISHES

1) RECTIFY CONVEYOR MALFUNCTION

2) RESTART MACHINE

J. SOURCE RACK PILOT LIGHT ILLUMINATES

1) TURN OFF MACHINE

2) IF SOURCE IS JAMMED IN A SEMI-EXPOSED OR EXPOSED POSITION NOTIFY ATOMIC ENERGY OF CANADA LIMITED IMMEDIATELY

K. ONLY ONE SOURCE UP PILOT LIGHT ILLUMINATES

1) LOWER THE SOURCE RACK AND ADJUST RACK GUIDE CABLES

FOR EMERGENCY SERVICE

CONTACT:
ATOMIC ENERGY OF CANADA LIMITED
Commercial Products
Installation & Services Dept.
P.O. Box 93, Ottawa, Canada.
613-592-2790

ABLE: Nemota, Ottawa.
LEPHONE: 613-836-2790

COBALT 60 IRRADIATOR TYPE J-6000 J-6500

BASIC OPERATING INSTRUCTIONS

TO START

1. CHECK ALL MONITOR READINGS ARE NORMAL.
2. CHECK TIMER SETTING FOR PRODUCT BEING IRRADIATED.
3. CHECK POWER IS "ON".
4. CHECK THAT DEIONIZER WATER PUMP IS OPERATING.
5. CHECK THAT COMPRESSORS ARE OPERATING.
6. CHECK THAT CELL VENTILATING FAN IS OPERATING.
7. CHECK THAT PRODUCT BOXES ARE ON THE SUPPLY STORAGE CONVEYOR.
8. TURN "POWER" KEYSWITCH TO RESET AND RELEASE.
9. REMOVE "POWER" KEY FROM "POWER" KEYSWITCH.
0. CHECK HAND MONITOR FOR AUDIBLE SIGNAL AGAINST TEST SOURCE (ONCE DAILY).
1. OPEN MAZE ENTRANCE DOOR WITH "POWER" KEY.
2. CHECK POSITION OF PRODUCT BOX CARRIER.
3. CHECK THAT THE IRRADIATION ROOM IS VACATED.
4. SET "SAFETY INTERLOCK" SWITCH.
5. CLOSE MAZE ENTRANCE DOOR.
6. CHECK CONDITION OF LOAD-UNLOAD AND INTERNAL CONVEYOR TO ENSURE THEY ARE OPERATIONAL.
7. TURN "MACHINE" KEYSWITCH WITH "POWER" KEY TO "START" POSITION AND RELEASE.

TO STOP

1. TURN "POWER" KEY IN "MACHINE" KEYSWITCH TO THE "OFF" POSITION, AFTER CARRIER ARRIVES AT "POS. No. 1".
2. REMOVE THE KEY.
3. CHECK MONITOR READING IS NORMAL.

IN AN EMERGENCY
PRESS AN EMERGENCY STOP BUTTON

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.
4. Water level float switch and water filtration unit.
5. The complete conveying system (using dummy product boxes) for smooth operation.
6. Interlock procedures 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 against the test source.

CHECK OUT PROCEDURE AFTER 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" key-switch (without conveyor operation)). The monitor 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 against the test source.
4. Final test of complete machine.

CHECK OUT PROCEDURE FOR HANDLING SOURCE SHIPPING FLASK FROM TRANSPORT VEHICLE TO IRRADIATION AREA

1. On arrival of the transport vehicle at the site, perform a radiation service on each flask and note that the findings agree with the shipping documents.
2. Select a suitable "Staging Area" which will permit the crane to pick-up the flasks from the vehicle. At no time is the loaded crane to be moved from one location to another.
3. Remove the flasks from the transport vehicle using sling drawing No. D-121-Z9 to the "Staging Area".
4. Remove the four 3/4 inch bolts that secure the flask to the shipping skid, hoist the flask clear of the skid and lower onto the transport trolley (A05664).

5. Using leak test apparatus (A05667), check flask cavity for removable contamination by connecting to the lower drain quick-connnect fitting and filling the flask cavity with water. When water reaches the top of the upper drain tube, lower the carboy allowing the water to re-enter while passing through the filter. Check the filter with the survey meter for signs of removable contamination.

6. Move the flask to a point below the I Beam in the irradiation chamber and connect up slings (A05538). Lower the flask to a point just above the water level.

7. Remove all but Two of the bolts that secure the top loading plug to the flask. Loosen the remaining two bolts not more than three turns. Attach plug sling cable and temporarily secure the free end in such a manner as to prevent the cable falling into the pool when the flask is lowered.

8. Lower flask to floor of pool; remove crane hook from sling. Remove the two remaining bolts from the top loading plug and by means of the cable in 7 above, remove the top loading plug.

9. Proceed to remove the source shipping cage and store on the work table.

10. Connect the crane hook to the hoisting sling and lift flask to a point just above the surface of the pool.

11. Install top plug; drain tube plug, hoist flask and place on transport trolley. Outside the building, attach flask to shipping skid.

12. Remove Class D Poison Stickers, etc., from flask and affix "EMPTY" Sign.

13. The above procedure is to be adhered to for subsequent flask unloading operations.