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Radioisotope Development Laboratory Building 3047 Safety Analysis

OAK RIDGE NATIONAL LABORATORY
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RADIOISOTOPE DEVELOPMENT LABORATORY BUILDING 3047 SAFETY ANALYSIS

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Oak Ridge, Tennessee 37830
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UNION CARBIDE CORPORATION
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CONTENTS

RADIOISOTOPE DEVELOPMENT LABORATORY BUILDING 3047 SAFETY ANALYSIS

R. A. Robinson and E. E. Pierce

INTRODUCTION

The Radioisotope Development Laboratory, Bldg. 3047, was originally designed and constructed for development work with low, intermediate, and high level beta- and gamma-emitting radioisotopes. A detailed description of the facility is included in this report.

Increasing requirements for alpha emitters such as ^{244}Cm have made it necessary to install special facilities in Bldg. 3047 for development work with these materials. The facilities are located in Rooms 110, 211, and 212 (see 3047 Building Plan — Fig. A-1, Appendix A).

Modifications have been made to the Bldg. 3047 hot cell area including the following: (1) HEPA filters in each of the four cells, (2) revised containment system utilizing a HEPA filtered roof exhaust system, and (3) emergency electrical power system for essential services.

FACILITY DESCRIPTION

Building Description

The Radioisotope Development Laboratory, Bldg. 3047, is a three-story, structural-steel-frame building having concrete block exterior walls. The overall dimensions are 142 × 40 × 31 ft. Building floor area and volume are distributed as shown in Table 1.

Table 1. Floor Area and Volume of Radioisotope Development Laboratory (Bldg. 3047)

	Volume (ft^3)	Net Usable Area (ft^2)	Service Area (ft^2)	Wall Area (ft^2)	Total Area (ft^2)
First floor[a]	92,320	4,811	810	734	6,355
Second floor	81,920	4,330	1,040	310	5,680
Third floor	30,000	1,037	2,118	217	3,372
Roof[b]	990	—	92	27	119
Total	205,230	10,178	4.060	1,288	15,526

[a]Includes vacuum pump pit.

[b]Includes stairwell (penthouse only).

The building is bound on the west by Bldg. 3028, on the south by Isotopes Circle, and on the north by Hillside Avenue. On the east the building is joined to the Isotopes Technology Building, Bldg. 3047A, a three-story structural-steel-frame, concrete block building (see Fig. A-2, Appendix A) that has volume and floor area distributed as shown in Table 2.

Table 2. Floor Area and Volume of Isotopes Technology Building (Bldg. 3047A)

	Volume (ft^3)	Net Usable Area (ft^2)	Service Area (ft^2)	Wall Area (ft^2)	Total Area (ft^2)
First floor	33,800	1,031	1,552	237	2,820
Second floor	33,800	2,013	634	173	2,820
Third floor	33,800	2,222	424	174	2,820
Total	101,400	5,266	2,610	584	8,460

The Isotopes Technology Building is not a radiochemical facility; its air handling system is not connected in any way with the Radioisotope Development Laboratory ventilation system, and it is separated from the containment zone of the Radioisotope Development Laboratory by at least three doors in series. For these reasons, the Isotopes Technology Building is considered a separate building, even though there are connecting corridors between it and the Radioisotope Development Laboratory.

The Radioisotope Development Laboratory houses four manipulator-type hot cells, four laboratories, three alpha handling areas, a decontamination room, ten offices, a change room, and storage and service areas. The four hot cells and three of the laboratories are in the original containment zone of the building; the three alpha handling facilities (Rooms 110, 211, and 212) are in other containment zones; the offices, service areas, and one laboratory for low-level radioactive work are in noncontained parts of the building. Building location and floor plan drawings are shown in Figs. A-1 and A-2, Appendix A.

All rooms in Bldg. 3047 are equipped with a built-in sprinkler system for fire protection.

Building Alterations

The chemical engineering section located in the west end of Bldg. 3047 (Rooms 110 and 212) and the radioisotopic laboratory-west (Room 211) have been converted into three facilities for handling alpha emitters (Fig. A-1, Appendix A). Room 110 contains $\sim$900 ft^2 of floor area. This does not include the air lock, Health Physics office, and stairwell. A lift truck access air lock permits entry to Room 110 through gasketed doors, and access to Room 212 is accomplished through a gasketed hatch. A 3-ton overhead crane permits the transfer of equipment and material from the air lock to Rooms 211 and 212.

Each of the four shielded cells in Bldg. 3047 has been equipped with dual HEPA filters, and the cell operating area containment system has been revised to exhaust through an existing HEPA filtered exhaust system on the roof of the building.

An emergency electrical power system has been installed to provide standby electric power for essential services in Bldg. 3047 and Bldg. 3028.

Cell Description

The four manipulator cells designated A, B, C, and D are located as shown in Fig. A-1, Appendix A. A description of the cells is given in Table 3.

Table 3. Building 3047 Cell Description

Cell	Inside Dimensions (ft)	Cell Liner[a]	Equivalent Standard Concrete Shielding (ft)
A	8 × 6 × 13	3/16-in. 304 stainless steel	4.4
B	8 × 8 × 13	3/16-in. 304 stainless steel	4.4
C	8 × 8 × 13	3/16-in. 304 stainless steel	5.9
D	8 × 6 × 13	3/16-in. 304 stainless steel	4.4

[a]The cell roof plugs are concrete painted with four coats of Amercoat 33HB.

The walls and tops of Cells A, B, and D are fabricated of 3-ft-thick barytes concrete ($\rho = 3.5$). The top plugs and front and rear walls of cell C are fabricated of 2-1/4-ft-thick barytes concrete and 9-in.-thick steel plate. All common walls between cells are 3-ft-thick barytes concrete. The rear access doors on cells A, B, and D are of 16-in.-thick laminated steel plate; cell C has a 21-in.-thick laminated steel access door (see Fig. A-4, Appendix A).

Each cell has a laminated lead-glass viewing window composed of 6.2- and 3.3-density lead glass arranged to give shielding which is equivalent to the cell walls. The windows are of stepped construction (28 by 34 in. on operating face, 40 by 40 in. on inside cell face) and are sealed in the cell wall by 20-gage stainless steel flashing that is welded to the cell liner.

All steam, air, electrical, and water services originate from headers located above the operating corridor and enter the cell through a valve (or switch) on the operating face. The radioactive services, cell exhaust, hot drain, process drain, hot off-gas, and vacuum enter the cells from underground headers located behind the cell block.

Each cell has the following service penetrations:

Two 10-in.-ID manipulator sleeves
One 6-in. stepped sleeve and plug built into roof plug
Four 1-1/2-in. stepped sleeves and plugs built into south wall of cell
One 4-in. stepped sleeve and plug built between adjacent cells
Six 1-in. offset sleeves capped inside and outside of cell
Four 1/2-in. offset sleeves capped inside and outside of cell
Five 1-in. electrical conduits
One 1-1/4-in. electrical conduit
One 6-in.-ID cell ventilation exhaust line with two 100-cfm HEPA filters
Two 1-in. vacuum lines
One 2-in. hot off-gas line
One 2-in. radioactive hot drain
One 2-in. process drain capped inside cell
Four 1-in. process water lines
One 1/2-in. hot process water line
Two 1/2-in. 90-lb plant air lines
Two 3/4-in. 15-psig steam lines
Two 1/2-in. transfer lines from cask unloading station
Seven 1/2-in. air lines for in-cell air hoist operation
One 28- by 34-in. stepped shielding window penetration
One 3-1/2- by 8-1/3-ft stepped cell door
Roof plugs giving full cell opening (8 by 8 ft and 8 by 6 ft)
Two 16-1/2 by 17-1/2-in. inter-cell conveyor openings
One cell air inlet line (8-in. ID for cells A, B, and D and 12-in. ID for cell C)

Personnel entrance to the cells is normally through the cell doors on the south side of each cell. Equipment which is too large to go through the cell doors will enter through the roof plugs.

The introduction or removal of small items such as glassware and samples during cell operation is accomplished by using the inter-cell conveyor system which terminates in loading-unloading cubicles located on the east and west ends of the cell block. These cubicles having 6 in. of lead shielding and a 6.2-density lead-glass viewing window. The cubicle floor pans drain directly to the hot drain system, and the conveyor cart tunnel extending the length of the cell block drains to the individual cells. The conveyor cart can tolerate loads up to 50 lb having dimensions not exceeding 12 × 12 × 12 in.; it is driven by electric motors located outside each of the terminal cubicles. Cell ventilation on the cubicles is obtained by way of the cells, i.e., the cubicles have no independent ventilation system.

The stepped plugs which enter through the rear of the cells are provided only for bringing in instrument or special power bundles associated with a specific experiment. When they are not in use, these plugs are locked in place by a steel bar bolted to the wall. The 6-in. stepped plug entering the top of each cell can be used for surveying a cell during decontamination and to introduce a hose or spray rig during the initial phases of cell decontamination.

The cells are equipped with mercury vapor lamps for lighting during operation and incendescent lamps for lighting during maintenance and decontamination

The cell air handling equipment and containment instrumentation are described in the section on "Containment," subsection "Primary (Cell) Containment."

Description of Manipulator Cubicle (Room 110)

The inert atmosphere manipulator cubicle is located as shown in Fig. A-1, Appendix A.

The cubicle has a stainless steel liner with inside dimensions of 54 in. wide × 55 in. deep × 65 in. high. Enclosing the liner are six reinforced steel tanks with 18 in. of water shielding. A total radiation dose from 7.5 g of $^{244}Cm_2O_3$ inside the cubicle at a distance of 42 in. will be 0.3 mrem/hr.

An 18-in.-thick water-filled viewing window is incorporated in the operating (east) face of the cubicle, and the manipulators are Central Research Laboratories Model L (sealed) Master Slave units.

A glove box is attached to a vacuum access port on the south face of the cubicle and provides bag-in and bag-out capability for introducing and removing materials to and from the vacuum access port.

The cubicle is equipped for a controlled flow of argon and is operated at -0.5 in. water gage below the Room 110 pressure which is -0.3 in. water gage relative to the outside pressure. The cubicle exhaust is directed to the hot off-gas system through dual high-efficiency filters that are accessible for routine testing. One set of filters is located inside the cubicle, and each filter may be changed while the other is in operation. The second set of filters is located on the west wall of Room 110. The filters are replaced when the pressure drop exceeds 3 in. water gage.

The instrumentation is designed for fail-safe operation in the event of electrical or air failure; a schematic outline is shown in Fig. A-5, Appendix A.

Pneumatically operated pressure control valves regulate the cubicle exhaust and the argon inlet flow. Sensing units on the exhaust system prevent excessive pressure or vacuum in the cubicle. All exhaust and inlet lines are protected by high-efficiency in-line filters.

The cubicle temperature is monitored by a heat-sensing unit that is connected to an audible alarm. The alarm activates the Bldg. 3047 panel alarm system in Room 109. Combustion inside the cubicle will be controlled by maintaining an inert gas atmosphere.

Personnel entrance to the cubicle is through an opening in the rear (west) side of the cubicle liner. The opening is equipped with a removable cover that contains glove ports and a viewing window. The water-shield tank for the rear of the cubicle is movable to permit access to the services, gloves, etc. All services to the cubicle are routed through service panels in the rear of the cubicle liner.

During major equipment changes in the cubicle through the rear access panel, a temporary plastic film enclosure will be erected to confine any radioactive contamination that may escape during the transfers. The enclosure will be connected to the cell ventilation system.

A vacuum access port permits the introduction and removal of materials to and from the cubicle without disturbing the inert-gas atmosphere.

The access glove box is equipped with a bag port and is designed to confine any radioactive contamination that may escape from the cubicle during the transfer of equipment or materials through the vacuum air lock. The glove box is connected to the cell ventilation system, and the inlet and exhaust are equipped with high-efficiency filters. The filters are accessible for routine testing.

The cubicle atmosphere is monitored as required with a Beckman Model G-2 oxygen analyzer.

An evaluation of each new experiment is made by the Operations Division Safety Review Committee before the development work is started. Experiments involving significant quantities of hazardous materials (^{252}Cf, ^{242}Cm, ^{238}Pu, etc.) are also evaluated by the Radioactive Operations Committee.

Description of Glove Boxes in Room 211

Three interconnected glove boxes and one access glove box are located in Room 211 as shown in Fig. A-1, Appendix A. The four boxes are constructed of stainless steel with safety glass viewing windows.

The access box and box C are equipped with bag ports for the introduction and removal of materials under sealed conditions.

All services, such as water, electricity, vacuum, etc., are introduced through sealed metal connectors in the rear of the boxes. Box A is connected to the hot drain system through a valved connection (See Fig. A-7, Appendix A).

Each box is equipped with a pressure-vacuum relief vessel to prevent overpressure of the box. The three process boxes are equipped with fire sensors and water detectors that are connected to a local alarm and the Bldg. 3047 alarm system. The exterior of the glove boxes is protected from fire by the overhead sprinkler system in Room 211.

A description of each new experiment to be performed in the glove boxes is submitted to the Operations Division Safety Review Committee for examination relative to mechanical, chemical, and radiation safety before the development work is started.

An operating procedure including an equipment check list is available for experimenters using the glove boxes in Room 211.

Description of Vacuum Glove Box in Room 212

A vacuum glove box assembly is located in the southwest corner of Room 212. The assembly consists of a stainless steel vacuum glove box with four glove ports connected to an access glove box through a vacuum transfer chamber. The vacuum glove box and transfer chamber are equipped for vacuum purge-argon atmosphere, and the access box operated with an air atmosphere.

The vacuum glove box is limited by control and relief valves to a maximum negative pressure of 9 in. of Hg. Argon flow to the box is controlled by automatic valves.

The vacuum glove box and the access glove box are equipped with Pyrex pressure-vacuum relief vessels to prevent over-pressure of each box. The vacuum glove box is equipped with a heat sensor and a water detector that are connected to a local alarm in Room 212 and to the Bldg. 3047 alarm system. All glove and bag ports are protected with solid metal covers when not in use. The exterior of the vacuum glove box assembly is protected from fire by the overhead sprinkler system in Room 212.

A description of each new experiment to be performed in the vacuum glove box assembly is submitted to the Operations Division Review Committee for examination before the development work is started.

An operating procedure including an equipment check list is available for experimenters using the vacuum glove box assembly in Room 212.

Process Equipment

Building 3047 is a research and development laboratory, and most of the radioactive processing equipment is set up for each experimental investigation and is dismantled at the conclusion of the experiment. Three high-temperature vacuum furnaces are installed in "contained" areas of the building (Rooms 113 and 212) and are used for long-term compatibility experiments with radioactive compounds and encapsulating materials. All radioactive materials to be tested in the furnaces are encapsulated to reduce the probability of contamination.

The access port to each furnace is equipped with a glove box enclosure with bag-in, bag-out, and inert-gas capabilities. Each enclosure is equipped with a heat sensor and a pressure relief vessel. When it is necessary to remove the access port in order to make repairs to the furnace components, remove the access port in order to make repairs to the furnace components, a plastic enclosure is erected around the furnace to denote a contamination zone. The enclosure prevents the spread of radioactive contamination to the surrounding area. A copy of the operating procedure for the glove boxes is included in Appendix C.

Auxiliary Equipment

Vacuum System

House vacuum for both the cells and laboratories is provided by a single-stage, rotary, water-sealed pump (Nash Hytor Model H-4). The pump and all piping and valves in the system are 300 series stainless steel (304L and 347). The seal water is recirculated through a heat exchanger which can discharge the water to hot drain if it becomes contaminated. The cooling water passing through the heat exchanger to cool the seal water is discharged to the process drain at the rate of 8 gal/min. The air flowing in the system passes through a 100-gal stainless steel surge tank before going into the pump to disengage any liquid or solid that may be pulled into the vacuum system. The exhaust air from the pump is discharged into the cell ventilation duct under the building.

The system also includes an air eductor in parallel with the mechanical vacuum pump to provide high pumping capacity during the last stages of pump-down from 7-in. Hg abs to 3-in. Hg abs. The eductor uses air from the vacuum pump room for the motive fluid and discharges into the cell ventilation system. The entire system including the vacuum pump, air eductor, seal water circulating pump, seal water hold tank, seal water heat exchanger, and the vacuum surge tank is located in an underground pit below first floor equipment Room 102. Access is through a manhole on the south side of the building. The roof and wall facing the access way provide 12 in. of concrete shielding.

Refrigeration

A Trane "Centravac" compressor and chiller unit (Freon-22) with a capacity of 175 tons provides chilled water which is circulated at 100 gal/min to the air-handling units in the building. The unit is located in the first floor equipment area, Room 102. Heat removal from the compressor is accomplished by a closed-loop water system operating through a dual cooling tower located on the roof. The water-circulating pumps for both the tower water and chilled water are located in the second floor equipment area, Room 206. Both the tower-water and chilled-water circulating systems have an installed spare pump.

Hot Water Systems

The equipment for both domestic and process hot water systems is located in Room 206 and consists of a steam-to-water shell and tube heat exchanger, hot water hold tank, and an expansion tank. A centrifugal pump is used to circulate the process hot water through the reheat coils of the air-handling system. Steam taken from the 90-psig header and reduced to 15 psig is used in the heat exchangers. Both systems are equipped with high-temperature and high-pressure relief valves.

All auxiliary equipment in Bldg. 3047 is included in the Plant and Equipment Division (P&E) routine maintenance program and is inspected and serviced regularly.

Air-Handling Equipment

The description and operation of this equipment are given in the section on "Containment."

Jet Eductors

Table 4 describes the jets having service functions in Bldg. 3047. All jets except the vacuum booster are manually operated.

Table 4. Building 3047 Jet Eductors

Size and Material	Motive Fluid	Location	Discharge Point	Function
2-in. IPS, 347 stainless steel	Air, atm pressure	Vacuum pump pit	Cell ventilation duct	Booster for vacuum system
3/4-in. IPS, 347 stainless steel	Steam, 60 psig	Vacuum pump pit	Hot drain	Emptying vacuum surge tank, seal water tank, and sump
3/4-in. IPS, 347 stainless steel	Steam, 60 psig	Cell D	Hot drain	Emptying cell ventilation duct sump
3/4-in. IPS, 347 stainless steel	Steam 60 psig	Cell D	Hot drain	Emptying hot off-gas header sump

EMERGENCY ELECTRICAL POWER SYSTEM

A 45-kW emergency generator assembly has been installed on the north side of Bldg. 3047 to provide emergency electrical power for Bldg. 3047, Bldg. 3127 (vault), and Bldg. 3028. The electrical distribution panels and transfer switch are located on the north wall of Room 110 in Bldg. 3047. Electrical service panels are located as follows:

Panel No. EP-1	Circuit No. 5	Bldg. 3047	Room 201
Panel No. EP-1A	Circuit No. 1	Bldg. 3028	East Airlock
Panel No. EP-2	Circuit No. 2	Bldg. 3047	Room 102
Panel No. EP-4	Circuit No. 4	Bldg. 3047	Room 110
Panel No. EP-5	Circuit No. 3	Bldg. 3047	Room 212
Receptacle	Circuit No. 6	Bldg. 3047	Room 110 (Generator test)
Panel No. EP-A	Circuit No. 7	Bldg. 3127	Equipment Room (Vault)

Emergency power is distributed in Bldg. 3047 to provide emergency electrical power to the following equipment: cell emergency lights; radiation detection and survey instruments, including CAM, CAAM, monitrons, neutron monitors, etc.; Bldg. 3047 and Isotopes Area public address systems; Bldg. 3047 fire alarm; alternate exhaust fan AJ-102B; and spare circuits for future experimental equipment. The location of the distribution system is shown on Drawings E-20399-ED-005-D and E-20399-ED-007-D-1.

The emergency power system is tested regularly by Plant and Equipment Division personnel according to the Emergency Generator Testing Procedure.

CONTAINMENT

The containment zones of the Radioisotope Development Laboratory are shown in Fig. A-1, Appendix A. The cells, cubicles, and glove boxes are considered the primary containment, and the portions of the building housing the facilities are considered the secondary containment. The east end of the building is not contained.

Primary Containment — Cells

The primary volume to be contained is the cell block. Containment of this volume is obtained by means of the structural strength resulting from the concrete and steel construction of the cells and by controls to maintain the cells at a pressure that is always less than the surrounding building.

The physical description of the cells, including service penetrations, is given in the section "Facility Description," subsection "Cell Description." The cells, including windows, doors, and plugs, will withstand static pressures in excess of 600 lb/ft^2 without movement. An accident that would cause a massive failure of the cell walls is not considered "credible" because of the procedural safeguards described under "Chemical Processing" regarding the type and quantities of reagents used during cell operation.

The cell doors are constructed of laminated steel plate, lined with 11-gage stainless steel, and stepped to prevent radiation shine. The doors on cells A, B, and D are 16-in. thick, and the door on cell C is 21 in. thick. The doors are suspended on crane-type hinges and, when closed, they seat against a soft neoprene gasket. The first (cell side) step in the door threshold is sloped toward the cell and is equipped with a drain to carry off any decontaminating solutions that may be sprayed against the door. The cell floor is 6 in. below the door threshold to prevent the loss of any liquid which might accumulate on the floor. Each cell floor has a nonvalved floor drain to hot drain connection and is equipped with a removable trap and screen.

Each cell has a three-piece roof plug. In addition, cell C has two separate pieces of armor plate under the concrete plugs to provide the additional shielding designed for this cell. The plugs are arranged so that it is necessary to remove a relatively narrow key plug on each cell before any of the other plugs can be removed. When this key plug is lifted, a circuit is deenergized which closes the inlet air damper to provide increased air flow across the opening.

Under normal operating conditions, air enters each cell through a roughing filter, an automatic flow control valve, and a back-flow preventer. The air leaves the cell by way of two in-cell 100-cfm HEPA filters and goes through an underground duct to the Isotopes Area Filter Pit, where it passes through a bank of FG-25 roughing filters and a bank of HEPA filters before going to the 3039 stack.

The leakage of air into the cells by paths other than the normal air inlets is minimized by sealing all wall penetrations. The cell doors when closed compress a 1/2-in.-thick neoprene gasket to 7/16 in. to prevent air flow through door cracks; the cell roof plug cracks are sealed with oakum and tar; all spare service sleeves are capped both inside and outside the cell; spare service plugs are sealed with putty; the cell window liners are sealed by 20-gage stainless steel flashing welded to the cell liner; the slave arms of the manipulators are fully booted; and the manipulator operating tapes pass through a felt wiper seal in the through tube.

Before a cell door or roof plug is opened, the cell is decontaminated to a safe level as determined by smear results and radiation surveys; and one of the 100-cfm HEPA filters is removed from its sealed position to allow a greater flow of air into the cell. When the door or roof plug to a cell is opened, a switch automatically closes a damper in the inlet air duct to the cell which directs all air flow through the door or roof opening. Each exhaust duct is equipped with a damper that may be controlled from outside the cell wall by a lead-filled rotary seal. Each damper is normally set in the full-open position and the cell pressure and air flow controlled with the inlet air damper.

During normal operation, the cells are maintained at -1 to -2 in. water gage pressure with respect to the building pressure. Each cell has a diaphragm-type (Magnehelic) pressure-differential indicating instrument to show the difference between cell and operating corridor pressures. Each cell also has Magnehelic gages on the operating face to indicate the pressure drop across the in-cell filters and on the access side of each cell to indicate the pressure drop across cell air inlet filters. All of the cell air-flow controls are of fail-safe design. The loss of electric power and/or compressed air for damper operation will result in the dampers being opened to their fullest extent to provide maximum cell ventilation flow. The in-cell filters are tested on a routine dioctylphthalate (DOP) test schedule.

Building Containment

The portions of the building designed to meet maximum containment standards include the cell block, cell operating and access areas, three hot laboratories on the second floor, and the decontamination room (Room 105) in the central part of Bldg. 3047. Rooms 110, 211, and 212 in the west part of the building operate continuously under contained conditions (-0.3 in. water gage). The portion of the building designed to meet these maximum containment criteria is outlined in Fig. A-1, Appendix A.

The air supply system for the building is comprised of three independent units designated as System 1, System 2, and System 3.

System 1

System 1 has been revised to a recirculating system with high-efficiency filtration. It supplies air for the west end of the building including Rooms 110 and 212, laboratory Room 211, and office Rooms 213 and 111. Rooms 110, 211, and 212 are included in the maximum containment areas of the building. The return air from Rooms 110 and 212 is filtered locally through high-efficiency filters, travels through a bank of roughing filters and a bank of 90% efficiency filters in the room 315 plenum, and is discharged into a duct-distributor system serving the areas mentioned above. The fan and filter housing for this system is located in plenum 1, Room 315. Automatic dampers are set to prevent the negative pressure in Rooms 110, 211, and 212 from exceeding -0.5 in. water gage.

Revisions to the system include conversion from 100% makeup to a recirculating system with minimum makeup to maintain a safe and comfortable environment for the operating personnel. The recirculating air is filtered in Rooms 110 and 212 through FG-50 roughing filters and high-efficiency filters.

Rooms 110, 211, and 212 exhaust continuously to the cell ventilation system through FG-50 filters in each room and high-efficiency filters at the Isotopes Area Filter Pit. Each room is maintained at -0.3 in. water gage.

The three rooms are protected from fire by overhead sprinklers and a fire alarm pull box, and Rooms 110 and 212 have hose cabinets. Each room has one door with access to a stairwell and one door accessible to an emergency exit. A vehicle air lock permits vehicle entry to Room 110 through gasketed doors and entry to Room 212 through a gasketed hatch.

Each room is equipped with a constant alpha air monitor (CAAM) that is connected to the monitored alarm panel in Room 109. Alpha personnel monitors are positioned at each personnel access door, and neutron detectors with built-in alarms are located in each room. A manual switch for emergency use is located in each room and connected to the alarm panel in Room 109.

All operating personnel assigned to Rooms 110, 211, and 212 have had training with the fire-control equipment and are experienced in the detection and handling of radioactive materials.

System 2

System 2 supplies air to the central (contained) portion of the building. The air is drawn through a stack on the roof of the building and through a bank of roughing filters and a bank of 90% efficiency filters. Air is discharged from the System 2 volume by way of the hoods in Rooms 105, 109, 208, 209, and 210, by way of the four cells, and by an exhaust fan on the roof. The roof fan exhausts through a bank of roughing filters and a bank of CWS-type absolute filters. The filters are routinely DOP tested. When the central portion of the building goes into containment, the roof exhaust fan continues to operate, the System 2 supply fan shuts down, and an automatic damper closes the duct going to the outside. The contained area pressure changes from 0.1 in. water gage to >-0.3 in. water gage in <20 seconds.

The central portion of Bldg. 3047 is equipped with two exhaust fans and damper assemblies. These are AJ-102A (primary) and AJ-102B (secondary or emergency). AJ-102A runs under normal conditions, and the control panel is located in the SE corner of Room 113. A photohelic gage measures the fan discharge air flow. A pneumatic damper control permits control of the air flow through the fan. If the primary fan (AJ-102A) malfunctions allowing the stack pressure to drop below the photohelic gage low-set point (0.1 gage 1320 cfm) the secondary fan (AJ-102B) is energized and supplies auxiliary exhaust capacity. AJ-102B is also connected to the emergency power system and will operate during periods of electrical power failure.

The central portion of Bldg. 3047 can be put into "contained" condition by two methods:

1. Manually by means of a push button located in the southeast entranceway.

2. Automatically by CAM-type radiation monitoring instruments. There are eight of these instruments tied into the containment circuit, and a radiation signal from at least two instruments simultaneously is needed to put the building into containment. The location of the instruments is shown in Fig. A-6, Appendix A.

When the central portion of the building goes into containment, the following things happen essentially simultaneously:

1. An audible and visual alarm is given at a containment panel in the operating corridor, red warning lights flash at all entrances to the containment area, and audible alarms sound throughout the containment area.

2. The exhaust system serving the central portion of Bldg. 3047 continues to operate. Exhaust which is going by way of the cell ventilation system (hood exhaust and cell exhaust) continues. The exhaust fan serving the east end of the Radioisotope Development Laboratory (office area) stops to assure an air flow pattern toward the central portion of the building.

3. The air supply fan serving System 2 ceases operating, and an air-operated damper seals it off from the outside. The air supply fan serving System 3 continues operating to ensure that these noncontained areas stay at a higher pressure than the contained (System 2) area. See Appendix B for the containment system test procedure.

All the damper actuators associated with the containment operations are air actuated and move to the containment condition in the event of an air or electrical failure.

There are no doors which connect directly from the contained area of the building to the outside. Both personnel and vehicles must pass through two doors to enter the contained portion of the building. The vehicle doors are interlocked to permit only one door to be open at a time; the personnel entrances are not interlocked. A remote radiation indicator station is located in the central stairwell to indicate the radiation level at each of the CAM's in the contained area. Another indicator is located in the operating corridor.

System 3

System 3 supplies air to the office areas, laboratory Room 207, east end storage, and change and equipment areas. These areas are not within the maximum containment zone of the building. The supply fan is located in plenum 3, Room 313. Air is drawn in through a stack on the roof, through a bank of roughing and 90% efficiency filters, and into a duct system serving the System 3 area. Air is discharged from this area by way of the hoods in Room 207 and by an unfiltered exhaust fan on the building roof. When the central portion of the building goes into containment, the roof exhaust fan shuts down, creating a positive pressure which assures that the air flow pattern will be toward the contained area.

The adjoining Isotopes Technology Building, Bldg. 3047A, has its own air supply and exhaust systems, which are entirely independent of those in the Radioisotope Development laboratory.

CHEMICAL PROCESSING

Since Bldg. 3047 is a research and development facility, there is no standardized routine chemical processing. A wide variety of processes and operations is carried out on an experimental basis, such as solvent extraction, ion exchange, precipitation, and distillation. In addition, mechanical testing of sources is performed in both cells and laboratories.

Feed for the experimental processes may be in the form of purified radioisotopes from the Isotopes Area operations, reactor targets, gross fission product waste solutions from fuel processing operations, and fission product fractions separated at other DOE facilities. In addition, it is expected that numerous experiments using nonradioactive solutions or tracer quantities of activity will be performed in the laboratories.

A list of all the reagents to be used is not feasible because of the experimental nature of the work. All proposed experiments are submitted to the Operations Division Safety Review Committee for review with particular emphasis on possible side reactions that could be hazardous. The use of flammable solvents in the cells is restricted to quantities not in excess of 1 liter, and the routine use of equipment using natural gas, such as furnaces and burners, is not permitted in the cells. Compounds which can decompose explosively, such as alkali chlorates and ammonium nitrate, are not used in the cells in quantities exceeding 1/4 lb, unless they are in solutions known to be safe and to have no chance of being concentrated to dryness.

The chemical processing equipment used in the cells will vary from ordinary laboratory glassware up to multigallon stainless steel process vessels. The total volume of all the process vessels in a cell will not exceed 200 gal in cells B and C and 150 gal in cells A and D. These volumes are less than those that could be held in the cell floor pans (256 gal and 192 gal) without the level of the liquid reaching the door thresholds. Experiments for manipulator cubicle and glove box operation in Rooms 105, 110, 211, and 212 are outlined in writing and submitted to the Operations Division Safety Review Committee for evaluation prior to the installation of the equipment assemblies.

CRITICALITY

There will be no fissionable materials present in quantities that are subject to a nuclear chain reaction. No more than 500 g of ^{235}U and 10 g of ^{239}Pu will be in the building at one time. Some materials such as ^{244}Cm which undergo spontaneous fission decay will be used, but they will not be subject to a nuclear excursion-type incident.

OPERATING SAFEGUARDS

Procedures

Procedures for various service operations have been established and are available for use by all Bldg. 3047 operating personnel. Deviation from the approved procedures is not permitted without supervisory approval. New or modified procedures are reviewed and approved before being distributed for use. All procedures are reviewed on a regular basis.

Run Sheets

Formal process run sheets are not normally used in the operation of the building due to the experimental nature of the work as contrasted with routine production operations. Each experiment involving radioactive materials, whether in the cells or laboratories, is under the direction of a qualified scientist; and, as noted previously, the experiment is planned and reviewed with particular emphasis on hazards. The scientist may have one or more technicians operating his apparatus, and he will provide them with written or verbal instructions depending on the comcomplexity and hazard of the operation. The technician is not permitted to deviate from these specific instructions unless he obtains permission from the scientist in charge of the experiment. In the case of high-level experiments in the cells, the scientist in charge is not permitted to deviate from the planned and approved experiment with respect to chemicals used, temperatures, pressures, or other critical conditions without first consulting his supervisor.

Built-in Safeguards

Several built-in safeguards have been designed into the building to provide protection in the event of operating error or equipment failure.

Containment System

As mentioned in the section on "Containment," the containment system, in addition to manual actuation, will be actuated automatically by any two of eight radiation detection instruments. Also, the system will fail in the safe (contained) condition if any utilities operating the system (electricity, air) should be shut down.

Cell Radiation Monitors

A beta-gamma monitron is located behind each cell in line with the cell door so that it "sees" into each cell as the door is opened and will give an audible alarm if there is an exposed source in the cell. Neutron monitors are installed in Rooms 110, 211, and 212 to continuously monitor the areas for excessive neutron radiation.

Constant Air Monitors

Alpha monitors and beta-gamma monitors are installed in all areas where radioactive materials are handled. Selected instruments are connected to the alarm systems of the contained areas.

Neutron Monitors

Neutron monitors with adjustable set point for an alarm are installed in Rooms 110, 211, and 212.

Vacuum System

The entire vacuum system is constructed of stainless steel, and all vacuum lines coming out of the cells are shielded with a minimum of 12 in. of concrete to provide shielding in case radioactive materials are accidentally pulled into the system. The pump is protected by a 100-gal disengaging tank to provide a volume for dropping out any radioactive materials that might get into the system. The pump, surge tank, and accessory equipment are located in an underground pit with a minimum of 12 in. of concrete shielding. A beta-gamma monitron in the pit provides a reading at the operating panel in the equipment room to indicate if radioactive material has been pulled into the pump system.

Laboratory Hot Drains

All hot drain lines coming from the laboratory areas are shielded where necessary to the point where they go underground. The annular lead shields are equipped with drains to permit the draining of any liquid that would collect if one of the hot drain lines developed a leak.

Air Handling

The building air supply is broken into three separate systems to minimize the possibility of contaminating the whole building from an incident in one section of the building. The air intakes are equipped with 90% efficiency filters to provide protection against contamination resulting from an incident outside the building.

Cell Floor Drains

The cell floor drains are not valved and have raised screens to ensure that they will be open when a cell is being washed down. They are equipped with removable water-sealed traps to prevent the backflow of contaminated air.

Back-flow Preventers

Back-flow preventers are provided on all cell air inlets and on all cell ventilation headers tying into the main building cell ventilation duct. All above-ground building cell ventilation lines are of stainless steel, all-welded construction; the underground headers are of concrete.

Hot Hoods

The walls behind the hot hoods in the three hot laboratories have 5-in.-thick lead panels to ensure that a source placed in a hood in one laboratory will not irradiate an individual in the next room.

Inter-cell Plugs

The 4-in. stepped plugs in the walls between cells are located 6-1/2 ft above floor level to ensure that an individual entering one cell will not be in line of sight of a source in an adjoining cell even if he forgot that the inter-cell plugs were open. The inter-cell walls provide a full 3 ft of barytes concrete shielding.

Alarms

The following visual and/or audio alarms are provided in the building:

1. Containment system actuated
2. Low cell pressure differential
3. High level, hot off-gas sump
4. High level, cell ventilation sump
5. Inter-cell conveyor in or entering an open cell
6. Laboratory evacuation alarm
7. Fire alarm
8. Radiation monitor alarms
9. Vacuum system mal-operation alarm
10. Air supply ductstat temperature alarm
11. Low building voltage alarm
12. High-temperature sensing unit alarm
13. Glove box water-level alarm
14. Low oxygen detector for Rooms 110, 211, and 212
15. High or low temperature alarm for animal room (2nd level, Bldg. 3028)
16. Emergency assistance switch (Rooms 110, 211 and 212)

Procedural Safeguards

In addition to the procedures previously mentioned, the following regulations are in force in the building:

1. Electrical maintenance is done only when the appropriate circuit breaker is tagged out.

2. Entrance to a cell is not permitted until a Health Physics survey has been made.

3. All maintenance and set-up work in a cell requires a standard Radiation Work Permit and an observer.

4. Lead burning and welding work require a standard Burning Permit.

5. Technicians and operators are not permitted to experiment on their own.

6. Laboratory regulations regarding the tagging of equipment, carriers, and samples are strictly followed.

7. Modification of building services and service equipment is not permitted except as specifically authorized by the Department Supervisor. Procedural changes may only be authorized at the Department Supervisor level or higher.

Building Services and Equipment Maintenance

The service equipment in Bldg. 3047 is on the Routine Maintenance System administered by the P&E Division. This includes a routine inspection of machinery components on a schedule based on P&E Division experience with similar equipment, lubrication of moving parts, tightening or replacing valve packings, etc. In addition, all equipment associated with the containment system is tested at least once a week. Pressure drop gages are connected across all filters in the building to provide an indication of when the filter should be changed. Filters are replaced by the P&E Division on request; all nonscheduled maintenance is done by request to P&E.

PERSONNEL EXPOSURE

Maximum Curie Load

It is expected that virtually all radioisotopes below uranium, as well as a few transuranium elements, will be handled in varying amounts in Bldg. 3047. The isotopes representing the greatest amounts of activity, as well as hazard, in the building are given in Table 5.

The distribution of the downwind dose normalized to a 1000-Ci stack release and stable atmospheric conditions is plotted in Fig. 1. The calculation method used for Table 5 and Fig. 1 is given in Appendix B. The values in Table 5 are based on the assumption that the in-cell filters are 99.95% efficient in removing particles sized 0.3 μm and larger as shown by the DOP test and the Isotopes Area Filter Pit is 99.6% efficient. The values can be adjsuted for other filter efficiencies. A plot of these correction factors which can be used with Table 5 is given in Fig. 2. The downwind dose and contaminated area values given in Table 5 are based on the assumption that the entire dispersible inventory of a cell becomes airborne and 20% of this activity reaches the cell filters. The leakage of activity from the cell and building will be insignificant compared to the stack release. An accident which breeches the cell block is not considered credible because of the previously mentioned limitations (page 15) on the quantities of potentially explosive materials allowed in the cells.

The maximum dose to personnel in the building due to overpressurization of the cells will depend largely on the length of time the cell is pressurized and the pressure level. Assuming an accident that releases about 2.7 ft^3 of gas to the containment zone of the building, the doses received by personnel in 2 min while evacuating the building were calculated (Appendix D), assuming that this gas carried 10 mg/m^3 of radioactive dust (equivalent to a very dense fog) which mixes uniformly with the air in the containment zone, and are shown in Table 6 for the radioisotopes of significance.

Table 5. Hazards Summary — Building 3047

Isotope	Maximum Inventory (Ci)			Stack Discharge[b] (Ci)	Maximum Credible Accident Results	
	In Plant	In Cell	In Dispersible Form[a]		Downwind Dose[c] (millirem)	Maximum Contaminated Area[d] ($mile^2$)
Strontium-90	1×10^6	2.5×10^5	1×10^5	1.0	13.7	1.5
Cerium-144	1×10^6	1×10^6	5×10^4	0.5	0.7	0.8
Promethium-147	1×10^5	1×10^5	5×10^4	0.5	0.11	0.8
Cesium-137	5×10^5	1.25×10^5	1×10^5	1.0	0.23	1.5
Mixed fission products[e]	2.5×10^4	2.5×10^4	2.5×10^4	0.25	0.5	0.4
Cobalt-60	6×10^4	6×10^4	6×10^4	0.6	0.03	0.9
Curium-242	4×10^4	4×10^4	4×10^3	0.04	5.5	2.0
Curium-244	3.2×10^4	3.2×10^4	3.2×10^3	0.03	45.7	1.5
Americium-241	1.8×10^3	1.8×10^3	1.8×10^3	0.02	45.7	1.0
Uranium-235	1×10^{-3}	1×10^{-3}	1×10^{-1}	1×10^{-8}	2.7×10^{-7}	$5.0 \quad 10^{-7}$
Plutonium-239	6.13×10^{-1}	6.13×10^{-1}	6.13×10^{-1}	6.0×10^{-6}	0.04	$3.0 \quad 10^{-4}$

[a]In solution or a nonencapsulated dispersible solid.
[b]Based on 20% of dispersible inventory reaching the cell ventilation filters.
[c]Total integrated (lifetime) dose assuming filter operation described in Appendix D.
[d]Contaminated to greater than 30 dis/min·dm^2 alpha or 1000 dis/min·dm^2 beta, assuming filter operation described in Appendix D.
[e]Six months' decay containing 760 Ci $^{90}MPCa_{40} = 6.6 \times 10^{-9}$ µCi/cm^3.)

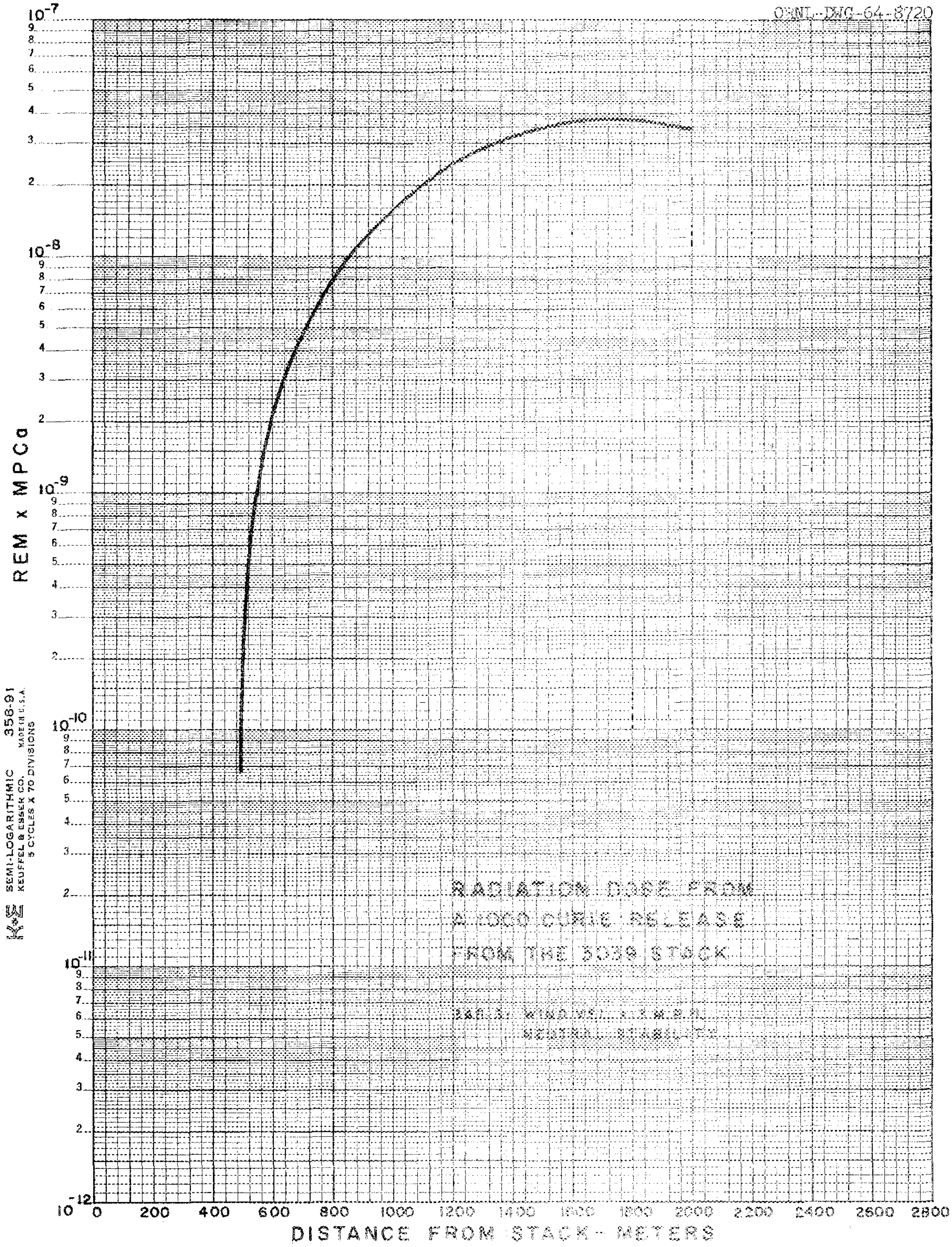

Fig. 1. Radiation Dose from a 1000-Ci Release from the 3039 Stack.

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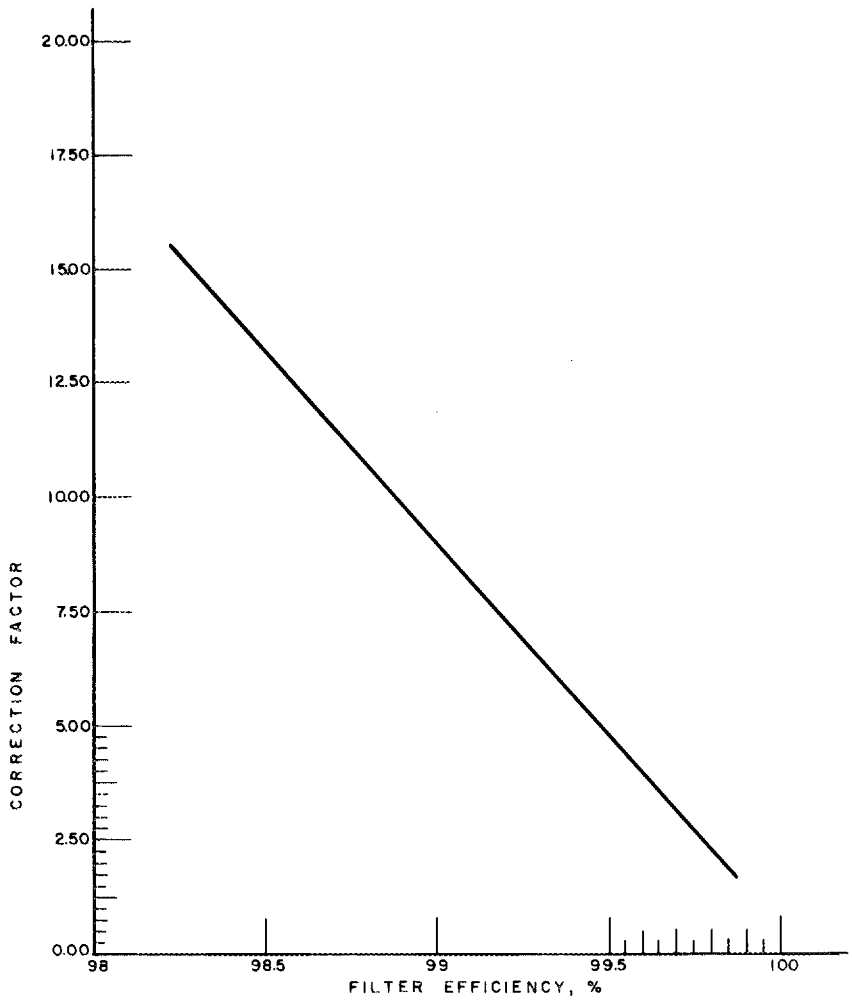

Fig. 2. Filter Efficiency Correction Factors

Table 6. Maximum Credible Accident Dose to Building Personnel

Isotope	Personnel Dose in 2 min (millirem)
Strontium-90 as titanate	91.5
Curium-242 as oxide	12,050
Curium-244 as oxide	53.5
Americium-241 as oxide	121
All other radioisotopes to be handled	<50

Building Personnel

The staff having offices or work areas in Bldg. 3047 consists of approximately nine scientists and seven technicians. Normally, all of these people will be working straight days, but on occasion there may be shift work in connection with a particular experiment or program. It is possible, but not probable, that all these people can be in the contained portion of the building at the same time. The building has an additional office for two health physicists who will carry out the health physics functions for Bldgs. 3047, 3028, and 3029. Normally, it is expected that there will also be present two or three P&E Division employees doing maintenance work or setting up equipment as well as one or two visitors not assigned to the building.

RADIATION AND CONTAMINATION CONTROL

The fixed radiation instruments normally available in Bldg. 3047 are listed in Table 7. The locations of the instruments in the building are indicated in Fig. A-6, Appendix A.

Table 7. Building 3047 Radiation Instruments

Type	Quantity	Type of Activity Detected	Containment Alarm Setting
β,γ CAM (Q-2240)	8	β,γ particulate	1800 counts/min
γ monitrons (Q-1154)	5	γ	None
β,γ personnel monitors (Q-2091)	10	β,γ	None
α CAM (Q-2340)	5	α particulate	600 counts/min
Neutron monitors	3	fast neutron	None
α personnel monitors (Q-2270)	6	α	None

In addition to the fixed instruments, there are ten portable soft-shell Cutie Pie Survey Meters and nine portable G-M Survey Meters with ∿1 mg/cm^2 end-window probes for detecting weak emitters such as ^{99}Tc and ^{147}Pm. A Survey Meter with an appropriate probe is located at each routine personnel exit in the containment zones, and there is a sign on the door to instruct all personnel to monitor their shoes before leaving the area. Nine portable (Q-2091) personnel alpha monitors are located in the building. Two fast-neutron monitors are used in Rooms 110, 211, and 212 as required. Four portable fast-neutron monitors and two portable thermal-neutron monitors are available in the Health Physics office. The containment areas are spot smeared routinely by Health Physics, and selected portions of the building are given smear checks each week. Cell entrance areas are roped off and covered with blotting paper before entry as described in the Bldg. 3047 Cell Entry Procedure.

LIQUID WASTES

Low-Level Radioactive Waste

The building connections to the low-level waste system (process waste system are:

1. All laboratory sink, bench, and hood drains
2. Cooling water (not seal water) for vacuum pump
3. All building floor drains
4. Process drain connection in each cell — normally capped unless directly connected to a particular piece of experimental equipment for the discharge of cooling water or steam condensate
5. Fan plenum chamber drains
6. Chilled-water system drain including cooling tower

The process drain system in the building is constructed of Duriron pipe except for those portions in the cells which are stainless steel. The process waste leaving the building ties into the existing Isotopes Area process drain system which flows directly to the settling basin with no intermediate hold-up tanks in the line. There are no cross connections between the process waste system and the hot waste system. The process waste stream from the building is not separately monitored or measured. Under full operating conditions, the total process waste flow should not exceed 5,000 gal/day.

Hot Waste

The building connections to the hot drain system are:

1. Floor drains in each cell
2. One hood drain from each laboratory
3. Hot off-gas sump jet discharge (via collection tank and cell D floor drain)
4. Cell ventilation sump jet discharge (via collection tank and cell D floor drain)
5. Vacuum pump surge tank, jet discharge
6. Vacuum pump seal water tank, jet discharge
7. Vacuum pump sump, jet discharge

8. Capped-off connection in Room 110

9. Capped off connection in Room 105

10. Carrier transfer line trench drain

11. Conveyor cubicles floor drains

12. Cubicle in Room 110

13. Personnel decontamination shower drain

14. Glove box drain — Room 211

15. Valved connection in Room 105

All hot drain lines in the building are shielded where necessary and are constructed of Type 304L schedule 80 stainless steel pipe. All joints are welded and have been radiographed, and the system has been pressure tested at 100 psig.

The hot drain header leaves at the west end of the building and ties into the existing Isotopes Area Hot Drain System which discharges into the WC-10 tank. This tank is sealed and approved for all types of radioactive liquid waste. The hot liquid waste leaving Bldg. 3047 is not separately measured or monitored; however, an inspection port permits a visual examination of the flow from Bldg. 3047. During normal operation, the volume of hot waste from Bldg. 3047 should not exceed 400 gal/day. During periods of cell decontamination, however, 2000-3000 gal/day may be discharged through the hot drain system.

The bulk of the hot waste will consist of aqueous solutions of various salts and nitric acid that are not unduly corrosive to stainless steel. Normally, the waste will contain only beta and gamma activities and will not exceed 10 Ci/liter. Small amounts of alpha activity ($\sim 10^5$ alpha counts/min·ml) may occasionally be discharged into the hot drain system.

Storm Sewer

The only connections from Bldg. 3047 to the storm sewer system are the building roof drains, the cooling tower pan overflow and dump line, the vacuum furnace cooling systems in Rooms 113 and 212, the cooling system manifold in Room 110, steam condensate from traps and steam condensate flash tank located in Room 102. The lines and associated equipment are not connected with any radioactive process or drain facility.

GASEOUS WASTE

Hot Off-Gas System

Hot off-gas service enters the west end of the building underground through a 4-in. stainless steel header which is connected to the existing Isotopes Area 6-in. off-gas main. One 2-in. line to each of the four cells and one 3-in. line to the alpha handling areas are the only hot off-gas service outlets in the building. The pressure on the building header normally runs about -30 in. water gage. There is no automatic pressure control on the building header, but local pressure regulators may be installed in connection with specific experimental setups where constant off-gas pressure is required.

There are no scrubbers or filters installed as permanent equipment in the building hot off-gas system. Temporary scrubbers and filters are installed as part of an experimental setup when there is a possibility of corrosive vapors or a significant quantity of radioactive particulate getting into the off-gas header. The hot off-gas is scrubbed and filtered at the 3039 stack area facility prior to being discharged.

The hot off-gas header in Bldg. 3047 is below the elevation of the Isotopes Area hot off-gas and hot drain headers. Any liquid which gets into the building header flows by gravity to a sump located in the line under cell D. The sump will hold about 4 gal before the liquid starts backing up into the header. The sump is equipped with an air purge-type liquid level instrument which trips a pressure switch and sounds an alarm on the operating corridor panel when the sump is 2/3 full. A manually operated steam jet is then used to transfer the sump contents to the hot drain.

In the event the hot off-gas sump alarm failed to function, water would back up in the header until it reached the point where it would start draining in the existing Isotopes Area hot off-gas system to the hot drain. The maximum liquid head in the line under these conditions would be -14 in. which, being less than the normal -30 in. water gage on the header, would not completely shut off the flow of off-gas from equipment in the cells unless some other pressure-restricting device was in the line. All of the off-gas service outlets in the building are well above the maximum height to which liquid would rise in the header.

CELL VENTILATION SYSTEM

The building cell ventilation main header comes off the Isotopes Area header and enters the building on the southwest corner as a 36-in. concrete pipe. In the building, cell ventilation service is provided for all hoods both in the containment and noncontainment portions of the building, each of the four cells, and the vacuum pump pit. The pressure in the header is normally -4 to -6 in. water gage and the pressure in the cells is normally at least -1 in. water gage. The dampers on the hoods are manually adjusted to give a 100-ft/min face velocity when the hood is onefourth open. Back-flow preventers are installed on all branches of the system except those serving the four cells.

Air leaving by way of selected radioactive hoods passes through a CWS-type absolute filter located in a housing on top of each hood and then goes to the Isotopes Area Filter Pit where it passes through a bank of roughing filters and a bank of CWS-type filters before going to the 3039 stack system. Air leaving by way of the chemical hoods and the vacuum pump pit is not locally filtered but is filtered by the Isotopes Area Filter Pit before going to the stack system. Air leaving by way of the cells passes through high-efficiency filters in each cell and then goes through the roughing and absolute filters in the Isotopes Area Filter Pit before going to the stack system. Air entering the cells under normal operating conditions passes through roughing filters.

Normal air flow through cells A, B, C, and D is as follows:

Cell	LFM	CFM
A	195	782
B	168	671
C	99	396
D	120	480

Before a cell door is opened, one of the high-efficiency filters is removed from its sealed position to permit an increased air flow into the cell.

All HEPA filters, both in the building and at the Isotopes Area Filter Pit, have pressure-drop measuring instruments installed across them to indicate when changing is required.

The cell is considered as the primary containment for most beta and gamma work that is carried out in the building. All of the automatic control devices on the cell air-handling system are of fail-safe design with respect to a building electrical or instrument air failure. They will provide maximum cell ventilation capacity in the event of failure of these control services.

The vacuum pump exhaust is discharged into the cell ventilation system and any gross contaminants are removed by the previously described surge tank and water-sealed pump.

The cell ventilation header is at an elevation below the Isotopes Area header and below the hot drain header. This problem is handled by providing a 6-gal sump in the low point of the line under cell D. The sump is equipped with an air purge level instrument which sounds an alarm on the operating corridor alarm panel when the sump is two-thirds full. A manually operated steam jet is used to empty the sump to hot drain. The hydrostatic head, which would exist if the sump alarm failed to function and the header filled with water, would be 18 in. water gage and would be sufficient to cut off cell ventilation. This is not considered a credible possibility because a rapid buildup of water in the header cannot occur unless water is introduced directly into the cell ventilation opening in one of the cells. At the same time, there would have to be a cell ventilation duct pressure surge to close the backflow preventer on the duct serving the vacuum pump pit in order that the water would fill up the header rather than run back into the pump pit and sound the sump alarm.

SOLID WASTE

Radioactive solid wastes from the building consist of contaminated experimental apparatus, wipes, and small process vessels. Small items such as wipes, handling tools, and small glassware are placed in 1-gal waste cans and transported by the inter-cell conveyor to cell B. The can is then enclosed in plastic and placed in a waste transfer cask and transferred to the burial ground for disposal. Any item larger than 12 by 12 in. or weighing over 50 lb cannot be handled in the inter-cell conveyor and will have to be decontaminated in the cell to a point where it can be removed through the cell door or top plug and placed in a hot Dumpster. Before a cell door or top plugs are opened for personnel access, radiation surveys are made by using a remote probe or a cutie pie survey instrument. All waste carriers are monitored and properly tagged by Health Physics before being sent to the burial ground. The standards outlined in the Radiation Safety Manual are followed. Alpha-contaminated wastes are bagged out of the alpha glove boxes before being placed in the approved containers.

Solid radioactive waste from Bldg. 3047 is handled according to Radioisotope Department Solid Waste Handling Procedure and Procedure 5.1 "Disposal of Solid Radioactive Wastes" in *Procedures and Practices for Radiation Protection, Health Physics Manual*.

PROCESS HAZARDS

Since Bldg. 3047 will not be used for any routine production operation, it is not possible to evaluate the hazards of specific processes which describe the activities being carried out from week to week.

Structurally, the cell block, including the windows, will withstand a sudden overpressure in excess of 600 lb/ft^2 without any type of failure or movement. The building structure will withstand a sudden overpressure of 5 psig without any massive failure and without damage to the emergency air-handling equipment and controls. Total hot off-gas capacity available to the building amounts to 600 ft^3/min. These building parameters along with others mentioned elsewhere in this report are used to establish the maximum quantities of chemicals that can be used in a particular experiment when the proposed experiment is reviewed. This review procedure, coupled with strict adherence to operating procedures, is expected to prevent any type of incident involving an unexpected chemical reaction.

APPENDIX A

DRAWINGS AND SCHEMATICS — BUILDING 3047

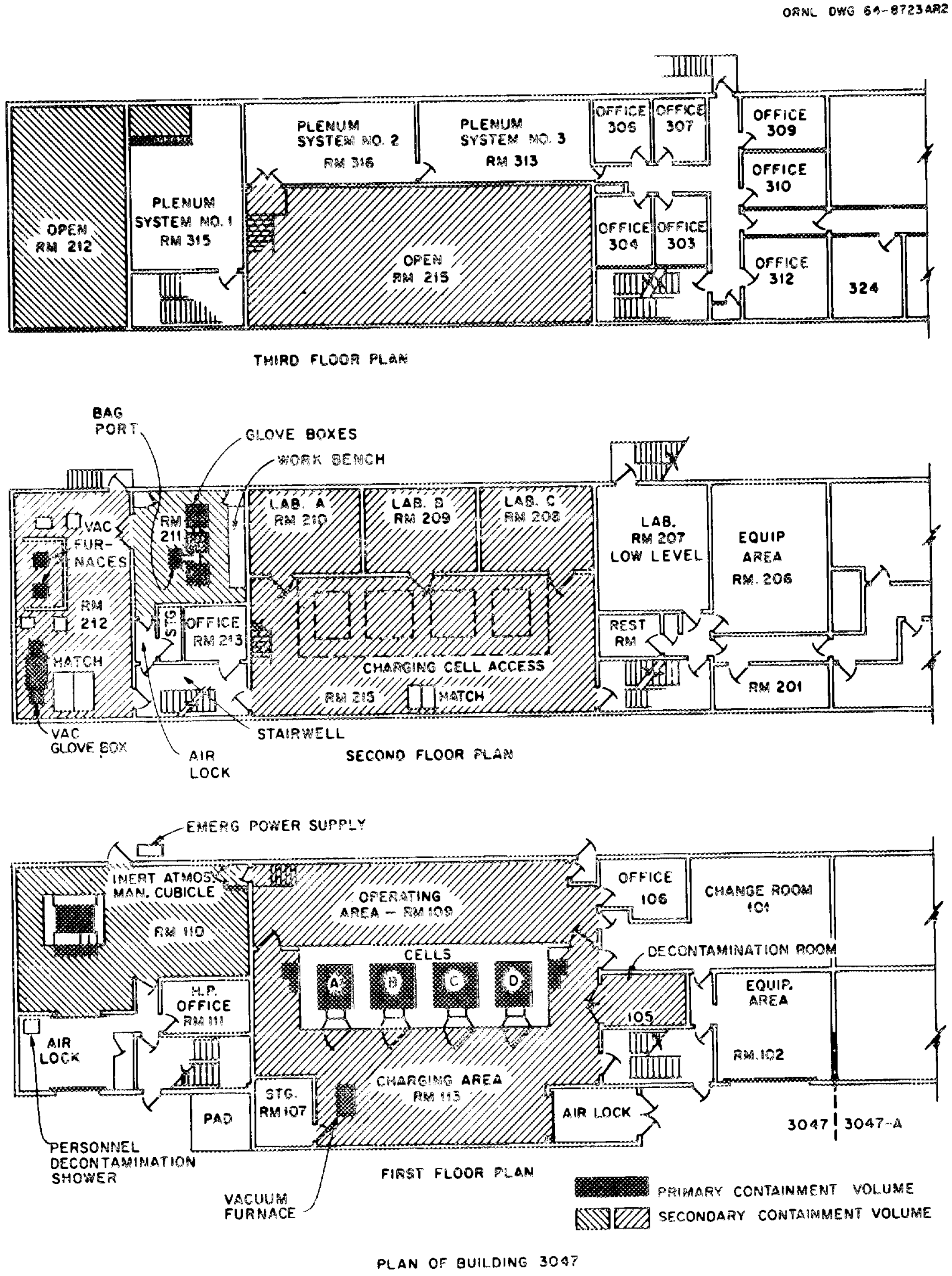

Fig. A-1. Building Plan.

ORNL-DWG 64-8722RA

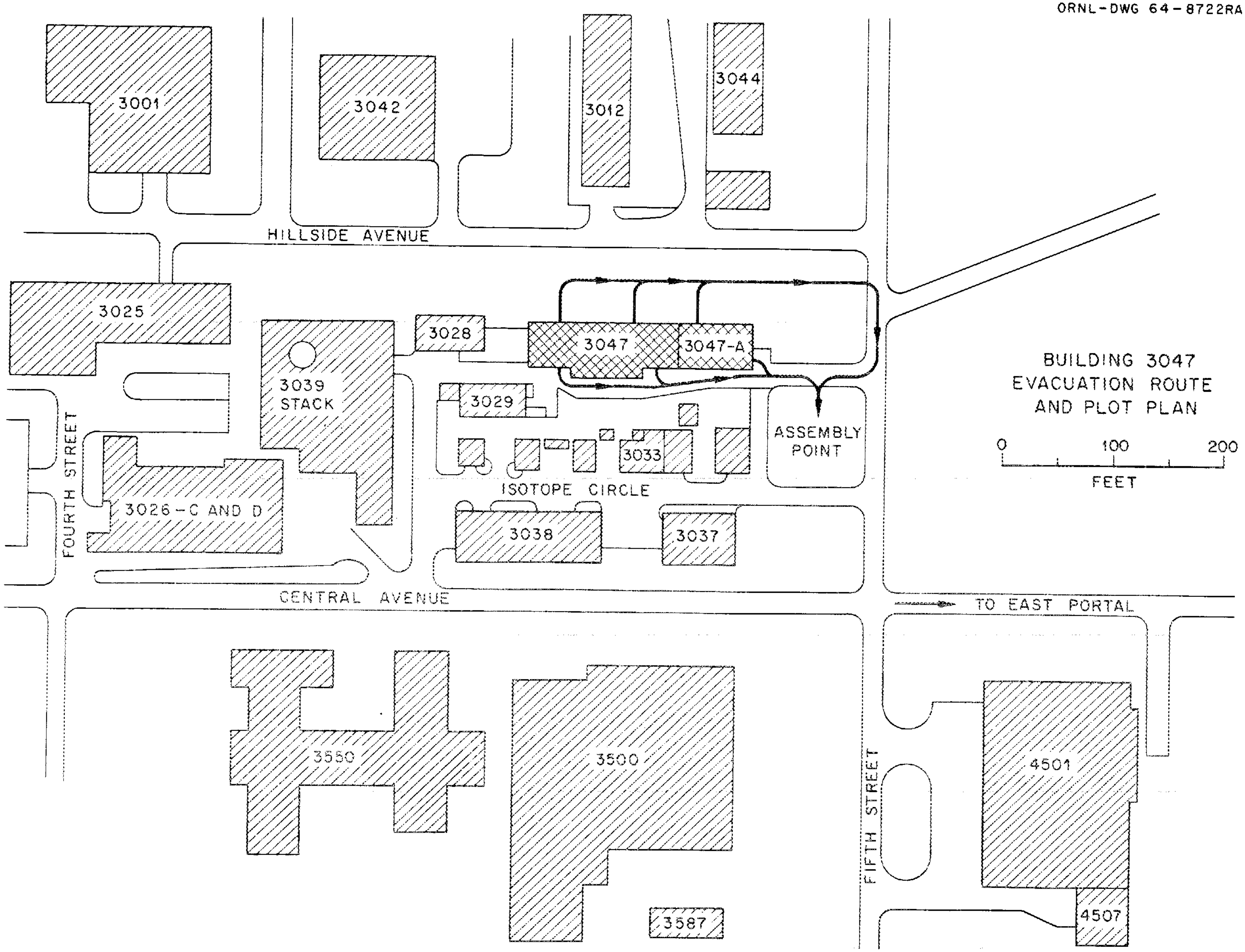

Fig. A-2. Evacuation Route and Plot Plan.

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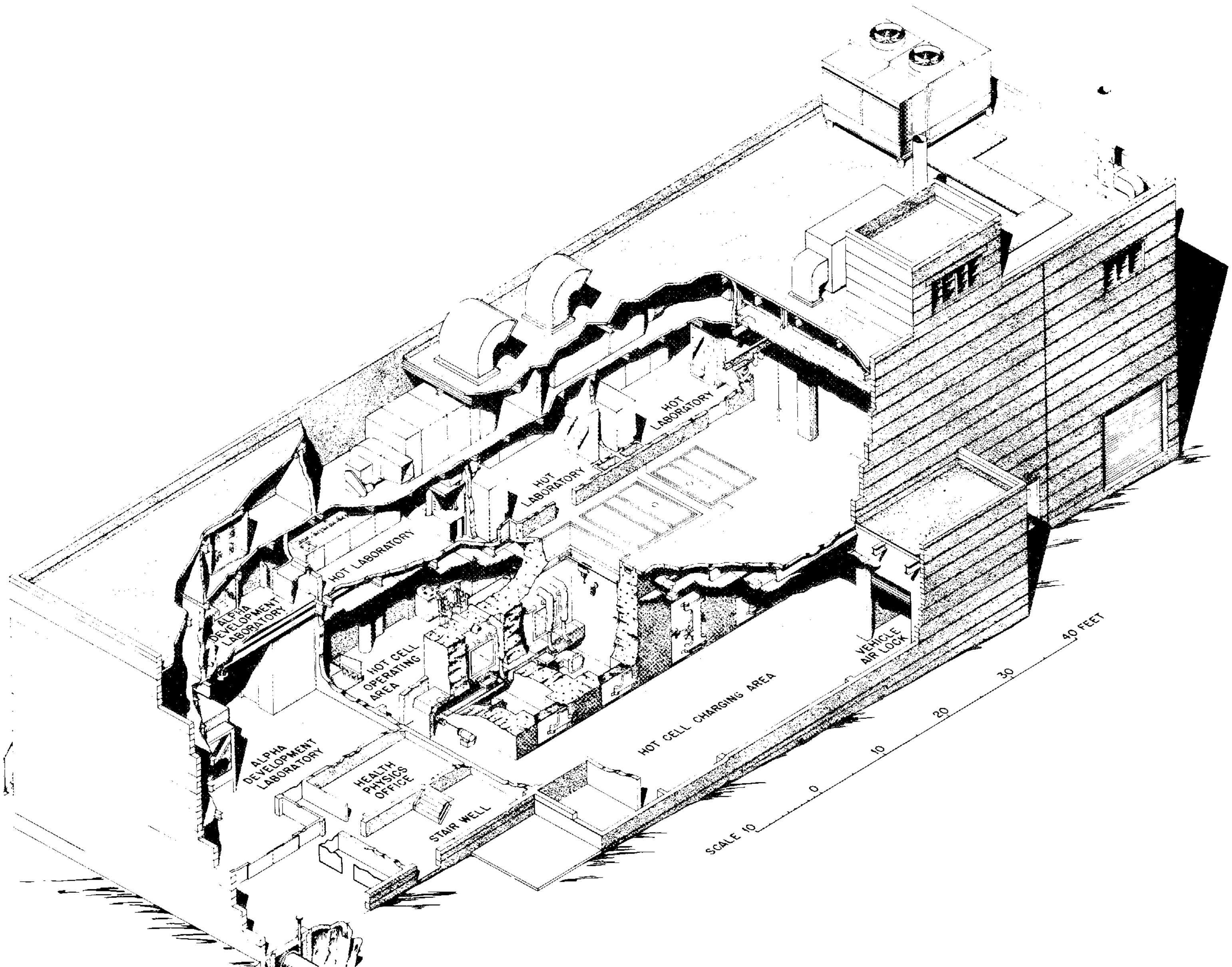

Radioisotope Development Laboratory

Fig. A-3. Radioisotope Development Laboratory - Isometric.

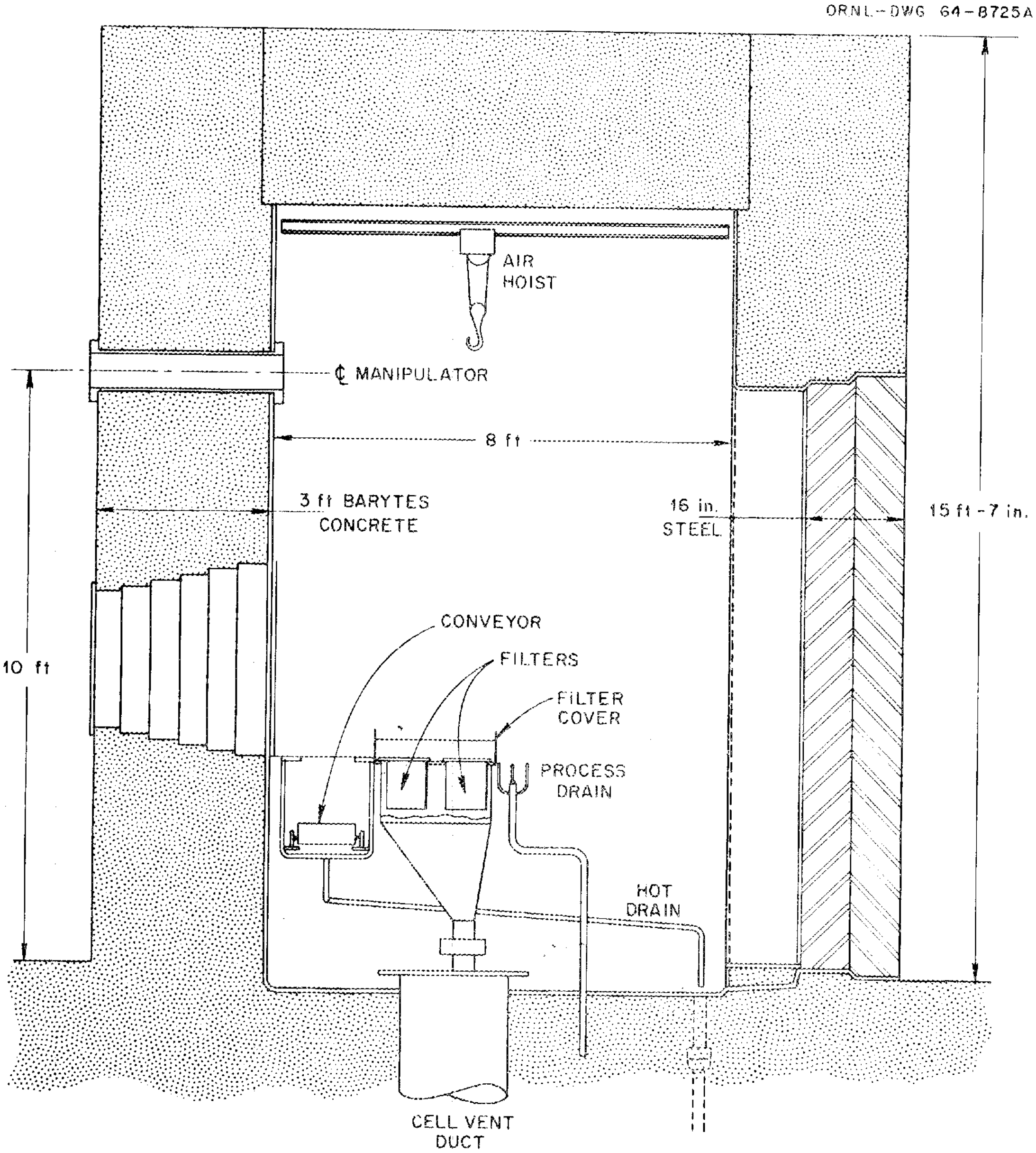

Fig. A-4. Cell Section - Typical Cells A, B, and D.

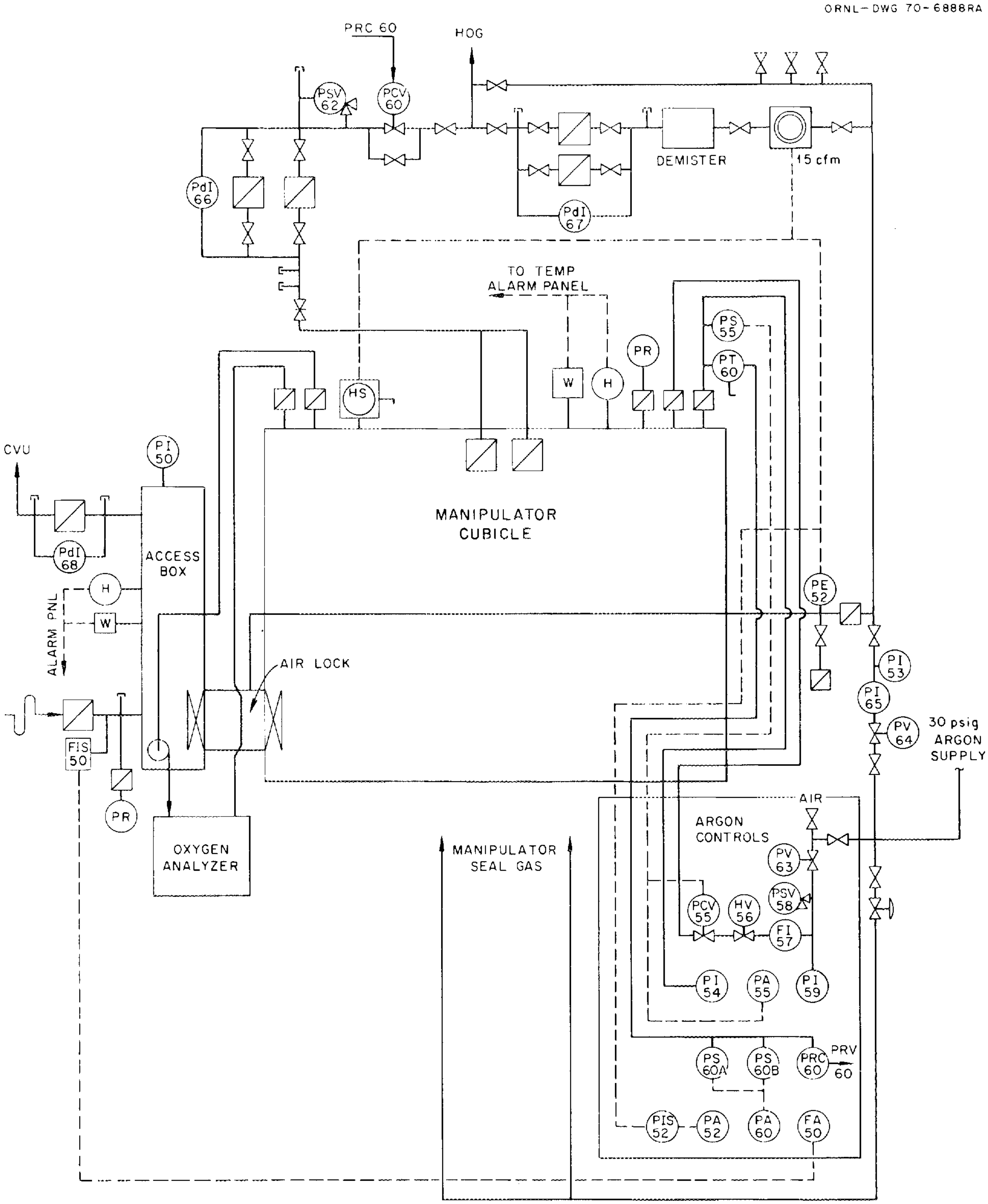

Fig. A-5. Manipulator Cubicle Instrumentation.

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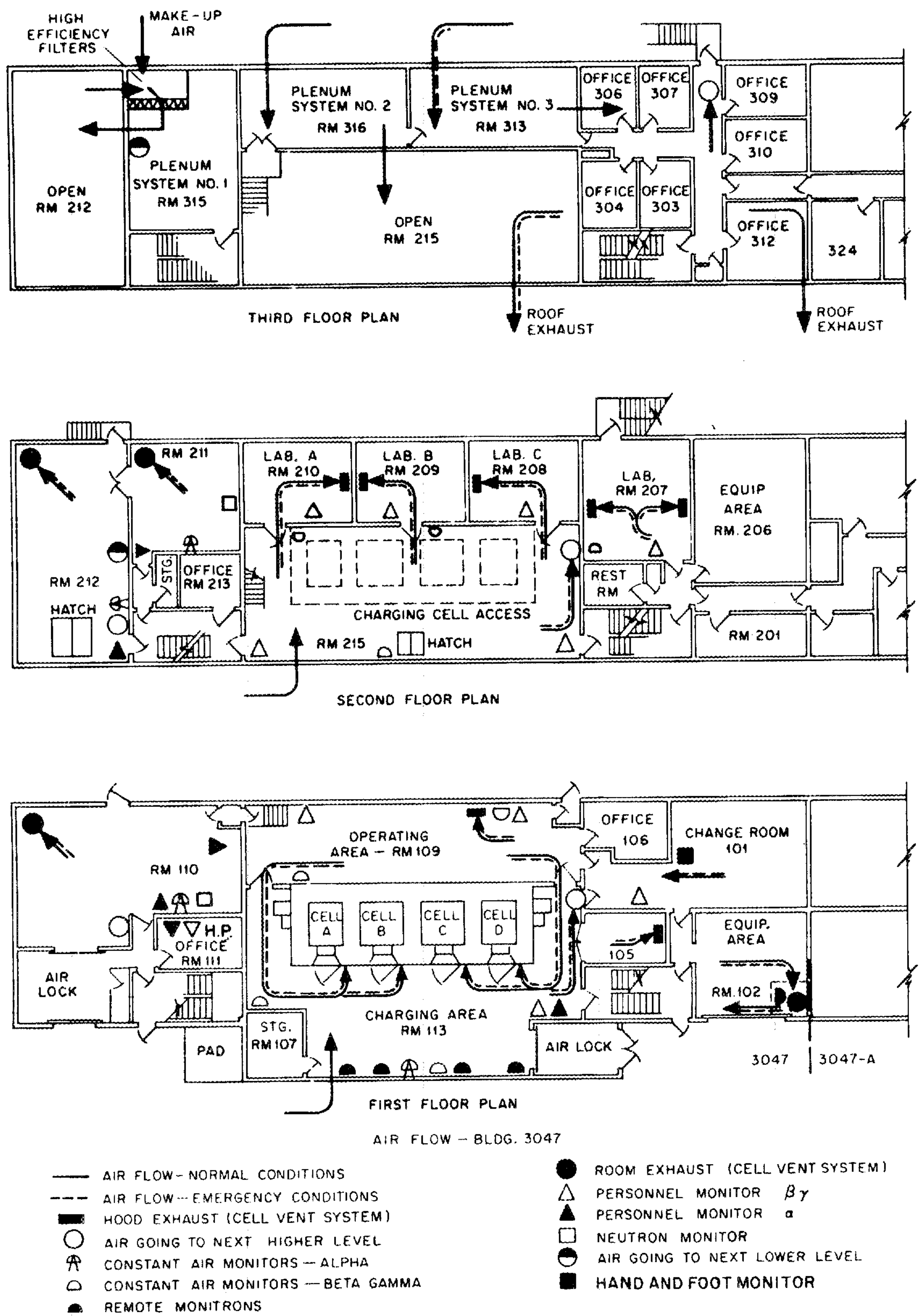

Fig. A-6. Air Flow Pattern and the Location of Radiation-Protection and/or -Detection Equipment.

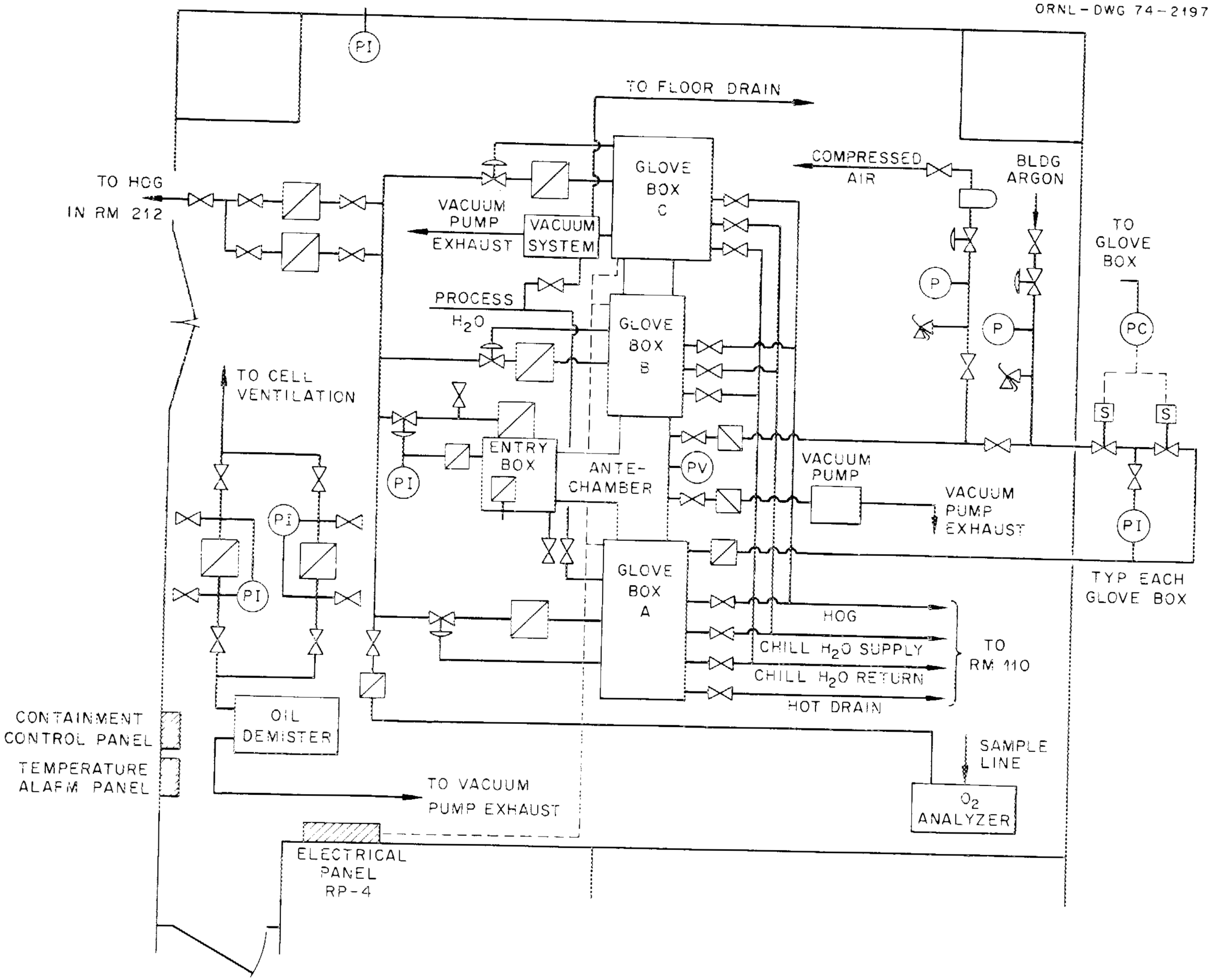

Fig. A-7. Service Piping Schematic - Alpha Glove Boxes, Room 211.

ORNL–DWG 74-2202

Alpha Glove Box Installation Building 3047, Room 211 – Reference Information

Sketch	Symbol	Description	Stores No.
SK1080A	P	Pressure Gage, 0–30 psig	
	PI	Pressure Indicator, Magnehelic, 0–4 in. wc, F. W. Dwyer	
	PC	Pressure Controller, Photohelic, 5 in.–0–5 in. wc, F. W. Dwyer	
	FI	Flow indicator, size 8	06-030-0100
	FS	Flow Switch, $^1/_2$ in. IPS	05-112-3957
	F	Heat Detector, 140F, Fenwal Detect-A-Fire, type 27121	
	PR	Pressure Relief Device (PYREX)	
		Filter, In-line, Absolute, $^1/_4$ in. IPS, MSA	
		Filter, HEPA, 50 cfm, rectangular	07-645-5012
		(cylindrical)	07-645-2675
		Filter, Prefilter	
		Electrical Receptacle, 230 VAC, 1 Φ	
		Electrical Receptacle, 115 VAC	
	FI	Flow Indicator, size 2	06-030-0125
		Flow Limiting Orifice	
	S	Solenoid Valve, $^1/_2$-in. orifice, $^1/_2$ in. IPS	07-896-2825
		Maxitrol Control Valve, 2 in. IPS, Model 210-DZ	
		Snap Tite Coupling, Female, $^3/_8$ in. IPS, SVALC-6	07-207-5317
	W	Water Level Detector, Honeywell Versa-Tran	06-020-1625
SK1081A	PV	Pressure-Vacuum Gauge, 30 in. Hg–15 psig	
		Pressure Regulator, Non-Bleeding, 0–50 psig	
		Relief Valve, 0–10 psig, $^1/_8$ in. IPS	
		Compressed Air Filter	

Fig. A-7A. Reference Information – Alpha Glove Boxes, Room 211.

APPENDIX B

CALCULATION METHODS

Maximum Downwind Dose

Radioactive material that may become dispersed in the air of a cell in Bldg. 3047 is filtered first in the cell through high efficiency filters then is carried through underground ductwork to the Isotopes Area Filter Pit and then to the 3039 stack where the air is discharged to the atmosphere at a height of 250 ft. All of the dispersible inventory in a cell will not reach the filters because some particles will be too large to remain entrained in the air stream and many others will be removed by impingement against the walls of the cell and equipment. For the purposes of these calculations, it is assumed that 20% of the dispersible inventory reaches the filters and that the particle size distribution and filter efficiency are as follows:[1]

Particle Size Range (μm)	Percent of Total Weight	Filter Removal Efficiency (%)
	In-Cell Filters	
≥0.3	98.8	99.95
0.1–0.3	1.1	95.0
>0.1	0.1	87.0
	Isotope Area Filter Pit	
≥0.3	42.1	99.6*
0.1–0.3	46.8	94.7*
≥0.1	11.1	86.7*

*Filter efficiencies for ≥0.3 verified by DOP testing other efficiencies obtained by scale down.

It is assumed that all material which passes through the in-cell filters reaches the filter pit.

If it is assumed that the radioactive material which penetrates the filters passes out the stack in a short period of time, the maximum dose will occur at the point where the plume hits the ground and will depend on the dilution of the plume as it expands upon leaving the stack. The extent of the dilution will vary according to the height of the stack, wind velocity, and the atmospheric conditions and is evaluated for a specific set of conditions as follows:[2]

$$k_{ma} = 2/(\pi e \mu h^2) \ ,$$

$$k_{ma} = 1.37 \times 10^{-5} \text{ sec/m}^3 \ .$$

where

k_{ma} = maximum average stack dilution factor, sec/m^3,

μ = wind velocity, m/sec,

h = effective stack height, m.,

and for the Bldg. 3039 stack (at a wind velocity of 3 mph, $k_{ma} = 1.37 \times 10^{-5}$ sec/m^3.

A value of 3 mph has been chosen as the wind velocity because k, which describes the maximum average ground concentration, goes through a maximum at about this value due to the dependence of the effective stack height on wind velocity.[3]

The maximum dose received downwind for a given set of atmospheric conditions (k) can then be written:

$$D = \frac{(C)(k)(0.1)(1.44)}{(1.44 \times 10^5)(MPCa_{40})} \text{ rem ,}$$

where

C = activity released from the stack, Ci,

k = stack dilution factor, sec/m^3,

MPC_{40} = maximum permissible concentration of radioactive material in air that will give a 100-mrem dose in 40 hr of exposure, Ci/m^3,

1.44×10^5 = seconds in 40 hr,

1.44 = factor to compensate for increased breathing rate.

The curies (C) of activity released from the stack can be obtained from the particle size distribution and filter efficiency as follows:

$$C = Q_D(0.2)[(0.988)(5 \times 10^{-4}) + (0.011)(0.05) + (1 \times 10^{-3})(0.13)] \times$$
$$[(0.421)(4 \times 10^{-3}) + (0.468)(0.053) + (0.111)(0.133)],$$

where

Q_D = dispersible inventory in cell, Ci.

Therefore the maximum downwind dose for a particular isotope may be written as:

$$D = \frac{(1.35 \times 10^{-16})}{MPCa_{40}} = Q_D \text{ rem .}$$

Downwind Dose Distribution

It is assumed that the particles discharged from the stack are small enough to behave essentially like a gas, and the dilution of the plume at any distance from the stack will depend on the wind velocity, atmospheric diffusion coefficient, and atmospheric stability conditions. The stack dilution factor at any distance, X, from the stack is:[4]

$$k = \frac{2}{\pi C_x^2 X^{2-n} m} e^{-(h^2/C_x^2 X^{2-n})} ,$$

where

k = stack dilution factor, sec/m^3,

μ = wind velocity, m/sec,

h = effective stack height, m,

X = horizontal downwind distance from stack, m,

C_x = atmospheric diffusion coefficient,

n = atmospheric stability parameter.

For the neutral atmospheric conditions assumed in this report, the values of C and n are 0.1 and 0.25, respectively.

The time required for the plume to reach the ground (the maximum average ground level dilution) is:[5]

$$t = \frac{1}{m}(h^2/C_x^2)^{1/(2-n)}$$

Therefore the horizontal distance from the stack at which the maximum ground level dose is incurred is:

$$X_{ma} = t\mu = (h^2/C_x^2)^{1/(2-n)} .$$

Maximum Contaminated Area

The maximum area enclosed by a specified contamination isopleth resulting from the plume of a stack release can be approximated by:[6]

$$A_{max} = 0.18/(w/c) ,$$

where

A_{max} = maximum contaminated area, m^2,

w = contamination level, Ci/m^2,

c = curies released from stack.

If an area is considered contaminated, it exceeds 30 dis/min·dm^2 alpha or 1000 dis/min·dm^2 beta-gamma, then

$$A_\alpha = (1.53 \times 10^3)c/30 \text{ mile}^2 \quad ,$$

and

$$A_{\beta\gamma} = 1.53c \text{ mile}^2 \ .$$

Dose to Containment Zone Personnel

The volume of air which will flow from the primary containment to the secondary containment if the primary containment volume becomes pressurized depends on the duration of the pressurization, the pressure differential between primary and secondary containment volumes during pressurization, and the leak rate of the primary containment barrier.

The dose received by personnel in the containment zone at the time of an accidental release of airborne radioactive material from a cell will depend on the type and quantity of radioactive material released, the extent to which the activity mixes with the air in the secondary containment volume, and the time required by personnel to evacuate the area.

No location in the containment zone is more than 15 sec walking time from an exit. The cell pressure-sensing switches would give the first alarm of the incident and would put the building in containment. Assuming there would be some reaction time on the part of individuals in the containment area, 2 min has been chosen as a reasonable evacuation time.

The amount of radioactive material carried by the gases escaping from the primary containment volume depends upon the size of the particles and the size of the openings through which they escape. Since these factors are unknown, a volume of 10 mg of solids per cubic meter of gas has been used for the dose calculations. This is equivalent to the maximum stable aerosol of water droplets in air and probably represents an extreme case. It is also assumed that the radioactive material is uniformly dispersed in the secondary containment volume when it escapes from the cell and that the breathing rate of personnel in the containment zone during the emergency will be 44% faster than normal. The dose received during the 2-min evacuation can be written as:

$$D = \frac{(W)(10)(SpA)(0.1)(120)(1.44)}{(V_B)(1.44 \times 10^5)(MPCa_{40})} \text{ rem} \quad ,$$

where

W = volume of gas escaping primary containment = 2.7 ft^3,

SpA = radioactivity of entrained material, Ci/mg,

V_B = volume of containment zone = 8.093×10^4 ft^3,

$MPCa_{40}$ = maximum permissible concentration of entrained radioactive material that will give a dose of 100 mrem in a 40-hr exposure period, Ci/m^3.

For example, in the case of ^{90}Sr as the titanate (47.7% ^{90}Sr):

$$D = \frac{(2.7)(10)(6.86 \times 10^{-2})(10^{-1})(120)(1.44)}{(8.093 \times 10^4)(1.44 \times 10^5)(3 \times 10^{-10})} = 0.0915 \text{ rem} .$$

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