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SAFETY ANALYSIS FOR THE THORIUM-URANIUM RECYCLE FACILITY

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OAK RIDGE NATIONAL LABORATORY
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METALS AND CERAMICS DIVISION

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J. W. Anderson
General Engineering Division

S. E. Bolt
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MAY 1969

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CONTENTS

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J. W. Anderson[1] S. E. Bolt[2] J. M. Chandler[3]

ABSTRACT

The Thorium-Uranium Recycle Facility (TURF), Building 7930 at the Oak Ridge National Laboratory will provide the initial focus for the Thorium Utilization program, but the facility is designed and constructed to have a much broader application for demonstrating and evaluating the economics and remote operability of experimental recycling of various fuels of importance in the AEC program. The TURF is to be used in developing a wide variety of processes for the several fuel types using the thorium cycle. It is intended to be useful over a long period, for it has sufficient space to accommodate the equipment for processing and fabricating two different types of fuel assemblies simultaneously. The processing methods to be developed are those that produce a low degree of fission-product removal and therefore require remote handling and operation.

This report presents a safety analysis for the Thorium-Uranium Recycle Facility and the proposed operations and procedures. The topics covered are: (1) a description of the building and building services, the cell bank processing area, and process services, with special emphasis on provisions for containment of hazardous materials; (2) provisions for handling liquid and gaseous waste; (3) containment and safeguards for processing radioactive materials; (4) operating safeguards; (5) control of personnel exposure; and (6) radiation contamination control.

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[1] General Engineering Division.

[2] Reactor Division.

[3] Chemical Technology Division.

1. INTRODUCTION

The Thorium-Uranium Recycle Facility (TURF) has been constructed at Oak Ridge National Laboratory to help develop and demonstrate economic remote methods for reprocessing irradiated thorium-based fuels and refabricating the purified fertile and fissionable material into fuel elements suitable for reuse in a power reactor. The reprocessing methods to be developed are those which produce a low degree of fission-product removal and therefore require remote handling.

Radiation exposure from thorium daughter activity can be minimized by purification of the uranium before fabrication; then, direct fabrication techniques can be used. This method can only be used for the fabrication of fuel with relatively low (< 50 ppm) (ref. 4) ^{232}U content, however, and is limited by the necessity to store the recycle thorium for a decay period of 10 to 15 years before its return to the fuel cycle. On the other hand, shielded, remote fabrication methods permit simplified reprocessing methods that yield only modest decontamination factors and will allow the thorium to be recycled currently.

The TURF is to be used in developing a wide variety of processes for the several fuel types that use the thorium cycle. It is intended to be useful over a long period; it has sufficient space to accommodate the equipment for processing and fabricating two different types of fuel assemblies simultaneously. The facility is divided into four major areas:

1. an office and conference area adjacent to but isolated from areas that contain radioactivity;
2. an operating area with a development laboratory, chemical makeup area, and equipment rooms for facility service equipment;

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[4]R. E. Brooksbank *et al.*, "The Impact of Kilorod Facility Operational Experience on the Design of Fabrication Plants for ^{233}U-Th Fuels," pp. 321–340 in *Thorium Fuel Cycle* (Proceedings of Second International Thorium Fuel Cycle Symposium May 3–6, 1966) R. G. Wymer, Coordinator, U.S. Atomic Energy Commission/Division of Technical Information, Oak Ridge, Tennessee, February 1968.

3. a maintenance operating area with service areas for receiving and storing spent fuels; and
4. a cell complex containing seven hot cells (six shielded and one unshielded).

These areas provide the following:

1. shielding to provide biological protection from fission-product radiation of sources as large as 35 kg ^{233}U irradiated to 25,000 Mwd/ton and decayed for 90 days (allowable exposure in routinely occupied areas is limited to 0.25 mr/hr);
2. provisions for receiving, processing, and refabricating fuel assemblies up to 12 ft long;
3. a chemical cell for chemical process research and development equipment;
4. a mechanical processing cell for mechanical operations, such as disassembly and feed preparation, incident to reprocessing irradiated fuel assemblies;
5. a contaminated fabrication cell for fabrication operations required to convert prepared uranium and thorium compounds into reactor-fuel assembly components, compacts, elements, etc.;
6. a clean fabrication cell for final fabrication and inspection of elements or fuel assemblies;
7. a decontamination cell serving as a radiation lock and as a decontamination area connected to a glove maintenance room for repairing decontaminated equipment;
8. a lightly shielded, stand-by storage cell for contaminated equipment that is still useful but not needed for the program in progress;
9. a fuel receiving station and storage basin for a small number of irradiated fuel assemblies from power reactors (the facility provides the enclosing structure and personnel bridge with hoist; not provided are special handling equipment, storage racks, transfer carriers, or shipping casks that must be designed for the particular fuel assembly to be accommodated);
10. liquid and gaseous waste disposal systems to safely collect and dispose of high-activity waste; and

11. provisions for future use of an inert gas blanket to permit work with pyrophoric fuel materials such as carbides (the purification system is not yet installed).

The purpose of this report is to analyze the facility and the proposed operating procedures to determine that the facility is suitable for safely housing radiochemical separation and fuel element refabrication processes for spent reactor fuels. It is not the intent of this report to analyze any particular process operation, since these will be treated as entities and covered under individual analyses prepared for each processing operation.

This report does identify the capacities designed and built into the facility; therefore, it provides the criteria against which the review of future processing operations can be evaluated.

2. PHYSICAL PLANT

The Thorium-Uranium Recycle Facility is located in the Melton Valley area at Oak Ridge National Laboratory (Fig. 2.1). Nearby facilities, which include the High Flux Isotope Reactor (HFIR) — Building 7900, the HFIR office and maintenance building — Building 7910, and the Transuranium Processing Plant (TRU) — Building 7920, are shown in Fig. 2.2.

2.1 Building Description

The three-story structure with partial basement was designed in accordance with the Southern Building Code for Group G industrial occupancy. It is constructed of structural steel, reinforced concrete, and masonry. Perimeter walls are of reinforced concrete block. Floors are reinforced concrete slabs that are either poured on compacted aggregate or supported on structural steel. The roof is metal decking covered with built-up roofing. The building is of irregular shape with an overall width of 124 ft, an overall length of about 162 ft, and a

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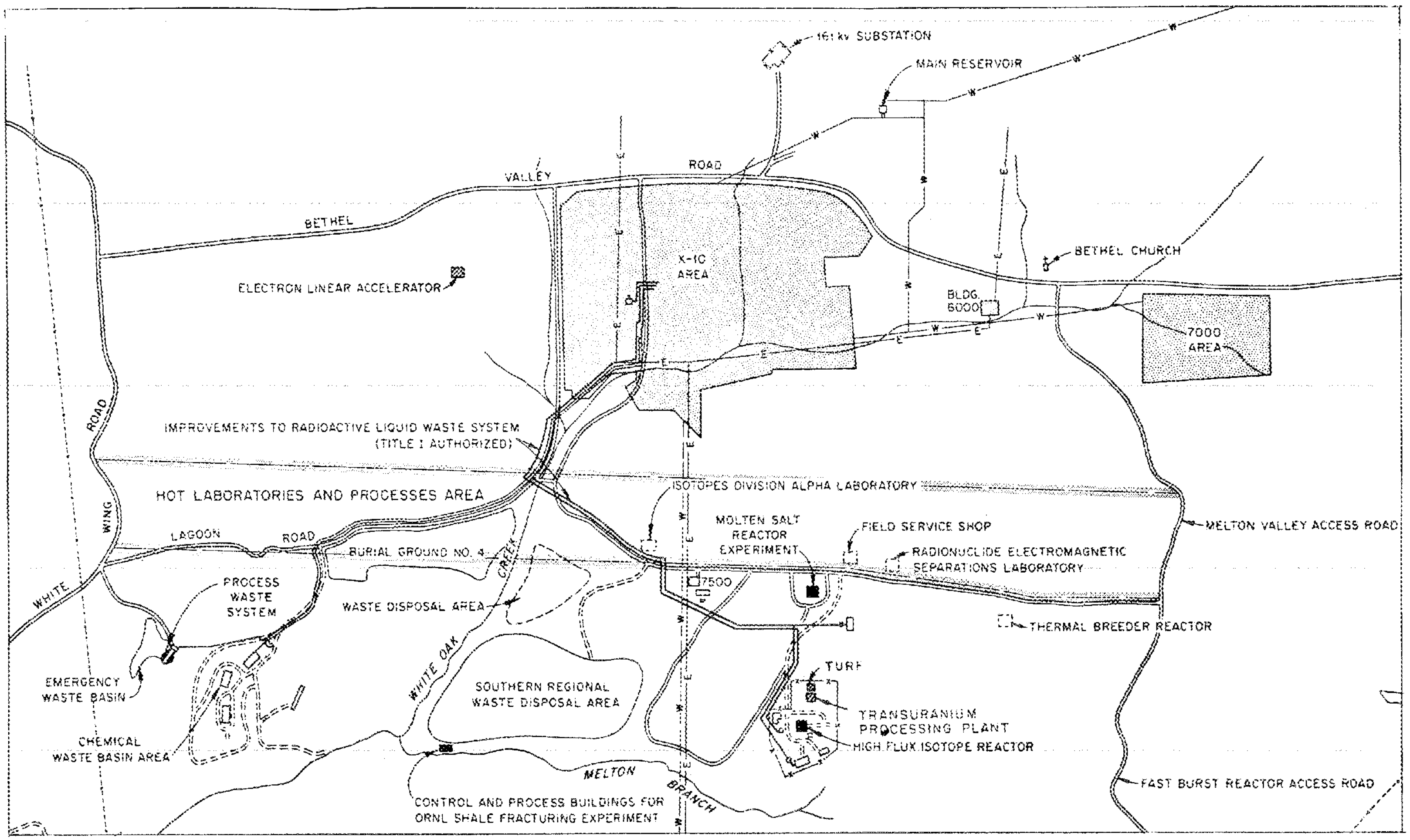

Fig. 2.1. Oak Ridge National Laboratory Area Map Including Melton Valley Facility.

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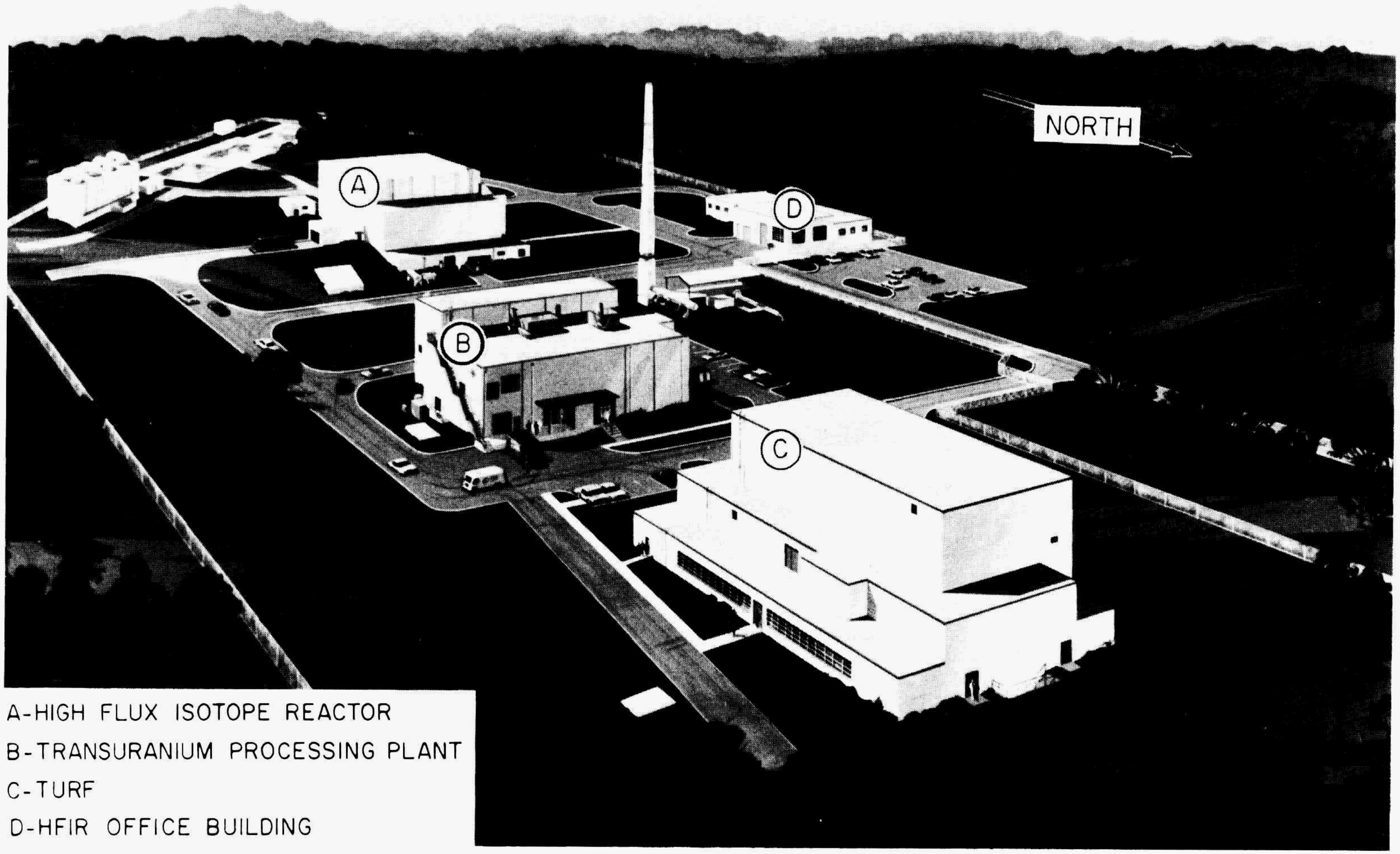

Fig. 2.2. Melton Valley Facilities.

gross floor area of 32,950 ft^2, exclusive of hot cells. The building is divided into areas as follows:

	Usable Area (ft^2)	Service Area (ft^2)	Volume (ft^3)
Basement area	1,120	1,137	22,091
Cell area	2,859	285	71,148
Office area	1,934	590	32,812
First floor area	6,588	2,461	117,637
Second floor area	2,676	5,348	108,324
Third floor area	400	2,590	195,672
Cell roof area	2,460	1,107	128,420
Filter and waste pit area		475	6,525
Site buildings		397	4,367
	18,037	14,390	645,996

The first floor provides space, as shown in Fig. 2.3, for technical personnel offices, operating space for cells and maintenance, a receiving area, a fuel storage room with deep, water-filled basin, hot and cold change rooms, a compressor room, and an elevator equipment room.

The second floor provides space, as shown in Fig. 2.4, for chemical makeup, sampling of radioactive materials, a development laboratory, a warm shop, a maintenance area, mechanical and electrical equipment rooms, a cask decontamination station, a checking and holding area, and working space around cell A.

The third floor, a high bay, includes the cell roof area, as shown in Fig. 2.5, and provides facilities for entry of cell services and cell access. It is equipped with a 50-ton overhead traveling bridge crane with a 5-ton auxiliary hoist. Some of the third floor space is used for cell and building ventilation equipment and will be used as necessary for mockup of cell process equipment.

A partial basement provides space for access to cell F and for installation of vulnerable radioactive equipment in a pump room adjacent to cell G.

The facilities for receiving, handling, and storing radioactive materials consist of six heavily shielded cells served by an overhead

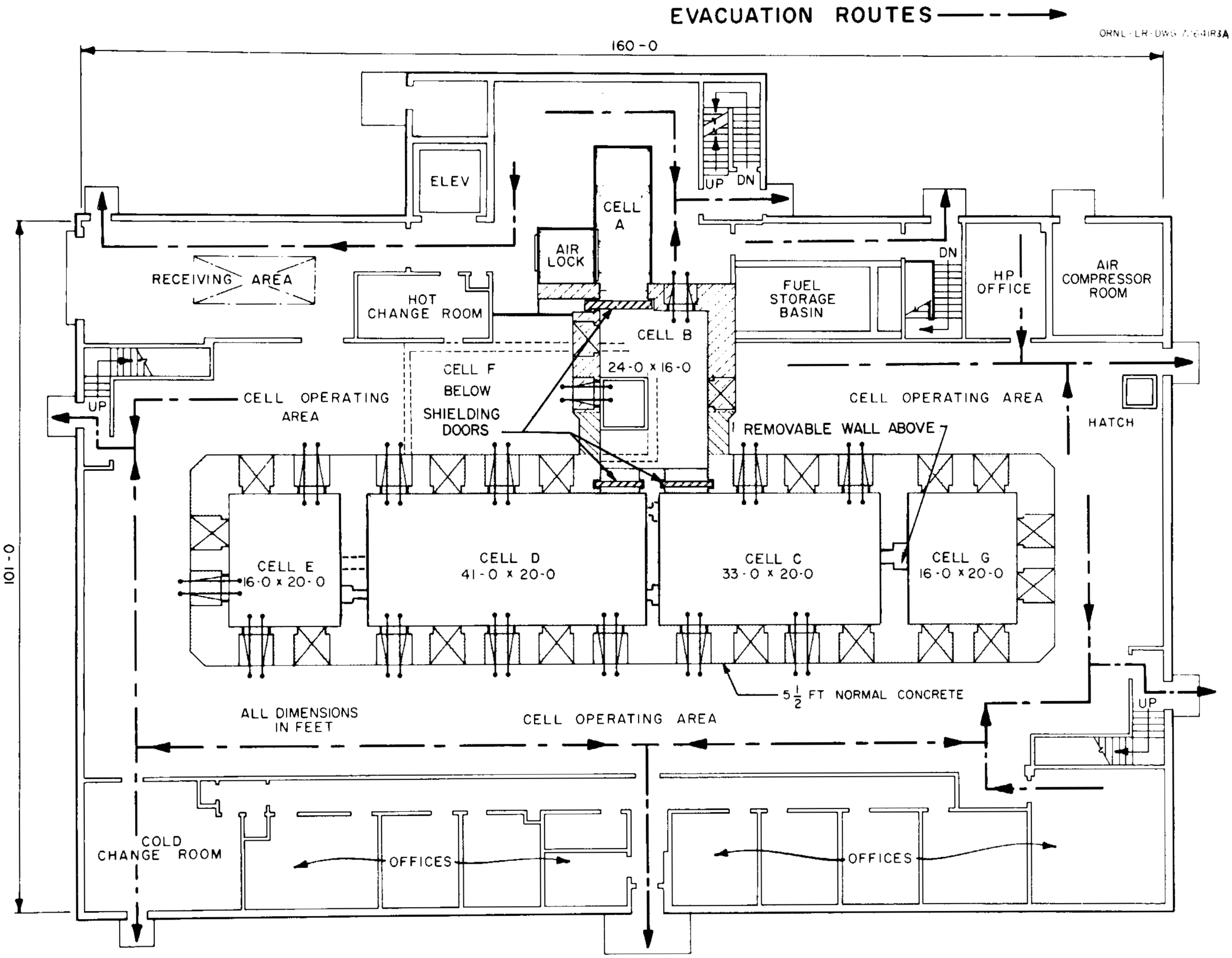

Fig. 2.3. First Floor Plan.

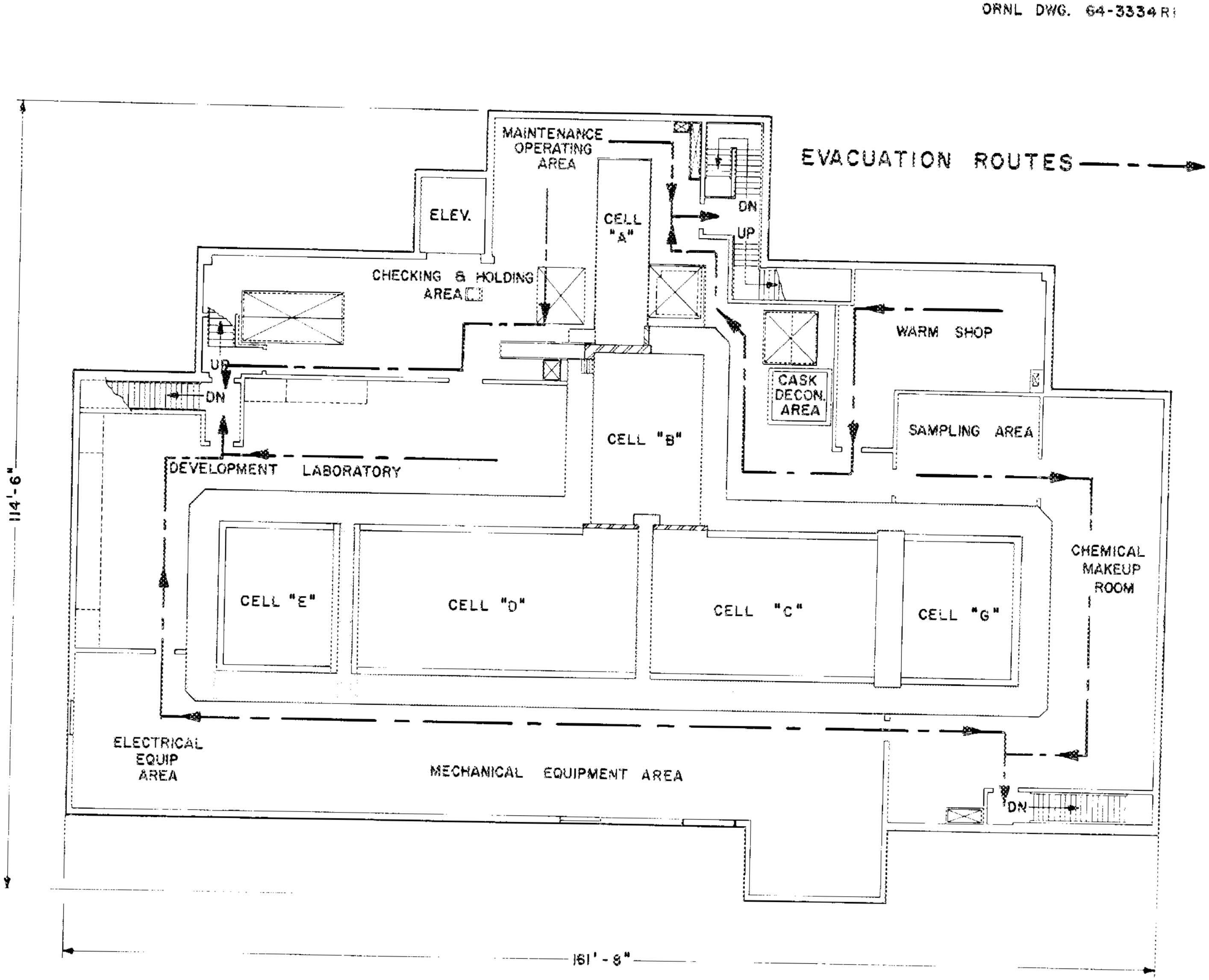

Fig. 2.4. Second Floor Plan.

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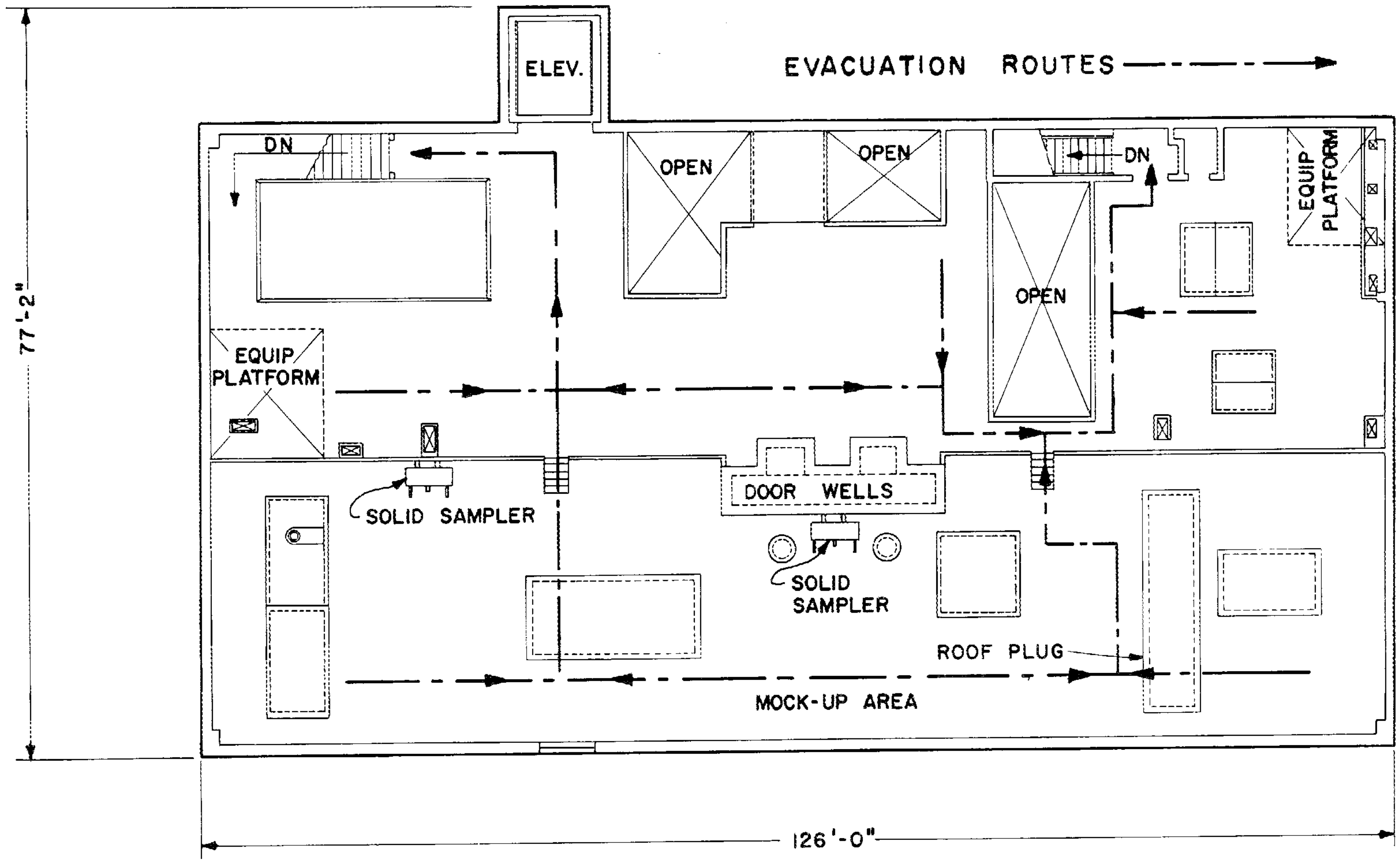

Fig. 2.5. Third Floor Plan.

crane and electromechanical manipulator system along with master-slave manipulators; in addition there is an unshielded glove maintenance cell; a fuel storage room with a deep, water-filled basin area with a cask support and decontamination area in the second floor. The development laboratory on the second floor will be used for cold development of equipment and for preparing materials in direct support of cell operations. The checking and holding area on the second floor will be used for maintaining equipment movement control and preventing the spread of contamination while moving things in and out of the building through the receiving area on the first floor.

The hot cell structure shown in Figs. 2.6 and 2.7 is in the shape of a "T" and consists of one straight section with exterior dimensions of about 127 ft long, 31 ft wide, and 29 ft high, excluding the cell pit areas, plus another section about 27 ft long, 24 ft wide, and 27 ft high that runs at right angles to the first section and abutts to it. In addition, a lightly shielded (2 ft thick) equipment storage cell about 15 ft wide, 37 ft long, and 13 ft high is adjacent to the lower elevation of the bulk of the structure.

The 127-ft-long cell section is divided into four main cells. Cell G (chemical cell) is constructed to permit future conversion to remote maintenance. The second and third cells in line, cell C (mechanical processing cell) and cell D (contamination fabrication cell), are for fully remote mechanical processing of spent reactor fuels and contaminated fabrication of new fuel elements, respectively. The fourth cell in line, cell E (clean fabrication cell) is to be used for fabrication and inspection operations on fuel element components that are free of external contamination. The 27-ft-long leg of the "T"-shaped cell bank will contain cell B (decontamination cell), which will be used for remote maintenance and decontamination of cell equipment. It is equipped with three shielding doors that open into the two central processing cells (cells C and D) on one end and to the glove maintenance cell (cell A) on the other end. A floor hatch connects cell B with cell F (fuel storage cell). Cell B is also connected to the fuel storage basin by means of a port to a short, water-filled canal for fuel transfers to cell B from the basin pool.

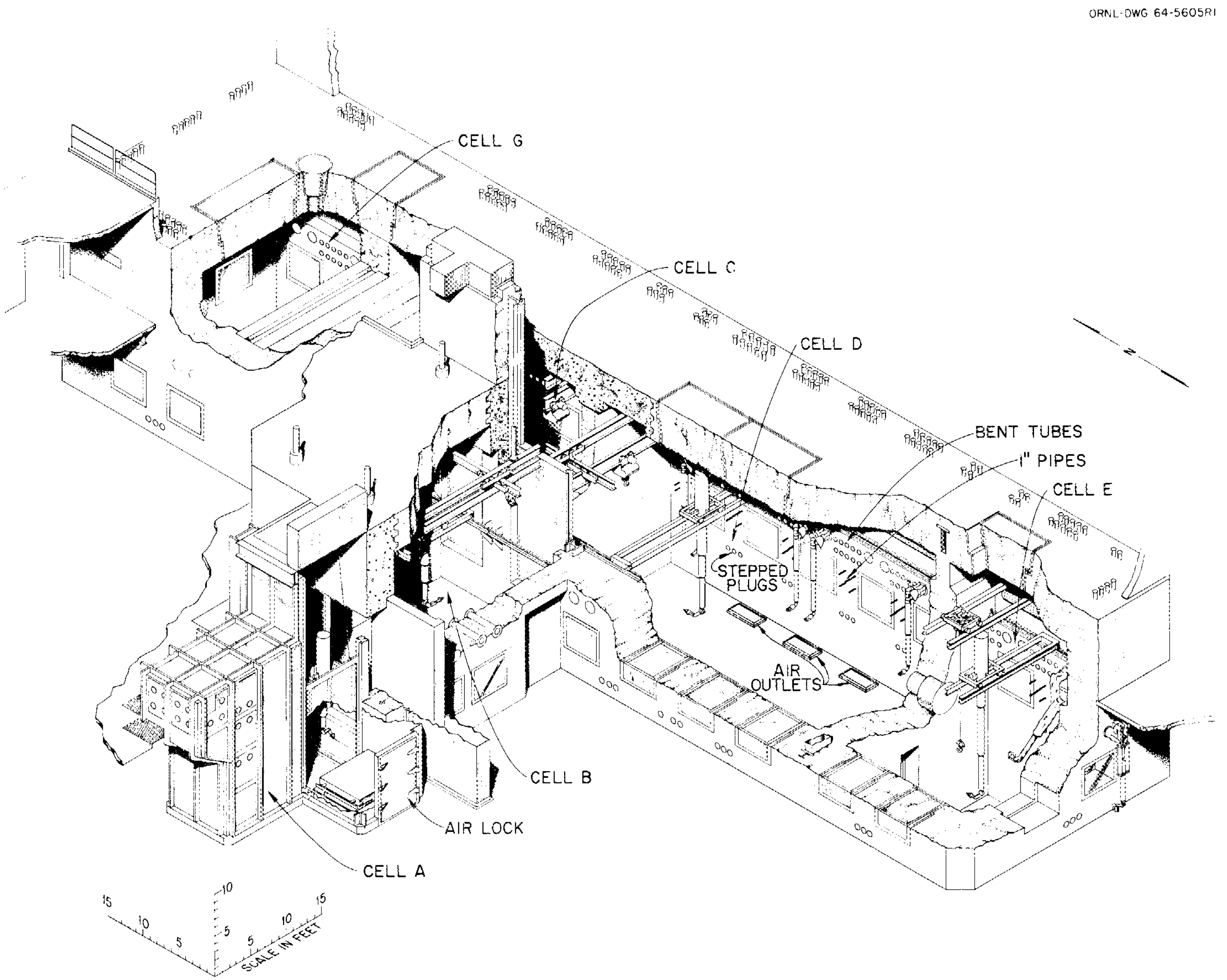

Fig. 2.6. TURF Cell Bank.

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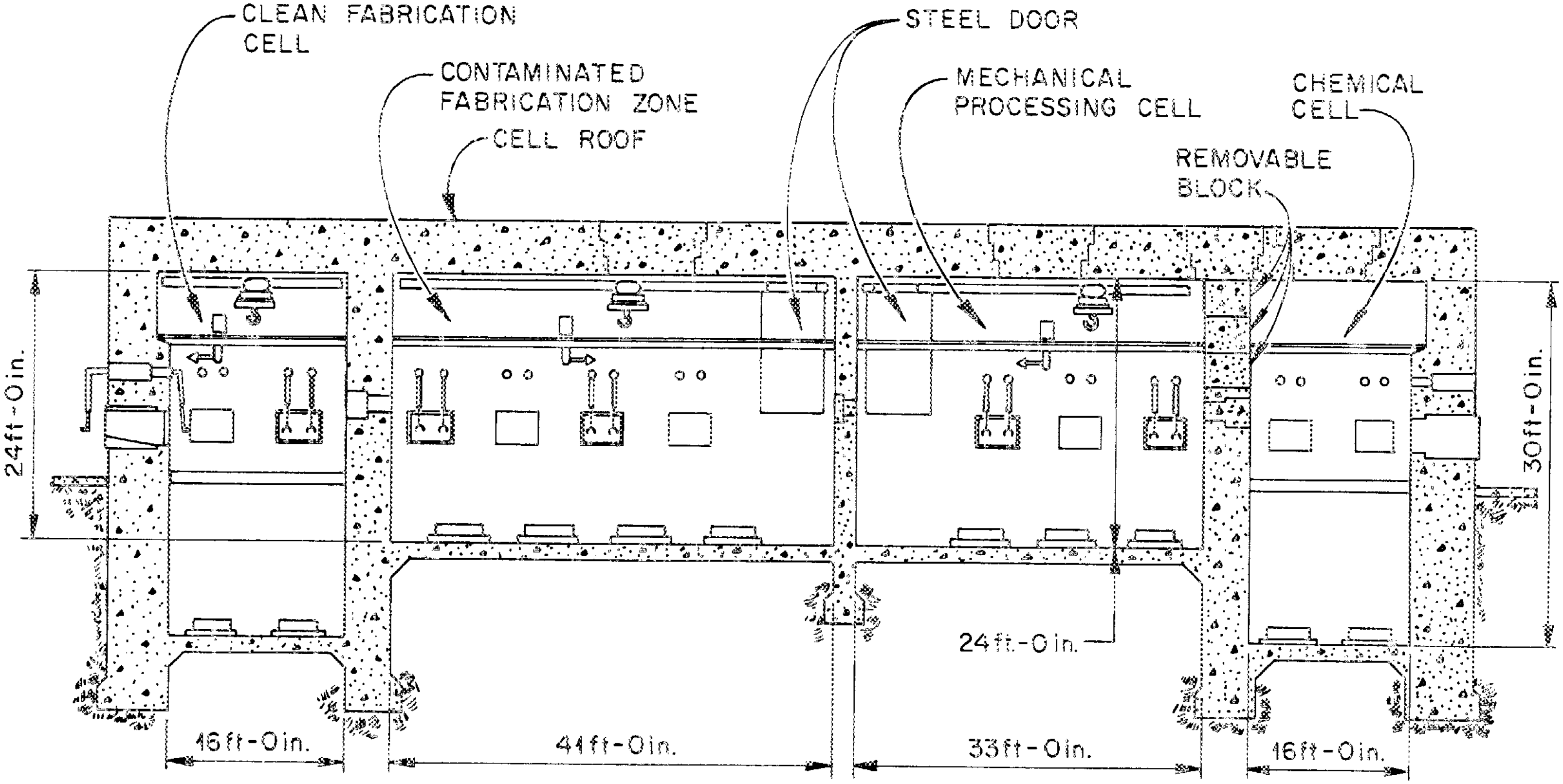

Fig. 2.7. Elevation of Operating Cells.

The operating face of each cell is divided into 8-ft operating modules. A typical module provides a viewing window, openings for master-slave manipulators, and openings for cell services. Viewing windows are provided at alternate operating modules in cells B, C, and D as needed for the particular process in cells G and E. Seven pairs of master-slave manipulators are provided at various cell modules as required for the process. The remaining windows, manipulator openings, periscope openings, and service sleeves will be plugged with removable shielding plugs.

The unshielded cell, which provides facilities for glove maintenance, is about 8 ft wide, 20 ft long, and 24 ft high and is connected to the shielded cell system through a shielded doorway about 7 ft wide by 17 ft high. This maintenance cell is entered through an equipment airlock adjacent and at right angles to the cell.

All cells are ventilated by air drawn from the occupied areas of the building through "absolute" type air filters and thence through the cells on a once-through basis (Fig. 2.8). The absolute filters on the cell air inlet, along with the specially designed check valves, prevent contaminated gas from the cells from flowing back to the occupied areas if an accidental increase in cell pressure should reverse the air flow. The air leaving the cells is filtered at the point of exit by a high-capacity roughing filter. After leaving the cell, the air is filtered by two banks of absolute filters in series and then released to the atmosphere from the 250-ft-high HFIR stack.

Although all the cells will operate initially with an air atmosphere, there are provisions for future addition of an inert gas cleanup and cooling system for all cells except cell E. Seals on cell openings are all designed for minimum leakage to confine radioactivity as well as to ensure for the future minimum dilution of any inert atmosphere in the cells.

The remote maintenance philosophy for operations in cells C and D depends upon an in-cell crane system and an electromechanical manipulator system that operate in cells A, B, C, and D. The crane system consists of two bridges with a net load capacity of 10 tons, two 5-ton hoists, and the other equipment needed to move a crane bridge or hoist to or

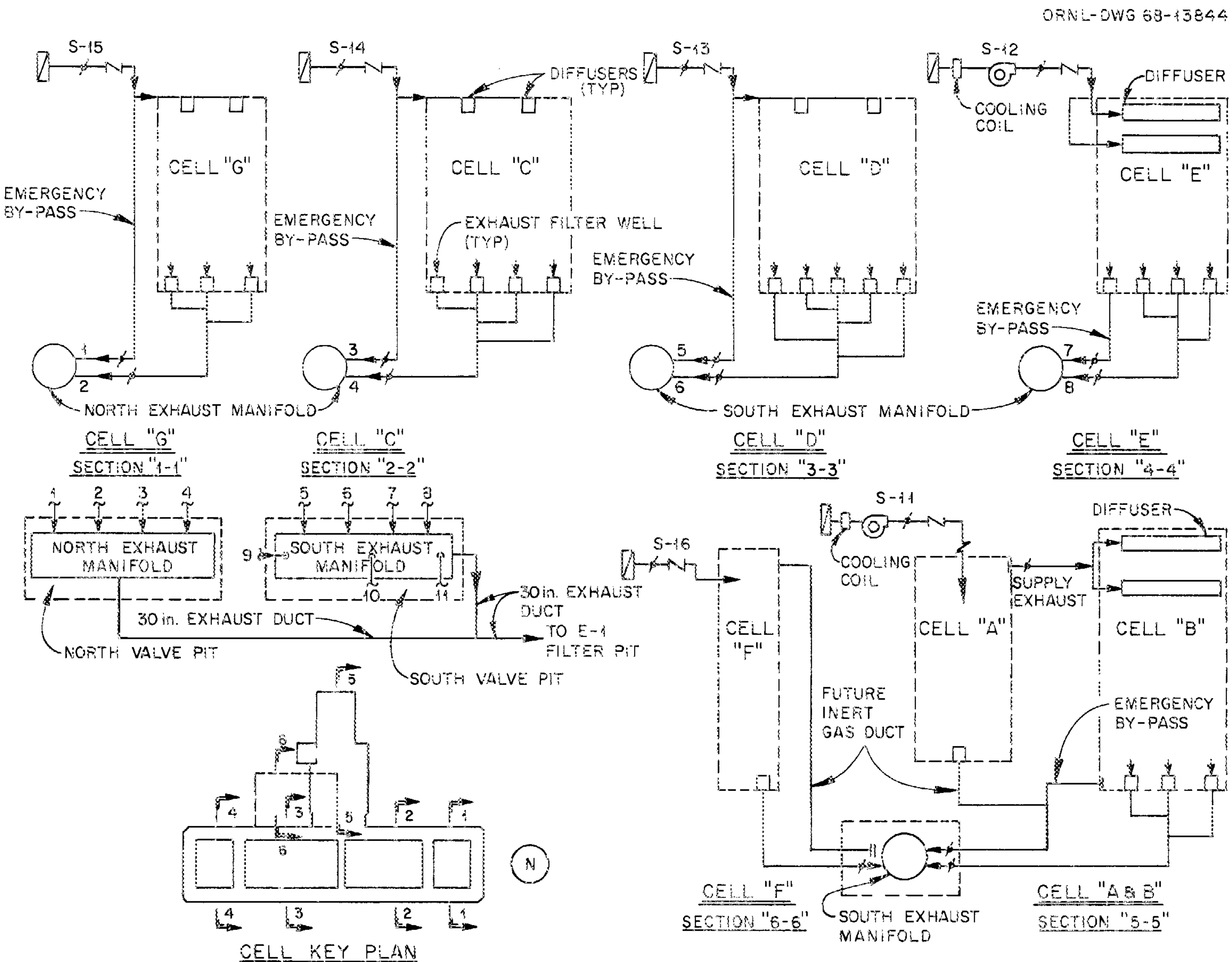

Fig. 2.8. Schematic of Cell Ventilation Systems.

from cells B, C, and D without requiring personnel to enter the process cells, even in the event of equipment failure. All moving parts of the crane system in cells C and D can be removed and replaced remotely. An isometric sketch of the major components of the in-cell crane system for cells A, B, C, and D is shown in Fig. 2.9. Under normal circumstances one crane bridge with hoist will be located in cell C and another in cell D. As an illustration of the functions of the crane system, assume that an object is to be brought from cell D into cell A:

1. The object is picked up by the hoist and the crane bridge and traversed to a point where it is centered in front of the door between cells B and D.

2. The door between these two cells is then opened, and the transfer bridge is butted against and mated with the crane bridge.

3. The crane hoist is moved from the bridge in cell D onto the transfer bridge.

4. The transfer bridge is moved so that no part of the bridge blocks the door opening between cells B and D, and the door is closed.

5. The rolling door between cells A and B is opened, and the transfer bridge is mated with the fixed monorail in cell A.

6. The crane hoist is powered to run into cell A.

The crane bridges in cells C and D can be moved into cell A: the transfer bridge is raised and moved to mate with a fixed rail in cell C or cell D, and a traction unit normally stored in cell A pulls the crane bridge and transfer trolley onto the bridge in cell B and from there into cell A.

Electric current is supplied to the hoist and drive motors on the bridges and on the fixed monorail in cell A through conductors on electric trolley pickups of a special design. The transfer bridge in cell B receives power through a pendant cable, whereas the bridges in cells C and D each get their power from a cable reel mounted on the end of the bridge that is automatically plugged into an electrical receptacle when a bridge is moved into position.

Nine feet below the in-cell crane system in cells A, B, C, and D is an electromechanical manipulator system that operates on a set of rails. The principal parts of the manipulator system are shown in

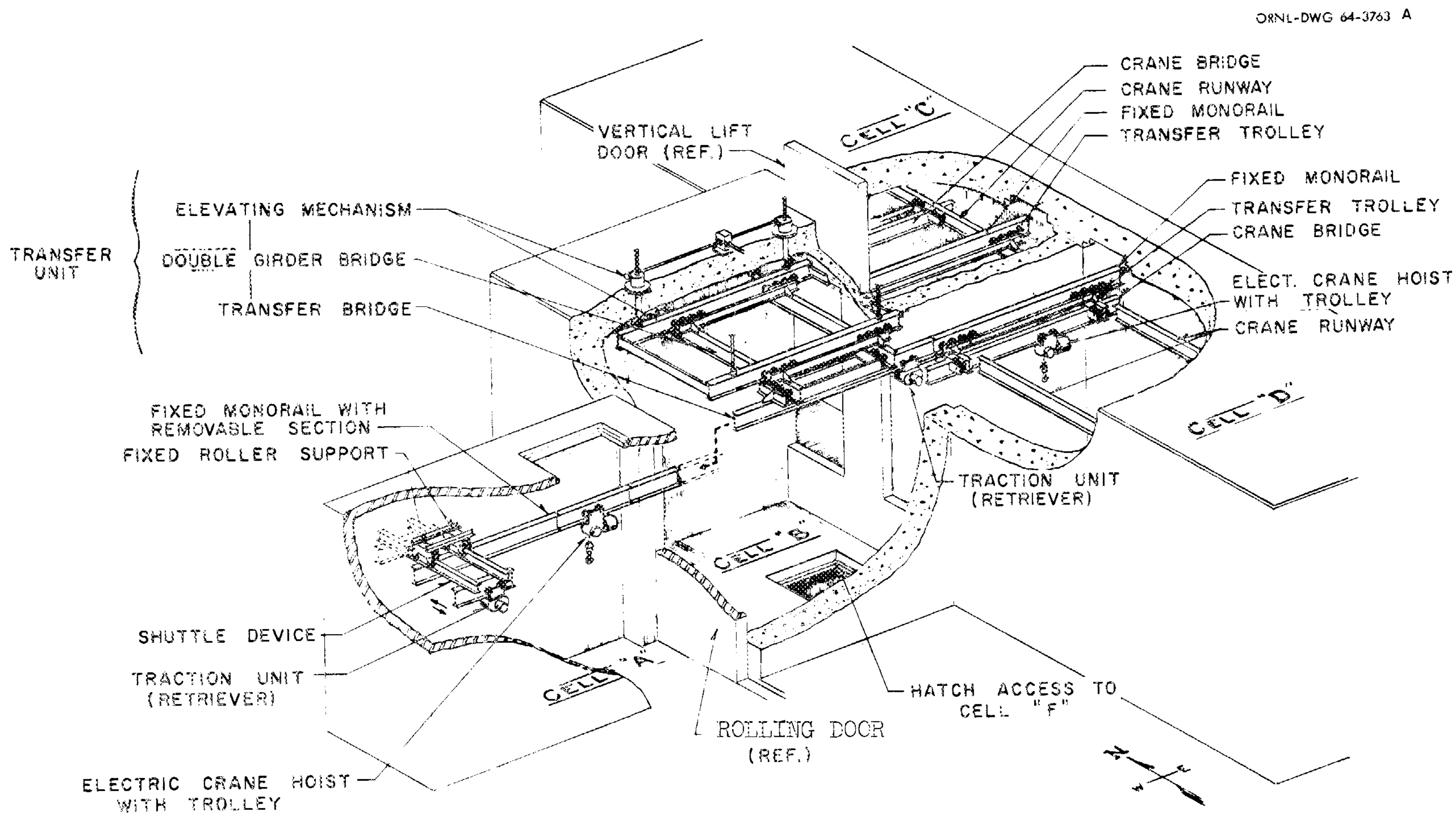

Fig. 2.9. In-Cell Crane System.

Fig. 2.10. The electric current supply for the manipulator is similar to that for the in-cell crane system except that a cable system rather than trolley pickups is used for electrical service between the bridge and carriage. The manipulator bridges are not equipped for self-movement from cell to cell. Instead, the manipulator bridge is so arranged that it can be picked up by two hoists operating on a single crane bridge and carried tightly coupled to that bridge from one cell to another. The manipulator unit is a Programmed and Remote Systems, Inc. model 3000 with a tube hoist that has a travel of 13 ft 6 in. and a net lifting capacity at the shoulder hook of 1000 lb. Two electromechanical manipulators can be operated simultaneously in either cell C or cell D, whereas only one unit can be used in cell B. An electromechanical manipulator can be used in cell A for maintenance purposes only.

A similar crane and manipulator with equivalent capacities is provided for cell E; however, installation, removal, and maintenance is entirely by contact methods through the roof hatch. A 5-ton-capacity crane system is also provided for cell F. In this case, installation and removal of the bridge for maintenance is through the hatch in the floor of cell B. Electric current again is supplied to this crane system by cable reel from the wall to the bridge and electrical trolley pickups on the hoist carriage. No means of remote retrieval of a failed bridge is provided in this cell since the radiation level will be relatively low and since the probability of failure is reduced both by the lower radiation field and by the relatively low rate of use. Access panels that can be equipped with glove ports are provided in cell F at three different locations; maintenance operations can be performed through these.

2.2 Penetration Radiation and Shielding

The radiation source used as a design basis for shielding calculations is a fuel element containing 35 kg of ^{233}U-Th mixture, approximately 1.75 kg of ^{233}U (with 600 ppm ^{232}U), that has been irradiated to 25,000 Mwd/ton and decayed for 90 days. Such a fuel element can be received in cell G and processed chemically to effect a partial separation

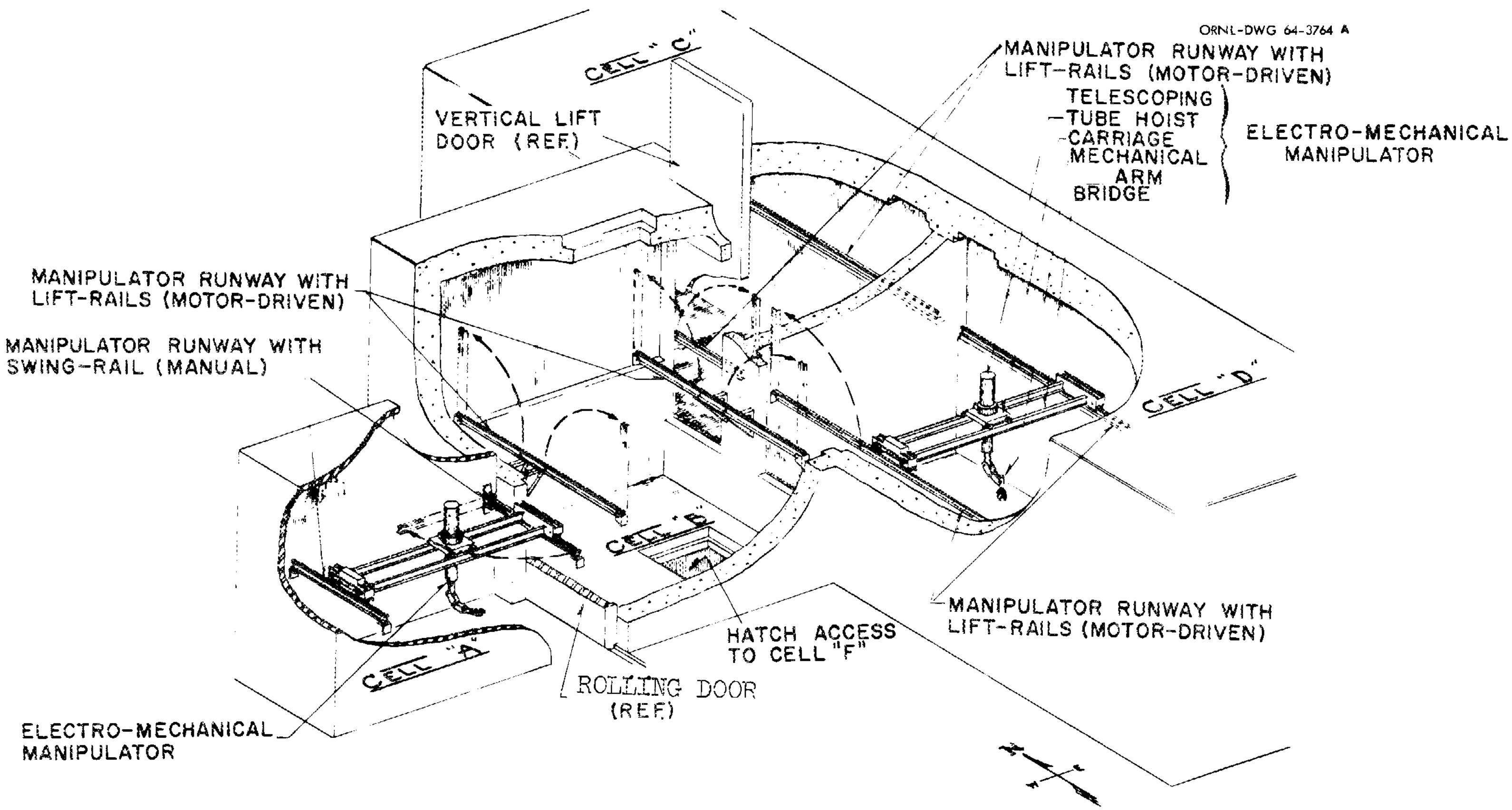

Fig. 2.10. Multirunway Manipulator System.

of the fuel material from fission products. The ^{233}U and thorium containing the original quantity of ^{232}U and 0.1 to 100% of the original fission products will then be refabricated into fuel elements in the fabrication cells (C and D).

The shielding of the TURF is designed so that during normal operation the penetrating radiation dose rates in normally occupied areas (cell operation area, operations office, change room, etc.) is no greater than 0.25 mrem/hr, with permissible hot spots of small area, such as those opposite wall penetrations, no greater than 2.5 mrem/hr. In limited access areas, not normally inhabited by operating personnel (cell roof area, sampling area, storage cell corridor, etc.) the dose rate is to be less than 2.5 mrem/hr with limited area hot spots no greater than ten times this value. The dose rate in the maintenance operating area and equipment airlock will be permitted as high as 10 mrem/hr for short term, nonroutine operations, during which time the affected areas will be vacated. For short term, nonroutine operations (such as filter removal, equipment removal, and carrier handling) radiation levels as high as 5000 mrem/hr will be permitted.

To reduce the radiation to an allowable level, the four operating cells have walls of normal concrete that are 5 1/2 ft thick to a height of 11 ft above the floor of the operating area and 4 1/2 ft thick from there to the roof, which is 5-ft-thick concrete. Cell B shielding walls are of high-density Barytes concrete or equivalent that are 4 ft thick up to the second floor level and 3 ft thick from there to the ceiling. Cell F has 2 ft of normal concrete shielding for the walls and 3 ft for the ceiling.

The shielding windows are essentially equivalent in shielding effectiveness to the concrete wall in which they are installed. The window consists of two major assemblies: a seal glass remotely removable from inside the cell, and a thicker shielded assembly removable from the nonradioactive side. The shielded window assembly is a composite unit consisting of about 7 in. of glass and 58 in. of zinc bromide solution. The window is well sealed to minimize leakage of air through cracks.

2.3 Description of Equipment Airlock and Cell A

2.3.1 Equipment Airlock

An airlock is located at right angles to cell A. A sealed door 4 ft wide and 7 ft high is provided for personnel and equipment access to the airlock from the maintenance operating area. A rolling floor hatch over the airlock provides a clear opening 7 ft 3/4 in. by 8 ft 1/2 in. to permit introducing heavy objects into the airlock with the 50-ton building crane. Both the entry door and the roof hatch are equipped with dual seals. A monitored positive pressure is maintained between the seals to detect any leakage that might occur across the sealing surfaces. The walls of the airlock are 1/4-in.-thick carbon steel plate coated with a three-coat system of protective vinyl on both the inside and outside. Plexiglass SE-3 viewing panels about 3/8 in. thick are installed with an "H"-shaped gasket of neoprene on the west wall and at a small opening on the south wall beside the entry door of the airlock. The floor and a wainscot about 2 ft high around the walls are 1/4-in.-thick type 304L stainless steel. A remotely controlled transfer truck and car ride on a track system embedded in the floor and attached as an integral part of the floor lining. This truck and car and the supporting floor are capable of carrying 50-ton loads.

2.3.2 Cell A

Cell A, the glove maintenance cell, adjoins cell B on one side and the equipment airlock on the adjacent side. A sealed door with a clear opening 7 ft 11 3/4 in. by 12 ft 9 in. provides access to cell A from the airlock. A removable hatch in the third floor area provides a clear opening 6 ft 2 in. by 7 ft 10 in. for introducing heavy objects into the cell with the 50-ton building crane. The cell is 8 ft wide, 20 ft long in the first floor area, and 24 ft long in the second floor area. Cell A is 24 ft high with a section rising to the third floor level, which is 30 ft high. The walls and ceiling are 1/4-in.-thick carbon steel plate mounted to a gridwork of rectangular tube that provides structural support for the cell. The walls and support structure are coated on both the inside and outside with a three-coat system of vinyl paint made by the Carboline Company. Plexiglass SE-3 viewing panels about 3/8 in. thick are installed with "H"-shaped gaskets of neoprene at numerous locations in the walls and ceiling. The floor and a wainscot that varies from 4 in. to 2 ft in height are 1/4-in.-thick type 304L stainless steel. The floor support structure can carry 50-ton loads on the transfer truck and car assemblies. The cell provides services in the lower section for equipment transfer, manual repair by means of glove hands, and decontamination when necessary. The upper section of the cell is for the gloved hand remote maintenance of the in-cell cranes and electromechanical manipulators. The upper portion of the cell contains the monorail support for the crane, the parking beam for the crane retrieval devices, and the shuttle beam for transferring hoists on the cranes. Provisions have been made in the monorail for removing a section below the hatch opening to permit introducing or removing equipment through the hatch of cell A. Stainless steel self-draining shelves are hinged to the walls at three elevations to assist in maintenance operations.

2.4 Description of Cell B

Cell B, the decontamination cell, adjoins cell A and is separated from it by shield door 1. Cell B has inside clear dimensions of 16 ft wide, 23 ft 4 in. long, and 22 ft 7 in. high. Shield door 1 provides a clear opening 7 ft wide and 16 ft 9 5/8 in. high. The cell serves as a shielded radiation lock for processing cells C and D and is separated from these cells by shield doors 2 and 3. These two doors provide clear openings of 6 ft by 15 ft. Two hatches are located in the cell floor; one provides a clear opening of 7 ft by 6 ft to cell F, and the other provides an opening of 2 ft by 3 ft to the fuel storage canal. The walls and ceiling of the cell are lined with 3/16-in.-thick type 304L stainless steel. The floor is lined with 1/4-in.-thick type 304L stainless steel. The area of cell B floor immediately to the east of shield door 1 can carry 50-ton loads on a track support structure on which the transfer truck operates. The remaining floor area can carry uniform loads of 500 psf. The lower part of the cell provides space for transferring equipment through cell B to and from the processing cells C and D and for setting equipment for decontamination. This part of the cell is provided with four cell-operating modules. A typical operating module is shown in Fig. 2.11. For supplying services into the cell there are fourteen 1-in. service lines, thirteen 4-in. bent service sleeves, five 6- by 8-in. dual diameter stepped service sleeves, and eight 4- by 6-in. dual diameter stepped service sleeves. There is a sleeve for future installation of a periscope for close viewing. All sleeves (Fig. 2.12) are equipped with a two-part seal and shield plug assembly. Two modules are equipped with viewing windows and the remaining two have window forms filled with removable shielding. Each operating module has a pair of sleeves through which master-slave manipulators can be installed. Each module is equipped with two 1500-w lighting fixtures hung on the inside of the cell wall between the manipulator penetrations. There are two 2-in. lines connected to the radioactive hot drain recoverable waste system (RHDR) and two 2-in. lines connected to the radioactive hot drain-hot off-gas waste system (RHD-HOG). Each connection to the waste systems is equipped with a Grayloc disconnect sealed with a blanking hub. On the north wall, a 2-ft-diam plugged sleeve, entering the cell from the fuel storage room, provides for future installation of transfer equipment. On the north wall there is a small-items entry port through which tools and miscellaneous equipment may be introduced from the outside of the cell through a bag box and airlock arrangement. The upper portion of the cell and the cell ceiling area contain the elevating and transfer equipment for the overhead traveling crane and manipulator systems.

2.5 Description of Cells C, D, and G

2.5.1 Cell C (Mechanical Processing Cell)

Cell C adjoins cell B and is separated from it by shield door 2. Cell C has interior dimensions of 20 ft wide, 33 ft long, and 24 ft high. The cell is divided by a 2-in.-wide floor trench into two areas for operating remotely controlled processes. The walls and ceiling of the cell are lined with 3/16-in.-thick type 304L stainless steel. The floor is lined with 1/4-in.-thick type 304L stainless steel. The cell

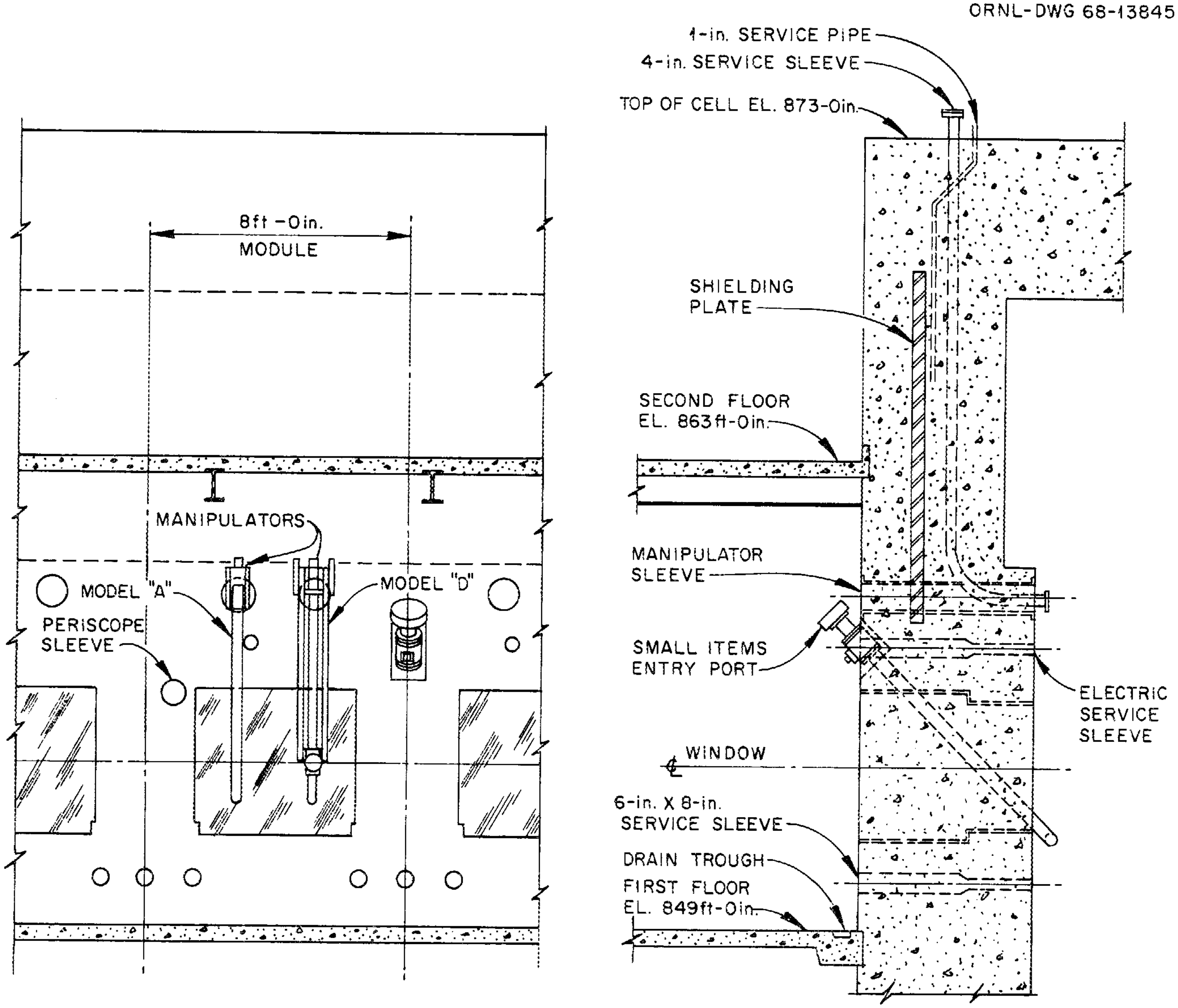

Fig. 2.11. Typical Cell Operating Module.

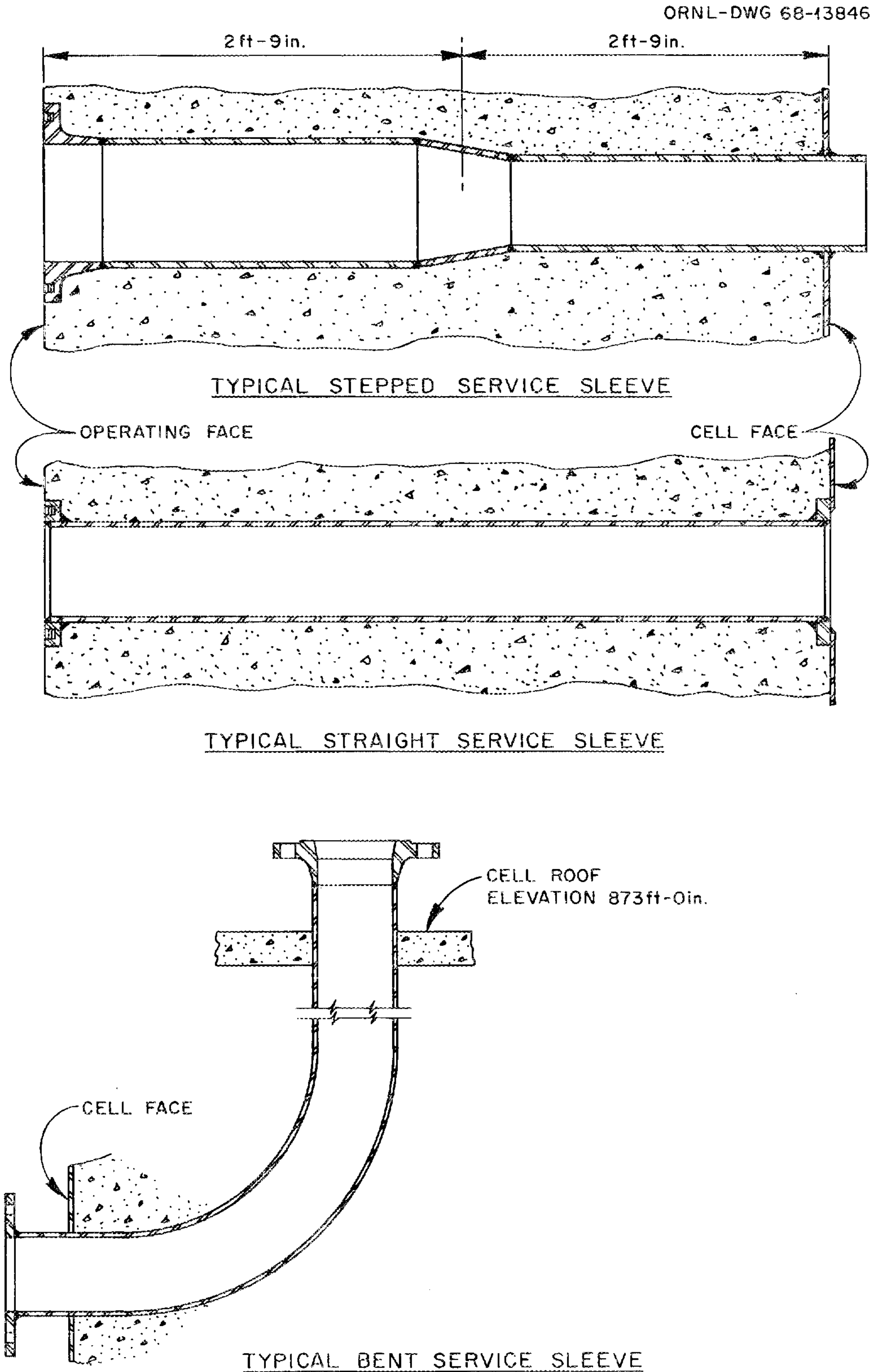

Fig. 2.12. Typical Cell Service Sleeves.

floor can carry concentrated loads of 10 tons on any 10-ft^2 area at 8-ft intervals on any north-south center line and uniform loads of 200 psf. The lower part of the cell, which provides space for the operating equipment, has seven cell operating modules (Fig. 2.11). For installing process services there are thirty-six 1-in. service lines, fifty-six 4-in. bent service sleeves, eighteen 6- by 8-in. dual diameter stepped service sleeves, and eight 4- by 6-in. dual diameter stepped service sleeves. There are three sleeves through which periscopes can be installed for future operations. All sleeves (Fig. 2.12) are equipped with a two-part seal and shield plug assembly. Three modules are equipped with viewing windows, and the remaining three modules have window forms filled with removable shielding. Each operating module has a pair of sleeves through which master-slave manipulators can be installed. Each module has two 1500-w lighting fixtures. There are four 2-in. connections and four 1-in. connections to the RHDR waste system. There are four 1 1/2-in. connections and four 2-in. connections to the RHD-HOG waste system. Each of these connections to the waste systems is equipped with a Grayloc disconnect sealed with a blanking hub. On the west wall there is a dispatch station for sending samples of solid materials to the outside of the cell. In the north wall there is a 2-ft-diam plugged sleeve through which transferring devices from cell G may in the future be installed. In the south wall there is a 2-ft-diam sealed sleeve through which conveying devices may be installed in cell D. There are two small-items entry ports through which tools and miscellaneous equipment may be introduced from the outside of the cell through a bag box and airlock arrangement. In the cell roof, a sealed and shielded hatch 8 ft by 8 ft provides access to the cell with the 50-ton building crane. The ceiling and upper portion of the cell supports and provides space for a 5-ton overhead traveling bridge crane and a model 3000 electromechanical manipulator system for remote installation and maintenance of processing equipment.

2.5.2 Cell D (Contaminated Fabrication Cell)

Cell D adjoins cell B and is separated from it by shield door 3. Cell D has interior dimensions of 20 ft wide, 41 ft long, and 24 ft high.

The cell is divided by a 2-in.-wide floor trench into two areas for operating remotely controlled processes. The walls and ceiling of the cell are lined with 3/16-in.-thick type 304L stainless steel. The floor is lined with 1/4-in.-thick type 304L stainless steel. The cell floor can carry concentrated loads of 10 tons on any 10-ft^2 area at 8-ft intervals on any north-south center line and uniform loads of 200 psf. The lower part of the cell, which provides space for the operating equipment, has nine cell operating modules (Fig. 2.11). For installing process services there are forty-seven 1-in. service lines, forty-eight 4-in. bent service sleeves, eighteen 6- by 8-in. dual diameter stepped service sleeves, and ten 4- by 6-in. dual diameter stepped service sleeves. There are four sleeves through which periscopes can be installed for future operations. All sleeves (Fig. 2.12) are equipped with a two-part seal and shield plug assembly. Three modules are equipped with viewing windows, and the remaining six have window forms filled with removable shielding. Each operating module has a pair of sleeves through which master-slave manipulators can be installed. Each module has two 1500-w lighting fixtures. There are five 1-in. connections to the RHDR waste system and ten 2-in. connections to the RHD-HOG waste system. Each connection to the waste systems is equipped with a Grayloc disconnect sealed with a blanking hub. In the north wall there is a 2-ft-diam sealed sleeve for the future installation of transferring equipment to cell C. In the south wall there are a 2-ft-diam plugged sleeve for future installation of transfer devices from cell E and a cleaner transfer port for future installation of a fuel element transfer conveyor and cleaning mechanism between cells D and E. On the west wall there is a dispatch station for sending samples of solid materials outside the cell. There are two small-items entry ports through which tools and miscellaneous equipment may be introduced from the outside of the cell through a bag box and airlock arrangement. In the cell roof, a sealed and shielded hatch 17 ft 6 in. by 7 ft 6 in. provides access to the cell with the 50-ton building crane. The upper part of the cell provides space for a 5-ton overhead traveling bridge crane and a model 3000 electromechanical manipulator system for remote installation and maintenance of processing equipment.

2.5.3 Cell G (Chemical Cell)

Cell G adjoins cell C and is separated from it by a 4-ft shielding wall. Cell G has interior dimensions of 20 ft wide, 16 ft long, and 30 ft high. The cell is divided by a 2-in.-wide floor trench into two areas for operating remotely controlled processes. The walls and ceiling of the cell are lined with 3/16-in.-thick type 304L stainless steel. The floor is lined with 1/4-in.-thick type 304L stainless steel. The cell floor can carry concentrated loads of 10 tons on any 10-ft^2 area at 8-ft intervals on any north-south center line and uniform loads of 200 psf. The lower part of the cell, which provides space for the operating equipment, has six cell operating modules (Fig. 2.11). For installing process services there are thirty-five 1-in. service lines, thirty-three 4-in. bent service sleeves, twenty-nine 6- by 8-in. dual diameter stepped service sleeves, and six 4- by 6-in. dual diameter stepped service sleeves. There are two sleeves through which periscopes can be installed for future operations. All sleeves (Fig. 2.12) are equipped with a two-part seal and shield plug assembly. Four modules are equipped with viewing windows, and the remaining two modules have window forms filled with removable shielding. Each operating module has a pair of sleeves through which master-slave manipulators may be installed. Each module has two 1500-w lighting fixtures. There are two 2-in. connections and two 1-in. connections to the RHDR waste system. There are three 2-in. connections and one 1-in. connection to the RHD-HOG waste system. Each connection to the waste systems is equipped with a Grayloc disconnect sealed with a blanking hub. In the south wall there is a 2-ft-diam plugged sleeve for future installation of transferring devices to cell C. The upper 8 ft of the south wall is so constructed that it can be removed to join cell G with cell C into a common cell if required for future operations. There is a small-items entry port through which tools and miscellaneous equipment may be introduced from the outside of the cell through a bag box and airlock arrangement. In the roof, a sealed and shielded hatch with a 10-ft by 6-ft clear opening provides access to the cell with the 50-ton building crane. Also in the roof there is a 2-ft-diam plugged sleeve to permit future installation of transfer devices into cell G.

The upper part of the cell provides space for a model 3000 electromechanical manipulator system for remote installation and maintenance of processing equipment.

2.6 Description of Cell E

Cell E (clean fabrication cell) adjoins cell D and is separated from it by a 4-ft shielding wall. Cell E has interior dimensions of 20 ft wide, 16 ft long, and 30 ft high. The cell is divided by a 2-in.-wide floor trench into two areas for operating remotely controlled processes. The walls and ceiling of the cell are lined with an 0.02-in.-thick modified Phenolic protective coating. The floor and the walls up to 12 in. are lined with 1/4-in.-thick type 304L stainless steel. The cell floor is capable of carrying concentrated loads of 10 tons on any 10-ft^2 area at 8-ft intervals on a north-south center line and uniform loads of 200 psf. The lower part of the cell, which provides space for the operating equipment, has six cell operating modules (Fig. 2.11). For installing process services there are thirty-five 1-in. service lines, forty-one 4-in. bent service sleeves, nine 6- by 8-in. dual diameter stepped service sleeves, and six 4- by 6-in. dual diameter stepped service sleeves. There are three sleeves through which periscopes can be installed for future operations. All sleeves (Fig. 2.12) are equipped with a two-part seal and shield plug assembly. All six modules are equipped with window forms filled with removable shielding. Each operating module has a pair of sleeves through which master-slave manipulators can be installed. Each module has two 1500-w lighting fixtures. There are three 1-in. connections to the RHDR waste system and three 2-in. connections and one 1-in. connection to the RHD-HOG waste system. Each connection to the waste systems is equipped with a Grayloc disconnect sealed with a blanking hub. On the north wall there is a dispatch station through which samples of solid materials can be transferred out of the cell. There is a small-items entry port in the south wall through which tools and miscellaneous equipment can be introduced from the outside of the cell through a bag box and airlock arrangement. In the ceiling of the cell, a hatch with a clear opening of

22 ft by 5 ft 10 in. with seal and shield plugs permits access for the 50-ton building crane to remove or install equipment. In the west part of the roof hatch is a transfer port through which assembled fuel elements may be removed from the cell. The upper part of the cell provides space for a 5-ton overhead traveling bridge crane and a model 3000 electromechanical manipulator system for remote installation and maintenance of processing equipment.

2.7 Description of Cell F

Cell F (equipment storage cell) is in the basement level below cell B. Cell F has interior dimensions of 15 ft 6 in. wide, 37 ft long, and 13 ft 1 in. high. The cell B floor hatch provides a clear opening 7 ft wide and 6 ft long through the roof of cell F. The cell serves as a shielded storage space for equipment being removed from the processing cells. The walls and ceiling are lined with an 0.02-in.-thick protective coating of modified Phenolic resin. The floor is lined with an 0.04-in.-thick protective coating of epoxy resin reinforced with fiberglass. The floor can carry 5-ton concentrated loads on any 4-ft^2 area or uniform loads of 250 psf. The lower part of the cell, which provides space for equipment storage, has four operating modules. Each module is equipped with a viewing window and a 400-w mercury vapor lighting fixture (Fig. 2.13). The upper part of the cell provides space for a 5-ton overhead traveling crane. There are two access ports in the east wall and one in the west wall through which the crane system can be maintained by glove techniques. In the south wall there is a 3-ft by 6-ft emergency access that is sealed and plugged but can be used for personnel entry if necessary. Liquid waste is collected in a critically safe sump in the southeast corner of the cell floor and jetted to the RHD-HOG waste system when necessary.

2.8 Description of Decontamination Area and the Fuel Storage Room with Fuel Handling and Storage Equipment

The decontamination station, a stainless steel pad 7 ft by 8 ft wide with a wainscoting on the north side 8 ft high, is on the second floor

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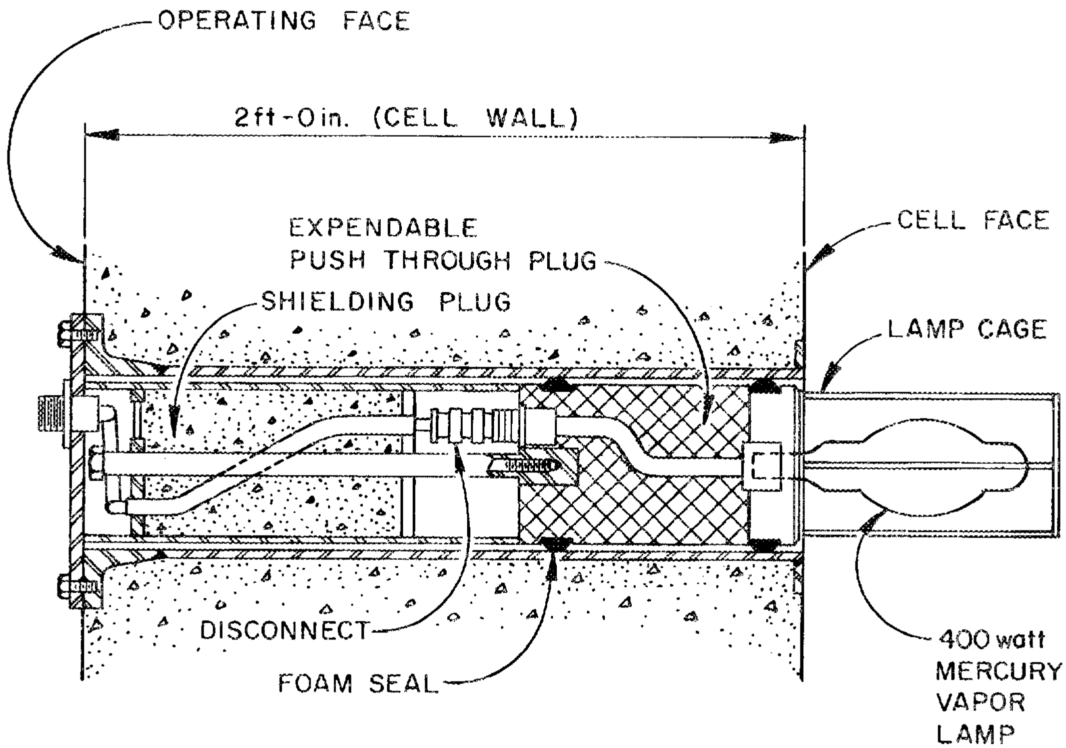

Fig. 2.13. Cell F Lighting Fixture.

just north of cell B. This pad is equipped with service into the RHD-HOG system and a plugged floor drain to the process waste system. Waste collected on the pad will be monitored for contamination before being released to either the hot waste or the process waste as appropriate. To the east of this pad are locations provided for future installation of support saddles for large casks or equipment necessary for orienting casks for handling. The floor area in the decontamination station is capable of supporting concentrated loads of 50 tons. Immediately to the west of the decontamination pad is a floor hatch providing a clear opening of 7 ft by 7 ft through the ceiling of the fuel storage room in the first floor level. The ceiling hatch from the second floor permits the introduction of heavily shielded casks containing fuel assemblies to and from the basin by the 50-ton overhead building crane.

The fuel storage room adjoins cell B on the north and provides maintenance and operating area to the fuel storage basin. The fuel storage basin is 9 ft 6 in. wide and when filled will contain 22-ft minimum depth of demineralized water for shielding. A deep pit, 7 ft wide and 12 ft deep, in the basin floor will provide a 34-ft depth of water for unloading shipping casks. The floor of the basin is lined with 1/8-in.-thick type 304L stainless steel. A canal joins the storage basin to the floor of cell B. The walls of the basin and the canal are lined with an 0.04-in.-thick epoxy resin protective coating reinforced with fiberglass. There is a personnel and crane bridge assembly mounted on a runway over the basin. This personnel and crane bridge is equipped with a 1-ton hoist for handling fuel elements and for maintenance operations within the basin. The hoist is constructed to maintain a minimum of 6 ft of water above the high point of the hoist lift. There is a remotely operated inclined conveyor for conveying fuel elements from the basin through the canal into cell B. The capacity of the conveyor is approximately 1000 lb.

2.9 Description of Development Laboratory

Adjoining cell D and cell E at the second floor level on the west and south side is a laboratory to be used for cold development of equipment and for operations involving preparation of materials that are to be used in the processing cells. The laboratory is equipped with two fume hoods with separate exhaust systems and with two laboratory counter-top work benches. The hoods have connections into both the RHD-HOG and process waste systems, each appropriately identified and usable as necessary.

2.10 Process Services

A service piping loop is installed around the cell bank at the second floor level. This loop supplies steam, air, water, and argon around the cell bank to stations that serve the cells or equipment outside the cells. On the first floor there are 19 service stations that furnish the following: (1) steam — 100 psig; (2) instrument air — 50 psig; (3) process water; and (4) recirculating cooling water.

These same services are provided at similar service stations in the second floor area. In the third floor area at the cell roof there are 20 service stations that provide the following: (1) steam — 100 psig; (2) instrument air — 50 psig; (3) process water; (4) recirculating cooling water; (5) demineralized water; and (6) argon.

Electrical wireways, 4- by 4-in. cross section, are installed from the first floor to the third floor through which electrical power and control circuits can communicate from the first floor cell operating modules to the cell roof service stations. Electrical power panels for equipment operations are provided at the cell operating modules on the first floor and at the service stations in the third floor cell roof area.

For removing process heat loads, a closed loop cooling water system is provided with an inventory of about 250 gal. Normal circulation in the system is provided by a 250-gpm pump. A 130-gpm reserve pump is provided for stand-by service. The water is cooled by a shell and tube heat exchanger with cooling tower water from the HFIR cooling system. In the event of water tower failure, process water will automatically be fed into the systems.

From the service stations outside the cells, services can be piped into the cells through either sleeve-type service penetrations or through service lines that are provided through the cell walls and that terminate at the in-cell side of the cell operating modules. The cell bank has about 450 of these service penetrations.

Electric, pneumatic, and hydraulic services may be extended from the operating modules in the first floor operating area into the cells through stepped service sleeves (Fig. 2.14). These stepped service sleeves are equipped with a two-part plug assembly. The in-cell end of the stepped service plug assembly is smaller in diameter than the opposite end. Expendable push-through aluminum-epoxy plugs are attached by a disconnect to the shield plug and pushed into the sleeve to the installed position shown in Fig. 2.14. The in-cell end of the plug assembly is equipped with a disconnect for plugging in process service lines. For service plug changeout, the joint between the shield plug and the expendable plug is remotely disconnected, allowing the shield plug to be withdrawn to the cold side of the cell wall and leaving the seal plug in position to maintain cell containment. A new plug assembly can then be thrust into place, forcing the old expendable plug into the cell to be disposed of as solid waste. Services are routed through the shield plug in spiral conduits or piping to prevent radiation streaming.

Electric, pneumatic, and hydraulic services may be extended into the cells from the third floor cell roof service stations through 4-in.-diam bent service sleeves (Fig. 2.15). The service lines are installed in the bent sleeve in a two-part plug assembly that separates at a disconnect and permits the expendable, push-through front portion of the assembly to be withdrawn into the cell and allows the backside of the plug assembly to be withdrawn into the service stations in the cold side of the cell roof area. These service sleeves are also equipped with disconnects on the in-cell end for plugging in process service lines.

Pneumatic and hydraulic services may also be extended into the cells from the third floor cell roof service stations through a series of 1-in. service lines extending from the cell roof area down through the cell walls and terminating at the face of the cell liner inside the cell at the operating modules. Each service line is 1-in. type 304L

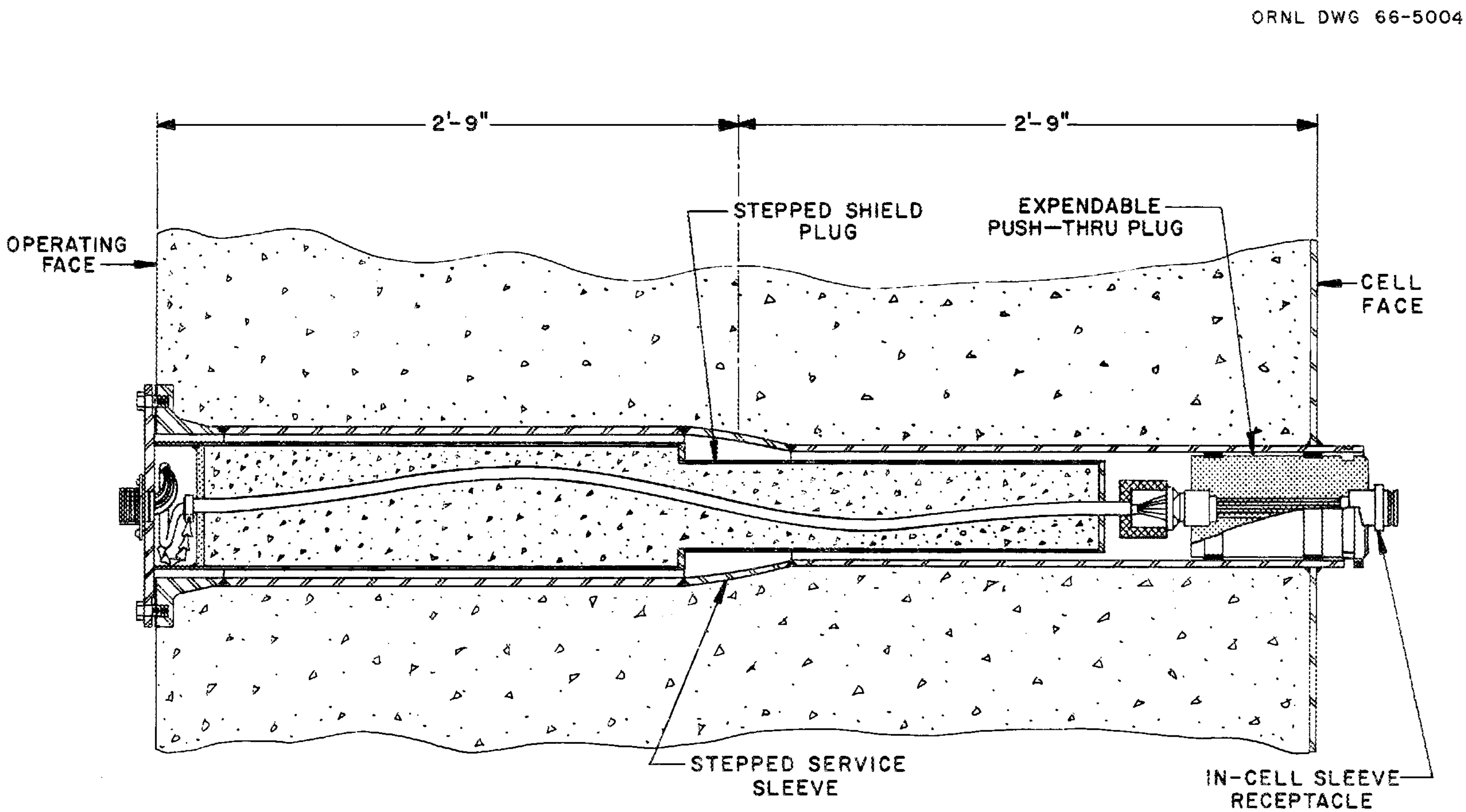

Fig. 2.14. Typical Stepped Electrical Service Sleeve and Plug Installation.

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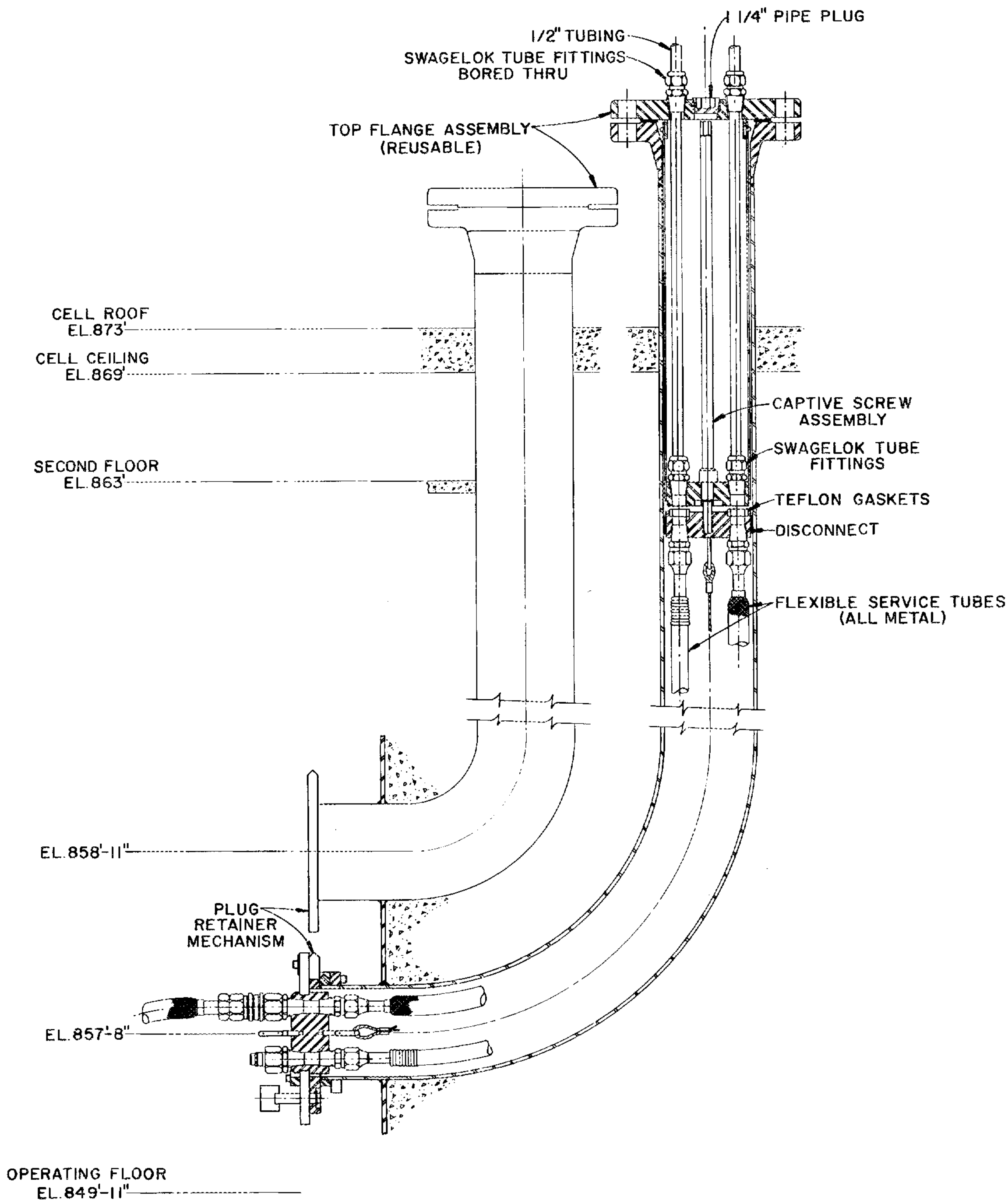

Fig. 2.15. Four-Inch Diameter Bent Service Sleeve and Plug.

stainless steel pipe fitted with a ball valve on the out-of-cell end and terminating at a Grayloc disconnect on the in-cell end (Fig. 2.16). All service lines are sealed with blanking hubs on the in-cell end when not in use.

All high activity radiochemical waste resulting from in-cell processes are classified under two categories: (1) radiactive hot waste and (2) radioactive hot waste recoverable. The radioactive hot drain recoverable system (RHDR) drains all waste that might contain economically recoverable materials, and the radioactive hot drain system (RHD) collects all other in-cell liquid waste. Connections into these two waste systems from processing equipment are made through the Grayloc disconnects inside the cells or, as necessary, from the floor drain systems. Process gaseous waste is collected in the combination hot off-gas and radioactive-hot drain piping system and conveyed by a gutter flow arrangement through the waste collection tanks to the facility hot off-gas (HOG) exhaust system E-3.

2.11 Building Services

2.11.1 Plant Electrical Power Distribution System

TURF receives electrical power from the ORNL 13.8-kv electrical distribution system. The primary source of power from this distribution system is feeder 294. Although there is no automatic backup for feeder 294, proper manual switching on the 13.8-kv system can supply TURF with primary power from feeder 234 if an outage occurs on feeder 294. The normal supply is fed into the 1500-kva outdoor substation designated as station 294-1 located adjacent to the TRU facility, Building 7920.

Power to the TURF distribution system is normally supplied by four separate feeders, all originating from the substation adjacent to TRU, as shown in Fig. 2.17. Three of these feeders are 480 v, 3 phase, 60 cycles and are fed directly from circuit breakers in the substation. The other feeder is a 120/208-v instrument power supply fed from the TRU plant instrument power panel physically located in room 213 of Building 7920.

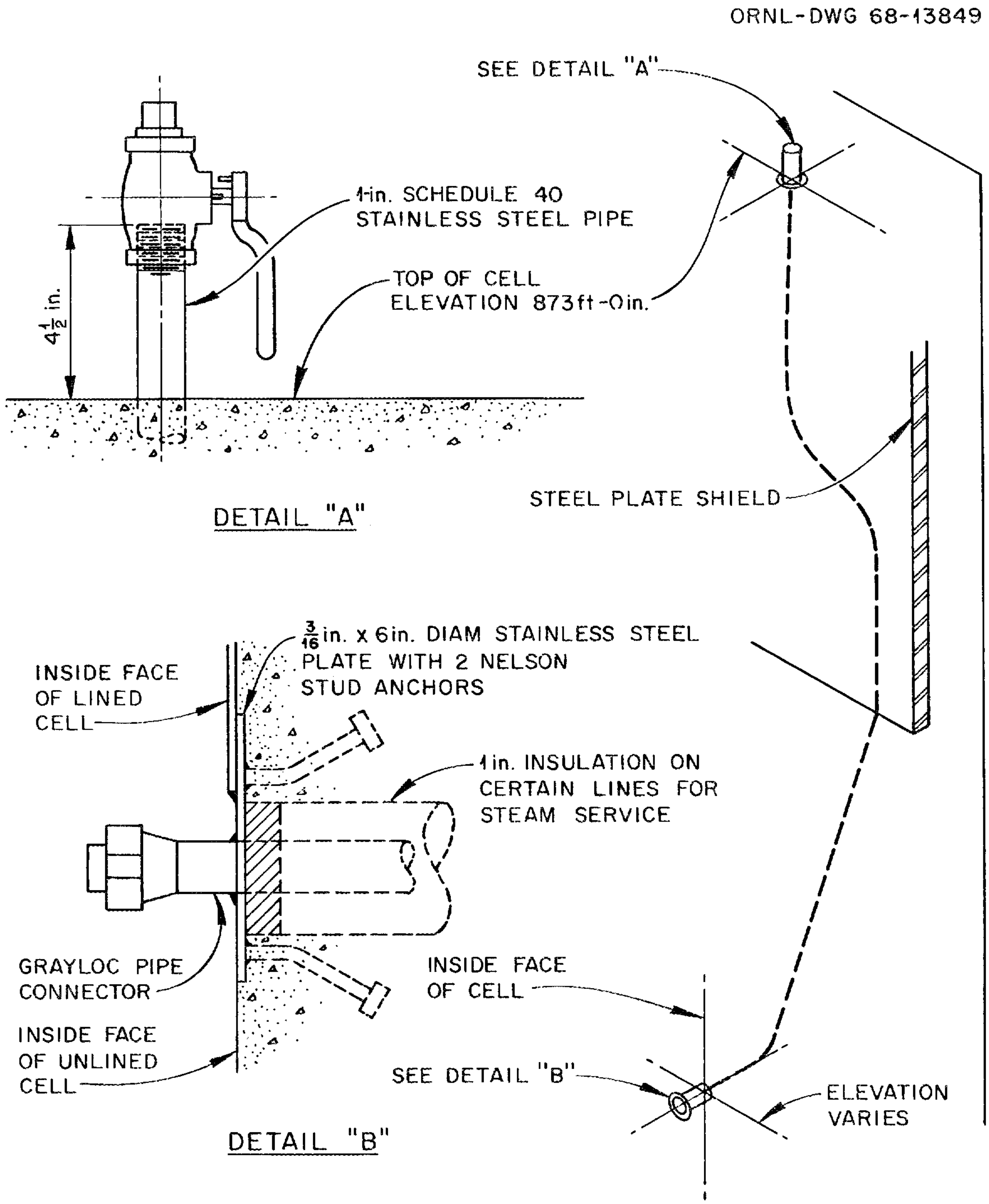

Fig. 2.16. One-Inch Stainless Steel Service Line.

Two of the 480-v feeders coming into the TURF supply motor control centers 1 and 2. From a breaker in the motor control center, power is fed through a 45-kva, 480-208/120-v transformer to motor control center 4. Motor control center 4 in turn supplies 120/208-v power to motor control center 3. The control centers are located in room 211, the electrical equipment room. The other 480-v feeder supplies power to the stack area and feeds both TRU and TURF stack fans. TURF fans are designated EF-1 and EF-2, E-1.

Normal Power Supply. — The plant electrical power in TURF is distributed as either 480-v, 3 phase, 60 cycles, ungrounded; 120/240-v, single phase, 3 wire; or 120/208-v, 3 phase, 60 cycle, 4 wire with solid grounded neutral. Low voltage power for lighting and receptacles and for motors 1/3 hp and smaller is supplied by 4-wire, dry-type transformers fed from the motor control centers.

Emergency Power Supply. — Power for equipment and lighting essential to containment and continued minimum operation in the event of failure within the normal power system is supplied from an essential bus in motor control center 2. The essential bus is fed from an automatic transfer switch that has two sources of power: one normal power source through motor control center and one from the TURF emergency power supply in Building 7931. Figure 2.17 shows the emergency power distribution system; here it may be seen that if normal power is interrupted to the essential bus automatic transfer switch, the switch immediately places the essential loads on the TURF emergency bus.

The TURF emergency bus is fed from an automatic transfer switch that has two sources of power: one normal power source through the TRU breeching area and one from the TURF emergency generator, which is a 480-v, 3-phase, 200-kw, diesel-engine generator located in Building 7931. If normal power is interrupted to the emergency bus, the generator automatically starts, and the automatic transfer switch places the bus on the generator.

The instrument and emergency lighting panels for TURF are fed through an automatic transfer switch that has two sources of power: one normal power source from the instrument power panel located in the TRU building and one from the essential bus located in motor control

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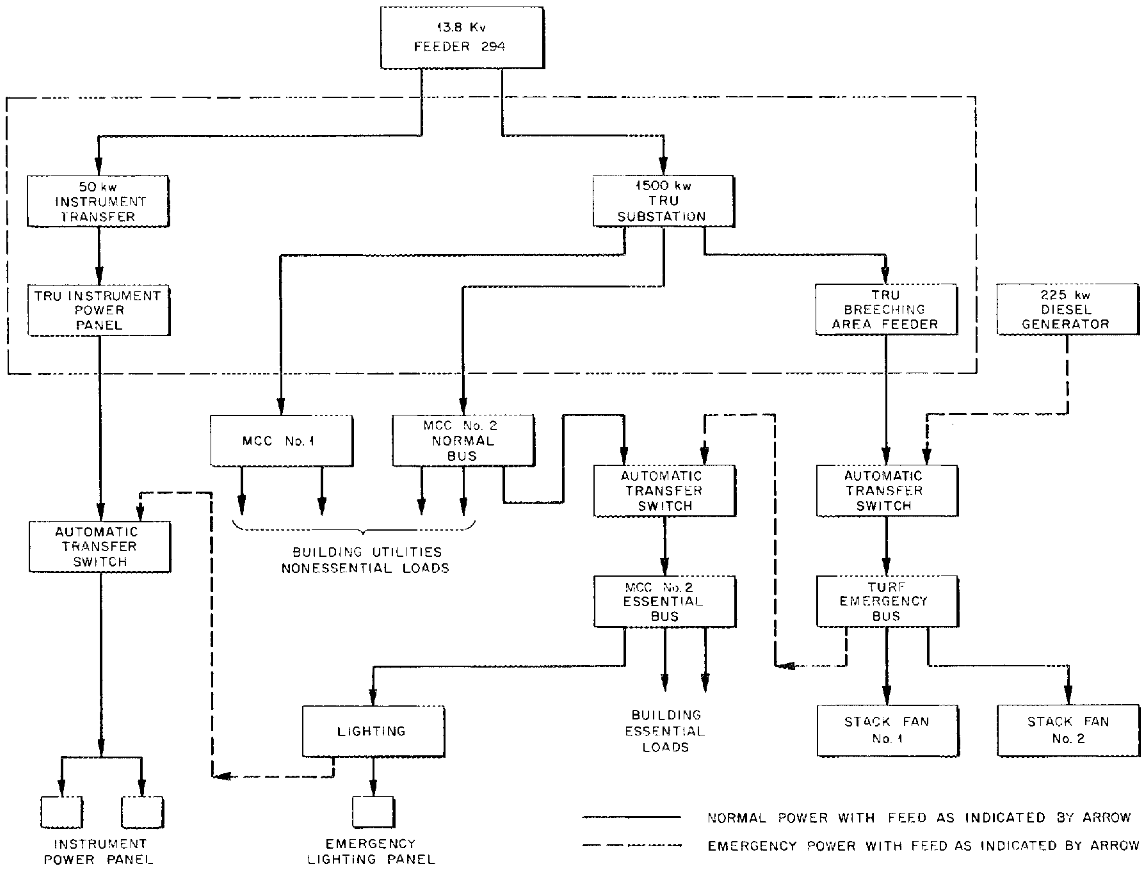

Fig. 2.17. TURF-Power Distribution System Diagram.

center 2. If normal power is interrupted to the instrument power automatic transfer switch, the switch immediately places the necessary instruments on the essential bus and, therefore, on the TURF emergency power system as shown in Fig. 2.17.

In the event of total failure of normal power, the diesel generator will immediately supply power for emergency lighting, instrument power for radiation monitoring equipment, and power for one stack fan (EF-1 or EF-2, E-1). Other equipment on the essential bus is then started automatically in a preset sequence by a sequence timer according to the schedule shown in Table 2.1.

2.11.2 Plant Compressed Air System

Compressed air is distributed in the TURF plant system at 100 psig and −40°F dew point. The air equipment is located in room 140, the air compressor room. In this room are located two air compressors, AC-1 and AC-2. From the compressors, air flows sequentially through an aftercooler and a moisture separator and into a receiver tank. From the receiver tank, the air flows through a desiccant-type automatic, heatless, regeneration dryer. From the dryer, the air flows through a filter and thence into the 100-psig piping system for distribution to the process service stations at the operating and service modules around the perimeter of the cell bank and to other locations throughout the building. Local reduction stations reduce the pressure to 50, 40, 20, and 15 psig as required to furnish air to control equipment.

Normal Air Supply. − The normal air supply is provided by air compressor 2 (AC-2), located in the compressor room. This 9-in., oil-free, vertical compressor can supply up to 330 scfm to the plant distribution system. Automatic controls are installed on the normal supply system to maintain the air pressure between 95 and 100 psig. The controls also sound an alarm on the building control panel when the pressure in the receiver tank falls below 60 psig, signaling an excess demand or failure in the normal air system. The system is more than sufficient to maintain the demands of all air-operated equipment in TURF and on occasion supplies compressed air to the TRU plant through an interconnecting piping system.

Table 2.1 Emergency Power Plan

Equipment	Identity	Time Cycle[a] (sec)	How Powered
Emergency lights	Panel ELP2-F1	None	From essential bus through automatic transfer switch.
Instrument power	Panels IPIF2-1, IPIF2-2	None	From essential bus through automatic transfer switch.
Cell exhaust stack fans[b]	EF-1 or EF-2, E-1	None	Direct from generator through automatic transfer switch.
Recirculating water pumps[b]	RWCP-1 or RWCP-2	15 30	From essential bus by sequence timer.
Emergency air compressor	AC-1	45	From essential bus by sequence timer.
Hot off-gas fans[b]	EF-1, E-3 EF-2, E-3	60 75	From essential bus by sequence timer.
Sampling area exhaust fan	E-6	90	From essential bus by sequence timer.
Development laboratory hood exhaust fan	E-9	105	From essential bus by sequence timer.
Warm shop exhaust fan	E-11	120	From essential bus by sequence timer.
Building air supply fan	S-1	135	From essential bus by sequence timer.

[a]Time delay in seconds after diesel generator has started.

[b]The pump or fan which was running at the time of the power failure will be restarted automatically.

Emergency Air Supply. — The emergency air supply is provided by air compressor 1 (AC-1), also located in the compressor room. This 5-in., oil-free, vertical compressor built by the Joy Manufacturing Company can supply up to 44 scfm to the plant distribution system. Automatic controls are installed on the system so that if an overload or a failure develops in the normal supply system, allowing the pressure in the receiver tank to fall to 65 psig, the emergency supply will be activated, bringing AC-1 into operation. The controls are set to operate AC-1 in the pressure range of 65 to 75 psig. The emergency air system can supply air for operation of essential control equipment to maintain facility containment controls and instrumentation. The emergency air system is designated as an essential load on the electrical power distribution system and receives emergency power when necessary. On occasions, extra emergency air may be received from the TRU plant system through the interconnecting piping system.

2.11.3 Plant Water System

The TURF water service systems include potable water (POW), process water (PW), demineralized water (DEM), cooling tower water (TWC), recirculating cooling water (RWC), chilled water (CHW), hot water heating (HWH), and fire protection water (FW).

Potable Water. — Potable water from the ORNL plant-wide system is distributed inside TURF in two systems: a cold water system and a hot water system.

The potable cold water (POW) system is distributed to drinking fountains, safety showers, lavatories, toilets, janitor's closets, and to sinks and showers in the cold change rooms. The main potable water supply header enters the building through an 8-in. pipe penetrating the floor of room 119. From there, it goes to room 210, the mechanical equipment room, where it supplies the distribution system in the building through a pressure reducing and control station at PRV-321. This potable water distribution system is maintained at hydrostatic pressure of 40 psig and ambient temperature.

The potable hot water system (POWH) supplies the lavatories, janitor's closets, and showers in the hot and cold change rooms. The system is fed from a 250-gal capacity, steam-heated hot water heater and storage tank located in room 210, the mechanical equipment room. The system operates at 40 psig and 140°F. Circulation is provided by a circulating pump, POWHP-1, capable of delivering 13 gpm at 10-ft head.

Process Water. — Process water is obtained from the potable water system through a reduced-pressure principal backflow preventer, manufactured by Crane Company (tradename "Crane-Line"), that has two spring-loaded vertical check valves and one spring-actuated differential-pressure relief valve. There is no interconnection of the potable and process water systems downstream of the backflow preventer. The supply to the process water system is located in room 210, the mechanical equipment room. Downstream of the backflow preventer is located a pressure reducing and control station at PRV-95, from which process water is distributed in two systems: (1) cold water system and (2) hot water system.

The process cold water system (PW) is distributed at ambient temperature to the service stations serving the cell bank. Water is also supplied to the service stations in the checking and holding area, the first and second floor maintenance operating areas, the cell F corridor, the cell G pump room, the decontamination station, the chemical makeup room, and the work benches in the development laboratory. Process water is also used as the driving fluid in sump jets in the cell G pump room, in the cell F corridor, and in the north valve pit. Process water is also supplied to the condensate coolers in the plant steam and condensate system. In case of emergency, process water is supplied as makeup to the RWC system, the CHW system, the TWC system, and the HWH system. The cold water system is distributed at 40 psig and ambient temperature.

The hot process water system (PWH) is supplied to the work benches in the development laboratory, the service stations in the chemical makeup room, the hot change room, the cell F corridor, and the decontamination station. The system is fed from a 60-gal capacity, steam-heated hot water heater and storage tank located in room 210, the mechanical equipment room. The system operates at 40 psig and 140°F. Circulation is provided by pump PWHP-1, which is capable of delivering 13 gpm at 10-ft head.

Demineralized Water. — Demineralized water (DEM) is supplied from the HFIR demineralizers. The demineralized water enters through a 2-in. pipe penetrating the floor of room 119. It is piped from there to room 210, where it is distributed to the process service stations located in the cell roof area on the third floor, to the work benches in the development laboratory, to the service station in the chemical makeup room, and to the demineralized water system for the fuel storage basin. The cleanup system for the demineralized water in the fuel storage basin is provided by a mixed-bed (cation-anion) exchanger demineralizer. The demineralizer has a minimum flow capacity of 25 gpm and an exchange capacity of 100,000 grain as $CaCO_3$ equivalence. The manual regeneration resin unit is model MB5-95 ILLCO-Way Mixed Bed, manufactured by the Illinois Water Treatment Company.

Cooling Tower Water. — Water from the HFIR tower water basin is received at the TURF facility at 85°F and is returned at about 90°F. A booster pump increases the water pressure to approximately 40 psi. This supplies 890 gpm to the facility. The water is used in TURF to remove heat from the heat exchanger for the recirculating cooling water (RWC), the air compressors, the 150-ton chiller for the S-1 air conditioning system, and the direct-expansion refrigeration units on S-11 supply to cell A and S-12 supply to cell E. The booster pump is located in a pit along with the booster pump for the TRU tower water system and is interconnected with the TRU control system to provide stand-by supply if either pump fails. This system is essential for removing heat loads from the RWC system and supplying cooling water to the compressors in the compressed air system; therefore, its control system provides an alarm at the building control panel when either the system temperature rises above 90°F on the supply or 95°F on the return (indicating an abnormal heat load condition), or when the pressure falls below 35 psig (indicating a loss in water flow). The system is provided with an automatic emergency supply from the process water system if the normal supply from HFIR is interrupted.

Recirculating Cooling Water. — Cold water for cooling equipment is circulated in a closed loop to process service stations at operating and service modules around the cell bank and to other locations within the facility. Cooling tower water is normally used to cool the heat exchanger for the recirculating water system. The system is designed to operate at 65 psig below limits of 105 to 115°F. A 60-gal receiver tank provides for closed loop contained operation. Circulation is provided by a centrifugal Peerless pump, RWCP-1, capable of delivering 250 gpm at 100-ft head. In case of failure of the normal pump, a stand-by pump (also a centrifugal Peerless pump, RWCP-2) capable of delivering 130 gpm at 100-ft head is available for emergency operation. The system controls sound an alarm on the building control panel if the water temperature exceeds the supply and return temperatures of 105 and 115°F, which indicate an abnormal heat load. An alarm is also sounded if the water level in the receiver tank falls below the half-full point, which indicates that makeup water is required in the system. Makeup water is admitted manually to the receiver tank from the process water system.

Chilled Water. — Chilled water (CHW) is circulated in a closed system to the cooling coils of the air conditioning units located throughout the building. Circulation is provided by two centrifugal Peerless pumps, CHWP-1 and CHWP-2. The system operates normally with one pump; the other is in standby for emergency operation. The system normally operates at about 40 psig and 50°F. A 150-ton York centrifugal refrigeration machine removes heat from the chilled water system. Makeup water to the chilled water system is supplied automatically from the process water system through a control station if the pressure in the distribution system falls below 30 psig.

Hot Water Heating. — The hot water heating (HWH) system provides auxiliary heating to the office area through the fin-tube heaters mounted along the outside wall of the offices. The system circulates hot water at 70 psig and at about 200°F. Steam condensing in a small heat exchanger heats the system. A centrifugal pump, HWHP-1, which is capable of delivering 16 gpm at 17-ft head, circulates the hot water. Makeup water is supplied automatically from the process water system through a control station if the pressure in the distribution system falls below 60 psig.

Fire Protection Water. — The fire protection sprinkler system is supplied from the fire water pipe loop outside the building, with main shutoff and control valves located at the northwest corner of the building. The fire water supply to the building enters through pipes penetrating the floor of room 131, the Health Physics office. From the central supply station in room 131, the system distributes water to the wet standpipe sprinkler system. The loop around TURF may be isolated by closing the two post-indicator valves at the southeast and southwest corners of the building. Controls on the system give alarms at both TURF and the ORNL Fire Department in the event valves are closed or pressure falls in the system. The system supply and its emergency backup come from the main ORNL fire water system serving all of Melton Valley.

2.11.4 Steam and Condensate System

Steam is supplied to the TURF steam and condensate system at 250 psig from the ORNL steam system serving all of Melton Valley. A pressure reducing station, PRV-3, is located east of the building above ground to reduce the steam pressure to 100 psig for service into the facility. The 100-psig steam enters the building through the floor of room 119 and from there passes to room 210, the mechanical equipment room. From there, it is distributed to the process service stations at operating and service modules around the periphery of the cell bank and to operate steam eductors in cell E, cell G eductor pocket, and the waste pit. In the mechanical equipment room, the steam pressure is further reduced to 15 psig at a pressure reducing station, PRV-6, and then distributed throughout the building for heating purposes and to potable and process water heaters. All condensate from the 100- and 15-psig systems is collected in a piping system throughout the building and then either dumped to the storm drain system or used for makeup water to the fuel storage basin.

2.11.5 Plant Gas System

An argon supply station made up of two 4-bottle racks is installed in room 203, the second floor maintenance operating area. The station supplies a distribution system serving the process service stations in the third floor cell roof area and to stations for zinc bromide window maintenance at the cell operating modules of cells B, C, D, E, F, and G. A local alarm is installed at the supply station to sound when the manifold pressure falls to 100 psig, indicating a depletion of gas supply or a failure in the piping system.

3. FACILITY FIRE PROTECTION

The TURF fire protection systems provide complete coverage to all parts of the facility. The cell bank interior is protected by a high-pressure, gaseous carbon dioxide system of unique design, and the out-of-cell building area is protected by a conventional wet standpipe water sprinkler system. Both fire protection systems are equipped with individual local alarm systems and are integrated with the ORNL plant fire alarm system.

3.1. Plant Fire Protection

3.1.1 Fire Water System

An 8-in. fire water loop encircles the building, providing water to two fire hydrants and to the building sprinkler main. The loop is equipped with three post-indicator valves, and the sprinkler main is equipped with a supervised post-indicator valve. Maximum operational readiness of the system is assured by water supply from the ORNL fire water loop.

3.1.2 Building Sprinkler System

The water main for the wet standpipe sprinkler system enters the building at the northwest corner, rising through the floor of the Health Physics office (room 121) where the main manual shutoff and control valve for the building sprinkler system is located. The Siamese water supply connection for use by the ORNL fire department pumper is located on the outside west wall of the building.

The entire building area, other than the cells, is piped for a conventional automatic wet sprinkler system. The system is divided into five sprinkler zones that cover the north and south basement areas and all three floors of the building.

Auxiliary to the sprinkler system are local hose cabinets equipped with 75-ft-long, 1 1/2-in. unlined linen hoses connected through hand valves to the sprinkler piping. Each cabinet is also provided with a 20-lb CO_2 fire extinguisher. These units are located as indicated in Fig. 3.1. Additional water and dry-chemical extinguishers are located throughout the facility to cover special activities. These units are located and maintained by the ORNL Fire Department.

3.1.3 Fire Alarm System

The system is divided into 24 local zones with local alarms and is interconnected to the master alarm system through master alarm box 834, located on the north wall of the main entry to TURF (room 101). The master alarm system is interconnected with the ORNL plant alarm system through Building 7920 to master alarm box 835, located at the southwest of TURF near the HFIR access road.

The fire alarm system also includes a trouble detection system. This system is interconnected to the master trouble detection system through master trouble box 834, painted blue and located adjacent to master alarm box 834. The master system is then interconnected with the ORNL plant trouble detection system through Building 7920 to master trouble box 835, which is painted blue and located adjacent to master fire alarm box 835 southwest of TURF.

The alarm system is monitored by a control and annunciation cabinet located adjacent to the master alarm and trouble boxes on the north wall of the main entry to TURF (room 101).

Fire alarm signals may originate from any of the following causes; (1) water flow into any of the five wet sprinkler system zones that cover the basement and three floors, (2) actuation of one of the 16 manually operated local fire alarm pull stations located as shown in Fig. 3.1, and (3) the actuation of any of the five fire protection heat actuated detector systems for the cells. The origin of the signal is indicated by individual signal lights visible on the face of the annunciator cabinet.

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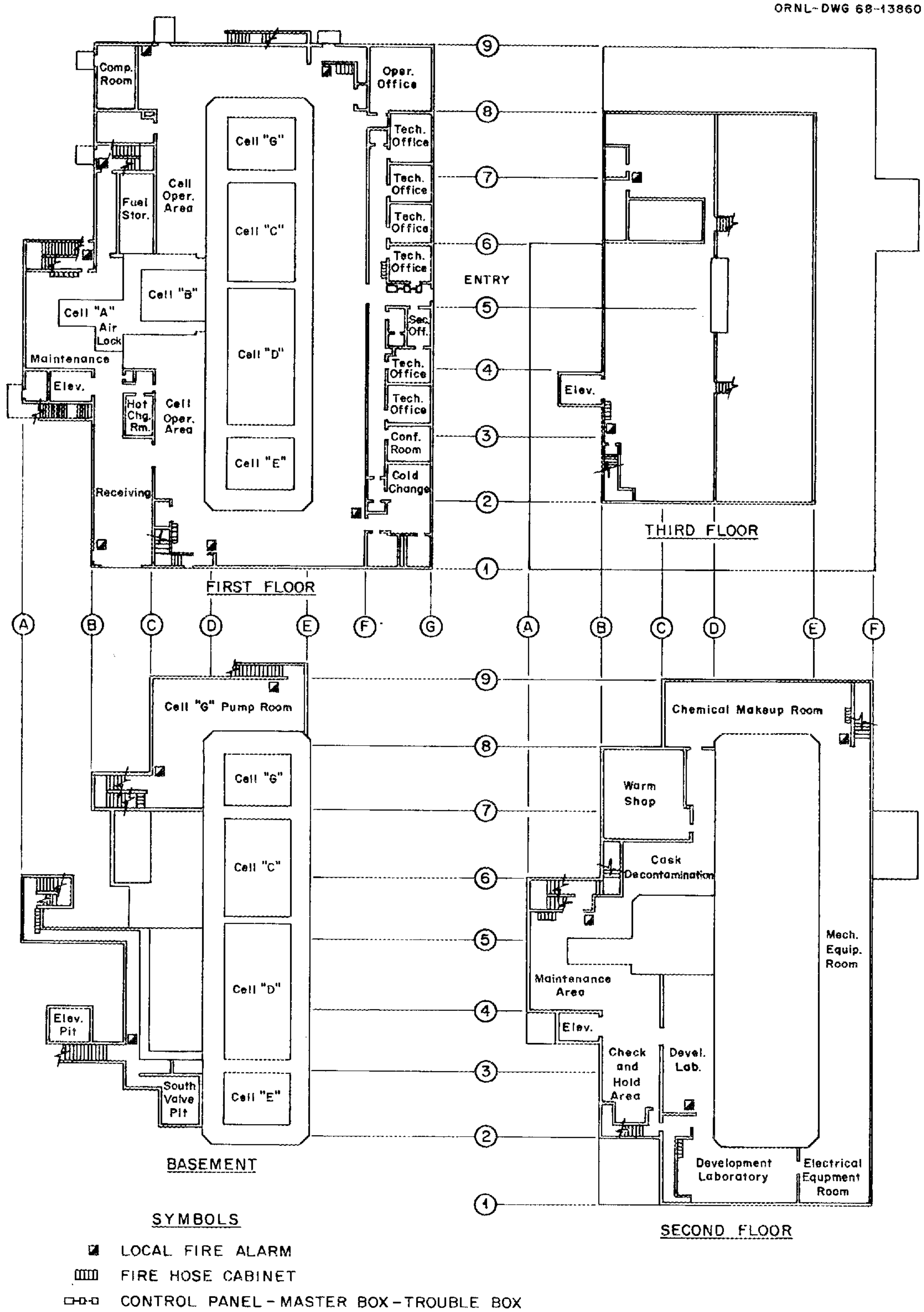

Fig. 3.1. Fire Alarm Stations and Local Hose Cabinet Locations.

The alarm stations are grouped into zones as follows:

Zone No.	Description and Location
1	Fire alarm station 1A, room 119, southwest Fire alarm station 1B, room 119, southwest Fire alarm station 1C, room 119, northeast Fire alarm station 1D, room 119, northwest
2	Fire alarm station 1E, room 134, stairwell 4 Fire alarm station 1F, room 130, stairwell 3 Fire alarm station 1G, room 127, southwest
3	Sprinkler, first floor areas
4	Fire alarm station BA, room 4, northeast Fire alarm station BB, room 4, southwest
5	Fire alarm station BC, room 2, north Fire alarm station BD, room 2, south
6	Sprinkler, basement areas
7	Sprinkler, building main, room 121
8	Fire alarm station 2A, room 203, north Fire alarm station 2B, room 208, east Fire alarm station 2C, room 212, west
9	Sprinkler, second floor areas
10	Fire alarm station 3A, room 302, southwest Fire alarm station 3B, room 302, northwest
11	Sprinkler, third floor cell roof areas
12	Fire alarm CO_2 station, cell D
13	Fire alarm CO_2 station, cells A and B
14	Fire alarm CO_2 station, cell C
15	Fire alarm CO_2 station, cell E
16	Fire alarm CO_2 station, cell G
17	Fire alarm master box 835

Zone No.	Description and Location
18	Spare
19	Spare
20	Spare

The zones that serve the trouble detecting system and the conditions that activate the alarms are as follows:

Zone No.	Description
21	CO_2 system supervisory contact TD275 — closed
22	Sprinkler system building main fire water valve — closed
23	Sprinkler system building main water pressure loss
24	Fire alarm system supervisory check switch

The annunciator control for the trouble system is also located in the control and annunciator cabinet panels on the north wall of the main entry to TURF (room 101).

The fire alarm system receives normal and emergency power through the instrument power supply. The system is also equipped with a stand-by 24-v, heavy-duty, wet-cell battery and a battery charger to ensure operation in case of complete electrical power failure.

3.2 Cell Fire Protection System

The fire protection system for the TURF cells, shown schematically in Fig. 3.2, will extinguish fires resulting from solvents or oils without damaging electrical and mechanical equipment, without producing large quantities of liquid waste, and without plugging in-cell ventilation exhaust filters, allowing cell pressure to rise above atmospheric. Carbon dioxide, as normally applied, very adequately meets the first two requirements but has caused problems with filter loading in one installation at ORNL. This difficulty could be attributed to freezing of the moisture in the cell air or to formation of carbon dioxide crystals and subsequent deposition of these solids on the filter media.

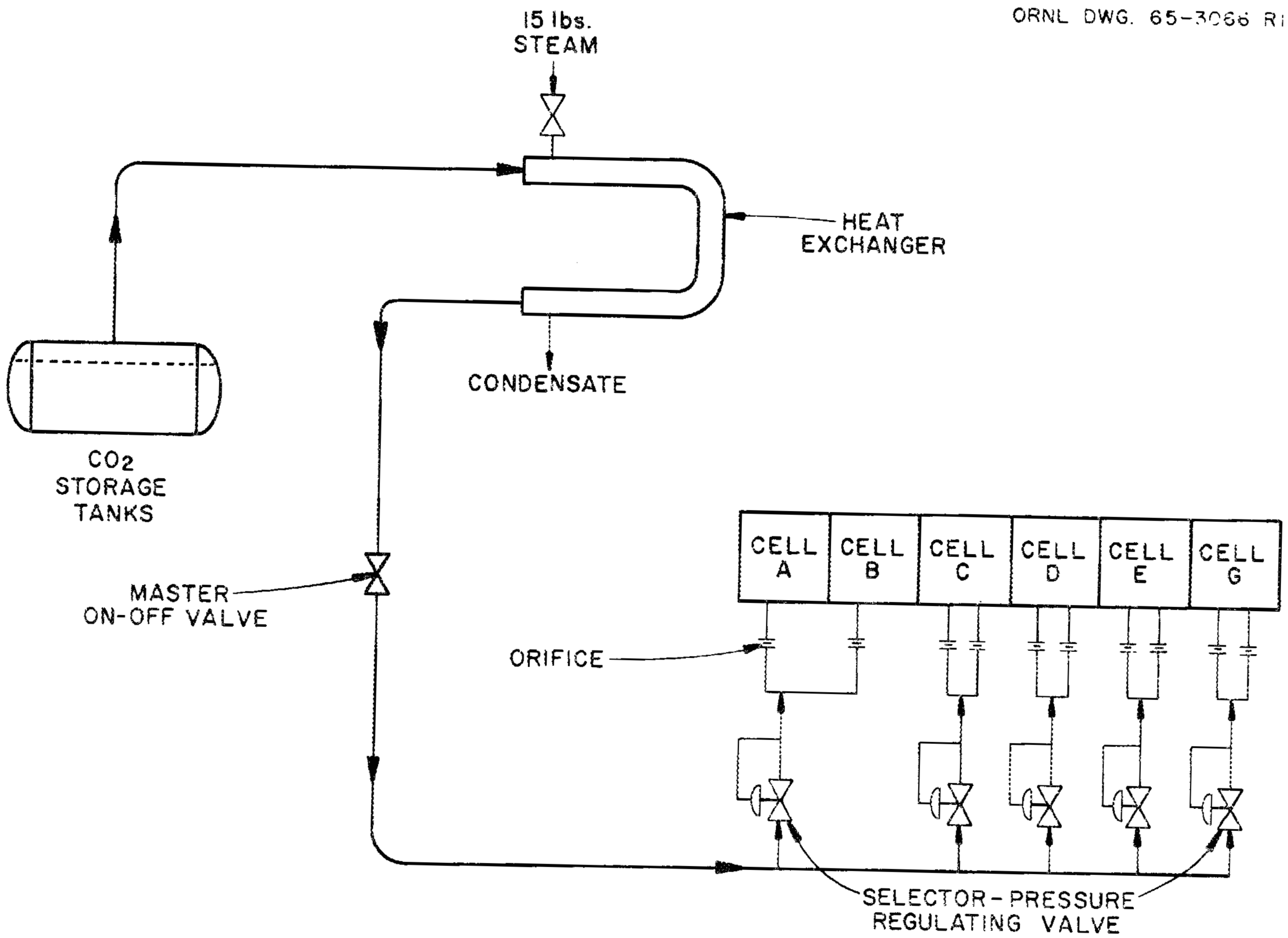

Fig. 3.2. Flowsheet for CO_2 Distribution System for TURF Cell Fire Protection.

Filter plugging resulting from these causes is avoided in the TURF system by introducing carbon dioxide with sufficient heat content that the temperature of the resultant air-CO_2 mixture will be at least 33°F. This is done by drawing off only gaseous CO_2 from a storage system and superheating it in a steam-heated shell and tube-type heat exchanger before discharging it into the gas distribution piping system. From the piping system, the gas is discharged to the required cell at a control pressure through limited-flow orifices to help maintain the cells at or below atmospheric pressure even while CO_2 is being introduced to combat a fire. The necessary air-CO_2 concentration required for extinguishing is assured in the system by (1) the mass of CO_2 discharged to the appropriate cell and (2) the fact that the supply points are at ceiling height and the exhaust points are in the cell floors, which assures the best possible mixing of the CO_2 with cell air upon entry to the cell.

The electrical controls are of conventional design and include a supervisory system to assure operability in time of need. System action is automatically initiated by temperature sensing devices, located in each cell and set to actuate at 140°F. Action may be manually initiated at any time in any cell at the operator's discretion. These manual switches are mounted in recessed boxes on the face of the cell bank. These units, marked in characteristic red, are clearly identifiable and are actuated by depressing a button. There is at least one manual control switch located in a cell operating module on the face of each cell. Controls for cell E and the cell A and B complex are equipped with keyed switches to lock out the system and prevent the injection of CO_2 into these cells during periods of personnel occupancy. Manual actuation of the system in the event of failure in the automatic control has been provided by the installation of manual pilot control valves. The master on-off valve and the selector-pressure regulating valves feed CO_2 into the distribution piping system and the cells, respectively.

Upon actuation of the system, air supply to all cells is stopped; pressure control is transferred to the exhaust dampers, one for cells A and B and one for cell E (in cells C, D, and G the exhaust dampers go wide open); and CO_2 is injected into the cell from which action was initiated.

The system controls are designed to provide to the cells from which the initiating signal originates, CO_2 in a quantity based upon cell size as shown in the following table.

Table 3.1 CO_2 Required for Each Cell in TURF

Cell	Cell Volume (ft^3)	CO_2 Required (lb)	Discharge Rate (lb/min)	Discharge Time (min)
C	15,250	915	860	1.06
D	19,000	1,140	1,050	1.09
E	9,340	560	468	1.20
G	9,340	560	468	1.20
A and B	13,650	1,144	844	1.35

Under normal conditions the system will develop a minimum CO_2 concentration of 34% in 1 min, with subsequent discharge to provide a final concentration of 40% for added safety. The system storage capacity is 5516 lb.

The cell A and B complex, which is treated as a single cell, places the most stringent demands on the system. The normal operation of cell B is such that any one of the three shielding doors or the floor hatch to cell F may be open at the time a fire developed in cell A or B. Since CO_2 is not directly discharged into cell F, the controls of the ventilation system are designed to automatically close both the supply and exhaust systems at the time the hatch is open. The systems for distributing and controlling CO_2 are designed to discharge a total calculated weight of 1144 lb of CO_2 into this complex upon signal. This provides 844 lb of CO_2 in 1 min, producing the 34% concentration in both cells with all doors and hatches closed. The system will then discharge the additional 300 lb of CO_2 in the next 0.35 min, bringing the final concentration to 40%, provided all doors and hatches are closed. This additional CO_2 is intended to provide for abnormal conditions and will provide 7.1 lb of CO_2 per ft^2 of floor opening if the hatch to cell F should be open. This additional capacity also provides at least a minimum of 90 lb of CO_2 to compensate for loss resulting if either shield door 2 or 3 to cells C or D should be open at the time of a fire.

The system is designed to safely extinguish fires with heat generation of 20,000 Btu hr^{-1} ft^{-2} of the following sizes:

Cell G	—	half the floor area	—	160 ft^2
Cell C	—	an area 16 ft × 10 ft	—	160 ft^2
Cell D	—	an area 24 ft × 10 ft	—	240 ft^2
Cell E	—	half the floor area	—	160 ft^2
Cells A and B	—	an area 16 ft × 10 ft	—	160 ft^2

We do not believe fires will be possible in cell F, since flammable materials will not be stored in that cell.

The system controls are designed to meet all the requirements for an NFPA Class B proprietary supervised system. Signals are transmitted to the ORNL Fire Department to indicate a trouble alarm from the supervisory system or a fire alarm from the control system. Interlocks within the control circuitry prevent over-pressurizing the cell and therefore assure that containment is maintained at all times. In the unlikely event that cell exhaust filters were to become plugged by icing, bypass ducts with control valves are provided to permit cell exhaust to bypass the in-cell roughing filters in the exhaust system.

A program of testing and inspection of the system has been developed. The master on-off valve and the selector-pressure regulator valves will be periodically tested and inspected to assure maximum reliability of the system. The quantity of CO_2 in the storage tanks will be kept under routine observation, and the system will be refilled after any use or when storage capacity drops by 10%. All components of the system have been tested and approved by Factory Mutual, a fire underwriting company.

4. LIQUID WASTE

Liquid wastes, including storm drainage, sanitary wastes, process draining from sources other than cells, and radioactive process by-product waste streams (RHD, RHDR) are collected by the networks installed for this purpose. Terminal points and disposal schemes for the various liquid streams are dictated by the kind of contamination in the different waste streams. Radioactive waste solutions are impounded and treated either in the TURF waste system or transferred to the appropriate ORNL radioactive waste treatment system. Nonradioactive process liquid wastes are monitored for contamination and piped to retention basins that provide controlled discharge to the surroundings. The sanitary waste is transferred into the Melton Valley disposal system, and storm drainage is discharged directly to a natural drain.

4.1 Storm Drains

Surface and subsurface liquid, as well as roof drainage, are piped away from the building foundation to an open drainage ditch west of Building 7930. This ditch is integral with the Melton Valley storm drainage system and provides adequate flow capacity.

Site preparation included landscaping and contouring of the terrain surrounding TURF to afford adequate flood protection from atmospheric precipitation expected from meterological and climatic experience.

Subterranean liquid is piped away from the facility by perforated, galvanized, corrugated metal pipe embedded in the earth around the building foundation and by drainage ways in the concrete cell wall foundation that extend to fresh shale. This drainage system extends from the facility foundation at a level below grade to an open drainage ditch. This system is placed at elevations to relieve maximum flood levels as defined by the Tennessee Valley Authority.

Ground water is drained from the cell area through the footer drainage system. This system can, however, allow liquid to rise in the cavity below cells C and D where the cell exhaust ducts are located. The exhaust ductwork, except where it drops to enter the valve pits, is located above the maximum possible elevation of water. These lower portions of the ducts are encased in approximately 5 ft of regular concrete. These cavities below the cell floor are drained at a level 14 ft below the floor level by discharging to the footer drainage system. With these provisions, it would be very unlikely that storm water or ground liquid would ever enter the facility or the cell bank.

4.2 Sanitary Waste System

The sanitary waste system collects biological wastes from the hot and cold change rooms and the ladies' rest room and waste water from several drinking fountains and gutter drains. This sanitary waste system is piped separately from the building to the Melton Valley area sanitary waste disposal units.

4.3 System for Process Waste Drainage from Sources Other than Cells

The process waste system receives solutions from operations conducted outside the cell bank and drainage from all zone 2 and zone 3 areas, such as the laboratory area, decontamination area, chemical makeup area, etc. The collection points of this system are shown schematically in Fig. 4.1.

The process waste liquid from sources other than the cells (Fig. 4.1), which is susceptible to slight radioactive contamination, is collected by the process waste system and monitored for contamination before being routed through settling ponds to disposal or further retention. Normally a storage pond is allowed to accumulate low-level waste until it is necessary to change to the alternate pond. These ponds are periodically sampled and, depending on analytical results, are released to natural drainage or pumped to the Melton Valley waste system.

Contaminated waste, of sufficient radioactivity content to be diverted to a large hold-and-disposal pond, will trip the diverter-valve activator circuit long enough before it reaches the diverter box to prevent contaminated waste from entering the low-level waste ponds (3 and 4). A sketch of the pond area is shown in Fig. 4.2. Ponds 3 and 4 are 50,000-gal capacity each and are for normal low-level process waste retention-disposal operation. Pond 2 is 500,000-gal capacity and receives and stores contaminated waste, pending treatment or return by pumping to the Melton Valley waste system.

The materials of construction for process waste handling systems are designed to contain the various types of wastes expected from the various feeder systems. The process waste system is in general

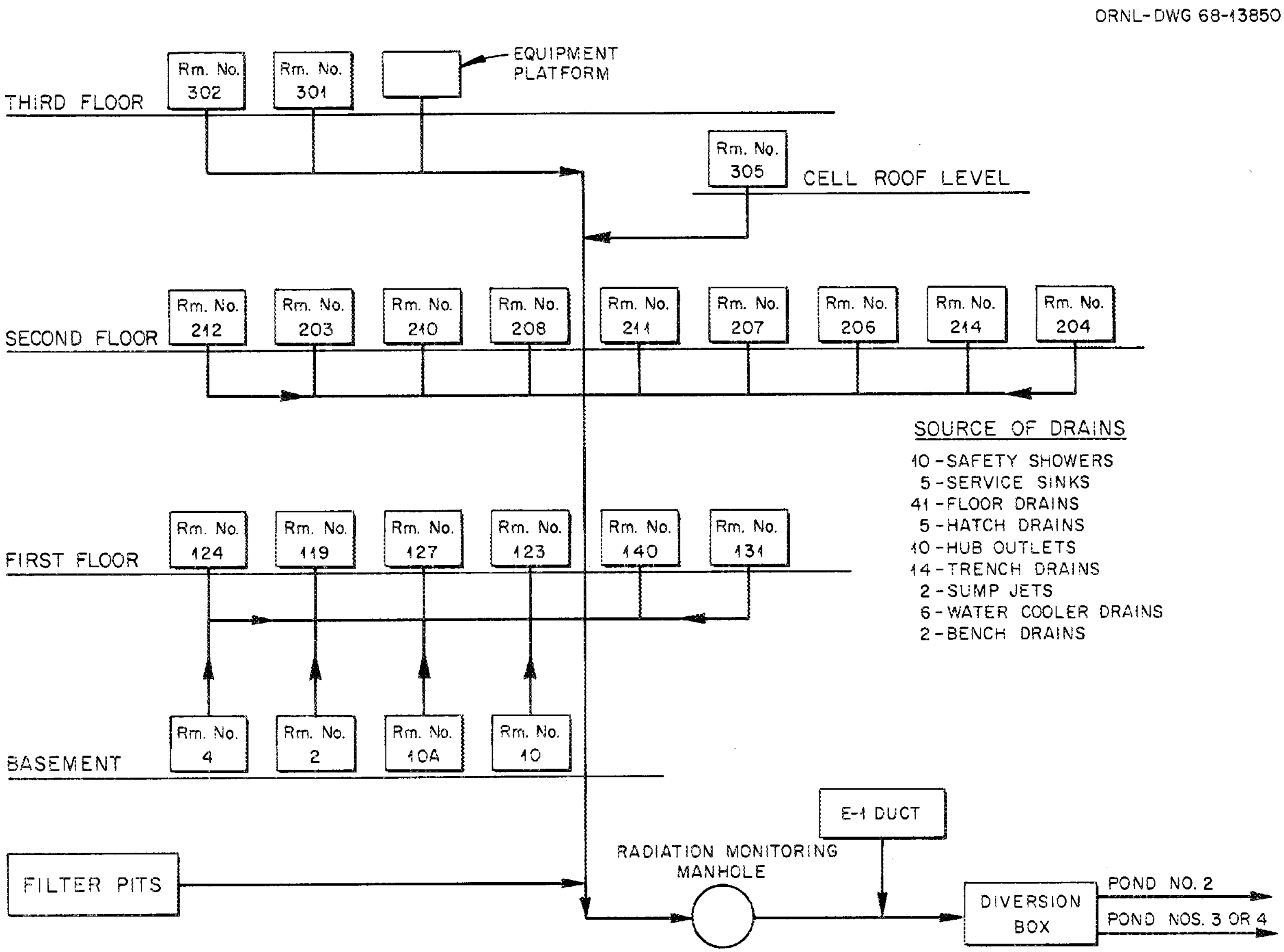

Fig. 4.1. Process Liquid Waste System.

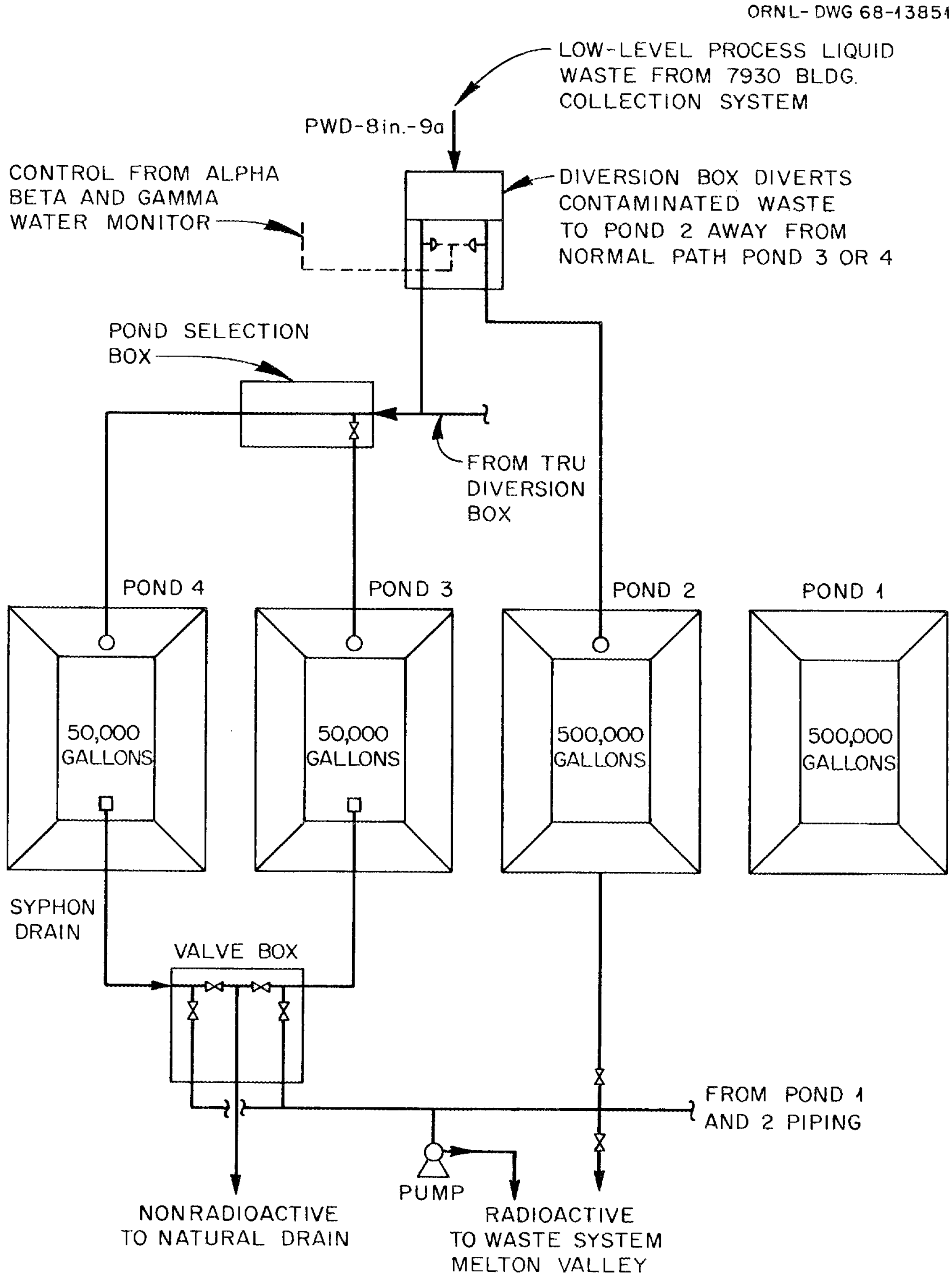

Fig. 4.2. Process Waste Retention Ponds.

fabricated from Duriron pipe inside the facility and vitrified clay pipe outside the facility. There are lead sink cups at the laboratory benches, stainless steel adaptors at the decontamination pad, and carbon-steel pipes at floor and trench drains. Manholes and the diversion box have been constructed with combinations of concrete and brick and have been coated on the inside with bitumastic coating materials for light acid resistance. Cognizance of this fact is sufficient to ensure proper care is given the concrete should acid solution exposure to this waste system occur.

4.4 Radioactive Hot Drain — Hot Off-Gas System

The radioactive hot drain — hot off-gas (RHD-HOG) system is a combination collection system for by-product waste and vessel off-gas system with inlet connections in penetrations to all the hot cells and collects from the trapped floor drains in the equipment airlock, cell A, and cell B. This system also has tributary piping collections from the laboratory hoods, the transfer ports atop cells E and C, sumps in the cell F corridor, cell F, the north and south valve pits with cell ventilation manifolds, the cell G pump room, the solid samplers serving cells C, D, and E, and the decontamination pad in the second floor maintenance operating area.

The RHD-HOG waste system contains piping as large as 6 in. inside diameter and is intended to receive and handle vessel off-gas and by-product waste solutions that contain negligible amounts of fissile materials. The pipe network of the RHD-HOG system, all of stainless steel, has a minimum slope of 1/4 in./ft and empties into the top of the RHD waste tank B-2-T. The RHD-HOG system is not geometrically safe for handling a critical mass of fissionable materials. It is the companion waste system to the RHDR system, which is designed for nuclear safety as described in Section 8.2.

The RHD-HOG piping network is designed to handle gas and liquid simultaneously. Liquid waste is separated from the off-gas and is collected in tank B-2-T. The gas stream flows onward through a pipe in the scrubber pit, through off-gas filters, and downstream into the cell exhaust system, which is upstream of the filter pit. The scrubber pit provides space for scrubbing equipment for future operations, should they become necessary. The RHDR B-3-T waste tank receives overflow or jetted liquid from B-2-T and is used as holdup capacity for monitoring and control operations. Tanks B-2-T and B-3-T, in the hot waste pit adjacent and to the southwest of TURF, are the termini of the RHD-HOG system. The contents of these two tanks may be sampled, inventoried, and disposed of by controls and equipment located in the waste sample room in Building 7932. This building is located over the east end of the waste tank pit. The contents of either B-2-T or B-3-T may be jetted to the Melton Valley waste system for disposal.

4.5 Radioactive Hot Drain Recoverable

The radioactive hot drain recoverable (RHDR) system is the companion to the RHD-HOG system. The RHDR system originates inside the processing areas of the facility and discharges into one of two waste storage tanks (C-6-T and B-3-T) housed in the underground waste pit adjacent to TURF. These waste tanks are located below grade in a separate pit adjoining the cell exhaust filter pit and are shielded by 5 ft of regular concrete. This RHDR drain system serves also as critically safe off-gas exhaust to in-cell vessels containing fissionable materials. The C-6-T tank is the terminus of the RHDR gravity drain system and serves as a "drip tank" in this vessel exhaust system as the off-gas flows through the tank downstream to the off-gas filtration and exhaust units in the adjoining pits. The inlet liquid is piped to the bottom of C-6-T for intimate mixing of incoming liquid with the tank contents, while the inlet off-gas bypasses the liquid pool in the tank. In the event of flooding from the process cells C and D to the RHDR system, overflow from C-6-T may pass to B-3-T. Liquids can be jetted to B-3-T if desirable and thence to the Melton Valley waste system if necessary.

The RHDR system piping is fabricated sched-40 stainless steel pipe, 3 in. or less in diameter, and is embedded below grade in concrete or soil for a distance of about 250 ft between extremities. The pipe network has a minimum slope of 1/4 in./ft and terminates in the 4-ft-diam, 7-ft-high stainless steel C-6-T RHDR tank. The C-6-T tank is filled with borated glass raschig ring nuclear poison.

Solution and/or vessel off-gas intake to the RHDR system is primarily through 1-in. and 2-in. pipe penetrations in the walls and floors of the cells. Unused off-gas penetrations are sealed when not connected to a vessel. Drain trenches in cells C and D have liquid trap seals and discharge to the RHDR waste system. Floor drainage from cells G and E is collected in a sump in each cell and jetted to the RHDR waste system. The RHDR system may also collect residues from the transfer port drain connections in the mockup area over cells G, C, and D.

Valuable materials can be reclaimed from the RHDR system; solution can be jetted into cell G equipment for recovery operations through piping installed from both C-6-T and B-3-T to cell G. The eductors and valving for this reclaiming operation are mounted in pockets in the cell G wall with access from the cell G pump room. The system valves and eductors are shielded with 8 in. of removable lead.

5. SOLID SAMPLING

5.1 Shielded Sampler

A pneumatic tube system to transfer solid samples from cells C and D through a 1 1/2-in. pipe to the third floor cell roof area is installed in TURF, as shown schematically in Fig. 5.1. Vacuum for the system is produced by an electric blower-driven exhauster unit. The vacuum draws the sample capsule, or "rabbit," up the pipe system from a dispatch station in either of the two cells. The dispatch stations are located on the cell wall at the cell operating modules adjacent to the shielded doorways into the cells. The dispatch stations are connected to the dispatch lines by Grayloc disconnects. The dispatch stations are large block valves, each with a cavity approximately 1 5/8 in. in diameter by 3 1/2 in. long, that can be rotated 90° for the insertion of the sample rabbit, and then repositioned so that the rabbit is conveyed up the dispatch tube. The system takes in air from the cell from which the

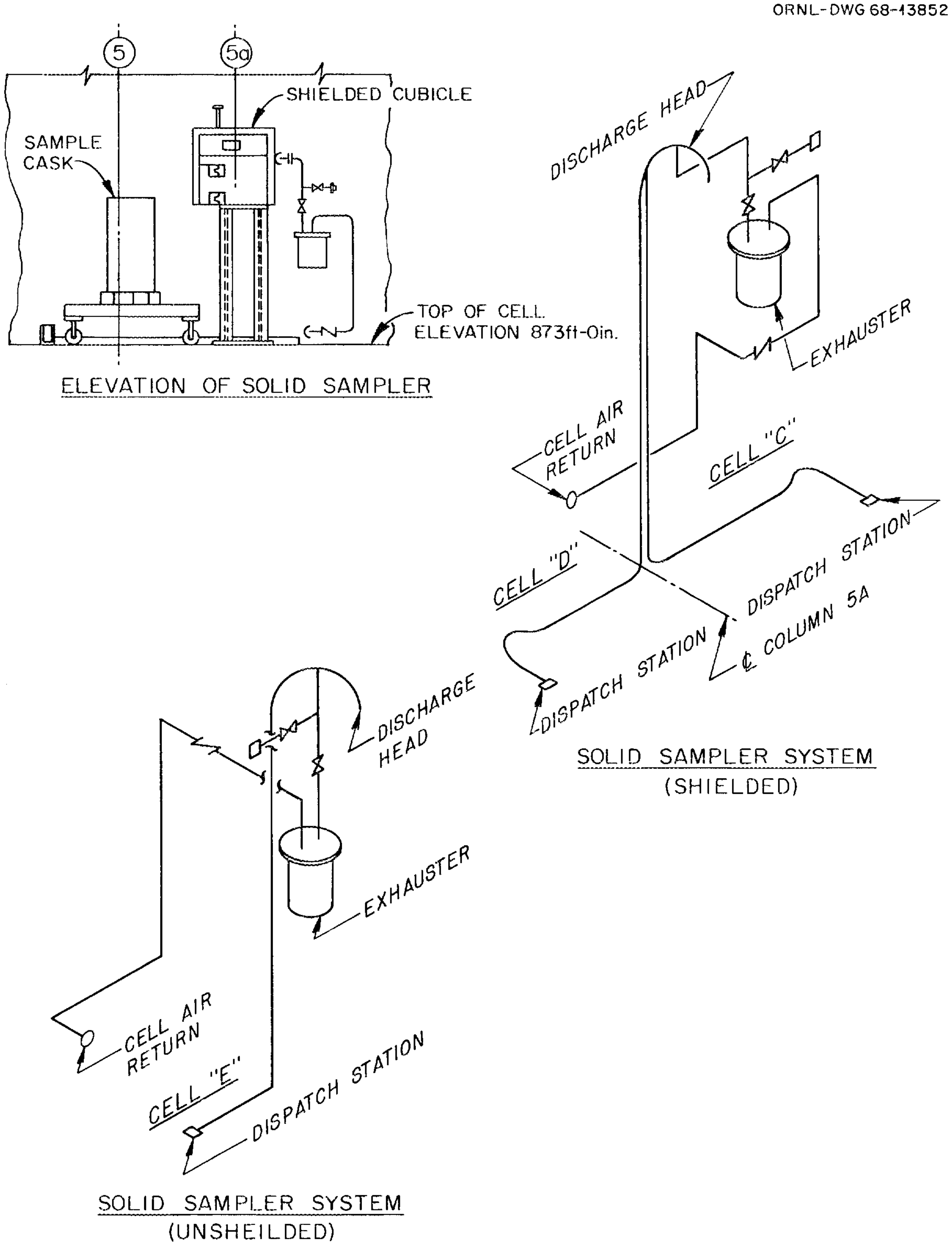

Fig. 5.1. TURF Solid Sampler Systems.

sample is being dispatched and exhausts the air to cell D. The system is capable of lifting a capsule filled to a maximum of 15 oz with samples of solid material. The sample is conveyed to the third floor cell roof area to a receiving station and deposited in a bag attached to the discharge head of the sampler unit. The discharge head and the auxiliary equipment of the receiving station are enclosed by a cubicle shielded by 9 in. of lead shot. The cubicle has a swinging door near the bottom of the south side which rotates out to permit a sample cask on a dolly to be rolled under the shield and positioned directly below the discharge head. The cubicle is equipped with a lead glass viewing window and a device for sealing and cutting bags. After the sample is deposited in the bag, the bag is then sealed, and the joint is severed in such a manner that both segments of the joint remain sealed. The sealing and cutting device is actuated from outside the cubicle. When the bag joint is sealed and the bag is severed, the bag containing solid sample drops into the cavity of the cask that has been placed under the shielded cubicle.

5.2 Unshielded Sampler

A pneumatic tube transfer system is installed in cell E for taking solid samples of material from process operations in the cell. This sample system is very similar to the system installed in cells C and D (described in Section 5.1) except that no shielding of the receiving station is provided due to the nature of process operations expected in cell E. The samples drawn from cell E are bagged the same way as those drawn from cells C and D. This sampling operation is operated by direct contact.

6. GASEOUS WASTE

A vessel off-gas system (HOG), which is combined with the RHD system described in Section 4.4, discharges gaseous waste from process vessels, sealed enclosures, and other limited-access points throughout the processing area of the facility. The off-gas flows through the

RHD-HOG collection system and then is discharged by exhaust system E-3 into the cell ventilation exhaust system E-1, which then flows to the HFIR stack.

A cell ventilation system supplies purge and conditioned air to the cells, collects gaseous waste from the general processing area, and discharges the waste through the exhaust system E-1 to the HFIR stack. These systems are shown schematically in Figs. 6.1 and 6.2, respectively. The 250-ft-tall HFIR stack has a capacity of 60,000 cfm of air with a maximum average atmospheric dispersion factor of 0.92×10^{-5} sec/m^3 released.

6.1 Vessel Hot Off-Gas (RHD-HOG)

6.1.1 Hot Off-Gas

The gaseous waste from the cells and certain limited-access points adjacent to the cell bank is collected and flows through a piping system embedded in the walls and under the floors of the facility. The gaseous waste enters the HOG system through pipe connections equipped with Grayloc-type disconnects. The HOG branch piping systems vary from 1 to 4 in. in diameter. The HOG header, which collects gaseous and liquid waste from all of the branches of the waste system, is 6-in.-diam pipe. The HOG header collects gas from the cell branches downstream of the pitot tube pit located in the floor of the cell operating area. In the pit, the flow of gas is monitored in each branch. The header then runs underground, at a depth varying from 6 to 8 ft, to the waste pit, where it enters the top of the 1870-gal RHD waste tank B-2-T. System E-3 exhausts the gas from the top region of the tank through a 6-in. pipe that passes through a scrubber pit (provided for caustic scrubbers but initially equipped with a spool piece in lieu of scrubbers), and thence through the HOG filter pit. From the filter pit, the hot off-gas flows through the centrifugal blower and into the inlet plenum to the E-1 cell exhaust filter pit. The entire HOG piping system is of welded type 304L stainless steel of the highest quality. There are two blowers (EF-1, EF-2, E-3) mounted parallel in the system, either of which will normally operate with the other held for stand-by service.

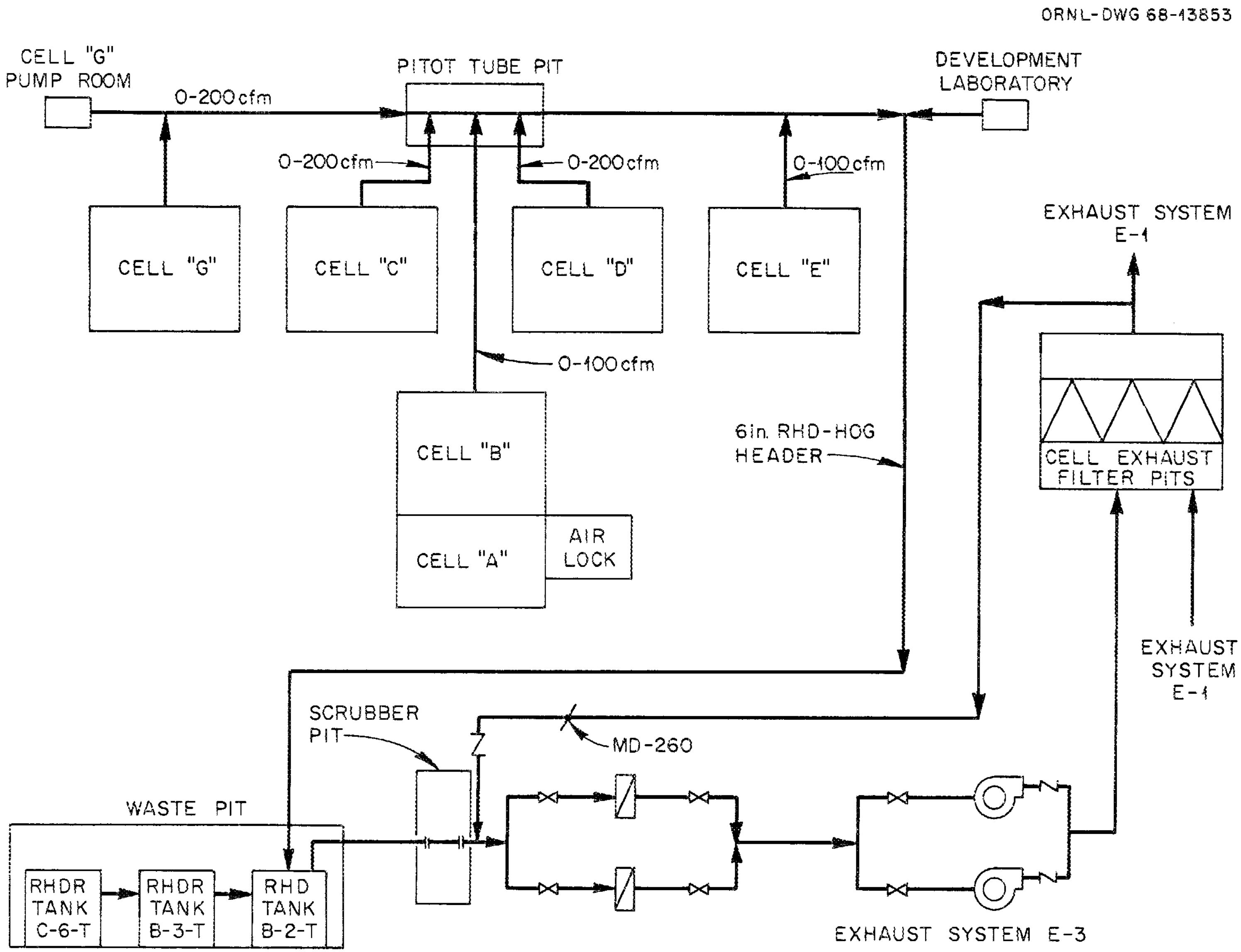

Fig. 6.1. Hot Off-Gas Collection and Discharge Schematic.

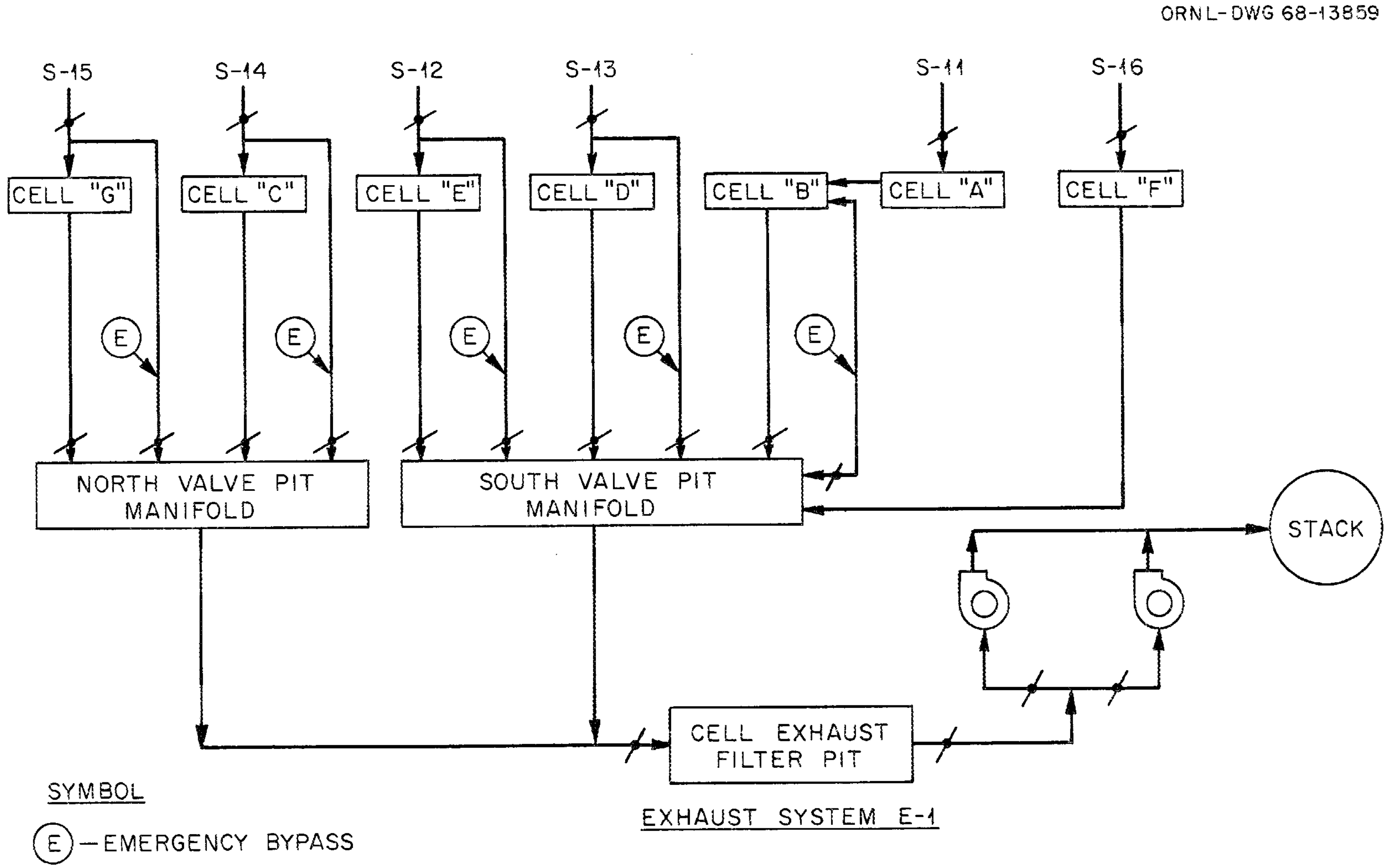

Fig. 6.2. Cell Air Flow Pattern Schematic.

6.1.2 Filters

The hot off-gas flows through the HOG filter pit through either of two parallel compartments. Each compartment is equipped with an entrance and exit manual control valve, a filter enclosure, two hydraulically actuated expandable bellows assemblies, and auxiliary supporting and alignment equipment. Each filter enclosure is a completely sealed sheet metal box containing two roughing filters and four HEPA filters. The filter mounting and the enclosure internal baffling provide for series flow through all six filters. The filter enclosure is connected and sealed into the duct system by the bellows assemblies, which compress gaskets between the mating flanges of the enclosure and the bellows assembly on each end.

There are taps provided into the ducts on either side of the filter pit for Dioctyle Phthacate (DOP) Smoke Test. Taps are also provided into each closure for DOP testing each pair of filters in the enclosure. The HEPA filters have been tested in place and found to have an efficiency equal to or better than 99.95%. A plan for periodic inspection and testing, as described in Section 9.2, will maintain this filter pit efficiency at all times. During normal operation, flow will be through only one HOG filter compartment, with the alternate filter compartment valved for stand-by service. The pressure drop across the filter pit is indicated on a differential pressure gage mounted on an instrument panel at the pit.

The filter pit itself provides 2 ft of regular concrete shielding. The design of the pit equipment is such that a shielded changeout of the filter enclosures using the ORNL filter pit maintenance equipment can be accomplished. Dirty filter enclosures will be transferred to the burial ground, where the entire enclosure will be discarded.

6.1.3 Pressure Control Instruments

The pressure at the inlet connections to the hot off-gas system is normally maintained at a constant −15 in. water gage, with respect to atmosphere, by a combined action between pressure controller 264 and the E-3 exhaust system that takes makeup supply from the downstream side of the E-1 exhaust filter pit. The controller maintains a constant 15-in. vacuum on the entry points to the HOG system by positioning the system makeup supply damper MD-260 to give a constant volume of flow to the centrifugal fans EF-1 and EF-2 of the exhaust system E-3. Pressure switches are also installed on the upstream side of these fans to sense a loss of flow in the exhaust system. In the event the pressure rises from the normal −45 in. water gage to −30 in. water gage, indicating a complete loss of vacuum in the HOG system at the entry points in the cells, the alternate exhaust fan will be started automatically.

6.2 Cell Ventilation

The cell ventilation system consists of supply systems that pass air into the cells, where the air and gaseous waste are collected, filtered, and dispelled by a common exhaust system to the atmosphere.

During routine operation of TURF, rare gas and halogen fission products and miscellaneous aerosols of nonvolatile fission products and reactor fuel materials will be released in small quantities through the cell ventilation system. The radioactive material inventory of the facility and the properties of the ventilation system are such as to assure that these releases will be maintained below the currently acceptable rates.

Controls will be exercised in TURF, based on negotiations with other users of the HFIR stack, to assure that the combined release rates during normal operations (averaged quarterly) will not exceed the following: rare gases, predominantly ^{85}Kr, $\leq$ 0.01 curie/sec; halogens, predominantly ^{131}I, $\leq$ 0.06 curie/day; aerosols of mixed fission products $\leq$ 0.001 curie/day; aerosols of alpha emitters, $\leq$ 0.000010 curie/day. These upper-limit release rates are based on safety analysis studies for HFIR and TRU. Experience with HFIR, TRU, and the radiochemical facilities in Melton Valley indicates that the release rates will normally be much less than these upper-limit values.

6.2.1 Cell Supply and Exhaust Systems

Cells A and B. — About 1760 cfm of supply air enters cell A from the second floor maintenance operating area through supply system S-11. The S-11 system is equipped with roughing and absolute filters, a centrifugal fan, and a cooling and heating coil for conditioning the air before discharging it into the cell through a control damper and a backflow preventer. The purge air with gaseous waste from cell A flows as supply to cell B through a transfer duct located at the second floor roof level between cell A and cell B. This transfer duct is equipped with a butterfly valve, with manual set, which is positioned to maintain a predetermined pressure differential between cell A and cell B. The supply air to cell B enters the cell through in-cell ducts equipped with diffusers and mounted along the north and south walls near the ceiling. The purge air with gaseous waste from cell B is collected in an underground exhaust duct after passing through bag-type roughing filters mounted in filter wells in the cell floor. The air is transferred to the E-1 manifold in the south valve pit through the underground duct. The exhaust duct from cell B is equipped with a flow control damper and a flow element located in the south valve pit.

Cell C. — About 2240 cfm of supply air enters cell C from the third floor cell roof area through supply system S-14. System S-14 is equipped with a roughing and absolute filter, a control damper, a backflow preventer, and a flow element to indicate air passage into the cell. The supply system distributes the air to the cell through in-cell ducts equipped with diffusers and mounted along the ceiling. The purge air with gaseous waste from cell C is collected in an underground exhaust duct after passing through bag-type roughing filters mounted in filter wells in the cell floor. The air is transferred to the E-1 manifold in the north valve pit through the underground duct. The exhaust duct from cell C is equipped with a flow control damper located in the north valve pit.

Cell D. — About 2900 cfm of supply air enters cell D from the third floor cell roof area through supply system S-13. System S-13 is equipped with roughing and absolute filters, a control damper, a backflow preventer, and a flow element to indicate air passage into the cell. The supply system distributes the air to the cell through in-cell supply ducts equipped with diffusers and mounted along the ceiling. The purge and cooling air with gaseous waste from cell D is collected in an underground exhaust duct after passing through bag-type roughing filters mounted in filter wells in the cell floor. The air is transferred to the E-1 manifold in the south valve pit through the underground duct. The exhaust duct from cell D is equipped with a flow control damper located in the south valve pit.

Cell E. — About 2000 cfm of supply air enters cell E from the third floor cell roof area through supply system S-12. System S-12 is equipped with roughing and absolute filters, cooling and heating coils for conditioning the air, a centrifugal blower, a control damper, a backflow preventer, and a flow element to indicate air passage into the cell. The supply system distributes the air to the cell through in-cell ducts equipped with diffusers and mounted along the north and south walls at the cell ceiling. The purge and cooling air with gaseous waste from cell E is collected in an underground exhaust duct after passing through bag-type roughing filters mounted in filter wells in the cell floor. The air is transferred to the E-1 manifold in the south valve pit through the underground duct. The exhaust duct from cell E is equipped with a flow control damper located in the south valve pit.

Cell F. — About 500 cfm of supply air enters cell F from the cell F corridor through supply system S-16. System S-16 is equipped with a roughing and absolute filter, a control damper, and a backflow preventer. The supply air enters the cell through a grill at the ceiling of the west wall. The purge and cooling air with gaseous waste from cell F is collected in an underground exhaust duct after passing through bag-type roughing filters mounted in filter wells in the cell floor. The air is transferred to the E-1 manifold in the south valve pit through the underground duct. The exhaust duct is equipped with a flow control valve located in the south valve pit.

Cell G. — About 1033 cfm of supply air enters cell G from the cell G pump room in the basement through supply system S-15. System S-15 is equipped with roughing and absolute filters, a control damper, a backflow preventer, and a flow element to indicate the air passage into the cell. The supply system distributes the air to the cell through in-cell supply ducts equipped with diffusers and mounted on the ceiling. The purge and cooling air with gaseous waste from cell G is collected in an underground exhaust duct after passing through bag-type roughing filters mounted in filter wells in the cell floor. The air is transferred to the E-1 exhaust manifold in the north valve pit. The exhaust duct from cell G is equipped with a flow control damper located in the north valve pit.

Open Cell Emergency Condition. — During periods of unusual maintenance or equipment movement in or out of the cell bank, it will be necessary for cell hatches, doors, etc. to be open for short periods of time. The E-1 cell exhaust system is capable of handling an additional 5000 cfm of air flow to maintain a minimum 100 fpm face velocity at the opening to meet ORNL safety requirements.

6.2.2 Cell Exhaust System E-1

The E-1 exhaust system transfers the cell exhaust through the north and south manifolds to the filter pits through an underground 30-in.-diam duct. From the filter pit the flow passes through a 30-in. duct to the centrifugal blower and into the HFIR stack. There are two blowers (EF-1 and EF-2, E-1) mounted parallel in the system, either of which will normally operate with the other held for stand-by service. The E-1 blowers are equipped with flow control dampers. Backdraft dampers are installed between the blower and the HFIR stack breeching.

6.2.3 Filters

The cell exhaust gas flows out of the cell through high-capacity bag-type roughing filters of the dry type that have an 0.3-μ DOP efficiency of 95% and sufficient strength to resist differential pressures up to about 15 in. water gage without failure. The normal operating differential pressure across the in-cell filters will be 1 in. water gage.

From the in-cell filters, the flow passes through the absolute filter pit through either of five parallel compartments. Each compartment is equipped with a manual control valve at entrance and exit, a filter enclosure, two hydraulically actuated expandable bellows assemblies, and auxiliary supporting and alignment equipment. Each filter enclosure is a completely sealed sheet metal box in which are mounted six HEPA filters. The filter mounting within the enclosure provides for series flow through two banks of filters. The filter enclosure is connected and sealed into the duct system by the bellows assemblies, which compress gaskets between the mating flanges of the enclosure and the bellows assembly on each end.

Taps for DOP testing are provided into the inlet plenum and into the duct on the outlet side of the enclosures, as well as into the enclosure itself, downstream of the first bank of filters. The filters have been tested in place and found to have an efficiency equal to or better than 99.95%. A plan for periodic inspection and testing, as described in Section 9.2, will maintain this filter pit efficiency at all times. During normal operation, flow will be through only three filter compartments, with the alternate two compartments valved for stand-by service. The pressure drop across the filter pit is indicated on a differential pressure gage mounted on transmitter rack 2 in the waste sample room, Building 7932, adjacent to the pit.

The filter pit itself provides 2 ft of regular concrete shielding. The design of the pit equipment is such that a shielded changeout of the filter enclosure using the ORNL filter pit maintenance equipment can be accomplished. Dirty filter enclosures will be transferred to the burial ground, where the entire enclosure will be discarded.

6.2.4 Pressure Control Instruments

The pressure in the cells is maintained as follows:

Location	Area Pressure (water gage, in.)
Cell A	−1.1
Cell B	−5.0
Cell C	−5.0
Cell D	−5.0
Cell E	−1.5
Cell F	−5.5
Cell G	−5.0

This pressure control is maintained through instrumentation that positions the dampers on the E-1 fans to maintain a constant 10-in. water gage in the cell exhaust duct at a point upstream of the filter pit. The flow control valves in the exhaust ducts from the various cells are positioned by manual control to pass the desired exhaust air flow. The control dampers in the individual cell supply systems are positioned by automatic controls that monitor and maintain desired cell pressure.

Pressure switches are provided to monitor the pressure in the exhaust duct upstream of the E-1 fan when it is in operation. In the event the pressure in the duct rises, the alternate fan will immediately be started automatically.

7. CONTAINMENT

The TURF has been designed and built to provide space for development and demonstration of programs relating to fuel reprocessing and fabrication. Based upon particular functions of individual areas, the facility is divided into four distinct areas or zones:

Zone 1. Cold area, including technical office area and outside rooms housing mechanical equipment.

Zone 2. Cell operating area, change room, electrical and mechanical equipment rooms, chemical makeup room, and the development laboratory.

Zone 3. Limited-access areas, including maintenance operating areas on first and second floors, receiving area, fuel storage room with handling and storage equipment, checking and holding area, and other rooms in access areas adjacent to the cell bank.

Zone 4. Cells.

To accomplish the research objectives planned for the facility and to provide the necessary safety features of protecting plant personnel and the general public from airborne radioactivity or direct radiation resulting from process operation, the facility is equipped with a processing area that provides shielded containment in the form of heavily shielded hot cells. These hot cells, as well as the unshielded maintenance cell and the equipment airlock, are sealed at every door, hatch, service sleeve, or similar penetration through the lining membrane on the inside of the cell. These sealed structures are maintained at a negative pressure at all times to prevent the escape of process material to the environment. It is this cell bank complex that constitutes the primary containment area of the facility. The building surrounding the cell bank constitutes the secondary containment area of the facility. The special features of these areas are described and analyzed in this section.

The facility has been designed to the criteria of similar facilities at ORNL with respect to applied loads that might be exerted upon the structure due to its location and climate. No special design factors were incorporated in the construction of the facility to allow for forces or loads resulting from seismic disturbances. This is considered satisfactory due to acceptability of other similar facilities which were built to standards comparable to those used in TURF and which have been analyzed and found safe for credible earthquake conditions in the Oak Ridge area.

In addition to the structural membrane of the primary and secondary containment areas of the facility, the building will be maintained at a negative pressure at all times to ensure against the escape of any airborne contamination to the environment except by the normal filtered discharge systems.

Air will enter the building through the offices and first floor operating areas and will pass sequentially through areas of higher potential contamination. The pressure in the offices (zone 1) will be essentially atmospheric pressure. The pressure in the rest of the building (zones 2 and 3) will range from −0.3 to −0.6 in. water gage. The pressure in the cells (zone 4) will be maintained, depending upon the particular cell, from −1 to −5 in. water gage, with respect to the atmosphere. Backflow dampers are provided between building areas of different contamination potential. More effective antibackflow devices and HEPA filters are provided in the air ducts leading from the building to the cells. The HEPA filters are not designed to be testable in place; however, they are purchased and tested by Laboratory standard practice procedure to a DOP Smoke Test efficiency of 99.97%. These filters are an added safety feature designed to prevent any loss of contamination from the cell due to reverse air flow in the cell supply systems. A portion of the building ventilation air is discharged directly to the atmosphere at the roof of the building via HEPA filters and a blower. These HEPA filter installations can be tested and will be maintained at a DOP efficiency of 99.95%. The remainder of the ventilation air is drawn into the cells from the crane bay area and exhausted by the cell exhaust system.

Cell exhaust air is filtered by a roughing filter system and two HEPA filter systems in series and is discharged to the atmosphere through the 250-ft HFIR stack, which has a maximum average atmospheric dispersion factor of 0.92×10^{-5} sec/m^3. The HEPA filter installations can be tested in place, and the systems will be maintained to a DOP efficiency of 99.95%.

7.1 Primary Containment

The containment envelope that meets the ORNL criteria is the shielded bank of processing cells. The structure of cells B, D, C, E, F, and G is designed to maintain its sealed structural integrity under the following conditions:

1. continuous operation with the interior cell pressure maintained at −5 in. water gage,
2. extended periods of abnormal operation with the interior cell pressure maintained at −20 in. water gage. This condition could result with the failure of a cell supply system sealing off air flow to the cell and the exhaust system developing its maximum capability of evacuating the cell.

The structure of these cells is also designed to withstand an internal shock wave having a pressure of 900 psf and an energy of 270 ft-lb/ft^2. This barrier will withstand, without rupture, the blast effects of the maximum credible explosion, postulated as equivalent to 3 lb of TNT located at the center of the cell, and will restrict the flow of air to the secondary confinement zone, the building, for the period during which the cell is pressurized.

The structure of cell A and the equipment airlock has also been designed to maintain its sealed structural integrity under conditions 1 and 2 above for the shielded cells. The viewing panels and their "H" gasket seals have been designed and proven capable of withstanding the abnormal internal cell pressure of −20 in. water gage.

All doors, viewing windows, hatches, ports, service sleeves, etc. that penetrate the cell structure and attach to the cell linings are designed to maintain the cell containment and integrity under the design conditions described. The design of these equipment items is similar to that of like equipment used successfully in similar research facilities at ORNL. Its integrity has been demonstrated through either mock-up operation or performance testing to demonstrate compliance with the design criteria.

During normal operation, all cells are isolated from each other, except for interconnection, by the cell ventilation ducts and piping in the CO_2 fire protection system.

It is anticipated that the leak rate into any cell will be less than 0.5% cell volume per hour at normal operating conditions. The actual quantity of cell leakage is not a limiting safety factor in the operation of the facility, but it is an economic consideration to be dealt with in operating the cell bank under an inert gas atmosphere.

It is expected that there will also be process vessels and shielded enclosures within the cells, but these are considered primarily as contamination control barriers rather than as lines of containment.

7.1.1 Cell Maintenance

The entire cell structure will be sealed during normal operation. The cell structure is divided into three types of cells based upon the potential contamination hazards associated with the operations to be performed in each. Cells C and D are expected to become highly contaminated under normal operation and hence will be remote maintenance cells. Cell G, having a lesser potential for becoming contaminated, will be maintained by a combination of remote and contact techniques. Should operations in cell G require it, the upper section of wall between cells G and C can be removed to allow a changeover to completely remote maintenance techniques. Cell E will have the least potential of contamination; thus, equipment in this cell will be served by contact maintenance after the gamma source is removed. This cell is provided with handling equipment that will permit some remote maintenance operations. Cell F will serve as a storage area for equipment that has not been completely decontaminated; therefore, the cell will be maintained remotely or by contact after the source is removed.

All of the remote maintenance equipment installed in cells C and D can be moved to cells A and B for its own maintenance. Maintenance equipment in cells A and B can be operated remotely; however, it is expected that some contact maintenance will be performed in the cells. Process equipment to be operated in cells C and D will be designed for operation on the basis of no personnel entry into the cell proper and equipment maintenance by either remote control or by removal of the equipment to cell A, where maintenance can be performed through gloves after decontamination. Personnel are not expected to enter further than the interior of cell B under any condition. Normal entry further than the maintenance operation area is not contemplated.

The remote maintenance equipment installed in the cells is not required to maintain containment of the processing area. A failure within the process services fed into the cells can be taken care of from outside the cell bank by closing valves or breaking disconnects. The equipment that maintains containment of the processing area in the event of a credible explosion or fire is not dependent upon the in-cell remote maintenance equipment for safe operation.

Access to cells G and E will be through hatches in the cell roofs. Normally these hatches will be closed and sealed with removable concrete plugs. Access to cell F will be through the cell B floor hatch or through access panels in the walls of the cell itself.

Air for ventilating each cell is drawn from the area immediately adjacent to or over the roof of the cell through a roughing filter, an HEPA filter, a control damper, and a backflow preventer located in the supply duct to each cell. The control damper is automatically actuated to maintain the preset cell pressure. The backflow preventer, Fig. 7.1, is designated to permit air to flow only toward the cell and to seal off upon a reversal of flow. Similar devices have been employed in other facilities at ORNL. The basic design of the device has been tested and found to maintain its integrity under simulated maximum operational or accident conditions in the cells.

Devices for measuring air flow rate are provided in the inlet duct to each cell. The air flow patterns are shown schematically in Fig. 6.2. All cell supply systems are sized to provide the minimum quantity of ventilating air to each cell that is required to remove both the cell lighting and process heat loads and to maintain the required minimum flow of one-tenth of cell volume per hour. Additional air flow capacity has been designed into the systems and can be used if required for special operations. Cell ventilating air is exhausted to the TURF filter pit through an underground duct and manifold system. The air is exhausted from each cell through bag-type roughing filters and an underground duct that ties into a manifold and thence to the filter pit by the underground duct system. Control dampers are installed on the

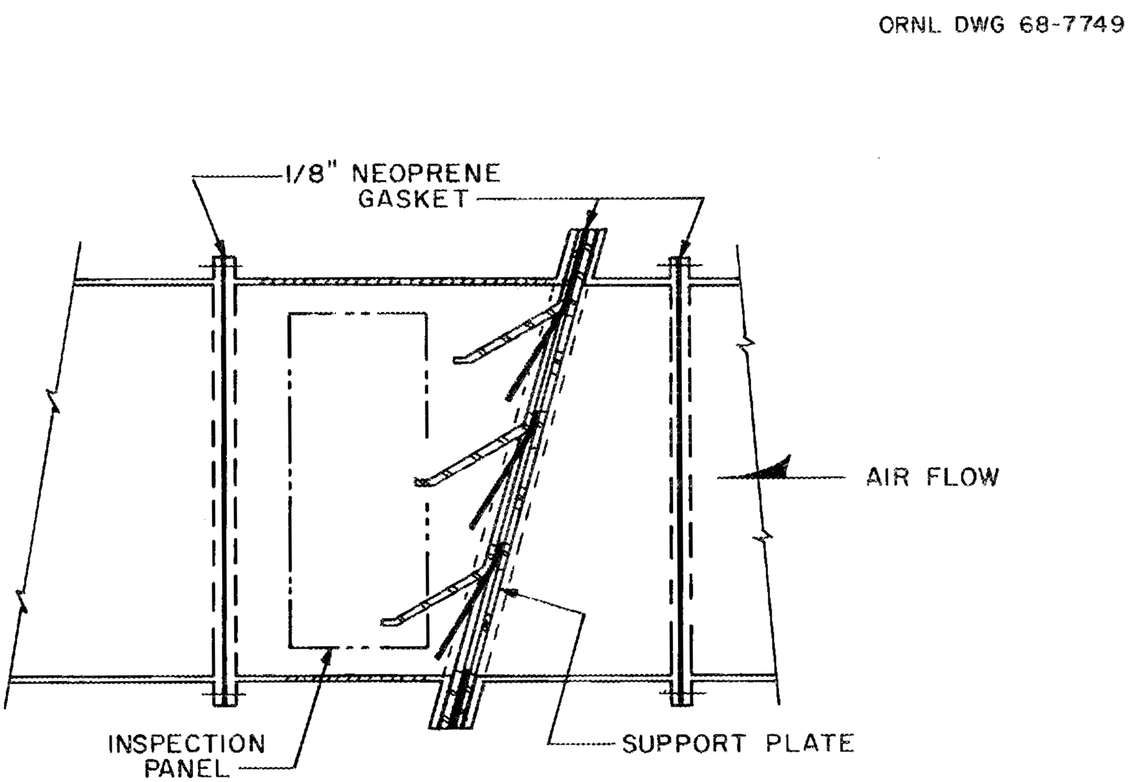

Fig. 7.1. Backflow Preventer.

outlet of each cell exhaust duct; these are manually positioned to maintain the predetermined flow rate and cell pressures. As shown schematically in Fig. 6.2, there are ducts providing a parallel path for air flow to exhaust from the cell if the in-cell roughing filters should become plugged due to fire, smoke, etc., and shut off the normal exhaust flow and allow the cell pressure to rise. In the TURF filter pit the air passes through two stages of HEPA filters in series before being discharged to the HFIR stack.

7.1.2 Cell Ventilation

The cell ventilation systems, which also remove gaseous waste as described in Section 6, are designed to maintain the cells at a negative pressure relative to their surrounding atmosphere. The exhaust system maintains a constant flow of air from the cells, and cell pressure controllers modulate the cell supply system dampers to maintain the desired cell pressure.

To assure continued controlled ventilation of the cells or to preserve at least the negative pressure in the cells, the following features have been designed into the ventilation system:

1. The cell supply, exhaust, and internal pressure control systems are provided with both a normal and emergency instrument air supply.

2. The compressor motor of the emergency air supply is connected to both a normal and an emergency electrical power supply. The compressor is connected to both a normal and an emergency supply of cooling water.

3. The motorized dampers on the cell supply and exhaust systems, as well as the control dampers on the exhaust blowers, are designed to fail safely in the event of total failure of the instrument air system (i.e., the supply dampers fail shut, the exhaust dampers fail open, and the control dampers on the blowers fail open).

4. Two exhaust blowers are installed in the E-1 exhaust system with interlocking controls such that if one blower fails, the other blower will be automatically started by a rise in pressure within the duct system.

5. The electrical components of the control systems are designed to fail safely to provide containment during the momentary interruption of power during automatic switching operations from normal to emergency power supply. In the event of total electrical power failure, the control components will fail safe, and the radiation instrument alarms will initiate the building evacuation system. During this kind of emergency, the facility structures themselves will be relied upon to confine the spread of radioactivity.

7.1.3 Service Sleeves

All service sleeves that penetrate the walls of the cells are designed and built as an integral part of the cell lining and are sealed with a two-part plug assembly (Fig. 2.11). One part of the plug assembly is an expendable push-through seal plug with two foam neoprene gaskets. The other part is a removable shield plug with a bolted closure at the operating side of the service sleeve. These service plug assemblies are changed by withdrawing the shielded portion of the plug to the cold side of the cell and pushing the expendable seal plug portion into the cell by inserting a new plug assembly. This allows changing plug assemblies without the loss of cell containment.

7.1.4 Small Items Entry Port

The small items entry ports are equipped with a ball valve and a bag box on the end of the sleeve outside the cell. These form an air-lock and maintain cell containment while items are transferred into the cells.

7.1.5 Viewing Windows

All windows consist of an embedded steel form designed and built as an integral part of the cell lining, a gas seal plate or alpha window on the inside of the cell, and a tank containing the shielding window shown in Fig. 7.2. This window design permits the alpha window to be replaced from either the hot or cold side of the cell. This will allow the maximum use of contact operations in replacement of the alpha window at times when the activity level in the cell is relatively low and when

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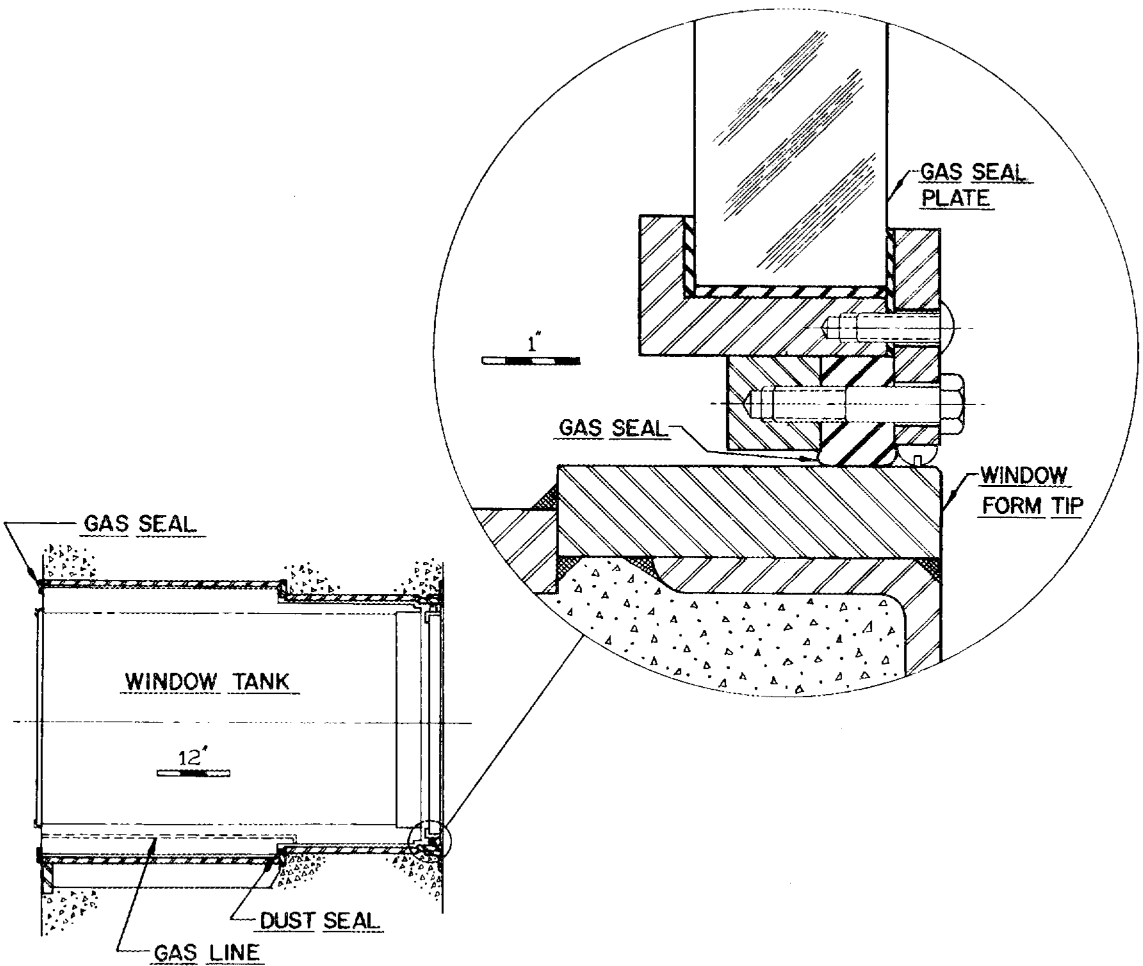

Fig. 7.2. Typical Viewing and Alpha Window Installation.

leakage of air into the cells can be tolerated. If either of these conditions does not prevail at times when the alpha window must be replaced, the window can be replaced from the hot side by entirely remote means without exposure of personnel to radiation or leakage of air by the window seal.

7.1.6 Hatches and Transfer Ports

All hatches and transfer ports into the cell bank are sealed with compression-type foam neoprene gaskets on the in-cell end of a shielding plug and caulked-sealed or sealed with a bolted closure on the out-of-cell end of the plug.

7.1.7 Shield Door Assemblies 1, 2, and 3

The door assemblies were designed, built, and preassembled as shown in Figs. 7.3 and 7.4. Door 1 rolls horizontally in a frame structure embedded in the west wall of cell B, shown in Fig. 2.3, to separate cells A and B. The frame extends far enough through the south side of the cell B wall to permit the door to be rolled completely clear of the doorway. A gas-tight enclosure has been built as an integral part of the door frame to permit door operation within the contained cell area. Doors 2 and 3 travel vertically in frame structures embedded in the wall between cell B and cells C and D, as shown in Fig. 2.3. The frames extend far enough through the cell roofs to permit the doors to be raised completely clear of their doorways. These assemblies also have a gas-tight enclosure built integral with the frames to permit the doors to operate within the contained cell areas. All three door assemblies are equipped with inflatable seals mounted in the door frames at the periphery of the doorway. When the doors are closed and the seals are inflated with air pressure, cells A, B, C, and D are sealed from each other at the door openings. A system of safety interlocks has been designed into the door assembly controls to assure opening of doors by procedures that ensure containment of the cell areas and protection of personnel from radiation exposure.

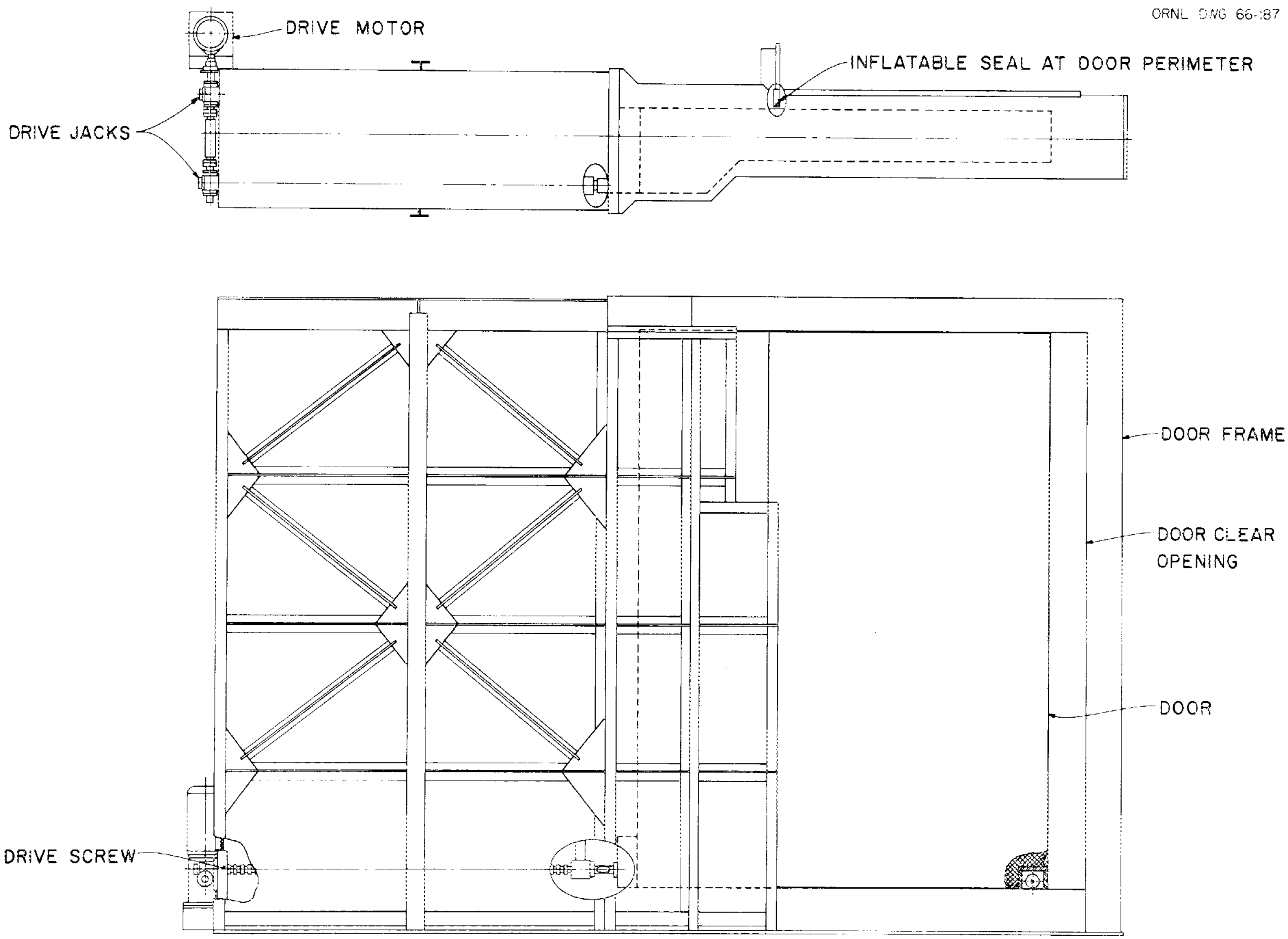
ORNL DWG 66-187
DRIVE MOTOR
INFLATABLE SEAL AT DOOR PERIMETER
DRIVE JACKS
DOOR FRAME
DOOR CLEAR
OPENING
DOOR
DRIVE SCREW

Fig. 7.3. Door 1.

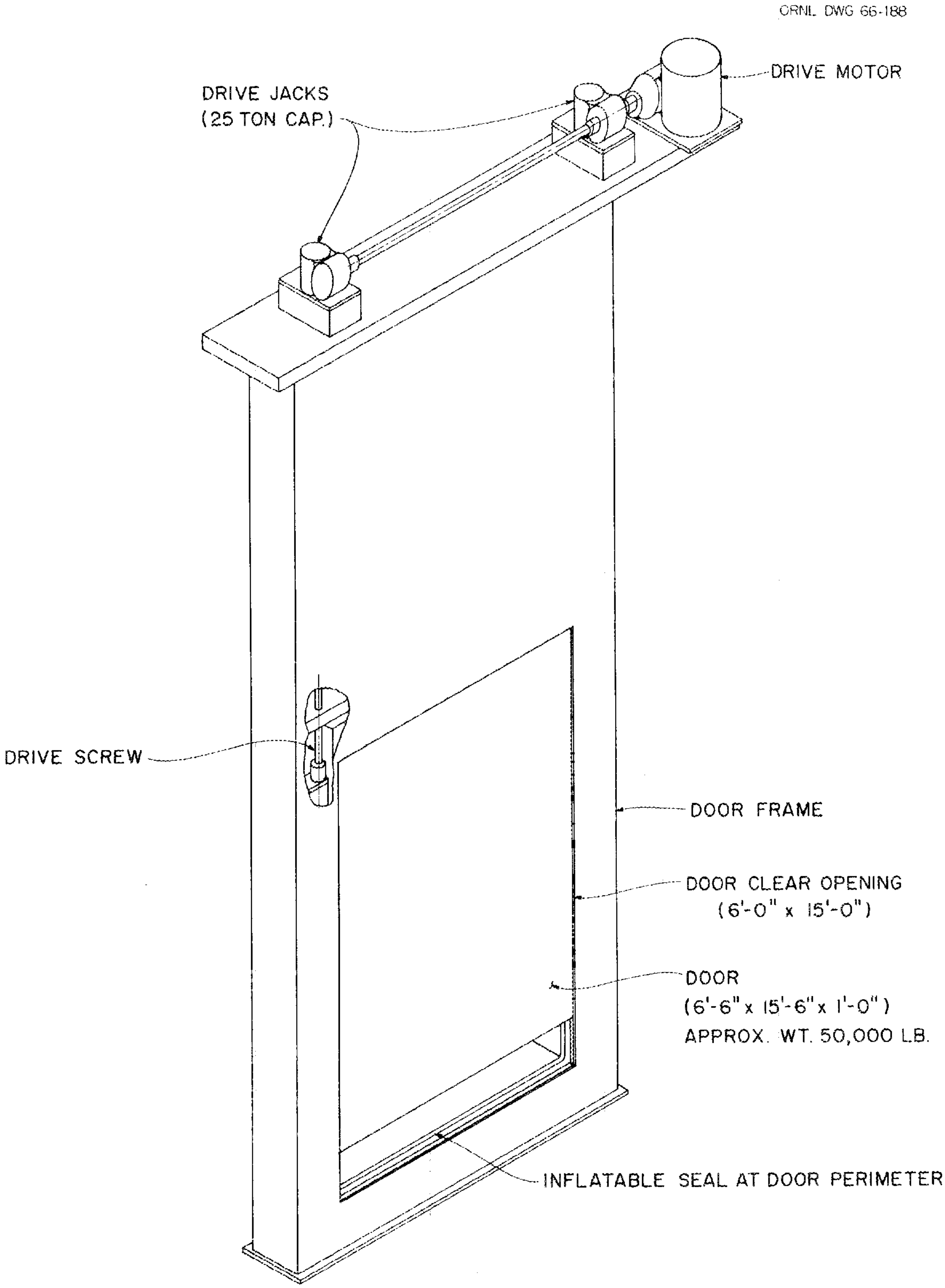

Fig. 7.4. Doors 2 and 3.

7.1.8 Airlock Door and Hatch Assemblies

The airlock door has dual bulb-type seals that compress against the swinging door when the door is in the closed position. A purge-air line is connected into the area between the seals to monitor leakage by the seals. The airlock hatch assembly is equipped with dual expanding seals that can be inflated with air pressure to seal against the rolling hatch cover. A purge line is also connected to the area between the two seals to monitor air leakage by the seals. Both the door and the hatch have electrical locks to prevent the opening of either assembly when the cell A door is open. These interlocks are designed to prevent the loss of containment by the simultaneous opening of doors in the cell A and the airlock.

7.1.9 Cell A Door and Hatch Assemblies

The cell A door assembly is equipped with an expanding seal that is inflated with air pressure against the frame of the door to seal the airlock from cell A. The cell A hatch assembly is equipped with a bulb seal that is effected by bolting the hatch assembly to the top of the cell. The door controls have been interlocked with the controls of shield door 1, the airlock door and hatch, and the cell pressure control systems to ensure safe operations that will maintain cell containment and protect personnel from radiation exposure.

7.1.10 Cell A Viewing Panels

The viewing panels, which are 3/8-in.-thick Plexiglass, are sealed with an "H"-shaped neoprene gasket with Dow Corning Silastic RTV applied to each side of the seal. The Plexiglass is type SE-3, manufactured by Rohm and Haas Company, with special fire-resistant characteristics. Mockup testing of a typical panel installation, as well as preoperational testing, has demonstrated that the panel structure is sufficient to maintain cell containment and integrity under maximum design conditions.

7.1.11 Cell A Glove Ports

There are glove ports through the viewing panels in the cell walls for maintenance of the in-cell handling equipment and for process equipment that has been decontaminated. Operations within the cell are carried out through these ports with neoprene gloves that are held in place on the glove port ring by either rubber O-rings or metal clamps. The procedure for replacing gloves is as follows:

1. Slip the old glove to the front part of the glove ring but do not remove it from the ring.

2. Turn the new glove inside out and slip it over the old glove on the glove ring.

3. After the new glove is firmly in place, pull the old glove off into the cell, making certain that the new glove does not slip off the glove ring. (Double grooves in the glove port ring facilitate this operation and virtually eliminate the possibility of an uncovered port — given normal operational skill.) Treat old glove as contaminated solid waste.

4. Monitor around the edge of the glove ring and decontaminate, if necessary.

7.2 Secondary Containment

The peripheral shell of the building around the processing areas constitutes the secondary containment for TURF. This containment membrane has been made with the following speical features. The concrete block walls of the building have been sealed on the inside with a protective coating. All doors into or out of the building have been equipped with seals, and all access openings have been fitted with sealed closures. All ventilation ducts penetrating the walls of the building have been equipped with backdraft dampers that close if the air flow reverses. All conduits or pipes penetrating the walls of the building have been sealed at their nearest terminal to the wall.

Within the building, area containment is effected by special design features that include the sealing of partition walls with protective coatings; the sealing of doors, ducts, conduits, pipe chases, wireways, etc. that penetrate barrier walls; and the sealing of liquid waste systems that drain all areas of the building.

The building contains a number of air conditioning, heating, and exhaust systems that are combined and operated to provide the pressure differential and area pressure gradients required for secondary containment. The cold area, which includes the technical offices and the outside rooms housing mechanical equipment, will be maintained at essentially atmospheric pressure but may vary from 0 to −0.10 in. water gage with respect to atmosphere. The barrier wall between the office area and the operating area divides the building into the cold area and a suspect cold area. Throughout the rest of the building inside this barrier wall, the ventilation systems are designed to maintain an area pressure gradient that varies from −0.3 to −0.6 in. water gage with respect to atmosphere, the required vacuum for containment under emergency conditions as given in the ORNL Radiation Safety and Control Manual. Details of the building ventilation systems are given in the following sections.

7.2.1 Building Supply System S-1

Most of the air entering the facility passes through a central air conditioning unit located in room 210, the mechanical equipment room, to supply 100% fresh, filtered, and heated or cooled air directly to building zones 1 and 2.

In general, the air flows from the zone 1 area to the first floor zone 2 area, then to the second floor zone 2 area and the first and second floor zone 3 areas, then to the third floor zone 3 area, and then out of the occupied areas into the cells zone 4 area. From the cells, the air is then exhausted from the facility through the E-1 cell exhaust system.

The S-1 supply system is divided into five separate duct branch systems of air flow. Branch 1 supplies air to the office area. The air from the office area is then exhausted from corridor 1 to the cell operating area, either directly through interconnecting ductwork or through the cold change room. From the cold area, small quantities of air are exhausted directly from the ladies' rest room and from the cold toilet and shower room. Branch 2 supplies air to the operating office and thence to the cell operating area. Branches 3, 4, and 5 supply air directly to the cell operating area.

The S-1 system takes air from the outside through bag-type roughing filters and conditions and heats the air by passing it over a preheat coil with face and bypass damper to provide freeze protection. The preheat coil is supplied from the 15-psig building steam system. The air is cooled and conditioned by passing over cooling coils supplied from the plant chilled-water system. The air is then discharged to the duct branch systems by a centrifugal fan for distribution to the various areas. Each duct branch is equipped with its own steam reheat coil, thermostat, control valve, and duct discharge system. As the supply air flows throughout the building (Fig. 7.5) providing building ventilation, recirculating air conditioning units located in various areas maintain building heating and air conditioning.

7.2.2 Building Ventilation and Air Conditioning

Technical Offices (rooms 104–112). – Conditioned air is supplied from the branch 1 distribution supply ducts through diffusers in the ceiling of the offices and exhausted to corridor 1 (room 102) through louvers in the doors.

Ladies' Rest Room (109). – Conditioned air is supplied from corridor 1 through a door louver and is exhausted directly to the atmosphere by exhaust system E-14. Exhaust system E-14 is equipped with a centrifugal fan with backdraft damper.

Cold Change Room, Shower, and Cold Toilet (115–117). – Conditioned air is supplied to the cold change room either through an interconnecting duct from corridor 1 or by air flow through the door from the personnel airlock (room 113) when personnel enter or leave. Air flows from the cold change room to both the cold shower and the cold toilet where it is exhausted from the ceiling area to the atmosphere through exhaust system E-13, which is equipped with a centrifugal fan and backdraft damper. The fan is interlocked with the facility radiation and contamination evacuation alarm system so that upon an evacuation alarm, the fan is shut down, stopping an unfiltered exhaust from

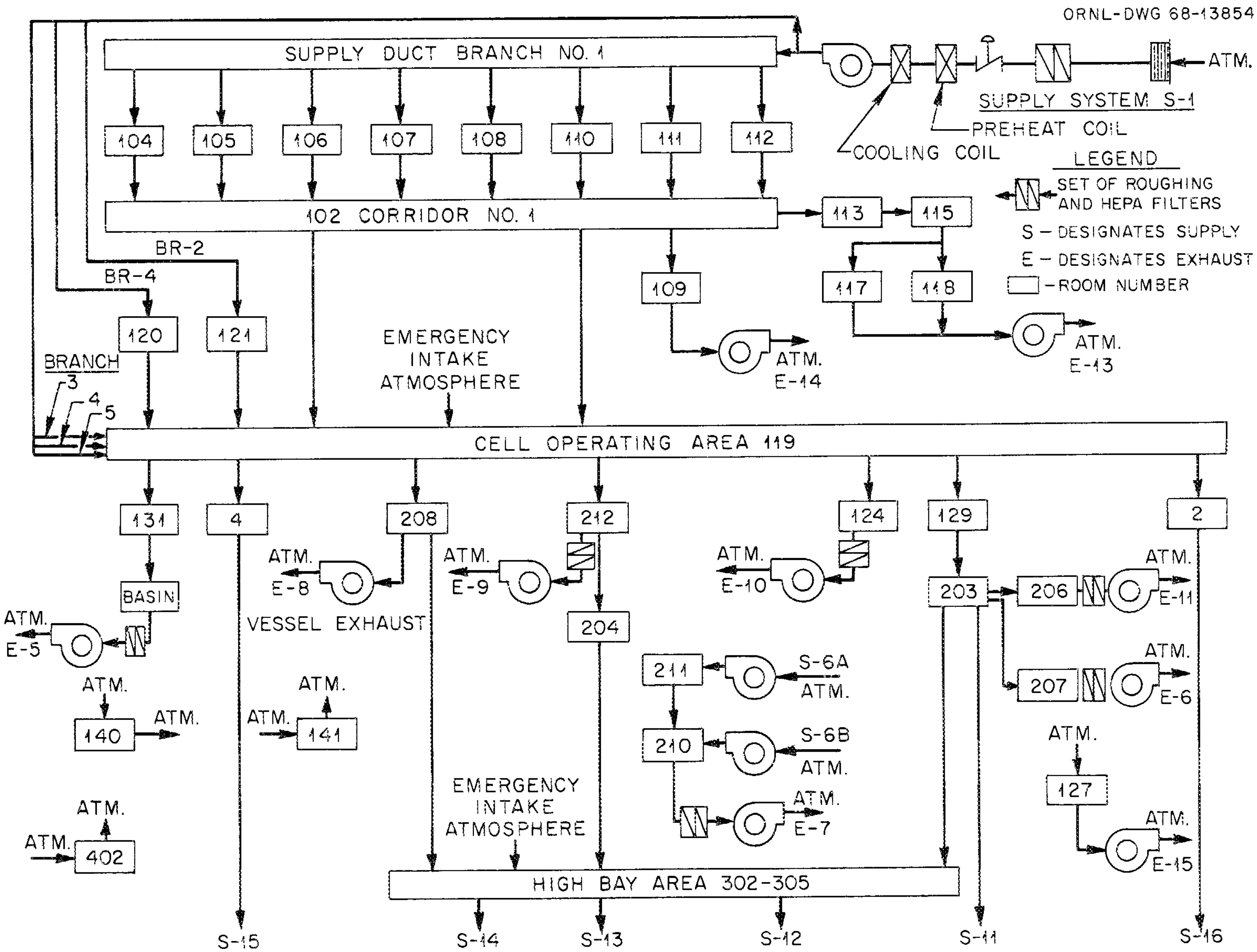

Fig. 7.5. Building Air Flow Pattern.

the building. Air is also exhausted from the cold change room to the cell operating area as personnel pass through the open doorways into the operating area (room 119).

Health Physics Office (121). — The Health Physics office receives supply air through the S-1 branch 4 duct system. The air is conditioned by a room reheat coil located in the overhead ductwork. The air enters the room through a louver in the ceiling and is exhausted to the cell operating area through a door louver.

Operating Office (120). — The operating office receives conditioned air through the S-1 system branch 2 supply duct, which feeds air into the room through a diffuser in the ceiling and exhausts air to the cell operating area through a door louver.

Cell Operating Area (119). — Conditioned air is supplied directly to the cell operating area through outlets from S-1 supply branches 3, 4, and 5. These outlets are at the ceiling level throughout the room. Exhaust air from corridor 1 transfers to the cell operating area through ceiling louvers in the corridor and flows directly through wall louvers into the room. Approximately 16,400 cfm of normal conditioned supply air enters the room either by these routes or as previously described. An emergency air inlet prevents reducing the pressure in the cell operating area below −0.4 in. water gage. This emergency air inlet takes outside air through a louver on the east wall of the building and exhausts it to room 119 through a wall grill located near the door to the cold change room. This system is provided with a backflow damper and automatic control damper that maintains the desired pressure in the operation area.

Fuel Storage Room (131). — This room receives about 1700 cfm of supply air from the cell operating area through a transfer duct equipped with a backdraft damper and a wall louver. The air flows across the fuel storage basin into a concrete plenum and is exhausted from the room through exhaust system E-5 to the atmosphere. Exhaust system E-5 is equipped with an automatic control damper and a series of roughing and HEPA filters that filter the air being discharged through a centrifugal fan to the outside through a backdraft damper at the wall louver.

<u>Cell G Pump Room (4)</u>. — About 1033 cfm of air enters room 4 at the ceiling through a transfer duct from the cell operating area. The transfer duct is equipped with a combination fire and backdraft damper and entrance and exit grills. The exhaust air flows from the pump room through a backdraft damper and through a sealed duct leading from the basement level to the third floor high bay area where it passes through supply system S-15, which supplies ventilating air to cell G.

<u>Chemical Makeup Room (208)</u>. — About 2330 cfm of air enters the room from the cell operating area through a transfer duct through the floor. The transfer duct is equipped with a fire damper and entrance and exit grills. Exhaust air from the chemical makeup room passes through a transfer duct to the third floor high bay area. The transfer duct system is equipped with a combination fire and backdraft damper and entrance and exit grills. Small quantities of air, up to 100 cfm, from chemical storage tanks in the chemical makeup room, are exhausted through system E-8 directly to the atmosphere. Exhaust system E-8 is equipped with a shutoff valve, a centrifugal blower, and a check valve. It is not anticipated that this system will exhaust contaminated gaseous waste; therefore, the exhaust is not filtered.

<u>Development Laboratory (212)</u>. — About 2975 cfm of air enters the room from the cell operating area through a transfer duct through the floor. The transfer duct is equipped with a fire damper and entrance and exit grills. The development laboratory is air conditioned with a recirculating supply system S-5. The S-5 unit takes about 1500 cfm of air from the room, passes it through roughing and HEPA filters, and then blows the air across cooling and heating coils for conditioning before discharging it back to the room. The absolute filters in the S-5 system are not intended to be testable. They serve merely to prevent contamination of the air conditioning equipment in the event contamination is released in the room. Air is exhausted from the development laboratory by two routes. One route is exhaust system E-9, which takes about 1028 cfm from each of two fume hoods and exhausts directly to the atmosphere on the south side of the building at about the third floor level. The exhaust system E-9 is equipped with manual dampers and passes the air through roughing and HEPA filters before discharging it by a

centrifugal fan through a backdraft damper and wall louver. The other route exhausts air from the development laboratory through a transfer duct to the checking and holding area. The transfer duct is equipped with a backdraft damper and an entrance and exit grill.

Electrical Equipment Room (211). – Air supply enters the electrical equipment room directly from the outside through supply system S-6A. This system is equipped with an automatic control damper, a preheat coil with face and bypass damper for freeze protection, and a cooling coil for conditioning. About 6000 cfm of conditioned air is discharged by a centrifugal blower from S-6A to the electrical equipment room. This supply unit operates year-round to maintain the electrical and mechanical equipment rooms within limits of 70°F minimum in the winter and 105°F maximum in the summer. During the summer, supply system S-6B takes about 6000 cfm of fresh air directly from the outside, passing it through a control damper and a roughing filter, and discharges it by a centrifugal blower to the mechanical equipment room. The air from both the electrical and mechanical equipment rooms is discharged by exhaust system E-7 directly to the atmosphere at the second floor level. The E-7 exhaust system is equipped with roughing and HEPA filters, a centrifugal blower with automatic control damper, and a backdraft damper at the wall louver. To prevent a rise in pressure in the electrical and mechanical equipment rooms, an automatic latching device controlled by pressure is provided on the door between the electrical equipment room and the development laboratory. This control will permit the door to open and exhaust up to 2000 cfm of air from the electrical equipment room to the development laboratory if necessary.

Hot Change Room (124). – About 230 cfm of conditioned air enters the hot change room from the cell operating area through a transfer duct in the wall. The transfer duct is equipped with a backdraft damper and inlet louver. The air is exhausted from this room through exhaust system E-10 directly to the atmosphere at the second floor level. The E-10 exhaust system is equipped with inlet louvers, roughing and HEPA filters, a centrifugal blower, and a backdraft damper at the wall louver.

First Floor Maintenance Operating Area (129). — About 4090 cfm of air enters this area from the cell operating area through a transfer duct in the wall. The transfer duct is equipped with a backdraft damper and entrance and exit grills. Air conditioning in the maintenance operating area is provided by recirculating supply system S-4. The unit extracts about 1000 cfm of air from the room, passes it through roughing and HEPA filters, and then blows the air across cooling and heating coils for conditioning before discharging it back to the room. The absolute filters in the S-4 system are not intended to be testable. They serve merely to prevent contamination of the air conditioning equipment in the event contamination is released in the room. The exhaust from the first floor maintenance operating area passes through a transfer duct through the ceiling to the second floor maintenance operating area. The transfer duct is equipped with a fire damper and entrance and exit grills.

Cell F Corridor (2). — About 680 cfm of air is supplied to the cell F corridor from the cell operating area through a transfer duct in the ceiling. The transfer duct is equipped with a combination fire and backdraft damper and entrance and exit grills. The exhaust from the corridor provides the air supply to cell F through supply system S-16.

Checking and Holding Area (204). — About 3016 cfm of air is received from the development laboratory through the transfer duct described previously and passes directly through the open ceiling to the third floor high bay area.

Second Floor Maintenance Operating Area (213). — About 4090 cfm of air enters this area from the first floor maintenance operating area through the transfer duct described previously. Air conditioning in this area is provided by two recirculating supply systems, S-7 and S-8. The S-8 unit extracts about 1000 cfm of air from the south side of the area, passes it through roughing and HEPA filters, and then blows the air across cooling and heating coils for conditioning before discharging it back to the room. The S-7 unit extracts about 1000 cfm of air from the north side of the area, passes it through roughing and HEPA filters, and then blows the air across heating and cooling coils for conditioning before discharging it back to the room. The absolute filters in systems S-7 and S-8 are not intended to be testable. They serve merely to prevent contamination of the air conditioning equipment in the event contamination is released in the room. Air is exhausted from this area by four different routes: (1) to the sampling area (room 207) through a doorway; (2) to the warm shop (room 205) through supply system S-10; (3) directly through openings into the high bay area; (4) and as supply air to cell A through supply system S-11.

Sampling Area (207). — About 900 cfm of air is received from the second floor maintenance operating area and decontamination area (room 214) as described previously. Air is exhausted from the room directly to the atmosphere at the third floor level through exhaust system E-6. The E-6 exhaust system is equipped with a roughing and HEPA filter, a centrifugal blower with automatic control damper, and a backdraft damper at the wall louver.

Warm Shop (205). — About 1000 cfm of conditioned air is supplied to the warm shop from the second floor maintenance operating area and decontamination area through supply system S-18. System S-18 is a transfer duct equipped with heating and cooling coils for conditioning the supply air. Air is exhausted from the warm shop directly to the atmosphere at the third floor level through exhaust system E-11. The E-11 exhaust system is equipped with a roughing and HEPA filter, a centrifugal blower with automatic control damper, and a backdraft damper at the wall louver.

High Bay Area (302 and 305). — This area receives air from the chemical makeup room through a transfer duct as described previously and from the adjoining checking and holding area and maintenance operating area on the second floor. Two recirculating supply systems, S-9 and S-10, condition the air in the high bay area. Each system extracts about 6500 cfm of air from the room, passes it through roughing and HEPA filters, and then blows the air across cooling and heating coils for conditioning before discharging it back to the room. The absolute filters in units S-9 and S-10 are not intended to be testable. They serve merely to prevent contamination of the air conditioning equipment in the event contamination is released in the room. To prevent the decrease of the area pressure in the high bay area to less than −0.7 in. water gage, an emergency air intake directly from the atmosphere is provided with counter-weighted louvers. Exhaust from the high bay area is directly into the cell bank through supply systems S-12 to cell E, S-13 to cell D, and S-14 to cell C. These systems were described under Section 7.1.

Elevator Machinery Room (141). — This room is ventilated by outside air entering a wall louver and exhausting directly to the atmosphere at a roof louver. Unit steam heaters maintain the temperature in the room above a minimum of 50°F in the winter, and ventilation maintains the temperature below a maximum of 105°F in the summer.

Air Compressor Room (140). — About 3580 cfm of air flows through the compressor room. Air enters the room from the outside through a manual control damper in a wall louver and is exhausted directly to the atmosphere through a roof louver equipped with a fan. The unit steam heater maintains a minimum of 50°F during winter and ventilation maintains a maximum temperature of 105°F during summer.

Receiving Area (127). — About 1500 cfm of air enters the receiving area directly from the outside through a transfer duct equipped with a wall louver and an automatic control damper. Exhaust from the receiving area is directly to the atmosphere at the second floor level by exhaust system E-15. The E-15 exhaust system is equipped with a centrifugal blower, a supply grill, and a backdraft damper at the wall louver. The ventilating air maintains a maximum temperature of 105°F during summer and two unit steam heaters maintain a minimum of 65°F during winter. The automatic control system for the supply damper and the exhaust system maintains an area pressure of −0.25 in. water gage with respect to the atmosphere.

7.2.3 Building 7931, Motor Generator Room

This building houses the emergency power equipment for TURF. Ventilating air enters the room through gravity louvers in the south wall of the building and is exhausted through a louver in the north wall of the building. An electrical unit heater maintains a minimum temperature of 70°F during winter.

7.2.4 Building 7932, Liquid Sampling Room

This building receives supply air through a wall louver with a gravity damper and exhausts directly to atmosphere through a roof louver. About 500 cfm of ventilating air maintains a maximum temperature of 105°F during summer, and a unit steam heater maintains a minimum temperature of 65°F during winter.

7.2.5 Building Pressure Control

Building pressure gradients are controlled throughout the facility by controlling the supply air flow through the S-1 system, which acts in conjunction with all the filtered exhaust systems but primarily with the E-1 cell exhaust system. The differential pressure controllers, which sense static pressure in the cell operating area, position the control damper on the S-1 system to maintain the cell operating area pressure at a constant −0.3 in. water gage. The high bay area is maintained at a constant area pressure of −0.6 in. water gage by the pressure controllers that actuate the cell supply systems, drawing air from the high bay area into the cells and exhausting it through the E-1 system. A pressure controller in the E-1 exhaust system positions the control dampers on the E-1 blower to maintain a preset static pressure in the exhaust duct. This set point has been determined to maintain stable exhaust conditions for the pressure gradient required for the building.

Separate controlled areas within the building are (1) the electrical and mechanical equipment rooms, which have a differential pressure controller that positions the control damper on the S-6A supply system to maintain an area pressure of −0.4 in. water gage in the equipment rooms; (2) the sampling area, where a differential pressure controller positions the control damper from the E-6 system to maintain an area pressure of −0.6 in. water gage; (3) the warm shop, where a differential pressure controller positions the control damper on the E-11 system to maintain an area pressure of −0.6 in. water gage; (4) the fuel storage room, where a differential pressure controller positions the control damper on the E-5 exhaust system to maintain an area pressure of −0.4 in. water gage; and (5) the receiving area, where a differential pressure controller positions the supply damper to the area and a pressure switch controls the exhaust blower in the E-15 system to maintain an area pressure of −0.25 in. water gage.

Area pressures throughout the other parts of the building are maintained by manually setting of dampers, louvers, and grills in the transfer duct systems to maintain the desired negative pressure gradients. Two emergency supply systems are provided to assure the pressure control in the cell operating area and in the high bay area. These are the automatically controlled emergency inlet to the cell operating area and the counter-weighted emergency inlet to the high bay area.

Safety features similar to those of the cell ventilation systems have been designed into the building ventilation system component and their supporting equipment to assure that the containing atmosphere of the building area pressure gradient is preserved during periods of equipment failure or accident conditions:

1. Supply system S-1 and exhaust systems E-6, E-9, and E-11 are supplied with both normal and emergency instrument air and electrical power.

2. The pneumatic controls on the motorized dampers in the S-1, E-5, E-6, E-9, and E-11 systems are designed to fail safely in the event of total instrument air failure.

7.2.6 Portals

There are a number of kinds of portals through which areas of the building are connected and through which the building is connected to the outside. Normal passage to and from the building (Fig. 7.6) is through corridor 1 (room 102) and the entry (room 101) at the office area. Entry into the operating area of the building is through a personnel airlock (room 113) connecting the monitored exit zone checking station and the cold office area. The receiving area (room 127) is an airlock through which the building is also connected to the outside. Entry of miscellaneous materials (Fig. 7.7) as well as entry and exit of transfer casks, will be through the receiving area. From the receiving area, equipment can be transferred into the cell operating

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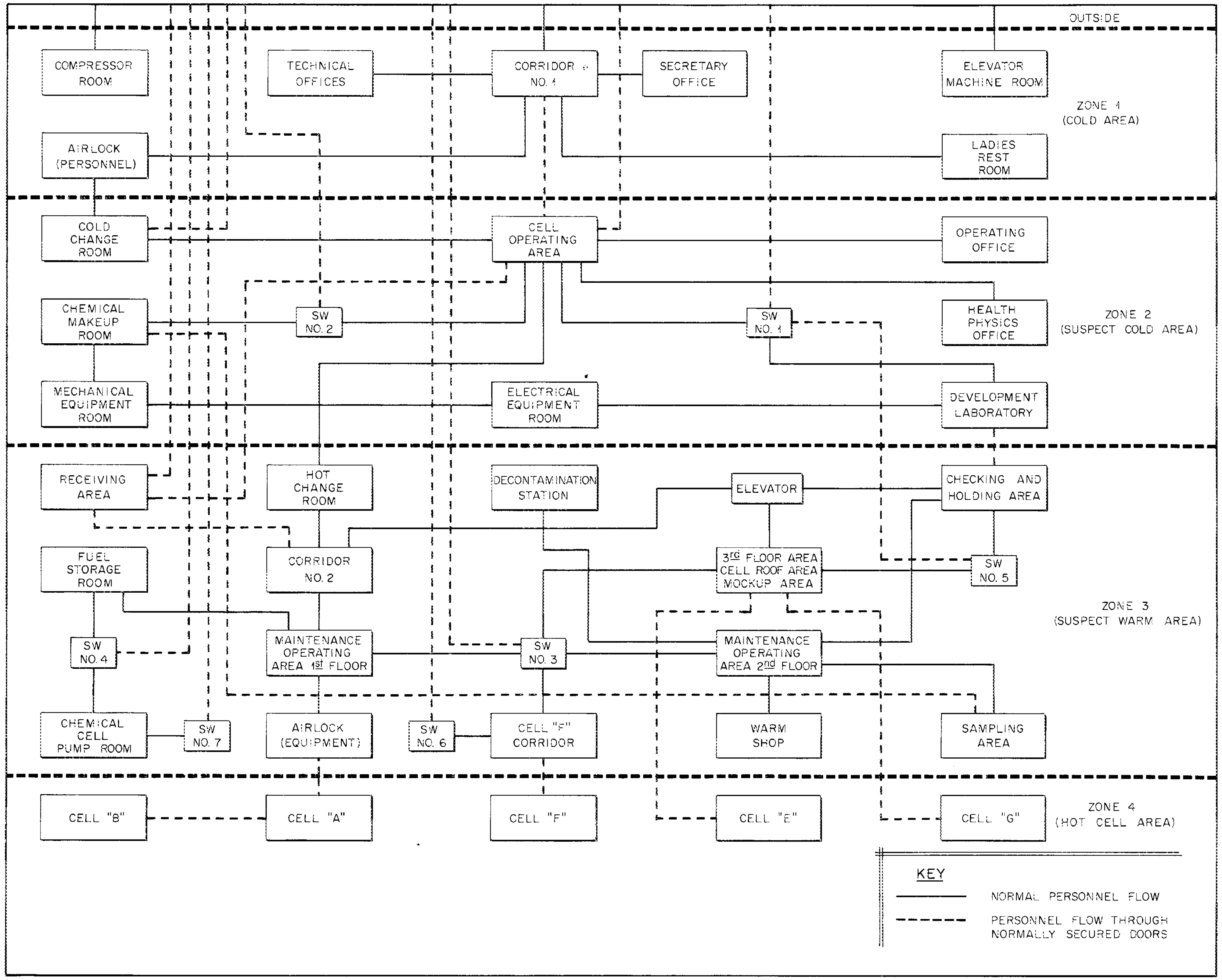

Fig. 7.6. Personnel Traffic Pattern.

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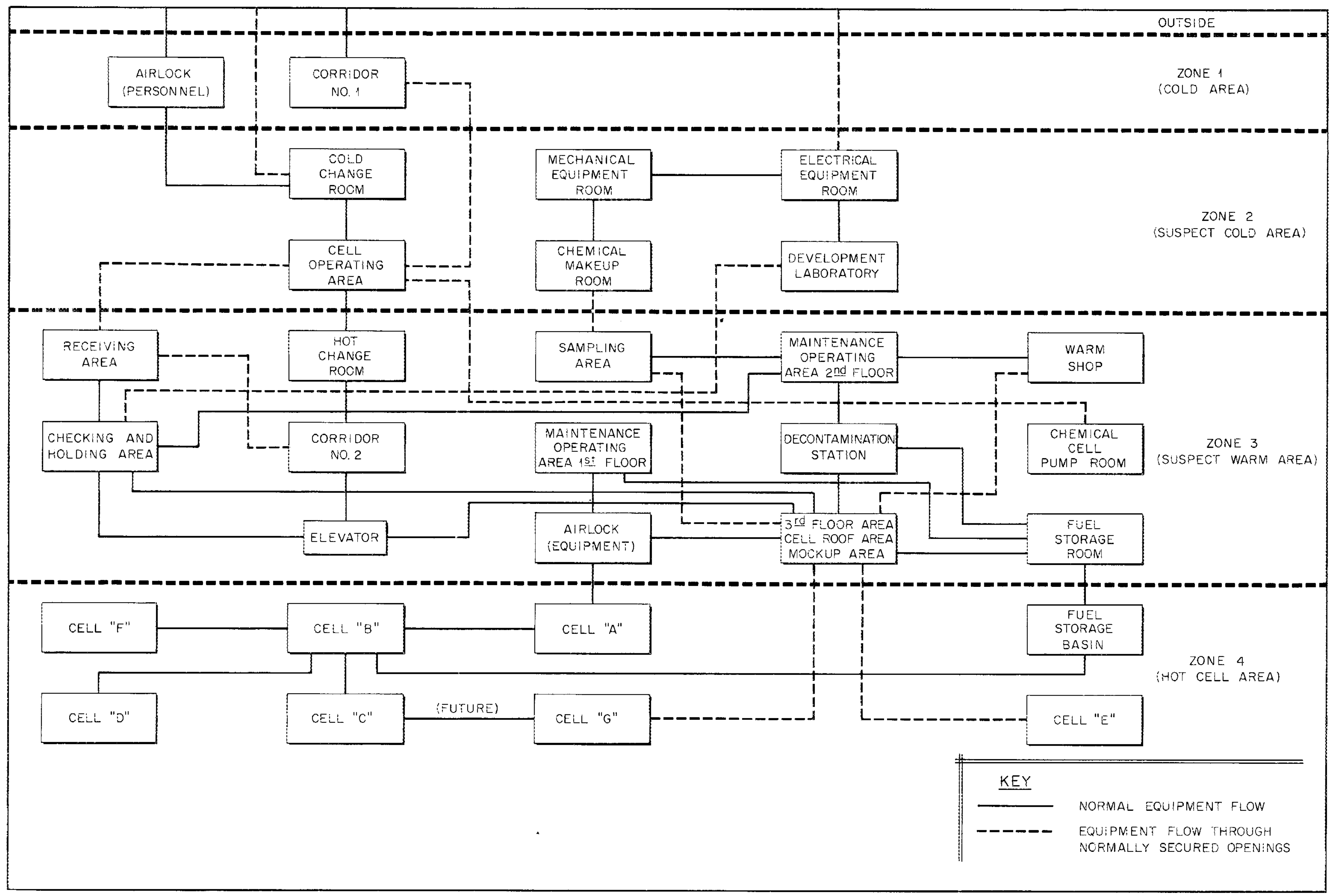

Fig. 7.7. Equipment Traffic Pattern.

area, the maintenance operating area, or to the checking and holding area where items are normally held for monitoring before shipment from the building. The equipment airlock, the airlock to the processing area within the cell bank (room 133), is used for transferring processing equipment into and out of the cell bank. This airlock separates the contaminated zone 4, hot cell area, from the suspect contaminated zone 3, warm area. There are two access ways into the equipment airlock: one through the entry door and the second through the rolling floor hatch from the second floor maintenance operating area. Both of these entry ways are equipped with automatic interlocks that prevent the opening of the door or the hatch when the door from the airlock to cell A is open or unsealed. These interlocks assure that there is no direct connection between the contaminated zone and the suspect contaminated zone.

The hot change room (124) also serves as an airlock, isolating the zone 3, suspect warm area, which is the maintenance operating area, and the zone 2, suspect cold area, which is the cell operating area and serves as a monitoring station for the suspect warm area.

Stairwell 2 on the northeast corner, stairwells 1 and 5 on the southwest corner, and stairwells 3 and 4 on the west side of the building serve as vestibule airlocks between floors. The outside doors will be sealed and used only as emergency exits.

Two basement areas, the cell G pump room on the north and the cell F corridor on the south, will have doors opening directly to the outside into stairwells 7 and 6, respectively. These doors will be sealed and used only as emergency exits from these basement areas.

In the northwest corner of the cell operating area there is also a door that opens directly to the outside. This door will also be sealed and used only as an emergency exit.

There are two equipment access panels to both the electrical and mechanical equipment rooms at the second floor level. These access ways are permanently installed and sealed and will not be opened unless there are major changeouts of large equipment items in the building, at which time the necessary special precautions and controls will be exercised.

Entrance to the fresh air side of the S-1 filter plenum is through an access louver from the outside at the second floor level. Access from this point is to change the filters on the main building supply system S-1. Passage of personnel from the filter plenum into the building is prevented by the filter installation itself.

The doors to the two equipment rooms (140, air compressor room, and 141, elevator equipment room) open to the outside and are the normal entry and exit to these rooms for maintenance operations. These rooms cannot be entered from any other location, and the only communication from these rooms to the inside rooms of the building is through the interconnecting piping systems.

The doors between zone 1, cold area, and zone 2, suspect cold area, as well as all other doors which communicate directly from zone 2, suspect cold area, to zone 3, suspect warm area, are equipped with seals that restrict air flow when the door is closed.

8. CREDIBLE ACCIDENT CONTROL

8.1 Processing Area

Safety in the 7930 facility processing area will be the result of inherent design features of the facility itself and strict administrative control of the operations of the facility and of the processing conditions under which the fissionable or hazardous materials are to be handled.

Special safeguards minimize the probability of potentially serious accidents involving criticality, fires, or explosion. If these safeguards should fail, however, and such an accident should occur, the design of the shielding, containment, and ventilation systems are such as to limit the effects of such accidents to a tolerable level.

The maximum credible accidents which the facility has been designed to safely handle are outlined below:

1. Criticality — A criticality accident involving a liquid hydrogeneous moderator that would result in a maximum burst or no greater than 10^{18} fissions and a total number of fissions not to exceed 10^{20}.

2. Fire — A fire which could result in the release of 300,000 curies gross of mixed fission products and 3000 curies ^{90}Sr.
3. Chemical explosion — An explosion that could instantaneously generate no more than the equivalent of 100 ft^3 of gas or cause shock waves at the cell wall with pressures greater than 900 lb/ft^2 or energy greater than 270 $ft/lb/ft^2$. This explosion could result in the release of 300,000 curies gross of mixed fission products and 3000 curies ^{90}Sr.

8.1.1 Criticality

The probability of a criticality accident in TURF will be maintained at an acceptably low level by strict adminstrative control of and adherence to written procedures and by other safety measures such as batch-size and mass limitation of hazardous materials. Each modification of an existing operation and each new operation or new process to be installed in TURF involving fissile material will be designed and analyzed for criticality control to assure that the facility capabilities are not exceeded, and the operation will be approved by the ORNL Criticality Review Committee.

The TURF cells in which a criticality accident involving solutions of ^{233}U is credible are cells G, C, D, or E. It is most likely, however, that solutions will only be handled or stored in cells G and C.

It is possible that a criticality accident involving the fissile inventory of one fuel element could take place in any of the processing cells; however, it is most likely that fuel element fabrication will only take place in cell D.

The maximum credible criticality accident could disperse gaseous fission products and an aerosol of nonvolatile fission products to the cell, a small portion of which could be released through the filtered ventilation systems. Using methods previously described[5] and assuming release of 100% of the volatile fission products from 10^{20} fissions to

[5] C. E. Guthrie and J. P. Nichols, Theoretical Possibilities and Consequences of Major Accidents in ^{233}U and ^{239}Pu Fuel Fabrication and Radioisotope Processing Plants, ORNL-3441 (July 1963).

the atmosphere, no more than eight square miles would require minor decontamination (predominantly from ^{131}I), and downwind personnel doses would not exceed 5 rem over an area of greater than 0.05 square miles. These effects would not be compounded by the release of aerosols of fuel and nonvolatile fission products, since significant quantities of these aerosols would not be released through the filtered ventilation systems.

Although the effects of this maximum credible accident are not disastrous and are in line with effects of maximum credible accidents in other ORNL facilities, the effects could be lessened through use of an iodine absorber in the cell ventilation systems. Provisions have been made for future inclusion of such an iodine absorber in TURF if required by the particular operation to be installed.

The penetrating prompt neutron and gamma dose to operating personnel through the 5 1/2-ft-thick wall or window would not exceed 1 rem, assuming that personnel could evacuate the area shortly after the initial burst of 10^{18} fissions.

Although carbon fuel elements may be fabricated in TURF, it is not credible that a solid carbon moderated criticality accident could occur. The quantities of carbon and fissile material in the fabrication cells will be sufficiently low that a carbon moderated accident is not possible (the order of 500 kg of carbon would be required to create a dry critical assembly with < 5 kg ^{233}U). More than the usual number of safeguards will be applied in an in-cell "dry" fuel storage area, either in cell B or cell E, where several carbide fuel elements may be stored, so that the probability of a criticality accident will be sufficiently low as to be considered "incredible." The effects of a dry criticality accident in the storage area would be not tolerable since the order of 10^{21} fissions could occur, which might burn a large portion of the fuel and cause lethal doses of penetrating radiation through the shielding wall.

Nuclear materials escaping in solution from containers located inside the processing cells as a result of a criticality accident would be collected and safely handled by the floor drainage system. Drain trenches 2 in. wide are located along the center line and at the apex of floors in shielded process cells B, C, D, E, and G. The floors of all cells slope 1/4 in./ft for a total of 2 1/2 in. fall in the 10-ft distance between the trench center line and the cell wall. The drain trenches in cells C and D are connected through trapped floor drains to the RHDR waste system described in Section 4.5. The drain trenches in cells G and E empty to 4-in.-diam in-cell sumps that are jetted batchwise to the RHDR waste system. The drain trenches in cell G and the floor drainage from cell A and the equipment airlock flow through trapped floor drains to the RHD-HOG system described in Section 4.4. The cell F floor drainage sump may be jetted to the RHD-HOG system if contaminated but would normally be discarded to the process waste system.

Nuclear safety in the trapped floor drains of cells C and D is assured by the use of Pyrex raschig ring nuclear poison. The sumps of cells G and E are nuclear safe by geometric design. The floor drains of the airlock, cell A, and cell B are not nuclear safe; however, they drain into the RHD-HOG system, which is designed to receive only safe amounts of fissionable materials.

Cell C is assumed to contain the feed uranium storage vessel for any process. For this reason, the floor holding capacity has been analyzed to determine nuclear safety if the storage tank containing ^{233}U in solution were to rupture and if concurrently the floor drain system were to be blocked or restricted. By design, the cell floor forms a large pan below the overflow elevation of the top of the ventilating air exhaust filter wells. The liquid holding capacity of the cell floor has been determined as a function of the heighth above the top of the floor drain trench, as shown in Fig. 8.1. The maximum holding capacity for cell C (Fig. 8.1) is 5460 liters. The cell floor at this volume could contain 600 kg of uranium in a 6-in.-thick slab of solution with a critically safe concentration of 11 g U per liter.

The design of the floors in cells C, D, E, and G is identical; therefore, the holding capacity of the other cell floors can be determined by a floor area relationship with respect to cell C.

To ensure nuclear safety in the floor drainage systems, the maximum uranium inventory in solution will be limited to 40 kg in cells C, D, E, and G. No storage of solutions will be permitted in the airlock,

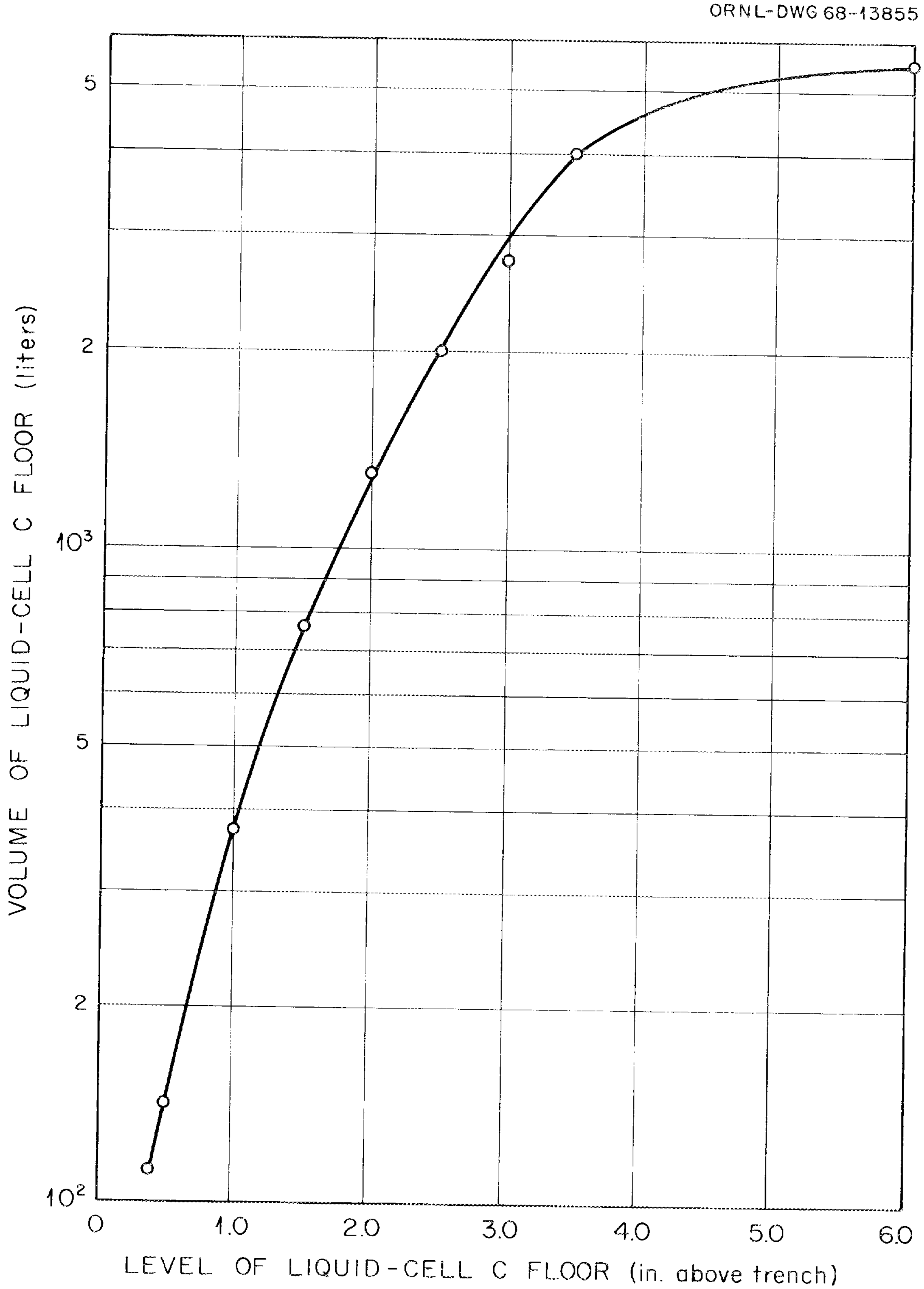

Fig. 8.1. Cell C Floor Volume.

cells A, B, or F where drainage is to the RHD-HOG waste system. Any materials being transferred through these cell areas will be required to be contained in nuclear-safe shipping containers approved for interplant shipments.

Further analysis has been made to determine safe holding capacity of the cell C floor (Fig. 8.2) for higher concentrations of uranium solution. From this analysis it has been found that the cell floor is critically safe if retaining as much as 100 kg of 200 g/liter ^{233}UNH solution.

8.1.2 Fires

The probability of a fire in TURF is low since the quantity of combustible material has been minimized, as is consistent with process and building requirements. There is still the possibility of a fire, however, since the building may contain small quantities of organic oils and solvents, paper, etc., and has vinyl flooring. The capacity of the cell fire protection system has been described in Section 3.2. Quantities of combustible materials will be restricted in the cells in order not to exceed the safe extinguishing capability of the fire protection system.

The building is protected by automatic water sprinklers, and the cells are protected by an automatic CO_2 extinguishment system. Water is not to be used as the general technique for extinguishing fires in the cells, since carbide fuels to be handled in the facility would react with water to form explosive gases. Other special fire extinguishment devices are planned for special operations within the facility; these devices will not be automatic but will be manually actuated as needs require. In addition, the facility has certain provisions for inclusion of inert gas in all cells except cell E in the event that future operations warrant it. This would provide inherent fire protection in the cells.

A fire in a cell would be sensed by rate-of-rise and fixed temperature heat-actuated devices strategically located at the cell ceilings. There are two elements each in cells C and D and one in each of the other cells served by the system. These devices will actuate the

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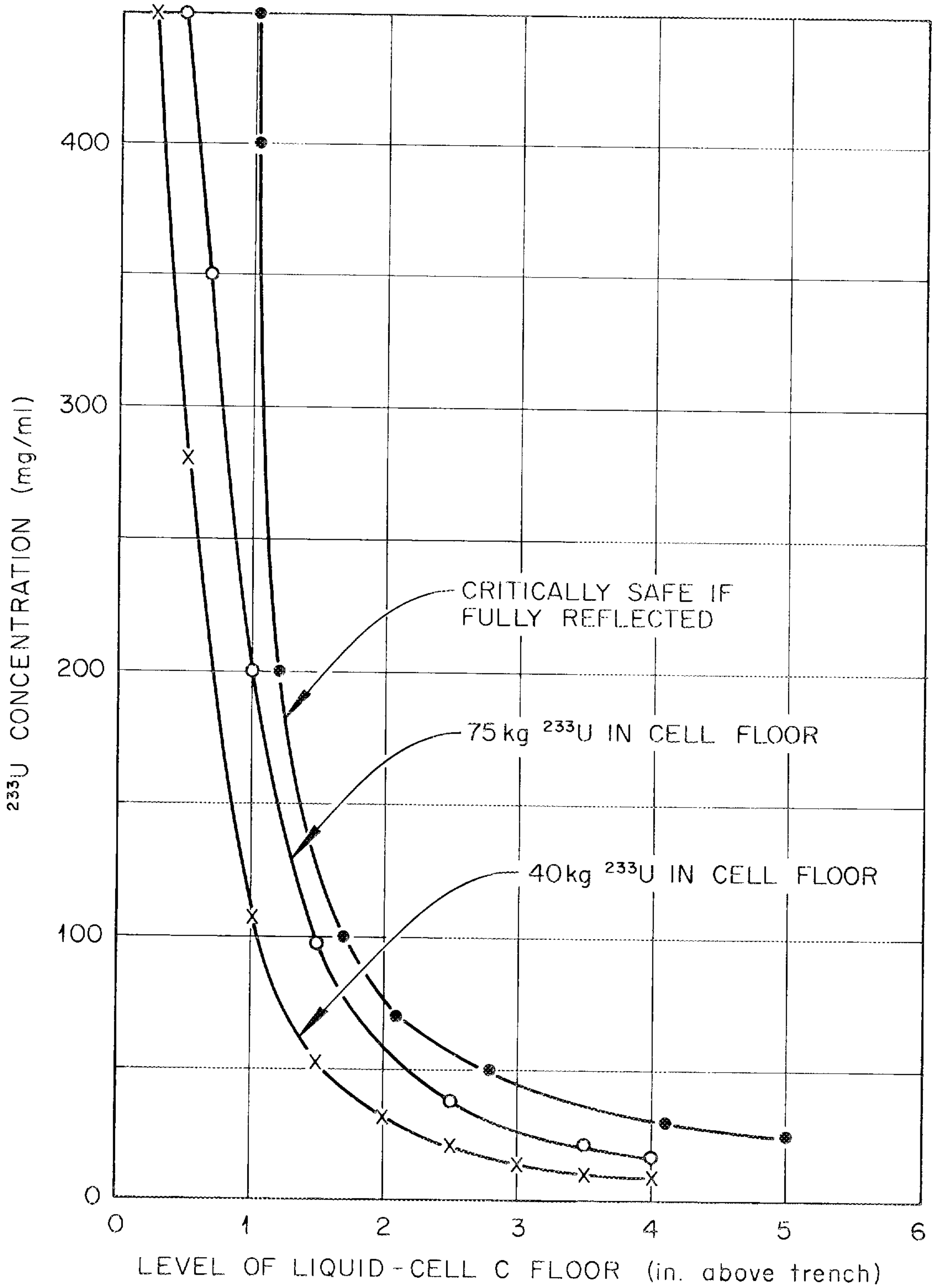

Fig. 8.2. Dilution of ^{233}U in the Cell C Floor Volume.

mechanisms to close all air intakes, place all exhaust valves on cell pressure control, and initiate the flow of gaseous CO_2 into the cell in which the fire is occurring. This system is expected to have high reliability with essential components tested routinely as described in Section 9.2.

The cell ventilation exhaust system is designed with sufficiently large capacity that the pressure in the cell will not rise above atmospheric in the event of a fire over a significant portion of the floor of the cell (see Section 3.2) concurrent with introduction of CO_2. Thus, the fire could not force radioactive smoke or gases out of the cells by other than the cell exhaust route to the stack through the exhaust system filters.

The maximum credible accident resulting from a fire could release radioactivity to the cell. Approximately 4% of the nonvolatile fission products and fuel material would be released as smoke, and 1% of the smoke (0.01- to 0.1-μ particle size) would be released through the filters to the stack. Since the techniques previously described[6] are used, the maximum personnel dose downwind would be less than 200 mrem, and no more than 0.8 square mile would require minor decontamination.

8.1.3 Chemical Explosions

The credible types of chemical explosions in TURF would involve limited volumes of mixtures of hydrogen, organic gases or vapors, or pyrophoric dust with air. Mixtures that would comprise a significant fraction of the volume of a cell are not credible because of the favorable balance between explosive material formation rate and cell exhaust rate.

Control measures to be used to limit the probability of limited volume explosions include procedures to minimize occurrence of explosive mixtures and sources of ignition. Vessels liberating radiolytic hydrogen or organic vapors will be purged with air to maintain lower-than-explosive concentrations. Fuel fabrication processes using hydrogen or

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[6] C. E. Guthrie and J. P. Nichols, Theoretical Possibilities and Consequences of Major Accidents in ^{233}U and ^{239}Pu Fuel Fabrication and Radioisotope Processing Plants, ORNL-3441 (July 1963).

organic vapors will, wherever possible, be prediluted with inert gases to assure nonexplosive concentrations. Careful operating procedures will be used to minimize the possibility of potentially explosive mixtures of pyrophoric dust.

Process operations will be limited to those that could not result in credible types of limited volume explosions that would exceed the design capabilities of the cell bank. The instantaneous gas generation accompanying the maximum credible explosion in the facility could result in the gas pressure in the cell rising to only about 4 in. water gage in cell E and 1 in. water gage in cell B; atmospheric pressure would not be exceeded in cells C, D, and G. Explosions are not credible in cell F. The pressure will return below atmospheric in less than a second. Escape of aerosol through the air intakes will be negligible because of the backflow preventer on the intake and because the intake filters would not be ruptured. All components of the containment membrane will maintain their integrity under these accident conditions.

The maximum credible accident resulting from a chemical explosion could disperse in the cell air an aerosol of irradiated fuel element dissolver solution. If 100 m^3 of air were to escape through the filters and from the stack, the maximum personnel dose downwind would be less than 1 mrem. This assumption, representing the loss of one cell volume, has been used and found satisfactory in analyzing similar facilities at the laboratory.

8.2 Waste Systems

8.2.1 Criticality

Nuclear safety in the radioactive process by-product waste systems described in Section 4 is assured by the design features of the waste system and of the process connections to the waste system. These will not permit a nuclear excursion should an accident in the processing area allow unsafe amounts of fissile material to enter the waste system.

The radioactive hot drain-hot off-gas waste system (RHD-HOG) is excluded from this criticality discussion because no process vessel or other source of significant amounts of fissile material will be connected to this system. The 7-ft-diam by 6.5-ft-high, 1870-gal RHD waste tank (B-2-T) is not poisoned and will be subjected to solutions which have less than 11 g/liter ^{233}U.

The radioactive hot drain recoverable (RHDR) waste system is constructed of 3-in.-diam, or smaller, tributory piping that collects waste from the cell floor drain system and also provides for cocurrent off-gas flow from process vessels containing significant amounts of fissile materials. The liquid is collected in RHDR tank C-6-T, and the off-gas flows through C-6-T to the off-gas treatment units beyond.

Tank C-6-T is 4 ft in diameter and 7 ft 6 in. high and is filled with Pyrex glass raschig rings (3.75% boron) that occupy greater than 30% of the tank volume. This kind of fixed poison has been used successfully in similar applications at the ORNL Pilot Plant, Building 3019, for seven years. The 7-ft-diam by 6-ft 5-in.-high, 1870-gal RHDR waste tank (B-3-T) is not poisoned and will receive solutions from C-6-T that, when diluted in B-3-T, will result in B-3-T solution content having less than 11 g/liter ^{233}U.

An airlift sampling device with solution addition provisions is installed in Building 7932 immediately above and adjacent to the three waste collection tanks for use in closely monitoring the composition of the collected waste. The sampling system is also equipped with provisions for serving the caustic scrubbers in the HOG system if scrubbers are required by future operations. It is not intended that significant quantities of uranium will be stored in the waste collection system. To assure continuous awareness of conditions in the storage system, a plan has been developed (see Section 9.2) to monitor, sample, and control the storage system and its essential safety and control equipment.

Nuclear safety has been provided for in the tank collection system should the maximum credible accident happen in the processing cells and 40 kg of ^{233}U as 200 g/liter uranyl nitrate were to flow undiluted to tank C-6-T. The safety provisions described below assure that any overflow of waste to the 7-ft-diam B-3-T tank will be diluted to a safe concentration of less than 11 g/liter ^{233}U in B-3-T waste tank:

1. The inlet liquid is piped to the bottom of the C-6-T waste tank.

2. The maximum normal operating level in C-6-T will be a minimum of 200 liters below the overflow outlet line to B-3-T waste tank.

3. An automatic device has been installed to assure a 1000 liter minimum liquid inventory in B-3-T waste tank.

4. Two separate automatic control systems have been provided to start the sparger in both C-6-T and B-3-T at any time the liquid level in C-6-T rises near the level of overflow to B-3-T waste tank.

5. Two separate instrument systems to activate a high level alarm annunciation at a continuously monitored point (ORNL waste control center) has been installed on C-6-T for a level alarm that is 200 liters below the overflow to B-3-T waste tank. This alarm is in addition to two local building alarms which first notify the facility operator of needed action to analyze and correct the potential hazard in C-6-T waste tank.

The above instrumentation and controls are redundant in providing safety. These precautions assure nuclear safety, even in the unlikely event that two local liquid level alarms were unheeded or undetected by the operator, that two separate level detection systems failed simultaneously, that normal sparger controls failed to mix the liquid contents of the tanks, or that low-level control instrumentation failed and this failure were unnoted due to neglect on the part of the facility operator during routine reading and recording of vessel levels.

Should overflow of liquid from C-6-T to B-3-T occur, the following dilution would take place to assure the safe concentration in B-3-T waste tank. The 40 kg of uranium in solution would flow into the bottom of C-6-T, where it would be diluted to 20 g/liter in the 2000-liter volume of C-6-T when filled to overflow. This 20 g/liter solution of uranium would then flow to B-3-T where the minimum 1000-liter heel would assure dilution of the liquid to no greater than 10 g/liter uranium concentration in B-3-T waste tank.

To prevent inadvertent transfer of unsafe solutions from tank C-6-T to either tank B-3-T, B-2-T, or cell G, the actuating switches on the three jets from C-6-T have been placed in a locked condition. To actuate either of the three jets, the appropriate key to unlock the switch must be secured from the facility supervisor, who maintains the ultimate control on the movement of waste solutions from the C-6-T waste tank.

In other sections of the report, it has been pointed out that every service line into the cells that might ultimately result in solutions being discharged into the waste collection system if failure of the lines were to occur is of 1-in., or smaller, pipe and is equipped with a cutoff valve immediately outside the cell. Isolation valves have been installed at strategic locations within all service systems to facilitate removal of a flooding hazard, even if accident conditions were to render areas of the facility inaccessible. It has been pointed out that batch-size limitations will be imposed upon all process material inventories to remove any possible flooding conditions that could not be handled within the capacity of the system. With these controls over operation of the waste system, it is incredible that overflow or inadvertent transfer of materials from the RHDR system into the RHD-HOG system could take place.

8.2.2 Fires

A fire in the waste systems is not credible since combustible materials are not permitted to enter the waste system. Sources of ignition are also absent from the waste system.

8.2.3 Chemical Explosions

Chemical explosions in the waste system are not considered credible due to the very low probability of significant quantities of explosive materials being released into the waste system and the high dilution rates that off-gas flow will maintain in the combination liquid-gaseous waste systems. Sources of ignition and conditions under which auto-ignition could occur are absent from the waste system.

8.3 Fuel Storage Basin

Safety in the TURF storage basin will be the result of inherent design features of the basin and its fuel storage and handling equipment and strict administrative control of the operations of the facilities.

Accidents involving fire or chemical explosions in the storage basin are not considered credible. Accidents involving criticality are considered credible in the storage basin, where space is provided for storage of up to 45 elements containing a total of 80 kg ^{233}U and 1500 kg Th.

The maximum credible accident that the facility has been designed to safely handle in the storage basin is a water-moderated nuclear excursion that would result in a maximum burst of no greater than 10^{18} fissions and a total number of fissions not to exceed 10^{20}.

Special safeguards minimize the probability of serious accidents involving criticality. The storage of fuel in the basin will be a part of the particular fuel recovery program to be carried out in the facility. As such, the design of the fuel element storage racks and the methods and safeguards for handling and storing the fuel will be designed and analyzed for criticality to assure that the facility capabilities are not exceeded, and the operation will be approved by the ORNL Criticality Review Committee.

8.3.1 Criticality

The maximum credible accident in the storage basin would not be expected to result in a meltdown or burnout of the element involved in the nuclear excursion. The demineralized water of the storage pool could safely remove the heat and preserve the fuel containment sheath to prevent the release of any radioactivity. At the most, small quantities of steam may be generated and released from the pool. This effect will be adequately handled by the room ventilation system.

The penetrating prompt neutron and gamma dose to operating personnel through the 10 to 20 ft of water in the storage basin would not exceed 1 rem, assuming that personnel could evacuate the area shortly after the initial burst of 10^{18} fissions.

To assure that the basin provides the required shielding and cooling capacity, the basin has been designed and constructed according to accepted methods used and found satisfactory in similar fuel storage basins. All static and applied load conditions that are significant and considered credible have been considered in the structural design of the basin. No special factors to allow for load conditions resulting from seismic disturbances were included in the design of the basin since earthquakes that would result in any appreciable effect upon the basin structure are not considered credible in the Oak Ridge area.

8.3.2 Handling Accidents

It is conceivable that damage or rupture to the fuel containing sheath of a fuel element could take place in the storage basin due to handling of elements with the personnel bridge crane and/or hand tools to be used in the basin. This could result in small quantities of gaseous fission products and particulate matter being released in the storage basin. The gaseous release would escape the basin and be handled safely by the E-5 exhaust system. The particulate matter would be captured by the water of the basin and safely handled by the basin demineralizer and cleanup system, with the waste being transferred to the RHD system.

Fuel element carriers destined for the storage basin for unloading will be handled at the second floor decontamination area before being lowered into the basin. The methods and procedures used for placing a carrier into the basin and extracting it from the basin are believed to be sufficiently safe to render dropping of a carrier an incredible accident.

The rupture of a fuel element as a result of an accident during handling of carrier accessories such as a top cover, etc., or handling of the fuel element itself while unloading the carrier is conceivable. The results of this type accident would again be the release of small quantities of gaseous fission products and particulate matter in the storage basin. Both conditions would be satisfactorily handled by the E-5 exhaust system and the basin demineralizer and cleanup system as previously described.

9. OPERATING SAFEGUARDS

9.1 Operating Organization

One of the primary factors in the safe operation of any facility such as TURF is an adequately staffed and highly trained operating group. The responsibility for the safe operation of the entire facility rests with the Fuel Cycle Technology Group of the Metals and Ceramics Division. Building service equipment, including all ventilation systems, is operated and routinely checked by the TURF operations section. It is their responsibility to see that the required services are operating normally for the supported project in the facility.

The staff consists of eight engineers and eight technicians, as shown in Table 9.1. The operation continues on a 7-day week, 24-hour day with a shift organization including a supervisor and two technicians on each shift, backed up by technical and engineering sections, and including a building safety officer.

9.1.1 Responsibilities

Building Supervisor. — All sections of the TURF staff report to the building supervisor, who has overall responsibility for the entire facility operations.

Operations Section. — The shift operating groups report to the Chief of Operations, who has the primary responsibility for administrative control of all operation of equipment in the facility.

Shift Supervisor. — The shift supervisor on duty is responsible for all current operations in the processing and secondary areas of the facility, including the determination that any maintenance to be started can be completed safely without interfering with any operation in progress. He must be aware of all building and process service equipment operations under way and has the authority and responsibility to stop or alter any of these operations. He must be familiar with all facility safety controls to assure that no unsafe operating conditions are allowed to develop that could result in radioactivity release, criticality, fires, or explosions. He must be familiar with facility emergency

Table 9.1 TURF Organization

- Metals and Ceramics Division
  - Fuel Cycle Technology Group
    - Fuel Recycle Projects
    - TURF Supervisor
      - Building Safety Officer
      - Secretary
      - Operations Section
        - "A" Shift
          - Supervisor
          - Technician
        - "B" Shift
          - Supervisor
          - Technician
        - "C" Shift
          - Supervisor
          - Technician
        - "D" Shift
          - Supervisor
          - Technician
      - Engineering Section
        - Facility Containment
        - Facility Services
        - P and E Area Engineering
        - P and E Craft Supervision
        - Instrument Engineering
        - I and C Technician Supervision
      - Technical Data Section
        - Data Analysis
        - Accountability
      - Health Physics Section

procedures to be followed in the event credible accidents or equipment failures develop.

Building Safety Officer. — The building safety officer is responsible for all safety matters in the building, including zoning regulations, administrative controls required to assure safe operation, emergency manuals and procedures, safety training and other similar functions. In addition, he is responsible for reviewing and approving all nonroutine maintenance requests and procedures.

Technical Data Section. — This section reviews and analyzes all data generated in the process operations and prescribes process conditions for all runs. This section also is responsible for radioactive material transfer procedures and general source and fissionable material handling and storage within the building.

Engineering Section. — This section is responsible for all maintenance in the facility and all engineering related to design and modification of equipment. In addition to direct engineering support for the facility, this section is responsible for supervision of all support crafts in the facility.

9.1.2 Training Programs

A full-time, three-week training session was held at the beginning of the operations to fully acquaint all operations section personnel with the facility, standard procedures, processes, and safety matters. This was followed by a two-month period of checkout operations in which all personnel were trained in their responsibilities. Future training is the responsibility of the shift supervisor, with process matters being coordinated by the Chief of Operations Section and safety training by the Building Safety Officer.

9.2 Standard Operating Procedures

Although all personnel have been trained so that they are completely familiar with the operations they will be performing, all operations will be done by following a detailed procedure and checklist.

9.2.1 Operating Manual, Checklists, and Run Sheets

An operating manual has been prepared that describes in great detail all building and process service systems and equipment and the general operating procedures to be followed. In addition to the normal equipment operations, these manuals provide all other information required for the safe operation of the facility, such as equipment startup and shutdown procedures, maintenance procedures, radiation safety information, and general building safety rules. These manuals are supplemented by an Emergency Manual devoted to the procedures for handling all abnormal conditions and emergencies.

In addition to the operating manuals, detailed step-by-step checklists are provided that list every operation, such as each valve to be operated, proper sequence of operations, and some supplementary information. Examples of sections of the operating manual and checklists for operation of the plant air system are in the appendix.

Equipment essential to the safe, routine operation of the facility has been emphasized in a special plan developed to assure that maintenance and inspection programs are carried out in an orderly sequence to give the plant maximum reliability under all normal and emergency operating conditions. A brief outline of this plan with areas of responsibility, procedure to be followed, and frequency of performance is shown in Table 9.2. This plan is implemented by computerized scheduling and printed card reminders to assure operational compliance.

9.2.2 Building Log

All building service equipment, including all ventilation systems, plant air systems, water service systems, steam and condensate systems, etc., are routinely inspected by a complete tour of the building at the beginning of each shift. Operating conditions are logged and compared with the normal. This log is checked by the shift supervisor, and any abnormal condition is immediately investigated.

Table 9.2 TURF Essential Programs of Safety and Maintenance Inspections and Test

Item	Responsible Organization	Frequency	Procedure
1. Emergency Generator Operational Test	P and E	W	TMIP-1[a]
2. Emergency Power Supply Functional Test	P and E	M	TMIP-1
3. Radiation Monitor (Permanent) Inspection	I and C	W	TMIP-2
4. Radiation Monitor (Permanent) Inspection	I and C	M	TMIP-2
5. Radiation Monitor (Portable) Inspection	HP	W[b]	TMIP-4
6. Radiation Monitor (Tape Deck) Inspection (IBM)	HP	W	TMIP-4
7. Radiation and Contamination Alarm and Evacuation System Inspection	I and C	3M	TMIP-5
8. Radiation and Contamination Evacuation Test	TURF	6M	TMIP-6
9. Process Waste Radiation and Contamination Monitor Inspection	Operations	W	TMIP-7
10. Cell (Stack) Exhaust E-1 System Radiation and Contamination Monitor Inspection	Operations	W	TMIP-7
11. HEPA Filter DOP Test System E-1 (Cell and Vessel)	IE	6M	TMIP-8
12. HEPA Filter DOP Test System E-3 (Vessel)	IE	6M	TMIP-9
13. RHDR Waste Tank C-6-T High LLA and Sparger (Inst. System 77-9)	TURF	3M	TMIP-10
14. RHDR Waste Tank C-6-T High LLA and Sparger (Inst. System 77-3)	TURF	3M	TMIP-10
15. RHDR Waste Tank B-3-T Low LLA and Sparger (Inst. System 77-4)	TURF	3M	TMIP-10
16. RHDR Waste Tank B-3-T Low LLA and Sparger (Inst. System 77-3)	TURF	3M	TMIP-10
17. RHDR Poison in Tank C-6-T Analysis and Inspection	TURF	Y	TMIP-11

Table 9.2 (continued)

	Item	Responsible Organization	Frequency	Procedure
18.	RHDR Poison in Cell Floor Drains Analysis and Inspection	TURF	Y	TMIP-11
19.	Master Valve in CO_2 Cell Fire Protection System Operational Test	TURF	3M	TMIP-12
20.	Selector Valves in CO_2 Cell Fire Protection System Operational Test	TURF	3M	TMIP-12
21.	Building Air Flow Patterns Observed	TURF	W	TMIP-13
22.	Building Pressure Gradients Observed	TURF	W	TMIP-13
23.	Building Supply and Exhaust Systems Air Filter DP's	TURF	W	TMIP-13
24.	RPP Backflow Preventer in PW System Tested	IE	6M	TMIP-14
25.	Cranes and Hoist Operational Safety Inspection	IE	6M	TMIP-15
26.	Slings and Lifting Fixtures Safety Inspection	IE	3M	TMIP-15
27.	Building Pressure Vessels Safety Inspection	IE	Y	TMIP-16
28.	Process Pressure Vessels Safety Inspection	IE	Y	TMIP-16
29.	Facility Fire Prevention Safety Inspection	Fire Department	W	TMIP-17
30.	Plant Fire Protection System Operational Inspection	Fire Department	W	TMIP-17
31.	Plant Fire Protection System Heat Detectors Inspection	Fire Department	3M	TMIP-17
32.	Plant and Cell Fire Alarm System Operational Test	Fire Department	M	TMIP-17
33.	Emergency Air Compressor Operational Test	TURF	W	TMIP-18
34.	Emergency Air Supply Functional Test	TURF	M	TMIP-18

[a]TURF Maintenance and Inspection Procedures.
[b]Weekly reminder of daily check.

9.2.3 Transfer of Information Between Shifts

The shift supervisor is responsible for maintaining in the shift log an accurate and concise record of operations during his shift. This continuing log is the primary means of transmitting information between shifts. An overlap period of 12 min by the nontechnical people provides an opportunity for smooth switch-over even for a continuous operation. Operations are not normally shut down at the end of a shift. The supervisors normally discuss the operation for about 30 min at the day-shift switchovers.

9.2.4 Procedure Changes

Procedures must be constantly changed as processes change or new projects are installed, to bring them up to date, to refine the operations, and to correct errors as they are noted. The Chief of Operations is responsible, with the concurrence of the Building Supervisor, for all changes in the operating manual and checklists. Certain changes are appropriately reviewed and approved by the Safety Officer and area Health Physics representative.

9.3 Maintenance Procedures

All maintenance procedures throughout the building are done under a system designed to ensure complete safety at all times. Routine maintenance of all equipment has been planned and developed into a computerized program of preventive maintenance. The administration of the program is implemented by schedule and activity printouts from the computer. Nonroutine maintenance is planned and procedures are developed as needs arise. The work plans and procedures are closely monitored by the TURF technical staff to assure safe conditions at all times. Appropriate people must approve each step and closely supervise the actual maintenance operations.

9.3.1 Work Request System

A Work Request Form (Fig. 9.1) has been devised to provide (1) a means of requesting maintenance, (2) spaces for the appropriate people

TO				WORK ORDER NO.	CHARGE CODE
COMPLETION DATE	REQUESTED	SCHEDULED	ACTUAL	WORK LOCATION	SAFETY PERMIT REQUIRED ☐ YES ☐ NO

(1) CRAFT	(2) NAME OR BADGE NO.	(3) DATE WORKED	(4) HOURS WORKED	(5) DESCRIPTION

REQUESTER	BLDG. NO.	PHONE NO.	DATE

DISTRIBUTION: WHITE - MAINTENANCE
YELLOW - MAINTENANCE
PINK - ORIGINATOR

UPON COMPLETION OF THE WORK, MAINTENANCE WILL FILL OUT COLUMNS 1, 2, 3, AND 4 AND RETURN WHITE COPY TO THE ORIGINATOR.

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Fig. 9.1. Work Request Form.

to approve the work along with all procedures required, (3) assurance of the proper safety reviews, and (4) a permanent record of the work performed. Maintenance work may be requested by many people in the building. These requests are first acted upon by the Chief of Engineering Section, who reviews the request and prepares the preliminary information on the Work Request form for the craft forces to do the work. At this stage, the job is reviewed by the Building Supervisor, who determines that the job should be done, what priority it should have, what safety reviews, if any, are required, and when the job appropriately should be started. The approved work order is then released to the craft supervisor, who completes preparations to do the job. When the preparations are finished, the foreman reviews the job with the shift supervisor on duty, who ascertains that the job can be done safely at that time and sees that any required equipment shutdown or other required action is done. He sees that valves and electrical breakers are appropriately tagged and that any other preparations are completed, such as Health Physics survey, before signing the form, thus giving approval for the job to proceed. Similar approval is made at the beginning of each new shift should a job carry over to the next shift or next day.

When the form has been completed, the foreman signs it, notifies the Shift Supervisor, and informs him of anything incidental to the work request that might affect the operations. The forms are then returned to Chief of Engineering, who permanently files them.

A "Safety Work Permit," form UCN-3694A (Fig. 9.2) and/or a "Radiation Work Permit," form UCN-2779 (Fig. 9.3), will be used in addition to the blanket Work Order Request where any hazard exists in the judgement of any one of the following: (1) craft foreman, (2) field engineer, (3) Chief of Engineering, (4) Chief of Operations, or (5) Building Supervisor. The Chief of Operations must sign this permit.

While some minor variation of the described sequence may occur, the key steps — review and approval by the Building Supervisor and final approval to proceed by the Shift Supervisor — are mandatory.

ISSUED TO: (FOREMAN-IN-CHARGE)	BADGE NO.	DEPARTMENT	PHONE	WORK ORDER NUMBER

GOOD FOR REGULAR SHIFT IN WHICH ISSUED

FROM: (DATE AND TIME)	TO: (DATE AND TIME)	BUILDING	ROOM

DESCRIPTION OF WORK:

THE FOLLOWING PREPARATIONS HAVE BEEN COMPLETED IN CONNECTION WITH THIS WORK

GENERAL PREPARATION	Yes	Does Not Apply
1. Valves closed, tagged and locked		
2. Pipelines under pressure		
3. Pipelines drained and depressurized		
4. Pipelines blanked		
5. Pressure vessels checked and cleaned		
6. Pipelines and equipment purged		
7. Machinery and equipment safe for work to proceed		
8. Other (specify)		

PROTECTIVE EQUIPMENT	Yes	Does Not Apply
1. Protective Equipment Required		

CHECK OR SPECIFY EQUIPMENT REQUIRED

TYPE OF CARTRIDGE OR CANISTER REQUIRED

- [ ] HALF MASK
- [ ] FULL FACE MASK
- [ ] FRESH AIR MASK
- [ ] IMPERMEABLE SUITS
- [ ] MONOGOGGLES
- [ ] GLOVES
- [ ] APRONS
- [ ] OTHER (SPECIFY)

2. SPECIAL VENTILATION REQUIRED

3. OTHER

FIRE PREVENTION	Yes	Does Not Apply
1. Explosive atmosphere test required		
2. Nonsparking tools required		
3. Welding and/or burning required		
IF WELDING AND/OR BURNING IS REQUIRED THE FOLLOWING PROVISIONS HAVE BEEN MET:		
4. Area personally inspected		
5. Surrounding floor area swept clean and wet down, if necessary		
6. All combustible materials removed to a safe location or protected with flame proof covers		
7. Ample fire protection equipment at hand: extinguishers, water pails, hose lines, etc.		
8. Monitor appointed		
9. Observer appointed, if necessary		

ELECTRICAL	Yes	Does Not Apply
1. Work is being done by nonelectrical personnel (Signature of Electrical Supervisor Required)*		
2. Circuits have been de-energized		
3. Electrical tags and lock-outs		

INDUSTRIAL HYGIENE	Yes	Does Not Apply
1. Industrial Hygiene survey made		
2.		
3.		

I have personally inspected site and certify that the work area has been properly cleared for work and that conditions are safe for the work indicated. This Safety Work Permit is therefore approved for the class of work indicated.

SUPERVISOR REQUESTING WORK ______ PHONE ______ FOREMAN-IN-CHARGE ______ PHONE ______

- [ ] WORK HAS NOT BEEN COMPLETED DUE TO: [ ] End of Shift [ ] Other Reasons (specify)
- [ ] WORK HAS BEEN COMPLETED

Remarks for temporary repairs, temporary installations, unusual characteristics of equipment, etc. ______

This Permit surrendered at ______ AM/PM Signed ______ (FOREMAN-IN-CHARGE) Badge ______

Prepare in Duplicate: The Original Copy is given to Foreman-in-charge or Representative and the Duplicate Copy is retained by Issuing Supervisor. Upon expiration of Permit, the Original Copy is signed, dated and returned to the Issuing Supervisor for forwarding to his Department Head and the Duplicate Copy is sent to the Safety Department or, if applicable, to the Fire Department.

RETURN OF SAFETY WORK PERMIT ACKNOWLEDGED BY:

______ SUPERVISOR REQUESTING WORK

UCN-3694A (3 8-66)

Fig. 9.2. Safety Work Permit.

	DATE AND TIME		EXTENDED BY	WORK PERMIT NO.
	FROM AM PM	TO AM PM	TO AM PM	R-

LOCATION & JOB DESCRIPTION

RADIATION SURVEY DATA (To be filled in by Health Physics)

LOC. CODE	SPECIFIC LOCATION AND DISTANCE FROM SOURCE	TYPE OF RADIATION	mrem/hr.	WORKING TIME FOR ____ mrem	CONTAMINATION		RADIATION SURVEY	
					TYPE	MEASUREMENT	BY	DATE AND TIME
A								
B								
C								
D								

INSTRUCTIONS*

HEALTH PHYSICS MONITORING REQUIRED: ☐ START OF JOB ☐ INTERMITTENT ☐ CONTINUOUS ☐ END OF JOB

CONTACT HP FOR SURVEY BEFORE STARTING WORK IN A NEW LOCATION		PROVIDE ASSISTANCE FOR REMOVAL OF PROTECTIVE CLOTHING	
TAPE COVERALLS TO GLOVES AND FOOTWEAR		MONITOR BREATHING ZONE	
CHECK TOOLS AT END OF JOB		NASAL SMEAR REQUIRED	
CHECK PERSONNEL AT END OF JOB		BIOASSAY SAMPLE REQUIRED	
TIMEKEEPING REQUIRED		DO NOT WORK ALONE-STANDBY OBSERVER REQUIRED	

PROTECTIVE EQUIPMENT AND MONITORING INSTRUMENTS

CAP		COVERALLS (1 PR.)		SHOE COVERS		POCKET METERS	
CANVAS HOOD		COVERALLS (2 PR.)		C-ZONE SHOES		DOSIMETER	
SAFETY GLASSES		GLOVES: CANVAS		RUBBERS		FILM RING	
EYE SHIELD		GLOVES: LEATHER		RUBBER BOOTS		DOSE-RATE ALARM	
HALF MASK		GLOVES: SURGEON'S		PLASTIC BOOTEES		DOSE ALARM	
ASSAULT MASK		GLOVES: PLASTIC		LAB COAT		CUTIE PIE	
CHEMOX MASK		GLOVES: RUBBERIZED CANVAS		SPECIAL FILM METER		GMS METER	
AIR-LINE HOOD		GLOVES: HOUSEHOLD RUBBER					
AIR-LINE SUIT							

REMARKS

REGULAR APPROVALS	SPECIAL APPROVALS
HEALTH PHYSICS CERTIFICATION	DIVISION DIRECTOR
SUPERVISION	H.P. DIVISION DIRECTOR
SUPERVISION	DEPUTY LAB DIRECTOR

UCN-2779
(3 7-61)

*Only items checked (√) apply.

(OVER)

Fig. 9.3. Radiation Work Permit. (a) Front.

1. Health Physics shall be present for line breaks or removal of shielding.
2. Notify Health Physics of any deviations from instructions and changes in working conditions.
3. Personnel survey is required when leaving contamination zones.
4. Return work permit to Health Physicist upon completion of job or expiration of permit.

TIMEKEEPING BY ____________________

DEPT. ____________________

PERSONNEL AND EXTERNAL EXPOSURE CONTROLS						PLANNED EXPOSURE (mrem)	TIME RECORD							ESTIMATED EXPOSURE (mrem)
NAME	DEPT.	P.R. NO.	LOCATION CODE	DOSE RATE USED	WORKING TIME		BEGIN	END	BEGIN	END	BEGIN	END	TOTAL TIME	

1. **Radiation Work Permit is required* when:**
   (a) expected dose is > 20 mrem to the body or 300 mrem to extremities for an individual during a single work assignment;
   (b) dose rate > 5 rem/hr (total body);
   (c) airborne radioactivity is > $(MPC)_a$ for a 40-hr week;
   (d) specified by divisional operating rules and procedures or by posted regulations.
2. **Supplementary Time Sheet**
   To be used if extra space is needed for the timing of individuals into and out of an area, etc.
3. **Special Approvals**
   (a) Dose Rate rem/hr (total body)

> 5	Division Director in charge of work area	Oral or written; noted and initialed on the permit by the person obtaining the approvals.
> 20	Above and Health Physics Division Director.	
> 50	Above and Laboratory Deputy Director.	

   (b) Dose (total body)

> 60 mrem/day for nonoperating personnel, or > 300 mrem/wk for operating personnel	Division Director in charge of individual
> 1 rem	Above and Laboratory Deputy Director

4. **Copies**
   (a) The RWP must be posted or available at work site.
   (b) Health Physics maintains a copy for record and reference purposes.
   (c) A copy must be distributed to appropriate line supervision.

*Posted regulations may be used in lieu of an RWP for *operating personnel* under specified conditions. (See Regulation 3, Procedure No. 26, ORNL Health Physics Manual.)

Fig. 9.3. (b) Back.

9.3.2 Detailed Procedures

The majority of maintenance jobs are done from instructions written on the Work Request form with auxiliary sketches and drawings. However, more detailed procedures are required for in-cell maintenance work. Maintenance work performed in the cells by technicians using manipulators is not done by work request form since that is designed only for craft support work. A separate form is provided for in-cell work and provides places for filling in the appropriate information. This work will be done under general instructions for simple operations, such as removing storage vessels. However, each specific job must be reviewed and approved either by the Chief of Operations or Building Supervisor before the start of the job.

Work that involves removing equipment from the cell bank and other in-cell maintenance where the cell is to be opened will be done using detailed step-by-step procedures. For semiroutine operations, these instructions will be prepared as part of the Operations Manual. For nonroutine jobs, a special procedure will be prepared at the time the job is to be performed.

10. PERSONNEL EXPOSURE POLICY AND CONTROL

The personnel exposure policy in effect at the TURF facility will be governed by the exposure standards set by the Atomic Energy Commission for its contractors and set by management of Oak Ridge National Laboratory. The methods by which these standards are met will conform to policy and control measures prescribed by ORNL management and delineated in the Radiation Safety and Control Training Manual, published by ORNL.

The ORNL policy states that all operations be conducted with the lowest reasonable personnel exposure to radiation and contamination. In no case shall internal and external exposures exceed the recommendations of the Federal Research Council (FRC) and the National Committee on Radiation Protection (NCRP). Furthermore, all work is to be performed in such a manner that losses resulting from contamination are minimized. Such losses may include research development and productive time, facility and equipment abandonment, and the cost of cleaning up contamination. Finally, the policy states that environmental contamination is to be maintained at a level as low as consistent with sound operating practices. In no case shall the atmospheric and water contamination outside the controlled area exceed maximum permissible concentration values for the neighborhood of an atomic energy installation.

The permissible dose for an individual worker will be limited to amounts less than the recommended maximum weekly dose in order to allow for accidental or abnormal exposure doses. Recommended permissible doses are tabulated in Table 10.1.

Table 10.1 Recommended Permissible Dose[a] to Body Organs of Occupational Workers Exposed to Ionizing Radiation

Organ	Recommended Maximum Weekly Dose (rems)	Maximum Permissible Dose (rems)		
		Quarterly (13 weeks)	Annual	Age Proration Total
Total body, head and trunk, eye lens, gonads, blood-forming organs	0.1	3	12	5(N-18)
Skin of whole body, thyroid	0.6	10	30	30(N-18)
Hands, forearms, feet, ankles	1.5	25	75	75(N-18)
Bone		30/4n[b]	30/n	30/n(N-18)
Other body organs		5	15	15(N-18)

[a]Values given are in addition to doses from medical and from background exposures.

[b]This n is referred to as the "relative damage factor." It is one for radium isotopes and for gamma radiation, otherwise it is set equal to five for all radionuclides in bone.

The radiation source used as a design basis for shielding requirement calculations is a fuel element containing 35 kg ^{233}U-Th mixture, approximately 1.75 kg ^{233}U (with 600 ppm ^{232}U), that has been irradiated to 25,000 Mwd/ton and decayed for 90 days. The cell shielding design and resulting radiation exposure dose rates used in this report were based on reprocessing of materials yielding radiation levels within this design limit.

10.1 Personnel Exposure

Personnel exposure to ionizing radiation from sources being handled inside the shielded processing cells will be held to a minimum consistent with reasonable operating efficiency. In all cases, the radiation exposure received by the individual will be less than the permissible level recommended by ORNL management representatives.

Personnel exposure to airborne or ingestible radioactivity resulting from process equipment failure will be prevented by containment of these materials by the facility containment structure or by equipment such as the ventilation system that was designed for this purpose. Facility containment is discussed in other sections of this report.

Radiation monitoring equipment has been located at strategic positions throughout the facility to detect radiation and sound alarms should the permissible levels of ionizing or airborne radiation be exceeded.

10.2 Exposure in Radiation Zones

The TURF shielding will attenuate sources smaller than the design limitation listed for the facility to less than 0.25 mrem/hr in normally occupied areas and with hot spots around penetrations in operating areas no greater than 2.5 mrem/hr. The dose rates in normally unoccupied areas will be no greater than 10 times these values or 25 mrem/hr for short periods of time during nonroutine operations.

As indicated above, exposure in the normal operating area will be less than 0.25 mrem/hr or less than 30 mrem per 40-hr week. However, there will be a number of operations — such as seal replacement in shield doors 1, 2, and 3, maintenance of the crane and manipulator systems permanently installed in cells A, B, E, and F, or emergency removal and decontamination of equipment — that will entail a short period of exposure to higher levels of radiation. These operations will be authorized with Health Physics personnel in attendance, and the working times will be carefully checked to make sure no individual receives an exposure in excess of that provided for in the ORNL radiation Health Physics Manual, Section 3.1. Records of accumulated exposure will be kept for all personnel regularly assigned to the building.

10.3 Exposure Possibilities

The table below lists the approximate number of people normally working in the TURF facility. Visitors who may be present from time to time will be escorted through the building. They will wear film badges and either electroscope dosimeters or pocket meters as required.

Table 10.2 Number of Personnel Working in the TURF Facility

Area	Working Days	Nights and Weekends
Main operating area	15	10
Maintenance areas	5	5
Office area	10	5

Due to the large numbers of people that may be exposed while working in the facility, the radiation level schedule (Table 10.3) has been prepared to provide an order of magnitude of the exposure dose rates for alpha and gamma contamination within the building. Each area is evaluated on the basis of the functions it is designed to perform. The columns on the left indicate the radiation levels tolerable for each area. The two right-hand columns indicate the possible peak levels these areas are likely to attain during the performance of their functions. Good housekeeping procedures will be used to maintain the facility at the lowest possible contamination level all of the time. Steps will be taken to confine and/or remove contamination resulting from operation at the time the contamination is released in order to allow safe operation during periods of credible emergencies.

Table 10.3 Radiation Level Schedule

Areas	Tolerable Level		Special Operations	
	Alpha (MPC)[a] (Above background)	Gamma (mr/hr)	Alpha (MPC)[a]	Gamma (mr/hr)
Zone 1 areas	< 0.1	background	< 0.1	background
Zone 2 areas	< 0.1	0.25	1.0	0.25
Zone 3 areas (except as noted below)	0.2	2.5	2.0	2.5
Hot change room	0.2	0.25	2.0	2.5
Maintenance operating area (in vicinity of cell A)	0.2	2.5	2.0	10.0[b]
Equipment airlock	1.0	2.5	10.0	10.0[b]

[a]Maximum permissible concentration for mixture of alpha emitters in air (1×10^{-11} μc/ml). The MPC is higher than this if only ^{233}U, ^{232}U, or Th is involved.

[b]When one shield door is open or a fuel element is in cell B.

11. RADIATION SAFETY

Only authorized ORNL personnel and official visitors will be permitted in the TURF facility. The TURF operations shift supervisor is in charge of the processing and related maintenance and storage areas. A sign on the door to room 119 indicates this and includes instructions for contacting the supervisors by using the building intercommunication telephone located by the entrance door to the facility.

Personnel entry to the cell bank is normally not required for operations or maintenance. Certain nonroutine maintenance operations will require entry of personnel into the equipment airlock and cells A, B, G, E, and F, but personnel will not be allowed to enter cells C and D.

There should be no likelihood that anyone could get confused and enter a cell "by mistake." All entry doors to the cell bank are locked by an automatic control system requiring a preset sequence of action for unlocking and opening of the doors. This system is under the direct administrative control of the operations shift supervisor.

11.1 Zoning

The building contains four classes of zones, as shown in Fig. 11.1: zone 1 — cold area, zone 2 — suspect cold area, zone 3 — suspect warm area, and zone 4 — hot area. These zoned areas have been marked with appropriate signs, and all personnel will observe and obey these signs. There are no unzoned areas, but the office area and rooms 140 and 141 are cold areas and contamination clothing is prohibited in these cold zone areas.

11.1.1 Contamination Zones

The checking and holding area, room 204, and all maintenance operating areas on the first, second, and third floor levels are suspect warm areas, which are contaminated zone 3, while the cell bank is a hot area, contaminated zone 4. Of course, these areas will not be restricted until they are first used to handle radioactive materials.

11.1.2 Monitored-Exit Regulated Zones

The hot change room, room 124, and the receiving area are monitored exit zones. This treatment is identical to an ordinary regulated zone except that personnel and materials leaving the zone must be monitored for radioactive contamination.

11.1.3 Regulated Zones

All zone 2 suspect cold areas are ordinary regulated zones.

11.1.4 Radiation Zones

These zones will be established at the time particular operations are planned in accordance with standard laboratory procedure.

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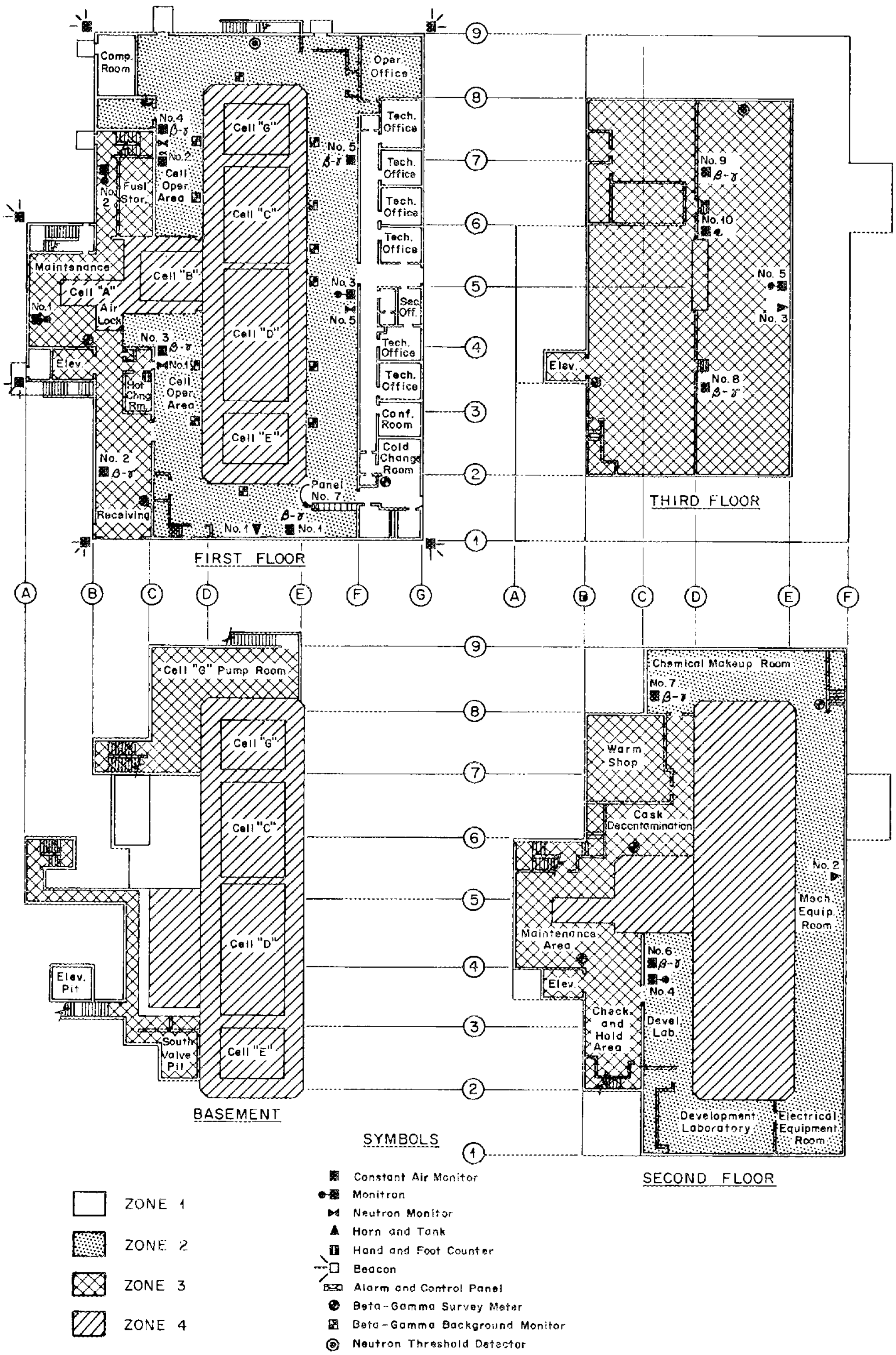

Fig. 11.1. Radiation Monitoring and Control Equipment Arrangement.

11.1.5 General Regulations

The following general regulations apply to the various zones:

1. Entry to and exit from the TURF facility regulated operating areas will be only through room 115. The other passage ways from the regulated areas are to be used for emergency exit only. Operational use of emergency exits may be permitted under controlled conditions.

2. All personnel leaving the regulated zone of the facility will check themselves for contamination with instruments provided in room 119.

3. No contamination zone clothing is to be worn in the cold zone areas. Contaminated zone clothing includes yellow shoes or shoe covers over safety shoes, coveralls or laboratory coats, gloves, safety glasses, and any other special safety equipment deemed necessary.

4. Film badges and pencil meters must be worn by all ORNL personnel in regulated zones. Pocket dosimeters may be worn by visitors.

5. Either street or clean contamination zone clothing may be worn in the regulated zone.

6. No eating or drinking, except from approved fountains, is permitted in the regulated zone. Smoking is permitted in the regulated zone except in the chemical makeup area (room 208), development laboratory (room 212), and the equipment rooms (210 and 211).

7. No eating, smoking, or drinking is permitted in the contamination zones.

8. The minimum clothing requirement in the contamination zone is one pair of shoe covers and a buttoned contamination zone lab coat. The nature of the particular job being done will determine the degree of additional clothing protection required.

9. All personnel entering the monitored-exit regulated zone from a contamination zone must survey themselves for alpha and beta-gamma contamination.

10. All articles taken from a contamination zone must be checked for alpha and beta-gamma activity. If the article is found to be contaminated, it should be either cleaned or properly bagged and tagged to permit its subsequent safe handling outside the contamination zone.

11. Personnel entering the receiving area from corridor 2 or the checking and holding area must survey themselves for alpha and beta-gamma activity.

11.2 Radiation Monitor and Control Instrumentation

Facility radiation and contamination detection and alarm systems are installed in the TURF to continuously and automatically monitor the air contamination level and the gamma and neutron radiation levels. This equipment is located as shown in Fig. 11.1. These monitoring instruments in the system are used to provide Health Physics monitoring information, local alarms when abnormal conditions occur, and remote alarms on a central radiation and contamination alarm and control panel located at the building control panel in the cell operating area (room 119). These instruments and their normal locations are listed in Table 11.1.

Each instrument is an independent unit that possesses local alarm features. The alpha constant air monitor sounds a buzzer to indicate a caution alarm at 500 counts/min and a bell (high-level alarm) at 800 counts/min. The beta-gamma constant air monitor sounds a buzzer (caution alarm) at 1000 counts/min and a bell (high-level alarm) at 4000 counts/min. The gamma monitron sounds a bell (caution alarm) at 7.5 mrem/hr. The neutron monitor operates "rate" alarms when a level of 23 mrem/hr is detected or operates a "burst" alarm when a neutron field equivalent to a current pulse of 3×10^{-6} amp with a rise time of 100 μsec is exceeded. Brief descriptions of these instruments are given in this section.

11.2.1 Air Monitors (CAM) Model 0-2240 and (CAAM) Model 0-2340

These two types of instruments operate essentially the same except that the CAAM is an alpha air monitor. Each has an aspirating system, a paper-tape filter, a radiation detector, a linear count-rate meter, a recorder, and visible and audible alarms. All constant air monitors have been equipped with a model 0-2311C-4 inoperative instrument alarm panel.

Table 11.1 Facility Radiation and Contamination Detection Devices in TURF

Room	Area Description	Instrument
115	Cold change room	1 stationary beta-gamma survey meter with GM probe
119	Cell operating area	3 beta-gamma constant air monitors
		1 alpha constant air monitor
		1 gamma monitron
		3 neutron monitors
		1 neutron threshold detector
		1 survey system consisting of 2 stationary beta-gamma survey meters and 12 GM probes
121	Health Physics office	1 alpha smear counter
		1 beta-gamma smear counter
		2 scalers — spares
123	Maintenance operating area	1 gamma monitron
		1 stationary beta-gamma survey meter with GM probe
124	Hot change room	1 hand-and-foot counter with GM survey probe
127	Receiving area	1 beta-gamma constant air monitor
		1 stationary beta-gamma survey meter with GM probe
131	Fuel storage room	1 gamma monitron
203–204	Checking and holding area Maintenance operating area	1 stationary beta-gamma survey meter with GM probe
208	Chemical makeup room	1 stationary beta-gamma survey meter with GM probe
212	Development laboratory	1 beta-gamma constant air monitor
		1 gamma monitron
214	Cask decontamination area	1 stationary beta-gamma survey meter with GM probe

Table 11.1 (continued)

Room	Area Description	Instrument
302	Top of cell B – third floor	2 beta-gamma constant air monitors
		1 stationary beta-gamma survey meter with GM probe
305	Cell roof – mockup area	1 alpha constant air monitor
		1 gamma monitron
		1 neutron threshold detector
		1 stationary beta-gamma survey meter with GM probe

11.2.2 Monitron (Model O-1154B)

The monitron is an AC-powered, null-type, radiation detection instrument for monitoring gamma radiation. The monitron consists of two basic units: (1) a control chasis that contains the power supply, the main amplifier, a radiation-level indicating meter, and the controls; and (2) a preamplifier and ion-chamber detector assembly. An O-2796 auxiliary alarm panel is used in conjunction with the monitron to provide the high level and instrument inoperative alarm functions.

11.2.3 Neutron Monitor (Model O-2562)

The monitor is a transistorized, AC-powered instrument for the continuous measurement of dose rates from fast and thermal neutrons and for the immediate warning of the occurrence of a critical incident. A polyethylene moderator that surrounds the BF_3 detector thermalizes the fast neutrons. The polyethylene is covered with 0.025-in.-thick cadmium sheet, which affords a lower cutoff limit to the thermal neutrons. The compression of the neutron energies results in a relative biological effectiveness (RBE) factor for the detector that is approximately the same as for the original admixture of fast and thermal neutrons. The dose circuit of the monitor has a single range of 0 to 25 mrem/hr (milliroentgens equivalent man per hour), which is indicated by a calibrated panel meter. A high-level alarm with manual reset can be adjusted to alarm at any value between 0 and 25 mrem/hr. The burst circuit is designed to detect fast bursts of neutrons such as would occur during a criticality.

11.2.4 Radiation and Contamination Alarm and Control Panel

In addition to the local signals and alarms indicated by the monitoring instruments, each instrument is connected to an individual module with indicating lights and a central buzzer alarm in the radiation and contamination alarm and control panel located on the west end of the TURF building control panel in the cell operating area. Table 11.2 gives the scheme of signal lighting for the control panel modules for the monitrons and air monitors. Table 11.3 gives the scheme for neutron monitors.

11.2.5 Building Evacuation Alarms System

The system is made up of three nitrogen gas-driven horns, located for audible building coverage as shown in Fig. 11.1, and flashing, magenta beacon lights located, as shown, on the corners of the building at the exterior first floor roof level. The system is also connected to the main building annunciator panel and is interlocked with the E-13 exhaust system to stop the fan upon alarm.

There are five constant air monitors on the first floor. Any two coincident high-level alarms from these monitors will activate the evacuation alarm system. On both the second and third floors, there are two constant air monitors. Coincident high-level alarms from either floor will activate the evacuation alarm system, as will a single high-level alarm and a single instrument inoperative condition or two instrument inoperative conditions. The constant alpha air monitors located on the first floor (room 119) and third floor (room 302) activate local and panel-mounted alarms only.

There are five monitrons located as shown in Fig. 11.1. Any two coincident high-level alarms from any of the instruments on the first and second floors will activate the evacuation alarm system. The monitron located on the third floor (room 302) will activate a local and panel-mounted alarm only.

Table 11.2 Central Control Panel Alarm Indications for Monitrons and Air Monitors

Instrument Alarm Condition	Lamp Intensities		
	Red	Amber	White
Normal operation	Dim	Dim	Dim
Caution level[a]	Dim	Bright	Dim
High level[b]	Bright	Bright	Dim
Instrument trouble or out of service	Dim	Dim	Bright
Instrument removed[c]	Bright	Bright	Bright

[a]Caution level for a beta-gamma air monitor is 1000 counts/min, for the alpha air monitor is 500 counts/min, and for the monitron is 7.5 mrem/hr.

[b]High level for the beta-gamma air monitor is 4000 counts/min, for the alpha air monitor is 800 counts/min, and for a monitron is 23 mrem/hr.

[c]Lamp intensities exist until a maintenance connection is made giving "out of service" indication.

Table 11.3 Central Control Panel Alarm Indications for Neutron Detectors

Instrument Condition	Lamp Intensities	
	Red	Amber
Normal operation	Dim	Dim
Burst level[a]	Bright	Dim
Rate level[b]	Dim	Bright
Burst and rate level	Bright	Bright
Instrument removed[c]	Bright	Bright

[a]Burst level is fixed in the instrument to that level whose current magnitude and rate of rise would be attained if a criticality should occur at a distance of 200 ft from the instrument.

[b]Rate level is 23 mrem/hr.

[c]Lamp intensities exist until a maintenance connection is made giving "normal" indication.

There are three neutron monitors located as shown in Fig. 11.1. Any two coincident burst level alarms from any of the instruments will activate the evacuation alarm system.

In addition to the automatic actuation of the building evacuation alarm system, there is a module in the control panel that will override all controls to activate the evacuation system.

Evacuation routes out of the building are shown in Figs. 2.3, 2.4, and 2.5, and evacuation routes away from the building are shown in Fig. 11.2. The way in which emergencies are to be handled and the circumstances under which the evacuation routes will be used will be examined in detail in an emergency manual for Building 7930.

11.2.6 Process Waste Drain Monitoring System

A monitor is installed on a pad near a manhole at the southwest corner of TURF for monitoring alpha and beta-gamma activity in the process waste drainage from the facility. The normal control of the process waste drainage is described in Section 4.3. However, a high-level alarm from the monitor will not only be indicated at the control panel but will automatically override the diversion valve controls in the waste system to divert the flow to the necessary waste retention basin.

11.2.7 Cell Exhaust Duct Monitoring System

An air monitor is installed near the exhaust duct upstream of the stack fans in the stack breeching area to monitor the level of beta-gamma activity in the cell exhaust from the facility. This monitor samples the exhaust gas flowing in the duct and signals a high-level alarm at the control panel.

11.2.8 Survey Monitoring Instruments

A total of nine count-rate meters with beta-gamma probes and one hand-and-foot counter are provided at strategic locations in the facility, as shown in Fig. 11.1. One radiation survey system comprising the operating area background monitors consists of two count-rate meters with local alarms, and twelve probes have been installed to monitor

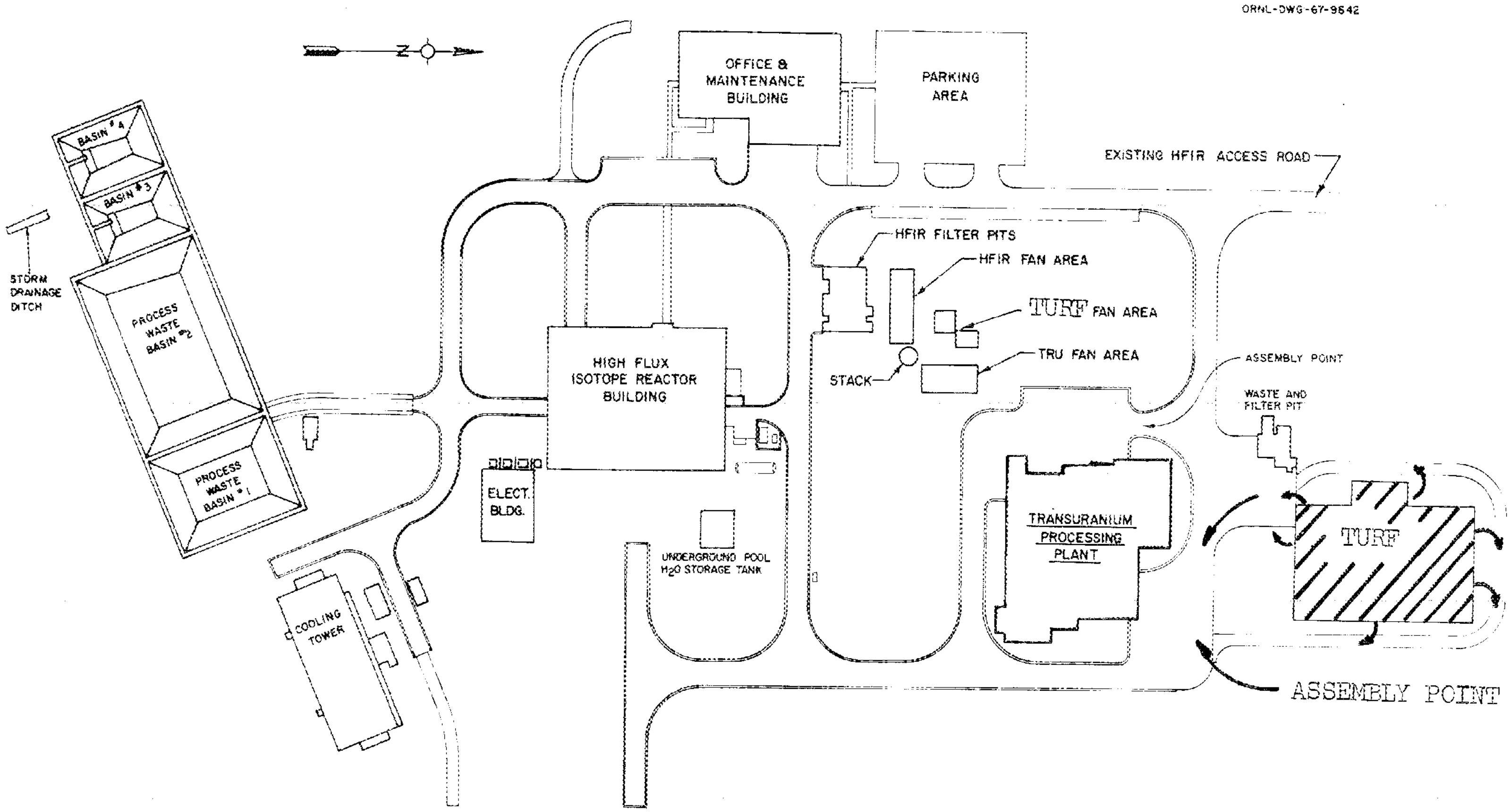

Fig. 11.2. Evacuation Routes Away from Building.

operations plus service and viewing penetrations into the cell bank at the cell operating modules in the cell operating area. The remainder of the instruments are placed for use in monitoring personnel and equipment as it flows through the facility. Brief descriptions of these instruments are given below.

Stationary Contamination Monitor (Model 0-2277). — This monitor consists of a versatile counting-rate meter, AC-powered, and either a zinc sulfide scintillation probe for alpha detection or a GM counter probe for beta-gamma detection. An associated alarm circuit permits a local alarm to be actuated at predetermined levels.

Hand-and-Foot Counter (Model 0-1939B). — This is a stationary semi-automatic device for detecting beta-gamma contamination of shoes and hands simultaneously. Counts obtained by GM tubes during an automatically timed interval are indicated by lights and registers. There is an auxiliary probe for monitoring other areas of the body or clothing.

11.3 Connection to ORNL Emergency Control Center

Signals from the building evacuation alarm system and the fire alarm systems are automatically transmitted by telemetry to the ORNL emergency control center. The signals transmitted not only annunciate at the control center but also differentiate the alarm as to radiation, contamination, or neutron "burst."

11.4 Connection to the ORNL Waste Monitoring and Control Center

Signals are transmitted by telemetry from the process waste drain monitor and the cell exhaust duct monitor to the waste monitoring and control center in Building 3105. Signals from the process waste drain monitor are received to indicate the following: (1) high-level beta-gamma alarm, (2) high-level alpha alarm, (3) water flow rate, (4) level of beta-gamma radiation, (5) level of alpha contamination, and (6) position of diversion valves.

Signals from the exhaust system E-1 duct monitor are received to indicate the following: (1) high-level beta-gamma radiation alarm,

(2) inoperative sample pump, (3) broken filter tape, (4) inoperative count-rate meter, (5) remote recorder reading, (6) remote range indicator, and (7) gas flow rate.

11.5 Radiation Surveys

Radiation surveys will be made at the discretion of the building Health Physics surveyor or as requested by the operations group. As a minimum, the facility will be smeared thoroughly once every four weeks, and the building will be "spot smeared" every week.

A check list will be used and a record maintained. Each week three rooms within the contamination zone 3, suspect warm area, will be thoroughly checked and the other rooms in that area "spot checked." Areas of high traffic, such as room 124, the hot change room, will be checked daily. Particular attention will be devoted to the maintenance operating areas (rooms 123 and 203), the checking and holding area (room 204), the decontamination station (room 214), and the fuel storage room (room 131). Whenever an operation is performed that has a high probability of spreading contamination, the area involved will be monitored with survey instruments and smears. Such operations are transferring carriers within the building and into and out of the building, transferring equipment through the equipment airlock (room 133), transferring equipment into or out of any of the cells, removal of a cask from the fuel storage basin, removal of solid samples from the cells, changeout of service plugs, and removal of the master-slave manipulators for repair. Such areas will be immediately isolated and checked.

The detection of contaminated articles at a monitoring station will require a thorough survey to determine the source of the radioactivity and the extent to which contamination has been spread.

APPENDIX

SYSTEM CHECKOUT PROCEDURE
PLANT AIR SYSTEM

I. CHECKOUT OF AIR COMPRESSOR AND ASSOCIATED ACCESSORIES

A. Air Compressors

1. Verify that the cooling water valves to AC-1 and AC-2 are open.
2. Verify that the main valves in the tower water system are open.
3. Verify that foundation and cylinder head bolts are tight.
4. Verify that hand valve downstream of PRV-39 is open (PW makeup to tower water).

B. Aftercooler

1. Verify that the valves in the cooling water line to the aftercooler are open.
2. Check telltale hole in downstream flange of aftercooler for leakage.

C. Moisture Separator

1. Verify that the gage glass valves on the moisture separator are open.
2. Verify that the hand valves on the upstream and downstream side of the trap on the moisture separator are open.
3. Verify that the hand valve in the vent line on top of the trap is open.
4. Verify that the valve in the bypass line at the trap is closed.

D. Receiver Tank

1. Verify that the hand valve on the outlet side of the receiver tank is open.
2. Open the hand valve on the bottom of the receiver tank to drain tank and then close.
3. Verify that PI's, PS's, and PSV are operable.

E. Dryers

1. Verify that the drain valve on the filter located downstream of the dryers is closed.
2. Verify that the hand valve in the 2-in. line downstream of the filter is open.

II. SYSTEM PERFORMANCE CHECK

A. Air Compressor 2

1. Start AC-2 at building control panel. Both AC-1 and AC-2 are equipped with a 15-sec time delay relay which automatically unloads the compressor during startup.
2. Observe operation of AC-2 until the following is completed:
   a. Verify that dryers are switching (dryers should switch at 10-min intervals) and being purged properly. Record dew point reading of air from each dryer. Check back pressure on dryer being purged (should not exceed 5 psi).
3. If dryer is not working properly by above procedure, check the following items:
   a. Close the inlet, bypass, and vent valves at the moisture separator and observe gage glass on the moisture separator until the water level can be seen.
   b. Open the inlet and vent valves on the separator and see if the trap discharges water to the floor drain via the 3/4-in. drain line.
   c. Check cooling water temperature on outlet lines from the compressor and the aftercooler. Temperature should not be above 120°F.
   d. Check cooling water outlet lines from the compressor. Temperature should not be above 120°F.
   e. Check compressor oil pressure (should be about 40 psig).
   f. Check compressor head for hot spots.
   g. Check compressor rod packing for leakage.
   h. Check dew point reading of both dryers (should be about −40°F at 100 psig).

A. Air Compressor 2 (continued)

i. Check pressure drop across both dryers (should not exceed 5 psig).

j. Check dryer desiccant for H_2O sorption capacity.

B. Distribution System and Accessories in Building 7930

1. With system at operating pressure, open all hand valves in distribution system, except valves in service modules.
2. Check pressure relief valves at all pressure reducing stations by adjusting pressure of PRV until relief valve discharges (PRV's at 20 psig stations should discharge 24 psig).
3. PSV's at 50 psig reducing stations should relieve at 55 psig.
4. Verify that hand valves upstream and downstream of all PRV's are open and that bypass valve around PRV's are closed. Open and close drain valves upstream and downstream of all PRV stations and let air flow until no trace of moisture is present.
5. Close valve in airline to leak monitor upstream of PRV-366.
6. Close hand valve in airline to demineralizer.

C. Distribution System and Accessories in Waste Sample Room

1. Verify that the 1 1/2-in. main supply valve in the 100 psig airline located in the waste sample room is open.
2. Close SV-308 in line IA-18 and SV-309 in line IA-32 (valves close when electrical power is turned off to valve).
3. Close the hand valve in lines IA-47, IA-42, IA-28, and IA-14.
4. Verify that the valve upstream and downstream of PRV-79 is open. Close the bypass valve around PRV-79.
5. Verify that the valve upstream and downstream of PRV-345 is open. Close the bypass valve around PRV-345.

C. Distribution System and Accessories in Waste Sample Room (continued)

6. Verify that the 50 psig air supply lines to MD-260 and MD-380 are connected.

7. Open the hand valves upstream of the PRV station behind transmitter rack 2 located in the waste sample room.

TUFCDF — Building 7930 Air Compressors

Operating Notes and Recommendations

1. Belt Tension — the question of belt tension will undoubtedly arise. Correct belt tension exists when the belts can each be deflected 1/64 in. per inch of span when applying a force of 4 to 5 lb at the center of the span.

2. Control — the control type is ELECTRO-PNEUMATIC-START-STOP (Dual) CONTROL. The Selector Switch, CONST-OFF-AUTO, is used to select the mode of operation.

   (a) Select CONST position if constant operation is desired. THIS IS THE RECOMMENDED MODE. In this mode, the compressor reciprocates constantly and automatically loads and unloads according to the set pressure of the receiver vessel.

   (b) Select AUTO position if it is desired that the unit start and stop with decline and rise of receiver pressure.

3. Time-Delay-Relay — this relay unloads compressor automatically for startup for a period of 15 sec. During this period, the oil pressure switch is de-energized to allow oil pressure to build up.

4. Daily or 8-hr Operations — clean the unit by wiping it down. Drain accumulated moisture from the strainer in the control piping. Check the crankcase oil pressure and oil level. Pressure to be 25 to 35 psig. Check the control operation. Check the cooling water temperature. It should be approximately 110°F. Drain all condensate traps. Check for air bubbles in the cooling water which might indicate a leak in the aftercooler.

5. Normal Starting:

   (a) Start the flow of cooling water.

   (b) Drain condensate at trap leg in discharge piping.

   (c) Start the compressor.

6. Normal Stopping:

   (a) Stop the drive motor.

   (b) Stop the flow of cooling water.

AIR COMPRESSORS

Recommended Programmed Maintenance

Nameplate Data:

Item AC-2, Location Bldg. 7930, NW Corner, 1st Floor
Item Model WGOL9 Size 11 1/4 × 9. Serial 84431.
Electro-Pneumatic Start-Stop Control
Motor 75 HP, 1750 RPM, 220/440 Volt-3-60.
Joy Mfg. Co., Michigan City, Indiana

Item AC-1, Location Bldg. 7930, NW Corner, 1st Floor
Model WGOL9, Size 7 1/2 × 5. Serial 84341
Electro-Pneumatic Auto Start-Stop Control
Motor 20 HP, 1750 RPM, 440 Volt-3-60
Joy Mfg. Co., Michigan City, Indiana

Monthly:

1. Check piston rod packing for leaks.
2. Inspect oil scraper rings for leakage.
3. Inspect air intake filter. Clean as necessary.
4. Check belt tension.

Semiannually:

1. Inspect valves.
2. Inspect cylinder liner.
3. Change crankcase oil.
4. Clean crankcase breather.
5. Change oil filter element.
6. Remove and clean air filter/strainers element at control panel.
7. Check all safety devices for operation.

Annually:

1. Inspect piston rings.
2. Remove and clean crankcase oil strainer.
3. Check foundation bolts for tightness.

AIR COMPRESSORS — RECOMMENDED SPARE PARTS

List No. 1, Model WGOL9, Size 11 1/4 × 9, Serial 84431, Joy Mfg. Co.

Part Number	Description	Number Per Unit	Number of Spares Recommended
29721W1	Spring - Retaining	4	2
32329W	Wrist Pin	1	1
33625W	Bearing (2 pieces)	1	1
43795W	Valve	8	8
43796W	Valve	8	8
43797W	Valve	8	8
202312	Gasket	1	2
202317	Element	1	2
A205965	Cap-Valve	4	1
241316	Ring-Piston	2	2
1247341	Cap-Diaphragm	4	1
124757	Cage-Valve	4	1
514006-213	Inlet Valve Assembly	4	4
514006-214	Disch. Valve Assembly	4	4
518426	Cap-Valve	4	1
518431	Cage-Valve	4	1
1600615	Yoke	4	4
1600779	Spring	8	8
1602081	Spring-Override	4	4
1602082	Spring-Return	4	4
1603228	Wrist Pin Bushing	1	1
1603569	Gasket-Head	2	1
900513-218	Set Screw	4	1
903729-6	Gasket	2	2
903729-91	Gasket	1	1
903729-134	Gasket	4	8
903729-138	Gasket	8	16
903729-198	Gasket	4	8
902519-77	Set of 8 matched V-Belts. Gates Hi-Power V-Belt Size C-158 or equal	1 set	1 set
241334	Ring-Bull	1	1

AIR COMPRESSORS — RECOMMENDED SPARE PARTS

List No. 2, Model WGOL9, Size 7 1/2 × 5, Serial 84331, Joy Mfg. Co.

Part Number	Description	Number Per Unit	Number of Spares Recommended
201115	Gasket Head	1	1
A210706	Cap-Valve	2	1
241308	Ring-Piston	2	2
243211	Element-Oil Filter	1	2
1245605	Valve	4	4
1245606	Valve	4	4
1245607	Valve	4	4
1247108	Spring	2	2
1247109	Spring	2	2
1247788	Bushing-Wrist Pin	1	1
1247814	Bearing (2 pieces)	1	1
1248146	Cap Valve	2	1
1248147	Cap-Diaphragm	2	1
1248170	Cage Valve	2	1
514006-234	Valve Assembly-Inlet	2	2
514006-236	Cage-Valve	2	1
1600626	Pin-Wrist	1	1
1601426	Yoke	2	2
1602917	Spring	2	2
1603836	Spring	6	6
1603837	Spring	2	2
900513-203	Set Screw	2	1
903729-8	Gasket	4	8
903729-122	Gasket	4	8
902489-65	Set of 3 matched V-Belts. Gates Hi-Power Size C-128 or equal	1 set	1 set
241336	Ring-Bull	1	1

AIR COMPRESSORS — RECOMMENDED SPARE PARTS

List No. 3 — Part Common by Part No. to Both Compressor Serial Nos. 84431 and 84341. Note: Before ordering from this list determine that all parts herein are interchangeable between compressor size 11 1/4 × 9 and 7 1/2 × 5 (Inquiry Pending).

Part Number	Description	Number Per Unit	Number of Spares Recommended
24458W	Spring	1	1
28170W	Gasket	2	2
36344W	Acorn Nut	2	1
200326A	Packing-Carbon	4	4
201189	Spring-Carter	4	4
A-203119	Scraper Ring Assembly	1	1
219743	Sleeve	8	4
220242A	Spring	8	8
220368	Plunger	8	4
A237023	Gasket-Compound		1
242508	Shoe	48	48
1247113	Button	2	2
1247311	Gland-Packing	2	1
1248314	Gasket	1	1
1600778	Spring	32	32
900513-155	Set Screw	6	3
900572-9	Ball	1	1
902277-19	Packing	2	2
903514-25	Gasket	6	6
903729-49	Gasket	2	2
903729-194	Gasket	1	1
903742-9	Acorn Nut	6	3
903943-16	Gasket	2	2
1249294	Diaphragm	4	4
5261000001	Valve, Solenoid for replacement on Control Panel Part No. 514004 0941	1	1
600713 0296	Switch, Pressure for replacement on Control Panel Part 514005 0941	1	1
600726 0011	Relay, Time Delay, for replacement on Control Panel Part No. 514005 0941	1	1

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