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DECONTAMINATION AND DECOMMISSIONING OF THE ARGONNE NATIONAL LABORATORY BUILDING 350 PLUTONIUM FABRICATION FACILITY

FINAL REPORT

by

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February 1985

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ABSTRACT

In 1973, Argonne National Laboratory began consolidating and upgrading its plutonium-handling operations with the result that the research fuel-fabrication facility located in Building 350 was shut down and declared surplus. Sixteen of the twenty-three gloveboxes which comprised the system were disassembled and relocated for reuse or placed into controlled storage during 1974 but, due to funding constraints, full-scale decommissioning did not start until 1978. Since that time the fourteen remaining contaminated gloveboxes, including all internal and external equipment as well as the associated ventilation systems, have been assayed for radioactive content, dismantled, size reduced to fit acceptable packaging and sent to a U. S. Department of Energy (DOE) transuranic retrievable-storage site or to a DOE low-level nuclear waste burial ground. The project which was completed in 1983, required 5 years to accomplish, 32 man years of effort, produced some 540 m^3 (19,000 ft^3) of radioactive waste of which 60% was TRU, and cost 2.4 million dollars.

Decontamination and Decommissioning
Building 350
Plutonium Fabrication Facility

FINAL REPORT

1.0 Introduction

In 1973, Argonne National Laboratory (ANL) began consolidating and upgrading its plutonium-handling operations with the result that a research fuel-fabrication facility (Figure 1-1) was determined to be unnecessary for further programmatic work and it was, therefore, shut down and declared surplus. Concurrent with that decision was the announcement that the New Brunswick Laboratory (NBL) in New Jersey would move to the Argonne site and occupy Building 350, the location of this facility.

1.1 Facility History

Building 350, located in the 300 Area at ANL (Figure 1-2), was constructed specifically to house the Plutonium Fabrication Facility (PFF) which became operational in 1959. Hundreds of kilograms of plutonium in metallic form as well as other fissile materials were processed in this facility which was used extensively during its fifteen-year life span for developing methods of alloying, casting, machining, cladding, and assembling fuel elements. To accomplish

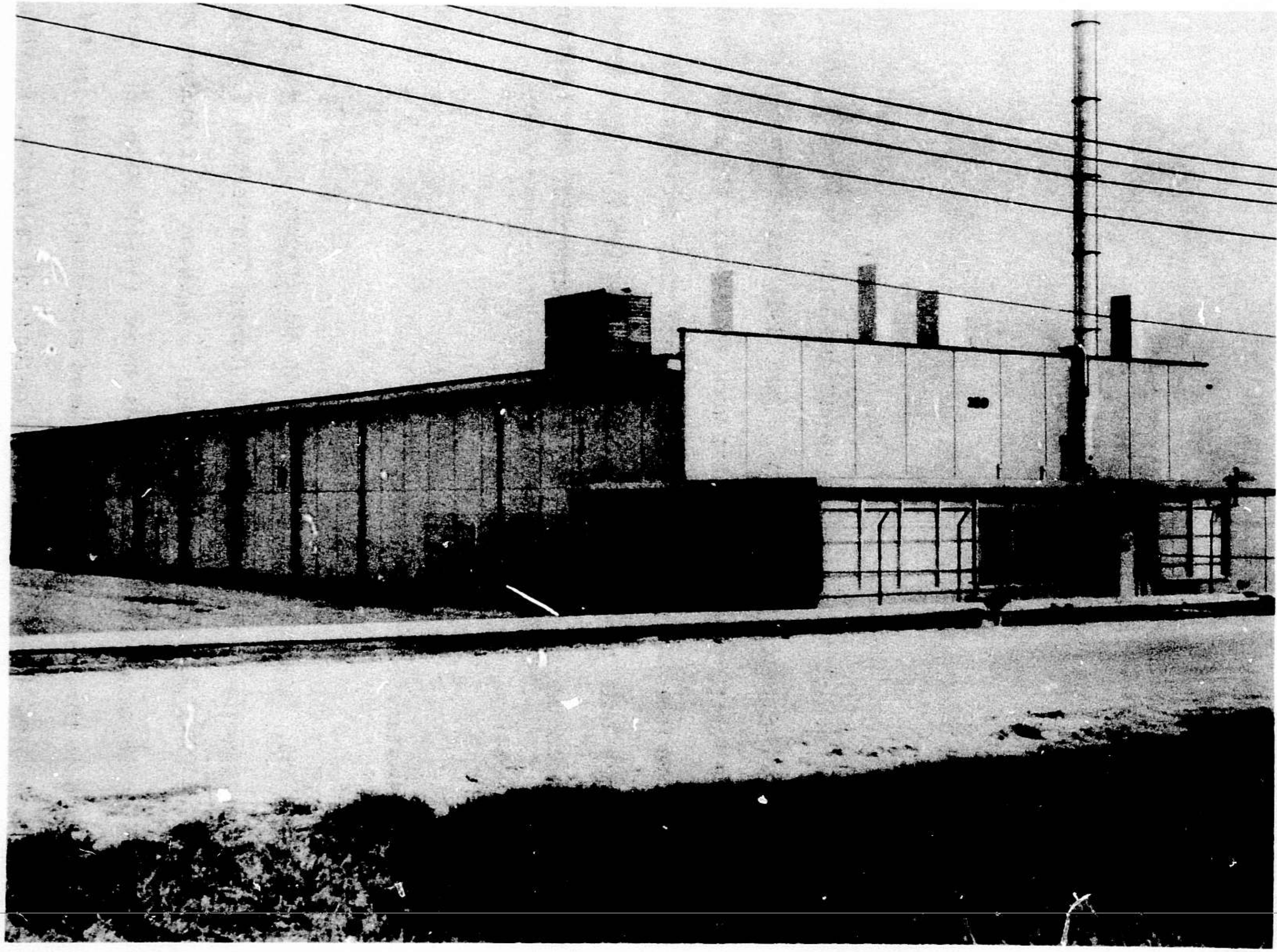


Figure 1-1 Building 350

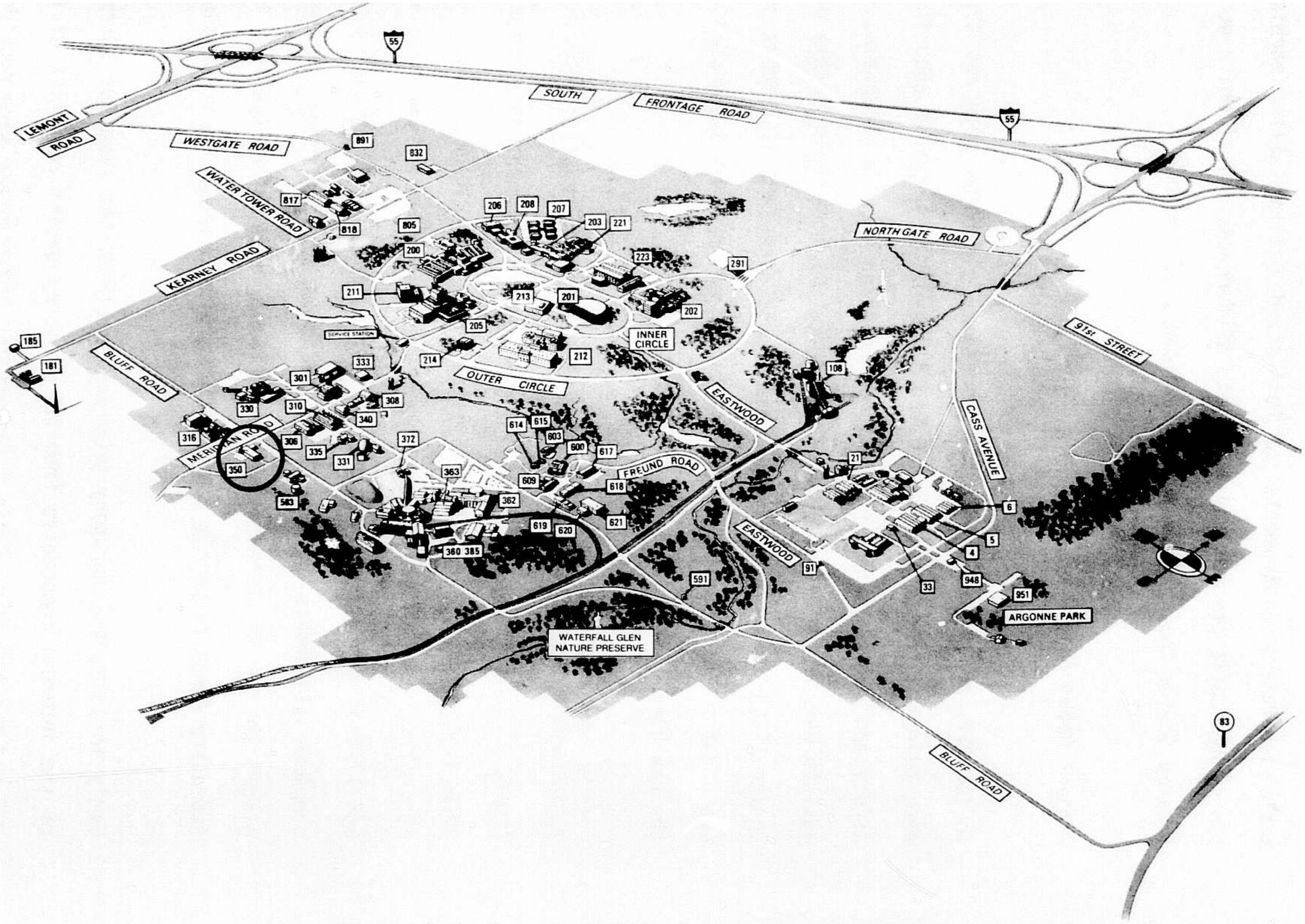


Figure 1-2 Argonne National Laboratory Site Map

this purpose, the PFF contained a variety of equipment, from small scale laboratory instruments to full-sized rolling mills, machine tools, hydraulic presses and a variety of furnaces all of which were located inside the various sized gloveboxes. (Table 1-1)

1.2 Project Background

To be able to continue with the necessary plutonium programs that were being performed in the PFF and to meet the upgraded security, safety and safeguard requirements for handling fissile materials, it was decided to transfer those operations to the Fuels Technology Center (FTC) in Building 212 along with the necessary gloveboxes and equipment. The soon to be vacated building was then designated as the new home of the New Brunswick Laboratory.

In order to provide NBL the required space within the allotted time frame, 16 gloveboxes, all with their interior equipment left intact, were disconnected and either reinstalled at the FTC or placed into controlled storage where maintenance and surveillance was provided until final decommissioning could be arranged. An additional seven complete gloveboxes were left in place at 350 and they too were placed in the maintenance and surveillance mode while awaiting the necessary funds to permit continuation of the dismantling activities.

Early in 1978, a Laboratory program identified the need for several of the internal components from the glovebox system remaining at the PFF and the necessary funds to accomplish the transfer were provided.

Table 1-1

List of the Building 350 Gloveboxes

Hood line Designation	Size H x W x L (in ft.)	Weight Pounds	Purpose	Remarks
PF-3	3 x 3 x 100	10,000	Conveyor System	
PF-4	4 x 4 x 21	7,000	Introduction & Extraction	
PF-5A	4 x 4 x 27	20,000	Machine Shop	
PF-5B	6 x 3 x 8	6,000	Milling Machine	
PF-6	4 x 4 x 18	7,000	Metallography	
PF-6A	2 Dia. x 18	2,000	Air Washer	
PF-7	4 x 4 x 18	7,000	Weighing & Inspection	
PF-8A	6 x 4 x 12	7,000	Centrifugal Casting	Reused at FTC
PF-8B	6 x 4 x 9	5,000	Centrifugal Casting	
PF-9	6 x 4 x 21	10,000	Ingot Casting	Reused at FTC
PF-10A	6 x 4 x 40	40,000	Stretcher-Detwister	
PF-10AA	10 x 6 x 16	120,000	Extrusion Press	
PF-10B	8 x 4 x 18	9,000	Workbox	
PF-11A	6 x 4 x 15	9,000	Rod Feed	
PF-11B	8 x 4 x 12	24,000	Rolling Mill	
PF-11C	6 X 4 x 18	9,000	Plate Feed	
PF-11D	8 x 6 x 15	20,000	Roll Storage	
PF-11E	4 x 4 x 6	2,000	Support Hood	
PF-12	7 x 4 x 15	30,000	Plate Shear	
PF-13A	4 x 4 x 27	12,000	Wire Fabrication	
PF-13C	6 x 6 x 7	8,000	Rolling Mill	
PF-14A	6 x 4 x 9	4,000	Dennison Press	
PF-14B	6 x 4 x 6	25,000	250-Ton Hydraulic Press	
PF-14C	6 x 4 x 12	7,000	Casting Furnace	
PF-15	6 x 4 x 18	7,000	High Temp Furnace	Reused at FTC
PF-16	6 x 4 x 12	5,000	Powder Loading	Reused at FTC
PF-17	6 x 4 x 15	6,000	Jacketing & Welding	Reused at FTC
PF-18	6 x 4 x 21	9,000	Decontamination	Reused at FTC
PF-19	Same as PF-11	12,000	Unused--Empty	Not Contaminated
PF-20	8 x 6 x 12	20,000	100-Ton press	Not Contaminated
PF-21	4 x 4 x 12	4,000	Tablet Pressing	
PF-22	6 x 4 x 9	4,000	Milling Machine	Reused at FTC
PF-23	6 x 4 x 15	7,000	Lathe	Reused at FTC
PF-24	6 x 4 x 15	5,000	Metallography	
PF-25	6 x 4 x 15	5,000	Liquid Metal Filling	Reused at FTC

This required equipment, including the glovebox containment, was removed from the system, modified, transported, and reinstalled at the FTC by the end of FY 1978 (Figure 1-3).

Just prior to the completion of these activities, the DOE Division of Environmental Technology at the urging of both ANL and NBL, agreed to start funding the actual decontamination and decommissioning (D&D) of the PFF and such operations began immediately after the ANL programmatic requirements were satisfied. Later, upon the formation of the DOE Division of Remedial Action Projects, this project became the responsibility of the Surplus Facilities Management Program (SFMP).

1.3 Project Purpose

The overall purpose of the project was to eliminate a surplus plutonium facility from the Argonne site and to provide additional space to the New Brunswick Laboratory for use in their nuclear endeavors.

2.0 Facility Description

The PFF was housed in a concrete building 75 meters (245 feet) long by 25 meters (72 feet) wide by 8 meters (25 feet) high and had a service floor extending 4 meters (12 feet) below grade. It was divided into an Administration and Technical Area and a Fabrication Area (Fab Area) with all of the gloveboxes being in the latter location as shown in Figure 2-1.

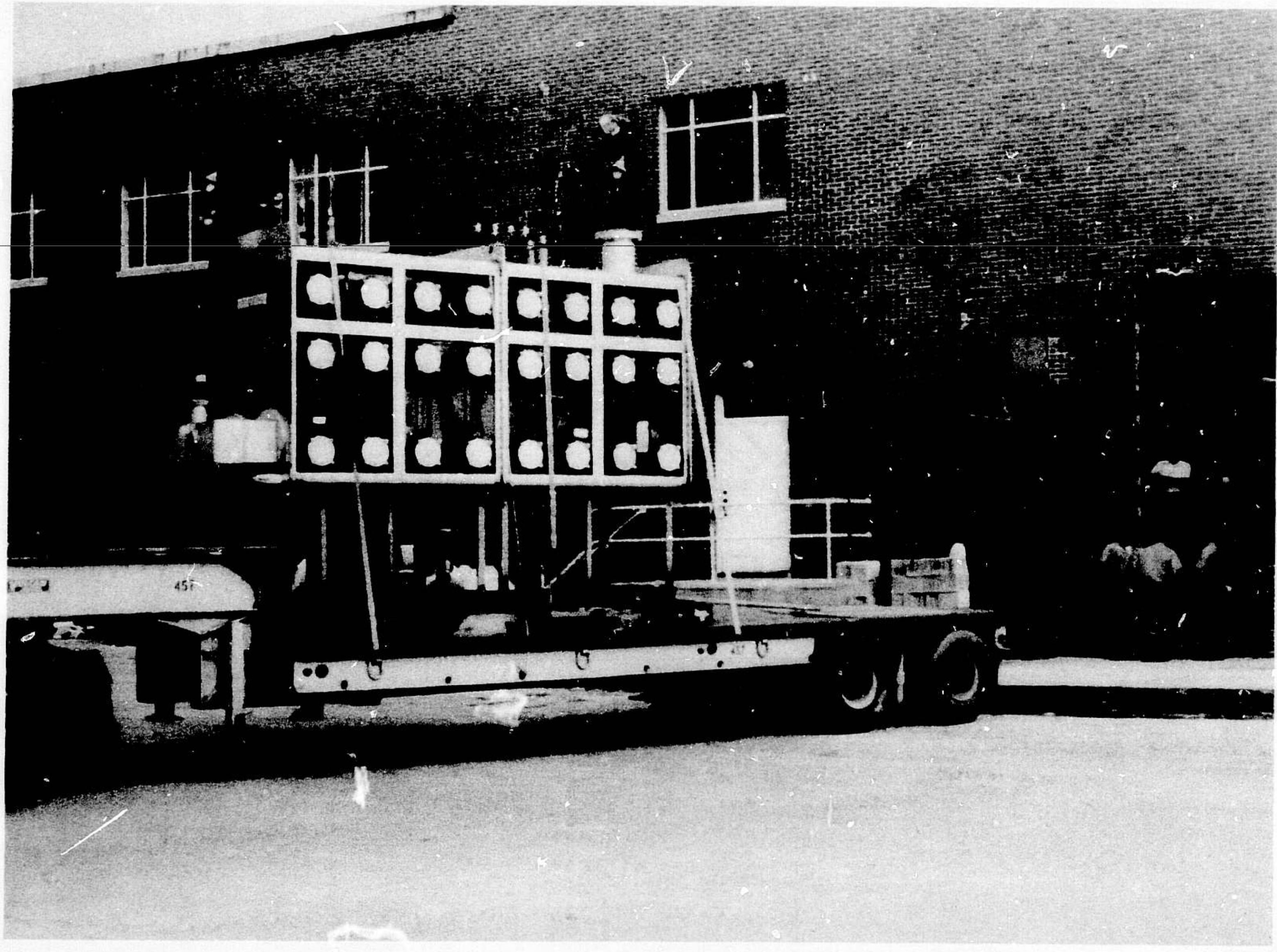


Figure 1-3 Relocation of Glovebox PF-8 Section to FTC

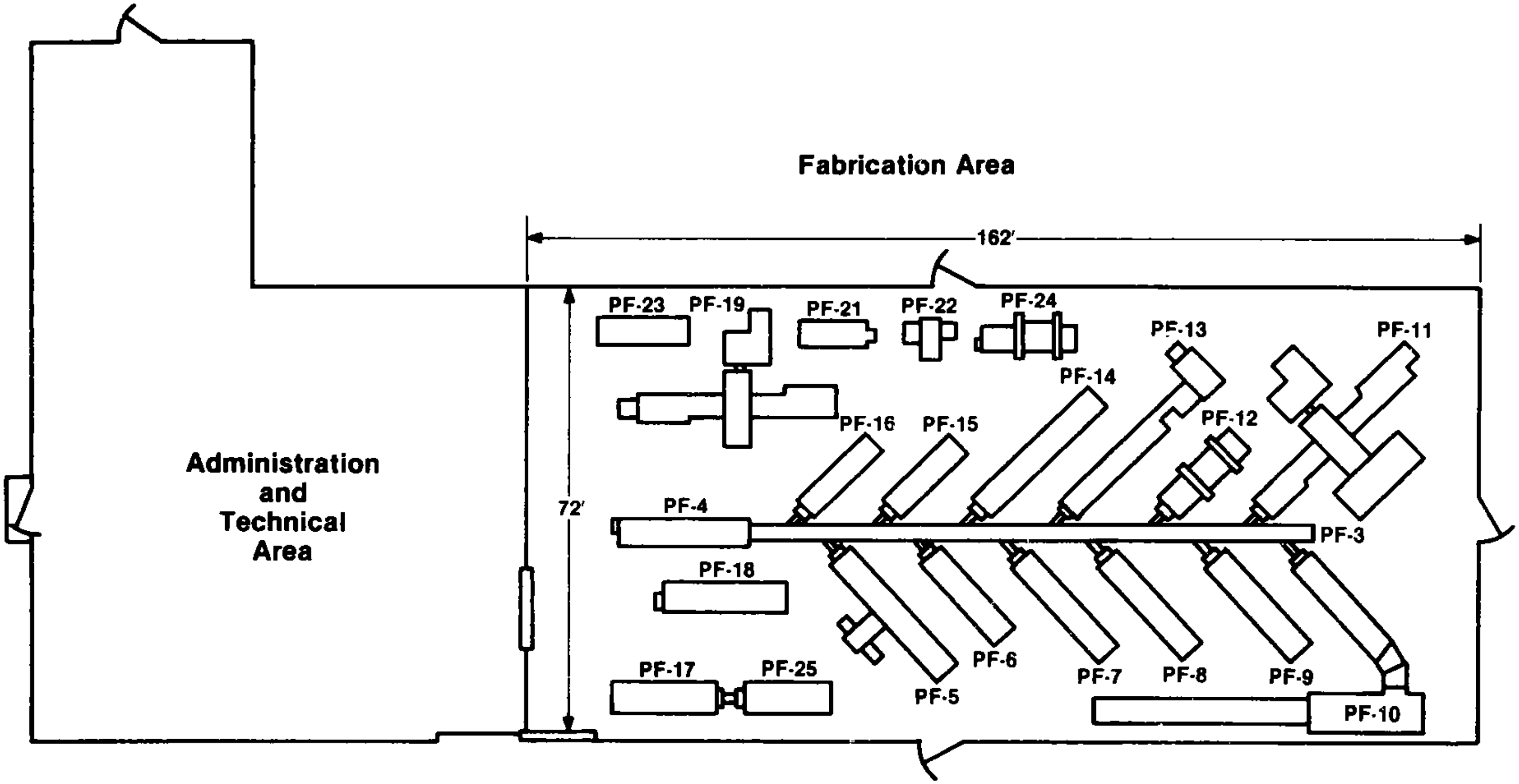


Figure 2-1 Building 350 Original Floor Plan

2.1 GLovebox System

A system of gloveboxes employing modules designed to be connected to form various length sections was utilized to house the equipment and carry out the processes performed in the PFF (Figure 2-2). The hoods consisted of aluminum alloy frames fabricated from extrusions which were so designed that 1 cm (3/8-inch) thick transparent allyl diglycol carbonate (CR-39) plastic or aluminum plates could be installed in pre-formed grooves by means of restrained, tight-sealing, neoprene gaskets. Manipulation within the hoods was by means of arm-length neoprene gloves sealed to glove rings on the transparent panels. Flanges and gasket grooves allowed bolting together of any number of hood modules (normally 6 feet in length) into assemblies that formed interconnecting hood lines. A modular design was worked out to allow the use of many standardized parts and to provide flexible conformity to a wide variety of equipment and operations through the modification of standardized hood sections. The hoods were designed for maximum tightness by the use of sealing and gasketing techniques developed for high-vacuum equipment.

Since each glovebox line was set up to perform a specific function, they varied greatly in size and configuration. (See Table 1-1.) Boxes ranged in size from 3.5-30 meters (12-100 feet) long, 1-3 meters (3-10 feet) high, and 1-2 meters (3-6 feet) in width. Because the facility was used for the development of reactor fuel manufacturing processes and for the limited production of experimental fuel

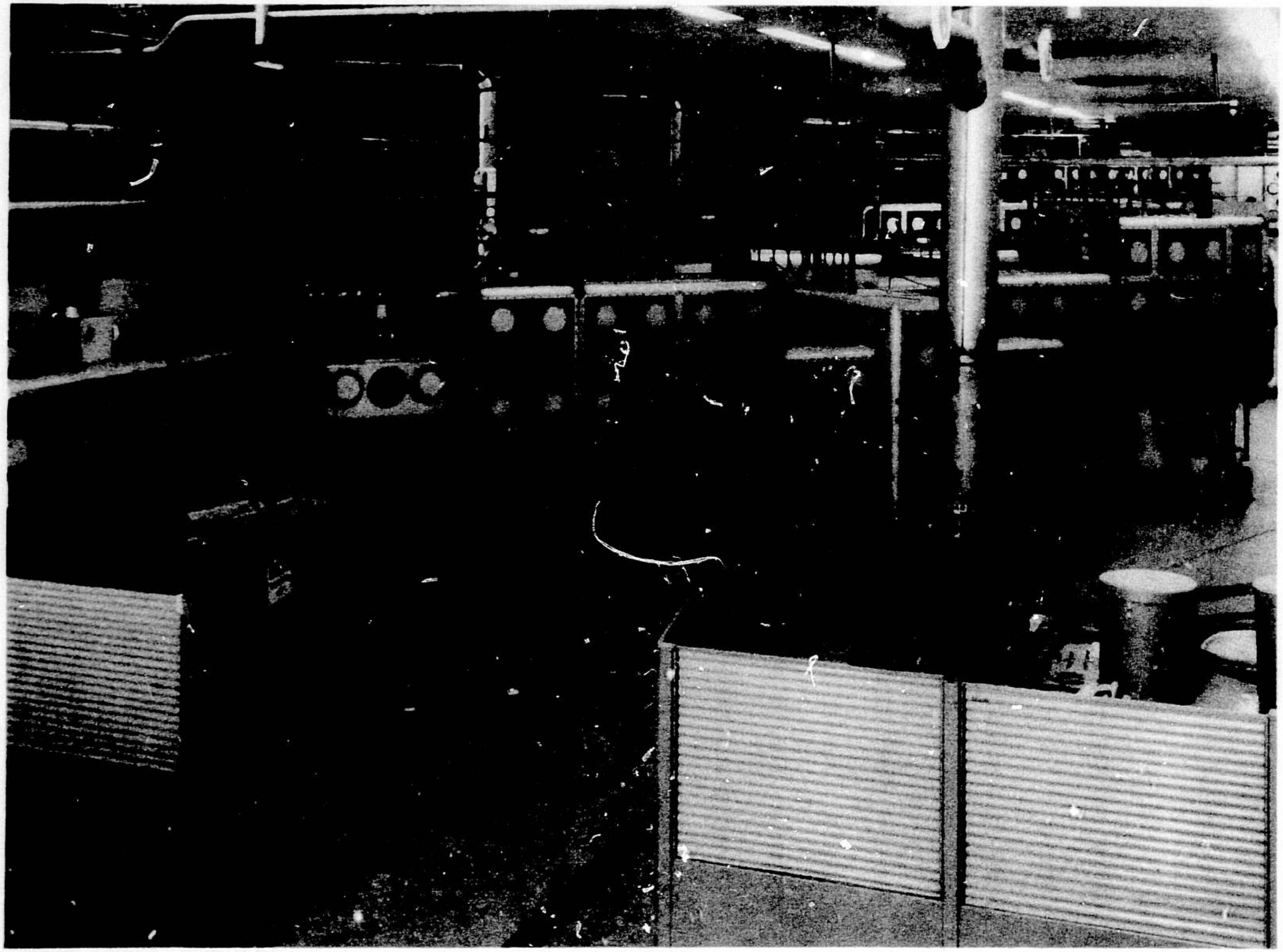


Figure 2-2 Gloveboxes in Plutonium Fabrication Facility

charges, a wide variety of large and heavy equipment was incorporated into the hood lines. Glovebox PF-12 contained a shear capable of cutting metal plates up to two meters (6 feet) long and 1-1/4 cm (1/2 inch) thick (Figure 2-3). The overall weight of this unit was about 14,000 kilograms (30,000 pounds). Part of box PF-10 housed a hydraulic extrusion press (Figure 2-4) that weighed 45,000 kilograms (100,000) pounds and PF-14 had a 250 ton capacity hydraulic press weighing 11,000 kilograms (25,000 pounds) (Figure 2-5). All of this equipment was enclosed within the individual glovebox lines which were interconnected through a central conveyor system (PF-3) approximately 30 meters (100 feet) long.

Five separate exhaust systems as listed below served the PFF:

Helium Atmosphere Return (HAR)
Normal Air Exhaust (Normal)
Purge Exhaust (Purge)
Process Air Exhaust (PAE)
Fabrication Area Exhaust (Room)

Most of the gloveboxes utilized a recirculating helium atmosphere (HAR) during process operations. The exhaust gas was passed through HEPA filters, purified and then returned to the hood lines. All of the gloveboxes were also connected to a once-through low volume air exhaust system (Normal) for normal ventilation purposes and a high volume emergency system (Purge) for use in case of an accidental

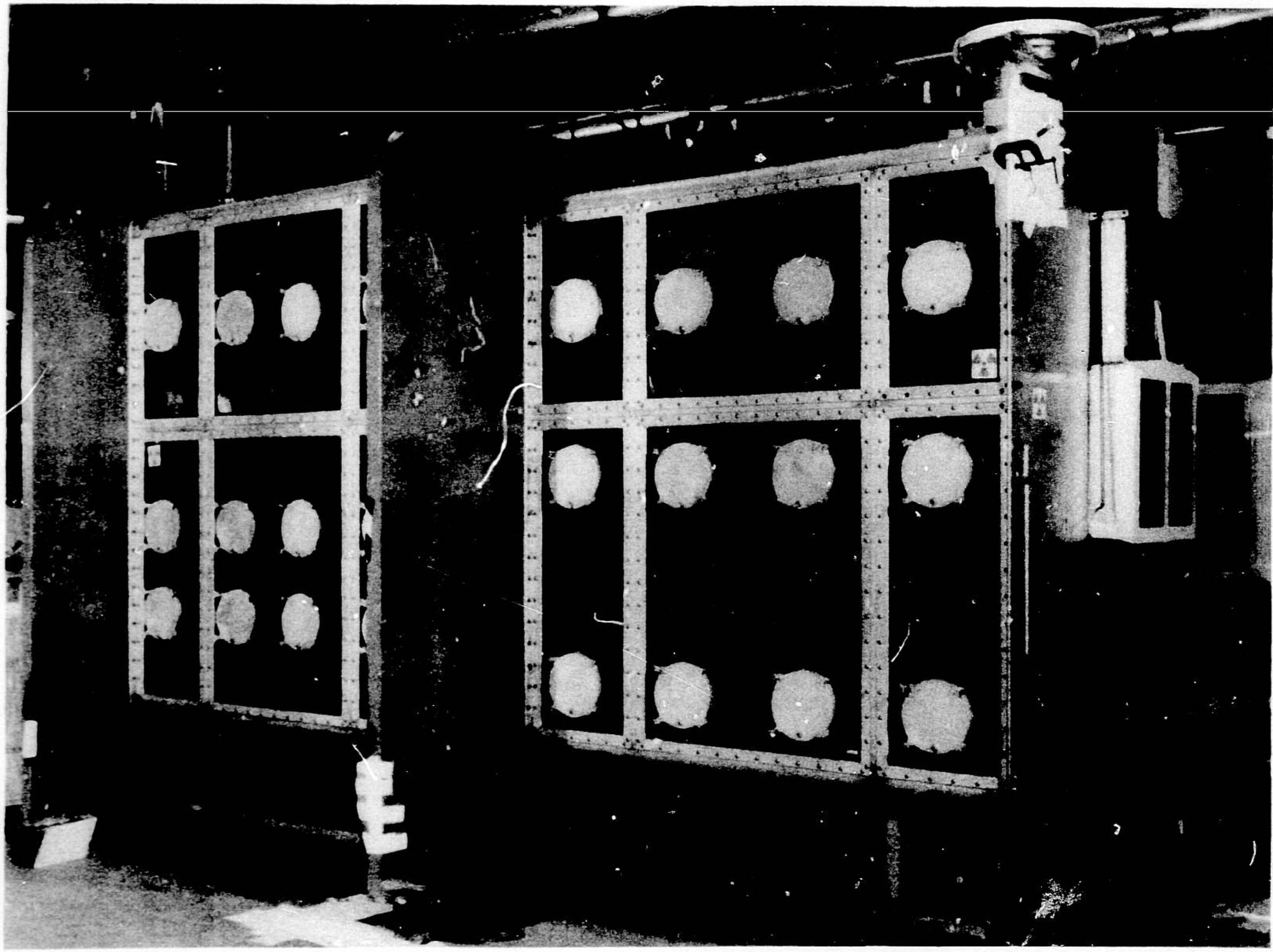


Figure 2-3 Glovebox PF-12 Containing Metal Cutting Shear

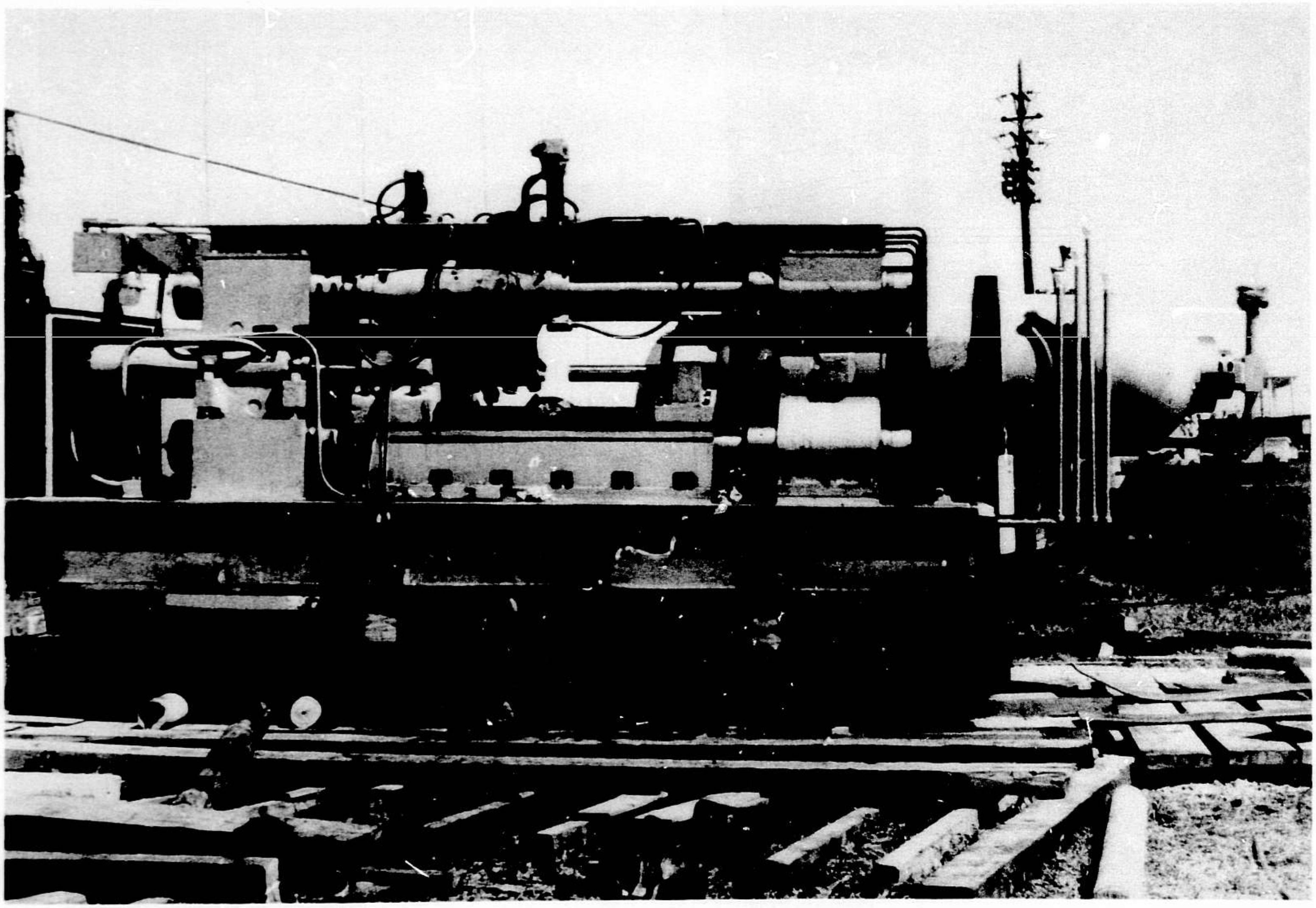


Figure 2-4 Extrusion Press before Installation in Glovebox PF-10

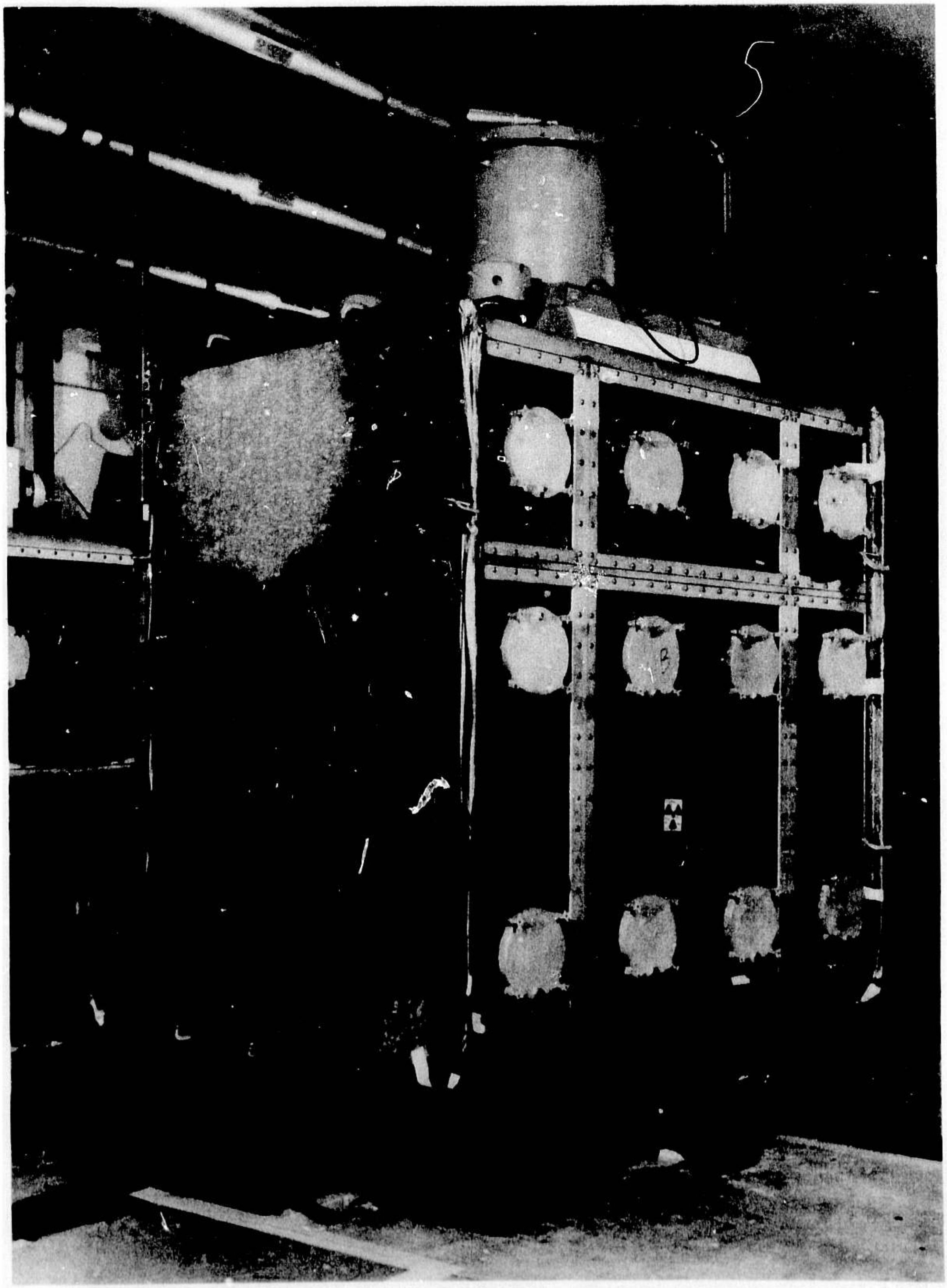


Figure 2-5 Glovebox 14B - Hydraulic Press

glovebox breach. In addition to these systems, a separate exhaust provided for the Fab Area (Room) which housed the hood lines and another small system (PAE) handled oil-laden air from air cylinders, hydraulic vent lines and other equipment that could not be discharged directly into the gloveboxes. This latter system included an oil separator which prevented the HEPA filters from premature plugging.

The ductwork for each of these systems utilized welded stainless steel and the pressure within the glovebox enclosures was maintained at approximately -13 mm (-0.5 inches) of water column. The exhaust to the atmosphere from all gloveboxes using radioactive material was passed through at least two HEPA filters connected in series.

2.2 Pre-Decommissioning Status

Since the initial decommissioning in 1974 was conducted simultaneously with shutdown, the facility was in excellent physical condition. In addition, during its entire operational life, every precaution possible was taken to keep all of the building areas free from radioactivity and thus only the interiors of the gloveboxes, the ventilation systems and certain external auxiliary equipment were contaminated. The levels of alpha activity, which was predominantly plutonium -239, varied greatly but in some cases exceeded 10^{10} dpm/100 cm^2 on the interior surfaces. Beta-gamma radiation from the associated americium -241 was also present and was responsible for some ambient radiation background in the range of 1-2 mR/h but this seldom caused any exposure problem.

3.0 Decommissioning Objectives and Work Scope

3.1 Objective

The objective of this project was to safely and prudently D&D all of the unusable radioactive components which comprised the PFF, including those in controlled storage, and send them offsite to a Department of Energy transuranic (TRU) retrievable storage facility or to a low level DOE nuclear waste burial ground.

3.2 Work Scope

The work involved dismantling the gloveboxes, ventilation ductwork, exhaust filter systems, utilities, and the associated equipment both inside and external to the hood lines. Those portions of the facility which were reusable were transferred to the Fuels Technology Center while the balance of the radioactive components were size reduced to fit acceptable packaging for shipment to an appropriate DOE nuclear waste management site. Non-radioactive materials were either sold for scrap or buried in the ANL landfill. The structure housing the PFF was then decontaminated and transferred to the New Brunswick Laboratory for their programmatic usage.

4.0 Work Performed

4.1 Project Management

Overall firstline responsibility for this project rested with the designated project manager who currently reports to the manager of Waste Management Operations (WMO) within of the Plant Facilities and Services Division (PFS) at ANL. The project manager was charged with the planning, coordination, direction, budget preparation, cost control, scheduling, and reporting for all aspects of the D&D effort. Assistance was provided by other Laboratory groups in the areas of safety, health physics, plant engineering, procurement, transportation, plant maintenance, and waste management as well as by the former facility user. In order to provide a mechanism for the review of the plans and procedures related to the project, the Director of the Occupational Health and Safety Division (OHS), who issued the final approvals, appointed a Planning and Review Committee made up of Laboratory technical, operating and safety personnel. This group was responsible for; reviewing the proposed plans and procedures in a timely fashion so that work would not be unduly delayed, resolving differences that arose regarding methods of operation and serving as the ANL internal safety evaluation committee for recommending adoption of the finalized plans and procedures to the Director of OHS. This committee remained active until the project was completed.

4.2 Site Preparation

Since the D&D effort was performed in the portion of the PFF Fab Area that remained after the initial dismantling was done in 1974, few site preparations were necessary. As a precaution, a sheet rock barrier (Figure 4-1) was constructed parallel to the wall which separated the NBL plutonium laboratory from the remaining gloveboxes in 350 as an aid to controlling contamination in the event of a spill or other incident. This plasterboard partition extended from floor to ceiling and provided isolation as well as creating a negative air pressure in the Fab Area with respect to the adjacent rooms (Figure 4-2).

Other minor preparations included relocation of some building utility pipes to provide overhead clearance when moving the gloveboxes, the installation of a high pressure air line for breathing purposes and the addition of numerous convenience receptacles for electrical equipment and tools.

4.3 Decommissioning Operations

4.3.1 Initial Dismantling

Even though the dismantling performed in 1974 was not actually part of this project, it had a very direct relationship from the standpoint of the procedures developed and the experience gained as well as the unfinished work it left behind.

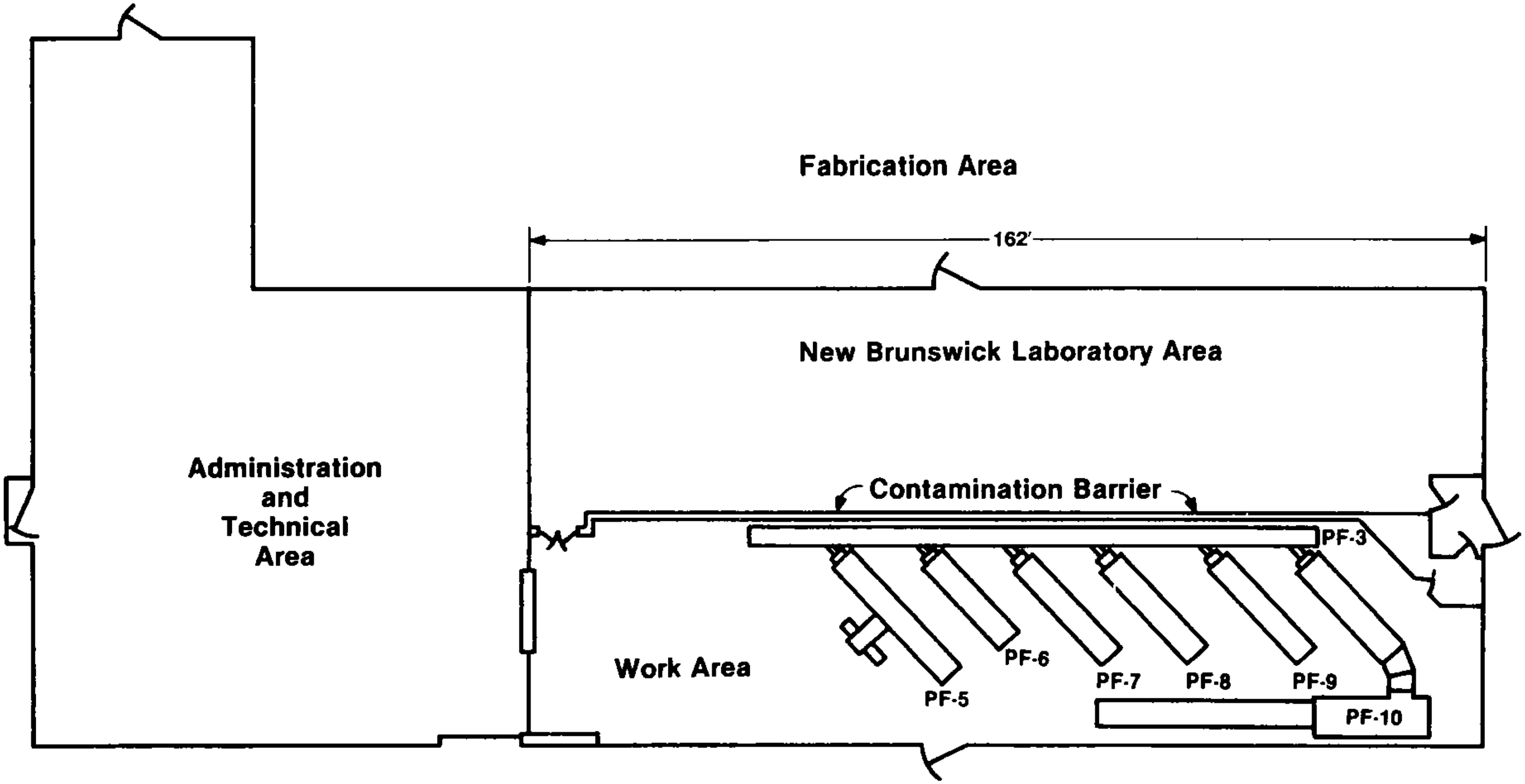


Figure 4-1 Building 350 Floor Plan in 1978

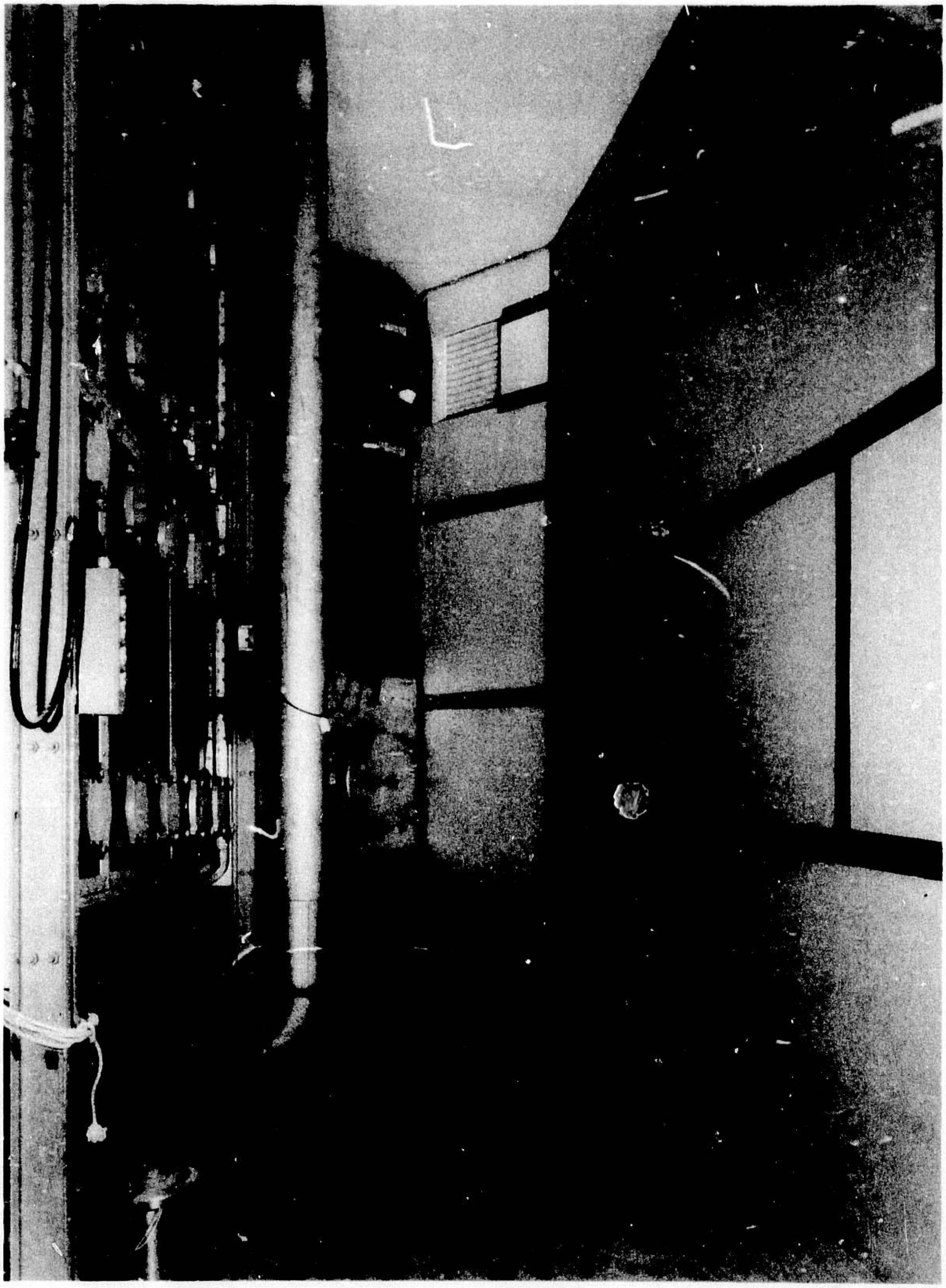


Figure 4-2 Contamination Control Barrier Wall

In order to provide space for NBL as soon as possible and to meet ANL programmatic requirements, planning of the initial D&D for the PFF started in early 1974. After considering such factors as: safety, internal contamination, the need to reinstall some units at the FTC; the size, weight, and modular design of the gloveboxes; and the shortness of time which was available to provide space for NBL, it was decided to separate the gloveboxes into sections and place those not wanted for reuse into controlled storage at another location until final disposition could be arranged. Procedures were prepared, demonstrated for adequacy with a trial run on an uncontaminated glovebox line, and modified to reflect the experience gained before any work was started on the contaminated systems. Also, prior to each glovebox line being released for dismantling, operating personnel removed all special nuclear material and performed cursory cleaning to eliminate the nuclear criticality hazard.

Dismantling efforts (Reference 1) on the contaminated systems started in late March 1974, and during the next year considerable progress was made in clearing the area. A total of 16 gloveboxes, all with their equipment still inside, were removed and either reinstalled for further use at the FTC or placed into controlled storage to await final disposition. This permitted NBL to acquire about one half of the floor space in the Fab Area (Figure 4-1) for the construction of their new laboratories. At this point, work was stopped since authorized funds were exhausted and, except for continual surveillance and maintenance, no additional direct effort was devoted to further decommissioning the facility during the next four years.

4.3.2 Resumption of D&D Activities

As of April 1978 when the D&D activities were resumed, the work which remained to be performed before the last portion of the building could be released to NBL consisted of dismantling the seven complete glovebox lines, which remained in place at Building 350, (Figure 4-1) with all their internal equipment and associated exhaust systems still intact, as well as, those seven boxes or fourteen individual sections that had been placed into controlled storage in 1974. Each required processing by disassembly and removal of internal equipment, size reduction of all components including the glovebox itself to fit standard packaging, segregation as to TRU* or non-TRU of the contaminated material, and shipment of all generated radioactive waste to the DOE Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering Laboratory (INEL). In addition, the area housing the remaining portion of the facility had to be decontaminated to the extent necessary for reuse as a nuclear facility.

4.3.3 Glovebox Processing

The space occupied by those remaining gloveboxes at 350 was used as a work area (Figure 4-1) and ANL in-house service personnel, experienced in this type of an operation, performed all of the D&D effort. The equipment within each box, as well as all other interior apparatus, was normally disassembled or otherwise reduced in size through

*During the term of this project TRU waste was defined as those materials having transuranic contamination in excess of 10nCi per gram.

the gloves (Figure 4-3) and then removed employing conventional bag-out techniques which sometimes were modified to accommodate large and heavy components. After the box was emptied, the interior surfaces were decontaminated using simple cleaning methods and then painted with several coats of latex paint to reduce and hold the remaining radioactivity.

With the completion of those steps, the glovebox was then separated into short lengths, normally 2 meters (6 feet) long, utilizing the bolted-together, flanged, modular design and employing a previously developed plastic pouch and heat-sealing technique (Figures 4-4 thru 4-8). This modular method of glovebox construction, which was not actually developed to simplify or aid decommissioning work, proved to be extremely fortunate as it permitted the hood lines to be disassembled rather than cut with a saw, and it resulted in small units that could be easily handled and transported. Following separation, the individual module, as well as any other components needing size reduction, were placed into a temporary plastic enclosure connected to a double HEPA-filtered exhaust system. Inside this tent, which served to control the spread of contamination, workers equipped with disposable protective clothing and supplied air, disassembled and mechanically cut each item using portable bandsaws, reciprocating saws and/or nibblers so that the resulting pieces would fit into the standard 1.2 X 1.5 X 1.8 meters (4 X 5 X 6 feet) high ANL M-III bin. No flame cutting could be employed due to the combustible nature of the plastic enclosure.

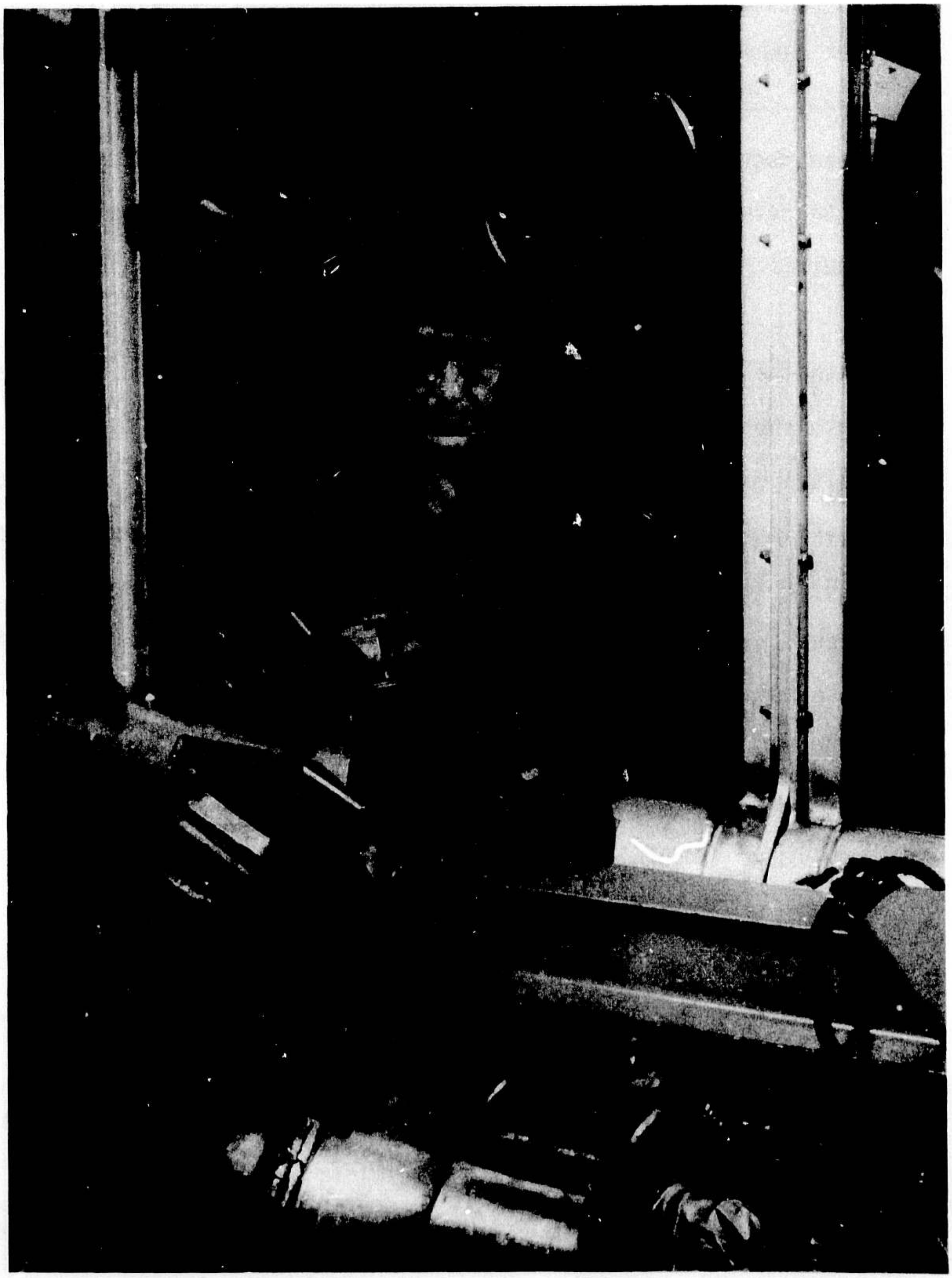


Figure 4-3 Size Reduction of Glovebox Components Through Gloves

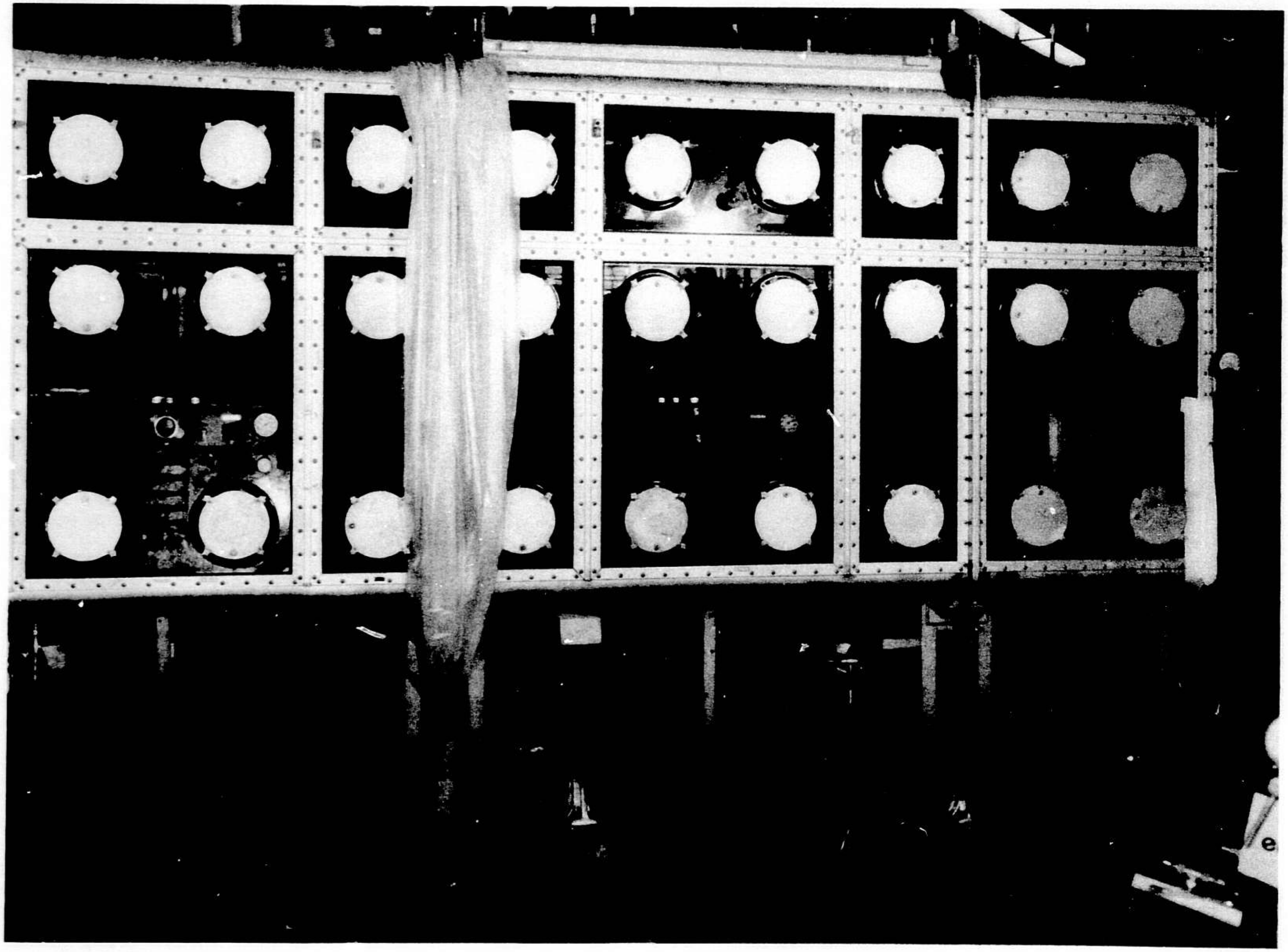


Figure 4-4 Glovebox Prepared for Separation

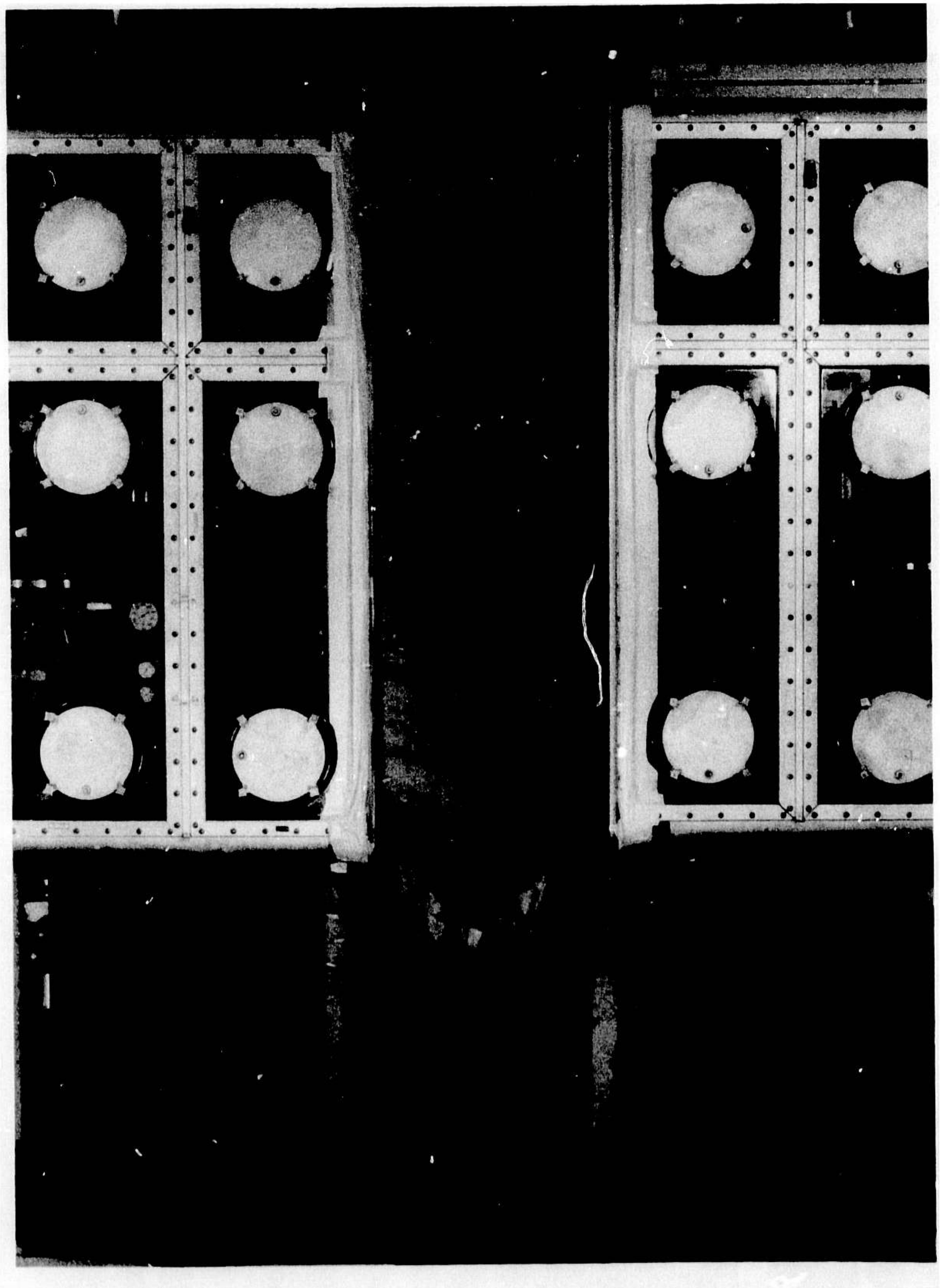


Figure 4-5 Separated Glovebox Prior to Heat Sealing Pouch

Figure 4-6 Heat Sealing Glovebox Separation Pouch

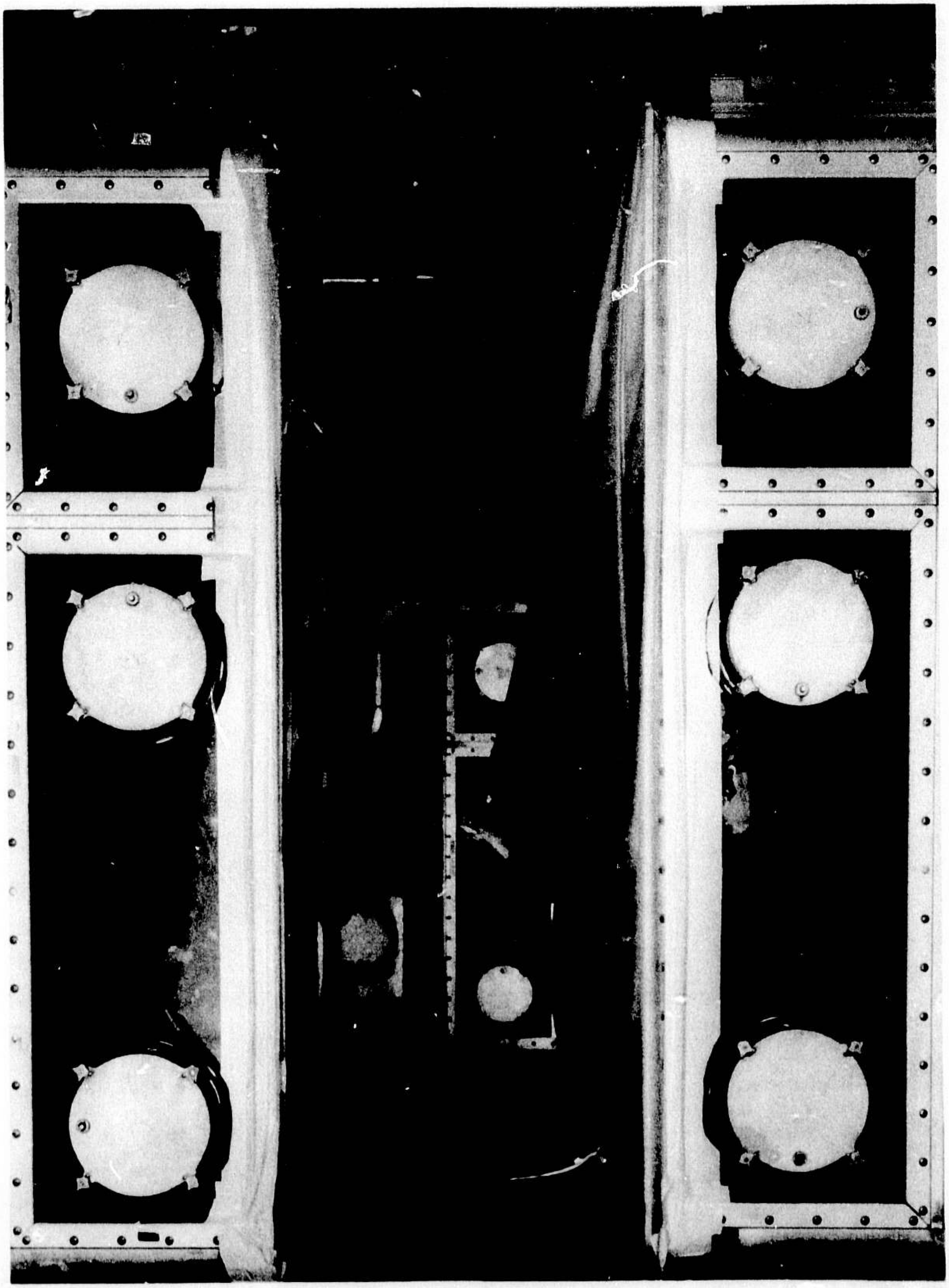


Figure 4-7 Glovebox Separation Complete

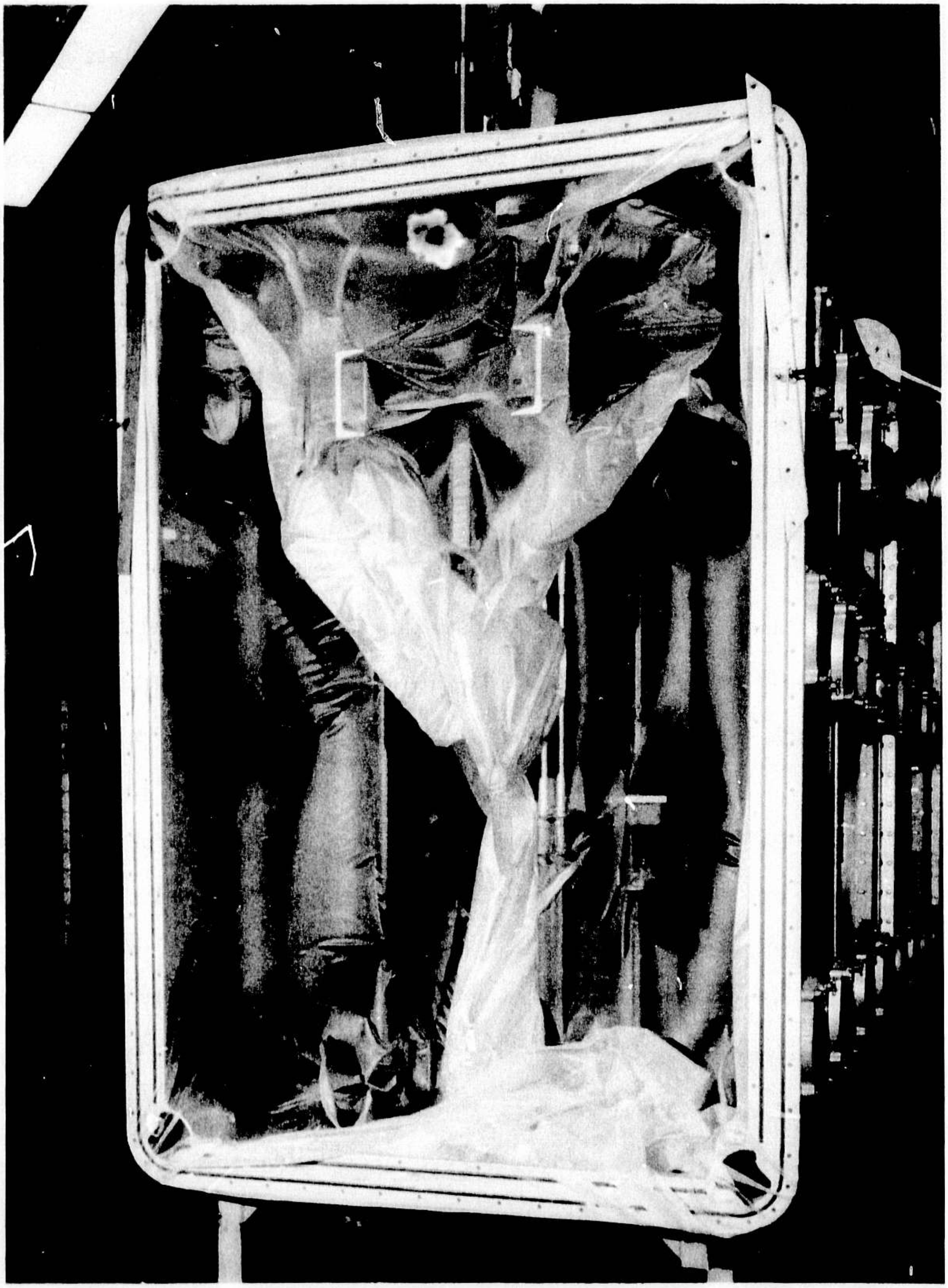


Figure 4-8 End View of Separated Glovebox

4.3.4 Waste Packaging and Disposal

Prior to the restart of D&D activities, a determination was made that since the ANL M-III bin (Figure 4-9) was already an acceptable 20-year retrievable package for TRU waste at the RWMC, all project wastes would be size reduced to fit this approved container. This decision insured that the work would not be delayed while new containers were being developed and qualified. Before any waste was packaged, assay results, obtained earlier, were evaluated to enable TRU material to be segregated from non-TRU as required by DOE regulations. In addition, all waste was further separated with respect to combustible and noncombustible.

Acceptance criteria at INEL specifies that TRU waste must be packaged in rigid containment inside the M-III bin. This requirement was met through the use of plywood liners. The style most often used was about 1 meter (3 feet) high and two could be put into each bin. These half-size liners (Figure 4-10) were convenient for personnel to load and were moved about the facility by fork truck or dollies. Placement into the bin was accomplished by the use of an overhead crane at a loading dock. Because of the ease in handling, they were also commonly used for non-TRU waste. A full-sized liner was used occasionally for components which could not be reduced to fit the half liner without undue effort. These were inserted into the bin first and the waste then loaded by hand or with a fork truck. Filled bins were combined with other ANL-generated waste and shipped by truck to the RWMC for placement into retrievable storage or disposal by burial.

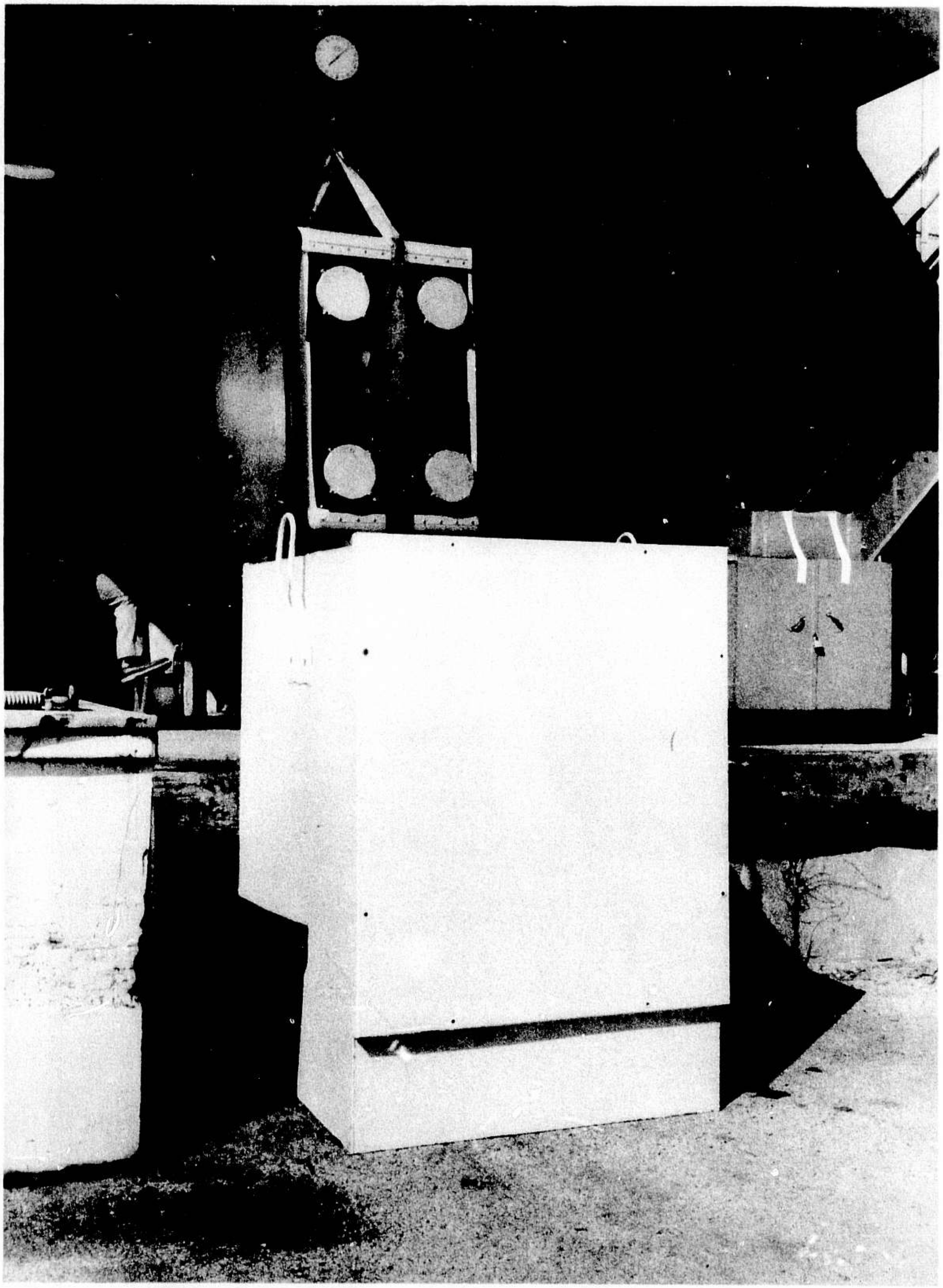


Figure 4-9 ANL M-III Bin

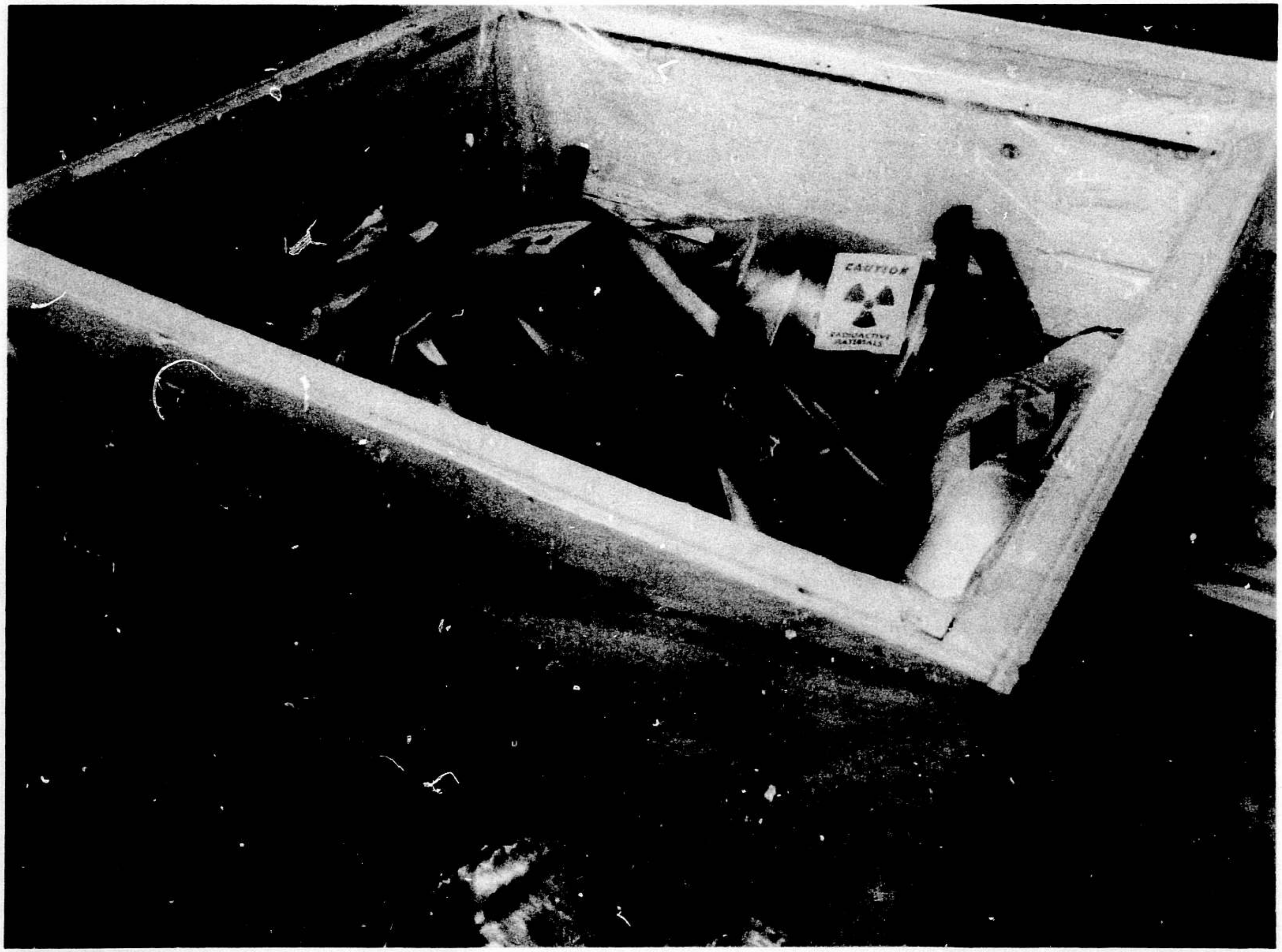


Figure 4-10 Half-Size Plywood Bin Liner

4.3.5 Problem Areas

During the initial stages of project planning, many problems of various magnitudes were identified. The most significant of these were (1) how to handle and remove large and heavy components from inside the gloveboxes, (2) where to perform size reduction of the gloveboxes and those components which were too big to fit into acceptable packaging, (3) what type of protective clothing and respirator equipment would be required for personnel entering a high contamination area, and (4) whether direct-reading instrumentation could be used to assay the gloveboxes for determining the quantity of radioactive materials present.

4.3.5.1 Handling Large and Heavy Components

Through visual observation, it became immediately evident that the first problem to overcome would be the handling and removal of equipment housed within the gloveboxes. Even though most boxes were quite long, the nut-and-bolt construction and the modular design permitted simple disassembly and separation into short lengths. However, before this could be done, the equipment and all other interior apparatus needed to be disassembled and taken out without the spread of contamination. Since most gloveboxes did not have any provisions for material removal except through the central-conveyor system (PF-3), a large bag-out port was fabricated. This port was designed to replace a window and was moved from glovebox to glovebox as the need

Figure 4-11 Bagging Waste Out of a Glovebox

arose (Figure 4-11). It had an opening of about 76 cm X 100 cm (30"X 39") and utilized a .5mm (20-mil) thick plastic bag which was held in place on the clamping ring with several layers of tape. The sealed end of the pouch was placed directly into the half-wood liner and large and small items alike were then carefully moved from the glovebox into the bag contained in the liner. When filled, the pouch was dielectrically triple sealed and cut off from the portion still attached to the window (Figure 4-12). The waste then was fully enclosed in plastic which provided the barrier to prevent the escape of any radioactivity. Often a fork truck equipped with an extending boom (Figure 4-13) was used to assist in the removal of heavy components that could not be easily handled through the gloves. A system of eyebolts, eyenuts, washers, clevises, and steel cable passing through the plastic pouch (Figure 4-14) permitted bag out of items weighing as much as 325 kilograms (700 pounds). While the basic bag-out technique is universally used in connection with glovebox work, the development of these modifications and enhancements are unique and proved very successful in solving many of the problems associated with the handling of large and heavy components.

4.3.5.2 Temporary Contamination Control Enclosures

With the decision that all waste generated by the D&D activities would be reduced in size to fit the ANL-MIII bin, a problem was created as to where such work could be done without the spread of contamination. Earlier, when a permanent facility had been proposed

Figure 4-12 Sealing Bagout Pouch Filled with Waste

Figure 4-13 Waste Removal Assisted by a Fork Truck Boom

Figure 4-14 Rigging System for Lifting Heavy Items When Fork Truck Boom Is Assisting

for construction at ANL, personnel at the Rocky Flats Plant had been consulted about design features and, at that time, they also discussed their experience with temporary plastic tents. Based on those and subsequent conversations, a prototype, freestanding Size Reduction Enclosure (SRE) was constructed at Building 350 in the area formerly occupied by gloveboxes PF-7,8 & 9 (Figure 4-15) for evaluation and operational-procedure preparation. It was made of .5 mm (20 mil) plastic hung from metal supports (Figures 4-16 thru 4-19) with seams heat sealed or double taped and consisted of a 5 meters (16 feet) long by 2.5 meters (12 feet) wide workroom, a 1.8 meters (6 feet) long by 1.2 meters (4 feet) wide personnel-entry isolation room (iso-room) and a 1.8 meters (6 feet) long by 2.4 meters (8 feet) wide waste-removal isolation room. All ceilings were 3 meters (10 feet) high. The enclosure was connected to a 5100 cubic meters/hour (cmh) 3000 cubic feet/minute (cfm) double-HEPA-filtered exhaust system and air was pulled from the main room through the iso-rooms and finally withdrawn from the work area. Doors and other barriers were used to control airflow and help maintain velocities across all openings at 30 meters (100-feet) per minute. It was soon found that the maximum negative pressure which the enclosure could withstand without possible collapse was about 1.8 mm (.07 inches) of water, and because the tent was relatively tight, this could be maintained with an exhaust rate of about 1400 cmh (800 cfm) when all the doors were shut. Therefore, a maximum negative pressure of 1.3 mm (.05 inches) of water was established and this was accomplished with about 1100 cmh (650 cfm) of exhaust when the tent was closed. Since it was planned to perform size-reduction operations with various tent doors

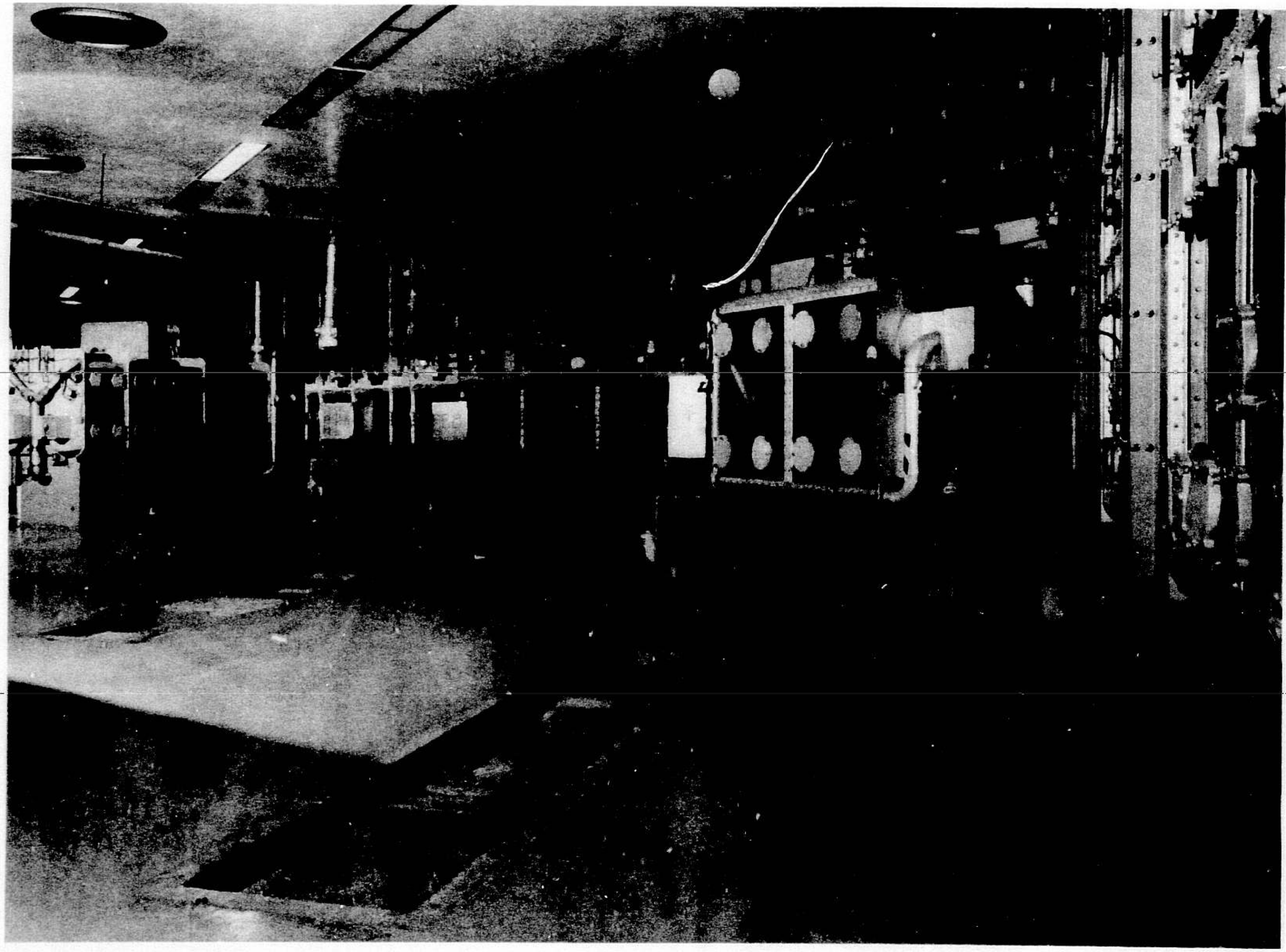


Figure 4-15 Fab Area After Removal of Gloveboxes PF-7, 8 and 9

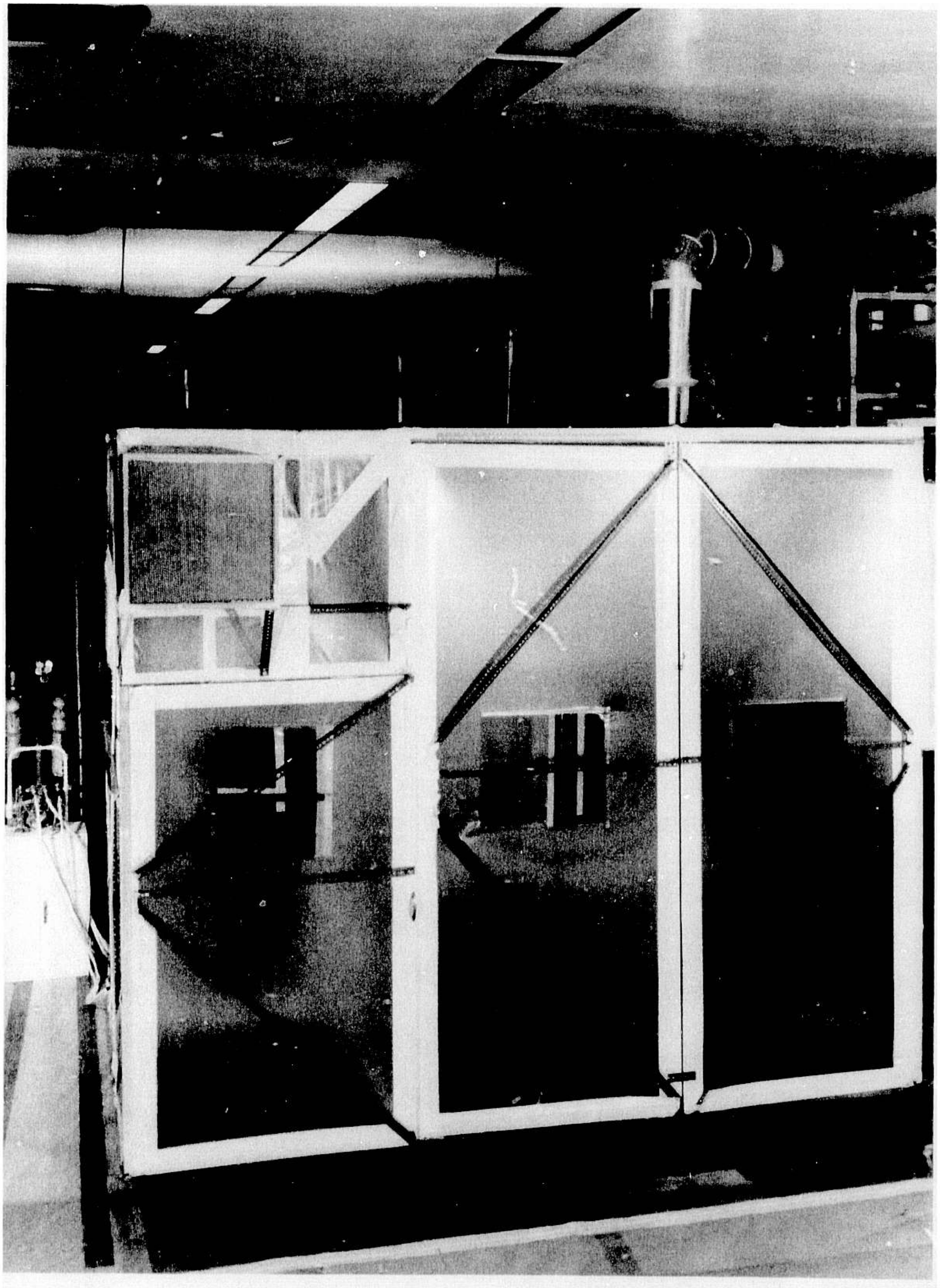


Figure 4-16 Size Reduction Facility

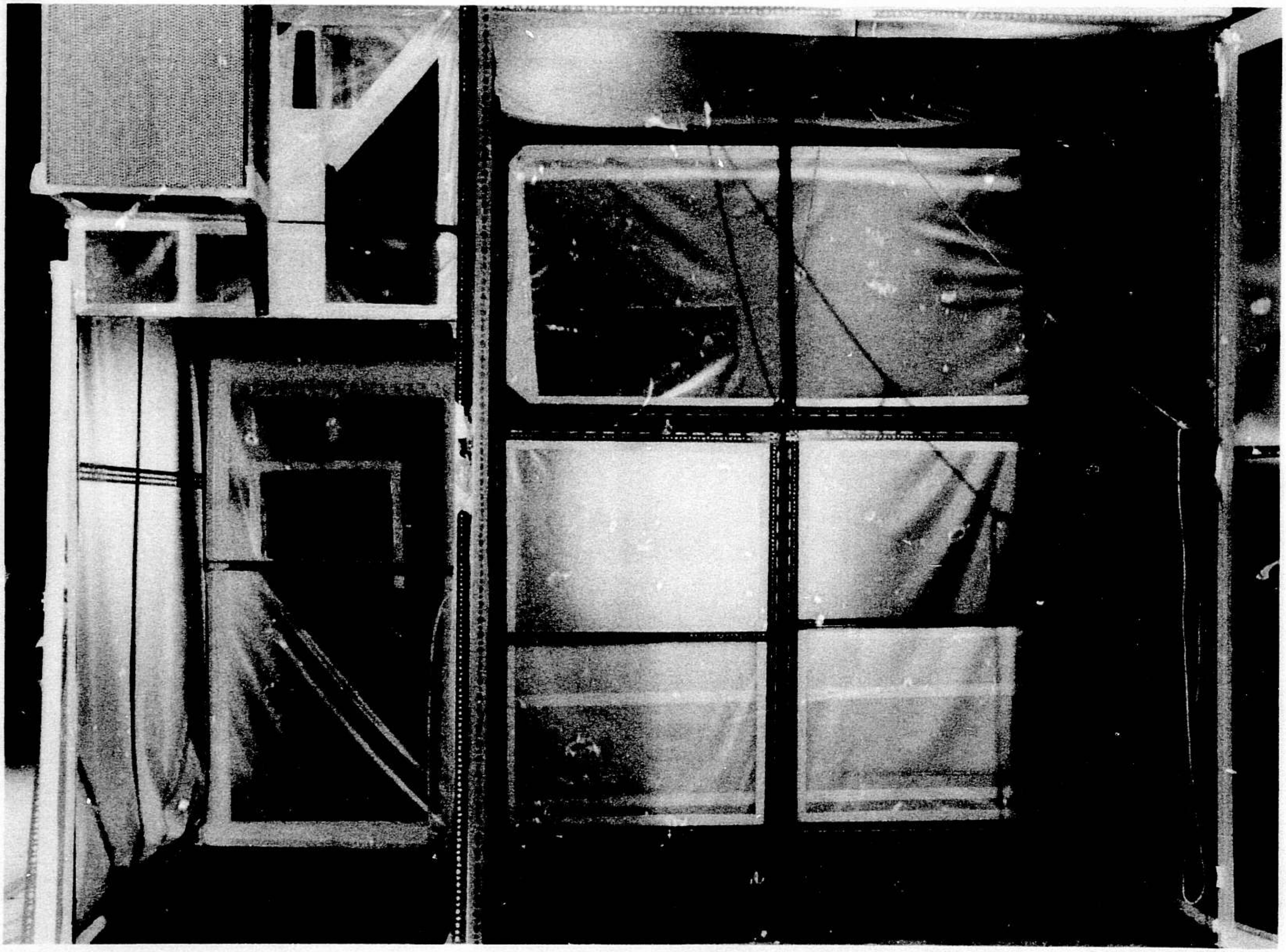


Figure 4-17 Size Reduction Facility Isolation Rooms

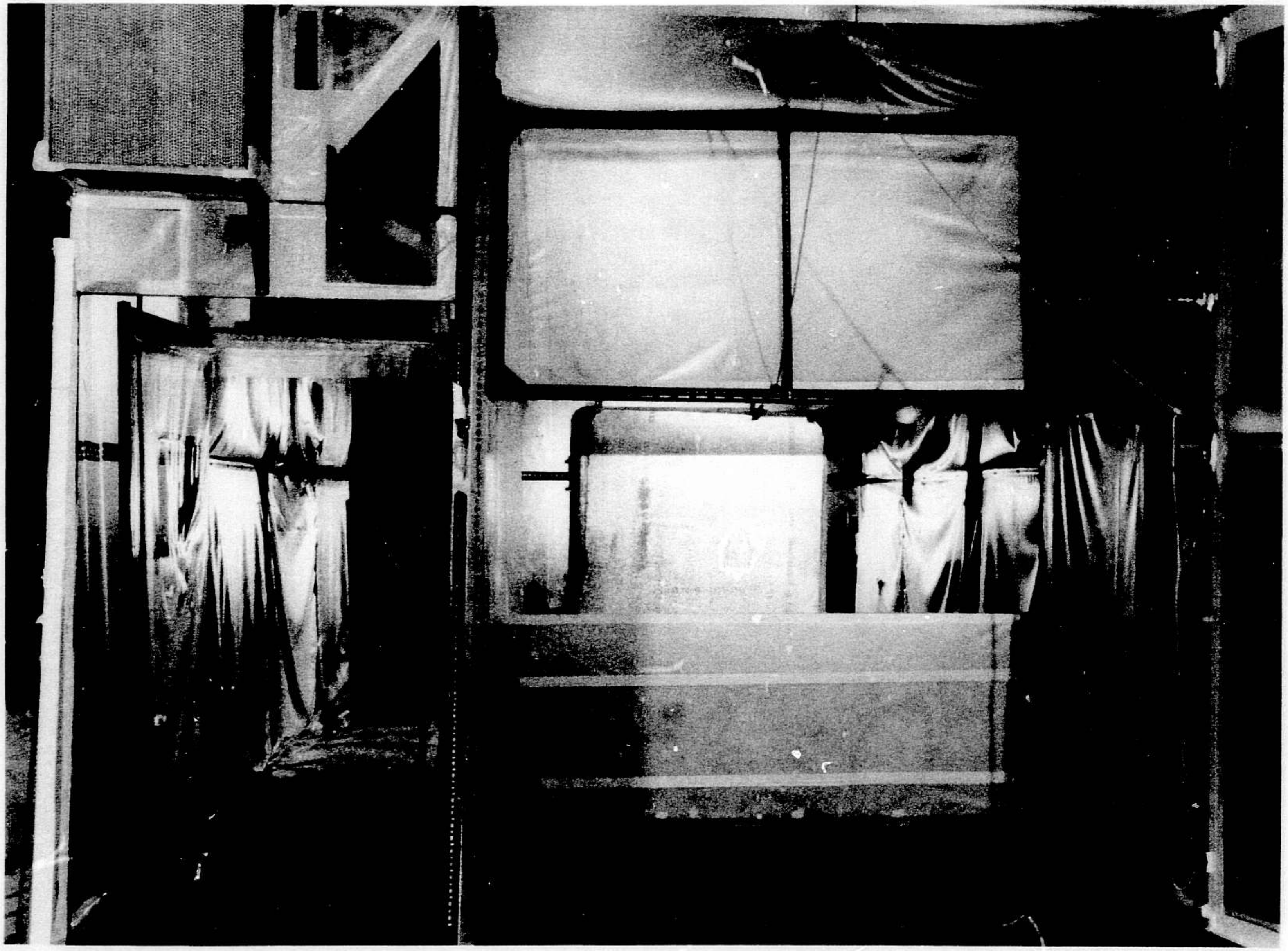


Figure 4-18 Size Reduction Facility Interior

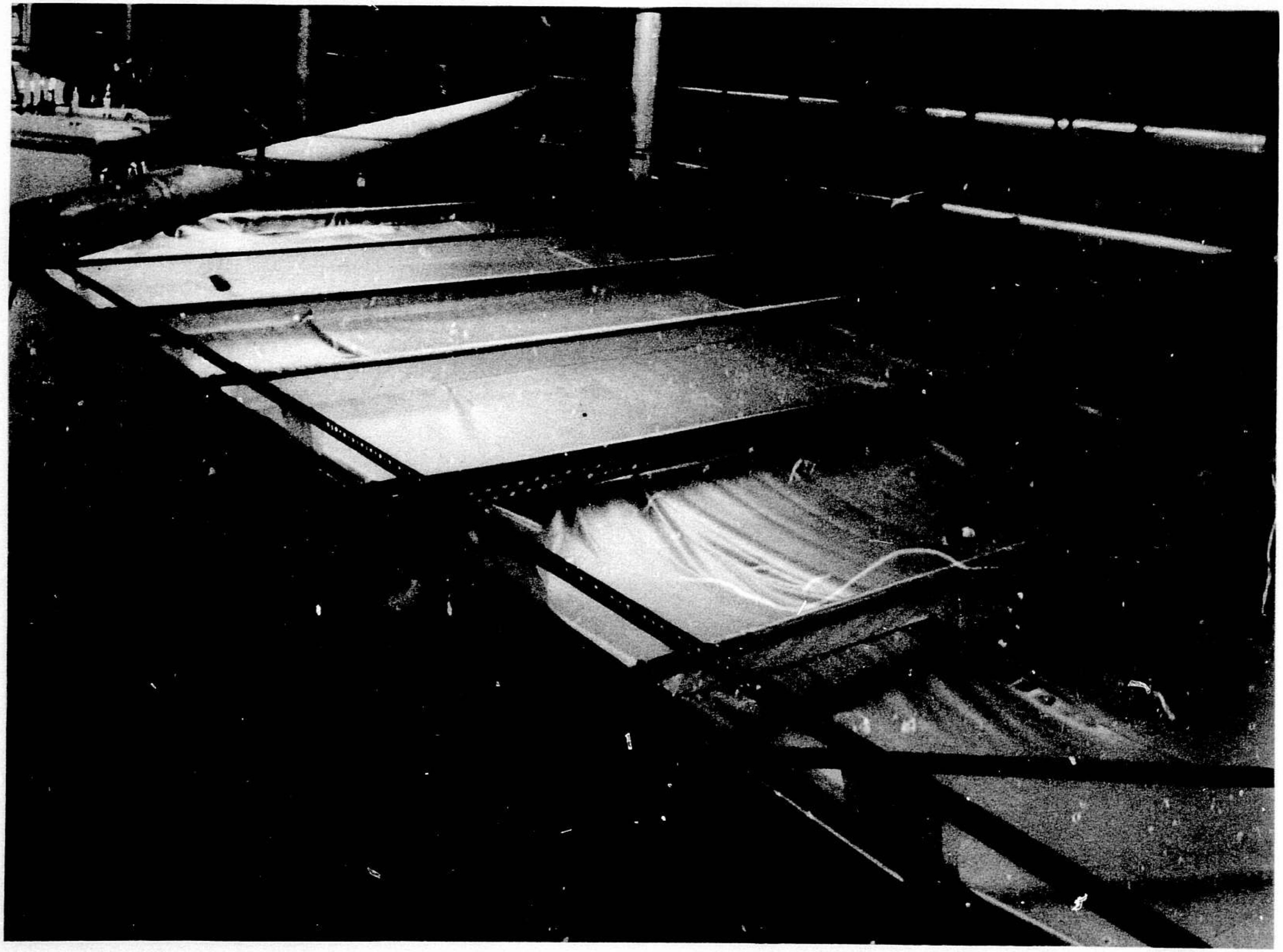


Figure 4-19 Size Reduction Facility Ceiling Supports

open and utilize the airflow to control the spread of contamination, it was necessary to increase the velocity up to 5100 cmh (3000 cfm) during those periods when such activities were being conducted.

After several test periods and a few enclosure modifications, operating procedures were prepared so that the first radioactive glovebox module could be cut apart. Briefly, the concept was to introduce a box to the work area through the waste-removal iso-room with all doors wide open, then partially close the inner doors to obtain the appropriate face velocity and begin size reduction (Figure 4-20). As waste was generated, it was loaded by those inside the tent--with help from the outside as necessary--into a half-bin liner that was located in the waste removal iso-room (Figure 4-21). After finishing each glovebox section, which usually required several tent entries, the workroom floor was vacuumed and wiped down with wet rags to remove gross loose contamination. The isolation room surfaces, however, were monitored and thoroughly cleaned as necessary after every usage.

With the completion of the first module, an evaluation of the experience gained was made by Management, Operating, and Health Physics personnel. It was concluded that the tent and its associated exhaust system met all expectations in that no activity was spread to the outside area; the iso-rooms needed little or no cleanup; waste could be packaged without the containers becoming externally contaminated; the procedures governing the operations were satisfactory and further size-reduction work could be undertaken.

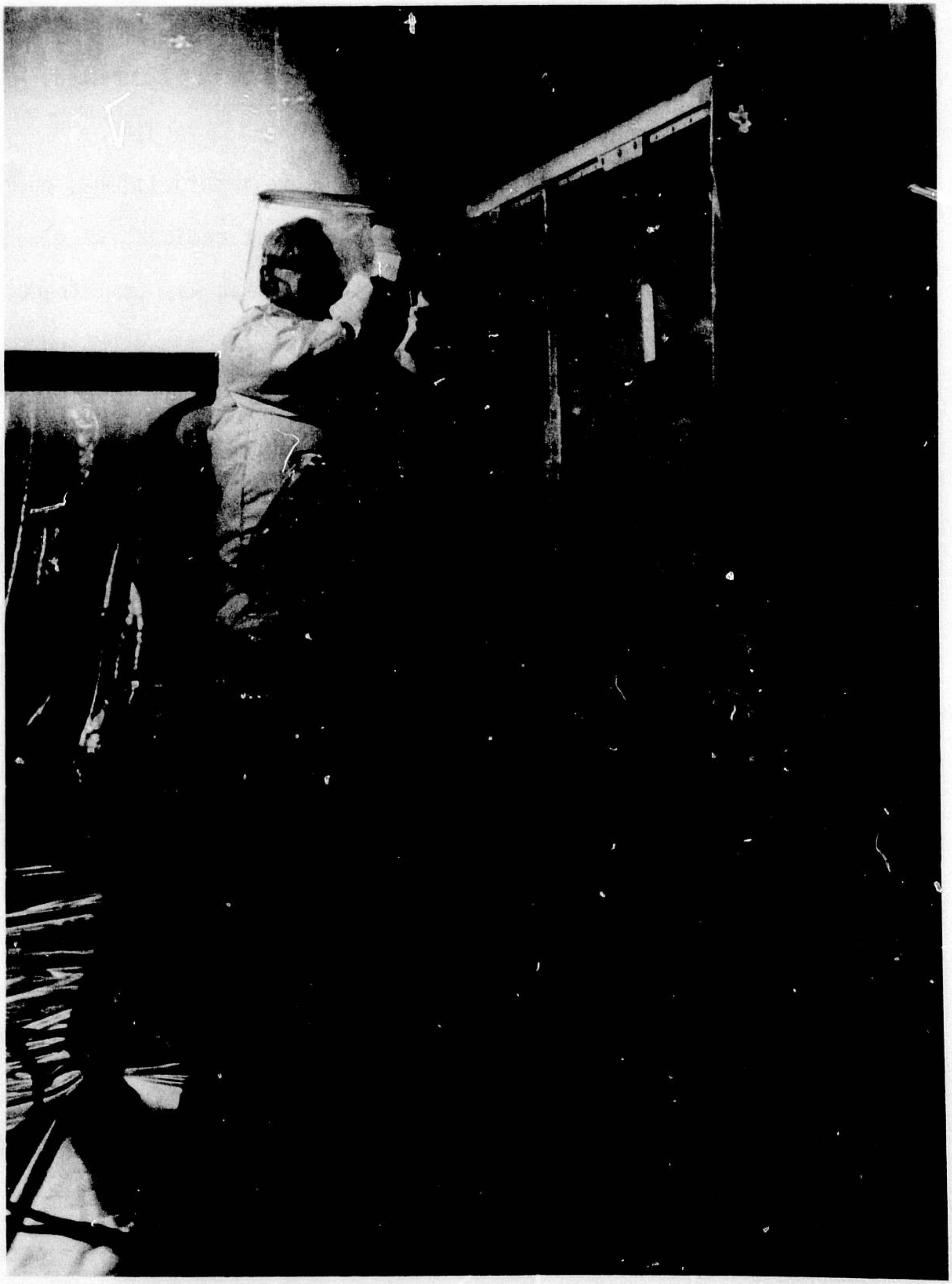


Figure 4-20 Glovebox Size Reduction in Contamination Control Enclosure

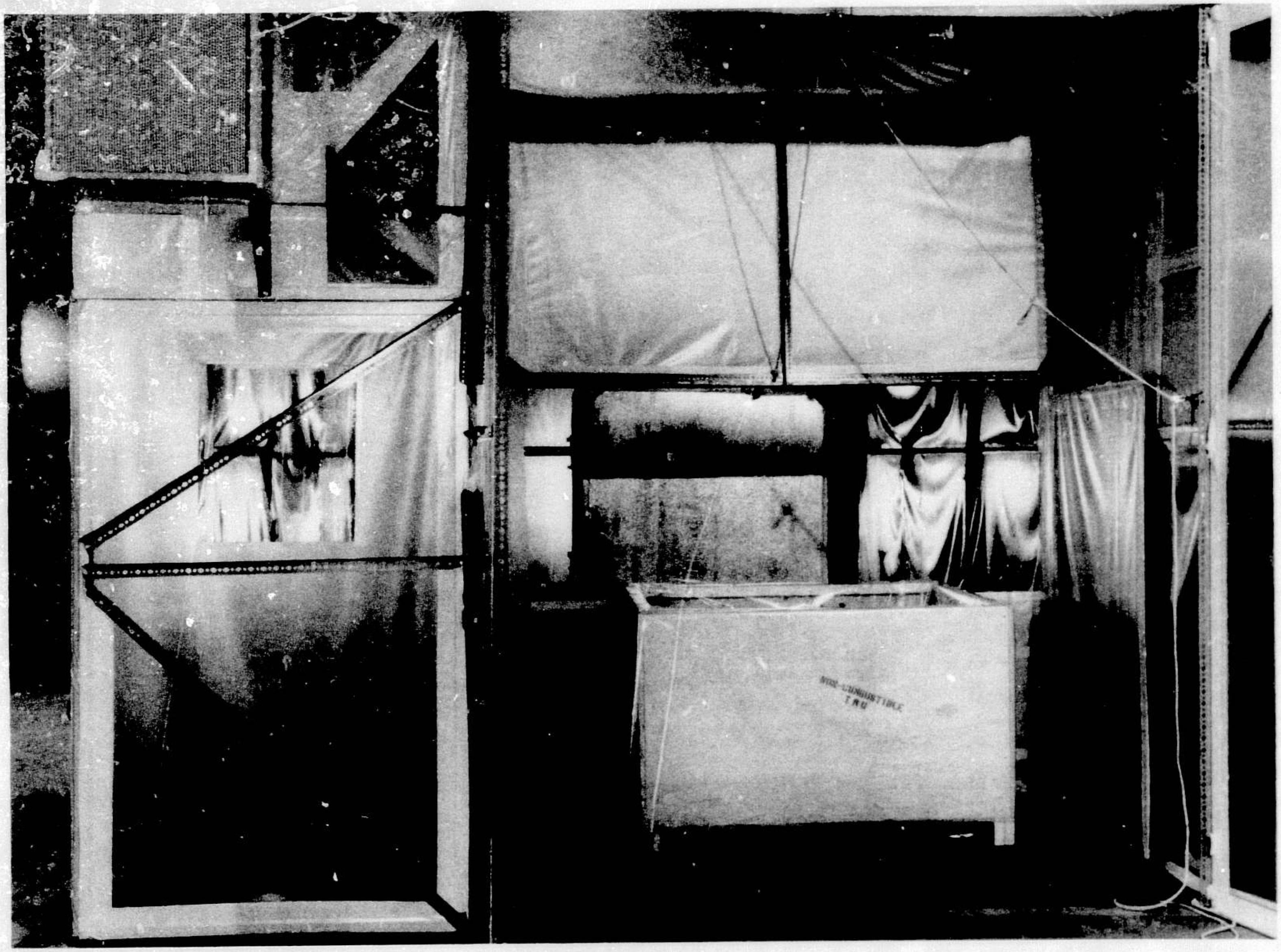


Figure 4-21 Half-Size Liner Positioned to Receive Waste in Contamination Control Enclosure

Since that time no changes in the basic operation of the enclosure have taken place. The same tent, which had been considered as mock-up, was used throughout the project. Over 150 entries were made and, at no time, were any significant amounts of radioactivity spread beyond the confines of the work area even though that space became quite highly contaminated and needed cleanup on several occasions. The only major deficiency encountered was that there was no way to incorporate any mechanical lifting device into the enclosure for use in handling heavy items. This was partially overcome by inserting the extension boom on the fork truck into the work area and using it to help maneuver those items which personnel could not handle themselves. This method was awkward and time-consuming--but workable.

With several gloveboxes, the interior equipment was so massive that it was necessary to construct a separate temporary plastic enclosure across one face of the box (Figures 4-22, 23, 24) and remove one or more windows so that hands-on disassembly operations could be conducted. In those cases, the boom-equipped fork truck was again utilized to aid in removal of the heavy and large components (Figure 4-25). Double filtered HEPA exhaust was also employed with these enclosures to control the spread of contamination.

4.3.5.3 Protective Clothing and Respirator Equipment

The use of workers inside enclosures which contained radioactive materials posed the problem of how to prevent the individuals from becoming contaminated and what type of respirator equipment would be

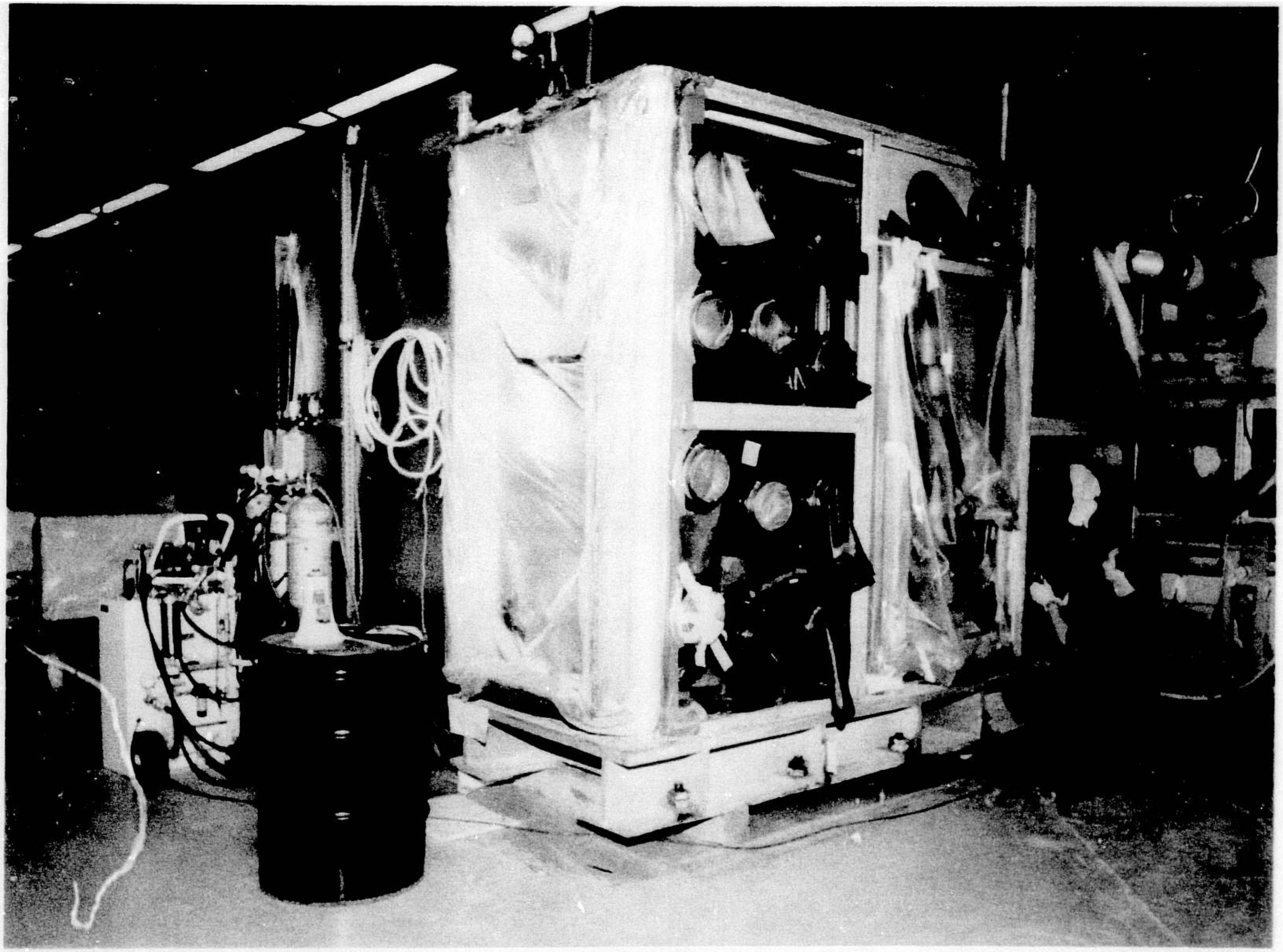


Figure 4-22 Glovebox with Separate Temporary Contamination Control Enclosure

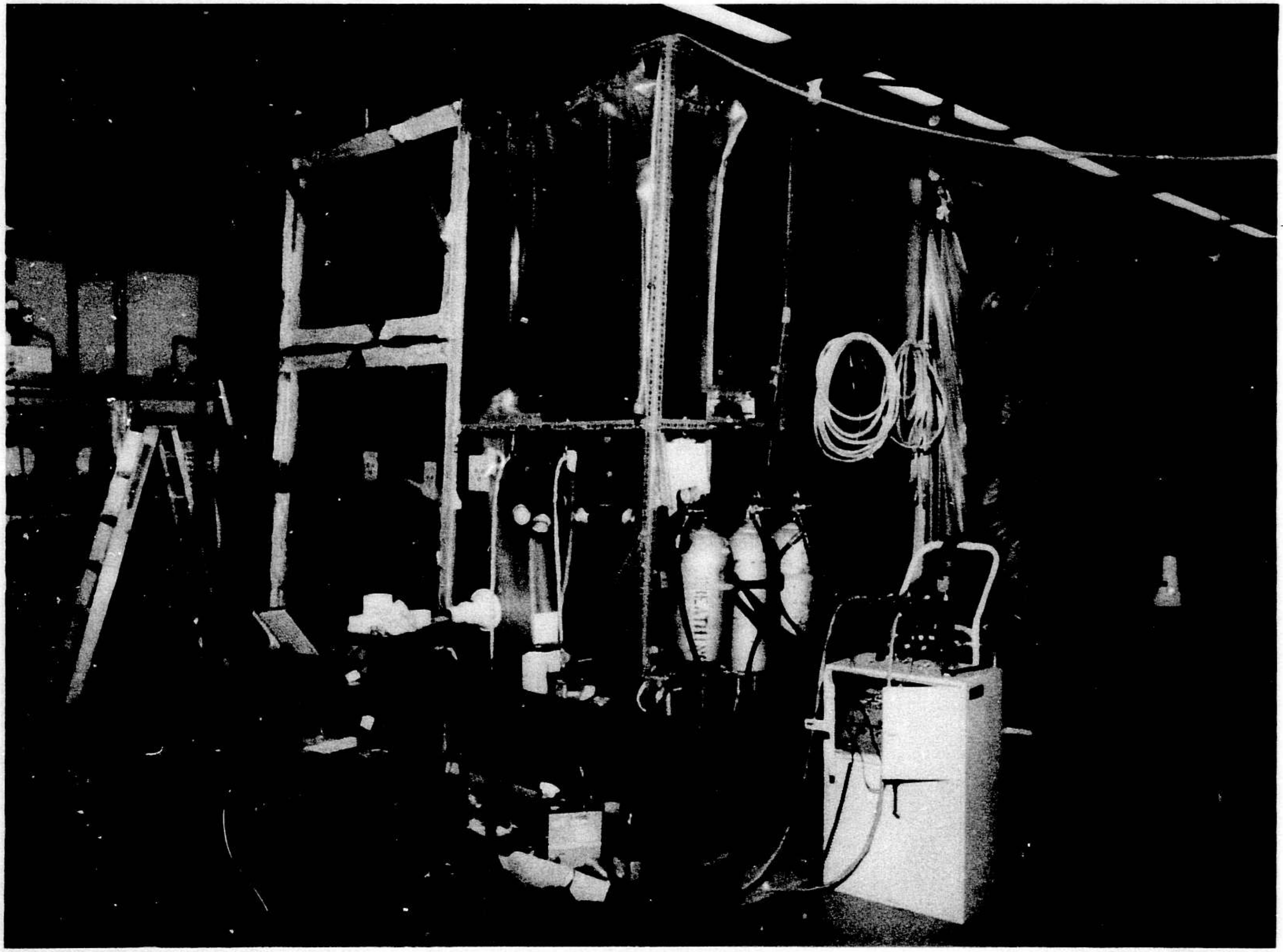


Figure 4-23 Separate Temporary Contamination Control Enclosure

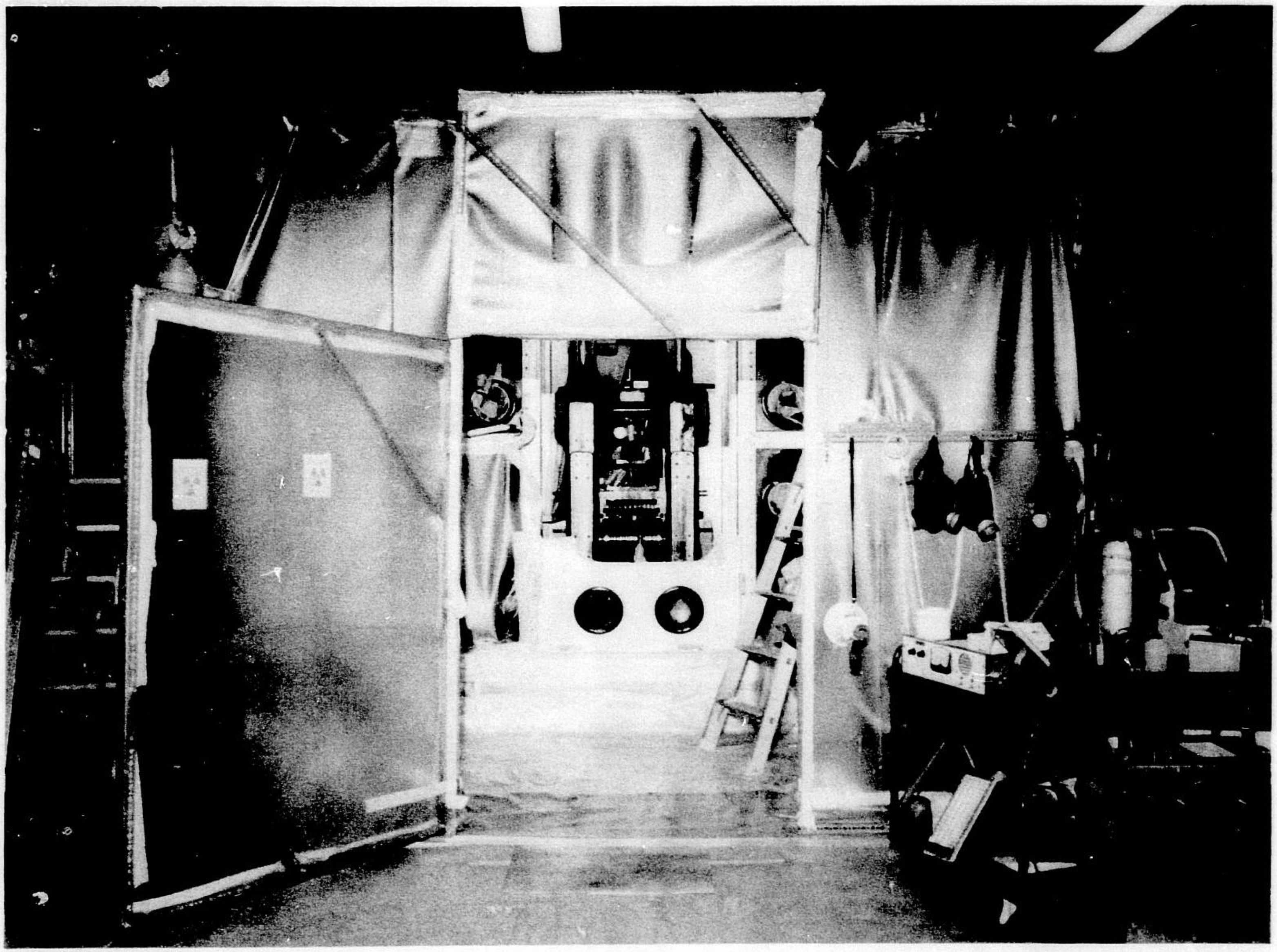


Figure 4-24 Separate Temporary Contamination Control Enclosure in Operation

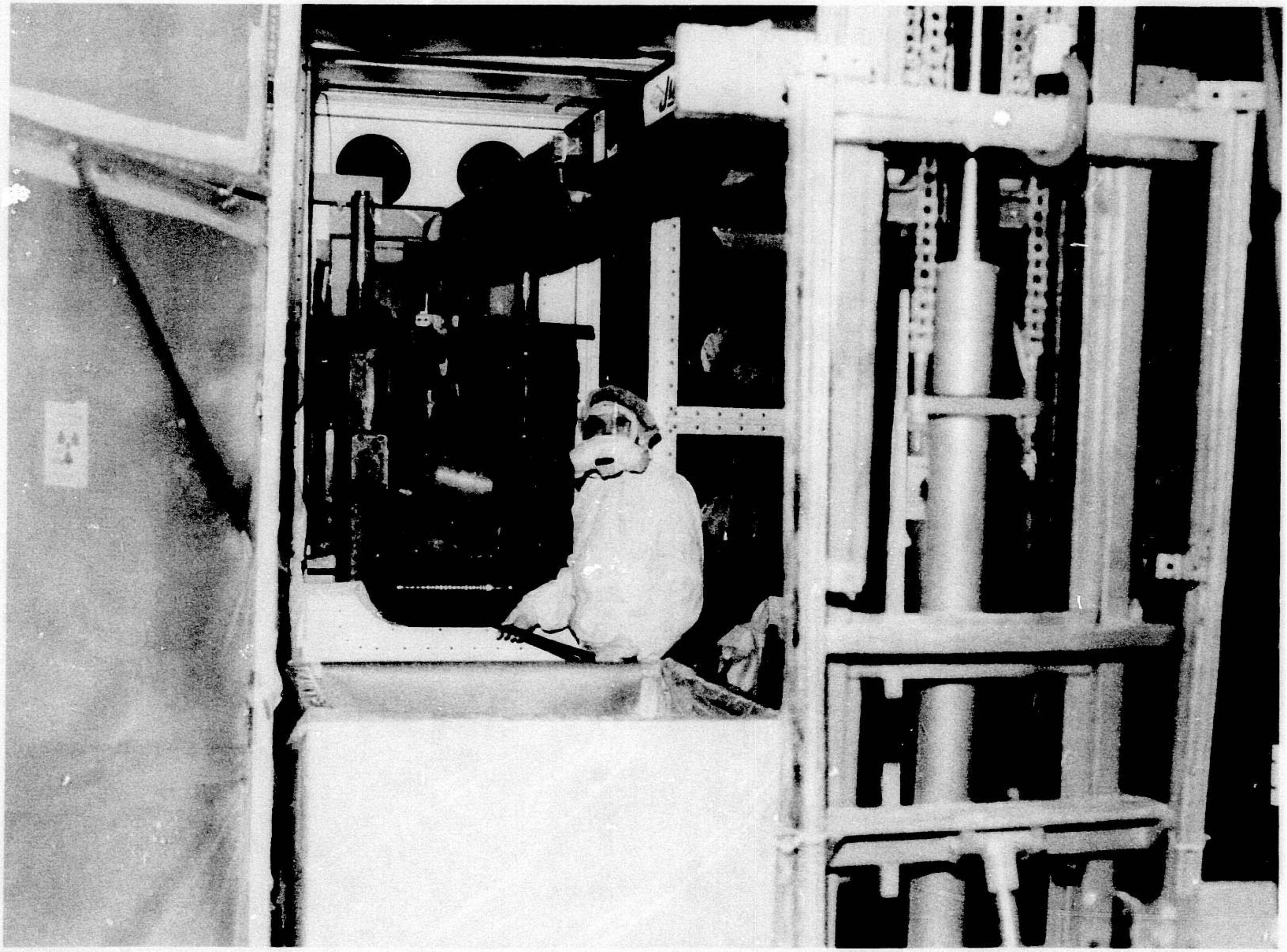


Figure 4-25 Fork Truck Boom Assisting in Waste Removal

needed. Again the Rocky Flats people were consulted and, using their expertise as well as much of their apparel, which was obtained by purchase order, a system of protection was developed and tested to the satisfaction of the ANL Occupational Health and Safety Division. It consisted generally (Figure 4-26) of several layers of disposable clothing, shoe covers and gloves; a reusable NIOSH-approved, commercially available supplied-air respirator; and communication devices that allowed conversation between all personnel involved in the tent entry both inside and outside the enclosure. Compressed house air was utilized for breathing and it was supplied to workers through a distribution center designed by Rocky Flats from whom it was purchased. This portable unit (Figure 4-27) contained pressure alarms, flow-monitoring devices, auxiliary battery power, and the communications amplifier. It was connected to both house air as well as bottled air which served as a backup in case of a compressor failure. The house air supply was routinely analyzed for purity in accordance with prescribed standards.

The protective clothing system underwent several trials in an environmental chamber using DOP as a test media and, after a few modifications, the data obtained indicated that the protection factors achieved fulfilled safety requirements. Personnel were then repeatedly trained in the proper methods of dressing and undressing before actually entering a contaminated atmosphere. Removal of the used, disposable clothing, which was always left inside the tent for pickup by the next crew to enter, took place at the doorway of the work area and the personnel iso-room under the guidance and assistance of a Health Physics technician.

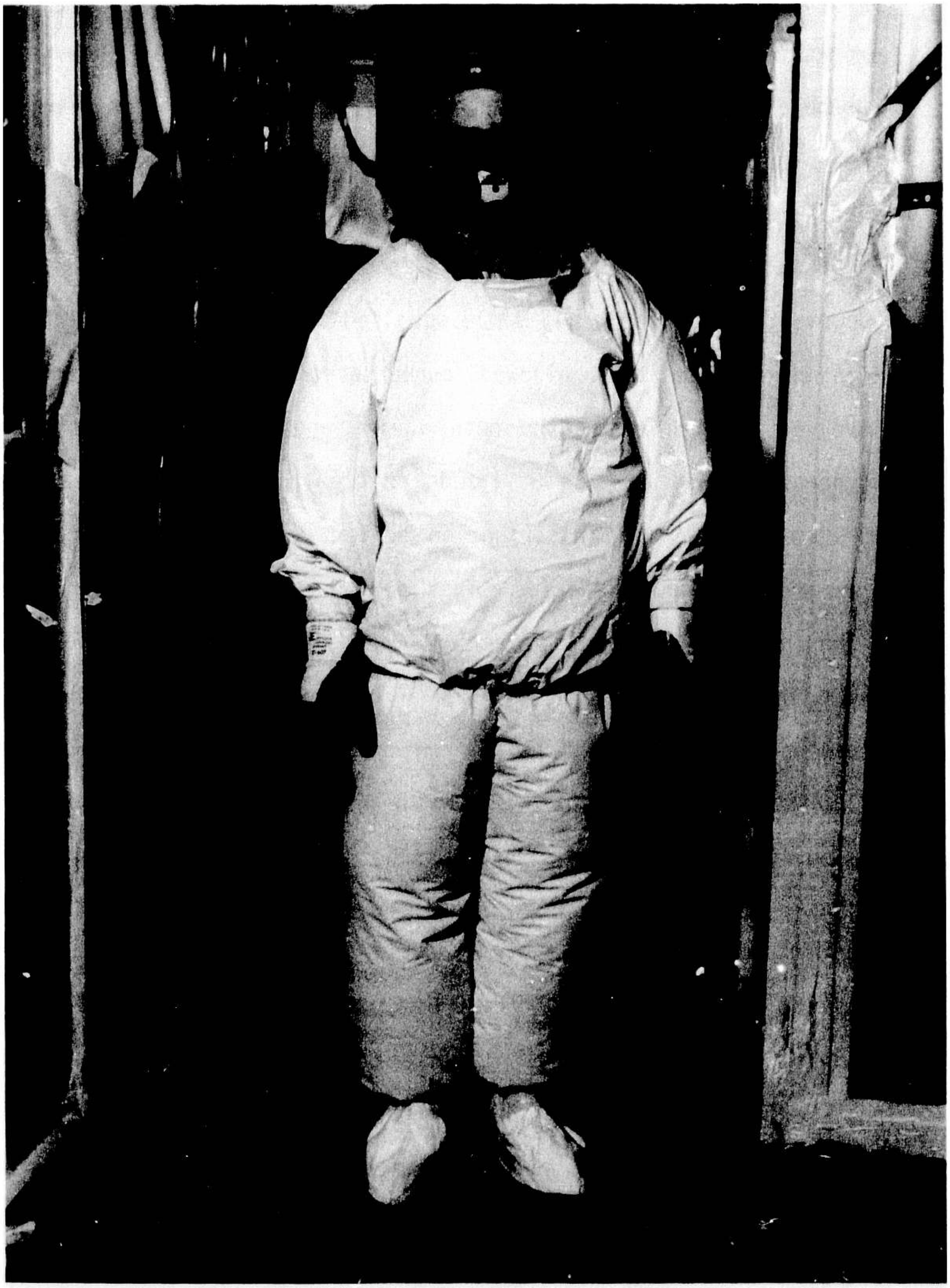


Figure 4-26 Worker Dressed for Tent Entry

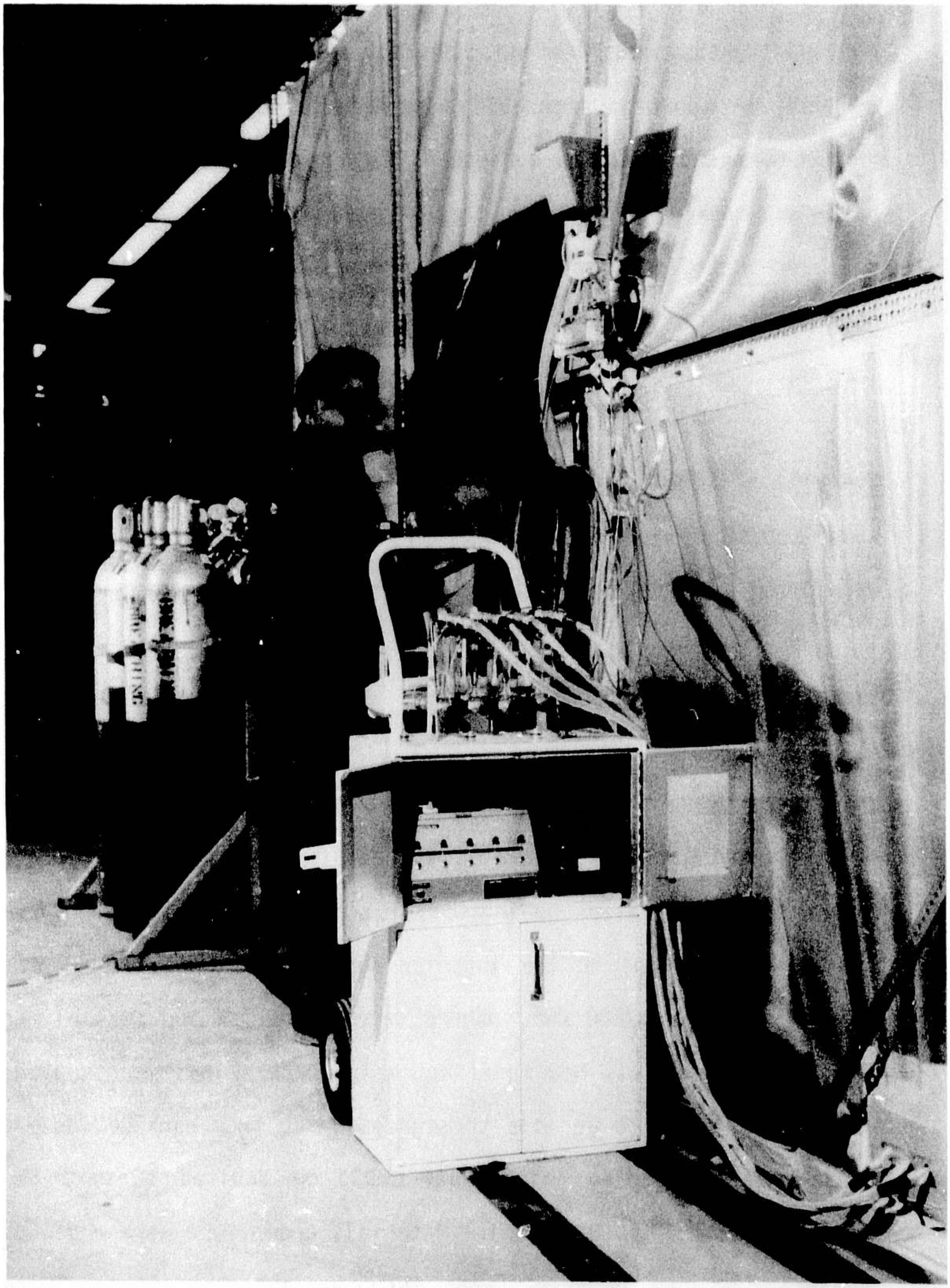


Figure 4-27 Supplied Air Distribution System

Use of this protective system continued throughout the project with only one further modification. Shortly after the original system was devised, an approved, reusable supplied-air hood came on the market and it was substituted, subsequent to an evaluation test, for the half-face-mask respirator which had been initially employed. This change resulted in more comfort to the workers and permitted the use of a headset for communication in place of a throat microphone and an earplug.

Overall, this method of protecting employees working in a contaminated atmosphere proved successful. Continual air samples from within the suit and bioassay results verified this conclusion.

4.3.5.4 Segregation of TRU from Non-TRU

When research work was terminated at the PFF in 1974, facility personnel removed all recoverable radioactive materials and performed cursory cleanup leaving behind only residual contamination. Whereas the levels of alpha on the interior surfaces of some boxes were in excess of 10^{10} dpm/100 cm^2, others were quite low and possibly non-TRU. The problem was how to effectively measure the amounts present in each box so as to be able to segregate TRU from non-TRU waste and whether direct-reading instruments could be devised to make those determinations. The ANL Special Materials group, who were engaged in developing methods of quantifying plutonium and other fissile materials contained in general Laboratory waste, undertook the task. The results of their efforts (Reference 2) produced a reliable technique which was used during the entire D&D effort. Health Physics staff personnel who utilized the procedure made further refinements so that, not only could it be used for segregation purposes, but also for developing data relative to the specific amounts of radioactivity in each waste container. This latter information was needed to comply with the Waste Acceptance Criteria at the INEL storage and burial site. A detailed discussion of this matter, as well as other Health Physics aspects as they concern the project is presented in Appendix C and in Section 7.0, respectively.

4.3.6 Exhaust System Removal

As mentioned in the facility description, five separate exhaust systems were used in the PFF. The HAR and the PAE were shutdown and partially dismantled in 1974 while the others (Normal, Purge and Room) remained in operation. Since these latter HEPA-filtered systems were utilized throughout the term of the project to maintain the remaining gloveboxes in a negative condition, to provide ventilation for the contamination-control enclosure, and to exhaust the workroom, disposal of those systems could not be undertaken until all of the boxes had been dismantled and size reduced. Once that effort was complete, ductwork removal was initiated. Starting at a point furthest from the filters and with the blowers still in operation so that air was constantly drawn into the pipe to control the spread of contamination, the overhead stainless steel ductwork (Figure, 4-15, top portion) was cut into suitable lengths. The ends were sealed and lowered to the floor. These long sections which varied in diameter from 25 to 50 cm (10 to 20 inches) were then further reduced in size to fit standard packaging either in a contamination-control enclosure (Figure 4-28) or after the tent's disassembly, in a walk-in hood at another location. Each length was cut (Figures 4-29 and 4-30) both horizontally and vertically so that the pieces could be nested within the half-size wooden liner and thus eliminate voids. A total of about 150 meters (500 ft) of duct was disposed of in this manner. One primary filter bank with the filters removed (Figure 4-31) and one 50 cm (20 inch) diameter section of normal exhaust pipe were left behind because they could not be removed from the loft areas where they were located without cutting large holes in the exterior building walls. In addition, two secondary filter banks were left for reuse as requested by NBL. The entire Fab Area ventilation system was also left intact to continue providing filtered exhaust for that room.

4.3.7 Fabrication Area Decontamination

Upon completion of the dismantling and disposal of the gloveboxes, exhaust systems, and other facility-associated equipment, the Fab Area was decontaminated consistent with the requirements of NBL (See Appendix A). The epoxy-coated fiberglass floor covering, which had been applied at the time of construction and served to protect the concrete during process operations as well as decommissioning, was removed. Also all horizontal surfaces throughout the room were wiped down as a precaution prior to the initiation of the monitoring effort. Thorough surveys were then performed, and as expected, only

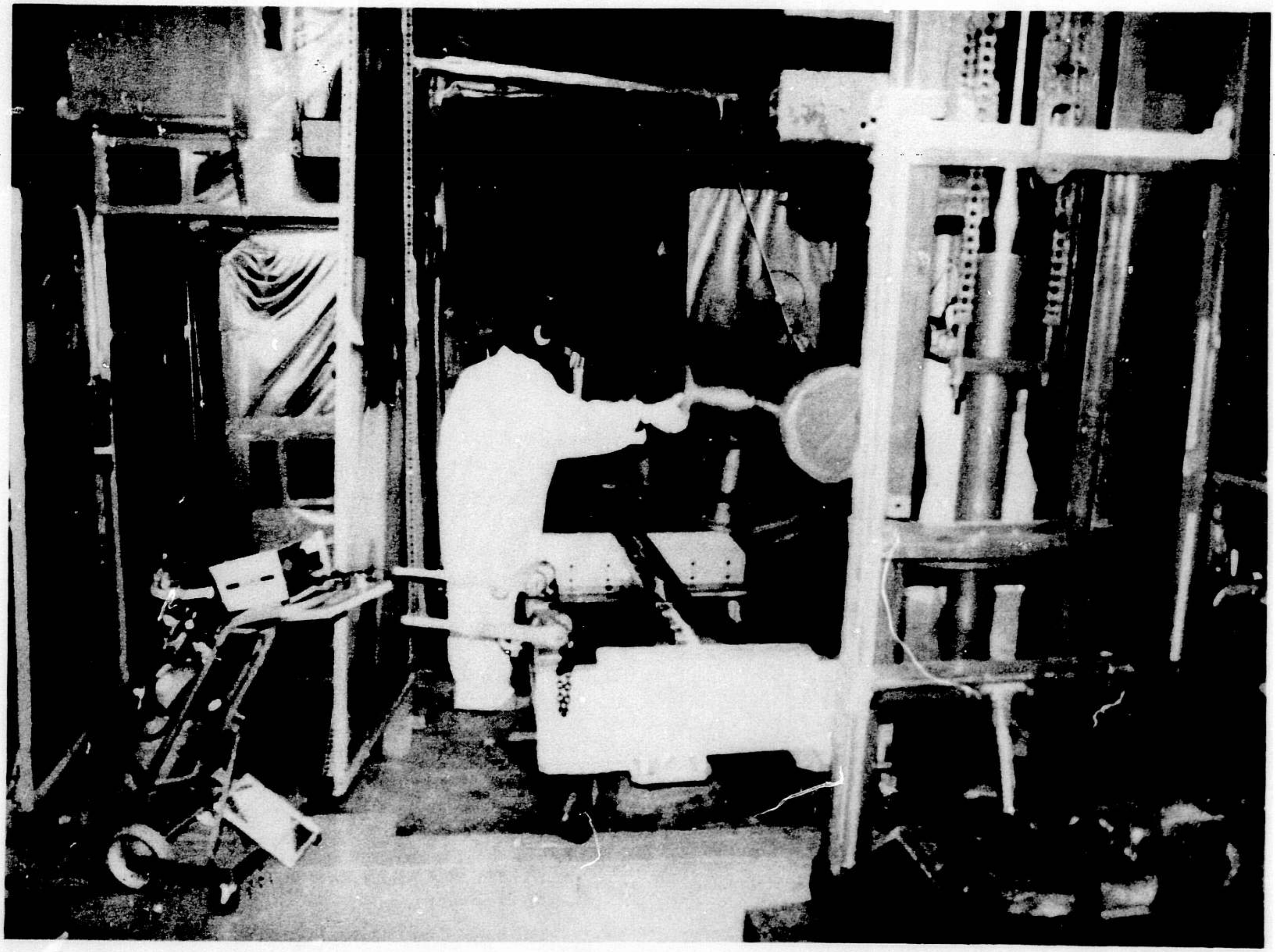


Figure 4-28 Exhaust Ductwork Being Placed in Tent

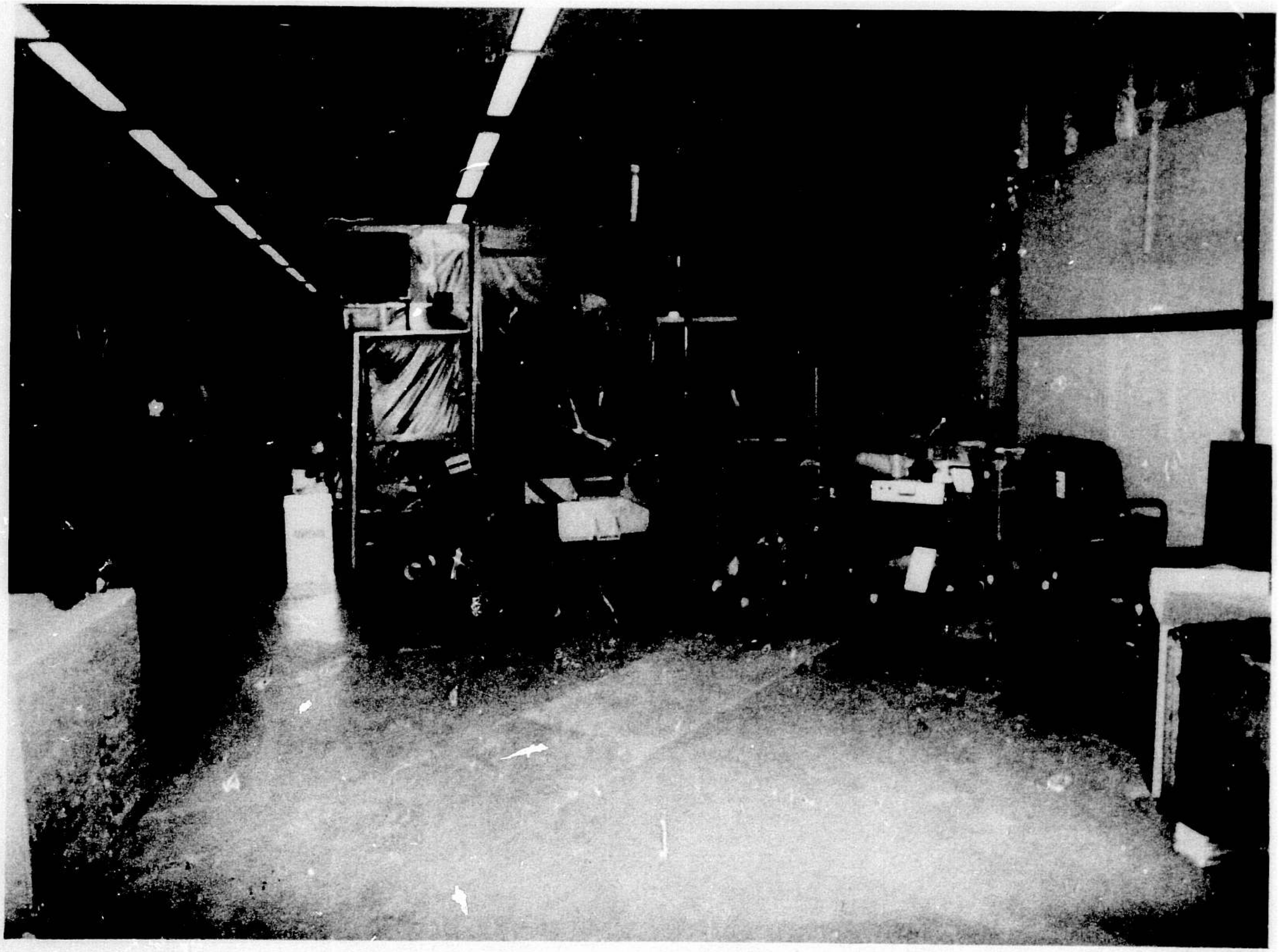


Figure 4-29 Size Reduction of Exhaust Ductwork

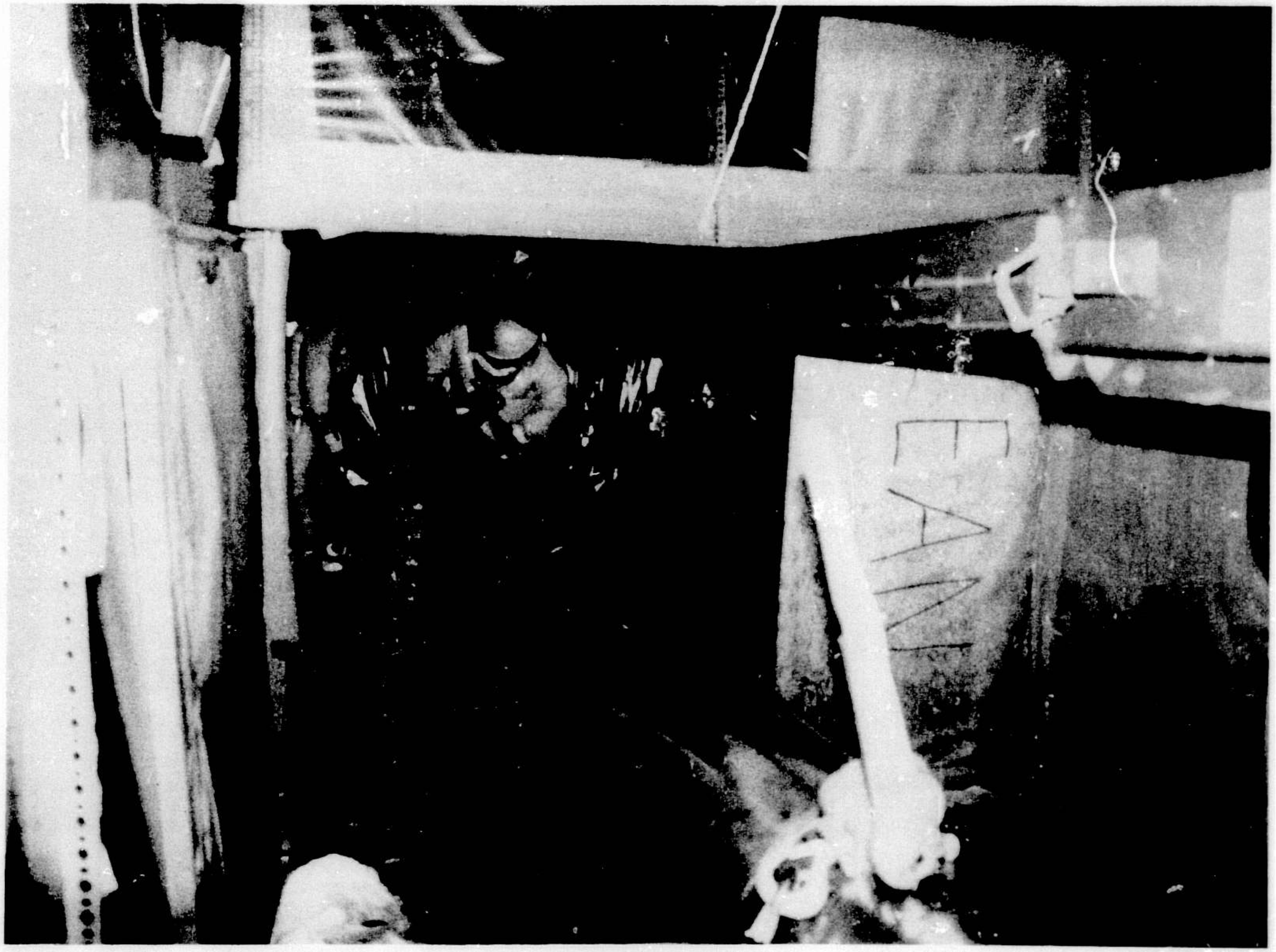


Figure 4-30 Closeup of Exhaust Ductwork Size Reduction

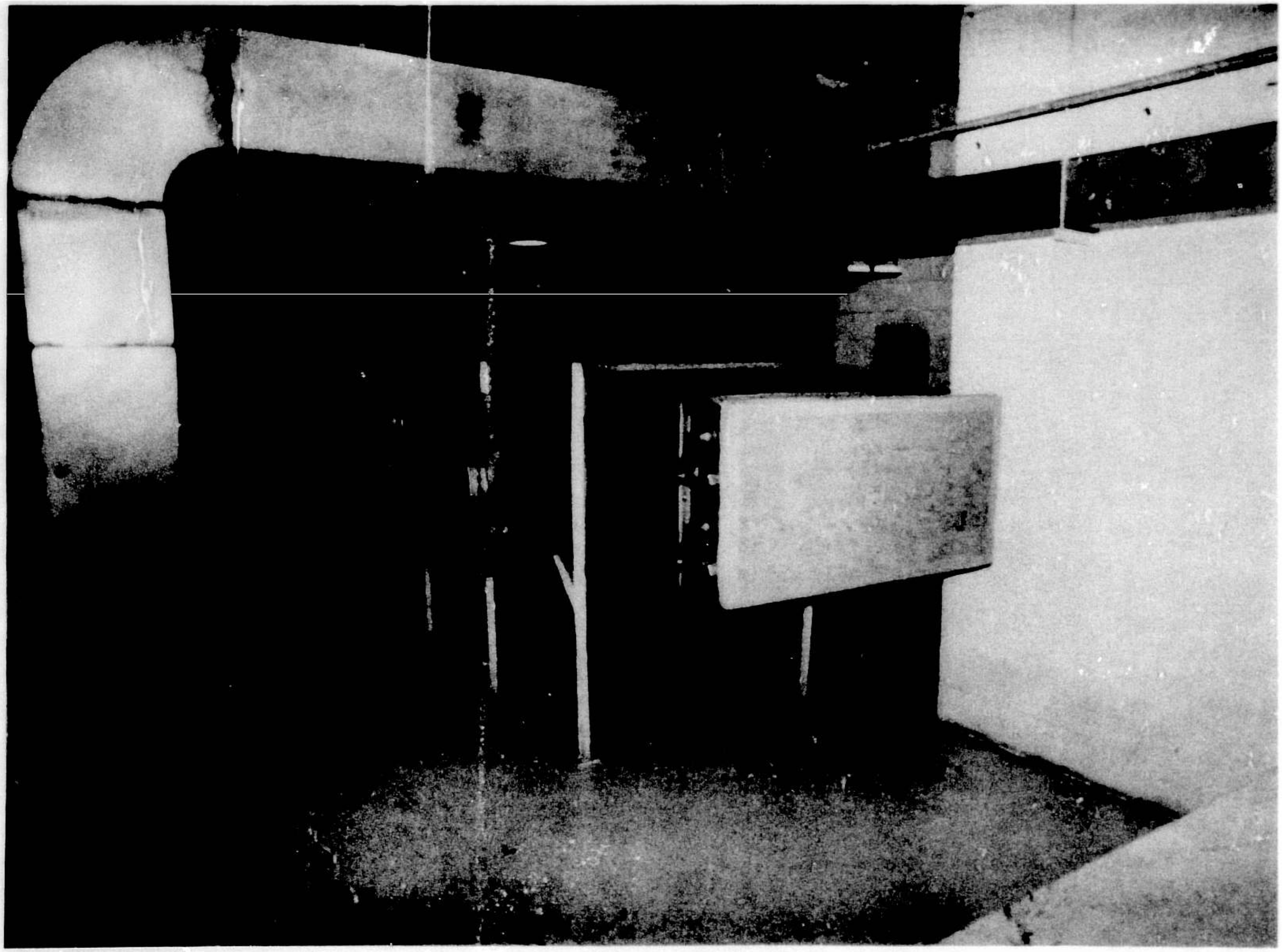


Figure 4-31 Exhaust Filter System Left in Fan Loft

a few minor spots of very low level contamination were detected. These were easily removed with cleaning solutions. The fact that little facility decontamination was necessary is not surprising as no significant spills occurred prior to, or while, the decommissioning was in progress . Also, during all phases of dismantling, frequent monitoring of floors and other surfaces was performed as a means of maintaining the area free from radioactivity.

4.3.8 Post-Decommissioning Radiological Survey

After the decommissioning crew had removed all of their equipment, tools, supplies, etc., and had vacated the facility, a Health Physics team conducted a follow-up survey of the entire area. They found no direct readings above background except for the several exhaust system components which had been left behind and on the smoke detectors. This completely satisfied the criteria specified by NBL and the area was subsequently occupied by them. The complete report documenting this survey is presented in Appendix B.

5.0 Cost and Schedule

Because of the complexity and size of the gloveboxes, and the equipment contained within; the limited availability of experienced labor which could be dedicated to the work, and the yearly funding constraints imposed by the various financial sponsors, the project required almost five years to complete at a cost of 2.4 million dollars. It consumed some 30 manyears of effort, generated around

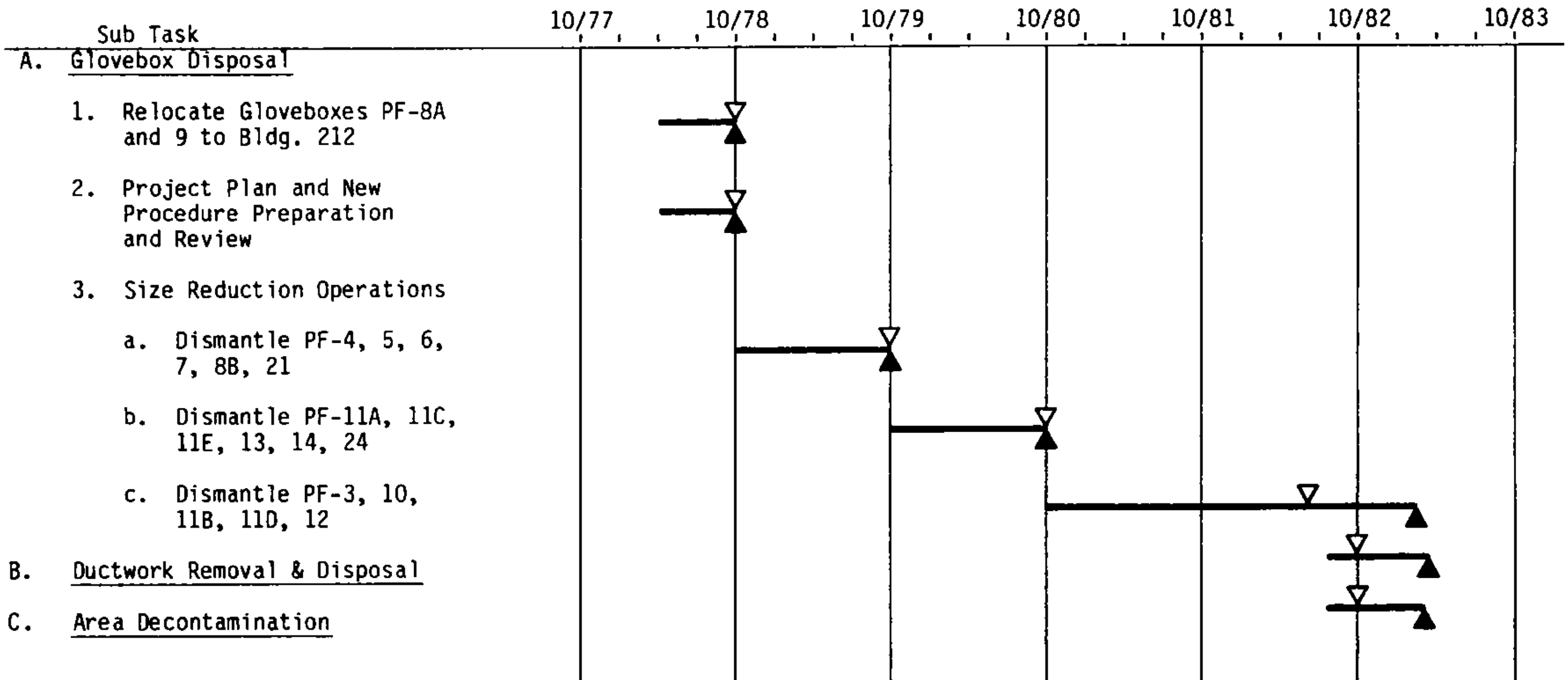
560 m^3 (20,000 ft^3) of radioactive, low-level waste--of which approximately 60% was TRU--and resulted in a total exposure to personnel of 5.6 person rem. Each of these statistics is very close to the original estimates prepared more than seven years earlier.

A milestone and cost schedule for the project is shown in Figure 5-1. In addition, a manhour and cost breakdown for each glovebox, for the exhaust system removal and for the decontamination and final survey of the Fab Area is shown in Table 5-1. Of interest is the fact that two of the fourteen gloveboxes processed required 40% of both the total manhours and the total cost of the entire project. Those two hood lines (PF-12 and PF-10), which needed two years to complete, contained large heavy metal working machinery (see Section 2.1 for further description). Disassembly and size reduction was so extensive and time consuming that a six-month schedule slippage was incurred. These units can also be considered as directly responsible for the need to reprogram the budget for an additional $200,000 to carry the project to completion in FY 1983.

6.0 Waste Volumes Generated

The project generated 322 m^3 (11,400 ft^3) of TRU and 224 m^3 (7900 ft^3) of non-TRU radioactive waste. All of this material was low level, solid waste and, except for four nonstandard boxes, was packaged in ANL-MIII bins and sent to the Radioactive Waste Management Complex operated by EG&G Idaho at the Idaho National Engineering Laboratory. The four nonstandard boxes contained large solid metal

DECOMMISSIONING OF THE PLUTONIUM FABRICATION FACILITY - BUILDING 350 - ARGONNE NATIONAL LABORATORY
Milestone and Cost Schedule



	10/77–10/78	10/78–10/79	10/79–10/80	10/80–10/81	10/81–10/82	10/82–10/83
Planned Cost:	$203K	$490K	$500K	$500K	$560K	$200K
Cumulative Totals:	$203K	$693K	$1193K	$1693K	$2253K	$2453K
Actual Cost:	$191K	$480K	$516K	$439K	$570K	$223K
Cumulative Totals:	$191K	$671K	$1187K	$1626K	$ 2196K	$2419K

▽ Scheduled Completion

▲ Actual Completion

Figure 5-1 Milestone and Cost Schedule

TABLE 5-1

Building 350 Glovebox Disposal Project

D&D Manhours and Cost Summary

Glovebox	Date		D&D Manhours			Cost - $000			
Number	Started	Completed	Estimate	Actual	Over (Under)	Labor	Waste Disposal	Materials & Support	Total
PF-7	4/78	4/79	980	795	(185)	24	12	30	66
PF-8	4/78	4/79	560	736	176	22	7	28	57
PF-9	5/78	9/78	500	545	45	16	1	20	37
PF-6	12/78	4/79	1080	1036	44	31	12	39	82
PF-5	3/79	8/79	1340	1974	634	60	18	74	152
PF-4	6/79	7/79	460	600	140	18	6	22	46
PF-21	8/79	9/79	640	301	(339)	9	4	11	24
PF-24	8/79	10/79	1040	923	(117)	28	4	35	67
PF-11E	10/79	12/79	380	272	(108)	9	2	10	21
PF-14C	10/79	12/79	680	587	(93)	19	8	22	49
PF-13C	10/79	2/80	800	629	(171)	21	6	24	51
PF-14A	12/79	2/80	600	636	36	21	4	24	49
PF-14B	2/80	7/80	1000	876	(124)	29	7	33	69
PF-13A	3/80	4/80	1500	1062	(438)	35	13	40	88
PF-11C	4/80	7/80	1390	833	(507)	27	5	31	63
PF-11A	7/80	9/80	1180	739	(441)	24	8	28	60
PF-11B	10/80	12/80	1280	1196	(84)	38	9	45	92
PF-11D	11/80	2/81	1080	1172	92	38	9	44	91
PF-12	1/81	1/83	1760	3783	2023	124	25	142	291
PF-10A	2/81	1/83	3280	6533	3253	242	33	246	521
PF-10B	3/82	7/82	920	1697	777	63	10	64	137
PF-3	7/82	9/82	1280	1065	(215)	40	12	40	92
Exhaust Systems	2/80	3/83	1920	1934	14	74	21	73	168
Facility Cleanup	1/83	3/83	600	391	(209)	16	15	15	46
Totals	4/78	3/83	26200	30315	4115	1028	251	1140	2419

components from gloveboxes PF-10 and PF-12 that would not fit the standard bin. In order to avoid costly size reduction operations which would have further delayed project completion, arrangements were made by DOE-RL for acceptance by Rockwell-Hanford, and the containers, which had combined weight of about 42,000 pounds, were promptly shipped to them at an estimated savings of about $75,000. Table 6-1 provides a summary of the waste generated from each of the various gloveboxes and the associated radioactivity.

7.0 Health Physics Program

The Health Physics effort during this D&D program was concerned with attaining these objectives:

- To assure that decommissioning activities were carried out in accordance with the radiation-protection standards in DOE Order 5480.1A, Chapter XI, REQUIREMENTS FOR RADIATION PROTECTION (Reference 3) or the corresponding precursory manual chapters and the ANL HEALTH AND SAFETY MANUAL (Reference 4) and with due regard for the ALARA philosophy.

- To delineate, carry out, and document a Health Physics Program which provided suitable procedures for maintaining control of contamination and personnel exposures.

- To perform instrument and smear surveys, establish an air-monitoring program and maintain records of the readings and sample results.

Table 6-1

Building 350 Glovebox Project

Radioactive Waste Summary

Glovebox Number	Low Level Waste Volume - Ft^2 Estimate	Actual TRU	Actual LSA	Actual Total	Weight - Pounds TRU	Weight - Pounds Non-TRU	Radioactivity ^{239}Pu Grams	Radioactivity Total Curies
PF-3	720	840	0	840	18900	0	223.5	19.62
PF-4	480	240	240	480	4400	3400	2.2	0.24
PF-5	1800	1320	0	1320	27600	0	13.2	1.16
PF-6	840	840	0	840	16200	0	8.1	0.70
PF-7	720	840	0	840	14200	0	7.1	0.61
PF-8	360	480	0	480	9500	0	4.8	0.40
PF-9	80	60	0	60	1100	0	0.5	0.05
PF-10A	2880	180	2540	2720	4300	108400	0.4	0.02
PF-10B	720	540	180	720	12000	2800	50.4	4.50
PF-11A	840	240	300	540	7000	6200	3.1	0.27
PF-11B	840	0	840	840	0	30900	0.1	0.01
PF-11C	840	60	360	420	1000	8100	0.6	0.06
PF-11D	1200	0	780	780	0	31400	0.1	0.01
PF-11E	120	120	0	120	3000	0	1.5	0.12
PF-12	1080	1560	200	1760	32900	12300	148.8	13.55
PF-13A	1080	960	0	960	20900	0	15.4	2.09
PF-13C	480	420	0	420	9800	0	192.5	16.19
PF-14A	240	300	0	300	6600	0	24.0	2.04
PF-14B	480	240	300	540	4700	26000	11.1	0.94
PF-14C	720	600	0	600	12000	0	11.0	0.92
PF-21	240	300	0	300	6000	0	3.0	0.26
PF-24	480	60	300	360	1400	5800	0.8	0.07
Exhaust Systems	3360	900	780	16780	17200	17000	18.6	1.60
Other Waste	1400	240	1080	1320	3700	25500	0.8	0.07
Totals	22000	11400	7900	19300	235100	273800	741.6	65.50

- To provide evaluations of proposed work procedures through safety review and indicate desirable modifications to ensure that personnel exposures and the potential spread of contamination were minimized.

- To perform radiation surveys and/or gamma spectrometry, assays of equipment, gloveboxes, ductwork, and samples to evaluate and document the radionuclide content and concentration in the decommissioning waste, and to determine its disposition as nonradioactive, low specific activity (LSA) or transuranic (TRU).

- To document by a final certification survey, including instrument and smear samples, that decontamination efforts have reduced contamination to acceptable levels consistent with the reuse of the facility.

From the beginning, it was recognized that the high levels of plutonium surface contamination (up to 10^{10} dpm/ 100 cm^2) in the gloveboxes would represent a condition which would require an active and extensive routine survey program to maintain contamination control in the work area. Since the main concern was the potential for internal exposure, special effort was directed toward personnel, clothing, and equipment surveys in conjunction with the routine surveys, and air-monitoring programs.

7.1 Procedure Review

Procedure review was provided by a Planning and Review Committee consisting of three members--one of them the Staff Health Physicist. This group reviewed all plans involving removal and/or size reduction of glovebox systems to assure that appropriate consideration had been given to the safety aspects. Finalized plans and procedures were sent to the Director of the Occupational Health and Safety Division for formal approval and these documents became part of the D&D Plan for the Glovebox Facilities in Building 350 (Reference 5).

7.2 Routine Surveys

Floor surveys of the entire work area were performed twice each day. Three hand and shoe monitors were strategically located in the area to facilitate checking for hand and shoe contamination and these were also checked for proper operation twice daily. An Eberline Alpha-3 constant air monitor, containing a silicon diffused-junction solid state detector was located near the Size Reduction Enclosure (SRE) and was used to continuously monitor for the 5.15 MeV ^{239}PU alpha particles (Figure 7-1). In addition, the membrane filter on this unit was changed daily and counted in an a. c. scaler. A continuous air sample was obtained from the building exhaust stack. The filter paper was changed every other day and counted for radioactivity. Smear surveys of taped surfaces were performed twice each week,

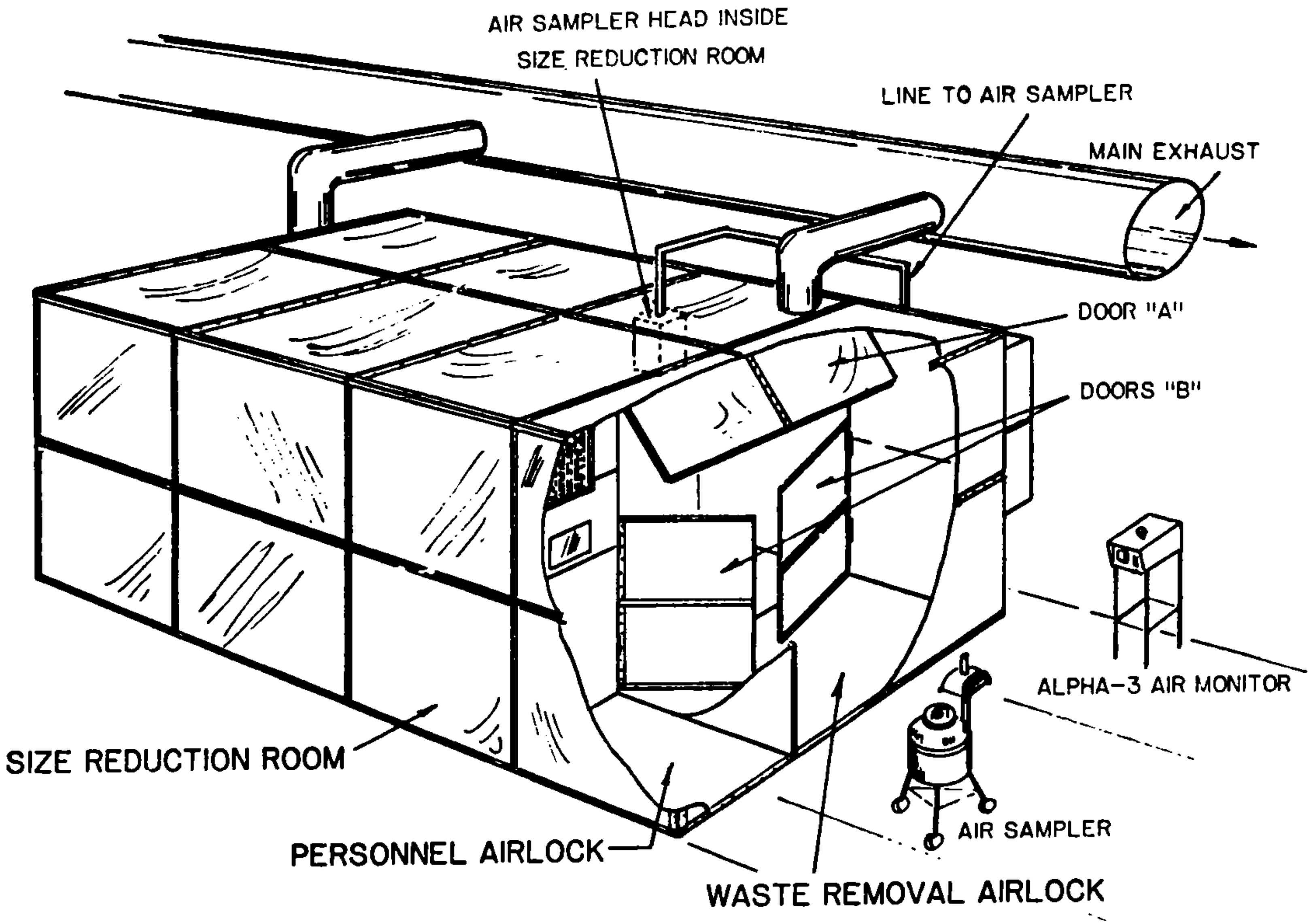


Figure 7-1 Size Reduction Facility Sketch

read directly with an Eberline PAC-4G (Figure 7-2) and counted on an a. c. scaler if the direct reading indicated no activity above background. All operations which involved cutting into utility systems or cuts on plastic pouches were surveyed using a PAC-4G. Personnel involved in dismantling operations were surveyed prior to breaks, lunch, and the end of their work shift. All work clothing was resurveyed prior to washing.

Although several minor incidents of room contamination were experienced during the five years of operations, these incidents were not very frequent in occurrence, were limited to localized areas, and were easily decontaminated so that little delay in operations was incurred. Since most of these contamination incidents were discovered during the course of performing routine survey procedures, it is felt that these procedures greatly aided in maintaining contamination control.

Results of the stack-sampling program revealed that the double HEPA-filtering of the exhaust air resulted in no release of plutonium contamination to the environment during the duration of this project.

The Alpha-3 monitor alarmed twice during the four-year period; both times due to unusually high radon concentrations. There were no alarms due to release of plutonium from the SRE during size reduction operations. All a. c. scaler counts taken on the millipore filters removed from the air-monitor decayed to background levels. All general-area air samples taken during the duration of the project decayed to background levels.

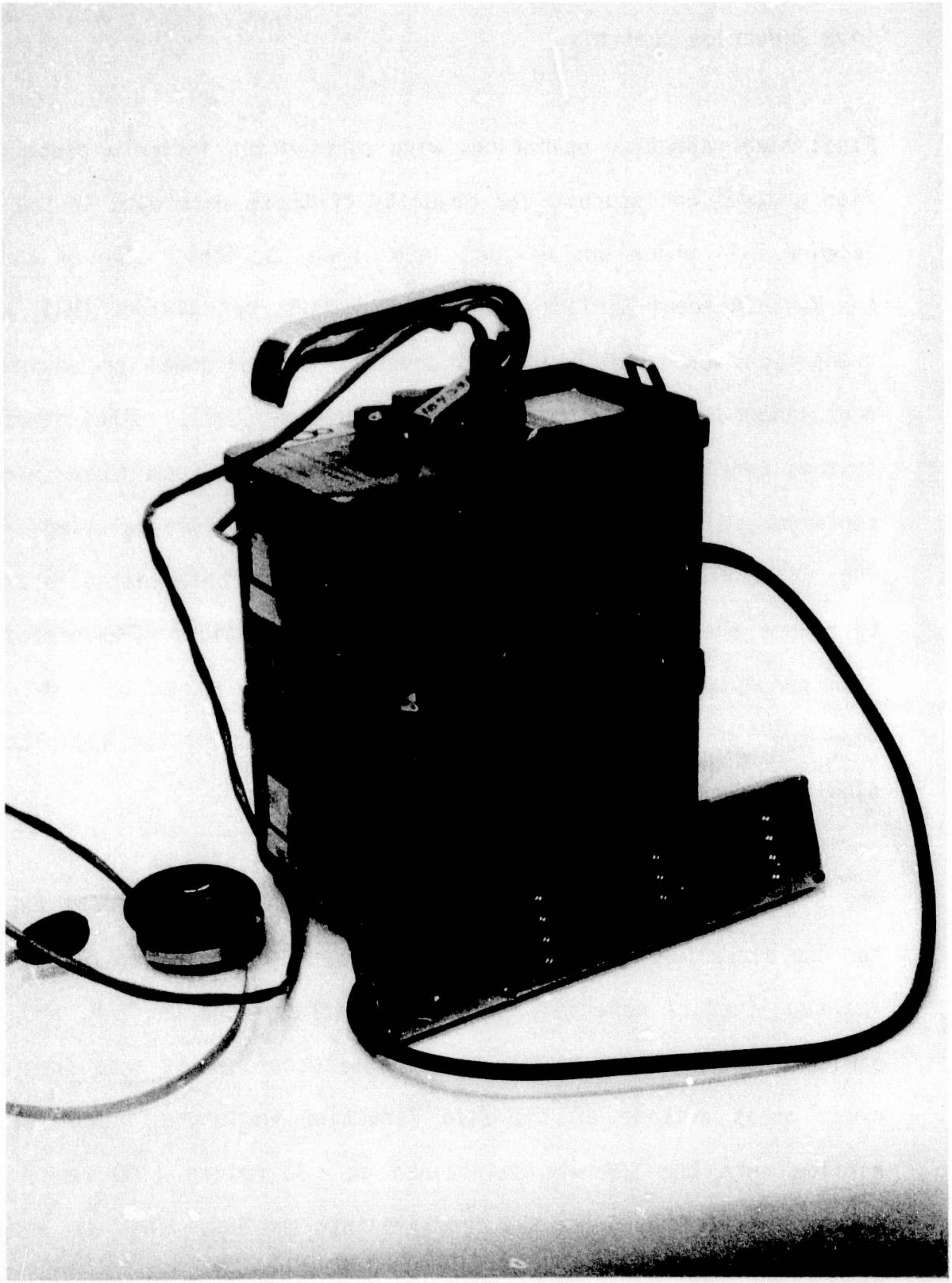


Figure 7-2 Eberline PAC-4G3 with 51 cm^2 Probe

7.3 Size Reduction Controls

Final size reduction operations were carried out inside a contamination control enclosure. The majority of these were done in the SRE (Figure 7-1) which was divided into three sections Two of these, the Waste Removal Airlock (WRA) and the Personnel Airlock (PA), were transition zones which allowed movement of personnel or equipment from clean areas into the Size Reduction Room (SRR). Since glovebox systems were size reduced in the latter zone, this room became highly contaminated (on occasion $\geq 10^6$ dpm/50 cm^2 alpha). Several times during the course of this project, this room was decontaminated in order to reduce the potential for spread of contamination. The procedure used consisted of dry vacuuming of the floor followed by a wet rag wipe down of the walls and floor and then covering the old plastic floor sheeting with a new layer.

The Size Reduction Room of the SRE served as the confinement region for the plutonium contamination. Containment was achieved by utilizing two lines of defense: an airflow pattern into the SRR, and the airlocks which separated the contaminated confinement area from the clean areas outside of the Size Reduction Enclosure. The linear airflow into the SRR was maintained at ≥ 30 meters (100 feet) per minute through the PA and WRA doorways into the SRR. This was accomplished by keeping the upper swinging door A shown in Figure 7-1 in a fixed position and by placing a sheet of plywood across the lower opening in order to reduce the area thru which the air passed when doors B (Figures 7-1 and 7-3) were both wide open. Prior to the start of size reduction operations, airflow rates for various sized openings were measured, utilizing an Alnor velometer, so as to determine the optimum size of the barrier needed to achieve the desired flow rate. This arrangement was then used whenever enclosure operations were conducted.

Since the purpose of the airlocks was to maintain a barrier to prevent contamination spread, both airlocks were surveyed before and after each tent entry. Any contamination which was noted was immediately wiped up before the start of any further operations.

Prior to actual size-reduction operations, a system of protective clothing and respiratory equipment was developed (Section 4.3.5.3). Dress rehearsals or dry runs were carried out to test both the components being worn, as well as, dressing procedures and tent entries and exits. These practice sessions were performed by the actual workers who would be doing the dismantling and the two Health Physics technicians assigned to the project. The technicians assisted the workers while they dressed for entry, surveyed the workers while helping them remove contaminated protective clothing prior to exiting the Size Reduction Room, and performed a final survey of an individual as he was about to exit the enclosure.

The practice sessions allowed trouble shooting of the proposed dressing and entry-exit procedures and permitted revision of flawed procedures prior to the start of actual operations. The personnel became

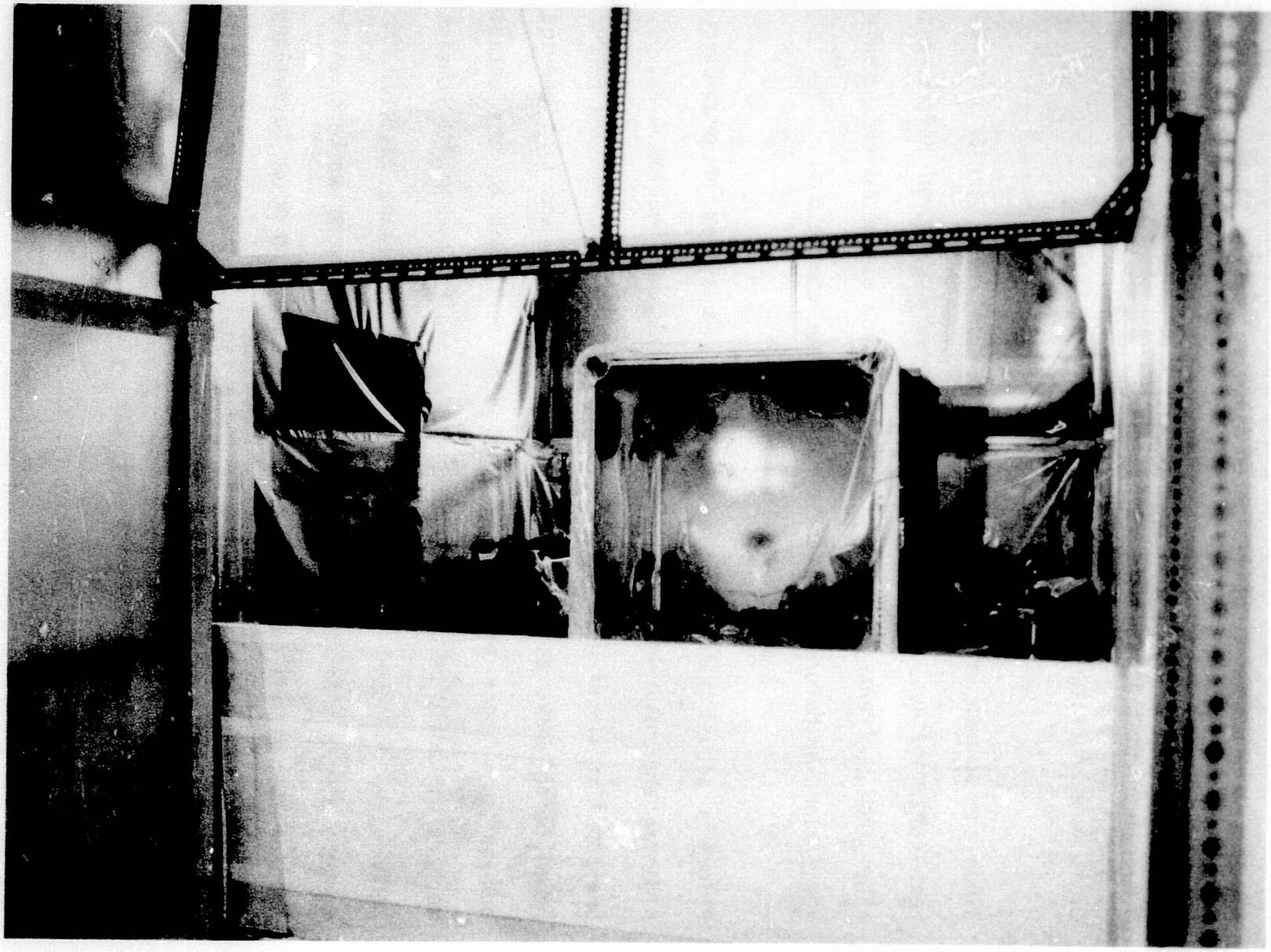


Figure 7-3 Plywood Barrier Positioned in Size Reduction Facility

familiar with the protective clothing, respiratory devices, and communications equipment necessary to carry out the operations safely. These sessions also helped establish the teamwork between the Health Physics personnel and the size reduction workers which was necessary for successful operations.

Health Physics support during all size-reduction operations consisted of standby coverage with two technicians during all SRE entries. These technicians assisted the work crew both during entry into, and exit from, the SRE. The use of the second technician proved absolutely necessary to expedite final checkout of workers exiting the tent while the other technician operated in the Personnel Airlock, helping crew members during de-suiting. In addition, his presence allowed for assisting the other technician on the few occasions when the first technician became contaminated. Also, on two or three occasions, the second technician was able to detect low-level contamination on worker's clothing before they exited the SRE.

Following any size-reduction work, and after the work crew was de-suited and out of the SRE, all Supplied Air Hoods worn in the SRE were carefully resurveyed to ensure that they were free of contamination. Smears were taken on all wooden liners containing glovebox pieces and they were counted in a. c. scalers to determine if any low-level loose contamination, not detectable by survey instrumentation, was present. In addition, the floor area of the Fabrication Area was surveyed with floor monitors, (330 cm^2 probe), utilizing an Eberline Pac-4G3.

Although contamination was occasionally found in the airlocks, it generally occurred as isolated spots near the entrances to the SRR, was of low activity (<5 X 10^4 dpm/50 cm^2 alpha) and was easily wiped up. On one occasion, levels as high as 4 X 10^5 dpm/50 cm^2 alpha were found in the airlocks, but no cases of contamination spread outside of the airlocks to the clean areas were noted. Some of the success in controlling contamination spread in the Waste Removal Airlock can be attributed to the presence of Health Physics coverage during loading of the liners, so that any actions which could have led to the development of large "spills" were caught and corrected before control was lost.

Filter paper air samples were taken both inside of the SRR and outside of the enclosure during all SRE entries (refer to Figure 7-1 for air-sampler locations). In addition, the Alpha-3 monitor which was set to alarm in the event of a release was situated in the immediate vicinity of the SRE. One of the crew members performing the size reduction would position the filter paper at the start of the operations and then remove it from inside the SRR when work was finished for the day. The samples were then counted on a. c. scalers to obtain the measured concentration. The results were compared to the Concentration Guide (CG) for ^{239}Pu (2 X 10^{-12} μCi/ml) found in Chapter XI of DOE order 5480.1A (Reference 3). In addition to these samples, personal air samplers were worn, on occasion, during size-reduction operations by the crew members. These filter samples were taken at a frequency of roughly one for every fifteen entries. The sample holder was located inside the hood worn by one of the workers in order to document the effectiveness of the protective suit and the supplied-air hood.

During the 153 enclosure entries, approximately 140 usable air samples were obtained inside the SRR. Several samples were lost due to inadvertent contamination of the sample during recovery, and on one occasion, the sample holder itself became contaminated and had to be removed and replaced. Results for the uncontaminated samples taken inside the SRR ranged from background to 13,700 X CG for ^{239}Pu. Samples taken outside the SRE yielded results which ranged from background to 0.74 X CG for ^{239}Pu, with the vast majority of the results being 0.1 X CG for ^{239} Pu, except for one. This sample showed 8 X CG for ^{239} Pu and was obtained during an operation in which the floor of the WRA had become contaminated. On this occasion, no contamination was found outside of the Waste Removal Airlock and the Alpha-3 monitor did not indicate an elevated reading.

For the samples taken inside the SRR, a distinct difference was noted for operations involving the cutup of gloveboxes which had been spray painted as opposed to those items, such as ductwork, pipes, etc., which could not be painted. Much higher results were obtained for the air samples taken when unpainted objects were cut up. This behavior was no doubt due to the greater mobility of the contamination when it had not been "fixed" with paint. Also, the nature of the material which deposited in ducts or air pipes tended to become more easily airborne. For the samples taken during reduction of painted systems, the results generally ranged up to a few hundred times the CG value; whereas, for operations involving unpainted surfaces, the results generally were in the range of a few thousand times the CG value. The highest result obtained for operations involving painted components was 2200 X CG, and only two samples exceeded 1000 X CG. The highest results obtained for unpainted systems was 13,700 X the CG and there were thirteen samples $\geq$1000 X CG of ^{239}Pu. Since most of the systems handled were painted, it is felt that using this technique prior to size reduction directly contributed to the excellent contamination control achieved during such operations. This was evidenced by the air-sample results which were obtained outside of the SRE.

With respect to the personal air sampler results, all thirteen of these samples decayed to background. Since, samples taken during each of the first six entries had negative results, the frequency was then decreased. In addition to the sampling checks, the respiratory protection afforded by the suit-hood protective apparel was evaluated by individual testing using a DOP particle fit-test apparatus. The results of these tests indicated a protection factor in the range 3000-4000 for the various exercises used to simulate work activity.

7.4 Personnel Dosimetry

Finger rings containing TLD chips and film badges, were worn by all personnel directly involved with volume reduction operations, as well as, by Health Physics technicians monitoring the operations. Approximately 30 different individuals were involved in the various facets of the job, although not all were directly involved in the dismantling and size-reduction operations. The average monthly hand or finger exposure, as indicated by the finger-ring results, was 15 mrem and the maximum individual monthly hand exposure recorded was 230 mrem. A total of 3.01 person rem of finger exposure was incurred over the duration of the size-reduction program.

Film badge results indicated an average monthly exposure of 25 mrem. The maximum individual monthly exposure recorded was 115 mrem. A total of 5.6 person-rem exposure was recorded on film badges during the entire operation.

Exposure control was facilitated by the high percentage of low-energy photon radiation emanating from ^{239}Pu and ^{241}Am, and the apparent absence of high-energy components from ^{240}Pu. Even when work was carried out inside the glovebox systems, the glovebox gloves afforded sufficient attenuation of the low-energy photons so that hand exposures were not a problem. The thick 1 cm (3/8") CR-39 plastic windows provided excellent shielding to reduce the potential whole-body exposures. Portable lead shielding was also employed for certain high-reading objects to reduce exposure to the workers while removing waste or dismantling equipment inside the boxes.

The program to assess any internal dose resulting from the intake of contamination utilized the following approach for routine determinations of concentrations and potential intakes:

- Initial bioassay samples and whole-body counting were performed for all size-reduction personnel and Health Physics technicians. Both urine and fecal samples were required.

- Periodic bioassay samples and whole-body counting were repeated after the individual began work on the project. Initially, individuals were recounted frequently but the intervals were extended when results indicated no intakes were occurring.

- Personal air samples were taken inside the supplied-air hood worn by the workers. When no activity was detected on the initial six entries, the frequency of sampling was relaxed to about one sample per fifteen entries. As discussed previously, no activity was detected on any of the personal-air samples obtained during the operations. The sample results were also confirmed by the results of bioassay and whole-body counting.

- Contamination concentrations were measured within the enclosure by the use of particulate air samples. The results obtained were previously discussed under air sampling.

In the case of suspected intake, as indicated by personnel contamination, nose blows were obtained. If activity was detected on the nose blow, bioassay samples and/or whole body counting were performed to determine any intake. Of thirteen potential intake incidents which involved personnel contamination in the five year history of this project, there were two cases of internal contamination, involving three individuals. One individual suffered a cut on his index finger while using a contaminated hacksaw in a glovebox. A wound monitor indicated a small amount of Pu in the finger (~7 nCi) most of which was excised. Chelation was also attempted, but no significant contamination showed up in subsequent bioassay samples.

The other incident involved two individuals who were attempting to perform cleanup operations on a glovebox system. Apparently, a pinhole leak in the gloves lead to contamination of these individuals and a suspected intake as indicated by positive nose blow results following discovery of an elevated initial reading on an air sample taken in the vicinity of the glovebox. Lung counts taken on these individuals indicated the presence of ^{241} Am. Using ICRP 30 (Reference 6) methodology and bioassay sample data, the intakes were computed as 3.4 nCi ^{239}Pu and 6.8 nCi ^{241}Am for one worker and 0.6 nCi (^{239}Pu and 1.2 nCi ^{241}Am for the other. These estimates lead to computed effective committed dose equivalents of 4.67 and 0.83 rem, respectively.

All other potential intakes did not result in measurable depositions as shown by the results of whole-body counting and/or bioassay samples.

7.5 Documentation

Results of all radiation surveys, air sampling data, survey instruments and assaying equipment calibrations; radionuclide identification and concentration in waste containers; radionuclide spectra of various samples, along with data associated with bin contents and tent entries has been documented and archived by Health Physics. Surveys were recorded on ANL/HP survey record sheets and air sample data and results were recorded on ANL/HP air sample data sheets. A daily log was instituted to track progress on the project as well as to record pertinent day-to-day information concerning glovebox systems, such as size, estimated weight and contamination levels. Photographs of individual glovebox systems and other information relevant to assay and identification of the glovebox were also entered into this log.

An additional log book containing data pertaining to each tent entry was kept. Information recorded in this log included; names of tent entry personnel, pertinent information about events or operations which took place, air sample information and data, and the duration of each entry. Any unusual events or occurrences were also noted in this log.

With respect to the assay of the glovebox systems, a calibration log was kept to detail the results of various calibrations utilizing different geometries, various sizes and thicknesses of different absorbers, and different shielded detectors. In addition, the analysis of counting data, discussions of instrument set-up parameters for the assay equipment, data for the calibration sources, and other measurement data relating to the calibration of the assay equipment, are contained in this log. Documentation of the spectra obtained for glovebox assays was initially accomplished by teletype printout and punched tapes. Later the equipment was upgraded and teletype printouts and cassette tape recordings, in some cases, were used. Details of assay procedures and equipment are discussed in Appendix C. A final certification survey, utilizing both instrument and smear techniques, was performed to document the condition of the Fab Area prior to release to NBL. The results of this survey can be found in Appendix B.

8.0 Final Facility Condition

After completion of the D&D, the area which housed the PFF was turned over to the New Brunswick Laboratory for their use (Figures 8-1 & 8-2). Since destructive decontamination was unnecessary, no rehabilitation was required before they could occupy the area. However, the programs which were intended to be performed in the Fab area by NBL were cancelled due to budget cuts so the space is being used for storage and no dollar savings can be directly attributed to this project.

9.0 Lessons Learned

Less manpower, but not cost, would have been needed had a well-engineered, permanent, size-reduction facility been available as initially envisioned. This would have permitted whole glovebox sections to be totally dismantled by "hands-on" techniques rather than the more time-consuming "thru-the gloves" method. However, planning for

Figure 8-1 Fab Area After D&D - Front to Rear

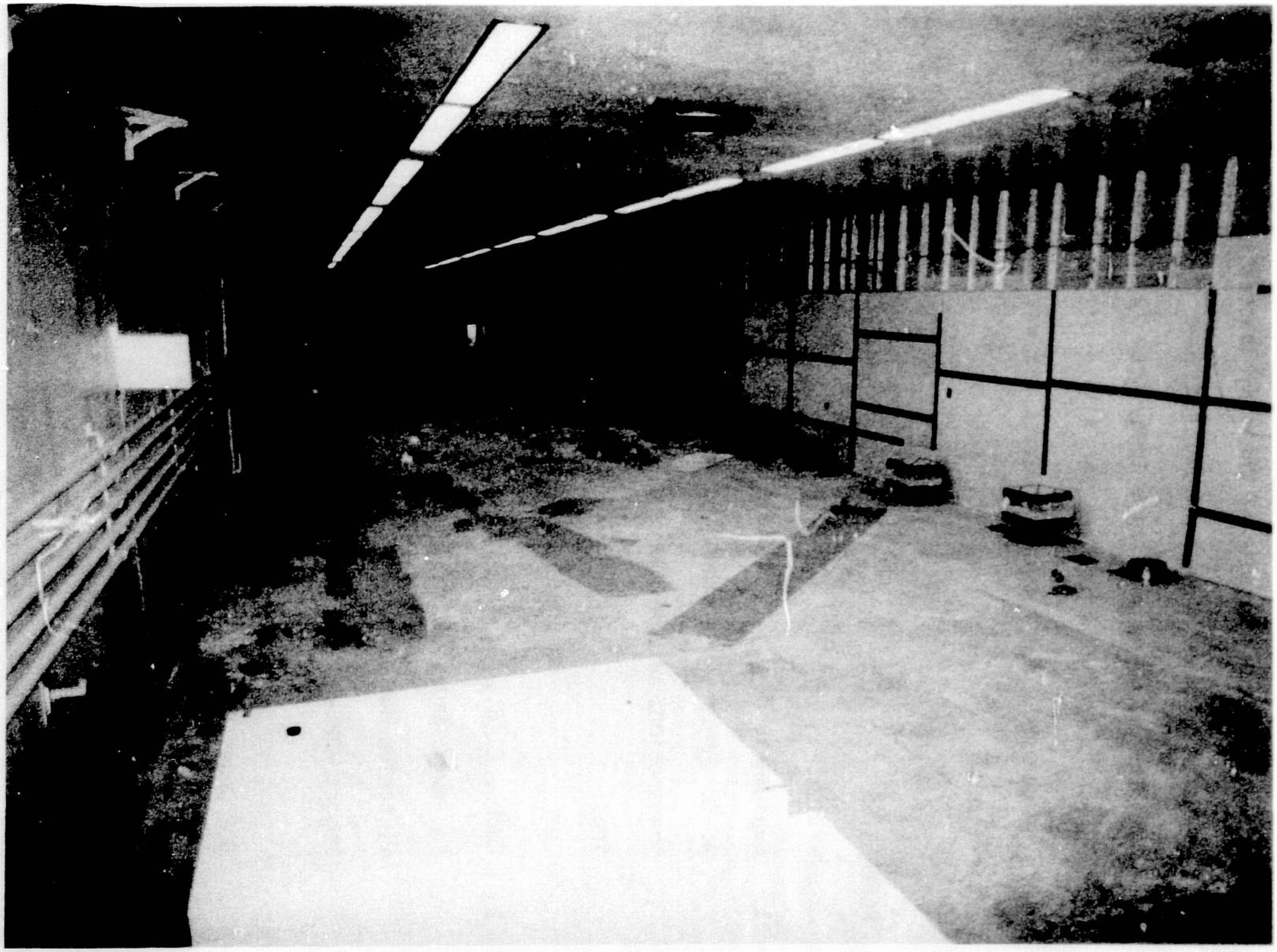


Figure 8-2 Fab Area After D&D - Rear to Front

such a facility was cancelled when similar future work seemed unlikely. Decontamination to less than the 10 nCi/g TRU levels was not overly successful because of the many inaccessible surfaces, but this trend might have been reversed had some of the more sophisticated methods becoming available today been fully developed several years ago. Overall the project met all of its objectives, provided useful experience for future endeavors and was considered a notable achievement.

10.0 REFERENCES

1. Koprowski, B. J., L. R. Kelman, D. R. Schmidt, S. Parker, A. G. Januska; "Dismantling a Plutonium Fabrication Facility," Transactions of the American Nuclear Society, 1975 Winter Meeting.

2. Roche, C. T., J. J. Vronich, F. O. Bellinger, and R. B. Perry, "A Nondestructive Assay System for Use in Decommissioning a Plutonium-Handling Facility," Argonne National Laboratory Report, ANL-79-60, July 1979.

3. DOE Order 5480.1A, "Environmental Protection, Safety, and Health Protection Program for DOE Operations," U.S. Department of Energy, Washington, D. C., August 1981.

4. Argonne National Laboratory, "Health and Safety Manual, ANL," Argonne, IL, July 1983.

5. Kline, W. H., "Plan For Decontamination and Decommissioning The Building 350 Plutonium Fabrication Facility," Argonne National Laboratory, June 1978, Revised June 1979.

6. ICRP Publication 30, Part 1, "Limits for Intakes of Radionuclides by Workers," Pergamon Press, Oxford 1979.

7. "Environment Assessment For Decontamination and Decommissioning of Plutonium Fabrication Facility, Building 350," Argonne National Laboratory, DOE/EA-0082, December 1978, Revised September 1979.

ABBREVIATIONS

ANL	Argonne National Laboratory
D&D	Decontamination and Decommissioning
DOE	U. S. Department of Energy
EG&G	EG&G Idaho
EW	End Window
FTC	Fuels Technology Center
HAR	Helium Atmoshpere Return
HEPA	High Efficiency Particulate Air (Filter)
ICRP	International Commission on Radiological Protection
INEL	Idaho National Engineering Laboratory
LSA	Low Specific Activity
MCA	Multichannel Analyzer
NBL	New Brunswick Laboratory
Normal	Normal Air Exhaust
NIOSH	National Institute for Occupational Safety and Health
OHS	Occupational Health and Safety Division
PA	Personnel Airlock
PAE	Process Air Exhaust
PFF	Plutonium Fabrication Facility
PFS	Plant Facilities and Services Division
Purge	Purge Exhaust System
PVC	Polyvinylchloride
Room	Fabrication Area Exhaust
RWMC	Radioactive Waste Management Complex
SFMP	Surplus Facilities Management Program
SRE	Size Reduction Enclosure
SRR	Size Reduction Room
TRU	Transuranic
WMO	Waste Management Operations
WRA	Waste Removal Airlock

APPENDIX A

NBL Requirements for the D&D at Building 350

Department of Energy
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

RECEIVED
W. H. KLINE
JAN 25 1983

Billy D. Shipp, Director
Technology Management Division

SUBJECT: BUILDING 350 PLUTONIUM GLOVEBOX DECONTAMINATION AND DECOMMISSIONING (D&D) PROJECT

Pursuant to my discussions with Messrs. F. Gorup and T. Adams, of your staff, and Mr. W. Kline, Project Manager, Argonne National Laboratory (ANL), and as requested, I am hereby submitting the following information concerning our agreements for final acceptance for the completion of the subject project. The 350 fan room drawing is attached for reference.

1. Remove purge exhaust duct up to primary filter housing.

2. Cap off primary purge filter housing inlet and outlet and replace HEPA filters.

3. Remove normal exhaust duct from fan room east wall to existing HEPA filter housing, and cap off openings (normal exhaust duct located in laboratory ceiling area can remain).

4. Remove temporary supply air duct from Fabrication area to laboratory ceiling area.

5. Remove remaining Fabrication area floor covering.

6. Decontamination of Fabrication area shall be such that activity levels greater than 500 dpm/100 cm^2 will be cleaned to less than this level or immobilized by tape and/or paint. Those areas having fixed levels of contamination shall be identified on the final survey diagram or area map.

In addition, it was agreed that three wooden crates containing radioactive waste material may be temporarily stored in the Fabrication area until waste shipment arrangements are finalized. Also, I am requesting that the temporary plaster board wall separating the Fabrication area from the laboratory block wall and ceiling area be left intact.

If there are any questions concerning the above agreements, please feel free to contact me.

Carleton D. Bingham, Director
New Brunswick Laboratory

Enclosure:
As Stated

cc: S. Mann, TMD, w/encl.
F. Gorup, TMD, w/encl.
T. Adams, TMD, w/encl.
W. Kline, ANL, w/encl.
L. Cheever, ANL, w/encl.

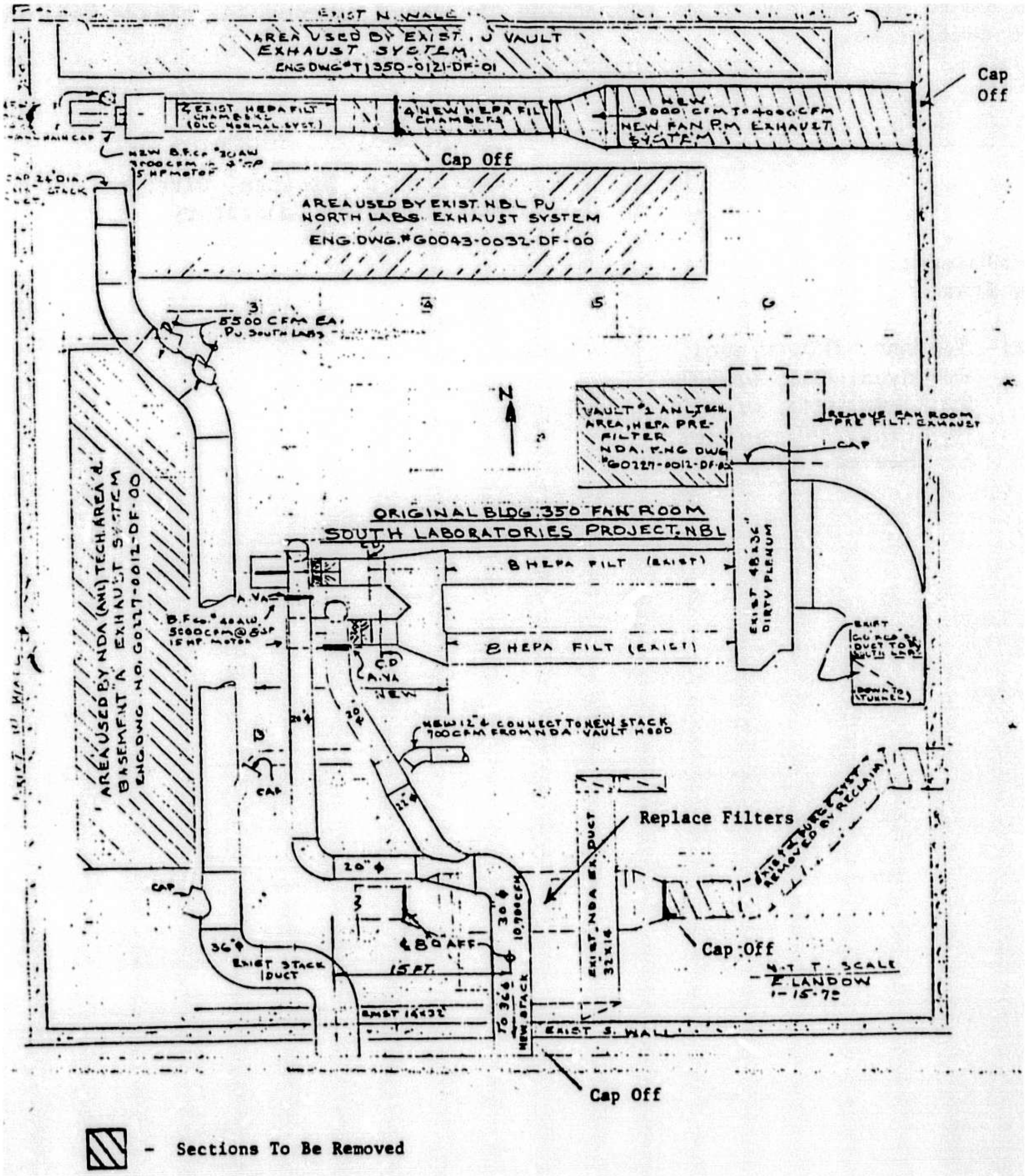


Figure A-1 350 Fan Room Area Drawing

Department of Energy
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

RECEIVED
W. H. KLINE
APR 20 1983

PR 22 1983

Billy D. Shipp, Director
Technology Management Division

SUBJECT: BUILDING 350 PLUTONIUM GLOVEBOX DECONTAMINATION AND DECOMMISSIONING (D&D) REQUEST

Reference: Memo, Bingham to Shipp, dated January 24, 1983, subject as above

This will confirm my discussions with Mr. W. Kline, Project Manager, Argonne National Laboratory (ANL), on March 11, 1983, and Mr. F. Gorup, of your staff, on April 20, 1983, regarding the disposition of that portion of the Purge Exhaust duct system which passes through the wall between the Fabrication area and the Fabrication Loft area. Since this section of duct work is firmly anchored in the wall and would require removal of the surrounding concrete with a jackhammer in order to gain access, it was agreed that this short length could be left in place, securely sealed at both ends, and properly labeled, indicating the interior radioactive contamination levels. Under these sealed conditions the remaining duct work will pose no health problem or safety hazard.

It was also agreed that there would be no useful benefit from the standpoint of safety or any other reason to replace the HEPA filters in the primary purge filter housing as originally stated in my referenced memorandum. Instead, it will be sufficient to only remove the used contaminated filters and reseal the openings.

If there are any questions concerning the above agreements, please feel free to contact me.

Carleton D. Bingham, Director
New Brunswick Laboratory

cc: W. Kline, ANL
L. Cheever, ANL
S. Mann, TMD
J. Haugen, TMD
F. Gorup, TMD

APPENDIX B

Building 350 Final Radiation Survey

ARGONNE
NATIONAL
LABORATORY

INTRA-LABORATORY MEMO

RECEIVED
W. H. KLINE
MAY 9 1983

May 5, 1983

To: W. H. Kline — D&D Projects Manager

From: R. A. Wynveen — Associate Division Director, OHS

Subject: Final Radiation Survey of the Fabrication Area - Building 350

Attached please find a memo and survey report for the subject activity.

As I believe you are aware, the smoke detectors inherently contain a radiation source. Also, one might expect to find some radioactivity due to radon daughters in the exhaust system, particularly in the filters. The direct surveys which gave positive readings can most probably be attributed, at least in part, to such sources.

If you should have any further questions, please feel free to discuss them with either Harold Moe or myself.

RAW.llc
Attachment

cc: H. J. Moe
D. P. O'Neil
File

ARGONNE
NATIONAL
LABORATORY

INTRA-LABORATORY MEMO

May 3, 1983

To: R. A. Wynveen — Associate Division Director, OHS

From: H. J. Moe — Health Physics, OHS
G. E. Kinsella
K. O. Jordan
A. E. Lissy
J. R. McDade
L. S. Wild
K. F. Klotz

Subject: Final Survey of the Fabrication Area - Building 350 - Following Completion of the Volume Reduction Program

The final survey of the Fabrication Area, Building 350, was completed April 16, 1983. The instruments used in this survey included a Ludlum GM counter, two Eberline PAC-4Gs, an Eberline PRM-5-3 and two Eberline floor monitors. A total of 181 smears were taken and counted on a.c. scalers in the various offices in the 300 West Area. Results for the direct surveys and the locations and results for smears which were taken can be found in the attachment.

The general background in the area as determined with a GM counter was 0.01 mR/h. Direct surveys of the walls, pipes along the south wall, and ledge on the north wall with a PRM-5-3 and a PAC-4G, in both the α and $\beta\gamma$ modes, indicated no readings in excess of the instrument backgrounds. The ceiling was surveyed with a PAC-4G in the $\beta\gamma$ mode and showed no readings in excess of background except for the three smoke detectors, which indicated 1500 cts/min-61 cm^2 $\beta\gamma$ above background at contact. Direct floor surveys were accomplished with Eberline floor monitors and indicated no readings above instrument backgrounds. Background was determined by observing the high and low readings of the instrument fluctuations, using the average of these two values as the background and the difference between either the high or the low reading and the average value as a measure of twice the standard deviation in the background.

Other direct surveys which indicated activity levels were the following: a survey of the capped-off duct on the west wall indicated 500 to 6500 cts/min γ above background on a PRM-5-3 at about 3 ft. away, the capped-off PAE line on the north wall read 14,500 cts/min γ above background on a PRM-5-3 at the capped end and the exhaust filters near the floor by the north wall read 750 dis/min-61 cm^2 α and 2500 cts/min-61 cm^2 $\beta\gamma$ above background at contact on a PAC-4G.

Readings taken around the crates housing the two uprights from PF-12 and the base from PF-10-A ranged from 500 to 40,000 cts/min γ on a PRM-5-3. It is expected that these items will be shipped out as waste in the near future.

One hundred and one smears were taken on the walls, ceiling, pipes along the south wall and ledge on the north wall. Eighty smears were taken on the floor of the Fabrication Area. Only one smear indicated α contamination in excess of 20 dis/min-100 cm^2, twelve other smears showed activity levels less than this value, but above the background count rate ± twice the standard deviation of the background. All other smears indicated α levels less than this criterion. All smears were $\leq$ 50 dis/min-100 cm^2 βγ.

A recount taken for twenty minutes of the smear which indicated more than 20 dis/min-100 cm^2 yielded a final value of 22 dis/min-100 cm^2. This smear was obtained from smoke detector #3 (see ceiling map).

All notes, documents, original maps and smears generated during this survey are being retained.

HJM.GEK.KOJ.AEL.JRM.LSW.KFK.llc
Attachment

ATTACHMENT

A survey of Building 350 Fabrication Area was performed on April 16, 1983. An overall background taken with a Ludlum Geiger counter was 0.01 mR/h $\beta\gamma$ (meter reading). Direct surveys of the ceiling, walls, pipes on the walls and the north wall ledge were taken. Backgrounds were from 2 k to 3 k cts/min-61 cm^2 $\beta\gamma$ and from 50 to 100 cts/min-61 cm^2 α. All surveys were less than or equal to the area background. The walls, pipes and ledge were then surveyed with a PRM-5-3 in the gross 1 mode. Backgrounds were from 1 k to 1.5 k cts/min γ. All surveys were less than or equal to the area background.

A survey of three smoke detectors in the ceiling was taken. The detectors read 1500 cts-61 cm^2 above background at contact. A direct survey of the capped-off duct located on the west wall was taken with a PRM-5-3 (gross 1). Background readings were from 1 k to 1.5 k cts/min γ. Readings of the duct were from 500 to 6.5 k cts above background approximately 3 ft. away.

Another survey of the capped-off P.A.E. line located on the north wall was taken. A PRM-5-3 in the gross 1 mode was used. Backgrounds were approximately 500 cts/min γ. The reading at the capped end was 14.5 k cts/min above background. One hundred and one smears were taken on the walls, ceiling, pipes on the south wall and the ledge of the north wall. These smears were taken every 16 ft. unless otherwise indicated on the maps.

Direct surveys of the fabrication area floor were taken. All surveys were less than or equal to the background of 350 to 400 cts/min-330 cm^2 $\beta\gamma$ and 500 to 1000 cts/min-440 cm^2 $\beta\gamma$. Eighty floor smears were taken. Surveys of the exhaust filters located near the floor by the north wall were 2500 cts above background.

Sources Used to Calibrate Instruments

^{137}Cs	7 μCi	300 k dis/min βγ	6 mR/h
^{239}Pu	HPFC set #5		7.6 k dis/min α 72 k dis/min α

Instruments Used

Eberline Floor Monitor - ANL #155228   440 cm² probe

Background   50 to 100 cts/min α   yield 28%
               500 to 1000 cts/min βγ

$(n_b + 2\sigma_b)\alpha = 75 \pm 25$ cts/min
$(n_b + 2\sigma_b)\beta\gamma = 750 \pm 250$ cts/min

Eberline Floor Monitor - ANL #183894

Background   50 to 100 cts/min α   yield 14%
               350 to 400 cts/min βγ

$(n_b + 2\sigma_b)\alpha = 75 \pm 25$ cts/min
$(n_b + 2\sigma_b)\beta\gamma = 375 \pm 25$ cts/min

Eberline Beta Pac - ANL #193813

Background   200 to 250 cts/min α   yield 50%
               1000 to 1500 cts/min βγ

$(n_b + 2\sigma_b)\alpha = 225 \pm 25$ cts/min
$(n_b + 2\sigma_b)\beta\gamma = 1250 \pm 250$ cts/min

Eberline Beta Pac - ANL #193803

Background   50 to 100 cts/min α   yield 50%
               2000 to 3000 cts/min βγ

$(n_b + 2\sigma_b)\alpha = 75 \pm 25$ cts/min
$(n_b \pm 2\sigma_b)\beta\gamma = 2750 \pm 250$ cts/min

PRM 5-3 (HV1 gross 1) - ANL #14489

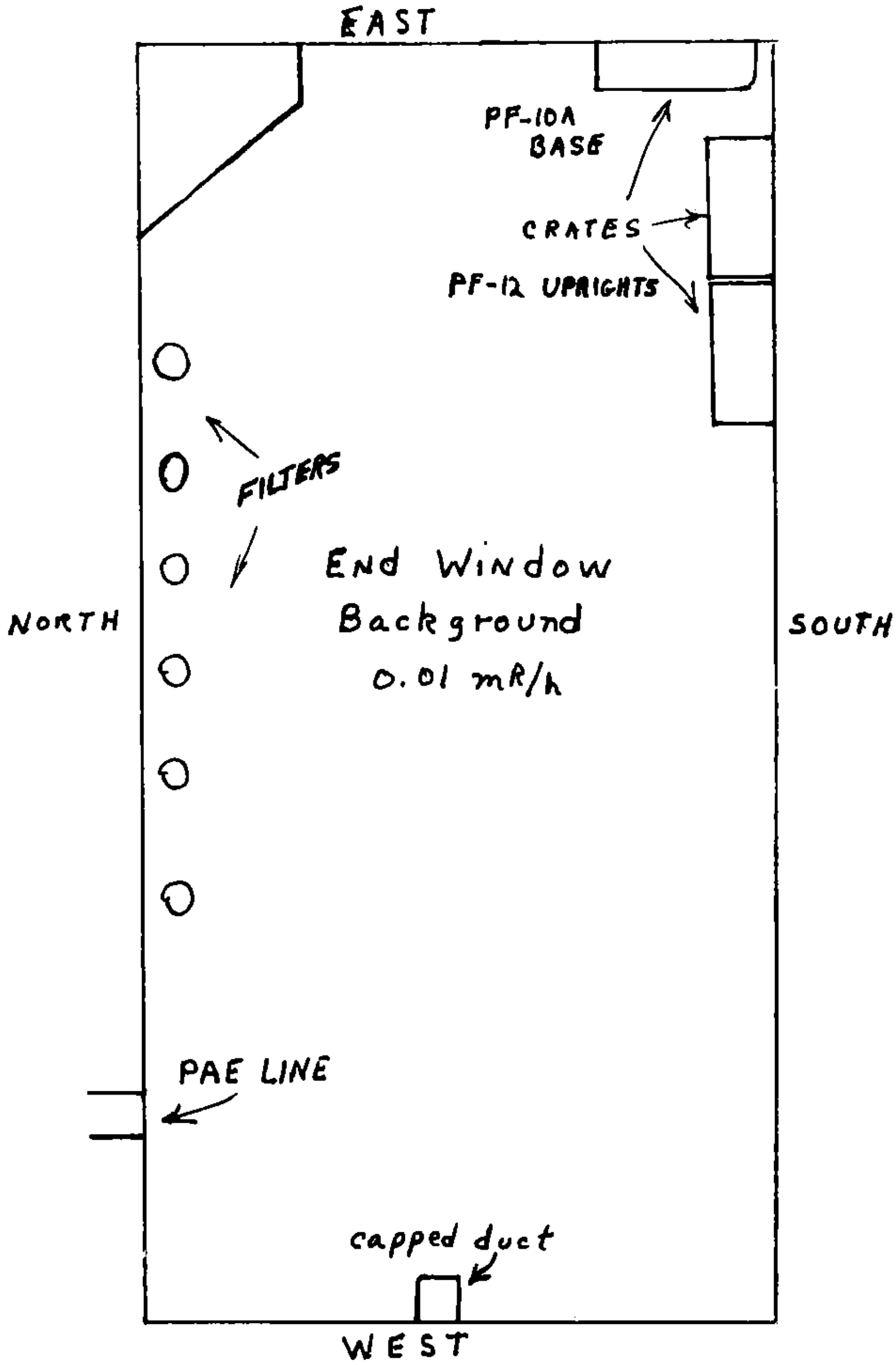
Background   1000 to 1500 cts/min α

$(n_b + 2\sigma_b) = 1250 \pm 250$ cts/min)

Ludlum End Window - ANL #25755

Fabrication Area

Building 350



Floor

EAST

NORTH (left side) / SOUTH (right side)

20	40	60	80
19	39	59	79
18	38	58	78
17	37	57	77
16	36	56	76
15	35	55	75
14	34	54	74
13	33	53	73
12	32	52	72
11	31	51	71
10	30	50	70
9	29	49	69
8	28	48	68
7	27	47	67
6	26	46	66
5	25	45	65
4	24	44	64
3	23	43	63
2	22	42	62
1	21	41	61

WEST

SMEAR AT CENTER OF GRID
~900 cm^2

FLOOR SMEARS

Smear#	dpm/100 cm^2 α*	dpm/100 cm^2 βγ*	Smear#	dpm/100 cm^2 α*	dpm/100 cm^2 βγ*
1	1.2 ± 0.9	4.2 ± 5.3	21	2.1 ± 1.0	1.4 ± 5.3
2	- 0.4 ± 0.7	3.1 ± 5.3	22	0.4 ± 0.8	4.2 ± 5.3
3	0.6 ± 0.9	5.2 ± 5.3	23	- 0.2 ± 0.8	6.4 ± 5.3
4	1.4 ± 1.0	- 6.1 ± 5.1	24	- 0.4 ± 0.7	3.8 ± 5.3
5	0.0 ± 0.8	3.5 ± 5.3	25	- 0.2 ± 0.8	- 5.6 ± 5.1
6	1.2 ± 0.9	5.0 ± 5.3	26	0.4 ± 0.8	- 1.7 ± 5.2
7	- 0.4 ± 0.7	8.0 ± 5.4	27	- 0.4 ± 0.7	0.3 ± 5.2
8	0.6 ± 0.9	8.2 ± 5.4	28	0.2 ± 0.8	4.9 ± 5.3
9	0.6 ± 0.9	- 3.5 ± 5.2	29	- 0.8 ± 0.7	5.2 ± 5.3
10	- 0.2 ± 0.7	5.9 ± 5.3	30	2.1 ± 1.0	0.9 ± 5.2
11	- 0.4 ± 0.7	4.3 ± 5.3	31	0.4 ± 0.8	0.5 ± 5.2
12	0.4 ± 0.8	- 1.2 ± 5.2	32	- 0.4 ± 0.7	4.5 ± 5.3
13	- 0.6 ± 0.7	- 2.3 ± 5.2	33	0.0 ± 0.8	- 8.2 ± 5.1
14	- 1.2 ± 0.6	- 5.7 ± 5.1	34	0.2 ± 0.8	- 1.2 ± 5.2
15	0.2 ± 0.8	- 2.6 ± 5.2	35	0.4 ± 0.8	6.4 ± 5.3
16	0.2 ± 0.8	- 2.4 ± 5.2	36	- 1.0 ± 0.6	4.5 ± 5.3
17	- 0.8 ± 0.7	3.3 ± 5.3	37	- 1.2 ± 0.6	- 6.4 ± 5.1
18	0.0 ± 0.8	14.2 ± 5.5	38	0.0 ± 0.8	- 4.7 ± 5.2
19	0.0 ± 0.8	13.5 ± 5.4	39	- 1.2 ± 0.6	3.1 ± 5.3
20	1.0 ± 0.9	- 1.6 ± 5.2	40	0.6 ± 0.9	- 1.7 ± 5.2

*Results: activity ± standard error (dpm/100 cm^2)

Background: 6 α
378 βγ

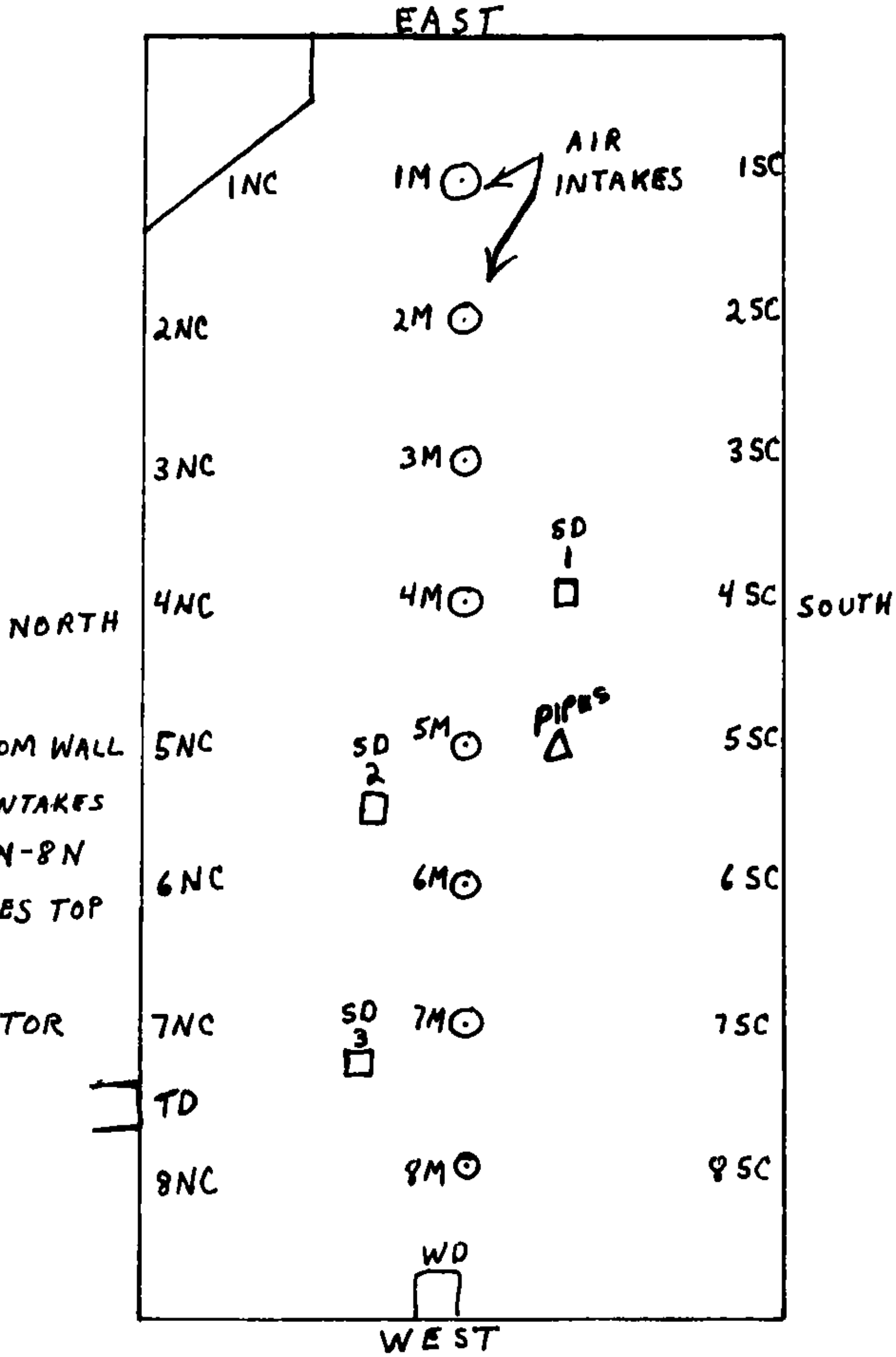
Yield: .35
.32

FLOOR SMEARS

Smear#	dpm/100 cm^2 α*	dpm/100 cm^2 βγ*	Smear#	dpm/100 cm^2 α*	dpm/100 cm^2 βγ*
41	0.0 ± 0.8	- 1.9 ± 5.2	61	1.9 ± 1.0	- 7.6 ± 5.1
42	- 1.2 ± 0.6	5.0 ± 5.3	62	- 0.2 ± 0.8	9.5 ± 5.4
43	- 1.0 ± 0.6	5.2 ± 5.3	63	- 0.8 ± 0.7	-10.1 ± 5.1
44	- 0.4 ± 0.7	- 5.4 ± 5.1	64	- 0.4 ± 0.7	5.4 ± 5.3
45	- 0.6 ± 0.7	- 2.4 ± 5.2	65	0.2 ± 0.8	- 0.2 ± 5.2
46	0.6 ± 0.7	- 4.3 ± 5.2	66	0.2 ± 0.8	1.0 ± 5.2
47	0.2 ± 0.8	1.7 ± 5.3	67	0.4 ± 0.8	- 5.0 ± 5.1
48	8.0 ± 1.5	- 1.4 ± 5.2	68	- 0.8 ± 0.7	- 5.6 ± 5.1
49	0.6 ± 0.9	7.3 ± 5.3	69	- 0.6 ± 0.7	1.7 ± 5.3
50	0.0 ± 0.8	- 2.4 ± 5.2	70	0.2 ± 0.8	0.2 ± 5.2
51	- 0.6 ± 0.7	5.0 ± 5.3	71	1.7 ± 1.0	5.7 ± 5.3
52	0.0 ± 0.8	1.7 ± 5.3	72	- 0.6 ± 0.7	- 2.3 ± 5.2
53	- 0.6 ± 0.7	1.0 ± 5.2	73	- 0.4 ± 0.7	- 1.2 ± 5.2
54	- 1.0 ± 0.6	1.4 ± 5.3	74	- 0.4 ± 0.7	- 8.0 ± 5.1
55	0.2 ± 0.8	3.8 ± 5.2	75	0.2 ± 0.7	0.0 ± 5.2
56	- 1.0 ± 0.6	- 4.2 ± 5.2	76	- 0.4 ± 0.7	- 0.7 ± 5.2
57	0.4 ± 0.8	- 2.3 ± 5.2	77	- 0.2 ± 0.8	- 0.5 ± 5.2
58	0.0 ± 0.8	- 2.8 ± 5.2	78	0.0 ± 0.8	1.6 ± 5.3
59	8.0 ± 1.5	- 0.9 ± 5.2	79	0.0 ± 0.8	- 2.3 ± 5.2
60	- 0.2 ± 0.8	1.2 ± 5.2	80	0.6 ± 0.9	- 3.5 ± 5.2

*Results activity ± standard error (dpm/cm^2)

Ceiling



1N – 8N ~ 3 FT. IN FROM WALL
1M – 8M NEAR AIR INTAKES
1S – 8S – SAME AS 1N–8N BUT INCLUDES TOP OF PIPE
SD – SMOKE DETECTOR

ALL SMEARS ~900 cm^2

CEILING

Smear#	Location	dpm/100 cm^2 α*	dpm/100 cm^2 $\beta\gamma$*
1SD	Smoke Detector	3.5 ± 1.7	1.6 ± 7.8
4M	Ceiling Center	18.2 ± 2.5	13.0 ± 8.0
3M	Ceiling Center	- 0.2 ± 1.4	7.1 ± 7.9
5M	Ceiling Center	- 0.2 ± 1.4	-15.1 ± 7.6
2SD	Smoke Detector	4.2 ± 1.7	1.1 ± 7.8
PIPES	Near #5 Center	0.5 ± 1.5	-10.6 ± 7.6
6M	Ceiling Center	- 1.9 ± 1.3	- 8.5 ± 7.7
3SD	Smoke Detector	21.7 ± 1.0	10.5 ± 3.7
7M	Ceiling Center	- 0.5 ± 1.4	- 7.7 ± 7.7
1M	Ceiling Center	0.0 ± 1.4	7.9 ± 8.0
2M	Ceiling Center	- 0.9 ± 1.4	-11.6 ± 7.6
WD	West Duct	0.5 ± 1.5	- 4.0 ± 7.8
8SC	Ceiling South	- 2.8 ± 1.2	7.4 ± 7.9
TD	Top Duct	- 0.9 ± 1.4	- 0.5 ± 7.8
8NC	Ceiling North	3.2 ± 1.7	1.6 ± 7.8
7SC	Ceiling South	0.0 ± 1.4	1.1 ± 7.6
5SC	Ceiling South	0.0 ± 1.4	16.9 ± 8.1
7NC	Ceiling North	- 1.9 ± 1.3	- 4.8 ± 7.7
8M	Ceiling Center	0.9 ± 1.3	-14.0 ± 7.9

*Results: activity ± standard error (dpm/100 cm^2)

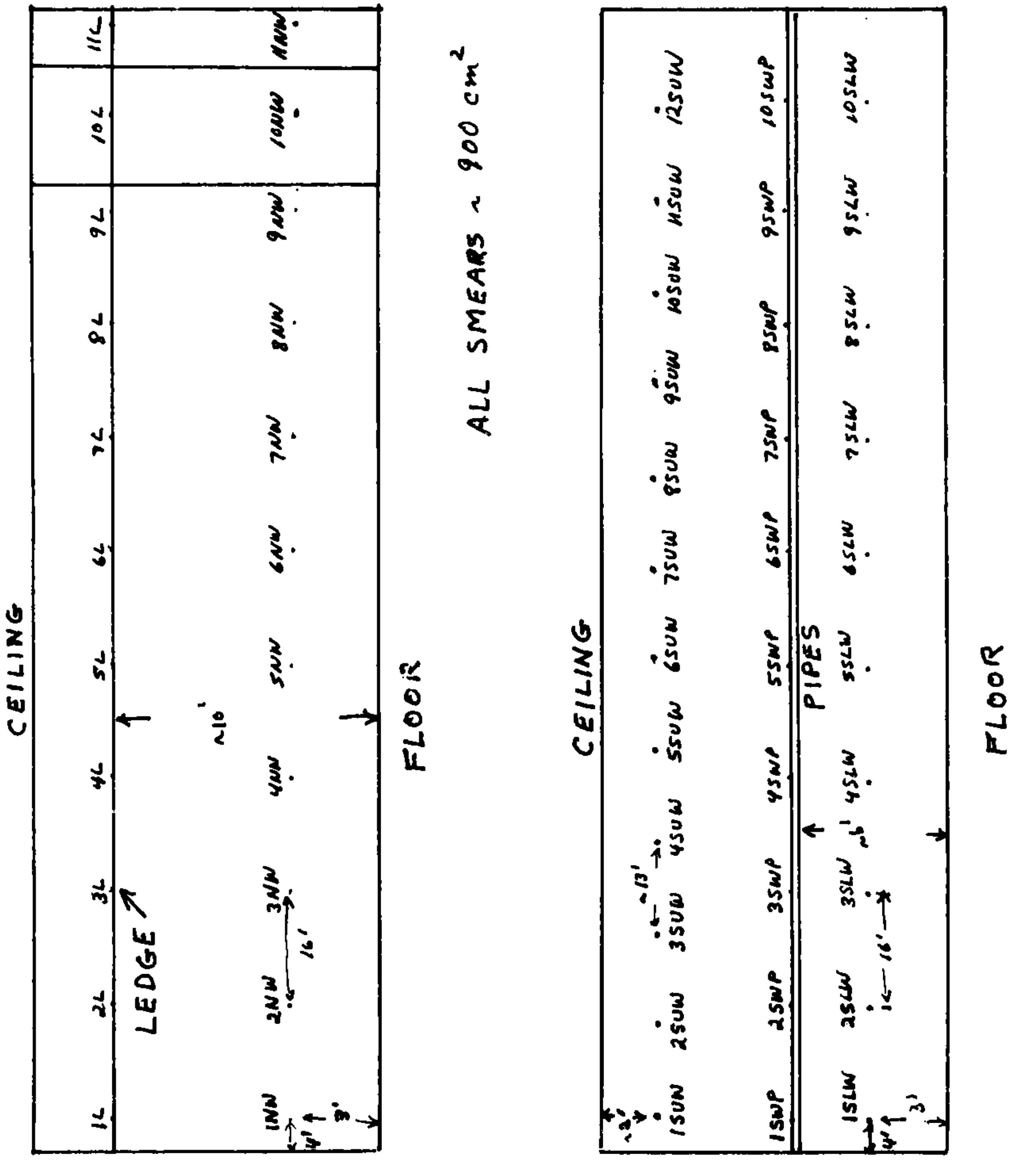
Background:	16 α	Yield:	.31
	364 $\beta\gamma$		.21

WALL AND CEILING SMEARS

Smear#	Location	dpm/100 cm^2 α*	dpm/100 cm^2 $\beta\gamma$*
1NW	North Wall	1.6 ± 1.1	10.0 ± 7.0
2NW	North Wall	0.2 ± 1.0	-10.4 ± 6.7
3NW	North Wall	7.6 ± 1.5	- 7.4 ± 6.7
4NW	North Wall	0.5 ± 1.0	4.4 ± 6.9
5NW	North Wall	0.7 ± 1.0	13.9 ± 7.1
6NW	North Wall	2.3 ± 1.2	- 7.2 ± 6.7
7NW	North Wall	0.4 ± 1.0	1.2 ± 6.9
8NW	North Wall	0.9 ± 1.1	2.1 ± 6.9
9NW	North Wall	1.2 ± 1.1	- 2.1 ± 6.8
10NW	North Wall	1.4 ± 1.1	- 1.2 ± 6.8
11NW	North Wall	0.2 ± 1.0	- 6.5 ± 6.8
5NC	North Ceiling	0.9 ± 1.1	0.2 ± 6.9
6SC	South Ceiling	1.2 ± 1.1	14.8 ± 7.1
6NC	North Ceiling	- 0.7 ± 0.9	- 1.9 ± 6.8
4SC	South Ceiling	0.4 ± 1.0	- 2.1 ± 6.8
4NC	North Ceiling	1.6 ± 1.1	- 2.8 ± 6.8
3SC	South Ceiling	0.5 ± 1.0	- 5.6 ± 6.8
3NC	North Ceiling	- 1.4 ± 0.8	1.6 ± 6.9
2SC	South Ceiling Pipe	1.9 ± 1.1	- 1.4 ± 6.8
2NC	North Ceiling	0.0 ± 1.0	8.3 ± 7.0
1SC	South Ceiling Pipe	0.4 ± 1.0	- 1.2 ± 6.8
1NC	North Ceiling	0.0 ± 1.0	6.9 ± 7.0

*Results: activity ± standard error (dpm/100 cm^2)

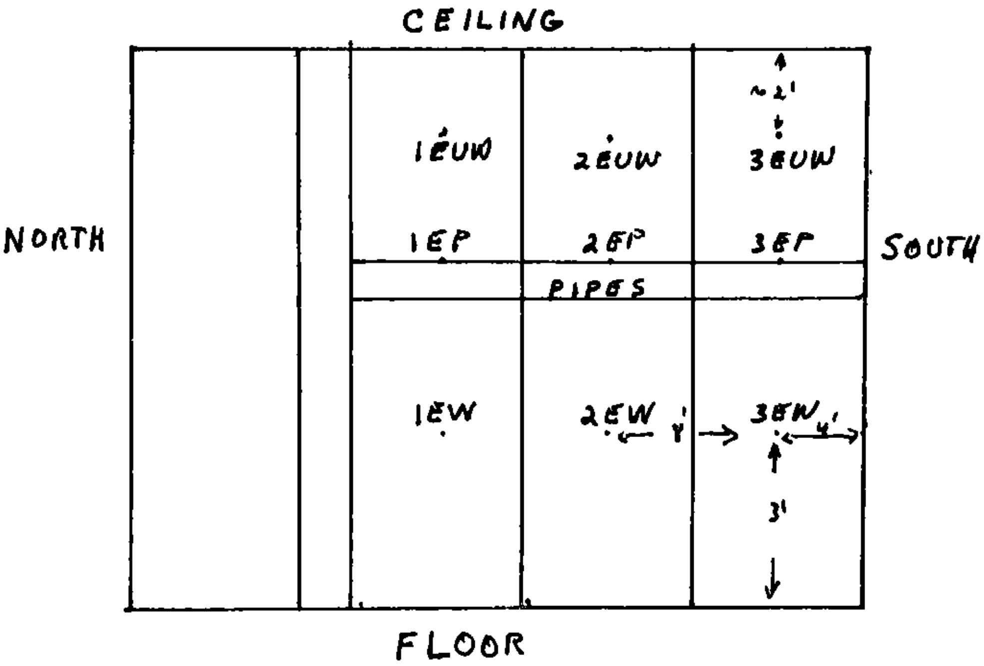
Background:	13 α	Yield:	.41
	366 $\beta\gamma$		.24



NORTH WALL

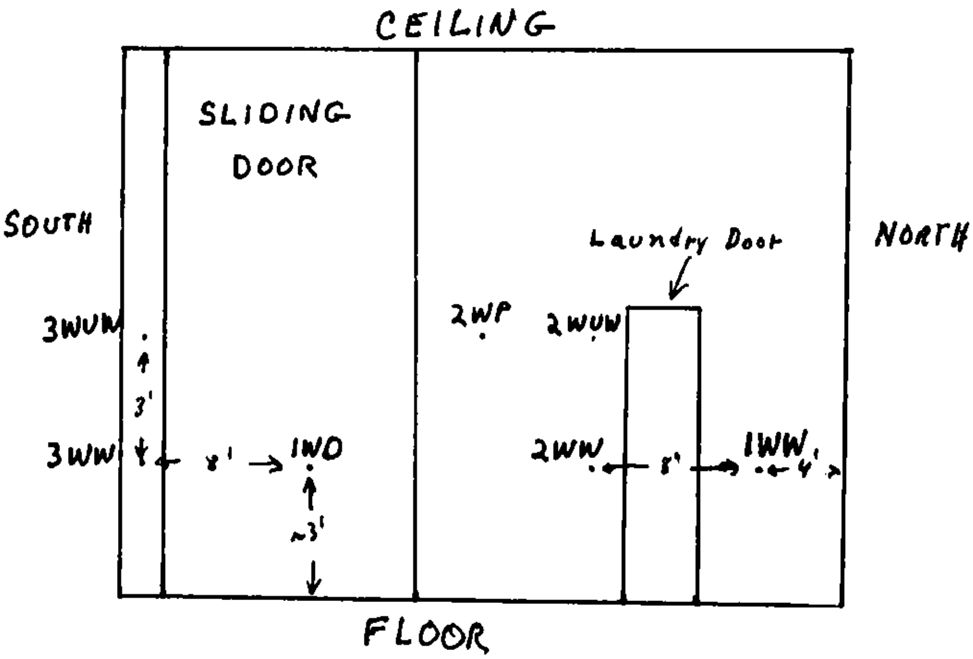
SOUTH WALL

East Wall



ALL SMEARS ~ 900 cm^2

West Wall



NORTH UPPER-WALL (LEDGE)

Smear	dpm/100 cm^2 α*	dpm/100 cm^2 βγ*
1L	- 5.4 ± 0.9	5.6 ± 7.9
2L	0.5 ± 1.5	6.9 ± 7.9
3L	- 0.5 ± 1.4	- 2.1 ± 7.8
4L	0.5 ± 1.5	4.8 ± 7.9
5L	- 1.4 ± 1.3	0.0 ± 7.8
6L	- 0.9 ± 1.4	6.9 ± 7.9
7L	0.0 ± 1.4	3.2 ± 7.9
8L	0.5 ± 1.5	- 1.6 ± 7.8
9L	1.9 ± 1.6	- 0.6 ± 7.7
10L	2.8 ± 1.7	6.1 ± 7.9
11L	- 2.8 ± 1.2	5.3 ± 7.9

*Results: activity ± standard error (dpm/100 cm^2)

Background:	16 α	Yield:	.31
	364 βγ		.21

SOUTH WALL AND PIPES

Smear#	Location	dpm/100 cm^2 α*	dpm/100 cm^2 βγ*
1SLW	South Wall	- 1.4 ± 1.3	5.3 ± 7.9
2SWP	South Wall Pipes	0.5 ± 1.5	4.8 ± 7.9
2SLW	South Lower Wall	- 0.9 ± 1.4	8.2 ± 8.0
3SWP	South Wall Pipes	3.3 ± 1.7	- 1.6 ± 7.8
3SLW	South Lower Wall	- 1.9 ± 1.3	0.3 ± 7.8
4SWP	South Wall Pipes	- 1.4 ± 1.3	12.2 ± 8.0
4SLW	South Lower Wall	0.5 ± 1.5	- 9.0 ± 7.7
5SWP	South Wall Pipes	1.4 ± 1.6	3.7 ± 7.9
5SLW	South Lower Wall	2.8 ± 1.7	- 4.2 ± 7.9
6SWP	South Wall Pipes	- 1.9 ± 1.3	0.5 ± 7.8
6SLW	South Lower Wall	0.9 ± 1.5	6.3 ± 7.9
7SWP	South Wall Pipes	- 1.9 ± 1.3	- 7.9 ± 7.7
7SLW	South Lower Wall	0.9 ± 1.5	10.6 ± 8.0
8SWP	South Wall Pipes	0.5 ± 1.5	- 5.8 ± 7.7
8SLW	South Lower Wall	0.9 ± 1.5	0.5 ± 7.8
9SWP	South Wall Pipes	- 2.8 ± 1.2	1.1 ± 7.8
9SLW	South Lower Wall	0.2 ± 1.5	- 1.6 ± 7.8
10SWP	South Wall Pipes	0.9 ± 1.5	0.0 ± 7.8
10SLW	South Lower Wall	1.4 ± 1.6	- 5.6 ± 7.9

*Results: activity ± standard error (dpm/100 cm^2)

Background:	16 α	Yield:	.31
	364 βγ		.21

WALLS

Smear#	Location	dpm/100 cm^2 α*	dpm/100 cm^2 βγ*
1EW	East Wall	- 0.6 ± 1.1	10.2 ± 6.7
2EW	East Wall	0.0 ± 1.1	15.7 ± 6.9
3EW	East Wall	4.3 ± 1.6	6.5 ± 6.7
2WW	West Wall	2.3 ± 1.4	4.6 ± 6.7
3WW	West Wall	0.3 ± 1.2	10.9 ± 6.8
3EUW	East Upper Wall	17.3 ± 2.5	23.1 ± 7.0
1EUW	East Upper Wall	- 0.3 ± 1.1	11.8 ± 6.8
3WUW	West Upper Wall	3.5 ± 1.5	50.2 ± 7.4
1WW	West Wall	1.2 ± 1.3	11.1 ± 6.8
4SUW	South Upper Wall	3.2 ± 1.5	- 1.4 ± 6.6
1SUW	South Upper Wall	0.3 ± 1.2	- 1.2 ± 6.6
11SUW	South Upper Wall	- 0.9 ± 1.0	1.6 ± 6.6
9SUW	South Upper Wall	0.3 ± 1.2	-10.2 ± 6.4
7SUW	South Upper Wall	1.4 ± 1.3	- 6.3 ± 6.5
5SUW	South Upper Wall	1.4 ± 1.3	- 4.6 ± 6.5

*Results: activity ± standard error (dpm/100 cm^2)

Background:	7 α	Yield:	.25
	338 βγ		.24

PIPES AND UPPER WALLS

Smear#	Location	dpm/100 cm^2 α*	dpm/100 cm^2 $\beta\gamma$*
1EP	East Pipe	1.0 ± 1.0	5.2 ± 5.3
2EP	East Pipe	1.0 ± 1.0	17.7 ± 5.5
3EP	East Pipe	0.0 ± 0.8	- 1.6 ± 5.2
1WD	West Door	0.6 ± 0.9	11.3 ± 5.4
2WP	West Panel	1.4 ± 1.0	- 2.6 ± 5.2
3WD	West Door	0.4 ± 0.9	1.4 ± 5.3
2EUW	East Upper Wall	1.9 ± 1.0	11.5 ± 5.4
2WUW	West Upper Wall	0.4 ± 0.9	12.3 ± 5.4
3SUW	South Upper Wall	1.4 ± 1.0	0.9 ± 5.3
2SUW	South Upper Wall	0.8 ± 0.9	- 2.6 ± 5.2
12SUW	South Upper Wall	0.6 ± 0.9	1.9 ± 5.3
10SUW	South Upper Wall	0.8 ± 0.9	4.0 ± 5.3
8SUW	South Upper Wall	1.4 ± 1.0	- 7.6 ± 5.1
6SUW	South Upper Wall	0.8 ± 0.9	- 3.6 ± 5.2

*Results: activity ± standard error (dpm/100 cm^2)

Background:	7 α	Yield:	.35
	381 $\beta\gamma$		.32

APPENDIX C

Assay Procedures

APPENDIX C - Glovebox Assay System

C.1 Equipment

The assay of the radionuclide content of the glovebox systems was accomplished by the use of an in-place analysis of the contaminated surfaces of these systems. The initial assay equipment was proposed and developed by the ANL Non-Destructive Assay group, who also performed the necessary testing of the equipment (Reference C-1). The desired features of the assay system were that it be portable, operationally simple, geometrically versatile and reasonable quantitative for use in segregating TRU from Non-TRU waste.

This assay system utilized three separate NaI detectors, housed in various shield-collimator arrangements, to measure photon radiation emitted by plutonium and americium. A 5cm (2 inch) diameter by 1.3cm (1/2") thick NaI crystal, contained in a 1cm (3/8 inch) thick lead shield (shown on the right in Figure C-1), was used for scanning purposes to indicate the relative intensity variations of contamination levels over an extended surface area. A 5cm (2 inch) diameter by 5cm (2 inch) thick crystal (shown in the center of Figure C-1), housed in a 1.3cm (1/2 inch) thick lead-shielded, double collimator, was used to take a series of individual readings for assay of high level plutonium contaminated spots ($>10^5$ dpm/cm^2). A 5cm (2 inch) diameter by 2 mm (0.8 inch) thick NaI crystal (on the left in Figure C-1), placed in a Cd-Cu-Al multishield collimator, was used to take a series of individual readings for assay of low level plutonium contamination. Readout

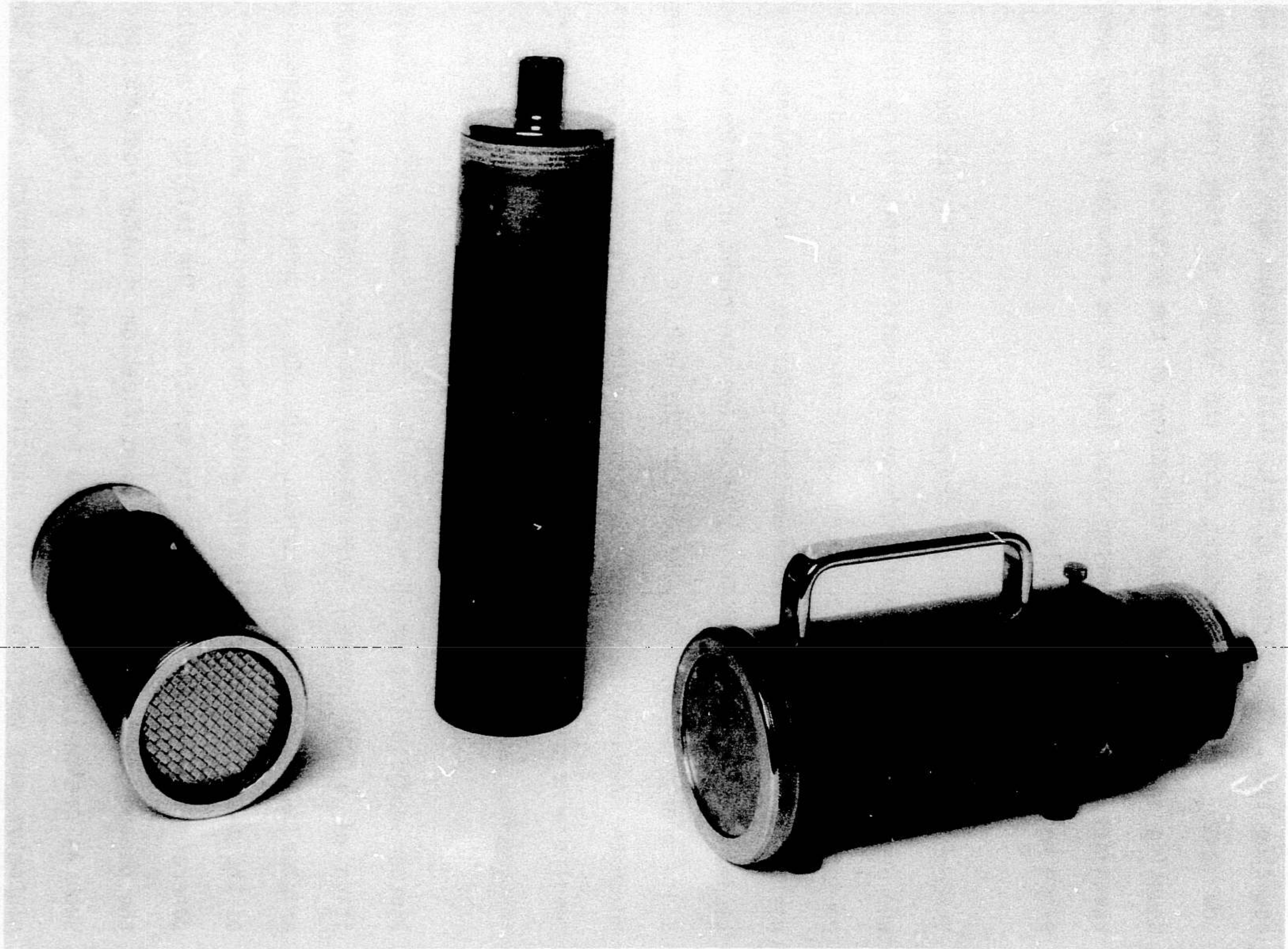


Figure C-1 NaI Detectors

was obtained on a single channel assay meter (Eberline SAM-2-shown in Figure C-2), by recording the indicated scaler counts for a given counting time. The virtues of this initial system were simplicity and low cost. Its main drawbacks were the length of time required for counting and the lack of any indication of the presence of other contaminants. Moreover, counting data had to be recorded in log books since no printouts were available.

Throughout the duration of the project, the Health Physics personnel, who used the assay equipment, made several modifications to the initial equipment which led to improved performance. The first modification was to substitute survey instrumentation for use in the scanning operations. An end window GM Survey Meter (on the right in Figure C-3) and a low energy X-Ray Survey Meter (on the left in Figure C-3) provided adequate scanning data for the contaminated surfaces. In addition, results were obtained faster than for the NaI detector and the survey instruments were easier to use.

Another modification which enhanced the assay process was the acquisition of a 512 channel multichannel analyzer (MCA), with teletype printer and punched-tape recorder. The MCA allowed visual inspection of the entire spectrum collected, while the punched-tape allowed one to generate a permanent record of the spectrum. The ability to display the photon spectrum allowed the identification of other radionuclides, such as cesium-137, which was also present, in some cases, along with plutonium and americium. In addition to a permanent record, the punched tape allowed review of spectra at a later date. This proved

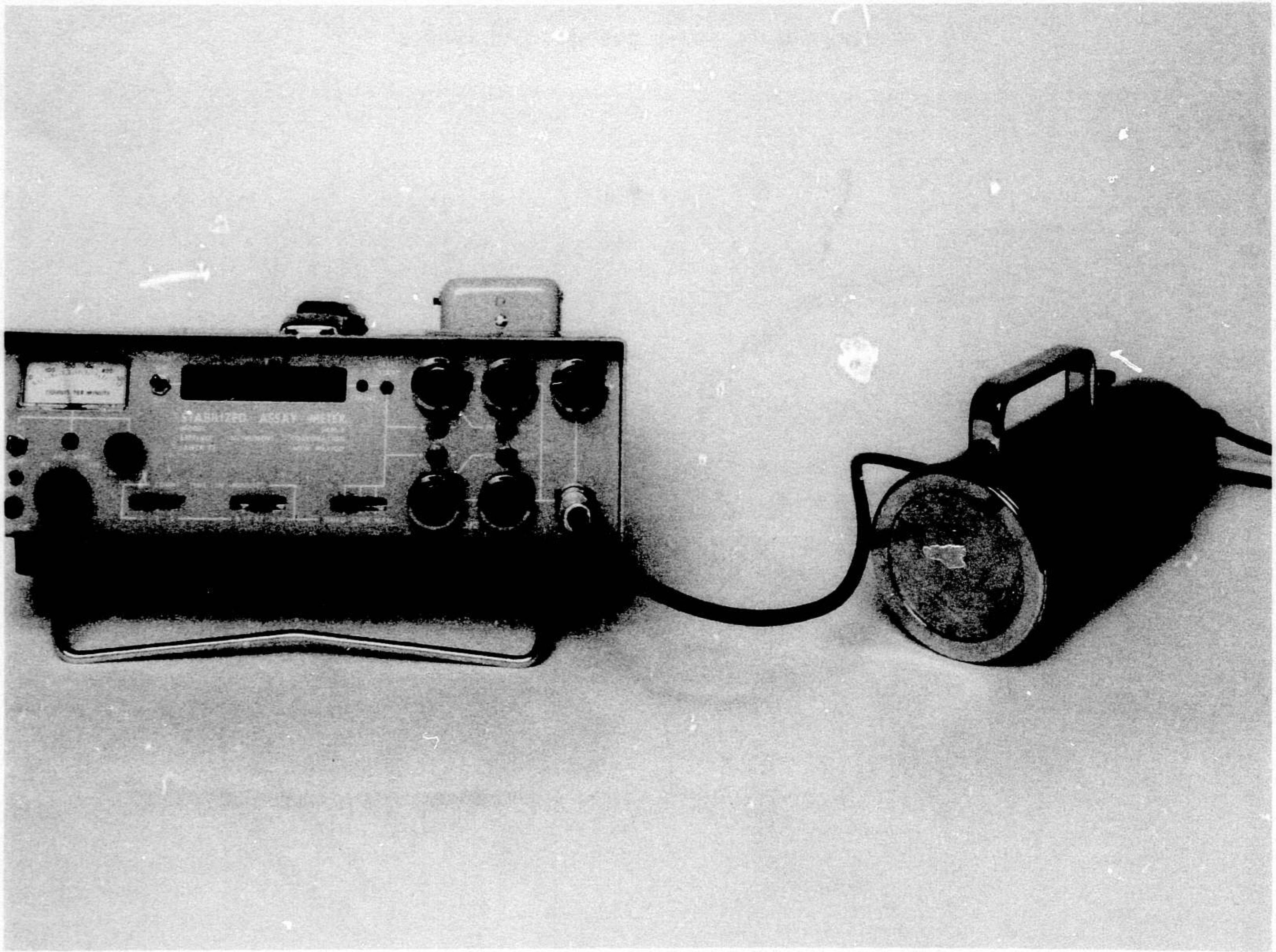


Figure C-2 Eberline SAM-2 With NaI Detector

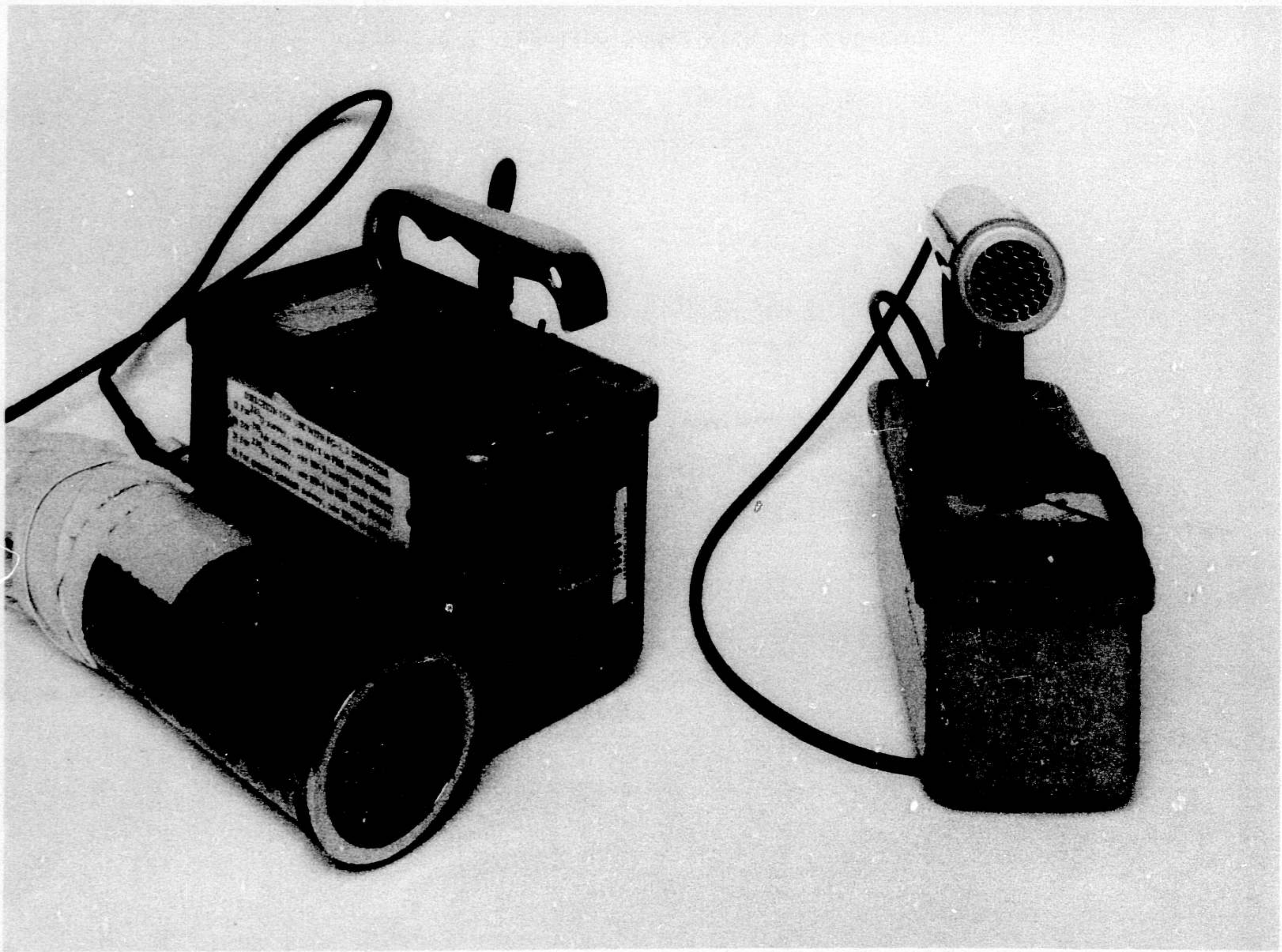


Figure C-3 GM and X-ray Survey Meters

valuable for a few cases in which radionuclide identification was difficult. The teletype allowed a printout of the counts in a given peak region which also aided in the assay process. The greatest improvement involved the reduced counting time made possible by the simultaneous acquisition of counts over the entire energy spectrum.

The above equipment was updated in 1981 by replacement with a 4000 Channel Canberra 40 MCA with teletype printer and cassette recorder (see Figure C-4). In addition, a new 5cm (2 inch) diameter by 5cm (2 inch) thick crystal (shown in the shield-collimator in Figure C-4) and a 5cm (2 inch) diameter by 1 mm (.04 inch) thick NaI crystal were also acquired.

C.2 Assay Technique

The assay technique used an initial scan of the entire surface area of a given region with an appropriate survey instrument, in order to determine regions of approximately the same relative intensity. These surveys were accomplished both outside of, and within, the glovebox system, as appropriate. The fractional area represented by each of these regions was then estimated and noted. Based upon the relative reading in the given regions, a decision was reached regarding which detector should be used for the assay. For example, when an end window (EW) survey meter was being used inside the box, contact survey readings, through the polyvinylchloride (PVC) pouch, in the range 0.2-0.5 mR/h and above, would allow the use of the 5cm (2 inch) by x5cm (2 inch) NaI for the assay. For readings below this, the use of the 5cm (2 inch) by 1 mm (.04 inch) crystal would be indicated.

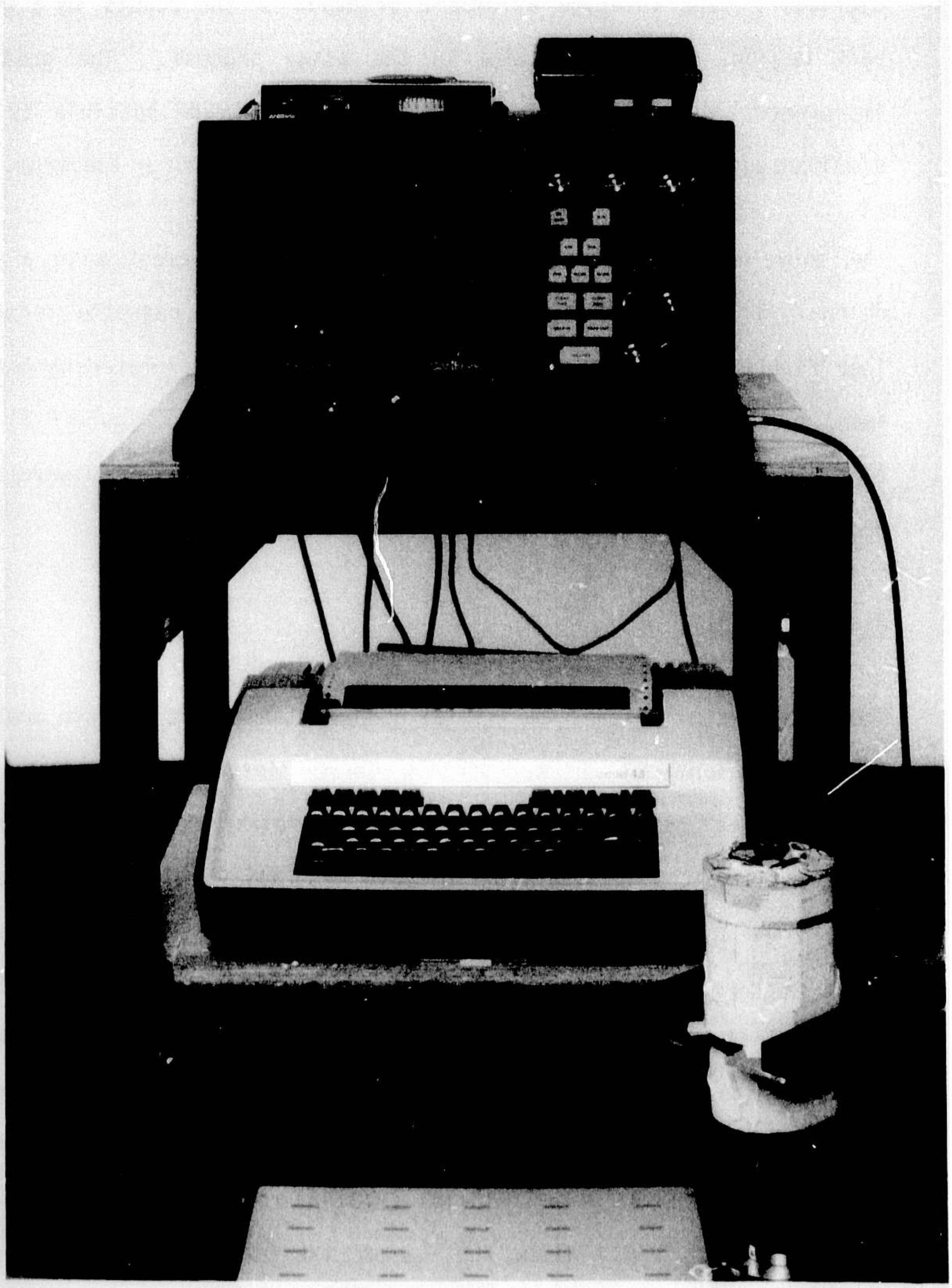


Figure C-4 Canberra Model 40 Multichannel Analyzer

Assay data was obtained with the chosen calibrated NaI detector in its shielded collimator. A number of readings were taken in each relevant region and the results were averaged to arrive at an estimate of the surface contamination level in that region. Depending upon the level of contamination, the detector would be positioned either on the exterior of the glovebox or inserted into the glovebox (see Figure C-5), inside of a PVC pouch. Generally, readings taken inside the glovebox were preferred since the counting time would be less to achieve a desired statistical accuracy. Moreover, absorption by the intervening glovebox material was too severe to use the x-ray detector to measure plutonium through the glovebox. A disadvantage of using the detector inside the glovebox was that positioning of the detector was cumbersome and time consuming.

Estimates of the average reading in each region, which represented a significant portion of the total area, were then obtained. In addition, "hot spots" noted during the scanning phase were also counted and the fractional area of the spot noted. The average surface activity was then obtained by weighting the average reading obtained for each significant region and "hot spot", by the fractional surface area represented by that region or "hot spot", and summing the results. The total surface activity was determined by multiplying this average surface activity by the total contaminated surface area. If a surface indicated about the same reading everywhere during the scan, then a number of counts were taken at various points on the surface and these were then averaged to obtain the average surface activity.

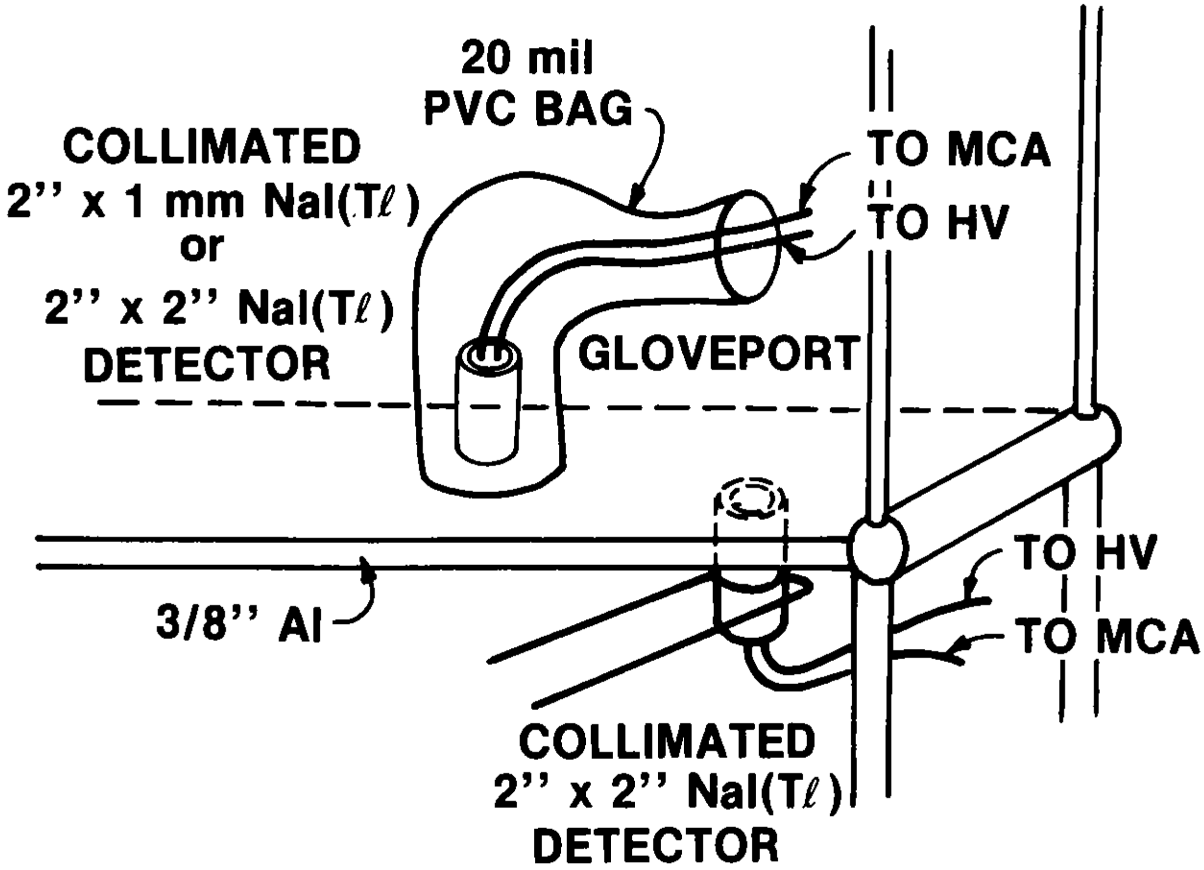


Figure C-5 Various Assay Techniques

C.3 Data Analysis

The 5 cm (2 inch) X 5cm (2 inch) NaI detector (802-3 crystal) was used to analyze the 59.5 keV photon emitted by ^{241}Am (36% of the transformations) and several photons in the energy region 375-450 keV emitted by ^{239}Pu (~5 X 10^{-3}%). As shown in Figure C-6, which represents the MCA display, there are four regions of interest; the ^{241}Am peak (P_{Am}), a background region (PH_{Am}) above this peak, the ^{239}Pu peak complex (P_{Pu}), and a background region BH_{Pu}) above this peak complex. Net count rates in each peak region are obtained by subtracting a fraction (kBH) of the count recorded in the background region from the count in the corresponding peak region (see Figure C-7), dividing by the count time, t, and subtracting any relevant ambient background (B_{Amb}). The net count rates are then converted to transformation rates using measured yields determined by calibration with known activity standards of ^{241}Am and ^{239}Pu (see Figure C-7 for approximate yields for the 802-3 crystal). More details of the calibrations and data analysis are presented in Reference C-2.

The x-ray detector (2 XM crystal) was used to analyze the 59.5 keV photon emitted by ^{241}Am and the L x-ray complex in the 13-22 keV region, emitted by ^{239}Pu (~5%). A typical spectrum obtained with an x-ray detector is shown in Figure C-8. Since transformations of ^{241}Am and other plutonium radioisotopes result in the emission of x-rays in the same energy region, the analysis of the spectrum is complicated. The ^{239}Pu content cannot be unambiguously determined unless the radionuclide content of the contamination is known. For the four regions of interest indicated in Figure C-8 ($^{P}Pu + Am$, $^{BH}Pu + Am$, ^{P}Am, counts were

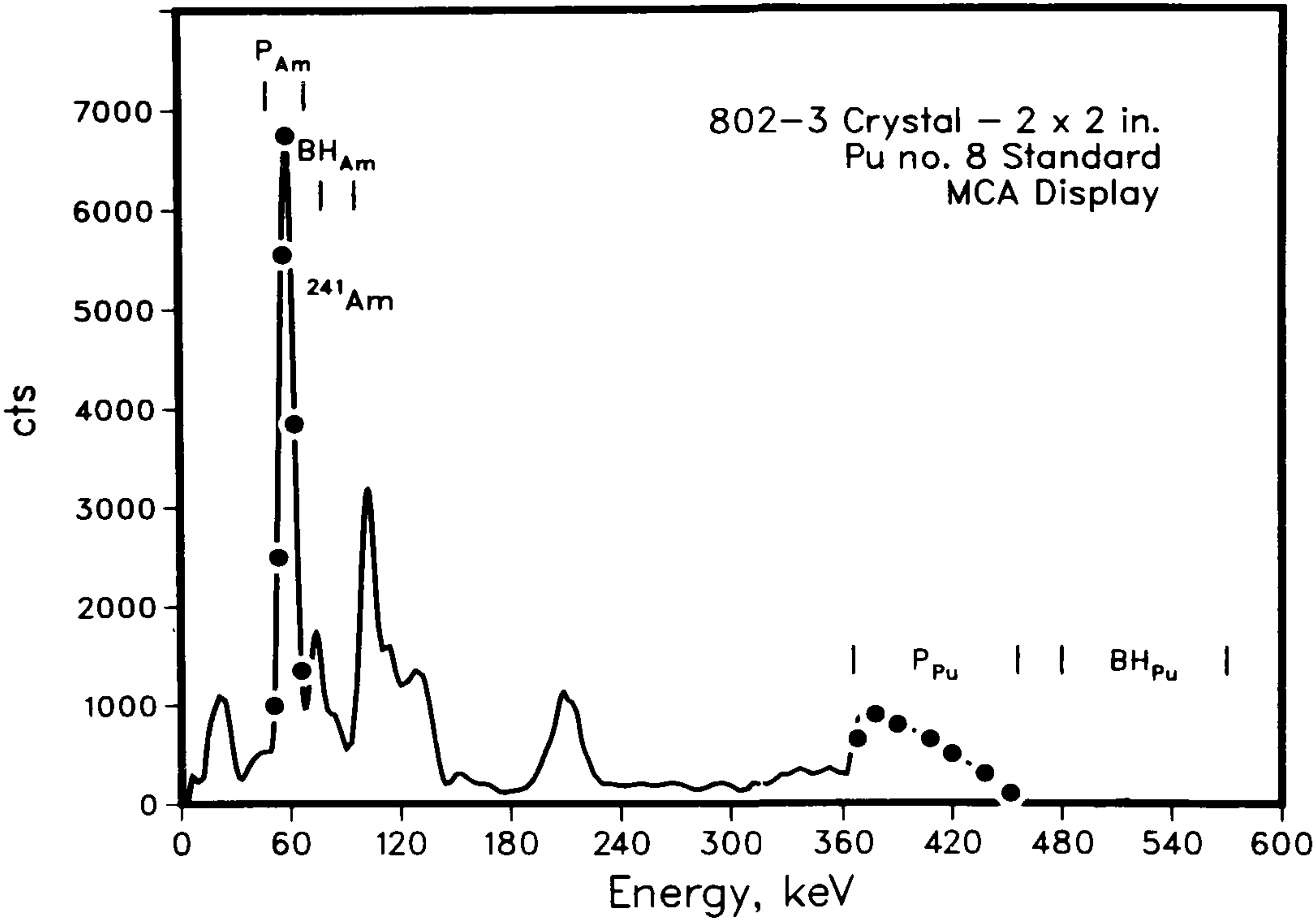


Figure C-6 Multichannel Analyzer Display

Data Analysis

802–3 Crystal – 2 x 2 in.

$$\text{Net cpm} = \frac{P - k(BH)}{t} - B_{Amb}$$

	k	$B_{Amb,cpm}$	Approx. Yield, cpm/dpm /cm² Vinyl	CR–39	Aluminum
^{241}Am	0.67	7.2	1.48×10^{-3}	1.85×10^{-3}	1.16×10^{-3}
^{239}Pu	1.05	3.9	2.97×10^{-6}	3.65×10^{-6}	3.39×10^{-6}

2XM Crystal – 2 x 1 mm

$$\text{Net cpm} = \frac{(P - BP) - k(BH - BBH)}{t}$$

	k	Approx. Yield, cpm/dpm/cm² Vinyl
^{241}Am	0.7	0.42
^{239}Pu	0.94	3.08×10^{-2}

BP and BBH are counts taken with the blank shield (no opening)

Figure C-7 Parameters Used to Assay ^{239}Pu and ^{241}Am

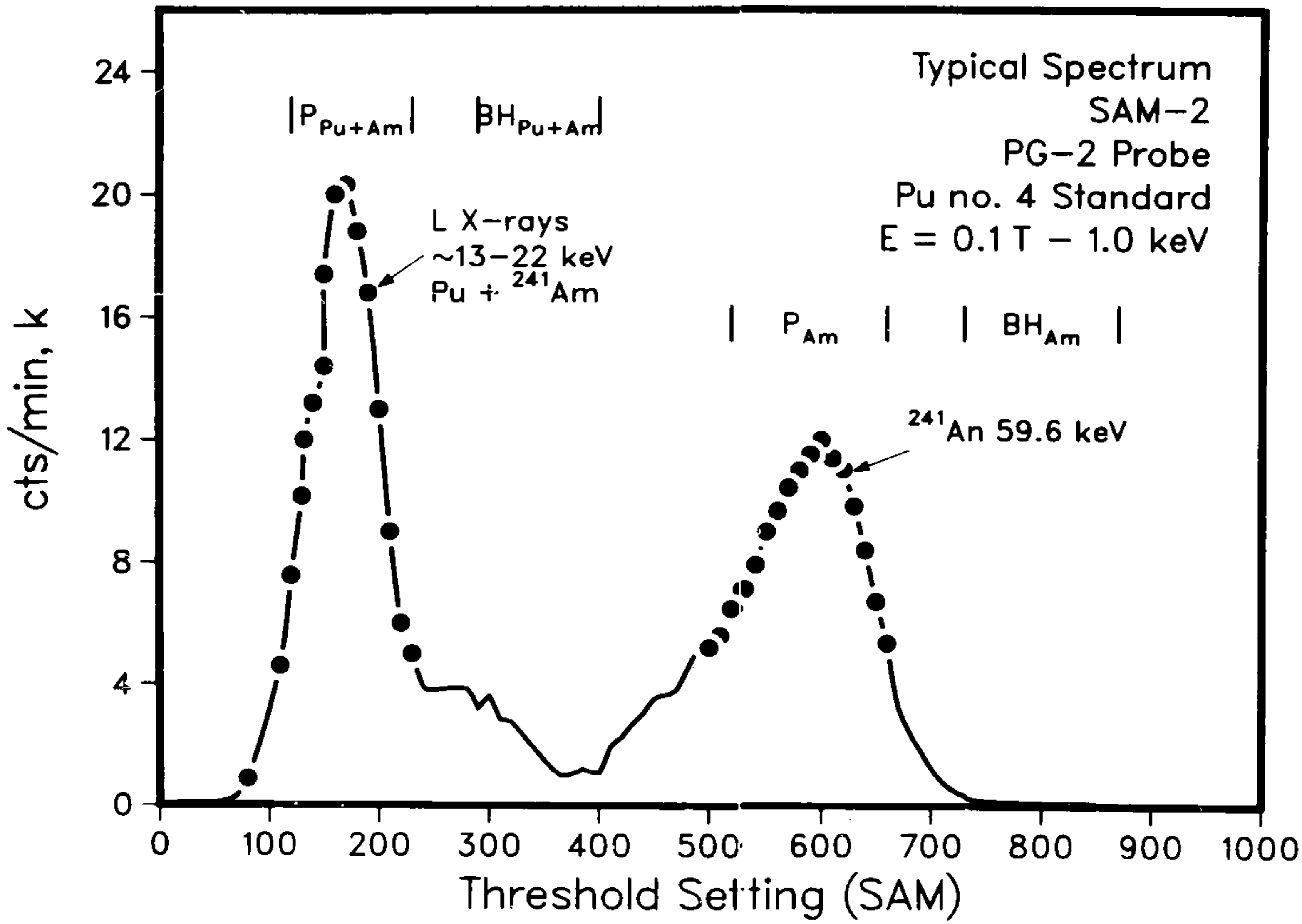


Figure C-8 Typical Spectrum for X-ray Detector obtained at a given location with a 1" diameter opening in the shield and no opening in the shield. The difference between these counts is assumed to be corrected for scattered radiation. Thus, the scatter-corrected count in a peak region is P-BP (see Figure C-7). The net count rate was then obtained as indicated in Figure C-7. Count rates for ^{241}Am were converted to transformation rates using the approximate yield shown in Figure C-7. The transformation rate for ^{241}Am was then used to estimate the counts in the 13-22 keV region contributed by x-rays which are emitted following transformations of ^{241}Am (38%). Upon subtracting these counts, the remainder represents the net contribution due to plutonium. The net count rate was converted to an estimated transformation rate using the approximate yield shown in Figure C-7.

To simulate detector response for actual situations involving the counting of contaminated surfaces comprised of different materials, different shapes and varying thicknesses, calibrations were also erformed using a variety of materials (see Figure C-9) in various configurations. In this way, detector response could be approximated for such things as ductwork, pipes, stainless steel vessel-walls, bagged out material, etc.

C.4 Activity Determinations and Classification

The approach used during the D&D operations to determine activity levels and waste classification (TRU or Non-TRU) of the equipment, tools, scrap and other waste removed from a glovebox, and the eventual classification of the glovebox components, is shown in Figure C-10. An

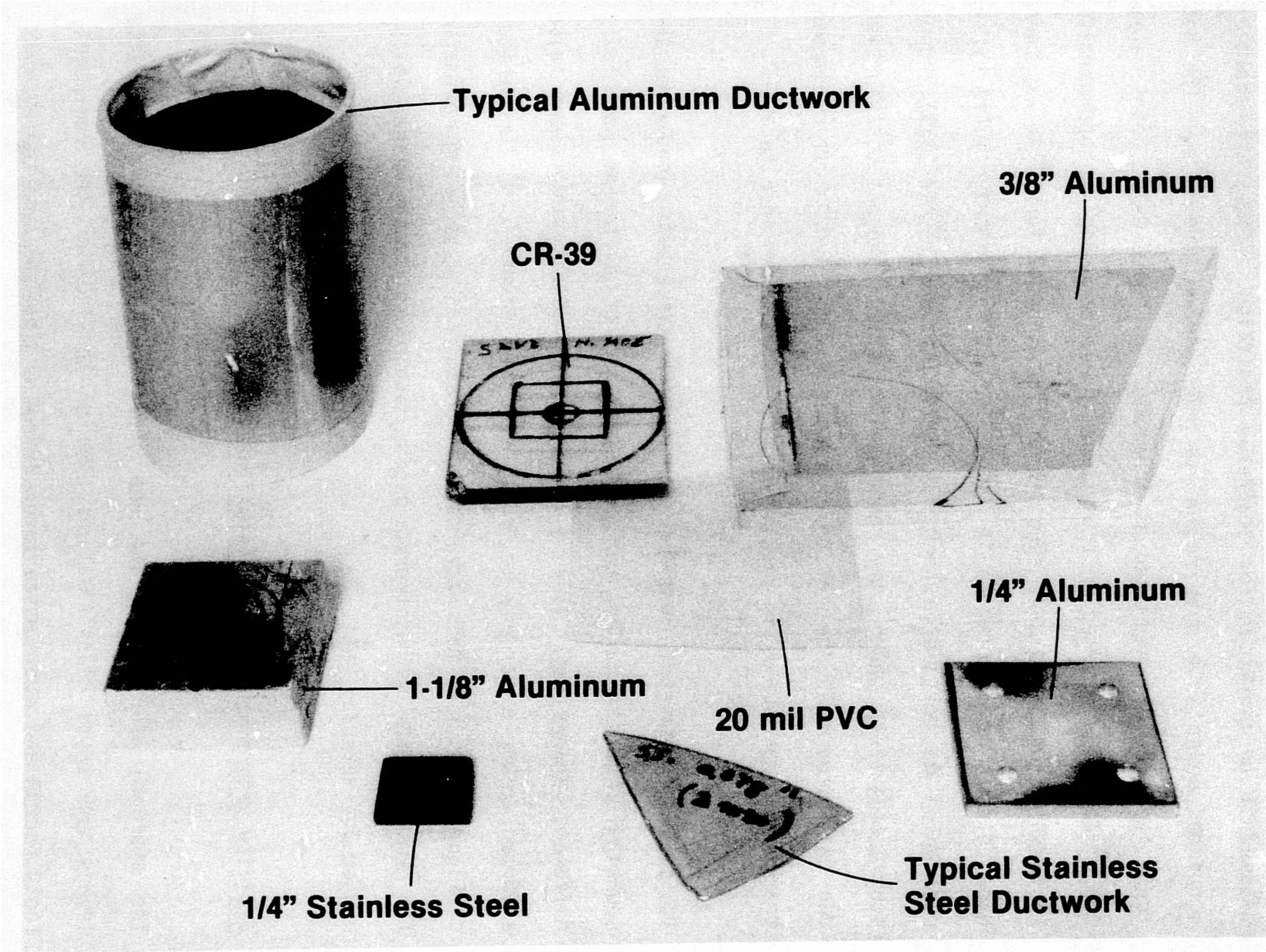


Figure C-9 Materials Used for Assay Calibrations initial survey and assay were performed and the activity levels obtained in this assay were used to estimate contamination levels on these materials bagged out of the glovebox system. Following removal of these materials, another survey and assay were performed to establish activity levels in the glovebox prior to decontamination attempts. In some cases, particularly when not much equipment or materials needed to be removed, this step was omitted.

At the beginning of the program, several attempts at decontaminating a glovebox were made. It was intended that the data be used to determine the optimum decontamination factor which could be obtained. From the assay data obtained following these attempts, it was found that the final decontamination factor one obtained varied and the results were erratic and inconsistent as more and more attempts were made. For this reason, the number of decontamination attempts (wash and wipedown) was limited to two for the remainder of the project. Following the second decontamination attempt, a final survey and assay were performed to estimate activity levels to determine the classification and disposition of the waste.

Following this assay, the glovebox was painted with latex paint to fix the internal contamination and taken into the SRE for disassembly and packaging into wooden bin liners.

C.5 Assay of Volume Contaminated Objects

In addition to the items which exhibited surface contamination, some objects were encountered which had to be treated as contaminated

Survey and Assay

↓

Remove equipment, tools and scrap
Sweep and vacuum glove box

Survey and Assay

↓

Wash and Wipedown
Repeat

Survey and Assay

↓

Paint with latex paint
to fix internal contamination

Disassemble glovebox module

Figure C-10 Glovebox Assay and Processing Flow Chart throughout their volume. The HEPA filters on the glovebox systems were the most important examples of this type of volume contaminated objects. In these cases, mathematical modeling to compute the effective yield, used in conjunction with simulated calibrations, had to be carried out to estimate activity concentrations. Since the filters needed to be read in place within their housing, this added more complexity to the modeling aspects. For further details concerning this aspect of the assay procedure refer to Reference C-2.

REFERENCES - APPENDIX C

C-1 Rocke, C. T. - ANL-79-60. (See Reference 2)

C-2 Moe, H. J. and Wynveen, R. A., "In-Place Assay and Classification of Waste During Decommissioning of a Plutonium Glovebox Facility," Paper presented at 28th Annual Meeting of HPS, Baltimore, MD, June 19-23, 1983.

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