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**Termination of the Special
Metallurgical (SM) Building at
Mound Laboratory--A Final Report**

*William R. Harris, Bernard R. Kokenge
and G. Clayton Marsh*

December 22, 1976

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Miamisburg, Ohio
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William R. Harris, Bernard R. Kokenge and G. Clayton Marsh

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Summary

This report describes and highlights the more important factors associated with the termination of the Special Metallurgical (SM) Building at Mound Laboratory. As a result, a written record of the more important techniques and procedures is now available for reference by others involved in similar termination efforts.

Included in this report is a description of the organizational units that were used in this effort along with a description of their responsibilities. A general description of the SM Building and a discussion of the more relevant procedures and equipment that were used are also presented. In addition, pertinent Health Physics information such as personnel exposure, final wipe levels in the terminated facility, and assays of the structure are provided.

Based on the experience gained from this project, recommendations were made regarding the design of future radioactive material handling facilities so that when they are ultimately terminated the effort can be accomplished more efficiently.

Section 1

Introduction

The decommissioning and decontamination (termination) of the Special Metallurgical (SM) Building at Mound Laboratory was initiated in August 1968 and was concluded in September 1972. The SM Building was a facility in which plutonium-238 was processed for use in the fabrication of isotopic heat sources. This building contained 585 linear feet of gloveboxes used to:

- 1) process plutonium-238 into a final product form for encapsulation in isotopic heat sources;
- 2) recover plutonium-238 residues generated from isotopic fuel production, R&D activities, and analytical support activities;
- 3) encapsulate plutonium-238 fuel forms in the fabrication of isotopic heat sources; and
- 4) perform analytical activities that were required to support the plutonium-238 production and recovery processes.

Because many of the interior surfaces and all gloveboxes and building services were contaminated with plutonium-238, special techniques, procedures, and equipment had to be developed to accomplish the objective of decontaminating the SM facility safely. Many of the techniques and procedures used were a result of efforts by Mound Laboratory personnel in combining existing and commonly-used procedures with those new techniques and procedures (which are described in this report) that were shown to be most effective in comparable decontamination efforts.

In addition, visits to other AEC (presently ERDA) sites were made to obtain information on techniques and equipment used in similar operations. A visit to the Savannah River Plant at Aiken, South Carolina was made to inspect their high-pressure cleaning unit and to discuss decontamination techniques utilizing this equipment. Although Mound Laboratory did not adopt this particular cleaning unit, the discussions held with the Savannah River personnel were helpful in formulating some of the techniques and procedures ultimately used in the cleaning of gloveboxes and in-line process equipment.

Three trips were made to Dow Chemical, Rocky Flats Division, Golden, Colorado for mutual discussions on termination efforts: because during the early phases of the Mound termination work, Rocky Flats experienced a fire in one of their plutonium areas and consequently were engaged in an extensive decontamination effort. Many of the ideas exchanged during these visits were helpful in accomplishing the Mound Laboratory termination goals and the upgrading of the SM-PP Building filter banks. Also, three trips were made to Polymer Insulators, Incorporated, Houston, Texas to discuss design of the foaming equipment used in this effort. Furthermore, visits were made to the Stainless Equipment Company, Denver, Colorado to discuss the design and fabrication of the high-pressure cleaning unit used for the cleaning of in-line process equipment. The equipment used in this effort is also described and was considered the most appropriate for our particular needs.

SM Building termination efforts were directed by a Nonweapons Program Manager from the Nuclear Operations Department. The work was coordinated through a special supervisory team, which consisted of representatives from the following departments: Nuclear Operations, Engineering, and Administrative Services.

The following subsections briefly describe the responsibilities of the various groups.

1.1 SM TERMINATION GROUP (NUCLEAR OPERATIONS)

The SM-Termination Group was responsible for the overall termination effort. This group's duties included: coordinating the efforts of other groups, removing plutonium-238 from the gloveboxes and contaminated services, preparing equipment for packaging, assisting in the bagging technique described in subsection 3.5, and tabulating data to obtain approval to discard gloveboxes.

1.2 PLUTONIUM ANALYSIS GROUP (NUCLEAR OPERATIONS)

The Plutonium Analysis Group performed all in-place gamma scan analyses of gloveboxes, as described in subsection 3.2 and gamma-ray assay of plutonium-238 residues in drums and crates, as described in subsection 3.6.

1.3 MATERIAL CONTROL GROUP (NUCLEAR OPERATIONS)

The Material Control Group was responsible for requesting calorimetric and gamma scan analyses and for reviewing analytical data to ensure that packages shipped complied with Department of Transportation regulations. In addition, this group was responsible for scheduling radioactive shipments and controlling the Special Source (S.S.) material after it was removed from the SM Building until it was either shipped for burial or transferred to the Plutonium Recovery Group.

1.4 PLUTONIUM RECOVERY GROUP (NUCLEAR OPERATIONS)

The Plutonium Recovery Group was responsible for recovering plutonium-238 from materials and residues removed during the termination effort. As a part of the recovery operations, the plutonium-238 was purified and returned to productive use. In addition, recovery operations included dissolution, leaching, concentration by evaporation, purifying by ion exchange, precipitation as plutonium oxalate and conversion to plutonium dioxide.

1.5 AREA ENGINEERING GROUP (ENGINEERING)

The Area Engineering Group was responsible for cost estimates, methods of accomplishing certain physical operations associated with the termination effort, and design and procurement of special equipment required in the termination effort.

1.6 AREA MAINTENANCE GROUP (ENGINEERING)

The Area Maintenance Group was responsible for the actual removal of gloveboxes and the performance of ancillary services. These services included the operation of the Polyurethane Foaming Unit described in subsection 5.4 and, with the assistance of the Decontamination Services Group, the loading of gloveboxes and equipment into shipping boxes.

1.7 HEALTH PHYSICS SURVEY SERVICES GROUP (ADMINISTRATIVE SERVICES)

The Health Physics Survey Services Group was responsible for area monitoring, personnel orientation, mode of dress, respiratory protection equipment and control of contamination as described in subsection 3.7. Other duties included the review of operating procedures and packaging and shipping procedures.

1.8 DECONTAMINATION SERVICES GROUP (ADMINISTRATIVE SERVICES)

The Decontamination Services Group was responsible for cleaning and decontaminating the terminated areas, operating the High-Pressure Water Blaster described in subsection 5.5, paint removal as described in section 6, erecting plastic enclosures, assisting in the separation of gloveboxes, and loading gloveboxes and equipment into shipping boxes.

As a result of this termination effort, all internal room walls, ceilings, floor covering, piping, conduit, and miscellaneous services (with the exception of drains and services under the floor) have been removed.

Finally, part of the filter banks and miscellaneous roof-ducts, which were no longer required, have been terminated. Presently, what was formerly the plutonium-238 processing side of the building has been stripped from floor-to-ceiling and from wall-to-wall and remains sealed off from the cold side. The quantity of plutonium-238 now estimated to be in the SM Building is approximately 0.25 g.

Section 2

Building Description and Layout

The Special Metallurgical (SM) Building, located at Mound Laboratory, was constructed in two phases. A layout of the SM Building is presented in Figure 2-1 and shows both phases of construction. The first phase was constructed of a steel superstructure with exterior walls consisting of two aluminum panels sandwiching a fiberboard insulating core. The dimension of this portion was 115 ft x 115 ft. The interior walls were fiberboard core aluminum panels, and the ceiling was a suspended type with drop-in panels.

The second phase, a 46 ft x 115 ft addition, referred to as the SM Addition (SMA), was constructed at the north end of the SM Building. This area was constructed with a steel superstructure with exterior walls of concrete block. All interior walls and ceilings were plaster on concrete block or metal lath.

The roof of both areas consisted of metal decking attached to the superstructure. The metal decking was covered with a conventional gravel built-up roof.

The floor of both areas was of poured reinforced concrete covered with vinyl-asbestos tile.

The work area, shown in Figure 2-1, contained 585 linear feet of alpha gloveboxes.

All piping and duct services were overhead in a 4 ft crawl space between the ceiling and roof. These services included ventilation ducts, steam and condensate return lines, water, compressed air, process gases (such as argon, helium and nitrogen), nitric acid supply lines, solution transfer systems, building vacuum system piping, and liquid waste transfer systems.

There were two filter banks serving the SM Building, namely the SMA filter bank, which was located on the southwest corner of the SMA Building roof, and the SM filter bank, which was located on the southwest corner of the SM Building roof. Both of these filter banks were 23 ft x 23 ft structures that were fabricated with double sheet metal walls sandwiching a layer of fiberglass insulation. The SMA filter bank contained prefilters and one set of High Efficiency Particulate Air (HEPA) filters that handled the exhaust from the fumehood, glovebox, and laboratory areas in the SMA. The SM filter bank, likewise, contained one set of HEPA filters that handled the exhaust from the fumehood, glovebox, and laboratory areas in the SM Building.

FIGURE 2-1 Layout of the SM Building.

Section 3

Special Termination Procedures and Techniques

Previously, no contractor in the AEC (presently ERDA) complex had terminated an entire radioactive facility that had been used for processing plutonium-238. Consequently, special termination procedures had to be developed by Mound Laboratory personnel. The special procedures that were developed were found effective in controlling and reducing contamination levels during the various phases of the termination effort. This section briefly describes these special termination procedures.

3.1 CONTROLLING TECHNIQUES

Several techniques were used in controlling contamination to confined areas. These controlling techniques were necessary to prevent the release of contamination to other work areas or the environment. Also, these techniques were useful in reducing the amount of contamination that would have to be removed later.

3.2 IN-PLACE GAMMA SCAN ANALYSES OF GLOVEBOXES

Before the gloveboxes could be removed from the individual laboratories, a procedure had to be developed to determine the amount of plutonium-238 in each glovebox in situ. This information was needed so that a decision could be made as to the disposition of the glovebox. Also from this information, a decision could be made as to whether or not additional glovebox cleaning was required, or if the glovebox could be removed, packaged and shipped for subsequent burial. Table 3-1 lists the general procedures followed for in-place gamma scan analysis of gloveboxes.

3.3 CLEANING OF IN-LINE PROCESS EQUIPMENT

A technique using a high-pressure cleaning unit, was developed to clean process equipment inside gloveboxes (the high-pressure cleaning unit used in this operation is described in subsection 5.3). This technique consisted of washing all external surfaces of in-line equipment with water from the high-pressure cleaning unit to remove and collect all solids associated with the exposed surfaces of the process equipment.

Both the high-pressure cleaning line and the suction return line were attached to the glovebox with a vinyl sleeve. The cleaning solution was pumped through the high-pressure line at approximately 500 psi nozzle pressure. The high-pressure line was equipped with a fan-shaped nozzle. The equipment inside the glovebox was washed with the high-pressure spray and the cleaning solution was pumped back to the Byrd Centrifuge, where the solids were continuously dumped and the effluent was returned to the liquid storage tank to be recycled. The solids were removed, packaged, and transferred to the recovery system for processing. The only cleaning solution used was tap water. This high-pressure cleaning unit performed satisfactorily for cleaning gloveboxes that were watertight. It is not recommended for boxes that are not watertight, however, because water could leak out of the boxes thereby releasing radioactive material. In gloveboxes that did not appear to be watertight, all cleaning was done manually with scrapers, brushes, and rags.

3.4 PACKAGING IN-LINE PROCESS EQUIPMENT

A technique to package in-line process equipment and associated piping inside the gloveboxes was developed. This technique consisted of filling the inside of the glovebox with polyurethane foam. The foaming was performed with all of the in-line process equipment in situ.

3.4.1 FOAMING

By foaming gloveboxes and equipment, contamination was trapped, thereby preventing the release of large amounts of contamination during equipment removal (see subsection 5.4 for additional information).

3.4.2 VENTING FILTERS

Internally, glovebox foaming was accomplished by attaching the foam line to the glovebox with a vinyl sleeve. Figure 3-1 shows the polyurethane foam being introduced into the glovebox. The foam was slowly introduced into the glovebox to allow for expansion within the glovebox without forcing off the glovebox front.

Table 3-1
GENERAL PROCEDURES
IN-PLACE GAMMA SCAN ANALYSIS OF GLOVEBOXES

1. Remove all shielding from the surfaces to be measured.
2. Check the calibration of the portable gamma meter daily with a standard source. Arrange for Health Physics to recalibrate the instrument if necessary.
NOTE: The procedure is based on measurements taken with an ionization chamber gamma detector capable of measuring gamma energies from about 75 keV to over 1000 keV. A gamma meter with a lower limit of no greater than 0.1 mR/hr is required for measuring small quantities of material.
3. Shield all sides of the gamma meter except the top, front, and the area on the bottom covering the detector with $\frac{1}{8}$ -in. lead sheet.
NOTE: The detector on the Radector III instrument is located 2-in. within the outside case of the instrument.
4. Make a top view sketch of the glovebox floor with corresponding dimensions and describe the material on each surface through which the measurements are taken (stainless steel or glass). Record in A.
5. Approximate the room background noting that strong radiation from an adjacent room or certain gloveboxes may influence readings on some gloveboxes more than others in the same room. Record glovebox background readings in B.
6. Measure two surfaces of the glovebox by one of the following methods and in this order of preference.
NOTE: Some gloveboxes may be physically restricted to allow only one surface to be measured.
 - 6.1 One measurement is centered on the front surface, 10-12 in. above the glovebox floor (between the glove ports), and the second measurement at the same spot on the back surface. Record in C.
 - 6.2 If the back cannot be measured, then, in addition to the front, a spot centered 10-12 in. above the box floor on a side surface is measured. Record in C.
 - 6.3 If the back and sides are not accessible, then, in addition to the front, a second measurement is made at the bottom, centered and 14 in. from the gamma detector (the detector being 2 in. within the case of the meter). Record in C.
NOTE: For 4, 5, and 6 ft boxes assume two sources located 1-1.5 feet in from each side. Measure each of these sources as described in Paragraphs 6.1, 6.2, or 6.3 for a single source.
7. Correct all measurements for background.
8. For those measurements made through glass, correct for attenuation (the standard operating curve was prepared and based on measurements taken through $\frac{1}{8}$ -in. stainless steel) as follows:
$$f = f_{(ss)} - f_{(bg)}$$

or

$$f = (f_{(glass)} - f_{(bg)}) \times 0.89$$

where: f = corrected measurement.
9. Record the corrected measurements of paragraphs 7 and 8 in D.

Table 3-1 (Continued)

10. Calculate the source distance (d) in one of two ways.

10.1. If measurements were made according to paragraph 6.1 (two measurements at opposite surfaces parallel to each other):

$$d = \frac{D}{1 + \frac{f_1}{f_2}}$$

d = Distance between detector position 1 and source.
 where: D = Distance between detector position 1 and detector position 2.
 f₁ = Corrected measurement at detector position 1.
 f₂ = Corrected measurement at detector position 2.

Record source distance in E.

10.2. If measurements were made according to paragraphs 6.1 or 6.2, or if only one surface could be measured, determine the source distance (d) by assuming the source is positioned exactly in the center of the glovebox floor then determine a distance (d) for each measurement. Record the source distance(s) in E.

NOTE: For 4, 5, and 6 ft boxes, determine distances for both sources as described in paragraphs 10.1 or 10.2 for a single source.

11. Calculate grams plutonium-238 by one of the following techniques using the operating curve and the equation:

$$\text{Grams } ^{238}\text{Pu} = \frac{f}{\text{mR/hr reading at } d \text{ from 1 g source}}$$

f = Corrected measurement (D)
 where: d = Source distance (E)

11.1. When determining d by the method described in paragraph 10.1, where two opposite surfaces are measured, calculate one value and record in F and result columns 19-26.

11.2. When determining d by the method in paragraph 10.2, where only one surface is measured, calculate one value and record in F and result columns 19-26.

11.3. When determining d by the method in paragraph 10.2, where two adjacent surfaces are measured, calculate two values, average, and record in F and result columns 19-26.

11.4. When two sources are assumed for 4, 5, or 6 ft boxes, calculate each source by one of the three techniques described above, sum the values obtained for each source and multiply by two-thirds for 4-ft boxes, three-fourths for 5-ft boxes, and one for 6-ft boxes. Record the final value in F and result columns 19-26. If results are below the sensitivity of the method, record in column 63. Do not report Q_g.

12. Distribute copies as shown on calculations page.

During the foaming process, freon gas is generated. To permit the freon gas to escape and to provide an outlet for the air displaced in the glovebox by the foam, the glovebox exhaust was left open during the foaming operation. However, when it was not practical to exhaust through the filter bank, a Mine Safety Appliance (MSA) high efficiency respirator filter was adapted to the glovebox for venting the glovebox. Figure 3-2 shows the use of such a device during the foaming operation.

3.5 BAGGING

As a barrier against the spread of contamination, plastic bags were fastened to equipment prior to separation. Also, plastic was used for protection against contaminated areas and equipment (see subsection 8-1 for additional information).

3.5.1 BAGGING TECHNIQUE

A loose-fitting vinyl bag was affixed to each point of separation of the service to be dismantled. The size of the vinyl bag was sufficient to permit unbolting or cutting of the service line inside the bag. When the necessary separations were made in the service line, that section of line was turned inside the vinyl bag, thereby

twisting a small section of the vinyl bag tightly at each end. This small twisted section of vinyl bag was wrapped with vinyl tape, and the bag was then cut at the taped area and the section of line removed. The technique ensured the containment of plutonium-238 during and after this operation.

3.6 GAMMA-RAY ASSAY OF PLUTONIUM-238 RESIDUES IN DRUMS AND CRATES

Fifty-five gallon drums and large crates, containing waste and scrap material, were routinely assayed by gamma spectral analysis to determine their plutonium-238 content. The lower detectable limits for the present system are 0.180 g plutonium-238 for drums and 0.500 g plutonium-238 for crates. The accuracy for these measurements is $\pm 28\%$ for drums and $\pm 60\%$ for crates.

A 3 in. x 3 in. NaI(Tl) detector was used to measure the intensity of the 766 keV gamma-ray from the decay of plutonium-238. The data were recorded on a multichannel analyzer and corrected for contributions from other gamma-rays emanating from plutonium-238, from impurities, and from (α, n) reactions. The gamma spectra were also corrected for self-attenuation.

FIGURE 3-1 Polyurethane foam being introduced into a glovebox.

FIGURE 3-2 Use of MSA filter on glovebox during foaming operation.

3.6.1 PROCEDURE

Since the self-attenuation was determined by measuring a transmission through the drum or crate of a 766 keV gamma-ray from external plutonium-238 standard sources, the following procedure was used:

- 1) A turntable to rotate the drum or crate was positioned between the NaI(Tl) detector and a rack that holds the external plutonium-238 sources.
- 2) A count was made and recorded of the intensity of the 766 keV gamma-ray from the external sources.
- 3) A similar count was made with the drum or crate rotating on the turntable between the detector and the sources.
- 4) A count was then made with only the drum or crate and no external sources.
- 5) The difference between the 766 keV intensity of the waste with and without the external sources was compared to the count with only the external sources to determine the self-attenuation of the waste.
- 6) The 766 keV intensity from just the waste was then corrected for this self-attenuation and used to calculate the grams of plutonium-238 in the drum or crate.

3.7 HEALTH PHYSICS PROCEDURES

Because of the magnitude of this project and the unique tasks to be performed, Health Physics procedures were used to protect personnel against exposure to radioactive material and to ensure the effective control of contamination and prevent the release of radioactive material to the environment.

Special orientations, instructions, and training were given to all personnel involved in the termination operations. In addition to existing procedures and guidelines, special procedures and techniques were developed to aid in personnel protection and contamination control. Some of the special orientations, procedures, and control techniques are described in the following paragraphs.

3.7.1 ORIENTATIONS AND TRAINING

Each individual was given a detailed health and safety orientation and tour of the termination area. This orientation and tour included special instruction on such subjects as radiation fundamentals, protective clothing, respiratory equipment, dosimetry, use of radiation detection instruments,

changeroom procedures, observance of signs, alarm systems, emergency procedures, and decontamination procedures. In addition, the above training was supplemented by pre-job conferences and on-the-job instructions.

3.7.2 PROTECTIVE EQUIPMENT

Protective clothing and respiratory equipment were worn as dictated by established Mound Laboratory guidelines. The type of protective items used were determined by evaluation of existing conditions based on radiological monitoring and the potential for a release. The following protective items were used: cotton shirts and trousers or cotton coveralls, two-piece plastic suits, head covers, rubber gloves and liners, safety shoes, shoe covers, safety glasses and hard hats.

The following respiratory equipment was used: the half face mask, full face mask, and the supplied-air bubble suit.

3.7.2.1 Bubble Suits For the most part, when termination of gloveboxes and associated equipment began, the supplied-air bubble suit (shown in Figure 5-7) was worn almost exclusively for maximum protection of personnel against internal exposures and skin contamination. The bubble suit and its proper usage is described in greater detail in G. L. Phillabaum and P. C. Adams, The Development of the Mound Laboratory Supplied-Air Bubble Suit, MLM-2008 (Feb. 26, 1973), 46 pp.

Users of respiratory equipment were fitted with the appropriate equipment and then oriented on its proper usage and limitations. In addition, all respiratory equipment was visually inspected and physically tested in the field prior to entry into the radiation areas. The respiratory equipment was also smoke-tested prior to entry.

Each entrance to the radiation areas was posted with conspicuous signs that defined current respiratory equipment and protective clothing requirements.

For operations that were known or suspected to produce airborne concentrations in excess of the Radioactive Concentration Guide (RCG), a person's working time and the type of respiratory equipment worn was logged on a Special Air Sample Report. These data were used in determining 40-hr personnel exposures to airborne contamination (in compliance with AEC Manual, Chapter 0524). In addition, personnel entering or exiting the immediate work area signed a log to

provide the Health Physics Survey Services Group with information regarding personnel and the relative amounts of time spent in controlled work areas.

3.7.3 MONITORING

A key part of personnel protection and contamination control was the radiological monitoring program. Airborne levels in the termination areas were monitored with both fixed position samplers and continuous air monitors. Sampling locations were continuously evaluated, and monitors were positioned to obtain maximum response to changes in air concentrations. Stack levels were continuously monitored to verify the integrity of the filter banks. Routine wipe surveys were performed to identify removable contamination levels, and instrument surveys were performed to determine fixed contamination levels and external radiation levels. Airborne and liquid effluents were routinely monitored as part of the total environmental control program.

The Health Physics Operations Monitoring Profile (see Figure 3-3) was implemented for recording and evaluating monitoring data and trends. The monitoring profile was used for distribution and communication of survey data, current radiological conditions, and recommended controls for use by appropriate management or laboratory personnel.

3.7.4 DOSIMETRY - INTERNAL AND EXTERNAL

Personnel were required to submit nosewipes upon exiting from the radiation areas to quickly indicate whether any radioactive material may have been inhaled. Film badges were worn to determine external radiation exposures, and urine samples were submitted to determine internal radiation exposures. The above mentioned dosimetry items were supplemented with special radioassay samples and whole body counting.

3.7.5 CONTROL TECHNIQUES

Entry and exit from the radiation areas were made through a series of three control zone enclosures. This zoning technique was called the "contamination control concept," which is illustrated in Figure 3-4. Outer protective clothing was removed in zone No. 1; initial personnel monitoring was performed in zone No. 2; the remaining clothing was removed in zone No. 3. Follow-up personnel monitoring was performed in the clean area before a nosewipe was submitted and a shower was taken. Shoe covers were changed before proceeding through each control zone, and airborne and removable contamination levels inside the control zones were routinely monitored.

3.7.5.1 Tents and Enclosures The use of plastic tents and enclosures (see Figure 8-9), both prefabricated and custom-made, were used frequently to aid in personnel protection and afford contamination control when opening contaminated systems and equipment. These enclosures were especially useful when working outside the building removing ductwork on the roof (as described in subsection 8.8).

3.7.5.2 Fire Watch A 24-hr, seven-day-a-week, fire watch was instituted during the termination work to provide additional (besides automatic alarms) early warning protection.

3.7.5.3 Painting Equipment was painted to trap contamination and prevent any subsequent release of contamination during equipment removal.

3.7.5.4 Sealing Outside doors and joints not in use were sealed with RTV or foam to preclude the release of contaminated water to the environment during decontamination.

3.7.5.5 Dock Extension To provide a secondary level of environmental protection, enclosures were installed on the exits from the building. In order to provide a suitable area for the installation of these enclosures the two building docks external to the SM-Building were extended.

HEALTH PHYSICS OPERATIONS - MONITORING PROFILE

_____ Bldg. Survey trends in counts/min Week Ending _____

Freq.	Area	Last week's av	Monday	Tuesday	Wednesday	Thursday	Friday	
☐	Air { High Low Av							
☐	Wipe { High Low Av							
☐	Air { High Low Av							
☐	Wipe { High Low Av							
☐	Air { High Low Av							
☐	Wipe { High Low Av							

Comments: _____

FIGURE 3-3 Health Physics monitoring profile.

FIGURE 3-4 Contamination control concept.

Section 4

Radiological Exposures

During the SM termination project, there were no significant external radiation exposures or internal depositions of plutonium-238.

4.1 INTERNAL EXPOSURES

There were no significant internal depositions of plutonium-238 for personnel involved in the SM termination project. Based on nosewipes, urine and fecal samples, and whole body counting, all personnel internal exposures were less than 50% of their yearly allowable maximum when compared with body and/or lung burden standards.

4.2 EXTERNAL EXPOSURES

There were no significant external radiation exposures for personnel involved in the SM termination project. All personnel received less than 4.0 rem whole body exposure per year [AEC (presently ERDA) allowable whole body exposure is 5.0 rem/yr). The average personnel external radiation exposure for this project was less than 0.80 rem/yr with a range of 0.00 to 3.83 rem.

From 1968 through 1972, four main groups were involved in the SM termination project: and Table 4-1 gives the external radiation exposure to employees in these groups during that period of time. This data represent maximum exposures because some of the employees worked on other projects aside from termination during each of the given years. Numbers have been assigned to the personnel whose exposures are given in Table 4-1 rather than actual names. A study was made on the operating

personnel in the four main groups to determine an average yearly external radiation exposure, and these averages are given in Table 4-1. Overall, the average external radiation exposure for the personnel in the four groups was less than 0.80 rem/yr per person.

4.2.1 SM-TERMINATION GROUP (NUCLEAR OPERATIONS)

This group was responsible for the removal of recoverable plutonium-238 from equipment. The average exposure per person in the group was 1.45 rem/yr.

4.2.2 AREA MAINTENANCE GROUP (ENGINEERING)

This group was responsible for the termination and removal of equipment. The average exposure per person in the group was 0.35 rem/yr.

4.2.3 DECONTAMINATION SERVICES GROUP (ADMINISTRATIVE SERVICES)

This group was responsible for cleaning, decontamination, area preparation, and waste packaging. The average exposure per person in the group was 0.66 rem/yr.

4.2.4 HEALTH PHYSICS SURVEY SERVICES GROUP (ADMINISTRATIVE SERVICES)

This group was responsible for radiation monitoring and contamination control. The average exposure per person in the group was 0.76 rem/yr.

Table 4-1

SM TERMINATION EXTERNAL EXPOSURE DATA IN Rem
(Based on Whole Body Film Badge)

Group	Employee No.	Calendar Year				
		1968	1969	1970	1971	1972
SM Termination Group (Nuclear Operations) This group was responsible for removing recoverable quantities of material from equipment.	1	1.14	0.44	0.76	0.86	0.16
	2	1.38	1.53	2.98	2.86	0.82
	3	1.62	1.21	1.95	3.83	1.34
	4	2.34	1.32	1.60	3.50	0.85
	5	1.16	1.92	1.40	1.47	0.14
	6	1.08	1.05	2.04	2.75	1.03
	7	0.66	0.34	2.17	3.22	0.80
	8	0.06	1.53	0.73	1.25	0.83
Area Maintenance Group (Engineering) This group was responsible for the termination and removal of equipment.	9	0.12	0.13	0.51	0.36	0.10
	10	0.12	0.16	0.15	0.23	0.15
	11	0.12	0.55	0.56	0.76	0.15
	12	0.37	0.40	0.49	0.49	0.23
	13	0.30	0.22	0.34	0.17	0.12
	14	0.30	0.20	0.34	0.42	1.16
	15	0.78	0.26	0.46	0.11	0.15
	16	0.07	0.89	0.84	0.70	0.09
	17	0.37	0.42	0.12	0.44	0.53
	18	0.35	0.26	0.85	0.94	0.20
	19	0.16	0.20	0.21	0.22	0.07
	20	0.22	0.00	0.09	0.12	0.14
	21	0.57	0.66	0.63	0.69	0.35
Decontamination Services Group (Administrative Services) This group was responsible for cleaning, decontamination, area preparation, and packaging of waste.	22	--	0.47	0.52	0.77	0.26
	23	1.17	0.72	0.73	0.46	0.61
	24	1.16	0.39	0.88	1.17	0.30
	25	1.81	1.04	0.78	1.03	0.38
	26	0.70	0.91	0.71	0.62	0.23
	27	0.00	0.17	1.22	0.75	0.24
	28	0.79	0.54	1.49	1.38	0.44
	29	--	0.20	0.87	0.94	0.21
	30	0.00	0.08	1.07	0.85	0.29
Health Physics Survey Services Group (Administrative Services) This group was responsible for radiation monitoring and contamination control.	31	1.28	0.76	1.19	0.26	0.21
	32	1.55	1.02	0.86	0.28	0.40
	33	--	--	0.50	0.28	0.19
	34	--	--	1.12	1.38	--
	35	0.00	0.08	0.84	1.49	0.20
	36	--	--	1.14	1.11	0.51

Section 5

Special Equipment and Facilities

Because of the magnitude of this project and the unique tasks to be performed, several pieces of special equipment had to be procured and tested before being used. The equipment described below represents special devices that were found to be effective throughout the termination effort.

5.1 VACUUM CLEANERS

The use of large portable vacuum cleaners, equipped with absolute filters, afforded a method of providing a negative pressure differential for tents and enclosures. The purpose of this negative pressure differential was to contain the contamination within these tents and enclosures.

5.2 TEMPORARY EXHAUST CHANGES

Modifications were made to the six main exhaust systems so that two of the systems could provide exhaust while the other four (and their filter banks) were being terminated. By effectively diverting these main exhaust systems, radiological protection to the facility was maintained during the termination effort.

5.3 HIGH-PRESSURE CLEANING UNIT

This unit was used to clean in-line process equipment and was designed and fabricated by Stainless Equipment Co., Denver, Colorado. The operational principle of this unit in conjunction with a glovebox is illustrated in Figure 5-1. The unit consisted of a John Beam high-pressure pump (1000 psi max), a 6-in. continuous dumping Byrd Centrifuge, a recirculating pump, a 30-gal liquid storage tank, and associated piping and controls. Incidentally, all of this equipment was installed in two portable gloveboxes (Figures 5-2 and 5-3).

5.4 POLYURETHANE FOAMING UNIT

A Gusmer Foaming Unit, designed and fabricated by Polymer Insulators, Inc., Houston, Texas, was used in all foaming operations. A schematic diagram of this unit is shown in Figure 5-4. This unit was equipped with special accessory equipment that included a portable cart to hold the foam

unit, pumps, transformer, and drums of foam. Figure 5-5 shows the complete unit with the accessory equipment. The portability of the unit permitted ease of movement in the work areas. The foam unit performed satisfactorily primarily because: 1) the self-cleaning foaming gun did not require a solvent flushing system and 2) the equipment required little or no maintenance.

This foaming unit produced a polyurethane foam; the physical properties of which are given in Table 5-1. Also, Polymer Insulators, Inc., Houston, Texas supplied the polymeric isocyanate used to produce this foam.

5.5 HIGH-PRESSURE WATER BLASTER

A water blaster unit, capable of producing 10,000 psi at 12 gal/min was leased from Federal Screw Works, Inc., Port Huron, Michigan. This unit, shown in Figure 5-6 and 5-7, was used to remove contaminated paint from the inside roof decking and from the exterior of the inside walls. In addition, at higher operating pressures, this water blaster was used to remove relatively fixed contamination from portions of the concrete floor.

Since the discharge from this unit could sever an 8 in. concrete block, all personnel involved in its use were trained in proper handling and safety procedures before the start up of actual cleaning operations.

5.6 GAMMA SCAN EQUIPMENT

The plutonium-238 content of 55-gal drums and wooden crates was determined by gamma scanning using a 3 x 3 in. NaI(Tl) detector to measure the intensity of the 766 keV gamma-ray from the decay of plutonium-238. The data were recorded on a multichannel analyzer, and a turntable was used to rotate the drums and crates.

5.7 COMMUNICATIONS SYSTEM

After the removal of all internal telephone lines, a communications system was established. The communication network consisted of a citizens band radio base station

with six portable units (walkie-talkies). The base station was controlled by the SM Termination Group Supervisor, who relayed messages between portable units. The portable units were distributed in the following manner: one unit in the immediate work area inside the building for general use, one unit at the personnel monitoring station at the exit of the work area, and one each to the Area Maintenance Foreman, Decontamination Services Foreman, Area Maintenance Supervisor, and the SM Termination Supervisor. Even from inside the metal SM Building, this system worked very well.

In order that Health Physics personnel could monitor progress and activities in the work area and communicate with those personnel working in remote areas (such as filter banks), an inexpensive two-station, wire-connected, inner-communications system was installed between the work area and the Health Physics monitoring station.

FIGURE 5-1 Principle of operation of high-pressure cleaning unit in conjunction with a glovebox.

FIGURE 5-2 High-pressure cleaning unit inside a portable glovebox (high-pressure pump and recirculating pump).

FIGURE 5-3 High-pressure cleaning unit inside a portable glovebox (centrifuge, solids receiver and solution hold tank).

FIGURE 5-4 Schematic diagram of the Gusmer foaming unit.

FIGURE 5-5 Gusmer foaming unit with accessory equipment.

FIGURE 5-6 High-pressure water blaster.

FIGURE 5-7 High-pressure water blaster gun.

Table 5-1

PHYSICAL PROPERTIES - POLYURETHANE FOAM

Density, lb/ft ³	2
Compressive strength, psi	30
Tensile strength, psi	32
Water absorption, vol %	2
Moisture vapor transmission	
Perms, cut sample	1.92
Perms, sample with skin	0.92
Closed cell content, %	95
Thermal Conductivity ("K" factor) Btu/hr/ft/°F/in. @ 55°F	0.11
Thermal expansion linear coefficient per °F.	0.00004
Flammability, ASTM-D-1692 ^a	Nonburning
Weather resistance	
Uncovered foam	Fair
Covered or Coated form	Excellent
Vermin resistance	Excellent
Fungus resistance	Excellent
Adhesion, to most clean surfaces	Excellent
Dimensional Stability	Excellent

^a Complies with Interim Federal Specification,
 "Insulation Board, Thermal (Urethane)",
 HH-1-00530 (GSA-FSS), Type III, Performed
 Nonburning Class 2.

Section 6

Unique Equipment and Techniques

This section describes the unique equipment and materials used in the termination effort. The supplier and cost and time of procurement are given for each item. In addition, the approximate time and manpower requirements are given for certain unique techniques.

The glovebox high-pressure cleaning unit, which is described in subsection 5.3, was effectively used to clean nondeteriorated enclosures. At the time of procurement in 1969, this unit, consisting of two portable gloveboxes that housed a high-pressure pump, centrifuge and associated equipment, cost approximately \$35,000.

The two portable foam units which are described in subsection 5.4, were purchased at a total cost of \$14,500. One unit was used in contaminated areas and the other in the noncontaminated areas. The polyurethane foam cost approximately \$1 per expanded cubic foot. Normally, a typical 3-ft wide glovebox with well required 8 hr for two men to complete the in-place foaming operation. This manpower effort included both glovebox preparation (plastic sheet installed inside the glovebox at separation points, plastic bags installed on the exterior of the gloveboxes at their separation points, polyurethane foam lines installed in the glove port) and the actual foaming of the glovebox interior.

The stainless steel glovebox used in conjunction with the decontamination of a vacuum ballast tank (see subsection 8.2 for additional details) was purchased from the Stainless Equipment Company, Englewood, Colorado in 1971 at a cost of \$4300. This glovebox was welded onto the side of the vacuum ballast tank to facilitate the removal of plutonium-238 sludge.

The lucite glovebox used in conjunction with the sectioning of long lengths of service piping (also described in subsection 8.4) was fabricated at Mound Laboratory in 1971 at a cost of \$2000. On the average, a 20-ft section of 3/8 to 1-in. diam stainless steel piping, once cut loose from its service position, would require approximately four manhours of effort to process. This effort included bagging the piping and introducing it into the lucite glovebox, cutting the piping into 2-ft lengths, inspecting and cleaning (with wire bottle brushes) each 2-ft section, and removing the 2-ft sections from the glovebox.

The high-pressure water blaster, discussed in detail in subsection 5.5, proved effective in the removal of contaminated paint and general contamination. This unit was leased for seven months at \$550/mo. In addition, approximately \$3000 was spent on repair parts and nonreturnable (because of contamination) equipment.

A crew of five men was used for water blasting: one to perform the actual cleaning, three to direct (by "sweeping") the cleaning fluid (water) to the appropriate low-risk waste handling system, and one to maintain and operate the remote power/fluid end of the system. This crew was able to clean 300-400 ft² of ceiling, wall or floor per 8-hr shift.

Each cleaning with the water blaster reduced the contamination levels considerably; but, to achieve the levels that exist today, each area had to be cleaned up to ten times.

A major adjunct to the structural decontamination by the water blaster was the use of paint stripper (see subsection 8.9 for further details). This stripper, Oakite 157 (caustic-methylene chloride), was procured from Oakite Products, Inc., Dayton, Ohio in 1972 at a total cost of \$5400.

The paint stripper was applied by a crew of four at the rate of 300-400 ft² per 8-hr shift. As with water blasting, one man applied the stripper and three men swept the excess to the low-risk, waste handling system. Because the stripper could eventually attack the bubble suits worn by the stripper crew, the bubble suits were frequently rinsed with water during the stripping operation. The stripper was applied with a pneumatically operated drum pump. A flexible hose, valve, and fan-shaped nozzle completed the pumping system, which was procured in 1972 at a cost of \$500.

A portable core sampler was employed to determine the effectiveness of the decontamination effort and to determine the locations and levels of contamination in or near the building (see subsection 9.1 for details). The portable core sampler was procured from the Bowser-Morner Testing Laboratories, Inc., Dayton, Ohio in 1972 at a cost of \$4000.

Section 7

Trial Decontamination Techniques

This section briefly summarizes trial equipment and techniques that were evaluated during the SM-Building termination. For one reason or another, these equipment and techniques were found unsuitable for their intended uses. The reasons why these equipment and techniques were not satisfactory, as well as the objectives of these trials, are also presented.

7.1 HIGH-PRESSURE GLOVEBOX CLEANING UNIT

This unit was purchased to high-pressure clean the interior of all gloveboxes and the associated equipment inside them.

The water used to clean the gloveboxes was returned to a 6-in. bowl Byrd centrifuge to remove the solids and then was recycled for continued use in washing the gloveboxes.

Because of the deteriorated condition of some of the gloveboxes, contaminated water would leak from the gloveboxes thereby contaminating adjoining areas. Therefore, this type of pressure cleaning should be limited to gloveboxes that are not extensively deteriorated.

7.2 HYDRAULIC LIFT TABLE

This equipment was purchased to roll under the gloveboxes in order to move them about during the separation operation (see subsection 8.1) and load them into shipping crates. However, the gloveboxes would not rest on the table in a stable position because of the pipe nipples, flanges, and sections of angle iron that were attached to the bottoms of the gloveboxes. Consequently, this piece of equipment could not be effectively used.

7.3 WET SANDBLASTING

A sandblaster, sand hopper, and associated equipment were purchased for use with the high-pressure water blaster system to remove contaminated paint from the interior of the building.

However, several problems were encountered with this operation, namely, the plugging of the feed nozzle, feed hoses, and floor drain with sand. Because of these problems, the sandblasting procedure was not extensively used.

7.4 MECHANICAL PAINT CHIPPERS

Mechanical paint chippers were purchased to remove the primer paint from the interior surface of the building shell. After several attempts to use these chippers, it was decided that the procedure was too slow and would consume too many manhours to complete the job and was therefore discontinued.

7.5 STRIPPABLE VINYL LATEX

This material was purchased to paint the sections of gloveboxes at their separation points when a common partition existed at such points. In theory, the vinyl latex was to have provided an impenetrable barrier to the polyurethane foam as it was introduced into the glovebox and, when the two adjacent gloveboxes were separated, the vinyl latex was to have remained in place and provided a seal to the polyurethane foam. Unfortunately, the vinyl latex was penetrated by the polyurethane foam and provided no containment barrier whatever.

Section 8

General Termination Procedures

8.1 GLOVEBOX PREPARATION

Using the procedure described in Table 3-1, the amount of plutonium-238 in each glovebox was determined. Each glovebox was then visually inspected. The physical condition of the glovebox determined what cleaning method would be used: manual cleaning or cleaning with the high-pressure cleaning unit described in subsection 5.3.

The manual cleaning of gloveboxes, using such techniques as scraping and brushing, was most effective in reducing gross contamination within a glovebox. By using this cleaning method, the quantity of plutonium-238 that remained inside a glovebox was reduced to a level where further recovery efforts were no longer practical from an economic standpoint.

After the glovebox was cleaned, another determination (using the procedure stated in Table 3-1) was made of the amount of plutonium-238 that remained inside the glovebox. From the data obtained from this second determination, the amount of plutonium removed during the cleaning was determined. When the cost of labor required to remove the plutonium-238 during a given operation exceeded the value of the plutonium-238 removed during that operation, no further cleaning of the glovebox was performed. There were, however, instances where cleaning was terminated because of the generally poor condition of the glovebox: a condition where it was felt that the potential for radiological release was too high to warrant further cleaning.

8.2 DISCARD CRITERIA

In order to provide the official approval to discard contaminated gloveboxes and associated equipment and to exercise control over the amount of plutonium-238 discarded within a single glovebox, a discard committee composed of AEC (presently ERDA)/DAO-MRC personnel was established. The discard committee consisted of one representative from AEC (presently ERDA)/DAO and two representatives from MRC. The purpose of the committee was to review the data submitted by the operating group with respect to: 1) the amount of plutonium-238 remaining in the glovebox, 2) the economics of further reducing the amount of plutonium-238 contained in the glove-

box, and 3) the degree of radiological risk associated with further decontamination efforts.

The operating personnel maintained records documenting 1) the amount of plutonium-238 contained in each glovebox before and after each cleaning, 2) the amount of plutonium-238 removed during each cleaning step, 3) the costs of labor and supplies required for each cleaning, and 4) the physical condition of each glovebox. These data were tabulated by the operating supervisor and presented with a recommendation for disposition of the glovebox to the discard committee. The discard committee reviewed these data and comments and granted approval to proceed with the foaming and subsequent discarding of the glovebox when and if one of the three following criteria was met:

1. The amount of plutonium-238 remaining in the glovebox was less than a preestablished value based on the lower detectable limit of the gamma scan analysis used to assay the glovebox.
2. The cost of removing more of the plutonium-238 exceeded the value of the plutonium-238 to be recovered.
3. The physical condition of the glovebox was too poor to warrant any further cleaning.

8.3 GLOVEBOX REMOVAL

Once permission was granted by the discard committee to proceed with a glovebox removal, the glovebox was prepared for foaming. On the inside of adjacent gloveboxes, a sheet of 0.008 in. polyethylene film was taped in position at the separation points of the gloveboxes. The polyethylene film acted as a mold release to facilitate the separation.

At this time, the gloveboxes were readied for foaming by attaching the foam unit to the glovebox as shown in Figure 3-1. The glovebox was foamed as described in subsection 3.4. The expanding foam within a glovebox is shown in Figure 3-2.

When the foaming operation was completed, all glovebox services were removed to the

headers at the room ceiling level. Most of the service piping was removed using the bagging technique described in subsection 3.5. An example of this technique applied to service removal is shown in Figure 8-1. All services connected to a glovebox were dismantled with the assumption that contamination was present. The ductwork connected to the glovebox was foamed with the exhaust on and then bagged apart at the joints or cut inside a plastic bag. Figure 8-2 shows a section of glovebox exhaust piping that has been foamed, separated, and bagged. The duct foaming operation was accomplished by drilling 1-in. holes in the duct at approximate 3-ft intervals and introducing the polyurethane foam through these openings.

With the glovebox services and ductwork detached from the glovebox system, the foamed gloveboxes were ready for separation. Adjacent gloveboxes were unbolted at their separation point. Locking pliers (Vise Grips) were used to hold the sections together until a large polyethylene bag was installed around the separation point. Figure 8-3 shows adjacent gloveboxes with the polyethylene bag around their separation points. The polyethylene bag was sufficiently large to permit the gloveboxes to be separated by approximately 3 ft.

The polyethylene was then twisted, cut, and taped. The separated gloveboxes with the twisted polyethylene bag are illustrated diagrammatically in Figure 8-4.

After the twisted polyethylene bag was cut, false glovebox ends made of plywood were bolted or clamped over the plastic covering on the end of the glovebox to prevent the plastic from tearing during the final packaging operation.

Wooden shipping boxes were covered with vinyl film and transferred to the laboratory. The shipping boxes had their tops and one side removed to ease loading. The glovebox was placed in the shipping box with the aid of a portable crane. After the glovebox was inserted into the shipping box, one side of the shipping box was installed. The shipping box was then filled with polyurethane foam in preparation for off-site shipment. Figure 8-5 shows a shipping box being filled with polyurethane foam. The top of the box was then reinstalled and, after a Health Physics survey to ensure that no activity was present on the external surface of the box, the shipping box was removed from the building.

Each shipping box was identified with a box number and a description of the contents prior to movement to the waste box

FIGURE 8-1 Bagging technique used in removing glovebox service piping.

FIGURE 8-2 Section of glovebox exhaust piping that is being foamed, separated, and bagged.

FIGURE 8-3 Adjacent gloveboxes with polyethylene bags around their separation points.

FIGURE 8-4 Diagram of two separated gloveboxes with the twisted polyethylene bag in place.

FIGURE 8-5 Shipping box being filled with polyurethane foam.

scan area where the amount of plutonium-238 contained was determined by gamma scanning, as described in subsection 3-6.

After gamma scanning, the loaded shipping boxes were moved from the waste box scan area to a box staging area for subsequent shipment off-site.

Equipment items such as: tanks, balances, and dissolvers were packaged in 30/55-gal Department of Transportation (Specification 17H) steel drums. After analysis by gamma scanning, these items were shipped in accordance with Department of Transportation Special Permit No. 5948.

High-level, plutonium-238, concentrated scrap, such as floor sweepings, sludge and residues from storage tanks, were initially dried then packaged in double encapsulated storage containers. After calorimetric analysis to determine their plutonium-238 content, these items were transferred to the Mound Recovery Group or packaged for shipment to the Savannah River Plant in accordance with Department of Transportation Special Permit Nos. 5790 and 6000.

During the course of the termination effort, several special pieces of equipment or service facilities had to be decommissioned. The remainder of this section is devoted to the activities associated with these efforts.

FIGURE 8-6 Vacuum ballast tank with glovebox mounted on top.

8.4 VACUUM BALLAST TANK REMOVAL

A 500-liter, stainless steel, ballast tank in the SM Building provided a reservoir or ballast for the vacuum system. The tank became filled with caustic material from the seal water system to the vacuum pumps. This caustic material, which was solidified, contained approximately 1 kg of plutonium-238.

The tank had originally been fabricated with a glovebox attached to the top to enclose all valves associated with the service piping leading to the tank. This glovebox served as an enclosure to prevent the release of contamination in the event of any valve leakage. Figure 8-6 shows such a ballast tank with the mounted glovebox in place. All openings in the tank were one inch or less in diameter with the wall thickness of the stainless steel tank being 3/8 in.

To remove the solid material from the tank, a stainless steel box with windows and gloveports was welded to the side of the tank, as shown in Figure 8-7. To reduce the external radiation from the tank to a safe working level, 6 in. of SE-3 lucite were installed around the tank and attached to the glovebox. A Halon-1301 extinguisher was attached to the glovebox to be used in case of fire.

Using electric drills and power saws inside the attached glovebox, an 18 x 18 in. hole was cut in the side of the ballast tank. The solids were removed from the ballast tank and packaged in half-gallon metal cans lined with PVC liners. As the cans were filled and removed by bagging out through a gloveport, they were passed into the plutonium-238 recovery lines located in the Plutonium Processing (PP) Building. After the cleaning of the ballast tank was completed, the ballast tank was packaged for subsequent burial.

8.5 REMOVAL OF PLUTONIUM-238 NITRATE TANKS

Two plutonium-238 nitrate storage gloveboxes were in the SM Building, one in Room 27 and one in Room 35. Each contained 21 solution storage tanks. Each tank was approximately 8 in. square by 30 in. high. Approximately 4 yr after the tanks were put into service, leaks developed at the welded seams and plutonium-238 nitrate leaked into the wells of the storage gloveboxes.

When the storage tanks were originally installed, redwood shingles were used as spacers to wedge the tanks in place. Several layers of plastic or wax film materials, such as paraffin, had been poured over

FIGURE 8-7 Stainless steel box welded to the side of the vacuum ballast tank.

the tanks to seal the upper portion of the glovebox from the wells so process solutions would not leak into the wells of the storage gloveboxes. Also, several cubic feet of shielding, polypropylene beads approximately 1/8 in. diam, had been poured over the tanks to lower the external radiation given off by the plutonium-238 nitrate solution.

Before the termination of these tanks was initiated, new glovebox fronts were installed. The new fronts contained a 13 in. diam port assembly which permitted the removal of the tanks in an upright position. This was necessary because any residual solution remaining in the tanks could have spilled if the tanks were tilted too much to the horizontal.

In another area, Room 58, two gloveboxes and a drumming hood with a 30 in diam front were prepared to process the storage tanks. An ultrasonic cleaner and a sliding, frame-mounted, portable power saw were installed in the drumming hood to cut and clean the storage tanks. Carborundum blades were found to do an excellent job of cutting the stainless steel.

In addition, two dissolvers were repaired and placed into operation in an adjoining glovebox to dissolve any solids that were removed from the storage tanks.

When all of the equipment had been installed, and the necessary modifications made, termination of the solution storage tank area began.

Using a large plastic bag, each tank was bagged out of the glovebox through the 13 in. diam port on the glovebox front. Each bagged tank was separately placed in a 30-gal drum to be transferred to the processing area. In the processing area, the 30-gal drum containing the storage tank was attached to the 30 in. drum port with a plastic sleeve. The plastic bag containing the storage tank was placed inside the glovebox and the tank removed from the bag. The bag was rinsed with 0.35N nitric acid and was allowed to dry.

Using the portable power saw, each stainless steel storage tank was cut into three sections. Each section was scraped and brushed manually, then placed in 0.35N nitric acid in an ultrasonic cleaner for further cleaning. All of the tank sections were dried, and these sections, along with the plastic bag, were all placed back in the 30-gal drum and removed from the hood.

The solid material from the tank brushings and the solids filtered from the ultrasonic cleaning solution were air-dried in

shallow pans. The solids were then placed in a plastic bag in a painted metal can and transferred to the plutonium-238 Recovery Group for processing.

The drums containing the cleaned storage tanks sections were gamma scanned to determine the amount of plutonium-238 present, then transferred for subsequent shipment off-site.

After approximately one-third of the storage tanks had been removed from the storage glovebox in Room 35, a fire occurred in the glovebox. No radioactivity was released outside the SM Building. Apparently, when some of the tanks had been removed, air was allowed to enter the well area of the storage glovebox and when coupled with the heat output from the plutonium-238 present, permitted the ignition of the wood, plastic, and polypropylene beads.

As a result of this fire, the polypropylene beads were fused together, making the removal effort more difficult. These beads were removed from the gloveboxes in metal cans and transferred to the Room 58 drumming hood for processing in an ultrasonic cleaner filled with 0.35N nitric acid. The beads were then placed in dissolvers, which also contained 0.35N nitric acid, and refluxed for approximately 8 hr to remove any remaining plutonium-238.

The resulting nitric acid solution was then filtered to remove the beads and solids and was transferred to recovery for processing. After air-drying, the beads and other solids were removed from the glovebox and were gamma scanned to determine their disposition, that is, either further processed by the plutonium-238 Recovery Group or packaged for shipment and subsequent burial off-site.

8.6 VACUUM AND ACID SYSTEMS PIPING

The vacuum and acid transfer piping located overhead in the crawl space of the SM Building had to be removed. These lines, 3/8 to 1 in. o.d. stainless steel piping, were removed in sections. A section of piping to be removed was bagged at the point where a cut was to be made with the cut being made inside the bag. With personnel working from above, a section of piping, approximately 20 ft in length, was lowered to the floor level. The personnel worked above the piping to prevent liquid spilling on them in the event any leaks developed.

After the long section of piping had been lowered to the floor, a continuous plastic sleeve approximately 4 in. in diam was pulled over the pipe and attached to a

special Lucite glovebox. The long section of pipe was fed into the Lucite glovebox, which contained: a cut-off saw, small trays, brushes, and miscellaneous small tools for brushing and cleaning the pipe. This glovebox operation is illustrated in Figure 8-8.

Inside the Lucite glovebox, the long sections of stainless steel piping were cut into sections approximately 20 in. long. Each piece of pipe was drained of any liquid present and then cleaned by brushing. The 20-in. long pieces were then bagged out of the Lucite glovebox and packaged in 30-gal drums for removal from the building. The 30-gal drums were gamma scanned to determine their plutonium-238 content and then transferred for subsequent off-site shipment.

8.7 SERVICE PIPING REMOVAL

All service piping in the SM Building was located in the crawl space between the ceiling and roof. Piping was included for the following services: electrical, water, helium, argon, compressed air, and steam. Contamination from previous spills in the building had spread to the crawl space and been covered with several coats of paint to hold down the radioactivity. Each line was bagged, cut into long sections, and lowered to the floor to be cut into smaller sections for discarding. As

there was no definite method to check the interior of the lines prior to their removal, it was assumed that each line was contaminated inside until a survey of the pipe could be made. In all instances, the contamination levels were found to be low enough that the piping was cut into smaller sections in the room. Although there was contamination on the exterior of the piping, it contained no recoverable amounts of plutonium-238. The cut sections of the service piping were placed in 30-gal drums and gamma scanned and transferred for subsequent shipment.

8.8 DUCTWORK REMOVAL

Most of the ductwork in the SM Building had been fabricated of galvanized metal and was in poor condition from corrosion by nitric acid vapors. The exhaust ducts were highly contaminated internally but contained no recoverable quantities of plutonium-238. Because of the deteriorated condition of the ductwork, it was decided to fill the ductwork with polyurethane foam to give it added strength. In addition, the foam would also tie up most of the contamination inside the duct.

At approximately 3 ft intervals, 1 in. diam holes were cut in the duct. The holes were then covered with tape until the foaming operation was performed.

FIGURE 8-8 Processing pipe inside a special Lucite enclosure.

At the point farthest from the main trunk line or filter bank, the foaming operation was started by inserting a rubber stopper, which was connected to the foam gun with a tygon hose, into the 1 in. hole. Polyurethane foam was then introduced into the duct. This operation was repeated until the duct was filled.

Large plastic bags were placed around the area where the duct was to be cut. Working through gauntlets in the bag, or using the bag as a sleeve, the foamed duct was cut apart with a reciprocating saw. Each section of duct that had been cut was then bagged using a procedure similar to that described in subsection 3.5.

The foamed and bagged sections of duct were placed in the shipping box and foamed in the box to make a durable shipping package. Figure 8-5 shows the foaming of such a shipping box.

This procedure was repeated until all ductwork in the building was removed to the point of exit through the roof of the building.

The ductwork on the roof was removed in the same manner, except the sections of the ductwork were not bagged off. A large plastic tent was built over the duct on the roof, and all work was performed inside the tent so no radioactive material would be released to the environment. A portion of this operation is shown in Figure 8-9.

This procedure worked satisfactorily for the removal of the ductwork, and there were no problems encountered in keeping the ductwork intact during the removal steps. In summation, this general procedure proved to be an excellent method of preventing the spread of contamination during the removal operations.

8.9 INTERIOR WALL REMOVAL

The interior walls of the SM Building were aluminum panels sandwiching a fiber core. Because these walls contained many lapped seams, the fiber core became contaminated from previous spills in the building and from the termination effort. The amount of contamination, however, was so small that it did not warrant the recovery of plutonium-238 from these wall sections. Each section of the wall was folded, placed in a wooden box, foamed in place; then the box was sealed, sent to gamma scanning, and transferred for shipment off-site.

8.10 FILTER BANK TERMINATION

8.10.1 SMA FILTER BANK

After all of the gloveboxes, interior walls, ductwork, and services had been removed from the SM Building, the building exhaust was rerouted so the entire terminated portion of the building was exhausted through the SM filter bank.

During the SMA filter bank termination, a separate and temporary exhaust system with a high efficiency particulate air (HEPA) filter was installed on the exhaust of the SMA filter bank to provide that bank with a negative (air) pressure differential. The termination of the SMA filter bank was then initiated.

Because the SMA filter bank was located directly above a laboratory area, it was decided that the quickest and safest method of getting dismantled sections of the filter bank into the laboratory area would be by means of a chute. The removal of the main ductwork trunk from the SMA area to the filter bank had resulted in an opening in the floor of the filter bank, which permitted the installation of a temporary chute between the laboratory (SMA) area (the main floor of the SM Building) and the SMA filter bank. This chute was then

FIGURE 8-9 Removal of ductwork within plastic enclosure located on SM Building roof.

used to transfer dismantled sections of the SMA filter bank (filters, filter frames, and interior walls) to the laboratory area in a safe manner. The dismantled sections of the filter bank were then packaged in the laboratory area. The levels to which this area was cleaned are listed in Section 9 of this report.

8.10.2 SM FILTER BANK

A portion of the SM filter bank was dismantled in the same manner as was the SMA filter bank. This portion was equivalent to 75% of the SM filter bank floor area. However, no chute arrangement could be provided in the SM filter bank. For this reason, all of the dismantled sections were packaged in drums and crates in the SM filter bank enclosure. These drums and crates were then transferred to gamma scanning for subsequent shipment. One portion of the SM filter bank, representing approximately 33% of the original filter area, was left in operation after cleaning to provide a negative pressure to the entire terminated portion of the SM Building. The contamination levels in the SM filter bank after this termination effort are given in Section 9 of this report.

8.11 PAINT REMOVAL

As a result of the termination effort and/or previous spills in the area, several coats of contaminated paint remained on the roof decking, walls, ceilings, and floors.

Because a dry method such as sand blasting would produce contaminated dust, which could potentially be released to the environment, the high-pressure water blaster (described in subsection 5.3) was used to remove the paint from the interior surfaces. After testing, it was determined that the water blaster, which is capable of operating at 10,000 psi, would efficiently remove paint when operated at 5,000 psi.

Operating at this reduced pressure also had two advantages, namely, there was a smaller volume of water to process; and the water blaster was easier to operate. Using 5,000 psi pressure, all paint was removed down to the primer coat on all metal surfaces.

After testing several types of paint and varnish remover, Oakite-510 was sprayed on the surfaces to remove the metal primer. This spraying was done with a stainless steel Grayco drum pump and a fan nozzle. After spraying a section of approximately 400 ft² and allowing it to set for 4 to 8 hr, the area was cleaned with the water blaster operating at 7,000 psi. Using this procedure, the interior of the building was cleaned approximately four times. The final level of contamination that remained after this paint removal operation is given in Section 9 of this report.

8.12 FLOOR TILE REMOVAL

One method of removing floor tile involved the use of a hammer and chisel to chip the tile. However, this method generated a considerable amount of contaminated dust.

Another method involved the use of dry ice (CO₂) to chill the vinyl asbestos tile for approximately 30 sec; after which, the tile could be lifted out with a hand chisel without hammering -- thereby lessening the amount of contamination released during the tile removing operation. The tile adhesive that remained on the floor after this operation was removed with the water blaster. Floor contamination levels present after this operation are also given in Section 9.

Acids (a 0.25% solution of HNO₃ or HCl) were used on small areas and floors to remove fixed contamination.

Manual cleaning was used on isolated contamination spots. Decontamination was achieved with soap, solvents, acids, scrubbers, mops, and other janitorial devices.

Section 9

Health Physics Monitoring Data

After all equipment, interior walls, ceilings, and services were removed from the building, special emphasis was placed on the decontamination of the building structure. This special effort included the removal of paint from the underside of the roof deck and the interior face of the building walls, as described in subsection 8.11, and the removal of the floor tile as described in subsection 8.12. Additional decontamination was performed with the use of the high-pressure water blaster and detergent, which resulted in the contamination levels given in Table 9-1. These levels represent an average of the Health Physics monitoring data obtained from September 1, 1972 to October 1, 1973.

Health Physics monitoring data have been similarly obtained in the SMA and SM filter banks. These data are shown in Table 9-1.

9.1 SAMPLING TECHNIQUES

The following sampling techniques were used to determine the effectiveness of the decontamination effort and locations and levels of contamination in or near the building.

9.1.1 CORE SAMPLES

Several 2 in. core samples were taken inside and outside (within 100 ft) the SM Building to determine the extent of contamination migration. The core samples were taken to a depth of 7 ft.

9.1.2 ROOF SAMPLES

The tar and felt which covered the roof were removed at several locations to determine if the roof was contaminated.

9.1.3 EXTERIOR WALL SAMPLES

External walls were sampled by coring to determine if the walls were contaminated (exterior walls are defined here as the vertical concrete or sheet metal structures located on the periphery of the ground floor of the decommissioned SM Building).

Table 9-1

SM TERMINATION
HEALTH PHYSICS MONITORING DATA FOR PLUTONIUM-238^a

<u>Area</u>	<u>Wipeable Contamination (dis/min/100 cm²)</u>	<u>Surface Area Surveyed (ft²)</u>
General Floor	20,000	13,000
Underside of Roof Deck	400	13,000
Interior Face of Building Walls	8,000	7,000
SMA Filter Bank	2,300	2,300
SM Filter Bank (Decommissioned Section)	7,800	2,600

^aThe data obtained in this table represent an average of the Health Physics surveys taken from September 1, 1972 to October 1, 1973. During this time period, there were no significant changes in the levels of wipeable contamination throughout the decommissioned sections of the SM Building.

9.2 SAMPLING RESULTS

Core samples, test samples of roof and exterior walls, wipe, direct and air-borne survey tests show that the following contamination conditions existed:

- Approximately 3.0 Ci (0.171 g) in surface and aboveground (floor

surface, walls, roof, superstructure, filter banks, etc.).

- Approximately 11.2 Ci (0.640 g) underground (floor slab, underground, sewers, drains, etc.).

Section 10

Off-Site Shipments of Plutonium-238 Residues and Scrap - SM Termination

As a result of the SM termination effort, considerable plutonium-238 residue and scrap were packaged and shipped off-site for burial or recovery. Drums (30, 55 and 83 gal) and specially-constructed plywood boxes were used for removal and shipping of contaminated equipment. The burial sites for these wastes were either NECO

(Morehead, Kentucky) or Nuclear Fuels Services, Inc. (West Valley, New York). Table 10-1 shows the type and amount of Type B and Large Quantity plutonium-238 residues and scrap shipped, the deposition of these materials, and the Department of Transportation (DOT) permit under which the shipment was made.

Table 10-1

OFF-SITE SHIPMENTS OF TYPE B AND LARGE QUANTITY^a
PLUTONIUM-238 RESIDUES AND SCRAP

No.	Type	Purpose	DOT Permit No.	Plutonium-238 (g)
101	Pressure Vessel (Concentrated Residue) ^b	Recovery (SRP)	5790 6000	220
31	Equipment Drums ^c	Burial	5948	95
110	Wooden Boxes ^d	Burial	5948	332
75 ^e	Drums (Canned Discards) ^f	Burial	5948	93
20	Drums (Polypropylene Beads)	Recovery (SRP)	5948	520
22	Drums (High-Level Canned Residues)	Recovery (SRP)	5948	325

^a The LSA waste associated with the termination effort consisted of 324 30-gal drums, 1681 55-gal drums, 1 83-gal drum and 759 wooden boxes.

^b The concentrated residues, which were composed of floor sweepings, sludge, scrapings, and impure plutonium-238 oxide, were doubly encapsulated inside a 4 in. by 7 in. pressure vessel.

^c Thirty-gallon drums containing process equipment, balances, dissolvers, tanks, and sections of process transfer lines represent the equipment drums in this category. Each 30-gal drum was packaged inside a 55-gal drum.

^d Wooden boxes (ranging in size from 4 ft by 4 ft by 7 ft to 6 ft by 8 ft by 16 ft) contained sectioned process transfer lines, process gloveboxes and fumehoods, ballast tanks, and auxiliary processing equipment.

^e This is an estimated figure based on the volume of discardable wastes generated by the SM termination effort. This figure was estimated because the termination discard wastes were packaged along with discard wastes from other processing areas at the laboratory.

^f Drums of canned discards and high-level residues contained metal cans of combustible and various noncombustible categories of processing residues. Normally, each drum contained 3 to 12 metal cans.

Section 11

Recommendations

New facilities for the handling and processing of plutonium-238 should be designed with termination in mind. All walls should be seamless and have a smooth durable surface. Sandwich walls, such as those used in SM Building, should be avoided because of the difficulty encountered in their decontamination.

Processing areas should be compartmentalized to more effectively control the movement of any release of radioactivity. Sealed off access areas behind processing lines are highly recommended because they offer an effective means of controlling radioactivity while providing a suitable work area for maintenance and installation work in contaminated hoodlines.

Building and glovebox services should not be located overhead but should be located either beneath the floor level (service level) or in some area away from the laboratories. If these services (which contain radioactive materials) are located overhead, and if leaks should develop in

these overhead services, they present a hazard to the personnel working below in the laboratory areas.

In addition, building and process support equipment should be located away from laboratory and access areas to minimize the risk of contamination. Complete building systems, such as house vacuum, corrosive vapor removal systems, and glovebox exhaust systems should be located in isolated areas. This approach would not only prove to be beneficial in a future termination effort but would allow maintenance work to be performed with little or no interruption to on-going processing operations.

Finally, once a termination effort has been started, it is important that the same individuals stay with the project for the duration. Working with experienced, trained, personnel would negate the need for the continual training and retraining of new personnel on very specialized techniques and procedures and would result in a smoother, more efficient termination effort.

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