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**Hazard Evaluation of the Special
Metallurgical (SM) Building at
Mound Laboratory**

Thomas M. Flanagan

August 6, 1976

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Miamisburg, Ohio
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Hazard Evaluation of the Special Metallurgical (SM) Building at Mound Laboratory

Thomas M. Flanagan

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1. INTRODUCTION

1.1 PURPOSE OF REPORT

The purpose of this report is to identify, assess, and document the hazards which are associated with the existence of The Special Metallurgical (SM) Building at Mound Laboratory. This report is not intended to be as comprehensive as a formal Safety Analysis Report (SAR), although the same systematic approach used to analyze hazards in SARs was utilized to develop this document. Details of the Mound Laboratory site and the approach used to evaluate hazards can be found in Description and Safety Assessment of the Mound Laboratory Site, MLM-ENG-107 and Final Safety Analysis Report, Plutonium Processing (PP) Building, MLM-ENG-105.

1.2 HISTORY OF SM BUILDING

The SM Building was a radiochemical processing laboratory constructed in 1960. Figure 1-1 is a photograph of the exterior of the facility. Figure 1-2 shows the Mound Laboratory site and the location of the SM Building.

The SM Building was 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, from R & D activities, and from analytical support activities; 3) encapsulate plutonium-238 fuel forms in the fabrication of isotopic heat sources; and 4) perform analytical activities required to support the plutonium-238 production and recovery processes.

Construction of a new plutonium facility, PP Building, was completed in December 1967. The design of the new facility incorporated numerous safety-related features which the SM Building did not have. Plutonium operations were then transferred from the SM Building to the PP Building.

Termination of the SM Building began in August 1968 and continued through August 1972. During this effort approximately 6 kg of plutonium-238 was removed from the facility. Termination of 600 ft of gloveboxes, fumehoods, and enclosures was also

FIGURE 1-1 - Aerial photograph showing SM Building; SM Building is the structure at the right. The PP Building, the operational plutonium processing facility, is the large square structure at the left.

FIGURE 1-2 - Location of the Special Metallurgical (SM) Building at Mound Laboratory. The Laboratory site is 182 acres.

accomplished during this period. All internal room walls, ceilings, floor coverings, piping, conduit, and miscellaneous services were removed (excluding drains and services in and under the floor). Also parts of filter banks and miscellaneous roof ducts were terminated.

The termination effort ceased when it became progressively more difficult and costly to remove the small amount of plutonium remaining in the structure. When the termination effort ceased, the building was left with approximately 13,000 ft² contaminated with plutonium-238. The level of contamination is shown in Table 1-1.

The SM Building contains 5,500 ft² of uncontaminated space where no plutonium processing was conducted. The heating, ventilation, and air conditioning (HVAC) for the uncontaminated area occupies approximately 1800 ft² of the 5,500 ft². The remaining space now contains change room facilities for the PP Building, offices for 13 personnel, an analytical development laboratory, a testing laboratory, two maintenance shops, and two security vaults. Historical samples of several plutonium-238 batches are stored in the SM Building in double or triple containment. Figure 1-3 is a layout of the SM Building. Figures 1-4 and 1-5 are photographs of the interior of the SM Building.

1.3 BUILDING DESCRIPTION

The Special Metallurgical (SM) Building, located at Mound Laboratory, was constructed in two phases. The first phase, built in 1960, was constructed of a steel superstructure with exterior walls consisting of two aluminum panels sandwiching a fiber-board insulating core. The dimensions of that portion is 115 x 115 ft.

In 1964, a 46 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 are plaster on concrete block or metal lath. Figure 1-6 shows the areas of different construction.

The roof of both areas consists of metal decking attached to the superstructure. The metal decking is covered with a conventional gravel and tar roof.

The floor of both areas is poured, reinforced concrete.

The decommissioned area of the building is serviced by a High Efficiency Particulate Air (HEPA) filtration system. The SM-2 filter bank is located in a penthouse on the SM Building roof. The SMA and SM-3, 4 filter banks have been decommissioned.

Table 1-1

LOCATION OF PLUTONIUM-238 INVENTORY ABOVE GROUND LEVEL

Pu Inventory (Ci)	Location
0.094	Ball Room
0.010	Insulation (wall)
0.008	Roof (tar)
0.002	SMA Filter Bank Ducts
0.006	SMA Filter Bank
0.006	SM-2 Filter Bank Ducts
0.040	SM-2 Filter Bank
0.007	SM-3, 4 Filter Bank
0.007	Repackaging and Redrumming Facility (R&R)
0.001	Low Risk Waste Tanks
0.003	Stack and Plenum
0.031	Surface of Ground
0.012	Low Risk Waste Drains and Vents
0.003	Other
~ 0.3 Ci Total

FIGURE 1-3 - Floor plan of the SM Building and room functions.

FIGURE 1-4 - Photograph showing the SM-10 (ball room) area. This area was the plutonium-238 processing area before decommissioning.

FIGURE 1-5 - Photograph of the uncontaminated area of SM Building. Offices are to the right and change room facilities are to the left.

FIGURE 1-6 - Layout of the SM Building.

2. SUMMARY

The Special Metallurgical (SM) Building, although a nonoperational plutonium-238 facility, is Mound Laboratory's major source of plutonium-238 airborne effluents. The SM Building has contributed approximately 70% of the Laboratory's effluent since termination ceased. Indications are that the SM Building will continue to be the major source of effluents in the future.

The Maximum Credible Accident (MCA) for the SM Building is a fire involving the roof. The MCA would not result in individuals in the general public receiving a dose commitment in excess of the criteria given in ERDAM-0524 or require decontamination of public property. The MCA could, however, result in an environmental impact comparable to the design

basis accident for Mound Laboratory's major operational plutonium processing facility.

The probability of the design basis accident is extremely remote, whereas the MCA for the SM Building is a highly credible event.

The hazards associated with the continued existence of the SM Building are unacceptable because ERDA, MRC, and members of the general public are not deriving any benefits from the contaminated portion of the SM Building. The existence of the SM Building is inconsistent with the philosophy of "as low as practicable" (ALAP) and the intent of Executive Order 11752, "Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities."

3. PRESENT RADIOLOGICAL CONDITION

3.1 INVENTORY OF PLUTONIUM-238

An initial estimate of the inventory of plutonium-238 remaining at the SM Building site was made in August of 1972 when the termination effort was completed. Three methods were used to determine the inventory: 1) smears of surfaces to determine dispersible plutonium, 2) direct readings to determine fixed plutonium, and 3) core sampling to determine the quantity of plutonium below ground level.

Table 3-1 shows the results of the surveys taken of the structure. The total inventory is approximately 0.3 Ci and approximately 0.012 Ci is considered to be dispersible plutonium-238 under nonaccident conditions.

In July 1972, a core sampling program was undertaken to determine the quantity of plutonium below ground level. Twenty-four locations were sampled. Eleven samples were taken under the SM-10 (Ballroom) area, two under the present office area, and eleven exterior to the SM Building. The depth of the core samples ranged from 4 - 12 ft. The core samples were then subdivided into 1-ft increments which totalled 220 separate samples. In some instances not all of the individual samples were analyzed separately but recombined to make a composite sample of the core. Seventy-eight samples were analyzed. Three additional core samples A, B, and C were taken in March 1974 in the area adjacent to the highest 1972 core sample. These samples ranged in depth

from 7 - 12 ft and were also subdivided into 1-ft samples.

Figure 3-1 shows the location of all core samples that have been taken. Core sampling locations were selected from historical records of locations of past incidents and were, therefore, the most likely areas for plutonium-238 contamination. Table 3-2 identifies the location and the results of the analysis.

Based upon the 1972 core sampling data, a conservative estimate of the plutonium-238 inventory was made at that time. This estimate indicated that 1.5 Ci of plutonium was under the SM Building, and 9.7 Ci was exterior to the facility. Most of the 9.7 Ci was near the buried low-risk waste tanks (core sample number 13). The total plutonium-238 inventory remaining at the SM Building site was estimated to be 11.5 Ci.

In order to calculate the degree of confidence associated with this value of underground inventory, a much more sophisticated calculational technique has been utilized. This technique is basically the same one used to estimate the inventory of plutonium in the waterways adjacent to Mound Laboratory. The results of this most recent estimate of inventory indicate there are 1.6 Ci of plutonium under the SM Building and 2.3 Ci exterior to the facility. The degree of confidence has been calculated to be $\pm 50\%$ at two sigma. The total plutonium-238 inventory remaining at the SM Building site is thus estimated to be 2.2 to 6.1 Ci.

LOCATION OF PLUTONIUM-238 INVENTORY ABOVE GROUND LEVEL

<u>Pu Inventory</u> <u>(Ci)</u>	<u>Location</u>
0.094	Ball Room
0.010	Insulation (wall)
0.008	Roof (tar)
0.002	SMA Filter Bank Ducts
0.006	SMA Filter Bank
0.006	SM-2 Filter Bank Ducts
0.040	SM-2 Filter Bank
0.007	SM-3, 4 Filter Bank
0.007	Repackaging and Redrumming Facility (R&R)
0.001	Low Risk Waste Tanks
0.003	Stack and Plenum
0.031	Surface of Ground
0.012	Low Risk Waste Drains and Vents
0.003	Other
<hr/>	
~0.3 Ci Total

FIGURE 3-1 - Core sample locations.

Table 3-2

CORE SAMPLE RESULTS

<u>Location</u>	<u>Sample</u>	<u>Depth (ft)</u>	<u>Concentration (pCi/g)</u>
1	1-1	2	
1	1-2	3	
1	1-3	4	(Composite) 0.04
1	1-4	5	
1	1-5	6	
1	1-6	7	
2	2-1	2	
2	2-2	3	(Composite) 0.68
2	2-3	4	
2	2-5	6	
3	3-1	2	
3	3-0	1	
3	3-2	3	
3	3-3	4	(Composite) 2.73
3	3-4	5	
3	3-5	6	
4	4-1	2	
4	4-2	3	
4	4-3	4	(Composite) 0.29
4	4-4	5	
4	4-5	6	
4	4-6	7	
5	5-1	2	0.45
5	5-0	1	
5	5-2	3	
5	5-3	4	(Composite) 2.24
5	5-4	5	
5	5-5	6	
5	5-6	7	
6	6-1	2	1.00
6	6-0	1	
6	6-2	3	(Composite) 1.73
6	6-3	4	
7	7-1	2	0.47
7	7-3	4	1.54
7	7-0	1	
7	7-2	3	(Composite) 2.28
7	7-4	5	
9	9-0	1	
9	9-1	2	
9	9-3	4	(Composite) 6.48
9	9-5	6	
9	9-6	7	
9	9-7	8	
10	10-1	2	142.23
10	10-2	3	7.20
10	10-3	4	14.41
10	10-4	5	
10	10-5	6	(Composite) 8.83
10	10-6	7	

Table 3-2 (Continued)

CORE SAMPLE RESULTS

<u>Location</u>	<u>Sample</u>	<u>Depth (ft)</u>	<u>Concentration (pCi/g)</u>
11	11-1	2	0.90
11	11-2	3	
11	11-3	4	
11	11-4	5	(Composite) 0.06
11	11-5	6	
11	11-6	7	
12	12-0	1	60.58
12	12-1	2	0.31
12	12-2	3	
12	12-3	4	(Composite) 0.05
12	12-4	5	
13	13-0	1	8.55
13	13-1	2	35.58
13	13-2	3	0.24
13	13-5	6	200.45
13	13-3	4	
13	13-6	7	(Composite) 16,911.49
13	13-7	8	
13	13-11	12	
14	14-0	1	(Composite) 3627.52
14	14-1	2	54.10
14	14-2	3	61.98
14	14-4	5	34.08
14	14-6	7	10.14
14	14-3	4	
14	14-5	6	(Composite) 74.18
14	14-7	8	
15	15-0	1	(Composite) 2308.33
15	15-1	2	490.90
15	15-4	5	3.56
15	15-2	3	
15	15-3	4	(Composite) 136.12
15	15-5	6	
16	16-0	1	759.45
16	16-1	2	251.89
16	16-5	6	88.91
16	16-2	3	
16	16-3	4	(Composite) 187.83
16	16-4	5	
16	16-6	7	
17	17-0	1	100.36
17	17-1	2	51.21
17	17-2	3	13.42
17	17-3	4	35.94
18	18-0	1	60.58
18	18-1	2	22.34
18	18-2	3	
18	18-3	4	(Composite) 17.47
18	18-4	5	

Table 3-2 (Continued)

CORE SAMPLE RESULTS

<u>Location</u>	<u>Sample</u>	<u>Depth (ft)</u>	<u>Concentration (pCi/g)</u>
19	19-0	1	1318.91
19	19-1	2	15,654.59
19	19-2	3	435.22
19	19-3	4	988.55
19	19-4	5	585.76
19	19-5	6	41.57
20	20-0	1	0.54
20	20-1	2	30.31
20	20-3	4	25.11
20	20-6	7	
20	20-2	3	
20	20-4	5	(Composite) 678.06
20	20-5	6	
21	21-0	1	56.10
21	21-1	2	289.75
21	21-2	3	15.82
21	21-3	4	27.23
21	21-4	5	4.68
22	22-0	1	501.00
22	22-1	2	4.13
22	22-2	3	18.29
22	22-3	4	104.05
22	22-4	5	10.16
23	23-0	1	751.42
23	23-1	2	10.92
23	23-2	3	25.65
23	23-3	4	65.47
23	23-4	5	7.89
23	23-5	6	6.71
23	23-6	7	121.15
24	24-0	1	668.91
24	24-1	2	168.91
24	24-2	3	
24	24-3	4	
24	24-4	5	(Composite) 185.45
24	24-5	6	
24	24-6	7	
A	A-2	2	3.717
A	A-3	3	
A	A-5	5	
A	A-6	6	
A	A-7	7	
B	B-2	2	632.209
B	B-3	3	2343.400
B	B-4	4	424.754
B	B-6	6	256.718
B	B-7	7	120.489
B	B-9	9	380.630
B	B-10	10	245.881
B	B-11	11	98.072
B	B-12	12	28.459

Table 3-2 (Continued)

CORE SAMPLE RESULTS

<u>Location</u>	<u>Sample</u>	<u>Depth (ft)</u>	<u>Concentration (pCi/g)</u>
C	C-2	2	5.080
C	C-3	3	2.709
C	C-4	4	0.420
C	C-5	5	3.547
C	C-6	6	0.737
C	C-7	7	0.566

These data show that the inventory of plutonium is known with a satisfactory degree of confidence, and a major program to refine the estimate of inventory is not required.

3.2 AIR SAMPLING

Air sampling of the terminated section of the SM Building and of the airborne effluents has continued since the termination effort ceased. Figure 3-2 shows air sample results of the terminated section for the last year. These samples are typical of the condition which exists when there are minimal disturbances in the area. The

dashed line on Figure 3-2 is air sampling results obtained during the period October 1973 to February 1974 when the last major work was conducted in the area. This work involved the installation of the automatic fire protection system for the facility.

Although the SM Building is a nonoperational plutonium facility, it is the major contributor of plutonium-238 which is released to the environment from Mound Laboratory. Figure 3-3 shows that the SM Building has contributed approximately 70% of Mound Laboratory's plutonium-238 airborne effluents since the termination effort ceased.

4. POSTULATED ACCIDENTS

4.1 INTRODUCTION

The purpose of this section is to identify, assess, and document the potential consequences of postulated accidents involving the SM Building. Two major categories of accidents are addressed: operational types and those caused by acts of nature.

4.2 EXTERIOR FIRE

The maximum credible accident which could occur involving the SM Building is a fire originating in the roof. The estimated inventory of plutonium-238 in the roof is 8000 μ Ci. This material is not considered dispersible except in an accident condition such as a fire. There are no automatic fire detection or suppression systems available in the event such a fire does occur. Detection of the fire would have to be by visual observation. During normal working hours, there are 50-100 persons in the immediate area. Mound Guard Force conducts hourly tours of the SM Building during nonworking hours. It is postulated that the fire would consume 10% or approximately 2000 ft^2 of roof before being extinguished. This would result in an environmental

release of approximately 800 μ Ci of plutonium-238. Figure 4-1 gives the downwind ground level concentrations for all atmospheric stability classes. The maximum lifetime dose commitment an individual could receive from a 2-hr exposure would be 1.09×10^{-1} rem to the lungs. This dose is considered to be an overestimate because it is anticipated the plutonium would conglomerate with the combustion products, thereby resulting in an effectively large particle size of plutonium-238. Deposition would be much less than the known plutonium-238 background levels in the vicinity of Mound Laboratory. Decontamination of public property would not be anticipated as a result of this postulated accident.

This postulated fire is considered to be an upper limit because of the availability of manual firefighting capabilities. Mound Laboratory has a 14-man professional firefighting force. Four-man crews work on a 24-hr-on, 48-hr-off schedule. Fire response vehicles include an ambulance, a 750 gal/min high pressure/volume Class A pumper, a 13,500 ft^3/min "Hi-X" foam truck, and a small auxiliary pumper. Contact is also maintained with the fire department of the City of Miamisburg, which will

FIGURE 3-2 - SM-10 plutonium-238 airborne concentration relative to RCG.

FIGURE 3-3 - SM Building contribution to Mound Laboratory's plutonium-238 airborne effluents.

FIGURE 4-1 - Ground-level concentrations of plutonium-238 following a release of 800 μCi averaged over 2 hr. Each curve represents a different atmospheric stability condition. The distance is from the point of release.

respond, upon request, to a fire at Mound Laboratory.

The maximum credible accident for the SM Building would not result in an environmental impact which would require restoration or a dose commitment to a member of the general public in excess of the guidelines given in ERDAM-0524. No serious injuries or personnel exposures would be anticipated. Such an incident would have an environmental impact comparable to the design basis accident for Mound Laboratory's major operational plutonium facility as documented in the PP Building FSAR, MLM-ENG-105. The probability of the design basis accident is extremely remote whereas the exterior fire for the SM Building is highly credible.

4.3 INTERIOR FIRE

The interior of the SM Building has automatic fire suppression and detection systems in the form of ordinary hazard sprinklers, heat detectors, and smoke detectors. The filter bank has sprinkler and deluge systems available. A minimum of 575,000 gal of water with an estimated flow of 2000 gal/min at 70-80 psi is available for firefighting.

The low-risk portion of the SM Building has essentially zero fuel loading to be consumed in a fire. The uncontaminated section currently being utilized for offices and change rooms has a maximum fuel loading of 2-4 lb/ft². The average fuel loadings are less than 0.5 lb/ft².

The most probable location for a fire to begin is in the change-room area where clothing would be the major fuel. Because of the automatic fire protection systems available and the manual firefighting capability, the fire would be limited in duration and confined to the change-room area. Smoke generated by the fire would not adversely affect the

filter bank because of the minor air flow to the low-risk area. Plutonium-238 stored is not considered vulnerable because of the containment used for storage.

A fire originating inside the SM Building would not result in a release of plutonium-238 to the environment. The major impact would be the temporary loss of change-room facilities.

4.4 POWER OUTAGE

The low-risk area of the SM Building is maintained at negative pressure to the other zones. Because of the importance of maintaining this pressure differential, emergency power has been provided for the critical parts of the ventilation system. Adequate emergency lights have been provided to ensure that operating personnel can see to exit from the building.

The loss of electrical power would not cause any personnel injuries, radiation exposures, environmental releases, or contamination spread.

4.5 NATURAL DISASTERS

Mound Laboratory has had structural analyses performed on its major facilities to determine the damage which could result from a tornado or earthquake. The SM Building was not analyzed because of the minor quantity of hazardous material available and its close proximity to the PP Building which was analyzed. The plutonium stored in the SM Building is not considered vulnerable because of the storage below floor level and the double or triple containment used. Based upon the analysis and results documented in the PP-FSAR, the impact of the SM Building would be insignificant when compared to the PP Building.

5. HAZARDS ASSOCIATED WITH THE CONTINUED EXISTENCE OF THE SM BUILDING

Mound Laboratory identifies the following hazards associated with the continued existence of the SM Building.

1. The SM Building has contributed approximately 70% of Mound Laboratory's plutonium-238 airborne effluents since termination of the facility ceased. The levels of plutonium-238 are not in excess of the guidelines given in ERDAM-0524 but are

considered to be unwarranted and inconsistent with ERDA's policy of "as low as practicable" (ALAP) and the intent of Executive Order 11752. Indications are that the SM Building will continue to be Mound Laboratory's major source of plutonium-238 airborne effluents in the future.

2. A credible hazard exists in that a fire involving the roof will occur and result in an environmental release of 800 μ Ci of plutonium-238. Such an incident is comparable to the design basis accident documented for Mound Laboratory's major operational plutonium processing facility.

3. It is anticipated that as the SM Building continues to deteriorate additional release pathways will occur. Smears of the roof have indicated plutonium-238 surface contamination. The roof has also deteriorated to the point rainwater leaks into the decommissioned portion of the SM Building. There exists the potential

for plutonium-238 to be released to the environment in larger quantities through both airborne and waterborne effluents as deterioration continues.

Monsanto Research Corporation considers the existence of the SM Building inconsistent with its operating policy of minimizing radioactive effluents released to the environment. The hazards associated with the SM Building are unacceptable because ERDA, MRC, and members of the general public are deriving no benefits from the contaminated portion of the SM Building.

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