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J. A. Michelbacher, S. P. Henslee, K. E. Rosenberg and R. M. Coleman

Argonne National Laboratory
Engineering Division
P.O. Box 2528
Idaho Falls, ID 83403-2528

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ABSTRACT

An Analytical Laboratory Hot Cell Facility at Argonne National Laboratory-West (ANL-W) had been in service for nearly thirty years. In order to comply with current DOE regulations governing such facilities and meet programmatic requirements, a major refurbishment effort was mandated. Due to the high levels of radiation and contamination within the cells, a decontamination effort was necessary to provide an environment that permitted workers to enter the cells to perform refurbishment activities without receiving high doses of radiation and to minimize the potential for the spread of contamination. State-of-the-art decontamination methods, as well as time-proven methods were utilized to minimize personnel exposure as well as maximize results.

BACKGROUND

The Analytical Laboratory (AL) located at Argonne National Laboratory-West (ANL-W) contains six interconnected hot cells used to provide chemical analyses of irradiated nuclear fuels and materials. The long service history and current programmatic requirements for the cells dictated that they be decontaminated and prepared for further use.

Each hot cell is 183 cm (72 in) wide by 168 cm (66 in) deep by 376 (148 in) high, with a working tray located 96 cm (38 in) above the floor. The hot cell walls are made from high density barite concrete and are 61 cm (24 in) thick. A shielding door, 91 cm (36 in) wide by 203 cm (80 in) high provided access into each hot cell. Figure 1 depicts the hot cell operating corridor prior to the decontamination effort. As shown on Figure 1, each hot cell has a leaded glass window to view the internal area of the hot cell. In addition to the hot cells, a steel metallographic cell, approximately 150 cm (60 in) on each side was attached to the rear of hot cell #6 via a transfer port.

The filtering for the ventilation system for the hot cells consisted of 26 HEPA filters in parallel. These filters were also used for the remainder of the Analytical Laboratory contamination control ventilation exhaust systems.

SCOPE OF WORK

The work scope for the decontamination effort included erection of temporary containments and provisions for temporary ventilation for decontamination of the metallographic cell, hot cells, AL ventilation system, filter system removal, and associated equipment and areas. Due to the lack of in-house manpower and experience in this field, it was decided to contract this effort to an outside firm.

PREPARATION FOR THE DECONTAMINATION EFFORT

Prior to issuing the decontamination contract, ANL-W performed an initial hot cell cleanup. This process included the removal of an obsolete acid scrubber system contaminated with perchlorates from hot cell #2 (reference 1). Safety and radiological concerns drove ANL-W to design and build a low-cost robotic device (reference 2) that was operated from in front of the hot cell, enabling the system to be disassembled and sized remotely.

Over the nearly thirty years of hot cell operations, a significant amount of contaminated equipment was stored in the cells, the majority being beneath the working trays. Removal and disposal of this equipment from all six cells was performed, remotely aided by the robotic device (reference 3). Removal of this equipment and waste from the cells reduced the source term prior to the arrival of the decontamination contractor.

TEMPORARY CONTAINMENTS AND VENTILATION

To control the spread of contamination during the decontamination of the hot cells, temporary containments were erected at the front and rear of the hot cells. Since the contamination levels within the hot cells and metallographic cell were so high, inner containments were erected as an additional barrier to help keep the levels of contamination in the main containments at a minimum. These inner containments were erected at the locations shown on Figure 2.

The containments were maintained at a negative pressure with respect to the surrounding areas by means of a temporary HEPA filtered ventilation system. The containments at the front and rear of the hot cells exhausted into the cells and subsequently through the temporary HEPA filter bank and out through the existing AL stack. This provided for air flow from the least contaminated to the most contaminated areas.

When the hot cell facility was operating, 500 cfm was exhausted from each cell. In order to provide an adequate air flow through the containments and maintain a negative pressure differential across the containments, the flow through each cell was increased to 1500 cfm. This was accomplished by exhausting 3000 cfm from each pair of cells through a 3 X 1 filter housing and a 3000 cfm blower that tied into the existing AL stack. All temporary filter housings had bagout capability.

This temporary ventilation system added significant complexity to the efforts described herein and to the following construction phase not addressed in this paper. During this decontamination phase, all routine operations within the AL were performed with the support of this temporary ventilation system.

DECONTAMINATION

The primary motivation for decontamination of the hot cells was to create an environment that personnel could work in during cell refurbishment activities without receiving large doses of radiation or without concern about the spread of contamination.

General radiation levels within the hot cells prior to the decontamination effort ranged from 300 milliroentgen/hour (mR/hr) to nearly 2 R/hr, as shown in Table 1. Hot spots in excess of 25 R/hr were present in a number of locations.

Several methods were used in the decontamination effort, ranging from equipment removal, remote wipe-downs, CO_2 pellet impingement, scabbling (needle gun), vacuuming, and fixing contamination with paint.

The initial gross decontamination of the hot cells was performed remotely by vacuuming and wiping down or mopping of the cell internal surfaces to remove loose contamination. This method was effective in that it removed loose contamination that provided significant contributions to the general radiation levels within the hot cells. The operation was limited by the range of motion of the lead-follow manipulators. However, the limited range of motion did cover the areas of highest contamination, although the areas beneath the working trays were inaccessible.

The primary decontamination method proposed was the use of CO_2 blasting. This concept uses frozen CO_2 pellets, roughly the size of a grain of rice, entrained in a stream of compressed nitrogen gas. This mixture continuously flows through a nozzle at high velocity, and impinges on the article being cleaned. The collision between the pellets and the object causes the CO_2 to sublime.

The removal of contaminants comes from a combination of operations at work. The first is the kinetic energy caused by the movement of one solid material against another. Second is the spalling of the material surface that is caused by the expansion of CO_2 during its conversion from a solid to a gas. The relatively small solid is forced by pressure to completely fill the pores of the material and then rapidly expands, resulting in removal of a microscopic surface layer via hydraulic fracturing.

Refuse generated during this operation was vacuumed into a two stage refuse drum arrangement exhausting through a HEPA filter.

The interior of the hot cells was painted, and the area from the tray height to 120 cm (48 in) above the tray contained a layer of tape originally placed for decontamination purposes. The CO_2 blast was successful at removing the tape, but the paint was removed at such a slow rate, approximately 13 cm^2/min (2 in^2/min), that alternate removal methods had to be considered in order minimize worker radiation dose.

The method chosen to remove the paint was a needle gun, or scabbler. This device operates by pneumatically driving specially hardened needles into the surface being cleaned, removing a predetermined thickness of material. Shrouds provided with these units work in conjunction with HEPA filtered vacuum systems to collect the debris as it was generated.

The needle gun proved to be effective for our application. The rate at which it was operated was approximately 1000 cm^2/min (144 in^2/min). The entire surface of the cells was subjected to this process, removing approximately 1 mm of the surface of the concrete along with the paint. Since this is where the majority of the beta and gamma emitting materials resided, this method provided for significant reductions in radiation levels.

The walls were again blasted with the CO_2 pellets and further reduction in radiation levels were noted. Hot spots within the cells still existed, providing significant contributions to the general radiation levels. These hot spots were identified and further reduced by scabbling.

Areas were found where contamination "leached" from the surface. Frequent wipe-downs were performed, and pre-wipe-down contamination levels reappeared. In order to preclude further recurrence, the interior surfaces of the cells were primed and painted with an epoxy based decontaminable paint.

RESULTS

Table 1 provides a summary of the results of the decontamination effort. As shown, each method improved upon the reduction in radiation levels. Wiping of the cells and equipment within the cells provided an average reduction in levels of about a factor of two. The major reduction in levels occurred during the scabbling and CO_2 blasting, where the levels were reduced by greater than a factor of ten.

Radiation levels within some of the hot cells, particularly hot cell #2, were deemed too high for occupancy during refurbishment. The levels in these cells were further reduced by scabbling hot spots and applying shielding to the floors.

In order to fix any loose contamination within the hot cells, all surfaces were primed and painted with an epoxy based decontaminable coating.

Since survey results vary, in order to obtain an accurate measurement of the actual doses workers would be subjected to, dosimetry was placed within the hot cells at waist height. After 24 hours, the dosimetry was removed and read. These results provided the information given to the prospective General Contractors for bidding purposes. As shown in Table 1, the deep dose radiation levels ranged from 1.5 to 7.5 mR/hr.

LESSONS LEARNED

A number of lessons were learned in the process of performing the decontamination of this hot cell facility. This section discusses a few key points that are listed for the reader's benefit.

CONTAINMENTS

Originally all containments were fabricated from non-PVC bearing materials that were selected for their ease of disposal. However, the only available non-PVC sheeting was opaque and proved to be lower quality material requiring frequent and untimely repair. The non -PVC materials forced installation of windows with duct tape. Due to the nature of this material both the fabrication of containments as well as installation of windows was dependent upon the use of duct tape. Duct tape quality varies considerably and multiple-month pseudo-structural applications are not recommended by the authors.

Ultimately all containments were replaced with prefabricated, sewn reinforced PVC with integral floors and most importantly clear see through windows. The eventual replacement of these containments was driven by contamination control; the need for improved temporary ventilation system pressure differentials. The down side of the replacement was the volume of waste generated that was the initial driver for the selection of materials.

CO_2

The range of application of the CO_2 technique was ultimately questioned and should be closely considered prior to committing to this technique. From the experience at ANL-W it appears that this method is good for the decontamination of stainless and carbon steels (actually better on carbon steel), and for exposed concrete surfaces, but relatively poor for the removal of paint.

Experience gained indicates that specific applications should be investigated. One should closely evaluate decontamination requirements and potentially mock up specific conditions, paint types, surfaces, etc. Decisions should be based on actual data and relevant facts, not on contractor suggestions or 'vendor performance data'.

CO_2 decontamination has the potential to generate high levels of airborne contamination. If not prepared to handle the potential problems associated with derived air concentrations far in excess of those approved for standard full face respirators, then appropriate abatement or control measures should be engineered prior to committing to a contracted CO_2 operation. An additional point that will improve CO_2 performance is the use of experienced operators who understand equipment operational idiosyncrasies as well as how to minimize airborne contamination.

TEMPORARY VENTILATION SYSTEM

The use of temporary ventilation systems to either replace one being removed, as in the ANL-W situation, or as a supplement to existing systems, can make the decontamination effort successful. Careful planning, engineering, and operational flexibility are the basic requirements. The purchase of quality filter housings with isolation dampers, bag-out capability and prefilters is an absolute must. Closely coordinated engineering support was very beneficial in our experience and allowed AL operations to continue through periods of changing configurations and system evolutions.

CONCLUSIONS

The Analytical Laboratory hot cell facility at ANL-W required refurbishment in order to meet programmatic requirements and comply with DOE regulations. Through a well thought out process, the facility was decontaminated to levels that permitted personnel to enter the hot cells to perform the refurbishment tasks without exceeding the DOE and ANL-W imposed radiation exposure limits. A variety of decontamination methods were utilized to achieve the final results.

REFERENCES

1.) Removal of an Acid Fume System Contaminated With Perchlorates Located Within a Hot Cell, by K. E. Rosenberg, S. P. Henslee, W. R. Vroman, J. R. Krsul, J. A. Michelbacher, and G. C. Knighton, dated September, 1992.

2.) ELRA - The Exposure Limiting Robotic Apparatus, by G. C. Knighton, K. E. Rosenberg, S. P. Henslee, J. A. Michelbacher, and C. W. Wilkes, dated September, 1992.

3.) Disposal of Radioactive Waste from a DOE Analytical Laboratory Hot Cell Complex, by S. G. Johnson and J. R. Krsul, dated September, 1992.

TABLE 1. RADIATION LEVELS AT VARIOUS DECONTAMINATION PHASES

	Cell #1	Cell #2	Cell #3	Cell #4	Cell #5	Cell #6
Beginning Levels	800/150[1]	1800	800	300	1000/50	400/100
Gross Decon		500/200	500/150	300	500	
Equipment Removal	250	1000	400/100	100	300	300/80
CO_2 Blast & Scabble	20/8	80	10	10	10	10
Final Levels	27.4/5.6	45.0/2.5	12.3/3.5	11.0/5.5	12.3/7.5	35.3/1.5

[1] Levels specified as xx/yy signify skin dose (beta)/whole body penetrating dose (gamma). All levels are mR/hr.

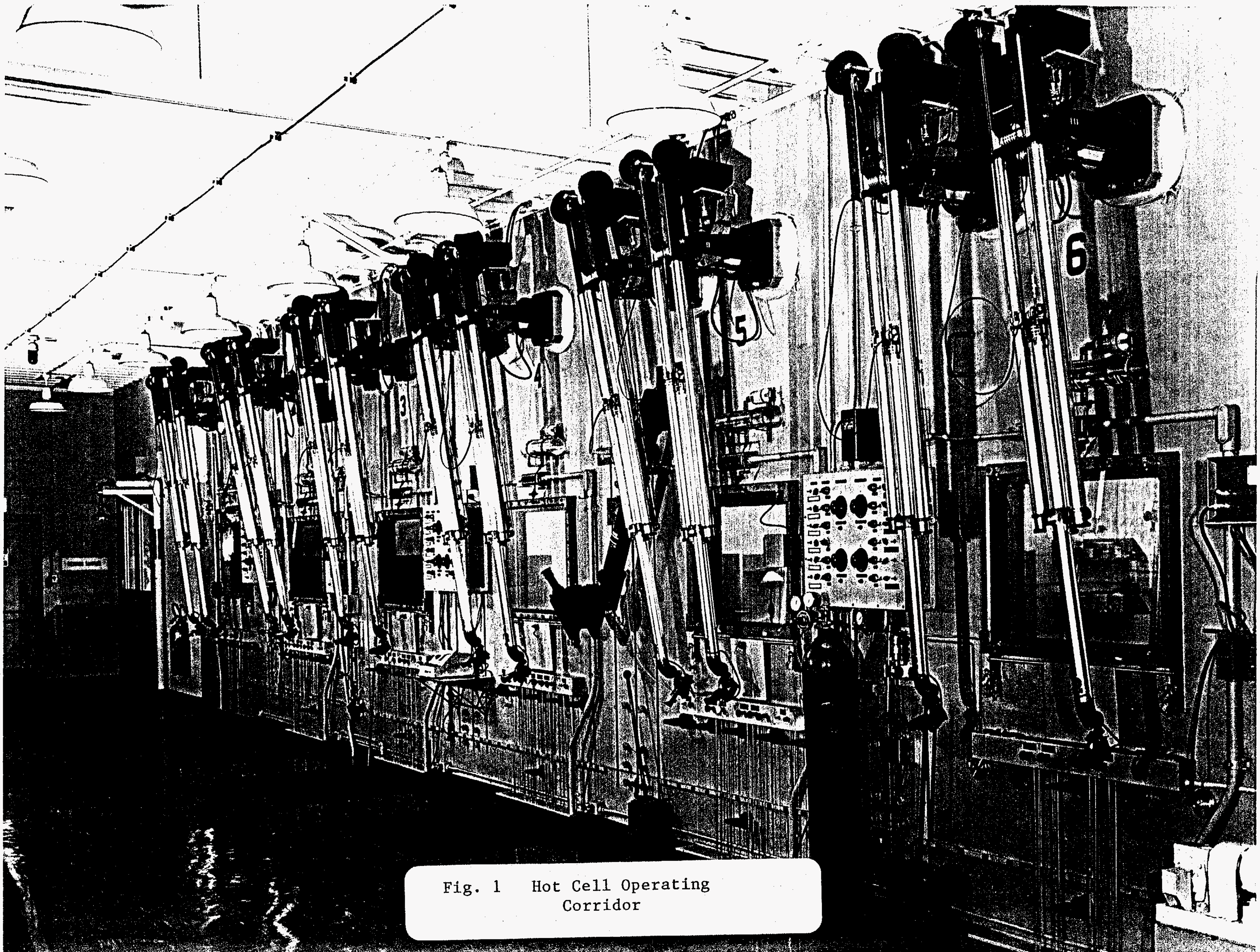

Fig. 1 Hot Cell Operating Corridor

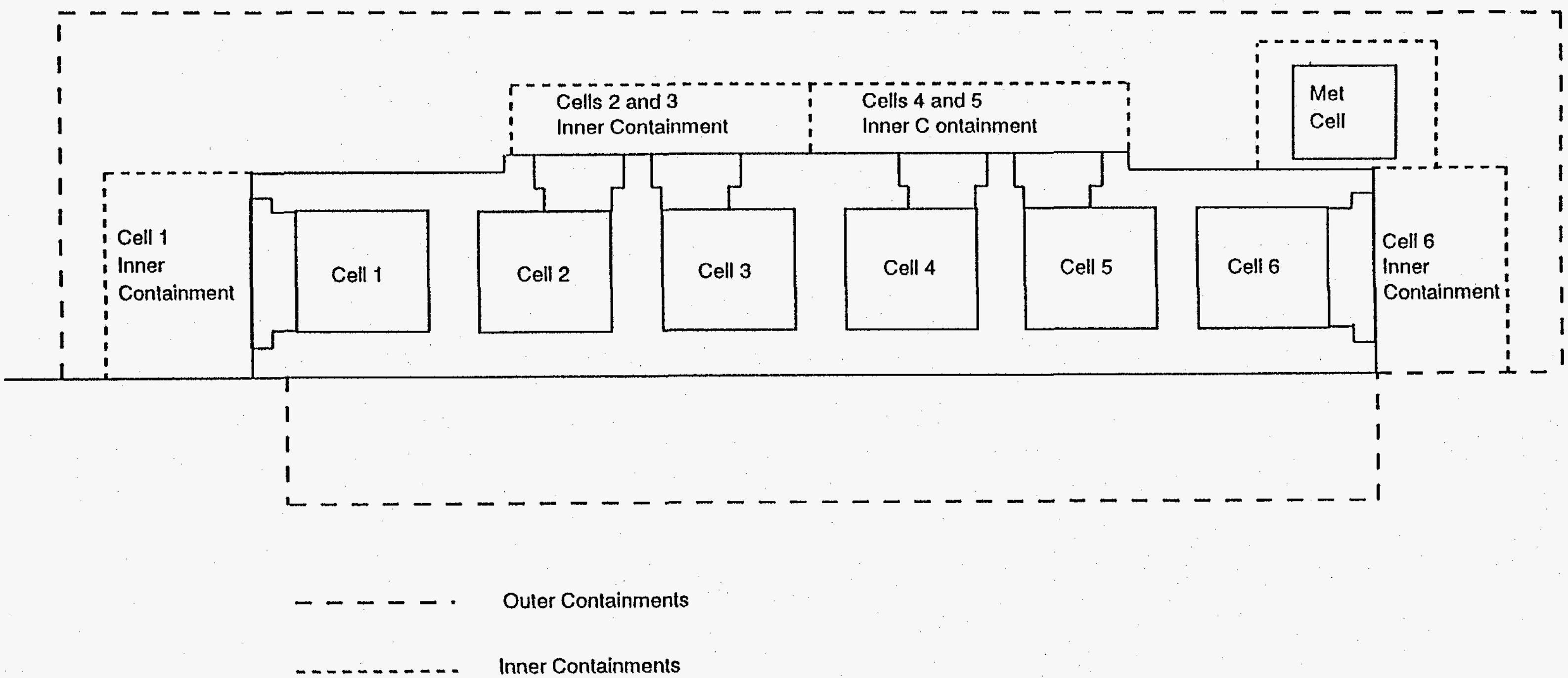

Fig. 2 Inner Containment Locations