# DECONTAMINATION AND SIZE REDUCTION OF FIVE HOT-CELL SHIELD DOORS

P. H. Waite, R. A. Marshall, and M. A. Spenard

The Boeing Company
Rocketdyne Propulsion & Power
P. O. Box 7922, Canoga Park, CA 91309-7922

## ABSTRACT

This paper describes the decontamination and size reduction of five shield doors from the dismantlement of a large hot cell facility. The 0.53-m-thick cast Meehanite® shield doors ranged in size from 2.4-m high by 2.4-m wide, weighing 29,000 kg (32 tons), to 3.1-m high by 3.7-m wide, and weighing nearly 40,000 kg (44 tons). Several significant technical challenges were encountered and addressed in their decontamination and size-reduction for disposal. The work was successful, resulting in the minimization of radioactive waste and the free-release of most of the material for recycle.

## BACKGROUND

The Rockwell International Hot Laboratory was located in Southern California at the Santa Susana Field Laboratory (SSFL), now owned by The Boeing Company. The Hot Laboratory was operated from 1959 to 1989, supporting a wide range of Department of Energy (DOE) and Nuclear Regulatory Commission (NRC) programs. It housed four multi-megaCurie hot cells, designed for performing remote nuclear fuel handling and declading operations. Each of the four cells was accessed through large, overhead roller-mounted shield doors. These shield doors were made of cast Meehanite®, a dense, fine-grained cast iron, and were some of the largest Meehanite® castings at the time of their manufacture. The 0.53-m-thick doors ranged in size from approximately 2.4-m high by 2.4-m wide, weighing 29,000 kg (32 tons), to approximately 3.1-m high by 3.7-m wide, and weighing nearly 40,000 kg (44 tons). After thirty years of use, the doors had become contaminated with leeched-in, ground-in, and painted-over radioactive material. Although they qualified for disposal as radioactive low level waste, road shipment of the radiologically contaminated doors was considered to be impractical both because of their extreme size and weight and because of concerns over an unfavorable political climate and public perceptions.

## DOOR REMOVAL AND RADIOLOGICAL CHARACTERIZATION

Removal of the doors from the Hot Laboratory required the design and fabrication of special wheeled fixtures and the drilling and threading of fixture mounting holes into the ends of each door (Figure 1). The doors were then lifted using "pancake" hydraulic jacks, which allowed the doors to be removed from the overhead rollers and the wheeled fixtures to be bolted to the ends of the doors. The doors were then moved to the loading dock of the Hot Laboratory, where they were loaded onto trailers for transfer to the on-site Radioactive Materials Handling Facility (RMHF). The RMHF is licensed to store and handle radioactive materials and houses a large, 390-$m^2$ high bay that is equipped with a 45,000-kg (50-ton) capacity bridge crane capable of handling the doors.

*Figure 1. Removal of a Shield Door from the Hot Laboratory Facility.*

Because the RMHF is located near the Hot Laboratory on the SSFL site, no special Department of Transportation (DOT) permits were required to move the doors to the RMHF. However, transporting the doors by truck even this short distance made it clear that over-the-road transport of the radiologically contaminated doors for disposal as low level waste (LLW) would be a complex and difficult endeavor.

Once at the RMHF, the doors were stored flat on the high bay floor and thorough radiological surveys were performed to evaluate the extent of their contamination. The purpose of the surveys was to determine the requirements for the disposition of the doors. Complete surveys required that the doors be flipped to access all sides. Simple lifting of the doors could be accomplished with standard rigging techniques, but turning them over was classified as "critical" lifts because of their large sizes.(1) Holes were drilled and threaded into the ends of the doors to allow the attachment of swivel lifting eyes. This allowed the doors to be stood on end and then gently tilted and lowered to expose the opposite sides. The radiological survey results indicated surface contamination levels up to 100 mrad/h $\beta$ on small areas of the bottom door edges, while the general surface contamination levels were approximately 20,000 dpm/100 $cm^2$ $\beta\gamma$ on the door faces. These contamination levels confirmed the requirement to decontaminate the doors or dispose of them as radioactive waste. Because the doors had been painted, it was felt that decontamination could be accomplished relatively easily using standard decontamination techniques, such as abrasive blasting or grinding. Their decontamination would minimize radioactive waste and make over-the-road trucking of the decontaminated material for recycle less restrictive and more acceptable to the public.

Examination of the door fabrication blue prints had revealed that the two largest of the five doors were made of 0.27-m-thick "slabs" that had been laminated and then bolted together to make up the full 0.53-m thickness. Also, several holes had been drilled and threaded into the doors during the manufacturing process for the attachment of handling and installation equipment. The prints showed that the lugs used to hang the doors were set into machined pockets and then pinned into place through the cast slabs. The laminated doors had to be separated, all existing holes drilled out, and the hanging lugs removed in order to perform complete radiological surveys to allow free release.

## DECONTAMINATION ACTIVITIES

Prior to attempting large scale decontamination of the doors, spot decontamination was performed for the higher contamination areas on the bottom of one of the doors using hand-held abrasive blasting equipment and grinders. Further, the bolts in one of the laminated doors were removed to allow for the separation of the two slabs. The bolt holes were drilled out and the door mounting lugs removed for decontamination. These decontamination activities significantly reduced contamination, and it was decided that the laminated doors could be decontaminated and released as non-radioactive scrap because the halves were readily separated. However, decontamination of the doors proved to be substantially more difficult than originally envisioned, and each step of the process was met with new, unforeseen challenges.

The first step in large-scale decontamination was the preparation of a controlled work area. The RMHF high bay is fully equipped to store and handle radioactive materials and is capable of being set up to perform decontamination procedures. However, a large HEPA-filtered containment structure with a negative pressure differential was built within the high bay because of the high contamination levels. This structure was constructed large enough to accommodate the extreme size of the doors, and was designed to be moveable so that it could be repositioned over each door to minimize door handling.

Decontamination efforts began with paint removal using hand-held needle scalers. This technique was effective but extremely labor intensive, prompting investigation into more efficient paint removal methods. The needle scalers were replaced by the use of a large, high-powered abrasive blasting unit.

This unit incorporated an abrasive recovery/re-use system which effectively removed the paint and minimized the quantity of contaminated abrasive produced. This system decreased the time and increased the cost effectiveness of decontaminating the door surfaces (Figure 2).

***Figure 2. Decontamination of a Shield Door Surface by Abrasive Blasting.***

The surface decontamination effort revealed additional contamination problems. The abrasive blasting uncovered casting irregularities along the door edges. These irregularities had allowed contamination to leech into the surfaces of some of the doors, and further aggressive abrasive blasting was ineffective in its removal. Shallow subsurface air pockets had apparently formed during the casting process and provided an ideal location for the entrapment of contaminants. Additionally, contaminants had ground into the bottom edge of the doors during the thirty-plus years of service. Some of the highest contamination levels were found on the internal surfaces of a through-port in the center of the largest door, which was of laminated construction. This port had been used for moving fuel assemblies into, and for the removal of declad fuel from, the hot cells during declading operations. Those surfaces were the most difficult to access.

The contamination in the subsurface pockets and in the bottom edges of the doors was shallow (less than 7 mm), and decontamination efforts were continued. Hand grinding initially replaced abrasive blasting for the removal of the bottom-edge contamination, as spot tests indicated that the grinding procedures would be successful in removing subsurface contamination. However, the hand grinding soon proved to be only marginally successful and extremely labor intensive. Investigations were made into more effective and efficient material removal techniques. Attempts to remove spot subsurface contamination using a magnetic-based drill press were successful, but also labor intensive. Milling machine tools were identified as a better option to remove the contamination from the side, bottom, and top edges of the doors. This method allowed much deeper metal removal, including most of the contamination entrapped in casting imperfections, and eliminated the "smearing" effect associated with grinding.

The doors were too large for conventional machining equipment to handle, and an off-the-shelf portable milling machine was acquired and adapted to a specially designed mounting fixture. This fixture allowed the milling machine to remove up to 7 mm of contaminated material from the door edges without moving the door (Figure 3). The decontamination of the door edges and the threaded holes using the portable milling machine resulted in the successful decontamination of over 90% of the door surfaces. One of the two laminated doors and all but the internal edges of the through-port in the second laminated door were cleaned to below release limits. The edges of all three non-laminated doors were decontaminated in this manner.

***Figure 3. Removal of Contamination Embedded in a Door Edge Using a Portable Mill.***

Disassembly and decontamination efforts on the three non-laminated doors encountered other difficulties when the mounting lugs could not be removed. The pockets that had been machined into the doors when manufactured were over 25 cm deep, and the 3.8-cm-diameter pins that had been installed to retain the lugs in the pockets had been pressed into blind holes. Lead had been poured into the pockets after the lugs had been installed to fill the voids between the lugs and the pocket-end radius. Most of the pins could not be pulled out, even using several different extraction techniques, which made the removal of the lugs impossible. Thus complete decontamination of the non-laminated doors could not be carried out, since the pockets could not be accessed for decontamination or verification surveys.

## SIZE REDUCTION

Since most of the door surfaces were successfully decontaminated, activities were redirected toward finding a method to remove those portions of the doors that contained residual contamination. This would still allow over 80% of the 163,000 kg (180 tons) of cast Meehanite® to be released as non-contaminated scrap iron. Size reduction of the doors would also make handling and shipping of the released components a routine matter.

A number of size reduction options had already been investigated, since segmenting the doors had originally been considered as an alternative to decontamination or one-piece low level waste disposal. Saws were ruled out because a size large enough to cut the doors is uncommon and extremely expensive to purchase or lease. Diamond wire cutting and abrasive water jet cutting were judged to be impractical, both because of the material to be cut and because of the difficulties in controlling the massive quantity of water needed. Traditional oxygen-acetylene and oxygen-propane torches cannot be used to cut cast iron, and even the largest plasma torch cannot cut a 0.5-m material thickness. Further investigation following the decontamination effort identified a powder torch as a viable option. The powder torch injects iron powder into the flame of an oxygen propane torch to cut non-ferrous metals and cast iron, and has been used extensively as a safe, reliable, and economical technique for over sixty years. It has been used successfully to cut material, including concrete, over 1 m thick. Powder torches, along with the required powder delivery systems, are available from several manufacturers.

A powder torch was acquired and used successfully to remove the remaining contaminated sections of the doors, and to segment the decontaminated door slabs into more manageable sizes for handling and shipping. However, even the use of the powder torch required significant preparation. Cutting 0.5-m-thick cast iron produces tremendous quantities of heat, molten dross, smoke, and sparks, requiring containment and other controls. A steel-sided penthouse structure, available from other SSFL demolition activities, was modified to install in the RMHF high bay, and fitted with three high capacity exhaust units. It could accommodate even the largest door and allow room for the cutting equipment. It was easily lifted and placed over each door using the facility's bridge crane. In order to minimize personnel hazards, the torch was track-mounted inside the containment structure (Figure 4), with the gas valves, powder flow, and motor drive controls located outside of the structure.

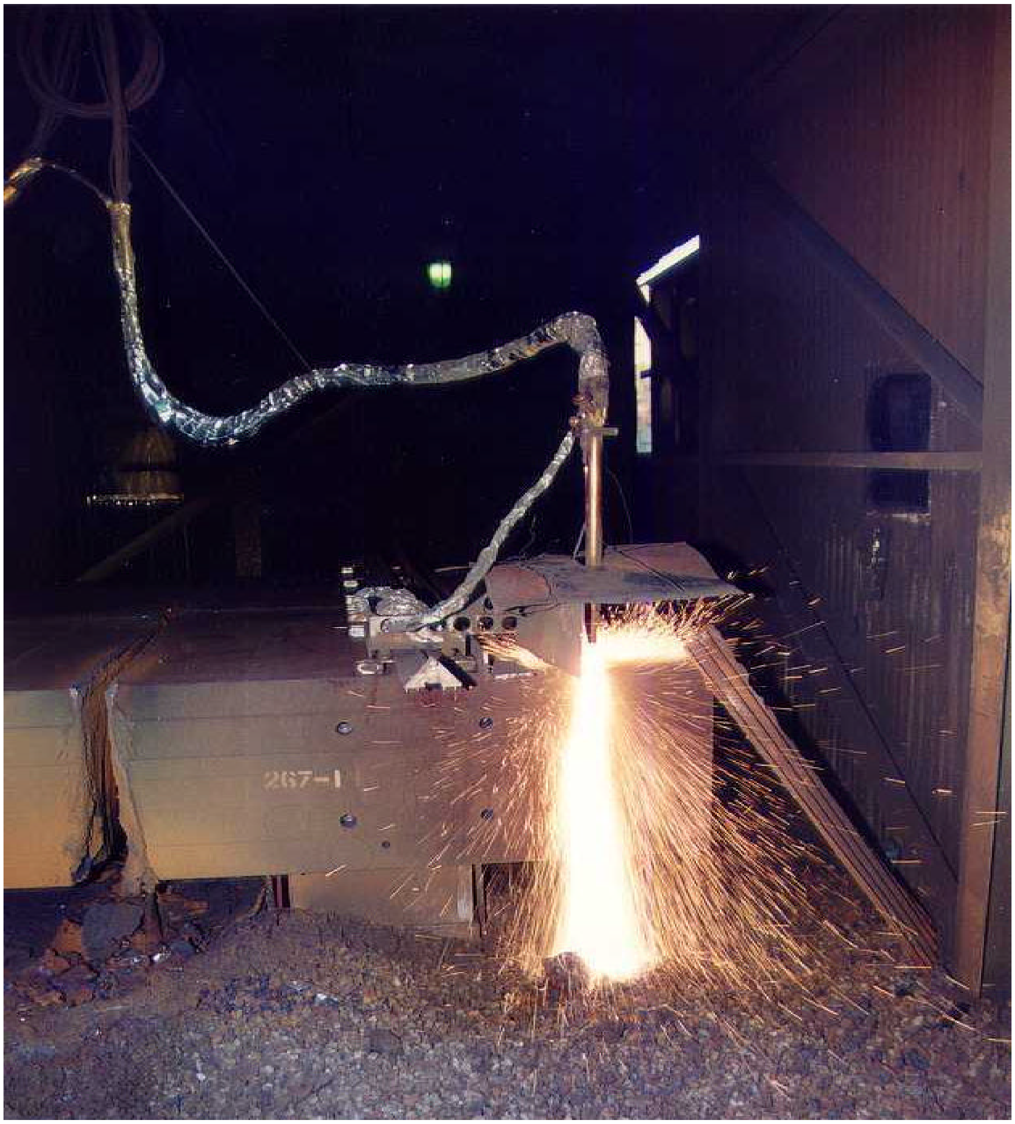

***Figure 4. Size-Reduction of the Shield Doors Using a Powder Torch.***

The sections of the doors that could not be decontaminated were first cut from each door, and then the door was cut into quarters. No cuts were made across contaminated metal, to avoid the generation of contaminated smoke and dross. The cutting procedure required that underlying door supports be carefully placed so that they were not in the torch path and each door segment remained fully supported after cutting. Steel sheet was placed over the floor in the area to be used for cutting and a 15-cm-thick layer of gravel spread over the plate. The gravel controlled the flow of molten dross produced by the cutting and insulated the floor by allowing for convective airflow through the gravel. After completing all required cuts on a door, the penthouse was removed to a staging area. The torch-cut contaminated segments were surveyed and packaged for disposal as low level waste. The four remaining door segments were then resurveyed to assure complete decontamination and released as non-radioactive scrap. The dross was removed from the cutting area and the gravel base refurbished as necessary before beginning the next door.

The first torch cutting was performed on the delaminated 0.27-m-thick door sections. This allowed the operators to "fine tune" oxygen-propane pressures and powder flow rates, and to address potential cutting problems before attempting cuts on the thicker sections. A number of issues were addressed during the initial cuts. For example, manufacturer-suggested settings required adjustments to obtain maximum cutting rates. Once the settings were optimized, cuts on the 0.27-m-thick door sections reached rates of up to 10 cm/min. Cutting the 0.53-m-thick doors was considerably more difficult, even with the experience gained on the thinner slabs. Initial cutting attempts could penetrate only to a depth of approximately 0.45 m. Consultations with the torch manufacturer led to a switch to a high-speed cutting tip and a reduction in the iron powder flow rates. With those adjustments, the 0.53-m-thick cast Meehanite® was cut at rates of up to 5 cm/min.

Overall, the decontamination and size reduction efforts were successful. They led to the release of over 17 $m^3$ (600 $ft^3$) of previously contaminated material, weighing over 127,000 kg (140 tons), as scrap metal for recycling (Figure 5).

***Figure 5. Decontaminated And Size-Reduced Shield Door Sections Released for Recycling.***

## LESSONS LEARNED

The decontamination and size-reduction of the shield doors for free release encountered a number of unexpected challenges. In retrospect, the simplest and most cost effective method of dealing with the doors would have been to dispose of them in one piece as low level radioactive waste. However, considering the condition of the doors when removed from the Hot Laboratory, in conjunction with the moderate contamination levels encountered, it was believed that decontamination would be a possible and preferable alternative to one-piece low level waste disposal.

One of the first issues was the composition of the doors. Fabrication drawings were available, but did not indicate what material was actually used in their manufacture. The original manufacturing requirements specified carbon steel or cast Meehanite®, and the erroneous assumption was made that the doors were fabricated of carbon steel. Based on that assumption, it was believed that the doors could eventually be size-reduced using standard oxygen-acetylene or oxygen-propane torch cutting methods. The cast Meehanite® composition was not recognized until machining of the doors had begun to remove subsurface contamination.

The extreme size and weight of the doors required a tremendous amount of floor space for the decontamination and size reduction efforts. Because the SSFL is in a decontamination and decommissioning mode, the RMHF high bay was available for both the decontamination and storage of the doors. Door storage alone consumed fully one-third of the available high bay floor space. Without the on-site availability of high-capacity lifting equipment, it would have been necessary to contract both cranes and operators to move and maneuver the large components. The work would have been constrained by the availability and scheduling of the lifting equipment necessary for decontamination and size reduction.

A significant amount of time was spent during the size reduction effort to find a technology that would work successfully. That investigation time paid off with significant time and cost savings once a satisfactory technology, in this case the powder torch, was located. Even then, the new application was a learning experience that called upon the resourcefulness and expertise of the site personnel.

For example, several set-up modifications had to be made during the cutting process. Significantly more smoke was generated during the cutting of the 0.53-m-thick doors than had been produced when cutting the 0.27-m-thick slabs. The increased smoke made it necessary to install an additional high-capacity exhaust blower in order to maintain visibility of the cutting process inside the containment. The intense heat produced by the cutting operations melted the iron-powder feed hose and placed the gas supply hoses at risk to melting. All of the hoses were repaired, wrapped with insulated heat-reflecting tape, and inspected after every cut to assure that hose integrity was maintained. Motors, other drive system components, and the torch were fitted with metal shields that both reflected heat and deflected molten debris. When all cuts on a given door were completed, it was necessary to allow the door segments to cool for at least twelve hours before they could be safely handled.

The cutting operations required careful preparation. It was found that if a cut was stopped, reestablishing the cut at the point at which it had been abandoned was difficult and often required that a new cut be started from an edge of the door. To minimize such problems, the oxygen supply required close monitoring and a fresh supply of oxygen was installed if the bottle in use did not contain enough oxygen to perform a full cut . Oxygen consumption was extensive, requiring approximately 2,800 $m^3$ (100,000 $ft^3$) to cut approximately 46 m (linear) of material. Propane consumption was minimal, requiring only 0.38 $m^3$ (100 gallons) to complete all of the required cuts.

Work with the powder torch demonstrated the importance of maintaining close contacts with equipment suppliers when using hardware in new applications. Some problems that appear to be significant can be remedied quickly by working with a supplier experienced with the use of the equipment and the material being handled.

## CONCLUSIONS

The overall decontamination and size-reduction of the large Hot Laboratory shield doors for disposal was successful, and was performed using proven tools and technologies. Radioactive waste was minimized, most of the material was released for recycle, and the remaining material that could not be decontaminated was readily repackaged for routine transportation and low level waste disposal. Significant information was gained on the decommissioning of large contaminated objects that should be beneficial to the rest of the waste management community.

The successful disposition of the shield doors in this manner did require a much greater effort than that which was originally planned. That raises the question of whether the one-piece disposal of the doors as low level waste would have been more cost-effective. The option of one-piece disposal was originally rejected in part because of the assumption that decontamination would be relatively easy, and in part because of intangible costs associated with an unfavorable political climate and public perceptions associated with the site's nuclear decontamination and decommissioning projects. The transportation of large escorted loads of radiologically contaminated material on the neighboring public roads would have generated concerns, and a transportation mishap of any kind with these large loads would have had a large negative impact on decommissioning work. However, in the present case it would have been much more cost-effective to dispose of the doors with no attempts at decontamination. An alternative option would have been to perform minimal decontamination to minimize handling and contamination issues during size-reduction, and then to section the doors for simplified transportation and radioactive waste disposal.

The most important lesson learned was that intangible costs associated with the possibility of unexpected technical challenges, in addition to outside political factors, must be addressed in making decontamination versus disposal decisions.

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