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Open Air Demolition of Facilities Highly Contaminated with Plutonium

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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OPEN AIR DEMOLITION OF FACILITIES HIGHLY CONTAMINATED WITH PLUTONIUM

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ABSTRACT

The demolition of highly contaminated plutonium buildings usually is a long and expensive process that involves decontaminating the building to near free- release standards and then using conventional methods to remove the structure. It doesn't, however, have to be that way. Fluor has torn down buildings highly contaminated with plutonium without excessive decontamination. By removing the select source term and fixing the remaining contamination on the walls, ceilings, floors, and equipment surfaces; open-air demolition is not only feasible, but it can be done cheaper, better (safer), and faster.

Open-air demolition techniques were used to demolish two highly contaminated buildings to slab-on-grade. These facilities on the Department of Energy's Hanford Site were located in, or very near, compounds of operating nuclear facilities that housed hundreds of people working on a daily basis. To keep the facilities operating and the personnel safe, the projects had to be creative in demolishing the structures. Several key techniques were used to control contamination and keep it within the confines of the demolition area: spraying fixatives before demolition; applying fixative and misting with a fine spray of water as the buildings were being taken down; and demolishing the buildings in a controlled and methodical manner. In addition, detailed air-dispersion modeling was done to establish necessary building and meteorological conditions and to confirm the adequacy of the proposed methods.

Both demolition projects were accomplished without any spread of contamination outside the modest buffer areas established for contamination control. Furthermore, personnel exposure to radiological and physical hazards was significantly reduced by using heavy equipment rather than "hands on" techniques.

INTRODUCTION

Over the last three years, Fluor has demolished two buildings that were highly contaminated with plutonium at the Hanford Site in southeastern Washington state . Both buildings had substantial alpha contamination (readings to 1 billion dpm/100cm^2) left in them when conventional demolition began. Both buildings were situated in operating plants or near other operational facilities where hundreds of personnel worked within a few hundred meters.

Basing decontamination end points on technical requirements such as waste acceptance criteria and dispersion modeling rather than on emotional (that's the way it has always been done, or fear of the unknown) provided defined and defensible results.

Because conventional methods and equipment were blended with innovative techniques and strategies, these buildings were safely and compliantly demolished and disposed of. Gone are the days of cleaning buildings to near "free release" conditions before demolition. Applying As Low as Reasonably Acceptable, (ALARA) principles, these projects chose tactical decontamination and heavy equipment versus a global hand decontamination approach as the path forward. Not only is it ALARA, but it is also safer, more cost effective, and faster.

Because of the significant hazard to the environment, decisions (under processes of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 [CERCLA])were made by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington Department of Ecology, (Ecology) to remove/demolish these facilities [1].

As part of the CERCLA decision process, separate engineering evaluation/cost analysis documents for removing the buildings were completed and the alternative of demolition to slab-on-grade was selected. The building slabs will be

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addressed as part of future remedial program activities for underground sites in the areas the buildings were located.

In keeping with the CERCLA requirements, the purpose of the Demolition Projects was to safely demolish, package and properly dispose of all material associated with the two buildings. The scope of the projects was to demolish the buildings, leaving behind the slab and the buildings' associated underground appurtenances. Figure 1 is a photo of the 232-Z Facility and Figure 2 is a photo of the 233-S Building.

Completion criteria required sealing the slab to mitigate potential movement of any remaining contaminants to the environment, covering with clean fill, and posting as an underground radioactive material area (UGRMA).

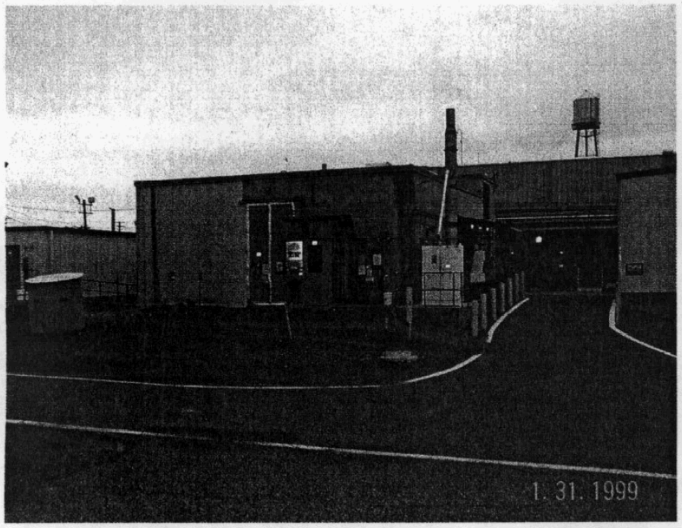

Figure 1. The 232-Z Facility and nearby buildings before demolition.

Facility Descriptions

The buildings were constructed in the mid to late 1950s and operated their respective processes for about 12 years. At 233-S, the process was to concentrate and package plutonium nitrate, and at 232-Z, the process was to recover plutonium by incinerating plutonium-contaminated combustible waste.

With most operations of this type, there were process upsets that contaminated the buildings with significant amounts of alpha contamination. Readings in excess of 7.00E6 disintegrations per minute were recorded in these facilities before demolition [2].

In the 1990s, it was determined that these facilities posed a significant hazard to the environment and efforts began to mitigate the hazard by decontaminating/decommissioning the buildings. During the deactivation phase, a considerable amount of equipment and waste was removed. In total, thousands of grams of plutonium were removed from the facilities in the form of contamination and material held-up in glove boxes, ventilation ducting, miscellaneous equipment, piping, and debris.

The two buildings combined represented less than 550 square meters (5,970 square feet) of total floor space. The biggest difference in construction was that 233-S had a 9.7 m (32 ft.) high concrete process cell. Otherwise, the buildings were primarily constructed of concrete block and sheet metal with roofs constructed of concrete over metal decking with insulation and built-up asphalt covering.

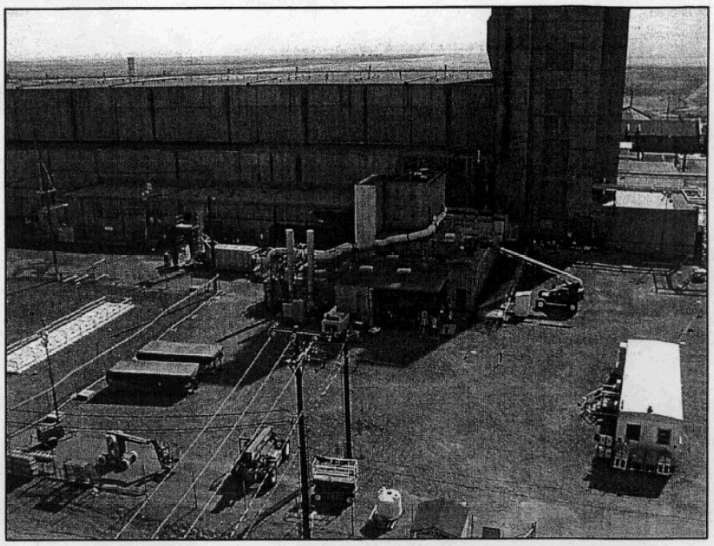

Figure 2. The 233-S Facility (front right) and nearby buildings (behind) before demolition.

Demolition Planning and Preparations

When considering demolition, there are several factors that guide the planning efforts to achieve the greatest chance for success. The primary factors include the following:

- Maturity of the team (and surrounding personnel) preparing for demolition
  - Is the team experienced?
  - Are there personnel in the vicinity and what is their comfort level or knowledge with demolition?
- Operating/control boundaries
  - Is this selective demolition (picking out a building among others)?
  - Or is the building(s) in an area of broad scale demolition?
- Contamination control
  - Type, location, and concentration of contamination
  - What needs to be done before starting demolition to control contamination?
  - What needs to be done during demolition?
- What is the end state?
  - Slab on grade or complete removal
  - How will the area be used when demolition is complete?

Team Maturity and Maturity of Any Surrounding Personnel

Is the Team Experienced?

An experienced team provides a much higher level of confidence than one that is just learning how to tackle demolishing a contaminated facility. An experienced

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demolition team must have experience in dealing with radiological contamination to fully appreciate the magnitude and other idiosyncrasies of these types of projects. On our first demolition effort, some personnel on the team were extremely skeptical that the demolition could be performed safely. By the end though, these people also became some of our biggest supporters.

An experienced contaminated demolition team helps alleviate fears of other personnel not associated with the project. The best option is to have no other personnel in the area, and the farther away the better. As our team's experience expanded, so was the confidence level of personnel not directly associated with the demolition.

These buildings were located in or near Hazard Category 2 nuclear facilities with operating facilities located within a few feet of the building being demolished. By holding informational meetings with non-project personnel working near the work area prior to the demolition, personnel were educated and questions answered. This open approach led to a smoother demolition effort as questions were answered before demolition began, rather than having to stop work to answer questions.

Establishing Operating and Control Boundaries

Establishing where your radiological control boundaries are placed will have a major impact on how much radiological contamination can remain in the building for the heavy demolition equipment. Using a graded approach and modeling tools will provide a defined process and defendable boundaries.

Hold Up Removal and Radiological Characterization

The goal is to balance the safety of deactivation efforts to remove plutonium contamination with the safety of demolishing the building with some plutonium contamination remaining. Using workers to manually remove all (or almost all) of the plutonium held up in various systems and building components is very labor intensive, costly and time consuming. Determining what the demolition effort could safely accommodate and what the deactivation effort needed to remove became an ALARA (As Low As Reasonably Achievable) balancing act between using manual labor, with a higher risk to individual health and safety, to remove contamination and using a machine with a higher risk of contamination spread outside the building footprint. By thoughtfully selecting which deactivation activities removed the largest concentrations of plutonium-contaminated equipment and fixing the rest for demolition with the heavy equipment, in the long run saved considerable time and money, and significantly reduced the hazards to the workers.

Atmospheric Dispersion Modeling

Extensive atmospheric-dispersion modeling was conducted using ISC3-PRIME (an EPA-developed program). The ISC-PRICE was selected because it calculates dispersion patterns considering building wake effects and other meteorological phenomena specific to the site being modeled. The objective of the modeling was to define the potential levels of airborne and soil exposures at surrounding control boundaries. Potential hourly emissions rate of plutonium were estimated for the days with planned demolition and loading activities. An air-dispersion model was used to compute air and surface concentration boundaries for each day of operations, accounting for local building wake effects, atmospheric dispersion climatology, and particle size distribution. The modeling used hourly meteorological data collected over ten years to examine the effects of wind speed, direction, and stability on projected concentrations of contaminants in the air and deposited on nearby surfaces. Using the long-term, worst-case weather averages for the time frame of the demolition provided concise, defendable, and conservative dispersion pattern and peak air exposure limits.

The different phases of demolition were modeled including demolition of each building segment and the loading of debris into roll-off cans [3].

The modeling results indicated that downwind deposition is the main limitation for demolition of a highly alpha-contaminated building [4]. The main downwind deposition contribution came from debris load out into the roll off cans. With this information, the projects positioned control boundaries for the demolition that provided safe operating distances for the project workers and other operational (non project) personnel in the surrounding area.

The demolition boundaries were established using the dispersion modeling and natural barriers (i.e., buildings, roads). The contamination levels inside the building foot print and within a few feet of the building dictated that this area would be considered a high-contamination Area (HCA). A contamination area (CA), surrounding the HCA, was established that allowed sufficient room for positioning the roll-off cans and moving equipment. A radiological buffer area was positioned around the CA to allow for some equipment and additional contingency space, and finally a demolition boundary for industrial safety and control of the area.

Based on actual survey results of the area and some post air-dispersion modeling it was determined that initial modeling results were overly conservative. Using more realistic input factors for estimating the potential emission rates is necessary to make the predicted exposures be more consistent with the monitoring data. Accounting for higher moisture in the rubble being loaded is an example of such an action [5].

Characterization

In compliance with the approved sampling analysis plans, to confirm the basis in the dispersion modeling, and for waste determination, extensive radiological surveys and nondestructive assay (NDA) measurements were performed during the deactivation phase. Between .5 and .9 grams of Transuranic (TRU) material remained in each of the buildings when the heavy equipment began demolition. At 233-S, an additional 12 grams remained in the three-story concrete room before it was demolished using concrete saws.

The isotopes of concern were predominately Pu-239 (85%-90%), with much smaller weight fractions of Pu-240 (8%-10%), Pu-241 (0.2%-0.7%), and AM-241 (~1%) [1, 2].

Protecting Adjacent Facilities

When performing demolition activities near operating facilities, protecting adjacent facilities and infrastructure will be required. Whether for controlling contamination control or preventing physical damage, careful planning and considerations is a must.

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Protection of adjacent buildings, underground pipe chases, exposed piping, conduits, walkways, and underground piping needs to be carefully planned to avoid serious cost and schedule impacts to a project.

In one instance, the building was sandwiched on three sides. With the closest adjacent building interface just 10 cm (4 in.) and the others at 5 m (15 ft.) and 7 m (22 ft.) respectively, precision demolition and tight radiological controls were required. The closest building had 24-7 operations with no intention of shutting down and was a Category 2 Nuclear Facility. To protect the critical components of the building, sheet metal was used to cover piping, conduit, and the walk-way to eliminate potential damage due to falling debris and to minimize the potential for contaminating these components. Sheet metal (rather than plywood) had to be used because of fire loading concerns.

Operations in the other two buildings were discontinued during demolition; however, when the project was completed, these buildings were to be returned to fully functional service. Plastic sheeting was draped on the buildings and held in place with industrial-type magnets. Although effective in keeping the buildings radiologically "clean," the plastic was difficult to place and occasional periods of high winds required maintenance of the plastic sheeting during the project.

Underground pipe chases were protected by construction of plywood tents to prevent debris from falling on the pipe chase lid and instituting working limit boundaries. Highly contaminated underground duct work was filled with flowable gout to prevent potential water intrusion and collapse.

Contamination Control

Pre-Demolition Fixing of Contamination

With contamination readings of up to 1 million dpm/100cm² on the walls and floors and readings over a 100 million dpm/100cm² in specific areas, significant care had to be taken to immobilize the contamination. A variety of fixatives were applied to the interiors of the buildings over their life cycles. At the conclusion of deactivation a final fixative coating of Polymeric Barrier System ™ (PBS) was applied to the interior surfaces of the building. This proactive measure proved effective at preventing the spread of contamination during demolition.

Another precautionary measure implemented was placement of approximately 0.15m (6 in.) of sand on the floors. The sand placement served two purposes: to help soften the impact of contaminated debris hitting the floor and to capture excess contamination and water used to control dust. In addition, as a bonus, the sand provided a "filter type" media to trap contamination.

Suppressing Potential Contamination Spread

The application of a water spray mist to control the dust has worked extremely well to control the spread of contamination. The mechanisms the projects have employed include large fog cannons that emit a heavy mist out to 150 ft, misting lines on and around buildings, and misting systems at the end effectors on the demolition excavators.

Water control decisions are determined by the proximity of the other buildings, amount of soil or the lack of soil around the building, and drainage concerns. Too little water would make it difficult to control the dust, and therefore, increase the potential spread of contamination. Too much water and the project could spend additional resources and time collecting and processing the excess water. To balance this situation, misting the demolition area along with minimal use of the fire hose approach was deployed to engulf the demolition areas in a cloud of mist. Figures 3 and 4 show the types of misting systems that have been employed for controlling contamination.

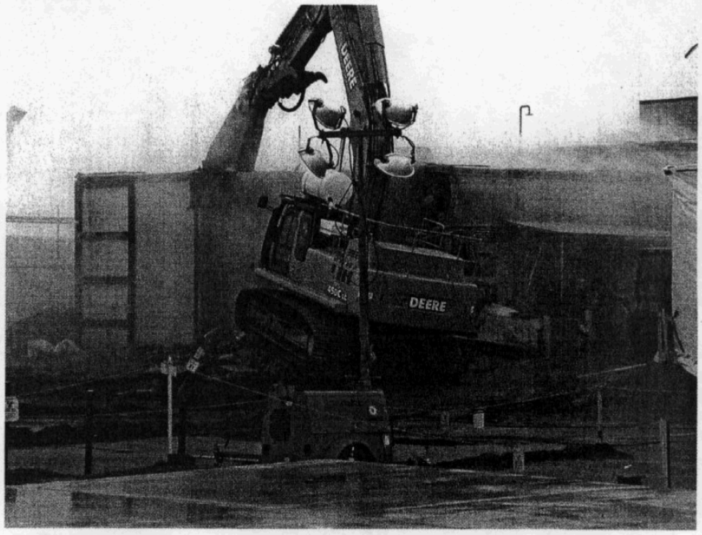

Figure 3. Misting equipment was installed on 232-Z, the surrounding buildings, and the demolition excavator.

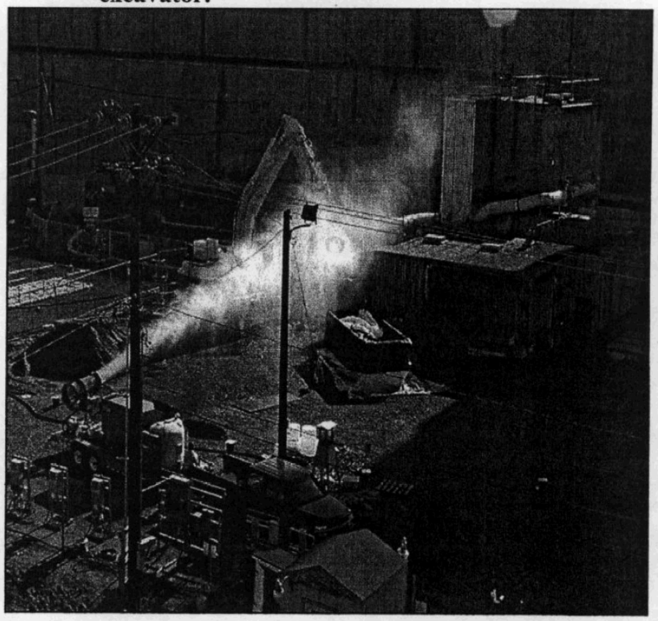

Figure 4. Misting equipment was used during the 233-S demolition project.

The misting worked very well at keeping the area moist and dust and contamination within the CA. However, when wind speeds exceeded 13 km/hr (8 mph), the effectiveness of

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misting was greatly diminished; however, because of the other controls implemented during demolition, activities were allowed to proceed until winds speeds exceeded 20 km/hr (12 mph).

Dust suppression using fire hoses also complimented the misting efforts for "point specific" locations. For this project, it was critical not to "over do" use of the fire hoses, as excess water had to be collected and disposed of. The combination of the misters and the fire hose worked well in keeping contamination within the immediate demolition area.

Weather conditions were continually monitored via a nearby weather station and wind socks to ensure the demolition was conducted within the guidelines established to control the spread of contamination. The maximum wind speed allowed per our procedures during demolition and waste load out operations was 20km/hr (12 mph).

Worker Protection

Work activities in the CA required personal protective equipment (PPE) that included a single set of coveralls, waterproof rain gear, and a power air-purifying respirator (PAPR) with hood. A lapel air sampler was required for personnel monitoring.

In addition, weather conditions were also monitored for the Wet Bulb Globe Temperature, as heat became a huge factor in limiting work efforts due to high ambient temperatures. The project adjusted the work shift from first shift to a graveyard shift to mitigate the effects of extreme day time temperatures (in excess of 100 °F).

Demolition Equipment

The demolition equipment used on these projects was similar (see Fig 3 & 4). A tracked excavator with shear was the tool of choice for "rubblizing" the buildings and some debris load out. A rubber tired front end loader was used to pick up and load the majority of the debris.

At the 233-S facility, concrete saws were used to segment the 30 cm (12 inch) walls of the process cell into manageable slabs. These slabs were lifted off the building with a crane. The slabs that met the waste acceptance criteria for low level waste were wrapped and placed on "roll off" flat beds and hauled to the waste disposal facility. The slabs that were designated as TRU waste were placed in TRU wasted containers.

As anticipated during the planning, equipment utilized in the actual demolition and load out of the building became regulated when the project was completed. The equipment used inside the contamination areas was considered contaminated upon completion and will be employed on future contaminated demolition work.

If contaminated equipment is brought in by a contractor or from another demolition site, understanding the type of contamination is paramount. Site specific requirements and/or waste acceptance criteria can be impacted if new radionuclide's have the potential to be introduced.

Verification Monitoring

To verify that the demolition did not emit contamination beyond the control zones, four continuous air monitors (CAMs) and four fixed head air samplers were placed around the demolition area, at the edge of the CA. In addition to the air sampling devices, fixed plate survey stations were placed along the perimeter of the CA boundary. Part of the monitoring included the lapel air samples that were collected from any individual who entered the CA.

The significant amount of data collected provided the project verification that no contamination spread outside the CA, confirmed dispersion modeling, and there were no personnel contamination events.

Waste Load Out

The building debris was loaded out on an ongoing basis into 25 cubic meter (30 yard) roll-off containers using a front end loader. The containers were prepared with liners and absorbent and placed into the contamination area. To keep the container shuttle truck and the exterior of the containers radiologically clean, heavy plastic was rolled from the clean area into the CA to accommodate both the truck and container placement. The plastic road allowed a significant reduction in survey time prior to removing the container from the CA.

For the most part, the entire building was designated as low-level waste (LLW) and was disposed in Hanford's Environmental Restoration Disposal Facility (ERDF). At one building, some of the concrete walls were designated as TRU waste and had to be cut out and disposed of in TRU containers.

In calculating waste-disposal volumes and weights, the type of building construction material and levels of contamination will affect the total waste volume. Buildings made predominately of concrete block will create less total volume than highly contaminated sheet metal. Higher levels of contamination typically will dictate less processing or size reduction prior to placement in the waste containers.

Lessons Learned

Noteworthy lessons that can be applied to future demolition activities are key to improving on the existing process. The lessons found to be noteworthy are provided below.

- *Fixative applications are effective* – The fixing of any smearable or removable contamination before the start of demolition proved effective. Furthermore, the fixatives applied during demolition, kept contamination locked down during loading and periods of inactivity.
- *Picking out a building among other buildings is difficult and more costly* – Selective demolition is more costly and time consuming due to adjacent facility protection, radiological contamination spread concerns, protection of non-demolition personnel, and mobilization/de-mobilization.
- *Misting devices and water are effective at controlling contamination* – The misting devices on and surrounding the building and on the shear controlled the dust and contamination. The fine mist performed well at capturing airborne particles and keeping them within the confines of our radiological boundaries. One down side to the misting is that during breezy periods, the effectiveness is reduced.
- *Dispersion modeling helped in setting radiological boundaries and provided a "level of comfort" for plant personnel* – The dispersion modeling supported our efforts to perform open-air demolition, helped in setting boundary locations and picking demolition methods. The results

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were discussed during the pre-demolition informational meetings and provided a "level of comfort" for the plant personnel. The modeling tends to be conservative; however, the project did revise the modeling inputs based on actual conditions for future use in dispersion modeling.

- *Selected removal of highly contaminated debris before the remainder of the building was demolished greatly reduced the potential for the spread of contamination* – By removing/packaging the selected, highly contaminated material contained in the building before demolishing the remainder of the building reduces the potential for the spread of contamination, the contamination of the demolition equipment, and airborne concerns [1].

SUMMARY AND CONCLUSIONS

Open-air demolition of a highly plutonium-contaminated facility can be accomplished successfully. The decisions made with respect to performing open-air demolition without decontamination to near free release standards provided a successful mix of ALARA to the workers while accomplishing a safe, cost effective, and efficient demolition project.

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