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Decontamination and Decommissioning of a Fuel Reprocessing Pilot Plant

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Dear Mr/Ms Heine

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Paper No: C371/ 032 (PLEASE QUOTE IN ALL COMMUNICATIONS WITH US)

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SYNOPSIS The Strontium Semiworks Pilot Fuel Reprocessing Plant at the Hanford, Washington Site was decommissioned by a combination of dismantlement and entombment. The facility contained 9600 Ci of Sr-90 and 10 Ci of plutonium. Process cells were entombed in place. The above grade portion of one cell with 5-ft thick walls and ceilings was demolished by means of expanding grout. A contaminated stack was remotely sandblasted and felled by explosives. The entombed structures were covered with a 15-ft thick engineered earthen barrier.

1 INTRODUCTION

The Strontium Semiworks Pilot Fuel Reprocessing Plant is located in the 200 East Area of the Hanford Site in Washington State. The 200 Areas of the Hanford Site (Figure 1) have been used for more than 40 years for nuclear fuels reprocessing and radioactive waste management. The development of new techniques for reprocessing and waste management has naturally resulted in the obsolescence of many older facilities. These facilities have been declared surplus to current and future Department of Energy (DOE) needs and are now being decontaminated and decommissioned under the Surplus Facilities Management Program (SFMP).

The Strontium Semiworks complex was built in 1949 as a pilot plant for the oxidation reduction (REDOX) fuels separation process. In 1954 the complex was converted to a pilot plant for the plutonium-uranium extraction (PUREX) process. It continued in this capacity until it was shut down in 1956.

After extensive decontamination, the complex was modified and put back into service in 1961 for the recovery of strontium from fission product waste. The last processing operation performed was the purification of one batch of americium, curium, and promethium. The facility was retired in 1967 and maintained in a safe storage mode until the start of decommissioning in 1983.

The Strontium Semiworks complex (Figure 2) consisted of 11 structures, of which the main structure was the 201-C Process Building. The 201-C Process Building was made up of three concrete cells in which radionuclides were processed and two other concrete cells for storage and loadout of the product. These cells extended to 25 ft below ground, as noted in Figure 3. Service galleries, a maintenance shop, and treatment facilities for process water and air were also included in this building. Other structures in the complex included a solvent handling building, stack exhaust system, and underground storage tanks. The estimated radiological inventory for the complex includes 10 Ci of plutonium and 9600 Ci of strontium.

2 PROJECT PLAN

Planning for decommissioning of the complex began in 1982 with the preparation of an evaluation of the various decommissioning alternatives for the 201-C Process Building. The alternatives included:

- o Entombment
- o Partial dismantlement followed by entombment
- o Razing to grade level
- o Total dismantlement and removal
- o No action (continued safe storage).

The estimated costs and occupational radiation doses associated with each alternative are listed in Table 1.

Table 1. Estimated Doses and Costs for Each of the Alternatives

Alternatives	Occupational Dose (Man-Rem)	Costs (Millions 1984\$)
(1) Entombment	2.7-4.1	3.5
(2) Dismantlement/Entombment	11-21	4.9
(3) Razing	25-58	8.0
(4) Total Dismantlement	135-400	18.0
(5) No Action ¹	5	10

¹ Continued safe storage; routine annual exposure and costs for the first 100 years. Non-routine exposure and costs not included. These costs would continue indefinitely.

A decision was made in 1983 to proceed, and the pre-project documentation, which consisted of a detailed Project Plan, an Environmental Assessment, and a Safety Analysis Report, was prepared. These documents supported the conclusion that the project could be carried out at reasonable cost and with minimal risk to personnel or the environment. Alternative 2, which was selected as the preferred option, called for demolishing the service galleries and B-Cell to 10 ft above grade, filling the remaining service galleries and cells with concrete (Figure 4) and covering the site with an engineered earthen barrier. The worker radiation exposure was estimated to be from 0.11 to 0.21 man-Sv (11 to 21 man-rem) and the estimated cost was \$4.9 million in 1984 funds, with no contingency. The acceptability of the entombment was evaluated on the basis of calculated long term doses to an on-site intruder one-hundred years following completion of the project (Table II).

Table II. Calculated Doses to Intruders

	<u>Salvage Digger (Rem)*</u>		<u>Homesteader (Rem)</u>	
	1-year dose	50-year dose	1-year dose	50-year dose
Total Body	0.013	0.55	0	3.6 E-4
Bone	0.25	7.5	3.0 E-5	8.5 E-3
Lung	700	7.3	7.1 E-5	8.7 E-5

* Sv = Rem/100

3 SUPPORT STRUCTURE DECONTAMINATION/DISMANTLING

The "hands on" decommissioning of the site began in April 1984 with completion projected for September 1988. The initial efforts were directed toward decontamination and/or dismantling of the support buildings.

3.1 215-C Gas Preparation Building Decommissioning

The 215-C Building is a two-room, one-level concrete structure which housed the compressor, air dryers, and controls for the 201-C process air system, and fused switches for operating the compressor and air dryer.

Decommissioning was performed by removing all equipment and packaging it for transport to the low level waste burial ground. The building structure was decontaminated by wiping down and is currently being used for non-contaminated storage.

3.2 2707-C Storage and Change House

The 2707-C Building was a one-level wood frame structure, which contained maintenance and instrument shops and hot and cold locker rooms, including a personnel decontamination room. This facility was decontaminated and dismantled to make room for the barrier over the entombed 201-C.

3.3 276-C Solvent Handling Facility

The 276-C Facility is a four-story building constructed of steel framework, insulated metal siding, and concrete floors. The building contained equipment and tanks for the treatment and storage of process solvents used in 201-C operations.

Decommissioning was performed by dismantling all piping and conduit, and removing tanks from the upper floors through removable wall panels. The building surfaces were then decontaminated and the building retained for reuse.

3.4 271-C Aqueous Makeup and Control Building

The 271-C Building, a three-story structure on a concrete foundation, was constructed of steel framing with insulated metal siding, a steel deck roof, and concrete floors.

The building contained piping, pumps, and control instrumentation for the 201-C Building, a heating and ventilation unit and twenty-one aqueous chemical tanks. The tanks ranged in size from 113 to 3030 L (30 to 800 gal.).

The building was decommissioned via dismantlement. All piping, conduit, instrument lines, and small equipment were removed after they had been identified as to potential hazards (acids, radioactivity, etc.). All loose radioactive contamination in the building was removed or stabilized by painting. The building superstructure was then dismantled by means of oxyacetylene torches. The large tanks on each floor were removed as that floor level became accessible by crane.

4 MAIN PROCESS BUILDING (201-C) DECONTAMINATION/DEMOLITION/ENTOMBMENT

The 201-C facility consisted of three integrated cells (A, B, and C), seven process galleries, a gallery exhaust system, a hot shop, and an air treatment room. In addition, two below-grade cells (D and E) were connected to the east side of the facility.

This building housed all of the process tanks, piping, and columns. Although the building was designed for contact maintenance, very few, if any, entries were ever made into A and C cells. All of the valves, pumps, and columns were located in B-Cell away from the process tanks.

Decommissioning of 201-C was carried out in four phases: (1) gallery, hot shop, and air treatment room dismantlement; (2) B-Cell decontamination; (3) cell and gallery entombment; and (4) B-Cell demolition.

4.1 Gallery, Hot Shop and Air Treatment Room Dismantlement

The B sample gallery contained process samplers, several of which had leaked during operation. One sampler had leaked an acidic solution in sufficient quantities to contaminate the wall down to grade level. The contamination was etched several centimeters into the concrete. The galleries were decommissioned by removing contaminated equipment, fixing or removing smearable contamination, and dismantling the upper gallery structures by removing the roof and siding and cutting the superstructure. A large wall area below the leaking sampler was chipped out to a depth of up to 8 cm.

Concrete saws were used to score the wall before chipping out the concrete with hydraulically-operated chisels.

The hot shop and the air treatment room were decontaminated and dismantled using the same methods used on the galleries.

4.2 B-Cell Decontamination

Since the Project Plan called for the demolition of the upper 6 m (20 ft) of this cell, it was necessary to decontaminate, and remove all equipment and piping from the upper portions. This task proved to be most demanding because of the high levels of contamination and the high radiation dose rates present. The initial dose rates encountered were several Gy/hr from the floor with one hot spot measuring 50 Gy/hr (5,000 rad/hr). The first effort performed was to pour a 0.3-m- (1-ft-) thick cap of concrete on the floor to seal in the contamination and reduce dose rates to a manageable level. Concrete with a superplasticiser additive was pumped onto the floor and smoothed out with rakes to accomplish this effort.

An electrically-driven scaffold was then suspended from the ceiling along the centerline of the cell to allow access to the upper portions for decontamination. Initial radiation levels in the areas where piping and equipment had to be removed were approximately 1 to 50 mGy/hr (0.1 to 5 rad/hr) at 0.6 m (2 ft) from the wall. The radiation levels were reduced to 0.1 to 1.0 mGy/hr (10 to 100 mrad/hr) at 0.6 m (2 ft), by spraying heated solutions of potassium permanganate and sodium hydroxide onto the walls.

The scaffold was then relocated in turn to each wall to facilitate removal of the piping and equipment. Piping was removed by first assuring that it was drained by tapping into it with an explosively actuated pipe tee. Any residual liquids were drained into a container and disposed of. The piping and equipment were removed down to 0.6 m (2 ft) above grade and placed on the cell floor where concrete was poured to entomb it.

After the piping and equipment were removed, the cell interior was sandblasted with a water injection sandblaster to remove residual contamination. This system decontaminated the walls to generally less than 0.1 mGy/hr (10 mrad/hr). Spots greater than 0.1 mGy/hr were limited to hairline cracks and other discontinuities in the concrete. These spots were removed by chipping them out with a small ram-hoe. The west wall of the cell was not decontaminated to this level, since it was to be treated separately during the demolition phase, due to its overall interior and exterior contamination status.

4.3 Gallery and Below-Grade Cell Entombment

The remaining cells and the lower galleries were then filled with a bulk grade of concrete which was formulated to be essentially self-leveling.

Before the cells could be filled, it was necessary to fill ten large tanks (greater than 1900-L [500-gal.] capacity) with grout to prevent them from breaking loose and floating and to preclude large void areas in the entombed cells. Filling these tanks was a difficult task, since there were no readily-accessible fill pipes, and high radiation levels in the cells prevented access to the tanks. Several alternatives were evaluated, including remote cutting of holes in the tops of the tanks. The method chosen was to pump a thin slurry of grout into each tank via its liquid level measurement tube (0.6-cm [1/4-in.] inside diameter). Testing disclosed that a slurry of 50 percent fly ash and 50 percent cement mixed with water could be pumped, and would cure to a dry form. Thirteen tanks were filled with slurry, including three which were included for operational convenience.

After a temporary exhaust duct had been installed, the cells were filled by pumping concrete through cover block openings. The temporary exhaust connection was necessary since the normal exhaust port was located at the bottom of the cells. Concrete was pumped at a rate of approximately 60 m³/day (80 yd³/day) during the filling, by means of a stationary pumper truck fed by 7.6-m³ (10-yd) delivery trucks.

The lower galleries were filled by pumping concrete in lifts of 1.2 m (4 ft), allowing a cure of 48 hours before the next pour, so that the gallery walls would act as their own forms. Even so, one section of wall broke through and had to be formed up with plywood.

4.4 B-Cell Demolition

The demolition of the B-Cell was accomplished using a commercially-available expanding grout. The project plan required the removal of the upper 20 feet of the cell, which consisted of five-foot thick, lightly reinforced concrete walls and roof. The presence of contamination internal to the walls and the potential for release resulted in the rejection of explosive or high-impact methods of demolition.

The demolition of the upper 6 m (20 ft) of the 1.5-m-(5-ft-) thick walls and roof of B-Cell was performed by drilling vertical 5-cm-(2-in.-) diameter holes on a 1-1/2 by 2-ft grid by means of a track-mounted rock drill. The holes were filled with an expanding grout (S-Mite^R) and allowed to cure for five days.

Placement of the grout took place on a hot day, with ambient temperatures up to 90 degrees F. The high temperatures required the addition of ice to cool the grout and retard premature setting, which causes the grout to be "blown-out" of the hole. Even with some "blow-out" experienced, the Semiworks cell was fractured to the point that the demolition was quickly completed using a ram hoe.

Due to the fact that the west wall contained numerous penetrations in the form of sample tubes and instrument spirals, it was determined that fracturing this wall posed an unacceptable risk of a release of contamination. The west wall of the cell was demolished by felling it into the cell cavity. The steel reinforcing bars in the wall were scored with 10-cm-(4-in.-) deep cuts on the inside and outside surfaces. Slanting holes were drilled into the base of the wall at the cut point and filled with S-Mite to provide a fracture zone. Two D8-L caterpillars were attached by steel cables to lifting eyes installed near the top of the walls to pull the wall over into the cell. After felling, the wall section was capped with concrete to seal it into the monolith.

5 TANK 241-CX-70 CLEANING

Tank 241-CX-70 is a 190,000-L (50,000-gal.) capacity waste tank located southeast of 201-C. The steel-lined concrete tank is 6 m (20 ft) in diameter and 4.5 m (15 ft) high and its top is located 3.3 m (11 ft) below grade.

The tank contained 39,000 L (10,300 gal.) of residue waste with 300 Ci of strontium-90, 51 Ci of cesium-137, and 10 Ci of plutonium-239, -240. The Project Plan required that this waste be removed to the high-level waste storage and processing system in the 200 East Area of the Hanford Site.

The tank was cleaned by installing a rotary tank sluicer and pump assembly in a caisson located in the ground immediately over an access riser. Due to the radiological restrictions of this task, the sluicing was performed semi-remotely. The waste solution was pumped overground in a 5-cm (2-in.) diameter pipeline for 33 m (110 ft) where it connected to an existing below-ground waste transfer pipeline.

6 291-C-1 STACK DECONTAMINATION AND DEMOLITION

The 291-C-1 stack, 61 m (200 ft) tall, was built as a stack within a stack. The outer stack was constructed of concrete and steel and tapered from 4.3 m (14 ft) in diameter at the base to 2.3 m (7.5 ft) in diameter at the top. The inner stack was constructed of brick and mortar, and tapered from 2.7 m (9 ft) in diameter at the base to 1.5 m (5 ft) in diameter at the top. The inner and outer stacks were separated by a free annular space. An annular shaped sheet metal cap on the top sealed the inner and outer stacks together.

The interior of the inner stack was contaminated with high levels of strontium and very low levels of plutonium. A radiation exposure profile taken in September 1986, showed radiation levels of 2.5 to 3.5 mGy/hr (250 to 350 mrad/hr) measured along the centerline from the top down to about 12 m (40 ft) from the bottom. From that point, the radiation level increased to greater than 90 mGy/hr (9 rad/hr) near the bottom. Contamination smears taken in the annulus near the bottom of the stack revealed only low level contamination.

Decontamination was performed via remote sandblasting. The rotary blast head was lowered down the stack with a winch at a rate of 25 cm/min (10 in./min). The airflow in the stack was reversed to draw the dust down the stack and into the large fiberglass and high-efficiency particulate air (HEPA) filter system. A pneumatic sand transfer system moved spent sand from the stack base into boxes for transport to the low level waste burial grounds.

The stack was radiologically surveyed to assess decontamination as cleaning progressed. Following sandblasting, the inner stack and annulus were filled with grout to the 2.1-m (7-ft) level (grade). The inner stack was painted with remote rotary spray paint heads as necessary to cover minor remaining contamination.

Following decontamination, the stack above grade level was felled with explosives using the vee cut technique. The stack fell into a trench excavated in the earthen barrier material directly south of its base. A water deluge system was set up along the trench to control dust and to capture any residual materials becoming airborne when the stack hit the ground. After felling, the stack remnants were broken up and covered over with an earthen barrier.

7 EXHAUST FILTER SYSTEM ENTOMBMENT

The exhaust filter system consisted of a fiberglass filter unit and a HEPA filter unit. The fiberglass filter unit contained 40 deep-bed fiberglass filters which are 1.5 x 1.5 x 1.2 m thick (5 x 5 x 4 ft). The filters were housed in an underground concrete cell that is 15.8 m long by 8.2 m wide by 2.4 m high (52 x 27 x 8 ft). The fiberglass filter unit contains a calculated 600 Ci of strontium and cesium and 5 Ci of curium and plutonium.

The HEPA filter unit was 4 m long by 1.9 m wide by 2 m tall (13 x 6 x 6.5 ft) and housed 22 filters. The HEPA filter system contains an estimated 900 Ci of strontium and cesium.

Decommissioning of these filter units was performed by high pressure grouting to fill all internal voids followed by capping with concrete.

8 BARRIER EMPLACEMENT

The entombed structures; (1) 201-C Process Facility, (2) liquid waste storage tanks, (3) exhaust filter systems and ducts, (4) low level liquid waste disposal sites, and (5) stack rubble, were covered with the engineered earthen barrier (Figure 5).

The Project Plan called for a barrier in which at least 15 feet of earthen material was emplaced above the surface of the buried waste or any contaminated surface.

A review of the availability of acceptable nearby native materials for use in construction of the barrier disclosed that the bottom ash from a nearby coal-fired steam plant would function at least as well as soil for construction of the main body of the barrier. Toxicity extraction and pH tests were performed to demonstrate that the bottom ash is "non-hazardous" in terms of the criteria established by United States and State of Washington regulatory authorities. Other tests demonstrated that the bottom ash is an excellent deterrant to deep-rooted plant growth and has good water-retention characteristics.

The bottom ash was emplaced over the entombed structures to a minimum depth of ten feet. The ash was machine compacted to 95 percent maximum density in six-inch lifts. At the grade level below the barrier, a layer of five-inch diameter ceramic discs was emplaced on ten-foot centers. These discs (Figure 10) are intended to warn an inadvertent intruder into the barrier at some point in time after loss of institutional control, which is assumed to be 100 years from the present.

A filter bed composed of sand and gravel was placed on top of the bottom ash to preclude downward wicking of moisture from the overlying topsoil to the fly ash. A geotextile (fiberglass drainage fabric) was placed above the filter bed and, finally, a four-foot thick layer of topsoil was added to the top of the barrier. The topsoil was revegetated with a shallow-rooted bunch grass to enhance evapotranspiration.

The sides of the barrier, which are 3:1 slopes were armored with cobbles to prevent possible water erosion. One section of the side slopes was extended to 7:1 to allow access to the barrier by maintenance vehicles.

The barrier extends over 2.5 acres and stands 25 feet above grade level. Concrete marker posts capped with engraved medallions were put in place around the perimeter of the site.

9 FINAL REPORT

A final report describing in detail the decommissioning of the Strontium Semiworks Facility is in preparation and will be available sometime in 1989.

FIGURE 3. CROSS SECTION OF 201-C PROCESS BUILDING

FIGURE 4. ENGINEERED EARTHEN BARRIER

FIGURE 5. LAYOUT AND CROSS SECTION OF BARRIER

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