**CHARACTERIZATION OF THE HEAD-END CELLS AT THE
WEST VALLEY NUCLEAR FUEL REPROCESSING PLANT**

By

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ABSTRACT

The head-end cells at the West Valley Nuclear Fuel Reprocessing Plant are characterized in this report. These cells consist of the Process Mechanical Cell (PMC) where irradiated nuclear fuel was trimmed of excess hardware and sheared into short segments; and the General Purpose Cell (GPC) where the segments were collected and stored prior to dissolution, and leached hulls were packaged for disposal. Between 1966 and 1972, while Nuclear Fuels Services operated the plant, these cells became highly contaminated with radioactive materials.

The purpose of this characterization work was to develop technical information as a basis for decontamination and decommissioning planning and engineering. It was accomplished by performing remote in-cell visual examinations, radiation surveys, and sampling. Supplementary information was obtained from available written records, out-of-cell inspections, and interviews with plant personnel.

SUMMARY

The objective of the head-end cell characterization work was to establish a technical basis for decontamination and decommissioning planning and engineering. This objective was accomplished by performing remote in-cell visual examinations, radiation surveys, and sampling. Supplementary information was obtained from available written records, out-of-cell inspections and interviews with plant personnel.

Inspections and records revealed that much of the auxiliary equipment has lost the capability to function as designed. The majority of the shielded viewing windows do not provide useful clarity; original in-cell lighting is out-of-service; bridge cranes are unreliable; one crane room door is inoperable and the other is in need of major refurbishment; power manipulators are inoperable or inaccessible; and the master-slave manipulators are generally inoperable.

Visual examinations were conducted by inserting television cameras through master-slave manipulator ports, suspending them from bridge crane hooks, then moving them throughout the cells using the bridge crane controls. These examinations revealed the physical contents of the cells including items not visible through the shielded viewing windows such as fuel cans on the floor in the Process Mechanical Cell (PMC) and liquid in the General Purpose Cell (GPC) sump area.

Radiation surveys were made by inserting radiation probes through master-slave manipulator ports, suspending them from bridge crane hooks, then moving them throughout the cells using the bridge crane controls. These surveys revealed that the general radiation intensities 1.8 m (6 ft) above the cell floors range from 40 R/h to 340 R/h, and that there are "hot spots" as intense as 2050 R/h. The fuel cans in the PMC were found to be insignificant sources of radioactivity and therefore probably do not contain fuel.

Sampling of loose solids was conducted by inserting a vacuum sampling device and sample cartridges through a master-slave manipulator port, suspending the device from a bridge crane hook, then moving it throughout each cell using the bridge crane controls. Sampling of the liquid was accomplished by dipping a sponge into the sump area. Samples were transferred to the analytical cells

for analysis. The samples revealed high levels of activity from cesium-137. Fissile and transuranic materials were found in all the samples.

The radiation survey and chemical analyses performed are generally consistent with the data used and assumptions made when preparing in-cell nuclide estimates for the project Safety Analysis Report (SAR). One exception is that the SAR accounted for the fissile material and fission products without fully accounting for the neutron activation products. A neutron activation product, cobalt-60, was found to be the second most significant radiation source in the samples taken from the PMC. Neutron activation products must also be present in the hulls scattered about the GPC. The primary significance of this difference is that the SAR had a bias toward over-estimating the fissile material inventory. Fissile material estimates were 7.6 kg (3.5 lbs) in the PMC and 9.8 kg (4.4 lbs) in the GPC.

1.0 INTRODUCTION

The West Valley Nuclear Fuel Reprocessing Plant near Buffalo, New York, was constructed in 1966 and was operated by the Nuclear Fuel Services Company until 1972. At that time, when the plant was down for the purpose of making modifications to increase capacity, changing government regulations and economic considerations led to its closure. Before the plant was closed, 640,000 kg (700 tons) of spent nuclear fuel were reprocessed. All of it was processed through the head-end cells.

The head-end cells consist of the Process Mechanical Cell (PMC) and the General Purpose Cell (GPC). The PMC was used for trimming fuel assemblies and chopping them into short sections in preparation for chemical dissolution operations. The GPC was used for collection and storage of the sheared fuel prior to dissolution operations and for packaging of the leached hulls for disposal. Because of the operations that were conducted in these cells, they became highly contaminated.

The objective of the head-end cell characterization work was to develop technical information as a basis for decontamination and decommissioning (D&D) planning and engineering. It was accomplished by performing remote in-cell visual examinations, radiation surveys, and sampling. Supplementary information was obtained from available written records out-of-cell inspections and interviews with plant personnel.

2.0 FACILITY DESCRIPTION

2.1 Process Mechanical Cell

The PMC is located on the ground level of the process building as shown in Figure 2.1. It is 16 m (52 ft) long north to south, 4 m (12 ft) wide, and 8 m (25 ft) high. The walls are of concrete 1.7 m (5 ft 6 in) thick. A large rectangular concrete pedestal in the center of the floor serves as the base for the saw table. The cell is lined with stainless steel 6.3 m (20 ft 8 in) up from the floor. Above the stainless steel, the interior surface is carbolite-coated concrete.

FIGURE 2.1
Ground Level Layout of the Reprocessing Facility

There are six shielded viewing windows. Four, PMC-A, -B, -C, and -D, are along the west wall; PMC-A being at the north end of the wall. Windows PMC-E and -F are in the northwest and southeast corners respectively. Shielding is provided by slabs of lead glass immersed in mineral oil.

The PMC is serviced by two bridge cranes, a power manipulator and miscellaneous master-slave manipulators (MSMs). Both bridge cranes are rated at 900 kg (2 tons) and share a common set of rails 6.5 m (21 ft 2 in) above the floor. The power manipulator is mounted on separate rails 5.6 m (18 ft 3 in) above the floor. One MSM is installed at each of the four windows along the west wall.

Access to and from the PMC is available through a crane room, the fuel storage pool, the operating aisle, and three adjoining cells. The Mechanical Crane Room (MCR) is located at the north end of the PMC and is accessible through a 1 m (3 ft) thick, vertical lift, concrete shielding door. The Fuel Receiving and Storage (FRS) pool is accessible through a 0.53 m (21 in) diameter floor hatch in the southeast corner of the PMC. Access from the operating aisle is available through a hatch approximately 0.56 m (22 in) square in the east wall of the PMC. The GPC is accessible through a 0.9 m x 1.2 m (3 ft x 4 ft) floor hatch at the north end of the PMC. The analytical Sample Storage Cell (SSC) is accessible through a ceiling hatch in the southwest corner of the PMC. The Miniature Cell (MC) is accessible through a 0.51 m (20 in) diameter tube in the north end of the PMC.

2.2 General Purpose Cell

The GPC is located below ground level in the process building as shown in Figure 2.2. It is 14 m (45 ft 7 in) long east to west, 3.4 m (11 ft) wide and 5.9 m (19 ft 6 in) high. The walls are of concrete 1.2 m (4 ft) thick. The floor slopes toward a sump located 2.4 m (8 ft) from the east end. Two eductors are used to transfer liquids from the sump area to the hold side of the first uranium cycle waste tank. A 0.3 m (1 ft) thick concrete wall stands in

FIGURE 2.2
Below Grade Layout of the Reprocessing Facility

front of the seven chopped fuel storage and cooling rack positions in the southeast quarter of the cell. The GPC is lined with stainless steel 4.6 m (15 ft) up from the floor.

There are three shielded viewing windows, all of which are located in the north wall, identified from east to west as GPC-A, -B, and -C respectively. Shielding is provided by slabs of lead glass immersed in mineral oil.

The GPC is serviced by one bridge crane, a power manipulator, and two MSMs. The bridge crane is rated at 900 kg (2 tons) and rides on a set of rails 5.0 m (16 ft 6 in) above the floor. The power manipulator is west of the crane, and rides on a bridge that uses the same rails as the crane. The MSMs are located at windows GPC-A and -C.

One room and three cells can be accessed directly from the GPC. The General Purpose Crane Room (GCR) is located at the west end of the GPC and is accessed through a vertical lift shielding door. The PMC is accessible through a 0.9 m x 1.2 m (3ft x 4 ft) ceiling hatch at the east end of the GPC. The Chemical Process Cell (CPC) is accessible through a 1.6 m x 0.8 m (5 ft 3 in x 2 ft 6 in) ceiling hatch at the southwest corner of the cell. The Scrap Removal Room (SRR) is accessible through a 1.0 m x 1.2 m (3 ft 3 in x 4 ft 0 in) ceiling hatch at the northwest corner of the cell.

Discussions with employees who were present when the plant was operational revealed that there had been a metal fire in the GPC. Leached hulls had spontaneously ignited with flames when they were dumped.

3.0 AUXILIARY EQUIPMENT

Having been left idle and generally unmaintained for about fourteen years, much of the auxiliary equipment in the head-end cells has lost the capability to function as designed. The conditions of the auxiliary equipment in the PMC and GPC are summarized in Tables 3.1 and 3.2 respectively.

TABLE 3.1

Auxiliary Equipment in the PMC

<u>Item</u>	<u>Equipment</u>	<u>Condition</u>
1.	Shielded Viewing Windows	<ul style="list-style-type: none"> ◦ PMC-A was recently flushed with freon to restore clarity. It is leaking and clarity is being lost due to yellowing. ◦ PMC-B, although not absolutely clear, provides useful clarity. ◦ PMC-C, although not absolutely clear, provides useful clarity. ◦ PMC-D leaks and the glass is etched. It has been covered with plywood. ◦ PMC-E leaks and the glass is etched. It has been covered with plywood. ◦ PMC-F leaks, is dirty, and the glass is etched.
2.	In-Cell Lighting	The original lighting is out-of-service. Illumination is provided by fixtures installed in MSM ports at windows PMC-A, -C, and -E.
3.	Crane Room Shield Door	The concrete door places considerable stress on the operating mechanism causing vibrations that shake the process building. Frequent opening and closing should be avoided until the mechanism has been refurbished.
4.	Bridge Cranes	Both cranes operate, but the controls are unreliable. The south crane has continued to move after the button has been released.
5.	Power Manipulator	The PaR is in the crane room and is inoperable. Tube cables and wiring, trolley drive chain and the shoulder require repair or replacement. The wrist was salvaged for the CPC PaR.
6.	Master-Slave Manipulators	<ul style="list-style-type: none"> ◦ The MSM at PMC-A is new and in good condition. It was installed in 1984. ◦ The MSM at PMC-B has broken tapes and has no master handle. ◦ The MSM at PMC-C has broken tapes and has no master handle. ◦ The MSM at PMC-D has a broken tape.
7.	Fire Protection System	The Metal-X system is out of service. In-cell fire protection is provided by a CO ₂ bottle in the operating aisle with a hose extended to a nozzle suspended from a crane hook.

TABLE 3.2

Auxiliary Equipment in the GPC

<u>Item</u>	<u>Equipment</u>	<u>Condition</u>
1.	Shielded Viewing Windows	<ul style="list-style-type: none"> ° GPC-A was recently flushed with freon but clarity was not restored. It leaks from near the top. ° GPC-B provides useful clarity. It is holding oil now but records indicate it has leaked. ° GPC-C does not provide useful clarity and the in-cell protective cover is badly scratched from movement of the MSM.
2.	In-Cell Lighting	The original lighting is out-of-service. Illumination is provided from lights on the bridge crane.
3.	Crane Room Shield Door	The door is partly open and inoperable. The drive mechanism motor needs to be replaced.
4.	Bridge Crane	The bridge and trolley are operable. The wire rope to the hoist broke during characterization work.
5.	Power Manipulator	Records indicate the PaR is operable, but it is trapped in the crane room by the inoperable shield door.
6.	Master-Slave Manipulators	<ul style="list-style-type: none"> ° The MSM at GPC-A has broken tapes and no master handle. ° The MSM at GPC-C has broken tapes and no master handle.
7.	Sump Eductors	<ul style="list-style-type: none"> ° The jet that draws from above the sump well is operational. ° The jet that draws from the bottom of the sump well is plugged.
8.	Fire Suppression	The Metal-X system is out-of-service. In-cell fire protection is provided by a CO ₂ bottle in the operating aisle with a hose extended to a nozzle suspended from the crane hook.

4.0 VISUAL EXAMINATIONS

4.1 Procedure

Visual examinations of the head-end cells were conducted by inserting color television cameras attached to lifting bails (Figure 4.1) through the 25 cm (10 in) diameter MSM ports, suspending them from bridge crane hooks, then moving them throughout the cells using bridge crane controls. These cameras were equipped with adjustable wide angle/telephoto lenses and automatic focusing. The locations of the crane hung cameras were monitored by the use of black and white television cameras with fixed focus lenses installed in specially designed fixtures (Figure 4.2) placed in MSM ports at windows PMC-E, PMC-F, and GPC-A. When possible, the locations of the crane hung cameras were also monitored by observation through the shielded viewing windows. Permanent records of the examinations were made by videorecording the signals from the cameras.

4.2 Process Mechanical Cell

A view of the South end of the PMC as seen from the crane hung camera in a horizontal position is shown in Figure 4.3.

The visual examination revealed no standing liquid in the cell. The entire observable floor area is smothered with saw fines and small metal objects as shown in Figure 4.4. Of special interest, was the discovery of two fuel cans which were not visible from the shielded viewing windows. One was a Yankee fuel can, shown in Figure 4.5, on the floor between the maintenance table and the disassembly, inspection and pushout table. The other was a National Production Reactor (NPR) fuel can, shown in Figure 4.6, on the floor east of the saw table. The interior of neither can could be viewed by the cameras.

FIGURE 4.1
Crane Hung Camera Fixture

FIGURE 4.2
Stationary Camera Fixture

FIGURE 4.3
The Process Mechanical Cell

FIGURE 4.4
Fuel Assembly Hardware Amid Debris on the PMC Floor

FIGURE 4.5
Yankee Fuel Can on the PMC Floor

FIGURE 4.6
NPR Fuel Can on the PMC Floor

Major items of process equipment in the cell include the following:

- ° Fuel element shear without ram, knife, gages, or magazine.
- ° Maintenance table.
- ° Disassembly, inspection, and pushout table.
- ° Ram pulling fixture.
- ° Cut-off saw which is operable but requires a new blade.
- ° Pump and motor from the Tysaman saw that was replaced by the cut-off saw.
- ° Tilt fixture brackets without the tilt fixture.

4.3 General Purpose Cell

A view of the GPC as seen from the stationary camera in the northeast corner is shown in Figure 4.7.

Visual examination of the GPC revealed an accumulation of liquid in the sump area. It was not anticipated because the sump level indicator in the operating aisle indicated no liquid, and the sump area is not visible from the only useful window. A considerable amount of debris lies in the sump area including an overturned table, drums, drum lids, fuel hulls, and miscellaneous other metallic items. The sump area is shown in Figure 4.8.

The examination of the GPC also successfully verified that no unprocessed fuel is stored in any of the open storage positions, as shown in Figure 4.9.

Major items of process equipment in the cell include the following:

- ° Chopped fuel loading station.
- ° Chopped fuel storage and cooling rack.
- ° Cooling unit.
- ° Fuel basket storage sockets.
- ° Criticality guard rails.
- ° Hulls dump, sampling, and packing station.

FIGURE 4.8
Sump Area in the GPC

FIGURE 4.9
Fuel Basket Examination in the GPC

5.0 RADIATION SURVEYS

5.1 Procedure

Radiation surveys of the head-end cells were conducted using mid-range (0.1-200 R/h) and high-range (10-20,000 R/h) beta-gamma ion-chamber radiation probes. The surveys were performed by inserting fixtures holding the probes through 25 cm (10 in) diameter MSM ports, suspending them from bridge crane hooks, then moving them throughout the cells using the crane controls. The locations of the probes were monitored in the same manner used for the visual examinations.

Two separate radiation surveys were conducted in each cell. One used only the high-range probe, installed in a protective cage, to quantify gross beta-gamma radiation intensities. The other used both the medium and high-range probes mounted in the collimating fixture shown in Figure 5.1, to examine discrete areas of the floors in order to identify and characterize specific radiation sources. For this survey, beta shielding was placed over the probes.

5.2 Process Mechanical Cell

Radiation surveys of the PMC were conducted during April 1986.

5.2.1 Gross Intensity Survey

The gross radiation intensity survey was conducted using the unshielded high-range probe on April 16, 1986. An array of thirty-nine readings was taken 1.8 m (6 ft) above the cell floor. Additional readings were taken near items of interest. The data were recorded as shown in Figure 5.2. Readings of particular interest were as follows:

- ° The greatest reading obtainable near the filters in the shear vent line mounted on the east PMC wall was 110 R/h. This was at the bottom of each of the two filters. These

FIGURE 5.1
Collimating Radiation Probe Fixture

- NOTES:
- a. At filters on wall
 - b. In shear hatch
 - c. At NPR fuel can
 - d. At floor
 - e. On shear
 - f. In saw sump
 - g. Below saw blade
 - h. At MSM fingers

FIGURE 5.2
Gross Beta-Gamma Radiation Intensities in the PMC

- readings were relatively low in comparison to many of the general area readings at 1.8 m (6 ft) above the floor.
- ° A reading of 1080 R/h was taken at the floor just below the southeast corner of the disassembly, inspection and pushout table, indicating that a significant radiation source is there. At 1.8 m (6 ft) directly above this point, the reading was only 50 R/h. This suggests that an unknown intense radiation source was under something that provided shielding.
 - ° The near contact reading by the NPR fuel can was 140 R/h. This was low in comparison to the 1,000 R/h reading taken at the nearby end fittings. Therefore, the NPR fuel can is not a major source of radiation and it probably does not contain irradiated fuel.
 - ° The highest readings in the cell were 2,050 R/h below the cut-off saw blade, and 1,810 R/h inside the hatch on the shear.

Figure 5.3 is an isometric representation of the gross radiation intensities in the PMC at 1.8 m (6 ft) above the floor. This figure clearly reveals that the general area radiation intensity ranges from 40 R/h to 270 R/h, and that the primary sources of radiation are in the northeast corner, the location of the shear, and at the center of the cell, the location of the cut-off saw.

5.2.2 Collimated Survey

The collimated radiation survey was conducted using the shielded probes on April 10, 1986. Readings were taken in the same thirty-nine position array as was used for the gross radiation intensity survey. The data were recorded as shown in Figure 5.4. Readings of particular interest were as follows:

FIGURE 5.3
Isometric Representation of Radiation Intensities in Roentgens per Hour
at 1.8 meters (6 feet) above the PMC Floor

- NOTES:
- a. 1 m (3 ft) from floor
 - b. 10 cm (4 in) above shear
 - c. 30 cm (1 ft) above vent
 - d. Near floor
 - e. Near end fittings
 - f. Near NPR fuel can
 - g. 30 cm (1 ft) above open hatch to GPC
 - h. At top of drum(s)
 - i. At rail
 - j. 30 cm (1 ft) over table
 - k. 30 cm (1 ft) over Yankee Fuel Can

FIGURE 5.4
Collimated Gamma Radiation Intensities in the PMC

- ° The general area reading over the shear was 11.3 R/h, but the reading near the vent line was 59.6 R/h, an indication that during operation, fuel fines were drawn into, and were deposited within, the vent line.
- ° The reading at 0.3 m (1 ft) above the Yankee fuel drum was 11.8 R/h. This was considerably lower than readings from known high level radiation sources indicating that it does not contain unprocessed irradiated fuel.
- ° Readings over the closed waste drums in the cell were all relatively low indicating that none of them contained materials that were significant radiation sources.

5.3 General Purpose Cell

Radiation surveys of the GPC were conducted during April 1986.

5.3.1 Gross Intensity Survey

The gross radiation intensity survey was conducted using the unshielded high-range probe on April 17-18, 1986. An array of thirty-three readings was taken 1.8 m (6 ft) above the cell floor. Additional readings were taken near items of interest. The data were recorded as shown in Figure 5.5. Readings of particular interest were as follows:

- ° The general background reading was high at about 100 R/h and was attributed to the large number of leached hulls scattered on the floor.
- ° The greatest reading obtained from any location in the cell was 650 R/h at an elevation of 0.6 m (2 ft) above the floor near the chopped fuel loading station. A reading at contact with the floor there would probably have revealed a significantly larger radiation intensity; however, the probe could not be placed at the floor there because of

NOTE. a 1 m (3 ft) from floor
 b 0.6 m (2 ft) from floor
 c. 0.3 m (1 ft) from floor

FIGURE 5.5
Gross Beta-Gamma Radiation Intensities in the GPC

hardware that interfered with the movement of the probe, and because of difficulty observing the position of the probe in the east end of the cell. The reading at 0.6 m (2 ft) above the floor was, none-the-less, much greater than that found near the accumulation of leached hulls in the cell and suggests the presence of unleached, irradiated fuel bearing hulls spilled during fuel loading operations.

Figure 5.6 is an isometric representation of the gross radiation intensities in the GPC at 1.8 m (6 ft) above the floor. This figure clearly reveals that the general area radiation intensity ranges from 80 R/h to 340 R/h, and that the primary source of radiation is in the southeast corner, the location of the fuel loading station where chopped fuel was received from the shear in the PMC and loaded into dissolver baskets.

5.3.2 Collimated Survey

The collimated radiation survey was conducted using the shielded probes on April 15, 1986. Readings were generally taken in the same thirty-three position array as was used for the gross radiation intensity survey, except that each individual basket storage position was surveyed independently. The data were recorded as shown in Figure 5.7. Readings of particular interest were as follows:

- ° The reading near the top of the covered basket in the chopped fuel storage and cooling rack was 4.7 R/h. This reading is sufficiently low to indicate that the basket does not contain unprocessed irradiated fuel.
- ° The reading over the covered fuel basket storage socket was 6.4 R/h. This reading is sufficiently low to indicate that the basket does not contain unprocessed irradiated fuel.

FIGURE 5.6
Isometric Representation of Radiation Intensities in Roentgens per Hour
at 1.8 meters (6 feet) above the GPC Floor

NOTES: a. 1 m (3 ft) from floor
 b. Near floor
 c. 0.3 m (1 ft) from floor
 d. No access at 1 m (3 ft) from floor

FIGURE 5.7
Collimated Gamma Radiation Intensities in the GPC

6.0 SAMPLING

6.1 Procedure

Loose solids samples were taken by inserting a sampling fixture and a tray of sampling cartridges through a 25 cm (10 in) MSM port, suspending the fixture from a crane hook, then moving it to desired surface locations using crane controls. The fixture, shown in Figure 6.1, held an electric vacuum motor within the section of 15 cm (6 in) diameter pipe. The 2.5 cm (1 in) diameter nipple was used as a nozzle. Each sample was taken by positioning the fixture over an empty cartridge (shown in Figure 6.2), activating the vacuum motor to hold the cartridge against the nozzle, moving the fixture to the sampling location where the vacuuming action through the cartridge collected loose surface material, returning the fixture to the sample tray, then deactivating the vacuum motor to release the cartridge. Separate cartridges were used for each sample to prevent cross contamination. Samples were transferred to the analytical cells for analysis.

A liquid sample was drawn by inserting a sponge attached to a lifting bail through a 25 cm (10 in) MSM port in the PMC, suspending it from a crane hook, then moving it to the floor hatch in the PMC directly above the liquid on the GPC floor. The sponge was dipped into the liquid then transferred to the analytical cells for analysis.

6.2 Process Mechanical Cell

Twelve samples of loose solids were taken from the PMC May 12-13, 1986. The locations from which the samples were taken are shown in Figure 6.3. The analytical results are shown in Table 6.1. Results of particular interest are as follows:

- ° The principal source of radiation in the samples is cesium-137, a fission product. A significant source of radiation is cobalt-60, a neutron activation product.

FIGURE 6.1
Sampling Fixture

FIGURE 6.2
Sampling Cartridge

FIGURE 6.3
Sample Locations in the PMC

Table 6.1

Analyses of Loose Solids from the PMC

Sample													
Cartridge No.	(1)	1	2	3(2)	4	5	6	7	8(2)	9	10	11	13
Volatiles	(wt. %)	13.3	13.0		35	41.9	16.0	7.7		11.1	34.6	9.2	2.8
Total Uranium	(wt. %)	60.5	3.8		3.32	.771	.498	3.8		.785	1.79	15.7	.769
Activity	() Ci/g)												
Co-60		20	20		580	29	6	900		3	26	280	5
Cs-134		80	4			LTD ³						LTD	7-10
Cs-137		20,300	1,380		330	160	1.1	670		151	540	1,200	235
Eu-155		LTD	LTD		1	.6	LTD	LTD		.3	2	4-8	LTD
Pb-212					LTD	LTD	LTD	LTD		LTD	LTD		
U-235		LTD	LTD		LTD	LTD	LTD	LTD		LTD	LTD	LTD	LTD
Pu-238		250	.09		18	4	2	11		2.3	4	16	5
Pu-289/240		210	.07		18	3	2	11		2.2	5	30	5
Am-241		130			9	6.2	3	10		3	19	40	6

(1) See Figure 6.3 to relate sample cartridge numbers to sample locations.

(2) Insufficient loose solids were collected for analysis.

(3) Less than detectable.

- ° The positive analyses for Pu-238 confirmed the presence of fissile material throughout the PMC.
- ° The positive analyses for plutonium and americium confirmed the presence of transuranic materials throughout the PMC.
- ° The broad variations in the analytical results revealed that the fines distributed around the PMC are not homogeneous. For example, sample 1 is clearly spilled unprocessed fuel while the other samples appear to be contaminated debris such as saw fines.

6.3 General Purpose Cell

6.3.1 Smears and Hulls

On June 4, 1979, NFS personnel took three smears from surfaces in the GPC, and recovered three pieces of cladding hulls. These samples were placed into individual polyethylene bags and shipped to the Oak Ridge National Laboratory for analyses. Gamma-ray spectra were obtained for both the smears and hulls, and particle size distributions were obtained from the smears. The results of these analyses were reported in reference 1 and are presented in Tables 6.2 and 6.3, and in Figure 6.4. Results of particular interest are as follows:

- ° The primary source of activity in the smears was cesium-137, a fission product.
- ° The primary source of activity in the hulls was cobalt-60, a neutron activation product.
- ° The particles in the smear samples ranged in size from 2 to 40 μ m.

Table 6.2

Analyses of Smears from GPC

Nuclide	6-inch swipe from	8-inch swipe from	8-inch swipe from
	inside dumping station (μCi)	top surface of basket cooler (μCi)	vertical wall in front of GPC-A (μCi)
Cr- 51	0.27	≤ 4.2	≤ 0.6
Co- 60	2.7	1.0	0.13
Zr- 95	0.07	0.81	0.08
Sb-125	6.22	3.85	-
Cs-134	2.0	22.	1.86
Cs-137	51.	388.	48.9
Eu-154	0.97	11.6	1.23
Eu-155	0.27	2.6	0.33

Smears analyzed by gamma-ray spectra July 10, 1979.

Table 6.3
Analyses of Hulls from the GPC

Nuclide	Hull from GPC floor in front of east window (μCi)	Hull from center of GPC (μCi)	Hull from unknown location previously stored in analytical cells (μCi)
Cr- 51	-	9.02	5.82
Mn- 54	60.8	-	-
Co- 60	13,200	134.	32.3
Zr- 95	-	2.6	0.54
Sb-125	-	342.	133.
Cs-134	92.	40.	9.08
Cs-137	1,260	1480	447.
Eu-152	-	-	$\leq$ 0.5
Eu-154	35.	37.	6.5
Eu-155	-	5.8	1.73

FIGURE 6.4
Smear Particle Size Distributions from the GPC

6.3.2 Loose Solids

Five samples of loose solids were taken from the GPC on May 22-23, 1986. The locations from which the samples were taken are shown in Figure 6.5. The analytical results are shown in Table 6.4. Results of particular interest are as follows:

- ° The principal source of radiation in the loose solids samples is Cs-137, a fission product. A significant source of radiation is Co-60, a neutron activation product.
- ° The positive analyses for Pu-238 confirmed the presence of fissile material.
- ° The positive analyses for plutonium and americium confirmed the presence of transuranic materials.

6.3.3 Sump Liquid

On May 27, 1986, a single sample of the liquid in the GPC sump area was taken. The analytical results are shown in Table 6.5. The primary sources of activity in the liquid were found to be cesium-137 and strontium-90, fission products.

Table 6.5
Analysis of Liquid from the GPC

Volatiles	about 100 wt. % ⁽¹⁾
Total U	0.002 g/L
Activities	
Co - 60	0.004 - 0.006 μ Ci/mL
Sr - 90	0.7 μ Ci/mL
Cs -134	0.006 - 0.010 μ Ci/mL
Cs -137	4 μ Ci/mL
Pu	0.0006 - 0.0007 μ Ci/mL
Am -241	Less than detectable

(1) When left exposed in the analytical cells, the sample evaporated to dryness.

FIGURE 6.5
Sample Locations in the GPC

Table 6.4
Analyses of Loose Solids from the GPC

Sample					
Cartridge No. (1)		19 ⁽²⁾	20 ⁽²⁾	22	29 ⁽²⁾ 30
Volatiles	(wt. %)				45.1
Total Uranium	(wt. %)			5.94	8.34
Activities	(μ Ci/g)				
Co - 60					30
Cs -137				680 - 700	2030
Eu -155				LTD ⁽³⁾	
U -235				LTD	LTD
Pu -238				55 - 60	40
Pu -239/240				42 - 46	40
Am -241				70	53 - 57

(1) See Figure 6.5 to relate sample cartridge numbers to sample locations.

(2) Insufficient loose solids where collected for analysis.

(3) Less than detectable.

7.0 ACTIVITIES AND FISSILE MATERIAL INVENTORIES

Activities and fissile material inventories throughout the reprocessing plant were systematically estimated prior to this characterization study for the project Safety Analysis Report (SAR), reference 2. The estimates from the SAR are presented in Tables 7.1 through 7.4. Because reasonable estimates had already been developed and published, there was no intent for this study to produce new estimates.

A major difference between the loose solids sample analyses and the radionuclide estimates in the project SAR is the quantitative presence of cobalt-60 (Co-60), a neutron activation product. A trivial amount is predicted in the SAR yet it is a significant source of radioactivity in the head-end cells samples.

The reason for this discrepancy lies in the method used to predict nuclide inventories for the SAR at a time when no samples from the head-end cells were available. The total uranium processed was mathematically combined with the activity in the liquid high level waste to produce a calculated composite of all the various fuel elements processed through the plant. Other radioactive wastes, such as solids packaged in the GPC for disposal, were not included. The nuclide inventories in the cells were estimated based upon the calculated composite reference fuel and a few in-cell radiation readings taken in 1978. This approach accounted for unfissioned fuel and fission products, but did not fully account for neutron activation products in the fuel assembly structural materials.

Although sampling would reveal representative amounts of fission products from spilled fuel fines, it would not reveal neutron activation products in proper proportion to the fission products. This is because, unlike the fission products, the bulk of the neutron activation products are contained in hardware, such as fuel assembly structural materials and hulls, and could not be collected in the sample cartridges. The presence of structurals and hulls was documented by the visual/video examinations. Therefore, the conclusion is drawn that Co-60 is a more significant contributor to the activity in the PMC and GPC than the sample analyses indicate.

TABLE 7.1
SAR Estimate of Radionuclide Inventory in the PMC

<u>Fission & Activation Products</u>		<u>Actinides</u>	
Isotope	Activity (Curies)	Isotope	Activity (Curies)
C - 14	9.2E-2	U -233	1.2E 0
Fe- 55	6.8E-1	U -234	6.8E-1
Ni- 59	5.4E-2	U -235	1.5E-2
Co- 60	3.1E-3	U -236	4.6E-2
Ni- 63	4.3E 0	U -238	1.4E-1
Se- 79	2.5E-2	Np-237	7.3E-3
Sr- 90	4.6E 3	Np-239	1.6E 0
Y - 90	4.6E 3	Pu-238	2.4E 2
Zr- 93	1.6E-1	Pu-239	6.1E 1
Nb- 93m	1.6E-1	Pu-240	4.8E 1
Tc- 99	1.1E 0	Pu-241	3.2E 3
Ru-106	8.7E-2	Pu-242	6.1E-2
Rh-106	8.7E-2	Am-241	1.8E 2
Pd-107	7.8E-4	Am-242	1.4E-2
Sb-125	3.0E 0	Am-242m	1.4E-2
Te-125m	6.8E-1	Am-243	1.6E 0
Sn-126	2.7E-2	Cm-242	1.5E-3
Sb-126m	2.7E-2	Cm-243	1.1E-1
Sb-126	3.7E-2	Cm-244	1.5E 1
Cs-134	9.2E 0	Cm-245	6.8E-3
Cs-135	1.1E-1	Cm-246	2.9E-3
Cs-137	4.9E 3		
Ba-137m	4.5E 3		
Ce-144	9.2E-3	Total Activity	2.3E 4
Pr-144	9.2E-3		
Pm-147	2.0E 2		
Sm-151	1.4E 2		
Eu-152	2.8E-1		
Eu-154	8.7E 1		
Eu-155	1.6E 1		

Table 7.2
SAR Estimate of Radionuclide Inventory in the GPC

<u>Fission & Activation Products</u>		<u>Actinides</u>	
Isotope	Activity (Curies)	Isotope	Activity (Curies)
C - 14	1.2E-1	U -233	1.5E 0
Fe- 55	8.8E-1	U -234	8.8E-1
Ni- 59	7.0E-2	U -235	1.9E-2
Co- 60	4.0E-3	U -236	5.9E-2
Ni- 63	5.5E 0	U -238	1.8E-1
Se- 79	3.2E-2	Np-237	9.4E-3
Sr- 90	5.9E 3	Np-239	2.1E 0
Y - 90	5.9E 3	Pu-238	3.1E 2
Zr- 93	2.0E-1	Pu-239	7.9E 1
Nb- 93m	2.0E-1	Pu-240	6.2E 1
Tc- 99	1.4E 0	Pu-241	4.1E 3
Ru-106	1.1E-1	Pu-242	7.9E-2
Rh-106	1.1E-1	Am-241	2.3E 2
Pd-107	1.0E-3	Am-242	1.8E-2
Sb-125	3.9E 0	Am-242m	1.8E-2
Te-125m	8.8E-1	Am-243	2.1E 0
Sn-126	3.4E-2	Cm-242	1.9E-3
Sb-126m	3.4E-2	Cm-243	1.4E-1
Sb-126	4.8E-2	Cm-244	1.9E 1
Cs-134	1.2E 1	Cm-245	8.8E-3
Cs-135	1.4E-1	Cm-246	3.7E-3
Cs-137	6.3E 3		
Ba-137m	5.8E 3		
Ce-144	1.2E-2	Total Activity	2.9E 4
Pr-144	1.2E-2		
Pm-147	2.6E 2		
Sm-151	1.8E 2		
Eu-152	3.6E-1		
Eu-154	1.6E 2		
Eu-155	2.0E 1		

Table 7.3
SAR Estimate of Fissile Material Inventory in the PMC

Fissile Isotope	Mass (grams)
U-233	130
U-235	<u>7000</u>
Total Fissile Uranium	7100 (1)
Pu-239	1000
Pu-241	<u>32</u>
Total Fissile Plutonium	1000 (1)

(1) All values given to two significant figures.

Table 7.4
SAR Estimate of Fissile Material Inventory in the GPC

Fissile Isotope	Mass (grams)
U-233	160
U-235	<u>8900</u>
Total Fissile Uranium	9000 (1)
Pu-239	1300
Pu-241	<u>42</u>
Total Fissile Plutonium	1300 (1)

(1) All values given to two significant figures.

In the model used for the SAR, the detected radiation was assumed to be exclusively from cesium-137 (Cs-137) which emits one delayed 0.663 MeV gamma photon through its short-lived daughter, barium-137. Because Co-60 emits two high energy gamma photons per disintegration, 1.33 MeV and 1.17 MeV, fewer curies of Co-60 will produce a similar radiation intensity. Therefore, by assuming the radiation source was exclusively Cs-137, the model used for the SAR was biased toward predicting higher than actual curie contents. As a result, the SAR activity estimates for the PMC and GPC are probably high. Because the amount of a given fissile material is proportional to its activity, the SAR model was also biased toward predicting higher than actual fissile material inventories. Therefore, the SAR estimates of fissile uranium and fissile plutonium in the PMC and GPC are probably high.

8.0 CONCLUSIONS

1. Because of the high radiation intensities in the cells, 40 to 340 R/h at 1.8 m (6 ft) above the floor, D&D work will need to be performed remotely.
2. Because much of the auxiliary equipment needed for remote operations in the PMC and GPC requires repair, a considerable amount of preparatory work must be performed before significant direct D&D efforts can begin:
 - ° Adequate in-cell visibility must be re-established by in-situ refurbishment of shielded viewing windows, installation of radiation resistant in-cell camera systems, or both.
 - ° Crane room shield door operating mechanisms must be refurbished to allow for bridge crane and power manipulator transfers between the cells and their respective crane rooms for repair and routine maintenance.
 - ° Replacement, repair, or preventive maintenance; as appropriate on an item by item basis; must be performed on the cranes, power manipulators and master-slave manipulators to restore mechanical operating capabilities.

- ° The metal-X fire suppression systems must be returned to service, or suitable substitute systems must be installed, to protect against the consequences of an inadvertent metal fire.
3. Due to the presence of significant amounts of fissile material in both cells, appropriate administrative controls and physical constraints must be established to assure that a critical mass cannot be assembled when materials are handled. Because a high side bias was established in the method used to estimate the fissile material inventories in the PMC and GPC for the SAR, controls based upon those estimates should be conservative and therefore safe.
 4. The area where most of the fissile material is expected in the GPC is on the floor at the chopped fuel loading station. Fuel handling operations that could result in spills were conducted there, and it is the location of the greatest radiation intensity in the cell. The area is flooded so spontaneous neutrons emitted from fuel on the floor there must be considered as moderated. Therefore, one of the first tasks that should be performed in the GPC is the removal of the liquid in a manner that will not disturb the existing non-critical configuration on the submerged floor.
 5. Zirconic materials such as hulls, and metallic uranium such as spilled NPR fuel fines, are pyrophoric. Spontaneous combustion of materials currently in the cell is unlikely because oxygen from the air has had ample time during the fourteen years the plant has been idle to form a passive oxide layer over all exposed solid surfaces. However, to assure that a metal fire does not occur during D&D work, grinding tools, cutting torches, and other sources of direct flame should be restricted from the cells until all accumulations of hulls and fines have been removed or otherwise isolated.

6. Due to the unique set of characteristics exhibited by the wastes, an acceptable waste processing method, or final waste form, must be established. The unique set of characteristics are as follows:

- Non-homogenous
- Highly radioactive
- Fissile
- Transuranic
- Pyrophoric

9.0 REFERENCES

1. W. Davis Jr.,, Potential Radiological Impact of Tornadoes on the Safety of Nuclear Fuel Services' West Valley Fuel Reprocessing Plant, NUREG/CR-1530, Vol. 2, September 1981.
2. West Valley Demonstration Project Safety Analysis Report, Vol. II, Revision 1, April 1985.

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