Use of the Waste-Incidental-to-Reprocessing Citation Process at the West Valley Demonstration Project - 12250

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ABSTRACT

The West Valley Demonstration Project recently achieved a breakthrough in management of radioactive waste from reprocessing of spent nuclear fuel by taking advantage of lessons learned at other Department of Energy (DOE) sites in implementation of the waste-incidental-to-reprocessing citation process of DOE Manual 435.1-1, *Radioactive Waste Management*. This breakthrough involved a revision to the site procedure on waste-incidental to reprocessing. This procedure revision served as the basis for a determination by the DOE West Valley field office using the citation process that three secondary waste streams consisting of equipment that had once been contaminated by association with HLW are not HLW following decontamination and may be disposed of as low-level waste (LLW) or transuranic waste. These waste streams, which comprised much of the approximately 380 cubic meters of West Valley waste contaminated by association with HLW, included several vessels and certain tank farm equipment.

INTRODUCTION

The West Valley Demonstration Project is located some 48 km (30 mi) south of Buffalo, New York on the site of the only commercial spent nuclear fuel reprocessing facility to operate in the United States. This site is owned by the New York State Energy Research and Development Authority.

At this site, Nuclear Fuel Services, Inc. reprocessed irradiated nuclear fuel to recover uranium and plutonium from 1966 through 1972, using the PUREX (plutonium-uranium extraction) process and, for one fuel lot, the similar THOREX (thorium-uranium extraction) process. The nuclear fuel that was reprocessed came from commercial power reactors supplemented with a quantity of nuclear fuel from the N-Reactor at DOE's Hanford site. The most prevalent radionuclides in this waste were the fission products Cs-137 and Sr-90 and their progeny. [1]

The liquid waste from reprocessing was transferred to a tank farm, which includes four underground waste tanks: Tanks 8D-1 and 8D-2, each of 750,000-gal capacity, and Tanks 8D-3 and 8D-4, each of 15,000-gal capacity. Tanks 8D-2 and 8D-4 were used to collect liquid waste from reprocessing, with the other two tanks serving as spares. Tank 8D-1 was later used by the West Valley Demonstration Project as a waste treatment tank.

Congress passed the West Valley Demonstration Project Act of 1980 [2] to provide for cleanup of the site. The Department's statutory obligations under this Act include disposal of LLW and transuranic waste associated with the project and vitrification of the HLW. In response, DOE constructed new facilities for treatment and solidification of HLW and HLW vitrification took approximately 20 years. Two hundred seventy-five stainless steel canisters of vitrified HLW were produced and these remain temporarily stored at the site.

Approximately 2.3 million L (600,000 gal) of supernatant were pretreated before the HLW was vitrified. The pretreatment program consisted of (1) supernatant processing, (2) sludge washing, and (3) zeolite transfer to underground waste Tank 8D-2. The PUREX sludge in Tank 8D-2 was washed by adding a sodium hydroxide solution to dissolve the hard layer of sludge present in the tank, which solubilized the sulfate and other undissolved salts present in the sludge, and mixed the interstitial liquid trapped in the sludge with the wash solution.

Following the completion of sludge washing, the installation of the HLW transfer system – which linked all three underground waste storage tanks that contained HLW (Tanks 8D-1, 8D-2, and 8D-4) to the Vitrification Facility – was completed. To facilitate waste removal, waste transfer pumps were installed in Tanks 8D-1, 8D-2, and 8D-4. The Vitrification Facility was used to stabilize several HLW streams in a borosilicate glass matrix.

Waste Incidental to Reprocessing

The basis for the concept that certain wastes that are incidental to reprocessing are not HLW was established 1969 when the U.S. Atomic Energy Commission noted that the term high-level waste did not include all wastes originating from [spent nuclear fuel] reprocessing plant operations, and that wastes such as ion exchange beds, sludges, and contaminated laboratory items, clothing, tools, and equipment, along with radioactive hulls and other irradiated and contaminated fuel structural hardware, could be disposed of as LLW [3]. Although this language was deleted by the Atomic Energy Commission to preserve its flexibility as to how such material should be treated, the principle of incidental wastes had been established and has since been continually supported by both DOE and the U.S. Nuclear Regulatory Commission (NRC). For example, the NRC introduced the term ‘incidental wastes” in 1987 and stated that HLW does not include such waste streams [4].

The DOE also affirmed the concept of incidental wastes in DOE Order 435.1, *Radioactive Waste Management* [5], which was issued in 1999, along with the associated DOE Manual 435.1-1, *Radioactive Waste Management Manual* [6] and DOE Guide 435.1-1, *Implementation Guide For Use With DOE M 435.1-1* [7]. DOE Manual 435.1-1 made it clear that waste incidental to reprocessing is not a waste type but a process. The DOE Manual 435.1-1 states in Section II.B that:

> “Waste resulting from reprocessing spent nuclear fuel that is determined to be incidental to reprocessing is not high-level waste, and shall be managed under DOE’s regulatory authority in accordance with the requirements for transuranic waste or low-level waste, as appropriate. When determining whether spent nuclear fuel reprocessing plant wastes shall be managed as another waste type or as high-level waste, either the citation or evaluation process described below shall be used:
>
> (1) **Citation**. Waste incidental to reprocessing by citation includes spent nuclear fuel reprocessing plant wastes that meet the description included in the Notice of Proposed Rulemaking (34 FR 8712) for proposed Appendix D, 10 CFR Part 50, Paragraphs 6 and 7 [4]. These radioactive wastes are the result of reprocessing plant operations, such as, but not limited to: contaminated job wastes including laboratory items such as clothing, tools, and equipment.
>
> (2) **Evaluation**. Determinations that any waste is incidental to reprocessing by the evaluation process shall be developed under good record-keeping practices, with an adequate quality assurance process, and shall be documented to support the

determinations. Such wastes may include, but are not limited to, spent nuclear fuel reprocessing plant wastes that:

(a) Will be managed as low-level waste and meet the following criteria:

1. Have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical; and
2. Will be managed to meet safety requirements comparable to the performance objectives set out in 10 CFR Part 61, Subpart C, *Performance Objectives*; and
3. Are to be managed, pursuant to DOE's authority under the *Atomic Energy Act of 1954*, as amended, and in accordance with the provisions of Chapter IV of this Manual, provided the waste will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste as set out in 10 CFR 61.55, *Waste Classification*; or will meet alternative requirements for waste classification and characterization as DOE may authorize.

(b) Will be managed as transuranic waste and meet the following criteria:

1. Have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical; and
2. Will be incorporated in a solid physical form and meet alternative requirements for waste classification and characteristics, as DOE may authorize; and
3. Are managed pursuant to DOE's authority under the *Atomic Energy Act of 1954*, as amended, in accordance with the provisions of Chapter III of this Manual, as appropriate."

DOE Guide 435.1-1 states that:

> "The distinction between the two processes is important because it is clear from background events that citation process waste streams were so identified because of the ease of determining up front that they do not pose the long-term hazards associated with high-level waste. Evaluation process wastes, on the other hand, generally require a case-by-case evaluation and determination."

Thus the citation process is implemented for reprocessing wastes that can be demonstrated not to be HLW using readily available or observable information.

REVISING THE WEST VALLEY WASTE-INCIDENTAL-TO-REPROCESSING PROCEDURE

Like other DOE sites, West Valley developed implementing procedures for DOE Order 435.1-1 and the associated Manual and Guide not long after they were issued.

The West Valley Citation List

The West Valley waste-incidental-to-reprocessing procedure includes a list of items "excluded by citation." This list was based on a determination made by DOE-West Valley using the citation process that the listed items were not HLW and may be managed as LLW or transuranic waste, as applicable. These items included reprocessing wastes in five categories:

- Contaminated job wastes such as paper, plastic, hand tools, personnel protective equipment, and debris;
- Sample media such as laboratory equipment and expended samples;
- Measuring and monitoring equipment such as instruments and gages;
- Laboratory clothing, tools, and equipment such as lab coats, gloves, instrumentation, glove boxes, and fume hoods; and
- Decontamination media and decontamination solutions such as swabs, mops, strippable coatings, cleaning solutions, and piping and equipment used in decontamination processes.

The West Valley procedure was refined over the years. During the spring of 2011, West Valley Environmental Services, the DOE site contractor, began a revision to include additional waste streams in the citation process. After preparing a draft, West Valley Environmental Services turned to the Energy Facility Contractors Group (EFCOG) for assistance in completing the revision. (Formed in 1991, the EFCOG is an organization of DOE contractors that works to improve the cost effectiveness of DOE operations by exchanging information on matters such as best practices and lesson learned.) A team established by the Waste Management Working Group of the EFCOG assisted West Valley Environmental Services by recommending improvements based on lessons learned from other DOE sites which resulted in issuance of Revision 9, in May 2011 [8]. (Where the term *team* is used below, it refers to the three Energy Facility Contractors Group representatives along with the West Valley Environmental Services personnel involved with the procedure revision.)

Added Waste Streams

The new waste streams included in the expanded citation list were considered to be secondary waste – that is, waste byproducts resulting from management of retrieval, treatment, storage, handling, and analysis of HLW that have become radioactively contaminated by HLW. (The concept of secondary waste had been developed at the Hanford site.) The three new waste streams were as follows:

(1) The following seven vessels and connective piping between them and the associated components in the Main Plant Processing Building were included:
   - 4C-1, the Partition Cycle Extraction Column from Extraction Cell 1;
   - 4D-2, the Partition Cycle Waste Catch Tank from Extraction Cell 1;
   - 7D-1, the High-Level Waste Evaporator Feed Tank from Extraction Cell 1;
   - 7C-1, the High-Level Waste Evaporator from the Chemical Process Cell;
   - 7D-4, the High-Level Waste Accountability and Neutralizer Tank from the Chemical Process Cell;
   - 7D-10, the Low-Level Waste Accountability and Neutralizer Tank from the Chemical Process Cell; and
   - 7C-2, the Low-Level Waste Evaporator from the Chemical Process Cell.

(2) The second waste stream consisted of equipment installed in the underground waste tanks and used in managing and retrieving HLW, including 18 mobilization and transfer pumps and other similar and related items, including connective piping.

(3) The third waste stream was the waste transfer piping used to convey HLW from the waste tank farm to the Vitrification Facility and the associated equipment.

General Approach

In preparation of the procedure revision, the team considered similar citation procedure revisions that had been prepared by the Hanford site and the Savannah River Site, along with lessons learned by DOE sites in implementation of the DOE Manual 435.1-1 waste-incidental-to-reprocessing requirements that were taken into account in those procedure revisions. These lessons included:

(1) Many reprocessing waste streams consist of equipment used in some aspect of management of HLW that was not produced in reprocessing of spent nuclear fuel;

(2) Most of this equipment has a low potential for retaining significant amounts of waste due to its configuration and use;

(3) Sites managing HLW are required by DOE regulations, policies, and technical standards to implement the as low as reasonably achievable (ALARA) principle to decontaminate equipment that becomes contaminated by HLW;

(4) Decontamination performed in the field effectively removes most of the residual waste by simple processes such as flushing and rinsing with water;

(5) Characterization data typically show that radionuclide concentrations in waste packages containing the decontaminated equipment meet waste acceptance criteria for disposal as LLW;

(6) Meeting the waste acceptance criteria for disposal in a shallow-land LLW disposal facility ensures that the equipment does not require geologic isolation; and

(7) Meeting these waste acceptance criteria ensures that disposal of the reprocessing waste stream will not impact performance of the disposal site.

Such factors indicate that many reprocessing waste streams are not HLW.
As part of the West Valley procedure revision, as appendix was prepared to describe the technical basis for using the citation determination process for the added waste streams. This technical basis document established that each of these waste streams was not HLW by the citation process by confirming that it does not contain a significant amount of waste due to (a) its design and usage and/or (b) its decontamination consistent with ALARA requirements based on available information. It also described the site ALARA program to show how it led to decontamination when decontamination was necessary for safe handling and discussed the decontamination capabilities at the site.

Also, consistent with guidance in DOE Guide 435.1-1, the technical basis document included an analysis using the evaluation process criteria of Section II.B(2) of DOE Manual 435.1-1 that demonstrated that the subject waste streams met these criteria. This information was included to provide added assurance that the subject waste streams could not be HLW.

In addition, DOE-West Valley consulted with the DOE Office of Environmental Management to provide additional assurance that the revision to the procedure was consistent with applicable DOE requirements and guidance. The next section briefly describes the three added waste-streams and how the evaluation process criteria were considered for these wastestreams.

The Seven Vessels

Table I shows the approximate sizes and uses of the seven vessels from the Main Plant Process Building along with their estimated residual radioactivity.

Table I. Main Plant Process Building Vessels[a]

No.	Name	Size (m)		Estimated Activity		Use
		Length	Dia.	GBq	Ci	
4C-1	Partition Cycle Extraction Column	13	0.3	4.8	0.13	First separations column
4D-2	Partition Cycle Waste Hold Tank	4	1.8	2,850	77	Received bottom stream from 4C-1
7D-1	HLW Evaporator Hold Tank	3	1.8	11,100	300	Received 4D-2 waste stream
7C-1	HLW Evaporator	2.6	1.5	555	15	Reduced volume of aqueous waste from 4D-2
7C-2	LLW Evaporator	2.6	2.4	74	2.0	Reduced volume of aqueous waste from several sources
7D-4	HLW Accountability and Neutralizer Tank	2.4	1.5	370	10	Received evaporator bottoms from 7D-1 with <8 molar nitric acid concentrations
7D-10	LLW Accountability and Neutralizer Tank	2.7	1.8	30	0.8	Received evaporator bottoms from 7C-2

[a]From reference 8. The estimated activities are conservative, order-of-magnitude estimates.

Figure I shows three of the vessels in Extraction Cell 1 that were used for the first reprocessing partition cycle.

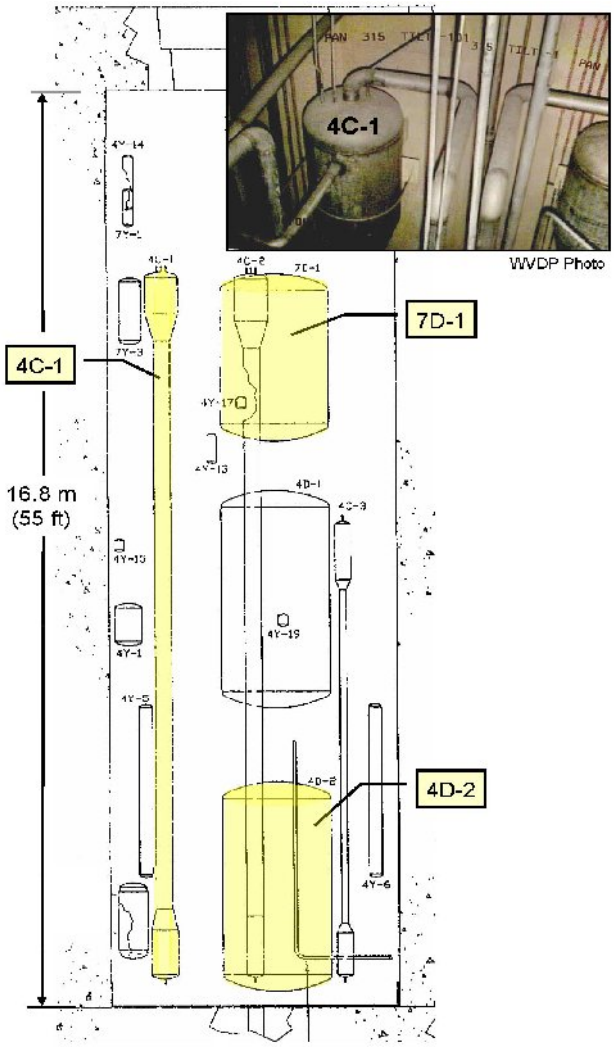

Fig. I. Extraction Cell 1 Vessels

In considering the first evaluation criterion on key radionuclide removal, DOE Manual 435.1-1 II.B(2)(a)1 (page 2 of this paper), the technical basis document described the 1972-1974 plant decontamination program. This program used a variety of chemicals and decontamination solutions in 14 cycles over a 13-month period to remove radioactive contamination from the plant systems and transport it to underground waste tank 8D-2. Figure II illustrates the results of this flushing, which removed approximately 4,070 TBq (110,000 Ci) from the partition systems [9]. The technical basis also noted that the exteriors surfaces of the vessel in Extraction Cell 1 had also been decontaminated with high-pressure water spray. The technical basis went on to consider other decontamination methods and concluded that additional decontamination would have produced no net benefit to human health or the environment.

In considering the second evaluation criterion of DOE Manual 435.1-1 II.B(2)(a)2 on meeting safety requirements comparable to NRC performance objectives for LLW disposal, the technical basis document indicated that the LLW waste packages were expected to meet waste

acceptance criteria for the planned disposal site and that this would be confirmed. It explained

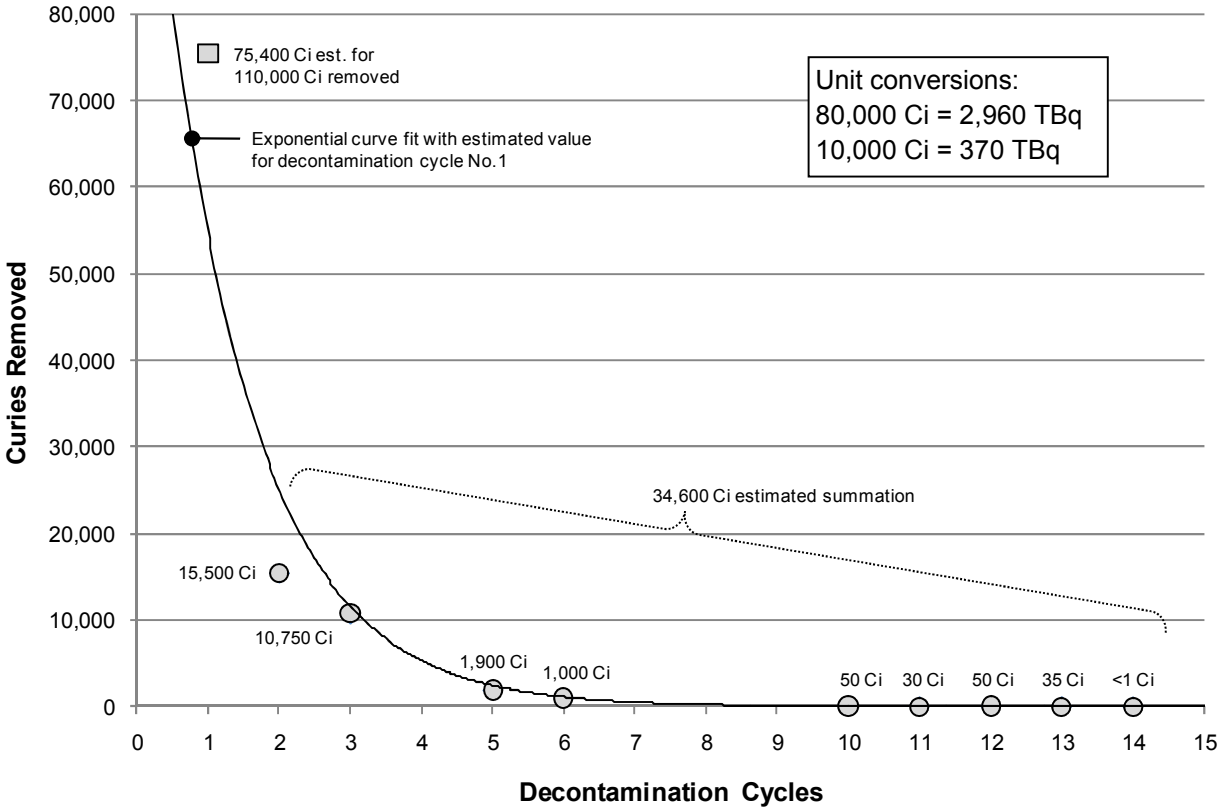

Figure II. Partition System flushing results [9]

that meeting these criteria would ensure compliance with disposal site performance objectives.

In considering the second evaluation criteria for transuranic waste, the technical basis document explained that those portions of the new waste streams meeting transuranic waste criteria would be in solid form and that meeting the waste acceptance criteria for the Waste Isolation Pilot Plant would ensure that the waste would be managed to meet alternate requirement for waste classification. (The WVDP does not presently have authority to ship transuranic waste to the Waste Isolation Pilot Plant.)

In considering the third LLW evaluation criterion of DOE Manual 435.1-1 II.B(2)(a)3 on management of the waste in accordance with DOE LLW requirements, the technical basis document explained that waste packages classified as LLW are expected to have radionuclide concentrations less than NRC's Class C limits, with any that did not being classified as transuranic waste since the transuranic radionuclides Pu-238, Pu-239, Pu-240, and Am-241 would drive the waste classification. The third transuranic evaluation criterion would be met simply by managing the waste as transuranic waste.

The technical basis document concluded that the seven vessels would meet the evaluation criteria of DOE Manual 435.1-1, reinforcing the position that they are not HLW by the citation process and may be managed as LLW or transuranic waste, as applicable.

Waste Tank Equipment

Most of the items in this category are mobilization and transfer pumps. Figure III shows a typical mobilization pump, which is approximately 15.2 m (50 ft) long.

Decontamination typically involved operating the pumps in increasingly dilute solutions and tank sluicing activities. The pumps are also decontaminated during removal by flushing the exterior surfaces with water, a process with a decontamination factor of around 20. (The amount of activity in one pump was reduced by a factor of 24 by this flushing process. Such a decontamination factor is relatively high for decontamination using water.)

As with the Main Plant Process Building vessels, the technical basis document considered each of the DOE Manual 435.1-1 evaluation criteria, as analyzed for the waste vessels, and showed that these criteria would be met for the waste tank equipment thereby reinforcing the conclusion that this equipment is not HLW and can be managed as LLW or transuranic waste.

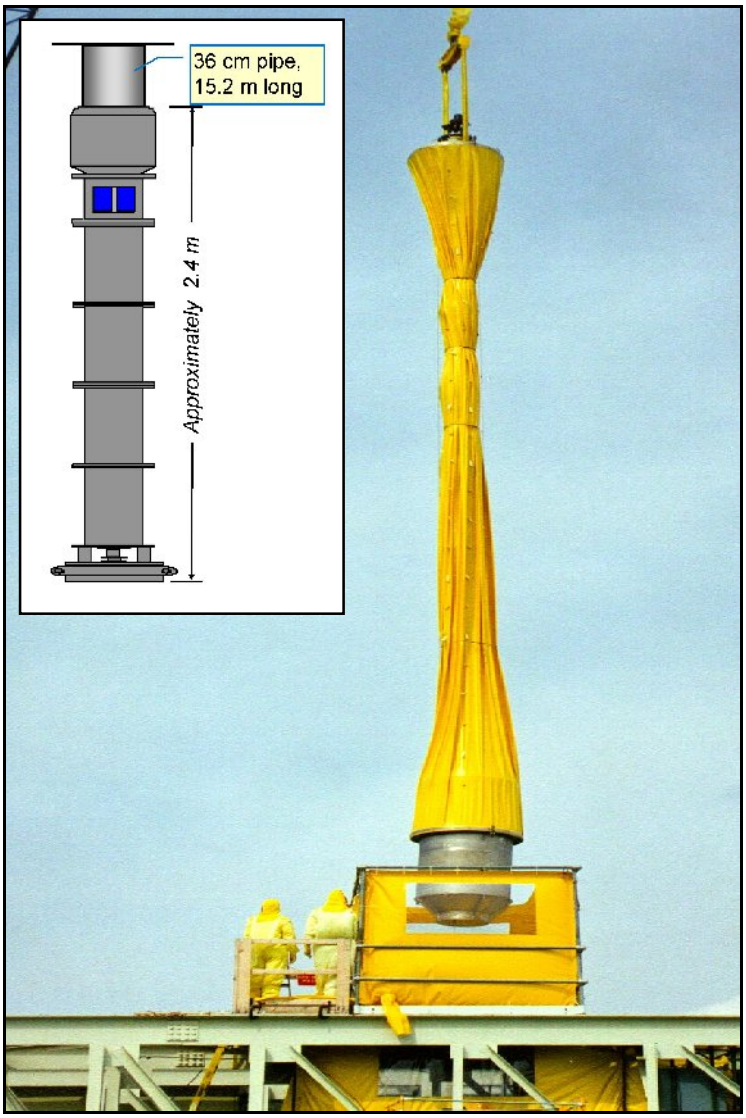

Fig. III. Mobilization pump during removal with detail of lower end (inset)

Waste Transfer Piping

Figure IV shows some of the piping during installation. This piping is located inside the HLW transfer trench, a concrete vault extending about 150 m (500 ft) from the area of Tanks 8D-3 and 8D-4 to the Vitrification Facility. Four piping runs within the transfer trench were used to convey liquid from the tank farm to the Vitrification Facility.

The technical basis document explained how each piping line was routinely flushed after each use and how all of the lines were flushed with nitric acid solution and water at the conclusion of vitrification. It noted that dose rates during vitrification ranged up to 50 mSv/hr (5 R/hr) based on limited data and that dose rates in 2004 after decontamination were a maximum of 0.096 mSv/hr (9.6 mR/hr). Based on consideration of such information, it was concluded after consideration of the evaluation process criteria that the waste transfer piping is not HLW and may be managed as LLW or transuranic waste based on waste package characteristics.

Fig IV. HLW transfer piping during installation

Conclusion

By making use of lessons learned in use of the citation process by other DOE sites and information developed to support use of the citation process at the Hanford site and the Savannah River Site, the team developed a technical basis for showing that use of the citation process of DOE Manual 435.1-1 for the three new waste stream was appropriate and technically justified. The Waste Management Working Group of the EFCOG assisted in transferring lessons learned by drawing on experience from around the DOE complex. This process shared knowledge about effective implementation of the citation process in a manner that proved to be beneficial to the West Valley Demonstration Project and resulted in a technical basis document that could be used to determine that the three new waste streams were not HLW [10].

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