Progress on Resolution of Technical Issues at the Hanford Waste Treatment And Immobilization Plant Project – 16285

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ABSTRACT

The U.S. Department of Energy's (DOE) Waste Treatment and Immobilization Plant (WTP) Pretreatment (PT) Facility has a number of first-of-a-kind technical challenges that have required additional expert analysis and testing activities to resolve. In 2006 an External Flowsheet Review Team identified 28 technical vulnerabilities with the plant design or future operability. Over a period of three months starting in September 2012, a number of top scientists and engineers conducted a review of the major technical issues associated with the design and operability of the WTP. These experts also provided independent advice on some of the broader challenges associated with completing the Hanford tank waste mission – highlighting the linkage between the physical and chemical properties of the tank waste and the PT Facility technical issues.

In 2012 and early 2013 DOE's Office of River Protection (ORP) directed the WTP contractor to suspend production work on the Pretreatment Facility until the outstanding technical issues could be resolved and the nuclear safety basis could be updated and brought into alignment with any updates to the facility design and/or process flowsheet. Specific plans for resolving each the technical issues have been developed and significant progress has been made over the past year in identifying solution sets for each of the issues.

The eight remaining technical issues (referred to as T1 to T8) are as follows:

(T1) Hydrogen Gas Release from Vessel Solids
(T2) Potential Criticality in Pretreatment Facility Vessels
(T3) Hydrogen in Piping and Ancillary Vessels
(T4) Pulse-Jet Mixing and Control
(T5) Erosion and Localized Corrosion in WTP Vessels and Piping
(T6) Design Redundancy in Black Cells/In-Service Inspection
(T7) Black Cell Vessel Structural Integrity
(T8) Facility Ventilation.

This paper provides a synopsis of the progress that has been made on resolving the Pretreatment technical issues over the past year, and how resolution of the issues will enable DOE to make an informed decision to resume design and production engineering for the Pretreatment Facility.

INTRODUCTION

The Hanford Waste Treatment and Immobilization Plant will cover 65 acres with four nuclear facilities – Pretreatment, High-Level Waste Vitrification, Low-Activity Waste Vitrification and an Analytical Laboratory – as well as operations and maintenance buildings, utilities and office space.

The Pretreatment Facility, also known as the PT Facility, is the first step in the process of vitrifying Hanford's tank waste. The PT Facility is the largest of the four major nuclear facilities that compose the Vitrification Plant. It is 165 m (540 ft) long and 66 m (215 ft) wide, the size of nearly four football fields, and 36 m (120 ft) tall, or 12 stories, high. When complete, its total area will be more than 45 500 sq m (490,000 sq ft).

Waste will be pumped from the Hanford tanks via underground pipes to the PT Facility's interior waste feed receipt vessels. There, during the first phase of pretreatment, the waste will be concentrated using an evaporation process. Solids will be filtered out, and the remaining soluble, highly radioactive isotopes will be removed using an ion-exchange process.

The high-level solids will be sent to the High-Level Waste Vitrification Facility, and the low-activity liquids will be sent to the Low-Activity Waste Vitrification Facility for further processing. The PT Facility is shown in its current construction state in Figure 1.

Figure 1. Pretreatment Facility Construction State

DISCUSSION

Hanford waste tanks contain complex and diverse mixtures of radioactive and chemical wastes in the form of sludge, salts, and liquids, necessitating a variety of unique waste retrieval and treatment methods. While the radioactive nature of the waste requires unique, remotely operated equipment and shielded facilities, it is the uncertainty and diversity of the physical and chemical properties of the 211 983 m^3 (56 million gallons) of waste that makes the Hanford cleanup mission uniquely complex. Consequently, the Waste Treatment and Immobilization Plant (WTP) has a number of first-of-a-kind technical challenges that have required additional expert analysis and testing activities to address. The DOE restricted certain engineering, procurement, and construction work on the PT Facility, and to a lesser degree the

HLW Facility in 2012 and early 2013 because of the impact of unresolved technical issues on the facility designs. A brief description of the eight technical issues is provided below:

(T1) Hydrogen Gas Release from Vessel Solids

High solids concentrations expected to be present in some waste feed could form a sediment layer on the PT Facility pulse-jet-mixed vessel bottoms as a result of incomplete mixing. This sediment layer may have the potential to retain hydrogen gas. A buildup of enough gas in the sediment could lead to a sudden episodic release of hydrogen into the vessel headspace in unacceptably high concentrations, creating a risk of combustion that could potentially damage internal or downstream components.

(T2) Criticality in Pretreatment Facility Vessels

Up to 16 of the 149 underground single-shell tanks at Hanford may contain plutonium particles of a size and density that could settle on internal surfaces or bottoms of the pulse-jet-mixed vessels during pretreatment. If such settling was to occur, and the pulse-jet mixers were unable to re-suspend the particles, plutonium could accumulate in a geometry that might initiate a criticality, resulting in localized heating and a release of gamma and neutron radiation.

(T3) Hydrogen in Piping and Ancillary Vessels

Highly radioactive liquid waste being processed in WTP vessels, piping systems, and components can generate hydrogen gas through radiolysis and thermolysis. If hydrogen accumulates and an ignition source is present, conditions could cause a deflagration and, in some cases, a detonation that could potentially damage the piping system or vessel. Hydrogen accumulation in piping and small ancillary vessels is an issue because it takes less time to reach hazardous concentrations than in larger vessels.

(T4) Pulse-Jet Mixing and Control

WTP will use pulse-jet mixers to mix liquids and slurries in 38 of its process vessels. Pulse-jet mixers are cylindrical tanks internal to process vessels that mix the vessel contents by drawing the liquids or slurries into the cylinders by a vacuum, and then pressurizing the cylinder to eject the liquid or slurry back into the vessel via discharge nozzles, much like a turkey baster. Pulse-jet mixers have been used in nuclear applications worldwide for mixing radioactive liquids, slurries, and sludges. The pulse-jet-mixing systems have no moving parts and do not require maintenance.

(T5) Erosion and Localized Corrosion in WTP Vessels and Piping

Given the uncertainties in waste feed characteristics, the existing erosion and localized corrosion design basis for WTP vessels and piping may not have established conservative margins to account for localized erosive wear expected over a 40-year service life. The potential for excessive erosion and localized corrosion could result in unexpected wall thinning, an extended work stoppage

for repairs, and, in a worst case scenario, the potential for piping or vessel failure.

(T6) Design Redundancy in Black Cells and In-Service Inspection

The current design for equipment/components located in black cells and hard-to-reach areas may not account for redundancy or in-service inspection to support a 40-year service life. Black cells are rooms that are not accessible during operation; hence, no monitoring or maintenance could be performed. The potential exists for major equipment to fail before the end of its design life because of material defects, fabrication errors, installation deficiencies, or other unforeseen reasons. The piping and equipment in these areas is not accessible for monitoring of potential signs of degradation, and is not accessible for repair or recovery, should it become necessary.

(T7) Black Cell Vessel Structural Integrity

Changes in the loadings for structural analyses of fabricated and installed black cell vessels, especially pulse-jet-mixed vessels, have identified the potential need for structural modifications to support internal components. The need for the modifications is driven primarily by changes to seismic criteria and analysis methodology. The seismic ground motion criteria for WTP changed around 2005—after the vessels were fabricated and installed. The current seismic categorization of these vessels may not be appropriate considering the safety function of the vessels and the overall mission risk. Implementing complex modifications to vessels that have been fabricated and installed potentially could introduce additional technical risks and/or hazards that must be evaluated and balanced with the benefits of making the modifications.

(T8) Facility Ventilation

Several normal, off-normal, and post-design basis event operational conditions have the potential to cause the HEPA filters to fail due to higher than anticipated aerosol loading onto the filters. In contaminated facilities, air-handling units are designed and installed to ensure air always flows from less contaminated areas to more contaminated areas. The report from a recent project design review of the HLW Facility concluded that airflow in the required directions and required volumes within the facility may not be adequate. This could result in the spread of contamination within the facility and put the workers at risk.

Significant progress is being made on resolution of the technical issues described above. In 2012, a number of top scientists and engineers led by the Secretary of Energy conducted a review of the major technical issues associated with the design and operability of the PT Facility, focused specifically on the PT Facility black cells. Following that review and based on the recommendations of the expert team, DOE concluded that the then-current plans for resolution of the technical issues was potentially cost prohibitive [1] because of the complexity of the PT Facility design and process flowsheet. DOE has developed a revised approach to technical issue resolution that includes consideration of potential design changes (“e.g.” a

standardized, smaller high solids vessel design), a simplified PJM vessel testing program based on the standard vessel design, process flowsheet changes, and focused activities targeted at resolution of the key nuclear safety issues (T1 through T3 above).

The WTP contractor has developed, and DOE has approved, plans for resolution of the remaining PT Facility technical issues. These plans form the basis for the PT Facility engineering work to be performed in the coming years. The plans for resolving the technical issues require a combination of engineering studies and analysis; modeling; and extensive test programs associated with vessel mixing, erosion and corrosion, and ventilation system HEPA filters. The technical issue resolution work has been prioritized and incorporated into PT Facility near-term execution baseline. This work, along with a corresponding update to the PT Facility safety basis, will result in an authorization to resume the engineering work necessary to complete the design of the PT Facility.

DOE is also in the process of evaluating a proposed Tank Waste Characterization and Staging capability in Hanford's tank farms. Tank waste feed mixing, sampling, and preconditioning are required to ensure the waste acceptance criteria for the PT Facility are met. Past testing and analysis has not provided definitive assurance of the ability to adequately perform these functions in the double shell tanks. The Tank Waste Characterization and Staging capability would enable tank farm waste to be particle sized, mixed, sampled, characterized, and fed to the PT Facility predictably and consistently. It would also provide a method of managing waste projected to be more technically difficult to process.

CONCLUSIONS

The WTP contractor has established plans for resolving each of the eight remaining technical issues for the WTP's PT Facility, and proceeded to update their near-term project execution baseline to implement the technical activities needed to resolve the issues. Resolution of the technical issues is expected to continue over a period of several years. DOE will closely monitor progress on resolving the technical issues. Resolution of the technical issues and establishment of a revised safety basis will be key prerequisites to resuming engineering, procurement, and construction activities for the PT Facility.

REFERENCES

1. DOE/ORP-2014-03, 2014, *U.S. Department of Energy Approach for Resolution of Pulse-Jet Mixed Vessel Technical Issues in the Waste Treatment and Immobilization Plant*, U.S. Department of Energy, Office of River Protection, Richland, Washington.