OFFICE OF RIVER PROTECTION
P.O. Box 450 MSIN H6-60
Richland, Washington 99352

AUG 30 2019

19-WTP-0092

The Honorable Bruce Hamilton, Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW, Suite 700
Washington, D.C. 20004

Dear Chairman Hamilton:

RESOLUTION OF DEFENSE NUCLEAR FACILITIES SAFETY BOARD CONCERNS RELATED TO EROSION WEAR ALLOWANCES FOR PIPING, VESSELS, AND PULSE-JET MIXERS AT THE WASTE TREATMENT AND IMMOBILIZATION PLANT

References:
1. DNFSB letter from P. Winokur to D. Huizenga, EM, "Erosion/Corrosion Wear Allowances, Waste Treatment and Immobilization Plant," dated January 20, 2012.

2. EM letter from D. Huizenga to P.S. Winokur, DNFSB, "DOE Response to Erosion/Corrosion Wear Allowances, Waste Treatment and Immobilization Plant," dated March 5, 2012.

In coordination with, and participation from the U.S. Department of Energy (DOE), Office of Environmental Management, the DOE, Office of River Protection (ORP) is submitting this record documenting the technical basis for the resolution of the Defense Nuclear Facilities Safety Board (DNFSB) safety concern associated with erosion/corrosion wear allowances in the Waste Treatment and Immobilization Plant (WTP) design for piping, process vessels, and pulse-jet mixers.

Background:

Over the last several years, ORP and DNFSB have jointly identified a number of technical issues at the WTP, specifically on the Pretreatment Facility and to a lesser extent with the High-Level Waste Facility. In 2012, ORP directed the WTP contractor to stop design-related activities on both facilities, except in areas of the High-Level Waste Facility not affected by these issues.

Also in 2012, the Secretary of Energy established a team to better understand fundamental technical weaknesses with the design of the WTP, particularly issues that could result in adverse consequences within the WTP black cells. A number of those issues overlapped with those identified by ORP and DNFSB. To provide a focus on resolution of all these technical issues, ORP and the WTP contractor assembled teams to address each of the issues.

In the subject letter (Reference 1), the DNFSB evaluated erosion/corrosion wear allowances specified by Bechtel National, Inc. for design of piping, process vessels, and pulse-jet mixers for

WTP and documented several issues. In response to DNFSB's issues, DOE responded (Reference 2) through commitment to address each issue in order to provide a defensible technical basis for design of wear allowances, which account for waste characteristics, operating parameters, and conditions representative of WTP processes.

DOE agreed with the DNFSB issues and provided two separate briefings to DNFSB staff. The first was on August 30, 2017, and a second briefing occurred on October 29, 2018, both in Richland, Washington. The presentations provided the approach for revising WTP erosion wear allowances based on reassessment of previous External Flowsheet Review Team Issue M2 test data, design basis waste characteristics, design and flowsheet changes, final assessment of the revised erosion wear allowances for installed vessels, and design changes to the standard high-solids vessel design.

Other design changes included revision of document 24590-WTP-DB-ENG-01-001, *Basis of Design*, to establish slurry particle property bases for erosion, mixing, and slurry transfers, and addition of Section 18, which is related to material selection for process and piping components. Section 18 now contains the consolidated set of erosion and corrosion basis of design requirements for material selection and thickness for process piping and equipment components used to treat Hanford Site tank farm waste.

This letter documents completion of our commitment to the DNFSB for providing a briefing and report on the resolution of issues regarding wear allowances, testing, and analysis. An extended discussion of the actions taken to resolve each specific DNFSB issue is provided in the Attachment.

If you have any questions, please contact me, or you may contact Tom Fletcher, Assistant Manager, Federal Project Director, Waste Treatment and Immobilization Plant Project, (509) 376-3434.

Brian T. Vance
Manager

WTP:IGP

Attachment

cc: w/attach
D.Y. Chung, EM-3.1
G. Sosson, EM-3.11
A.N. Suttora, EM-3.111
J. Olencz, AU-1.1
S.C. Petras, AU-1.1
P.K. Fox, DNFSB
B.K. Caleca, DNFSB

Attachment
19-WTP-0092

RESOLUTION OF DEFENSE NUCLEAR FACILITIES SAFETY BOARD CONCERNS RELATED TO EROSION/CORROSION WEAR ALLOWANCES AT THE WASTE TREATMENT AND IMMOBILIZATION PLANT

(6 pages including cover page)

ATTACHMENT
RESPONSE TO THE DEFENSE NUCLEAR FACILITIES SAFETY BOARD ISSUE: EROSION/CORROSION WEAR ALLOWANCE, WASTE TREATMENT AND IMMOBILIZATION PLANT

Based on the Defense Nuclear Facilities Safety Board (DNFSB) letter to the U.S. Department of Energy (DOE), Office of Environmental Management dated January 20, 2012, the DNFSB was concerned that the Waste Treatment and Immobilization Plant (WTP) Project team had not shown that the design wear allowances for WTP vessels, piping, and pulse-jet mixer (PJM) nozzles were adequate to ensure that components located in the black cells would reliably function for the 40-year design life of the facility.

Statement of Concern:

Background Issues Raised by the Board:

- WTP piping and vessels perform the safety-significant function of confining radioactive material, much of the piping and many of the vessels are contained in black cells.
- Design of black cells prevents observation and tracking of wear (erosion and corrosion) and does not provide easy access for repair or replacement.
- Inadequate wear allowances for piping, vessels, and PJM nozzles could result in component failures.
- Component failure due to wear jeopardizes the above safety functions and could stop waste processing for indefinite periods resulting in significant extensions in the time required to accomplish the facility mission.
- Existing design margins offer little or no flexibility for future operations or the opportunity to extend the life of WTP if required.

Specific Issues Raised by the Board:

1. Design wear rates were derived from information found in literature; assumptions have not been adequately validated (derived from literature and from studies not representative of WTP waste processing conditions).
2. Wear models do not have quantified conservatisms applied nor do they have applied safety factors.
3. The safety basis design curve does not bound data collected by the M2 wear testing. Consequently, the experimental testing does not validate the relationships and assumptions used to establish the design wear rates.
4. Process controls (which include safety controls) have not been established by the WTP Project to protect key assumptions or operating parameters.

Actions Taken by DOE:

The Office of River Protection agreed with the DNFSB's concerns on jet impingement wear. The following discussions address each specific issue individually and provide objective evidence through reference for resolution. Background issues are not specifically addressed, but are included in responses to the specific issues as applicable. Summary of actions committed by DOE are taken from the presentation to the DNFSB staff on October 29, 2018.

Specific Issue 1: Design wear rates were derived from information found in literature; assumptions have not been adequately validated (derived from literature and from studies not representative of WTP waste processing conditions).

Response: DOE committed to develop a design basis with validated assumptions, for waste characteristics due to process operations using test data that represents bounding characteristics, review the revised wear rate algorithm for all expected operating conditions, and determine if sufficient technical information is available to verify the wear rate model.

The WTP Project Resolution has:

- Reexamined WTP External Flowsheet Review Team Issue M2 jet impingement testing test coupons (by surface profilometry) to reduce uncertainty of the measured wear (i.e., scar depth rate) for vessel materials of construction (24590-WTP-M0C-50-00013, *Determination of DEI Test Plate Maximum Scar Depths*, Rev. 2)
- Evaluated the potential to experience synergy from the combined erosion/corrosion mechanisms (24590-WTP-ES-ENG-15-024, *WTP Engineering Study: Erosion/Corrosion Due to Synergy*, Rev. 1)
- Validated assumptions by revising wear allowance equation for localized erosion wear on both PJM vessel bottom heads and PJM nozzle based on empirical data, which does not extrapolate beyond the range of tested parameters (24590-WTP-ES-ENG-17-014, *T5 Erosion Engineering Study for Jet Impingement Erosion in PJM Vessels*, Rev. 0)
- Revised WTP flowsheet configurations to minimize the number of vessels subject to high-solids concentrations (24590-PTF-ES-ENG-17-001, *PT Facility Standard High-Solids Vessel Concept Design Alternative Study*) through streamlined process changes and piping reroutes
- Updated WTP's 24590-WTP-DB-ENG-01-001, *Basis of Design*, Rev. 8, to document revised requirements.

Specific Issue 2: Wear models do not have quantified conservatisms applied nor do they have applied safety factors to account for uncertainty in the design inputs.

Response: DOE committed to revise the wear rate calculation for WTP waste slurry systems. The revision includes additional erosion test coupon scar depth data obtained from profilometry measurements. The revision also identified design margins available to accommodate uncertainties in the input data to establish a conservative design basis wear rate model.

The WTP Project Resolution has:

- Reexamined test coupons from the M2 jet impingement testing (by surface profilometry) to reduce uncertainty of the measured wear for vessel materials of construction (24590-WTP-M0C-50-00013).
- Design margins were established for vessel and associated PJM nozzles based on materials of construction (24590-WTP-ES-ENG-17-014 and 24590-WTP-M0C-50-00020, *Localized Erosion Wear Allowances for WTP PJM Vessels*, Rev. A).
- Revised wear allowance used with other design requirements (i.e., structural load and corrosion) for end-of-life thickness of vessel and PJM nozzles.
- Additional wear resistant materials (e.g., Stellite®) were evaluated for PJM nozzles and vessel bottom heads in high localized wear area (24590-WTP-ES-ENG-17-014).
- Pretreatment and High-Level Waste Facility installed vessel thickness in both the bottom head and PJM discharge nozzle were evaluated using the revised wear allowances to determine bottom head thickness and PJM discharge nozzle margin at end-of-life. Results indicate no design modifications are required for installed vessels.

Specific Issue 3: The safety basis design curve does not bound data collected by the M2 wear testing. Consequently, the experimental testing does not validate the relationships and assumptions used to establish the design wear rates.

Response: DOE committed to perform additional work to validate the relationships and assumptions used to establish the wear rate model.

The WTP Project Resolution has:

- Developed a wear allowance equation, which no longer uses exponential relationships and assumptions. Instead, it uses the scar depth rate directly from the one-quarter scale jet M2 jet impingement testing. The design points chosen are bounding of the expected operating point of each vessel (24590-WTP-M0C-50-00020).
- Design scar depth rates used in design of all PJM vessel bottom heads and PJM discharge nozzles are dependent on vessel material and solids concentration with maximum PJM velocity of 17 m/s. Highest scar depth rate at highest solids concentration at maximum PJM nozzle velocity establishes the design basis line for bounding conditions that envelopes operations of WTP PJM high and low solids vessels (24590-WTP-M0C-50-00020).

Specific Issue 4: Process controls (which include design controls) have not been established by the WTP Project to protect key assumptions or operating parameters.

Response: DOE has committed to adjust limits on operational parameters, as required, to protect the safety basis assumptions and ensure maintenance of the material design margin. The project's initial integrity assessment plan will be updated to reflect any new in-service inspection

requirements based on the accessible locations where wear from corrosion and/or erosion are expected to be greatest.

The WTP Project Resolution has:

- Revised the process flow configuration to minimize the number of vessels subject to high-solids concentrations in the Pretreatment Facility (24590-PTF-ES-ENG-17-001).
- Identified seven locations for in-service inspection in the Pretreatment Facility within the high-level waste lag storage and feed blending system, ultrafiltration process system, and feed evaporator process systems black cell/hard to reach area piping to measure erosion and corrosion degradation during processing. The seven recommended locations are expected to provide a representative and bounding cross-section of the erosion and corrosion degradation mechanisms expected to be active. The recommended nondestructive examination locations are periodically examined through remote deployment of plug removal inspection and measurement equipment technology (24590-PTF-ES-ENG-15-013, *Pretreatment Facility Reliability and Integrity Management (RIM) Program for Black Cell (BC) Planning Areas 02, 03, and 04 with Pretreatment Optimization and Standard High Solids Vessel Design (SHSVD) Implementation*).

Conclusion:

ORP considers the erosion wear allowance concerns for WTP PJM and installed vessels by the DNFSB staff resolved by the actions outlined by DOE in the discussion of the specific issues as written above and briefed to the DNFSB staff on October 29, 2018. Erosion/Corrosion wear issues with process piping are discussed in Specific Issue 4 with inclusion of Section 18 in the WTP Basis of Design (24590-WTP-DB-ENG-01-001).

References:

24590-WTP-ES-ENG-17-014, *T5 Erosion Engineering Study for Jet Impingement Erosion in PJM Vessels*, Rev. 0

24590-WTP-M0C-50-00020, *Localized Erosion Wear Allowances for WTP PJM Vessels*, Rev. A

24590-WTP-M0C-50-00013, *Determination of DEI Test Plate Maximum Scar Depths*, Rev. 2

24590-WTP-ES-ENG-15-024, *WTP Engineering Study: Erosion/Corrosion Due to Synergy*, Rev. 1

24590-PTF-ES-ENG-17-001, *PT Facility Standard High-Solids Vessel Concept Design Alternative Study*

24590-PTF-ES-ENG-15-013, *Pretreatment Facility Reliability and Integrity Management (RIM) Program for Black Cell (BC) Planning Areas 02, 03, and 04 with Pretreatment Optimization and Standard High Solids Vessel Design (SHSVD) Implementation*

24590-WTP-DB-ENG-01-001, *Basis of Design*, Rev. 8.

The following references are provided for information only:

24590-QL-HC4-W000-00076-02-00003, *Report – Bechtel NQA-1 Erosion Testing Final Test Report*, Rev. A

24590-QL-HC4-W000-00095-02-00071, *Jet Impingement Erosion Testing for Bechtel National, Inc.: Test Report for Small Scale Testing*

24590-WTP-M0C-50-00022, *Total Corrosion Allowances for PJM and RFD Air Link Lines Supporting WTP PJM Vessels*

24590-PTF-M4C-V11T-00040, *Calculation for Pretreatment Fluid Properties for SHSVD to Support Testing*

24590-PTF-M4C-V11T-00041, *Low Solids Fluid Properties for SHSV Concept Design Alternative*

24590-WTP-M0C-50-00019, *Total Corrosion Allowances for WTP Stainless Steel and High-Alloy Piping Systems*

24590-WTP-MVC-50-00017, *PTF and Selected HLW Vessel Cyclic Datasheet Inputs, Rev. A; and 24590-HLW-MVC-RLD-00015, Vessel Cyclic Data for RLD-VSL-00002, RLD-VSL-00007, and RLD-VSL-00008*, Rev. B.