

U.S. Department of Energy Safety Design Strategy Review and Approval beyond Critical Decision 3 for the High-Level Waste Facility - 15525

Cheryl Arm *, Barry Burrow**, James Dahl ***

* DOE, Richland Operations Office

** DOE, Office of River Protection

*** Bechtel National, Inc.

ABSTRACT

The Waste Treatment and Immobilization Plant (WTP) in Hanford, Washington, is the nation's largest environmental remediation construction project. In 2012, at the WTP's High-Level Waste (HLW) Facility, the U.S. Department of Energy (DOE), Office of River Protection (ORP) restricted construction work at the Hazard Category 2 nuclear facility because of unresolved technical issues associated with the facility and of misalignment of the design and nuclear safety basis. By 2013, as additional issues were discovered, ORP limited HLW design and procurement activities.

Addressing the technical issues and the misalignment of the design basis with the Preliminary Documented Safety Analysis (PDSA) is a priority for ORP. A proposal was developed to use the concept of a safety design strategy (SDS), as documented in DOE-STD-1189-2008, *Integration of Safety into the Design Process*, as a planning mechanism to support facility design and PDSA alignment. The standard provides the processes to develop an SDS that will ensure safety is integrated into design early in the project, by the start of preliminary design. Ultimately, as design progresses, an SDS is intended to support development of the project's PDSA. However, in this unique case, the HLW Facility design and construction phase has progressed beyond Critical Decision 3 and DOE-STD-1189-2008 was issued in 2008; 6 years after ORP approved the first WTP PDSA.

In July 2013, ORP and the contractor recognized that the unresolved technical issues and design - safety basis misalignment should be addressed through a renewed look at nuclear safety requirements, and agreed that developing an SDS tailored to the criteria in DOE-STD-1189-2008 provided the best path forward to better integrate design and safety. Development of the SDS for the HLW Facility was one of many goals ORP established in a plan that describes how ORP will determine whether, and under what conditions, the contractor should be authorized to proceed with production engineering, procurement, and construction activities for the HLW Facility.

Over the next several months, the contractor developed the draft SDS, identifying design basis accidents and control strategies for those accidents. ORP monitored progress and, when appropriate, provided recommendations.

In April 2014, the contractor provided a draft SDS to ORP for initial review by an independent DOE Review Team. The Review Team was comprised of representatives from nuclear safety, criticality safety, engineering, fire protection, the Office of Environmental Management, the Assistant Manager WTP, and the DOE Chief of Nuclear Safety. A unique draft document review and interactive review process, facilitated through work sessions and continuous communication with the contractor, culminated in the development of 147 technical comments on topics varying from SDS implementation to hydrogen deflagration in vessels.

Comment resolution sought to improve project clarity, delineation of control strategies, and, holistically, facilitate integration of safety into design in the SDS, as it will guide the restart of the HLW Facility production engineering and limited procurement and construction activities. All comments were resolved in support of a contractor submission of the final SDS to ORP at the end of June 2014. Successful

resolution of these comments was achieved by continuing the real-time response and incorporation interaction with the contractor to ensure that mutual objectives were satisfied. The response times were facilitated through telephone, email, and a shared file server accessible to contractor and DOE reviewers across the DOE complex. As a measure of success of this process, the Safety Basis Approval Authority (ORP Manager) and the WTP Federal Project Director approved the SDS on August 1, 2014, with no conditions of approval.

DOE and the contractor recognized that it would be difficult to implement the SDS without changes to the existing contractor's engineering and nuclear safety processes. Accordingly, the contractor developed or revised a significant number of engineering and nuclear safety plans and procedures to implement the SDS into the design process. Over the coming year, the contractor will conduct a gap analysis between the SDS and the presently approved PDSA to incorporate the design basis accidents and preferred control strategies developed from the SDS into the PDSA. In addition, ORP will conduct an assessment of the contractor's implementation of the SDS into the design process at the appropriate stage of implementation, within 6 to 12 months of approval. Although the SDS was developed late in the HLW project timeline, the document will facilitate alignment of design and the safety basis, and is a key step in the return to full production engineering for the HLW Facility.

INTRODUCTION

The U.S. Department of Energy (DOE) is contracting with Bechtel National, Inc. (Bechtel) to design, construct, and commission the Waste Treatment and Immobilization Plant (WTP) to pretreat and vitrify high-level waste (HLW) and low-activity waste as a means of remediating the Hanford tank farm inventory. The WTP mission is to process and stabilize approximately 212 thousand cubic meters (56 million gallons) of mixed radioactive and chemical waste currently stored at the Hanford Site. The waste will be removed from 177 aging underground storage tanks, enabling follow-on remediation of these tanks. Some tanks are known or assumed to have leaked, contaminating soil and groundwater; the contamination from this and other sources is progressing toward the Columbia River. Given the magnitude of potential consequences to the nearby population and the acreage affected by the Columbia River, cleanup of these tanks is a national priority and DOE instituted a design-build paradigm for the WTP Project. The design-build approach called for construction of the facilities to begin prior to completion of the design. Construction of the WTP began in October 2001.

High-Level Waste Facility

WTP is a complex project with a construction site spanning 26 hectares (65 acres) and a facility design life of 40 years. The overall WTP scope includes designing, constructing, and operating four nuclear facilities to receive waste from the Hanford tank farms and to process and vitrify that waste. One of the facilities, the HLW Facility, will be a 46.5 thousand square meter (half million square feet) facility composed of a five-story, concrete and steel structure with melter cave areas that house the vitrification systems for production of immobilized HLW. The HLW Facility design production capacity is 7.5 metric tons of glass per day. Two identical melters immobilize concentrated HLW feed. Electrodes are used in the melters to attain nominal glass melt pool temperatures between 1,100°C and 1,200°C. Molten glass will be poured into immobilized HLW canisters as permanent packaging for disposal. The *Preliminary Documented Safety Analysis to Support Construction Authorization; HLW Facility Specific Information* to support construction authorization was initially approved by DOE in August 2002. Subsequently, there have been 38 updates and revisions to the document through July 2013.

Problem Statement

From August 2012 to March 2013, technical, design, and safety basis issues were identified with the HLW Facility heretofore under construction with design completion proceeding in parallel in accordance with the original design-build approach. At the time, the HLW Facility was approximately 89 percent design complete and 43 percent construction complete. Due to the technical, design, and safety basis issues, DOE Office of River Protection (ORP) issued direction to Bechtel that restricted HLW construction, procurement, and engineering activities. In order to resolve this situation, an approach was needed to address a partially constructed facility with a historically approved Preliminary Documented Safety Analysis (PDSA) that affects many technical issues that had arisen subsequent to that approval. The challenge is to resolve those issues in a manner that utilizes existing components and structures to the extent practical while ensuring timely completion of a facility that can be safely operated in compliance with the applicable regulatory requirements.

In July 2013, Bechtel proposed to DOE that resolution of the technical issues related to the design and construction of the HLW Facility be addressed through an update to the nuclear safety basis to ensure integration of safety into design. The path forward envisioned the development of a safety design strategy (SDS) for the HLW to facilitate this process by adapting the guidance provided by DOE-STD-1189-2008, *Integration of Safety into the Design Process*, as applicable for this unique project given its advanced stage of construction and incomplete final design.

High-Level Waste Safety Design Strategy Development

In October 2013, DOE developed a process to allow resumption of HLW Facility engineering, procurement, and the ramp up of construction. Among the requirements in the plan to support this process was a Bechtel developed and DOE approved HLW SDS document. Bechtel initiated development of the document in September 2013 and provided a draft in April 2014 for DOE review.

Application of an SDS to a project beyond Critical Decision 3 is unique and was achieved by focusing on consistency in the SDS with the following principles underlying DOE-STD-1189-2008:

- Guiding philosophies and assumptions to be used in continuing development of the project
- Safety-in-design and safety goal considerations for the project
- Approach to developing the overall safety design basis for the project
- Significant discipline interfaces impacting safety.

Bechtel initiated the HLW SDS development by selecting task teams from across operations, nuclear safety, and engineering disciplines to work on discrete sections of the document and provided training on DOE-STD-1189-2008 requirements to those personnel selected. Major tasks included compilation of design basis accidents descriptions, discussion of technical issue resolution in support of the safety basis, evaluation of historical safety basis issues, and Bechtel commitments related to the HLW Facility.

As the task teams' deliverables began to mature, a smaller core of operations, nuclear safety, and engineering personnel began to pull together the discrete sections into an integrated document. As the HLW SDS development proceeded, two safety-in-design-integration teams reviewed the products. The Safety Design Integration Team (SDIT) and the Senior Management SDIT were composed of Bechtel management level personnel with accountabilities in production engineering (design agency), plant engineering, and technical issue resolution teams (design authority). Project nuclear safety managers chaired the teams. The SDIT was made up of HLW Facility mid-level management personnel and the Senior Management SDIT was comprised of project level senior management personnel. As the document being developed neared completion, Bechtel conducted a self-assessment of the draft product against the stated objectives of the HLW SDS and its review plan.

REVIEW PROCESS

DOE developed a review plan for the HLW SDS, drawing on criteria documented in the Chief of Nuclear Safety (CNS) *Standard Review Plan, Safety Design Strategy* (DOE 2014) (written for new project SDS documents that must comply with DOE-STD-1189-2008), and established a Review Team to review draft and final HLW SDS documents. The Review Team process consisted of reviews and comments on several drafts with direct feedback to Bechtel, comment resolution and incorporation into the draft HLW SDS by Bechtel, and, ultimately, DOE review of the final HLW SDS document submitted by Bechtel to verify that agreed-upon dispositions were appropriately incorporated. The final HLW SDS, Rev. 0 was transmitted to DOE in June 2014.

The Review Team for the review and approval of the HLW SDS included representatives from the ORP Nuclear Safety Division, ORP Chief Engineer, DOE CNS, and DOE Office of Environmental Management (EM-40). Additional subject matter experts provided technical and administrative support to the Review Team, but were not assigned as primary Review Team members. Significant contributions were provided by ORP Fire Protection Engineering and the WTP Engineering Division.

The Review Team reviewed the draft HLW SDS transmitted on April 9, 2014, and associated supporting documentation including control strategy documents and Bechtel HLW SDS Support Team reports. On April 23 the Review Team met with Bechtel engineering, nuclear safety, and SDIT personnel to provide

initial feedback to Bechtel relative to questions, issues, and concerns developed during the review period. At that meeting, the Review Team provided an informal draft summary of 45 questions, concerns, and issues, and discussed several of the items in detail with Bechtel. Additional informal meetings with Bechtel were conducted to discuss and resolve questions, issues, and concerns over the next two weeks.

On May 8, 2014, a final outbrief of the draft HLW SDS document review was conducted with Bechtel. Following the outbrief, the Review Team lead provided Bechtel formal review comment record documents, reviewed and signed by the Review Team lead and the WTP Federal Project Director, containing 152 comments on the HLW SDS for Bechtel's disposition. Additional meetings were held with Bechtel to discuss resolutions over the next few weeks. Bechtel provided their initial feedback in writing on many of the issues on May 16. On May 28, Bechtel provided their formal review comment record disposition document to DOE for acceptance. Throughout the process, the Review Team lead provided weekly status reports to Review Team members, support members, and senior ORP and WTP personnel.

The Review Team evaluated the Bechtel review comment record disposition document and, after multiple iterations with Bechtel up through June 25, 2014, accepted all proposed dispositions for the draft document. All of the dispositions were satisfactorily incorporated into Rev. 0 of the HLW SDS, received by ORP on June 25, 2014, with one exception to be incorporated upon the initial revision to the HLW SDS.

Review of the HLW SDS draft and final documents focused on the suitability of the document to fulfill its purpose as defined in the HLW SDS, which is to "guide future hazard analyses, design activities, and technical issue resolutions, culminating in a revised preliminary documented safety analysis (PDSA) to be submitted for approval." This includes the plans and procedures to guide the restart of design and construction by addressing philosophies and assumptions to be used in resolution of outstanding technical issues and complete the design for HLW, the requirements and criteria that will govern preparation and approval of the final project documented safety analysis, and the strategy for involving ORP in the design completion process. The HLW SDS is intended to ensure an efficient process that yields an integration of design and safety bases, approvable PDSA updates, an approvable PDSA revision, and, ultimately, an approvable HLW documented safety analysis.

The HLW SDS is not a safety basis document and approval action does not require a DOE safety evaluation report. Subsequent PDSA updates and a revision will be subject to the safety basis approval process. Hence, the purpose of the review process was to document the DOE basis for approving the HLW SDS and, if appropriate, to recommend approval.

As previously discussed, reviews of the draft HLW SDS document and, subsequently, of the final document were conducted following the guidance provided by the CNS Standard Review Plan (DOE 2014) as implemented by the Review Plan for the HLW SDS document. In accordance with the CNS Standard Review Plan, the HLW SDS must be approved by the Safety Basis Approval Authority (ORP Manager) and the WTP Federal Project Director, following concurrence of EM-40 and the CNS. The CNS Standard Review Plan also specifies that the approval basis may be in the form of a letter formally transmitted to the contractor, which is the process followed by the Review Team. In accordance with the CNS Standard Review Plan, the DOE lead reviewer shall ensure that the formal correspondence package addresses whether the following elements have been met:

- HLW SDS is prepared by the design contractor's SDIT

- HLW SDS format and content are consistent with DOE-STD-1189-2008, Appendix E, “Safety Design Strategy”
- HLW SDS is submitted to DOE prior to official submission of a facility’s conceptual design documents
- EM-40 and the CNS have concurred.

Each of the four elements were met with the exception of the third bullet above concerning HLW SDS submission to DOE prior to official submission of a facility’s conceptual design documents. Given the present status of the HLW design and construction, this requirement cannot be met for those portions of the HLW design that have progressed beyond conceptual design or are constructed provided they are aligned with the HLW SDS (those that are inconsistent are, in effect, returned to the conceptual design stage). However, this requirement was met for conceptual, preliminary, and final design of new safety strategies (i.e., those not in the current design) that are to be implemented as recommended in the HLW SDS.

APPROVAL BASES

This section addresses the basis for approving the HLW SDS. It relied on meeting the HLW SDS content guidance from DOE-STD-1189-2008, the performance objectives and criteria (PO&C) from the CNS Standard Review Plan (DOE 2014) and, as previously discussed, satisfactory resolution of Review Team comments.

DOE-STD-1189-2008, *Safety Design Strategy Content Expectations*

The HLW SDS follows the suggested format of major section headings from DOE-STD-1189-2008, Appendix E, and includes more detailed information than might be expected of an initial HLW SDS document in subsections on hazard and accident analyses due to the advanced developmental status of the HLW Facility design relative to the conceptual design as addressed in Appendix E. The HLW SDS addresses the content topics that are important to the HLW Facility safety strategy given its present design status. For example, anticipated safety functions of safety class and safety-significant structures, systems, and components are summarized to clearly define those safety functions to prevent or mitigate accidents, and expected functional requirements as well as, to a lesser degree, performance criteria, have been defined.

Although the format and content guidance contained in DOE-STD-1189-2008, Appendix E, were used by Bechtel in the development of the HLW SDS, the standard is not directly applicable to HLW, as the WTP Contract between DOE and Bechtel does not include DOE-STD-1189-2008 as a requirement, nor is it adopted relative to providing implementation guidance in support of other regulatory (e.g., 10 CFR 830, “Nuclear Safety Management,” Subpart B, “Safety Basis Requirements”) or contractual requirements (e.g., DOE O 420.1C, *Facility Safety* or DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*). The HLW SDS summarized the previous DOE determination in Section 3.1 of the document, “Safety Guidance and Requirements,” as follows:

DOE determined that WTP does not need to meet the requirements of DOE STD 1189-2008 because the project was well into construction at the time the standard was issued in 2008. However, DOE O 413.3B still requires integration of safety into the design. As such, the DOE-STD-1189-2008 was used for the SDS format and content, as well as guidance where it made reasonable sense to apply.

High-Level Waste Safety Design Strategy Review Performance Objectives and Criteria

The Review Plan requires that the Review Team ensure that established PO&C, developed from Appendix A of the CNS Standard Review Plan (DOE 2014), are addressed and have been met in the HLW SDS. Bechtel personnel and the Review Team assessed the HLW SDS against the PO&C review criteria concurrently but independently, and the Bechtel self-assessment incorporated opportunities for improvement in the HLW SDS development process.

The information contained in or referenced by the draft HLW SDS was evaluated against each of the review criteria, and the results were verified upon receipt of the final HLW SDS document. For each individual review criterion, a summary is provided in that section of the report to document how that criterion has been met. Review of the HLW SDS indicated that all applicable PO&Cs were met, although, in a few cases, compliance is achieved in a manner consistent with the unique project status and contractual requirements.

The PO&Cs were developed to evaluate the content of project HLW SDS documents complex wide against the implementation guidance found in DOE-STD-1189-2008. Although the format and content guidance contained in DOE-STD-1189-2008, Appendix E, was used by Bechtel in the development of the HLW SDS, the standard is not directly applicable to HLW, as discussed earlier. The results of the Review Team assessment were documented in the Review Report.

LESSONS LEARNED

Due to the interactive nature of the review and approval process developed between DOE and Bechtel, the process resulted in opportunities to identify areas of improvement. The application of the wealth of knowledge and experience gained will benefit the development of an SDS for the Pretreatment Facility at WTP, and the review and approval process described in this paper may benefit the development of future SDS documents throughout the DOE complex.

High-Level Waste Safety Design Strategy Development

During HLW SDS development, use of multi-disciplined teams to work on the SDS collaboratively was a positive approach. However, that approach, to use multiple personnel on discreet task teams, was labor intensive and, from a scheduling perspective, was not efficient. On the future SDS effort for the Pretreatment Facility, Bechtel will use a small core team drawing on subject matter experts as needed and involving the management safety in design integration teams earlier in the process, as previously discussed in this paper.

The modular nature of the HLW SDS development and tiered management review yielded process benefits, efficiencies, and inefficiencies. The teaming approach fostered collaborative problem solving and broke down traditional stove-pipe functional roles. However, the SDITs did not involve themselves early enough in the process to share common expectations across the task teams. This led to disjointed deliverables from the task teams and rework to craft a final product that met Bechtel management and DOE expectations.

Although development of the HLW SDS took longer than originally anticipated, the benefit the document is providing to the project in linking the design and safety bases to support continuation of construction of the HLW Facility is of significant value in meeting the mission to process and stabilize the Hanford tank waste.

High-Level Waste Safety Design Strategy Review and Approval Process

As a measure of the success of the process outlined in this paper, the Safety Basis Approval Authority (ORP Manager) and the WTP Federal Project Director approved the HLW SDS on August 1, 2014, with no

conditions of approval. This success hinged on strong communication and integrative tools presented below:

1. Integration of ORP nuclear safety, engineering, and fire protection in addition to the approval authorities, CNS and EM-40, from conception of the Review Plan, throughout the review process and into final approval fostered a common understanding and objective. This led to expedited knowledge of challenges identified and their resolution.
2. A unique draft document review and interactive review process, facilitated through work sessions and continuous communication with the contractor, culminated in the development and resolution of 147 technical comments on topics varying from SDS implementation to hydrogen deflagration in vessels in less than 2 months. The interactive review process was facilitated by real-time response with comment incorporation and interaction with the contractor to ensure that mutual objectives were satisfied. The real-time response times were facilitated through telephone, email, and a shared file server accessible to contractor and DOE reviewers across the DOE complex.
3. Comment resolution sought to improve project clarity, delineation of control strategies, and, holistically, facilitate integration of safety into design in the HLW SDS through mutual respect and responsiveness. As a result, all comments were resolved in support of a contractor submission of the final HLW SDS that expedited the ORP approval process.
4. Important issues requiring a consensus for resolution between the HLW SDS development and the DOE review teams were, when appropriate, elevated to the proper level of DOE and Bechtel management in a timely manner for real-time discussion, with feedback to the team. Bechtel and DOE personnel at the working level were not burdened with solving all issues at their level, and escalating the discussion to management was not seen as a negative by Bechtel or DOE.
5. Review of the HLW SDS draft and final documents success was achieved by clearly defined criteria focusing on the suitability of the document to fulfill its purpose as defined in the HLW SDS, which is to “guide future hazard analyses, design activities, and technical issue resolutions, culminating in a revised preliminary documented safety analysis (PDSA) to be submitted for approval.”
6. The determination as to what will constitute the approval process and how the HLW SDS would be utilized in this application was restricted to the HLW SDS not being a safety basis document and approval not requiring a DOE safety evaluation report. Subsequent PDSA updates and a revision to the PDSA will be subject to the safety basis approval process. This understanding facilitated the resolution for implementation issues identified early in the review process.
7. With some Review Team personnel not experienced in the SDS approval process, especially in this unique application to align the design and safety bases, the CNS Standard Review Plan (DOE 2014) provided the guidance necessary to develop and implement the HLW SDS Review Plan.

CONCLUSION

The ORP Review Team determined that the HLW SDS, in conjunction with Bechtel implementation plans and procedures, is adequate and suitable to guide the restart of limited engineering, procurement, and design of the HLW Facility. The HLW SDS will support:

- Alignment of the design and safety bases
- Resumption of limited engineering, procurement, and construction
- Updates and ultimately a revision of the HLW PDSA.

Development of the HLW SDS has successfully achieved the significant benefit for Bechtel of gaining coordination and agreement among engineering, operations, and nuclear safety personnel with respect to a documented HLW SDS, which will support the design process and identifies a preferred control set of safety class and safety-significant structures, systems, and components. The iterative comment resolution process between the Review Team and the Bechtel SDITs, as well as between senior ORP and Bechtel management, for resolutions of issues helped to achieve general agreement and understanding among all parties. Successful utilization of the HLW SDS to complete the HLW design will require strict adherence to supporting plans and procedures as well as care and planning by Bechtel to coordinate the resolution of the remaining conceptual design issues with other parallel efforts, including procurement and construction of released systems, to finalize the design.

To ensure that Bechtel effectively executes the HLW SDS process to align design and safety bases in strict adherence to approved implementation plans and procedures, the Review Team recommended that the WTP Federal Project Director initiate an independent assessment to review the HLW SDS implementation process at an appropriate stage of implementation.

The Review Team recommended that the *Safety Design Strategy for the High-Level Waste Facility* be approved with no conditions of approval cited.

REFERENCES

1. 10 CFR 830, "Nuclear Safety Management," Subpart B, "Safety Basis Requirements," *Code of Federal Regulations*, as amended.
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3. 24590-WTP-PSAR-ESH-01-002-04, 2013, *Preliminary Documented Safety Analysis to Support Construction Authorization; HLW Facility Specific Information*, Rev. 5, Bechtel National Inc., Richland, Washington, July.
4. Contract No. DE-AC27-01RV14136, *Design, Construction, and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant*, U.S. Department of Energy, Washington, D.C., as amended.
5. DOE 2014, *Standard Review Plan, Safety Design Strategy*, U.S. Department of Energy, Office of Environmental Management, Chief of Nuclear Safety, Washington, D.C., April.
6. DOE O 413.3B, 2010, *Program and Project Management for the Acquisition of Capital Assets*, Office of Management, Budget and Evaluation, U.S. Department of Energy, Washington, D.C., November 29.
7. DOE O 420.1C, 2012, *Facility Safety*, U.S. Department of Energy, Washington, D.C., December 4.
8. DOE-STD-1189-2008, 2008, *Integration of Safety into the Design Process*, U.S. Department of Energy, Washington, D.C., March.