CONSERVATISM REDUCTION, A WIN-WIN SAFETY AND OPERATING STRATEGY FOR REDUCING AUTHORIZATION BASIS COST OF DISPOSAL FOR THE OFFICE OF RIVER PROTECTION AT HANFORD

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ABSTRACT

The Office of River Protection is reassessing overconservatism of the Hanford Site River Protection Project (RPP) tank farms Authorization Basis. Reassessment of overconservatism in Final Safety Analysis Report (FSAR) accident analyses and associated controls is currently underway in the following areas:

a. Major accident scenarios of historic concern;
b. Additional accident analysis bases and scenarios having broad potential impacts on operations;
c. Elimination of unnecessary overconservative safety-class and safety-significant structures, systems and components (SSC); and
d. Removal of costly and unnecessary constraints on operations.

The analyses are focused on incorporating the recent waste characterization knowledge, reevaluation of experience at Hanford and other U.S. Department of Energy (DOE) operating sites, and information obtained associated with the resolution of priority one safety issues. These efforts also provide a foundation for more efficient retrieval of the waste for disposal. The reduction of institutionally entrenched overconservatisms by implementing a more realistic data and experience oriented hazards and accident analysis, and propagating that information into operating practice, will enable the site to more cost effectively meet the challenge of waste disposal without compromising real safety.

INTRODUCTION

A general analysis of unreasonable conservatisms associated with the operations at the Hanford Site was recently made by Bishop (1). Bishop states

> . . . while accident analyses must be conservative, invoking excessive conservatisms does not provide additional margins of safety. Rather, beyond a fairly narrow point, conservatisms skew a facilities true safety envelope by exaggerating risks and creating unreasonable bounds on what is required for safety. The conservatism has itself become unreasonable.

As part of a systematic assessment of the Authorization Basis (AB) conservatisms, the Office of River Protection (ORP) is evaluating existing conservatisms by comparison to the following:

a. Accepted and documented practice at other U.S. Department of Energy (DOE) operating sites;
b. Industry standards;
c. Engineering assessment;
d. Actual operating experience; and/or
e. Overall reasonableness.

BACKGROUND

Recent progress in the definition of an integrated safety basis and completion of a Final Safety Analysis Report (FSAR) (2) for operation of the River Protection Project (RPP) waste tank associated programs has provided ORP an opportunity to reevaluate the historically necessary conservative operating basis for the Hanford tank farms and associated facilities. Completion of (a) an almost 10-year long process to obtain detailed characterization of the waste stored in double- and single-shell tanks at Hanford, and (b) gaining an understanding of the waste chemistry and physics associated with priority one safety issues and resolving these issues support the establishment of the protective safety basis for these waste storage facilities. The recent work has verified from the historical record (based on ca 8000 tank years of operation experience) that none of the high consequence significant accident scenarios identified as "anticipated" in the safety analysis done to date have occurred.

Historically, however, a combination of circumstances designed to be protective of both onsite workers, the public, and the environment has led to overly conservative and costly constraints of tank farm operations. These constraints were the result of the DOE's need to maintain safety of Hanford tank farm operations when there were large shortfalls in tank waste characterization data, especially waste energetics and safety system responses to potential accident scenarios. This led to the use of a bounding basis, as opposed to best engineering estimate basis for tank farm operation, as expressed in the Basis for Interim Operation (BIO) (3) under which the tank farms operated until FY 2000. Such conservatism, as is clearly identified in the Safety Evaluation Report (SER) (4) for the FSAR, is also propagated in the present AB as part of risk evaluation guidelines that were in effect one order of magnitude more restrictive than that used at other Hanford facilities and other DOE sites.

Other conservatisms identified include the use in defining AB of unrealistic and over generalized accident frequencies, unrepresentative unit-liter-dose source terms, and unrealistic, oversimplified airborne release analysis and their propagation into the daily tank farm operating routine.

DISCUSSION

The current AB-based restrictions on performing work results in increased costs and schedule delays. In many instances this has resulted from overconservatisms built into safety and operations systems. A change in philosophy from using bounding estimates to the use of data-supported best engineering evaluations appears to have the potential to significantly decrease the resultant costs and improve schedules in this era of demanding consent decree schedules and flat disposal budgets. The ORP Technical Support Division with support of other ORP divisions has implemented an aggressive program of reevaluating AB-based conservatism.

Work is currently underway in reassessing FSAR accidents and associated structures, systems, and components (SSC) and controls in the following areas:

a. Major accident scenarios of historic concern;
b. Additional accident analysis bases and scenarios having broad potential impacts on operations;
c. Elimination of unnecessary safety class and safety significant SSC; and
d. Removal of costly and unnecessary constraints on operations.

Coincidentally, it is recognized by DOE-Headquarters (HQ) and various oversight committees that the Hanford Site, particularly the management of the tank farms, has made great strides in increasing the safety in performing work. New improvement measures that are being defined and reported at the Waste Management 2000 (WM2K) Conference shall not compromise those accomplishments. The key to this success is that realistic analyses based on prior operating history does not result in increased operational risk for RPP operations from the changes proposed by ORP.

The reader should note that in the examples that follow there is an overlap between reanalysis to limit the need for safety-related SSC and Technical Safety Requirements (TSRs) controls (5) and the broader need for reanalysis of accidents on a best engineering basis that affects many systems or structures.

CURRENT ORP INITIATIVES

A wide variety of SSC for the Hanford tank farm facilities has been historically designated as either safety class or safety significant. Such designation requires, among other things, redundancy in control-associated instrumentation, higher quality standards for the equipment, and more extensive and costly instrument maintenance and calibration than is the industry standard. In addition, to provide these standards for new construction was much more costly as well.

Although ORP accepted the FSAR, numerous instances were identified in which the accident analysis was overly conservative as a result of not taking into account actual tank operating data and experience. This resulted in a prioritized effort to reevaluate the most important of the accident scenarios with the anticipation that a best basis analysis would lead to either reduction

in required controls, safety affecting SSC, or both, without a sacrifice of actual operating safety. Items of concern are listed in Table I.

Table I. Waste Tank Accidents Requiring Reanalysis.

Major Accidents of Historic Concern	**Additional Accident Analysis Bases and Scenarios Having Broad Potential Impacts on Operations**
1. Organic solvent fire accidents	6. Radiological and toxicological source terms
2. Flammable gas accidents	7. Waste tanks
3. Organic salt-nitrate Interaction accidents	8. Aging waste transfer controls
4. Natural phenomena seismic accidents (primarily associated with flammable gas scenarios)	9. Continuous air monitor (CAM) system
5. Spray and pool leaks	10. Electrical distribution system.
	11. Temperature controls associated with FSAR tank bump accident

MAJOR ACCIDENT SCENARIOS OF HISTORIC CONCERN

Priority One Safety Issues Associated Analysis

The requirement for safety-class SSC for many of the accident items in Table I resulted from the early 1990s priority one tank farm safety issues (items 1-4) associated with interim safe storage of high-level waste (HLW) in waste tanks at Hanford. The root cause for the concerns about organic solvent fire accidents (item 1) and organic salt-nitrate interaction accidents (item 2) were eliminated. A combination of applied R&D and detailed measurements on real wastes indicate that neither of these major accident scenarios is possible in Hanford HLW tanks under present storage conditions. Our knowledge of flammable gas generations storage and release (items 3 and 4) has provided a more realistic assessment of this risk, which is in the realm of natural phenomena associated with seismically induced accidents. As a result, the requirement for costly safety-class equipment on tanks associated with this risk was removed and the tank farms will be able to purchase, install, use, and maintain industry standard equipment to maintain control of tank farm operations associated with these phenomena.

In addition, the operating contractor was directed to reevaluate FSAR flammable gas accidents and associated natural phenomena—seismic accidents with historical, industrial failure modes

and plausible accident progression and system responses. This would lead to a reassessment of existing controls including flammable gas SSC (safety class and safety significant) on the basis of this accident reevaluation. The contractor will submit the reevaluated accident analyses and control strategy, including the appropriate flammable gas associated AB amendment request, for ORP approval

FSAR Spray Leak in Structure or From Waste Transfer Lines and Surface Leak Resulting in Pool Leaks (Item 5, Table I)

The variety of spray and pool leak accidents and the treatment of source terms are the two items that account for the identification, even with controls, of the most onerous safety associated SSC and TSR controls. The recently adopted FSAR identifies the above-grade portions of the waste transfer structures (such as portions of process pits, diversion boxes, valve pits, and cleanout boxes) as safety SSC. These structures are credited with maintaining the physical integrity of waste structures, containing waste leaks, and limiting the aerosol release from the structure. The FSAR classifies these structures as safety class for a variety of accident analyses including the following as safety significant:

a. Spray leak in structure or from waste transfer lines; and
b. Surface leak resulting in pool leaks.

The previously approved BIO, which predated the FSAR, does not explicitly identify these waste transfer structures as safety SSC. Subject to further analysis, ORP has accepted the operational risk of not classifying the above-grade operations of waste transfer structures as safety SSC in the current AB until accident reanalysis is completed.

In addition, ORP has noted that existing analyses using bounding release scenarios in the BIO and FSAR are significantly more conservative than that used at other sites [e.g., Savannah River Site (SRS) for comparable accidents]. This led to a directive to reevaluate the FSAR spray leak in structures or from waste transfer lines, and surface leaks resulting in pool accidents. The reanalysis requires that the operating contractor more rigorously assess historical, industrial failure modes and plausible accident progression and system responses, with special attention to actual leak accidents at both Hanford and other DOE operating sites. The operating contractor is being asked to reevaluate existing controls, including SSC, reevaluate the relevant accident analyses, and to submit reevaluated accident analyses and control strategy.

ADDITIONAL ACCIDENT ANALYSIS BASES AND SCENARIOS WITH BROAD POTENTIAL IMPACTS ON OPERATIONS

Update Radiological and Toxicological Source Term Analyses

Super tanks profiles used in the FSAR/BIO include unit-liter doses for the following:

a. Single-shell tank (SST) liquids, (wet) SST solids;
b. Double-shell tank (DST) liquids, (wet) DST solids;

c. Aging waste facility (AWF) liquids, (wet) AWF solids;

d. All liquids; and

e. All (wet) solids.

The profiles are based on bounding (worst case) and sparse characterization data that existed at the time of the development of these source terms. Because tanks grouped in these categories have widely differing inventories, it is unlikely that any given tank contains a combination of the highest concentration of the radionuclide or hazardous materials of concern. Thus the present source term used in accident analysis is based on the concepts of using a unit-liter dose application of the "super tank" concept to source term evaluations. That concept leads to what appears to be over an order of magnitude conservatism in the evaluation of risk consequences from waste release scenarios. The result is the definition of more extensive control requirements than would otherwise be necessary, encumbering operational efficiencies as well as adding cost.

The operating contractor is completing an analysis that updates radiological and toxicological source term documents to reflect plausible best known tank inventory as of November 30, 1999. ORP has directed reanalysis using these more plausible values to recalculate source term unit-liter dose and sum of fraction and reassess consequent source term tank groupings on accident source terms in the FSAR.

Waste Tank Classification as Safety Class/Safety Significant SSC (Item 7, Table I).

The FSAR identifies the waste tanks as safety SSC. Waste tanks are credited to maintain gross structural integrity and prevent waste release due to overpressurization. The FSAR classifies these structures as safety class or safety significant for accidents associated with the items listed in Table I. The BIO on which the tank farms was operating over the last 5 years and TSRs, however, identify the waste tanks as passive design features. The safety function of the waste tanks is to confine waste and limit the release of waste during and after a design basis accident. The safety classification assigned to tanks must be consistent with their safety function. ORP has directed the contractor to provide ORP with a licensing strategy and/or AB amendment for appropriate safety classification of the waste tanks.

Aging Waste Transfer Control (Item 7, Table I)

Several Hanford tanks contain wastes most recently transferred from the Hanford Plutonium-Uranium Extraction (PUREX) plant prior to its shutdown. These are the most highly radioactive wastes in the tank farms because they (a) have had the shortest time to cool due to radioactive decay and (b) still contain a significant portion of the most heat producing radionuclides. The FSAR credits a restriction on transfer of aging waste solids and liquids to AWF transfer-associated structures only to mitigate the consequence of the spray leak accident. The contractor has been directed to reassess excessively conservative assumptions in the spray leak in structure or from waste transfer lines accident analysis and provide ORP with a licensing strategy and/or Authorization Basis amendment for the FSAR.

Continuous Air Monitor (CAM) System Upgrades

The CAM system upgrades are required by the FSAR to include an interlock to shut down the ventilation exhaust system on CAM failure. The current AB (BIO and TSRs) relies on manual shutdown of ventilation systems on CAM failure and subsequent alarm. The current FSAR-based analysis increase in control does not seem warranted by either an evaluation of past occurrences at Hanford or accepted practice at other DOE sites. A reanalysis of this accident scenario by the operating contractor has been requested by ORP.

Electrical Distribution System Upgrade to Safety-Class SSC

The FSAR identifies the tank farm electrical distribution system as a safety class supporting SSC for several accidents because certain safety-class and safety-significant SSC (such as the tank ventilation system) are electrically powered. The BIO, however, did not explicitly identify the tank farm electrical distribution system as a safety-class or safety-significant SSC.

The DOE Standard 3009-94, "Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports," (6) requires selection of SSC as safety related whose failure could result in a safety-class or safety-significant SSC not performing their safety function. However, the pedigree assigned to these sub-tier systems is expected to be necessary and sufficient to support the primary SSC safety function. DOE Standard 3009-94 and DOE Order 5480.23, "Nuclear Safety Analysis Reports," (7) allow use of discretion and judgment as appropriate in selection and credit of safety features.

The time required to reestablish the safety function of each critical SSC is dependent on the electrical distribution system as required by the associated accident analyses, resulting TSR controls, and their respective Limiting Condition for Operation (LCO) bases. However, the current FSAR analysis indicates that there is a considerable time buffer (days to months) before conditions of the tank approach TSR limits. Because power failure would shut down all discretionary activities, the likelihood of an event is very low. It is not directly related to the safety category of the electrical transmission system. The failure of the electrical systems causes no new accident pathway or need for controls that has not already been analyzed and is a part of the existing safety basis. The affected systems are identified in Table II, which contains a discussion of the protective controls associated with each system and subsystem affected by an electrical outage.

Based on the information discussed in Table II, none of the safety SSC requires continuous electrical power to maintain their safety function. TSR controls identify adequate actions to safely shut down ongoing operations and activities to preclude accident conditions. Meanwhile, a reanalysis of the safety aspects of the electrical distribution system by the operating contractor has been requested.

Table II. Critical Safety-Related Systems Effected by an Electrical System Outage

System	Subsystem	Discussion
Ventilation	DST and SST active ventilation	The DST and SST active ventilation systems are required for flammable gas accident control. The worst-case scenario identified in the TSR bases for buildup of flammable gases to reach 25% of the lower flammability limit (LFL) in DSTs is 7 days for the DSTs and 24 days for SSTs. The LCO controls associated with these systems direct shutdown of transfers to the affected tank(s), restoration of the system, and periodic monitoring for flammable gases to preclude accident conditions.
	Double-contained receiver tanks (DCRTs) and 244-AR Tank-002 ventilation	The DCRT and 244-AR Tank-002 ventilation system is required for flammable gas accident control. These ventilation systems are required during waste transfer or when these facilities contain waste. The LCO controls associated with these systems direct shutting down transfers to the affected tank(s), restoration of the system, and periodic monitoring for flammable gases to preclude accident conditions.
Leak detection	Transfer leak detection	The transfer leak detection system is required to control transfer leak accidents. The leak detection capability is required only during transfer operations and activities. The LCO control associated with this system directs shutdown of discretionary activities and operations on loss of system operability to preclude accident conditions.
	Primary tank leak detection	The safety function of the primary tank leak detection system is to alarm if there is a misrouting of waste into the DST tank annulus to prevent a flammable gas accident and to prevent a surface leak resulting in pool accident. The LCO controls associated with this system direct shutdown of discretionary activities and operations on loss of system operability to preclude accident conditions

Table II. Critical Safety-Related Systems Effected by an Electrical System Outage (Continued)

System	Subsystem	Discussion
Leak detection (continued)	Pressure switch interlocks or alarms	The safety function of the pressure switch interlock or alarm system is to limit the volume of tank waste that could backflow into and leak from the service water piping system. The system detection capability is required only during transfer operations and activities. The LCO controls associated with this system direct shutdown of discretionary activities and operations on loss of system operability to preclude accident conditions.
Stack ventilation CAM	Stack ventilation CAM	The stack ventilation CAM system is safety class for a spray leak in structure accident analysis. The LCO controls associated with this system direct shutdown of discretionary activities and operations on loss of system operability to preclude accident conditions.
Temperature monitoring	Temperature monitoring	The temperature monitoring system is primarily required to mitigate the organic complexant and organic-salt-nitrate accident. The temperature monitoring frequency established in the TSRs is 10 days. An amendment currently in the formal approval process will revise the requirements in the AB to eliminate this requirement. The amendment provides the technical basis showing that this accident was analyzed over conservatively in the FSAR accident analysis.

REMOVAL OF COSTLY AND UNNECESSARY CONSTRAINTS ON OPERATIONS

A variety of controls presently in place are derived from assumption or conservatism made in accident analyses. A number of these critical for meeting either safe storage or disposal initiatives is being reevaluated in terms of accepted practices at other DOE sites and known conservatisms in the present AB or its underlying calculational notes or other basis documents (see Table III).

Portable Exhauster Use Requirement During Salt Well Pumping

Using information and data gained during previous operations, reevaluate the requirements for the use of portable exhausters during saltwell pumping based on existing flammable gas hazards. Based on this reevaluation, submit an AB amendment and/or licensing strategy for appropriate use of portable exhausters for the saltwell pumping activity.

Continuous Flammable Gas Monitoring During Saltwell Pumping

Using information and data gained during previous saltwell pumping operations, reevaluate the requirements for the continuous flammable gas monitoring during saltwell pumping operations based on existing flammable gas hazards. Based on this reevaluation, submit an AB amendment and/or licensing strategy for flammable gas monitoring for the saltwell pumping activity.

Table III. Operations Appearing to be Unnecessarily Constrained by Conservatisms (and their interpretation) in Safety Analysis.

Operation	Safety System
Salt well pumping	Portable exhauster use and availability requirement
	Requirement for continuous flammable gas monitoring
All intrusive operations in suspected flammable gas tanks	Restrictive lightning associated controls
All tank farm operational modes	Minimum staffing requirements for health physics technicians (HPTs).
All waste transfer operations	Restriction of the use of double-valve isolation mechanisms

Lightning Associated Controls

Using information and data gained during previous operations, reevaluate the requirements for the current set of controls associated with lightning in the area. Based on this reevaluation, submit an AB amendment and/or licensing strategy for appropriate lightning controls.

Minimum Staffing Requirement for Health Physics Technicians (HPTs)

The current AB requires that the minimum HPT staffing per shift complement be two for all operational modes. The FSAR identifies a requirement of a minimum of three HPTs to meet abnormal conditions. The operating contractor was directed by ORP to continue maintaining the minimum staffing requirements for HPTs at two per shift until a reanalysis of the FSAR analysis is complete.

Use of Double-Valve Isolation Mechanisms

Unlike the Idaho National Engineering and Environmental Laboratory (INEEL) and/or the SRS, Hanford procedures do not allow operations staff to take credit for use of double valves to isolate systems during maintenance activities. Based on spray leak and pool analyses, Hanford

procedures require physical separation of the transfer systems from the waste sources during maintenance or construction. The operating contractor was tasked to develop criteria and identify conditions under which double-valve isolation mechanisms can be used for ensuring that tank farm piping systems are physically disconnected when required by the FSAR controls. ORP expects this analysis to result in an AB amendment to modify applicable TSRs to allow use of double-valve isolation as an option to the current TSR requirement of "physically connected" as identified in the Hanford tank farm TSRs document.

CONCLUSIONS

The paper has presented the direction of an ongoing comprehensive ORP staff and expert analysis of the current RPP AB, as well as the derived operations and management conservatisms that exert an undue influence on operating the RPP cost and schedule. Such conservatism provides only a very limited degree, if any, of worker and public protection. The premise underlying the ORP approach to reducing selective conservatisms is that the proposed changes, subject to confirmation by formal best engineering judgement based accident analysis, not only maintains appropriate worker protection but focuses ORP and contractor management attention on more effectively dealing with frequent and low consequence accidents that are part of the normal operating environment of any chemical process facility.

When the combination of recent waste characterization knowledge and safety issue resolution is incorporated into the FSAR, that also provides a foundation for retrieval of the waste for disposal. The reduction of entrenched conservatisms by implementing a more data and experience oriented hazards and accident analysis and propagating that information into operating practice, as described in the examples above, will enable the site to more cost effectively meet the challenge of waste disposal without compromising real safety.

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