U.S. Department of Energy
Office of River Protection
P.O. Box 450, MSIN H6-60
Richland, Washington 99352

04-WED-063

NOV 22 2004

Mr. J. P. Henschel, Project Director
Bechtel National, Inc.
2435 Stevens Center
Richland, Washington 99352

Dear Mr. Henschel:

CONTRACT NO. DE-AC27-01RV14136 – TRANSMITTAL OF U.S. DEPARTMENT OF ENERGY (DOE), OFFICE OF RIVER PROTECTION (ORP) DESIGN OVERSIGHT REPORT ON HYDROGEN MITIGATION AND CONTROL SYSTEMS, D-04-DESIGN-007

Reference: BNI letter from J. P. Henschel to R. J. Schepens, ORP, "Information on Managing Feeds that Could Generate Large Amounts of Hydrogen," CCN: 099805, dated October 1, 2004.

DOE ORP has conducted a technical design oversight to understand and evaluate the Waste Treatment Plant (WTP) Contractor's technical approach, and results, for mitigation of hydrogen (H_2) generated from the processing of tank wastes. This letter transmits the subject Oversight Report which documents the conclusions, recommendations and open items that were identified during the conduct of this oversight.

The Oversight Team has concluded the following based upon the review of the project information, and discussions with Bechtel National, Inc. (BNI) project staff:

- The June 2004 Hydrogen Generation Rate (HGR) and Time to Lower Flammability Limit (LFL) calculations use assumptions that appear to overestimate the HGR. The Oversight Team believes that when the calculations are revised with appropriate assumptions, that the proposed operational restrictions (Reference) on specific tank waste compositions will be reduced or eliminated;

- BNI has acknowledged that a strong basis for the current time period of concern for H_2 generation and response, following a Design Basis Event, does not exist and is pursuing a reduced time period of concern. The results of these efforts should result in a WTP facility that has better balance between process safety and the projected facility capital and operating costs compared to the current situation in which the time period of concern is 3000 hours; and

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- ORP has identified, and BNI has confirmed, issues associated with the accumulation of H_2 in process piping, cooling jackets, small vessels and process ventilation dead zones. The potential outcome of these assessments may place additional operational restrictions, or require design changes, to the process piping systems. Thus, ORP will continue to monitor the outcome of these issues.

Based upon the results of this Oversight, the Oversight Team makes the following three recommendations:

1. Complete a short term evaluation to determine the impact of the primary technical assumptions on the results of the HGR and Time to LFL calculations, and to establish the current design margins. The final assumptions to be used in the HGR and Time to LFL calculations should be established based upon this evaluation. This evaluation should include assumptions on radioactive decay date, composition of the waste feeds, ratio of solids to liquids, and organic content of the process streams that currently exist in the calculations. The analysis should also assume that WTP will process the Cs/Sr capsules prior to 2028 consistent with design considerations including shielding, heat generation, and unit liter dose;

2. Complete the final set of HGR and Time to LFL calculations that defines the waste feed basis, and uses assumptions identified in Recommendation 1. These calculations need to be expedited to ensure that the design and safety basis are brought into alignment; and

3. Use the portable H_2 monitoring system, planned for implementation in the WTP facilities, as a tool to demonstrate the conservatism of the HGR calculations and the H_2 control design features during Hot Commissioning.

The Recommendations and Open Items identified in this Oversight Report are presented in Table 5. These Recommendations and Open Items, as well as draft versions of the Oversight Report, have been reviewed and discussed with your staff, who have acknowledged these issues.

BNI should formally notify ORP of the plan and schedule for closure of the Recommendations and Open Items. These Recommendations and Open Items should be entered into the BNI Recommendation and Issue Report Tracking System.

NOV 22 2004

If you have any questions, please contact me, or your staff may call William F. Hamel, Jr., Director, WTP Engineering Division, (509) 373-1569.

Sincerely,

Roy J. Schepens
Manager

WED:WFH

Attachment

cc w/attach:
G. Duncan, BNI
A. D. Edmondson, BNI
S. Lynch, BNI
R. J. Tosetti, BNI
I. G. Tsang, BNI
L. K. Holton, PNNL

Attachment
04-WED-063

Waste Treatment Plant Hydrogen Mitigation and Control Systems

WED:DHA
October 14, 2004

U.S. Department of Energy, Office of River Protection

Waste Treatment Plant
Hydrogen Mitigation and Control Systems

D-04-DESIGN-007

October 2004

Concurrence:

William F. Hamel, Director
WTP Engineering Division
Office of River Protection

Approved:

John R. Eschenberg, Project Manager
Waste Treatment Plant
Office of River Protection

Office of River Protection
Richland, Washington

Waste Treatment Plant
Hydrogen Mitigation and Control Systems

Prepared By:

Team Lead: 10/14/04
Don Alexander, WTP Engineering Division

Oversight Team: 10/14/04
Jennifer Holland, Tulane University

10/14/04
Langdon Holton, PNNL

10/14/04
CK Liu, WTP Safety Authorization Basis Team

Executive Summary

The U.S. Department of Energy (DOE), Office of River Protection (ORP) has conducted a technical design oversight to understand and evaluate the Waste Treatment Plant (WTP) Contractor's technical approach, and results, for mitigation of hydrogen (H_2) generated from the processing of tank wastes. This design oversight review was conducted while the final Hydrogen Generation Rate (HGR) and Time to Lower Flammability Limit (LFL) calculations were in progress. The Oversight Team has concluded the following based upon the review of the project information, and discussions with BNI project staff:

- The June 2004 HGR and Time to LFL calculations use assumptions that appear to overestimate the HGR. The Oversight Team believes that when the calculations are revised with appropriate assumptions that the proposed operational restrictions[1] on vessel operating volume associated with treatment of Envelope C/D tank wastes will be eliminated, and that the blending requirements (or vessel volume operating limitations) for Envelope B/D will be reduced or eliminated.

- The WTP Contractor has acknowledged that a strong basis for the current time period of concern for H_2 generation, and response following a Design Basis Event (DBE) does not exist and are pursuing a reduced time period of concern. The results of these efforts which need to be subjected to a formal ISM review should result in a WTP facility that has better balance between process safety and the projected facility capital and operating costs compared to the current situation in which the time period of concern is 3000 hours.

- The ORP identified, and the WTP Contractor has confirmed, issues associated with the accumulation of H_2 in process piping, cooling jackets, small vessels and process ventilation dead zones. The potential outcome of these assessments may place additional operational restrictions, or require design changes, to the process piping systems. Thus, ORP will continue to monitor the outcome of these issues.

Based upon the results of this Oversight, the Oversight Team makes the following three recommendations for the WTP Contractor:

1. Complete a short term evaluation to determine the impact of the primary technical assumptions on the results of the HGR and time to LFL calculations, and to establish the current design margins. The final assumptions to be used in the HGR and Time to LFL calculations should be established based upon this evaluation. This evaluation should include assumptions on radioactive decay date, composition of the waste feeds, ratio of solids to liquids, and organic content of the process streams that currently exist in the calculations. The analysis should also assume that WTP will process the Cs/Sr capsules prior to 2028

[1] BNI letter from J. P. Henschel to R. J. Schepens, ORP, "Information on Managing Feeds that Could Generate Large Amounts of Hydrogen," CCN: 099805, dated October 1, 2004.

consistent with design considerations including; shielding, heat generation, and unit liter dose.

2. Complete the final set of HGR and Time to LFL calculations that defines the waste feed basis, and uses assumptions identified in Recommendation 1. These calculations need to be expedited to ensure that the design and safety basis are brought into alignment.

3. Use the portable H_2 monitoring system, planned for implementation in the WTP facilities, as a tool to demonstrate the conservatism of the HGR calculations and the H_2 control design features during Hot Commissioning.

Recommendations and Open Items identified based upon the findings of this Oversight are presented in Table 5. These Recommendations and Open Items are for WTP Contractor action.

The results of this review have not identified any issues that directly impact the waste treatment capacity of the WTP facilities. However, the emerging issue associated with the management of H_2 generated in process piping has the potential to impact the waste treatment capacity. Two potential situations exist: 1) if significant process fluids are generated to flush waste from the piping and ancillary vessels, the waste streams may carry more water than necessary in mass balance analyses, and 2) additional instrumentation of process piping is required that impacts the availability of the process systems due to monitoring and maintenance.

No new safety issues were identified, in the conduct of this design oversight.

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Introduction

Background

"In June 2003, the Pulse Jet Mixer (PJM) Task Team (R&T, Engineering, R&D, and mixing consultants) developed an integrated strategy for scaled testing to demonstrate PJM mixing in Waste Treatment Plant vessels containing non-Newtonian fluid. Initial physical scaled testing demonstrated in October 2003 that the original pulse jet designs in these vessels did not mix the non-Newtonian slurries to the extent necessary to meet WTP requirements. In November 2003, Phase I of the PJM program developed an alternative "PJM-only" configuration that mixed the vessels containing non-Newtonian slurries in accordance with WTP requirements. In December 2003, Phase I scaled GR&R testing demonstrated that the WTP could provide safe gas control with these configurations. In the same time frame, the hydrogen generation source testing was completed using actual waste samples from "expected worst-case" tanks, and a better correlation was developed to predict hydrogen generation for use by the WTP Project (CCN 078291). While the alternative PJM configuration was acceptable, implementation of PJM-only mixing systems severely impacted the WTP facility designs due to increased numbers of PJMs, additional piping, and the significantly increased air consumption needed to operate these systems. The PJM Task Team was chartered to develop PJM hybrid mixing systems to minimize the impact to overall project cost and schedule. Phase II of the PJM program investigated further alternative configurations to assess the effects of slurry rheology changes, reduced tank volume, PJM jet velocity and nozzle size, sparging, and recirculation pump operation. Phase II PJM hybrid mixing systems recently completed additional testing to demonstrate that the modified configurations mix non-Newtonian slurries in accordance with WTP requirements. PJM hybrid mixing systems GR&R testing demonstrated that the selected PJM configuration provides safe gas control in accordance with WTP requirements." (24590-PTF-RT-04-0003, Revision 0)

Oversight Objectives

The objectives of this design oversight review are to:

1. Understand the requirements and assumptions for establishing the time to LFL for WTP normal-operations, and post-DBE conditions.

2. Determine to what extent vessels other than the nine vessels in the Pretreatment (PT) and High Level Waste (HLW) Vitrification facility acknowledged to process non-Newtonian slurries, experience non-Newtonian slurries under the following scenarios: 1) overflow; 2) misrouted transfers; 3) and receipt of Newtonian slurries in the HLW and Low Activity Waste (LAW) feed receipt vessels from the tank farms that upon solids settling may have the potential to create localized non-Newtonian conditions.

3. Determine if a technical basis has been developed for the description of Newtonian and non-Newtonian fluids (e.g. H_2 gas releasing versus gas retaining), and determine if this definition is reasonable and has been consistently applied in the design.

4. Determine if the ventilation system can adequately support the operation of the facilities to meet plant requirements and mission objectives for H_2 mitigation in normal operations considering recent Research and Technology (R&T) data.

5. Determine if the ventilation system can adequately support the operation of the facilities to meet plant requirements and mission objectives for H_2 mitigation in post Design Basis Event conditions considering recent R&T data.

6. Determine if the design has accounted for all locations within the WTP requiring management and monitoring of H_2 (e.g., plant wash and drains vessel, cesium eluent recovery process system, other)

This oversight review is being conducted as part of ORP's responsibility as owner and operator of the WTP facilities to ensure that the design and planned operation complies with the appropriate functional and operating requirements specified in the WTP Contract.

This review has been scoped to avoid duplication with any safety specific reviews associated H_2 generation and/or mitigation that would be conducted by appropriate safety organizations within ORP.

Approach

This design oversight was conducted by collecting and evaluating WTP project documentation. This information originated from:

- Presentations by key BNI staff on specific lines of inquiry;
- Discussion of specific aspects of the design and construction processes with key BNI staff; and
- Review and evaluation of design documentation.

This Oversight was conducted during the time period September 13, 2004, to October 7, 2004. During the initial part of the Design Oversight, September 20, 2004, to October 7, 2004, the Team met with BNI staff to participate in presentations by BNI and conduct follow-up discussions on each specific objective. A draft of the Design Oversight was provided to BNI for review and comment on October 5, 2004, and October 12, 2004.

The Oversight Plan is provided in Appendix A.

Oversight Assessment Results

The oversight assessment results are organized by the six Oversight Objectives.

Objective 1: Understand the requirements and assumptions for establishing the time to LFL for WTP normal-operations, and post-DBE conditions.

This specific Design Oversight objective is focused on evaluation of:

- The requirements and assumptions for estimating the time to LFL for WTP normal-operations and post-DBE conditions in the vessels that are anticipated to contain Newtonian and non-Newtonian process fluids[2] (except those vessels in the cesium ion-exchange process).
- The WTP Contractor request to remove tank waste AZ-101, AN-102 and AN-107 from the WTP Basis of Design.
- The emerging issue associated with the potential for H_2 buildup in process piping.

The WTP contractor has used a conservative and methodical calculation strategy to estimate the hydrogen (H_2) generation rates (HGR) from the anticipated processing of the Hanford tank wastes to provide a basis for specifying the Important to Safety (ITS) engineering systems in the WTP Plant design. This methodology and specific activities in this methodology have been subjected to a number of internal project reviews (CCN: 085712), and reviews by ORP, and Defense Nuclear Safety Facility Board staff. The key components of this methodology involve:

- Establishing a correlation to estimate the HGR from WTP process streams, known as the WTP Modified Hu Correlation (CCN: 078291);
- Evaluating the WTP waste feeds to determine bounding case conditions for hydrogen release rate analyses; and
- Completing a detailed material balance to provide a basis to estimate the time to reach the hydrogen gas LFL[3] for each of the process vessels in the Pretreatment and HLW Vitrification facility.

Overview

The WTP Contractor initiated formal estimates of H_2 production and preliminary definition of the requirements for mitigation in December 2003. Figure 1 summarizes the major events and decisions that have been made by the contractor to address the H_2 mitigation issues.

[2] The vessels that contain non-Newtonian fluids (HLP-00027A/B, HLP-00028, UFP-00002A/B) will be designed to incorporate Important to Safety mixing and gas sparging systems.
[3] The Lower Flammability Limit for H_2 is assumed to be 4 vol% in air at standard temperature and pressure in the analysis results presented.

In December 2003, the WTP contractor completed estimates of the HGR assuming that the LAW and HLW wastes feeds were comparable to the Contract maximum feed definition as identified in Specification 7, *Low Activity Waste Feed Envelopes* and Specification 8, *High-Level Waste Feed Envelope* of the WTP Contract. At the same time, issues were emerging associated with the requirements to effectively operate the PJMs to remove H_2 that may become trapped in settled solids, and the limitations associated with the design capacity of the process vessel vent system. These two emerging issues, combined with the need to prevent the accumulation of H_2 above the LFL led the WTP Contractor to conclude that the design of the WTP process vessel vent system and ITS controls and instrumentation for the PJMs, could be reduced with application of conservative, but less bounding waste characteristics. A major design change to the plant would be required to produce a WTP Contract compliant design.

The WTP Contractor further modified the HGR calculations in March 2004 based upon a more realistic waste feed basis that considered both the "as received" and contract maximum Total Organic Carbon (TOC) conditions for the waste feeds in terms of Na and radionuclide concentrations. The TOC content for LAW Envelopes A and B was based upon as received feeds with solids content and sodium molarity adjusted to contract values. Envelope C was based upon the Contract maximum concentration of TOC. This new calculation in combination with the addition of safety controls to protect certain vessels from reaching overflow conditions reduced the time to LFL by a factor of ~2. However, this revised H_2 design calculation did not provide sufficient decrease in H_2 generation rates to allow a large simplification in the WTP design.

In June 2004, the WTP Contractor further modified the HGR estimates (CCN: 092521) and Time to LFL calculation in an attempt to ensure that the design capability of the WTP and the feed basis for purposes of H_2 mitigation were mutually acceptable. This was achieved by establishing a design basis feed stream, elimination of the Envelope B/D and Envelope C/D feed compositions from the WTP feed basis. At this writing, the WTP Contractor has requested a modification to the feed basis assumptions (CCN: 099805) that is discussed in later sections of this report.

Figure 1 summarizes the HGR calculation history, illustrates impact to the WTP design from the calculation stages, and provides an example that shows the change in HGR for the HLW feed blend vessel, a large vessel containing the largest inventory of radioactivity in the WTP process system. Also presented is a qualitative assessment of the program risks. No formal cost assessments were completed as part of the design impact assessments associated with the different HGR calculations.

The following sections address in greater depth the development and the HGR and Time to LFL calculations during the time period March 2004 to June 2004. Emerging issues are also summarized, including the proposal by the WTP Contractor to modify the feed design basis (CCN: 099805).

Hydrogen Generation Rate Estimates-Current Status

The major steps, and key documents generated, to estimate the HGR, and time to reach the hydrogen lower flammability limit for the Pretreatment and HLW Vitrification facilities is portrayed in Figure 2. A summary of this calculation methodology is provided below. The reader should consult the reference documentation for a more detailed review. The calculation methodology used the following major steps:

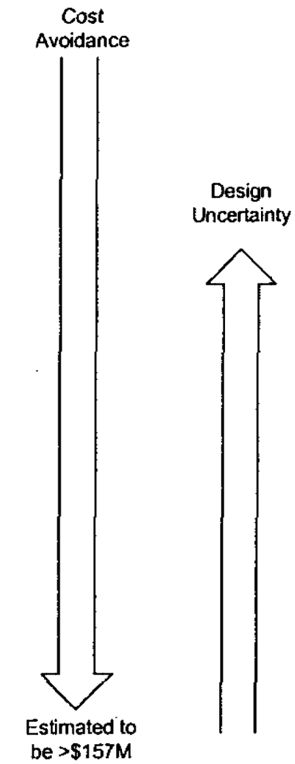
- Prediction of Hydrogen Formation: The WTP project built upon the Hu correlation, developed by the Hanford Tank Farm contractor to estimate H_2 generation rates for anticipated WTP process conditions. (CCN: 078291). The original Hu correlation had three terms for H_2 formation; 1) water radiolysis, 2) organic decomposition, and 3) thermally-induced organic decomposition. The original Hu correlation did not consider alpha radiation induced H_2 generation. Based upon experimental evaluations and anticipated operational conditions in the WTP, it was recommended that the Hu correlation be modified by: 1) addition of a term for radiolysis of water by alpha emitters, 2) addition of a term for radiolysis of organics by alpha emitters, and 3) modification of the original term for radiolysis of water by beta/gamma emitters. The evolution of the Hu correlation and the modified WTP Hu correlation for WTP evaluations is summarized in Table 1.

- Selection of Feed for WTP Process Performance: Prior to completion of the HGR estimates the contractor conducted an evaluation to select the wastes feed compositions that would bound the potential for H_2 generation. This evaluation used the following major assumptions:

  - Waste transfer activities in the tank farm do not preclude combining of supernatant from one particular tank with the solids in another tank.
  - Waste feed inventory for the "Phase I tanks" was based upon TFCOUP Revision 3A. (HNF-SD-WM-SP-012, Revision 3A).
  - Waste feed inventory for "Phase II tanks" was based upon a data set developed for the ORP System Plan, Revision 0. (24590-WTP-MRR-PT-02-010).
  - The WTP Hu correlation was used to estimate the HGR.

- Estimates were made for the HGR for each of the solid and liquid batches that could be delivered to the WTP using these assumptions. The batches were then ranked based upon their propensity to generate H_2. Using the LAW and HLW envelope designations, assigned to the tank waste composition, a set of potential waste feeds

HGR/LFL Calculation	Key Feed Assumptions	WTP Design Impact	Example HGR for VSL HLP-000028	Impact to Program Risks
December 7, 2003 Draft [a]	Contract Maximum Feed	• Majority of Plant Mixing Systems are ITS (Additional compressors and diesel generators needed) • Upgraded Ventilation System Required • *Major Design Rework Required* • Shielding Inadequate in bulges	360 L/hr	
March 18, 2004 Committed [b]	"As Received Feed", Maximum Feed Combinations for A/D, B/D, C/D	• ITS Plant Mixing Systems reduced by factor of ~2 • *Upgraded Ventilation System still Required* • Major Design Rework Required • Shielding Inadequate in bulges	290 L/hr	
June 22, 2004 LFL Calculation Only [c]	"As Received Feed", Maximum Feed Combination for A/D Feed Only	• ITS Plant Mixing Systems significantly reduced • Ventilation System Design adequate • No Design Rework Required • Shielding adequate with modified feed basis • Feed Management Required for Envelope B/D and C/D waste feeds	44 L/hr	



Notes
(a) *The draft December 2003 HGR calculation showed that there would be significant design impacts to the process ventilation and ITS air supply system designs.*
(b) The March 2004 HGR calculation was approved as a committed calculation.
(c) The June 2004 Time to LFL calculation was approved. The corresponding HGR calculation is a draft. The June 2004 LFL calculation is the current design basis for the WTP.

Figure 1 - Modification of HGR Calculation Feed Basis and Impact on the WTP Plant Design

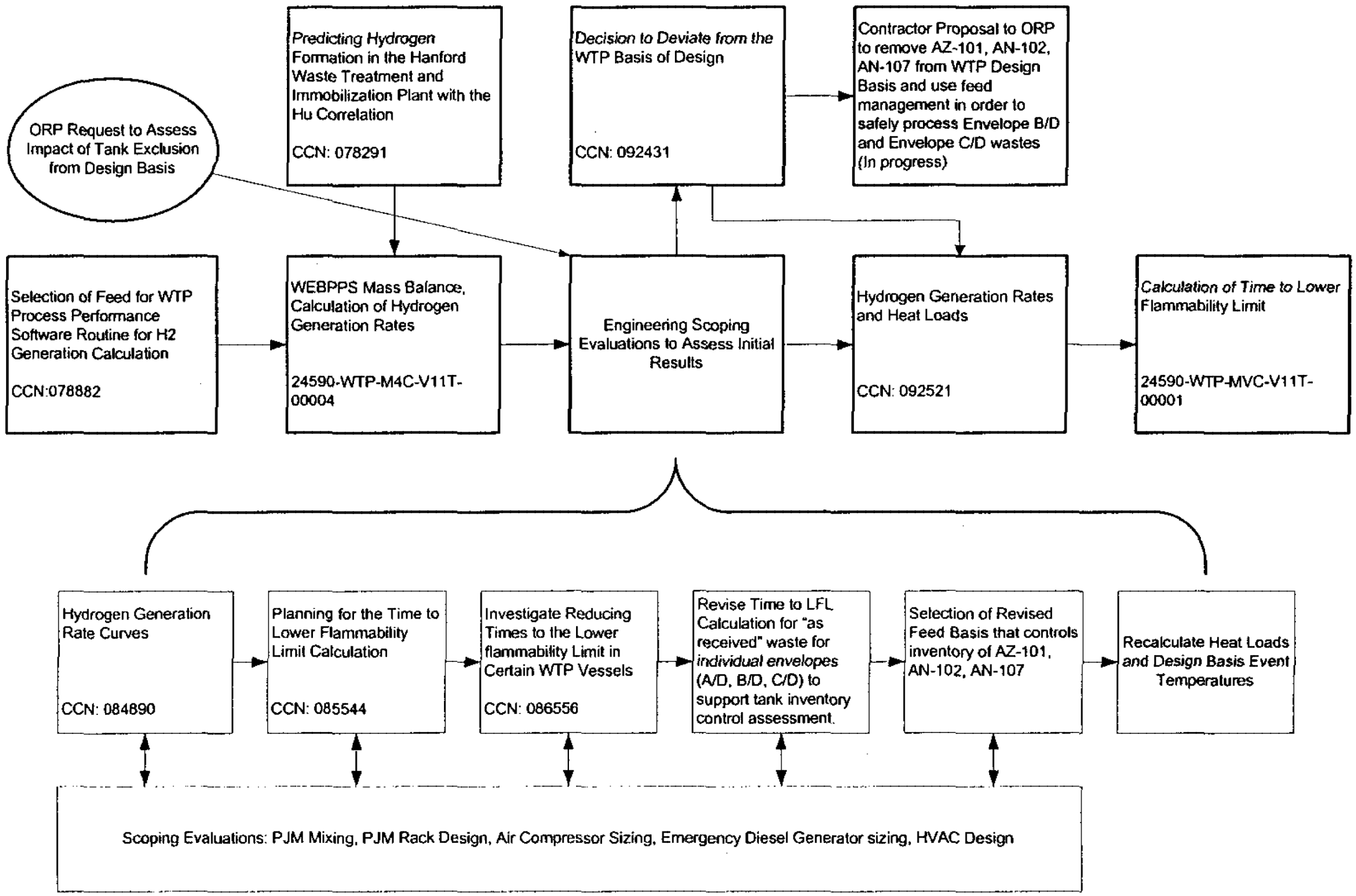


Figure 2 - Key Documents used in Assessment of Hydrogen Generation rates for the WTP

Table 1 - Summary of Development and Origin of Hu Correlation for Predicting Hydrogen Generation Rates at the Hanford WTP

Term	1997 Hu Correlation (HNF-SD-WM-CN-117, PNNL-11836)	WTP Project Adaptation of Hu 1997 Correlation, RPT-W375-SA00002, (Plys *et al.* 2000)	Hu 2000 Correlation Update (HNF-3851 Rev. 0b [Hu 2002])	Recommended WTP Project Adaptation of Hu Correlation (Stock & Sherwood 12/19/03)
Radiolysis of Water, $G_0(H_2)$ (H_2 molecules/100 eV)	greater of 0.031 or $0.45-0.31[NO_2]^{1/3}-0.41[NO_3]^{1/3}$	*Nominal:* greater of 0.031 or $0.45-0.31[NO_2]^{1/3}-0.41[NO_3]^{1/3}$ *Conservative:* greater of 0.031 or $0.45-(0.31^3[NO_2]+0.41^3[NO_3])^{1/3}$	greater of 0.005 or $0.45-0.56[NO_3]^{1/3}-0.43[NO_2]^{1/3}$	***Accurate/Bounding:*** $G_0(H_2)^{\alpha} = 1.05/(1+2.4[NO_3]+0.62[NO_2]) + 0.35/(1+3900[NO_3]+1400[NO_2])$ ***Accurate/Bounding:*** $G_0(H_2)^{\beta/\gamma} = 0.34/(1+2.4[NO_3]+0.62[NO_2]) + 0.11/(1+120[NO_3]+43[NO_2])$
Organic Radiolysis, $G_{TOC}(H_2)$ (H_2 molecules/100 eV)	$(0.15 \pm 0.05)[TOC]$	*Nominal:* $0.15[TOC]$ *Upper Bound:* $0.20[TOC]$	*Nominal:* $a_0 f[TOC]\exp(-Q_{rad}/RT)$ $a_0 = 2.49 \times 10^6$; $f = 0.7/0.4$ (for DST/SST waste); $Q_{rad} = 44.3\ (\pm 2.0)$ kJ/mole	***Nominal:*** $a_0 f[TOC]\exp(-Q_{rad}/RT)$ $a_0 = 1.25 \times 10^6$ for α, $a_0 = 2.49 \times 10^6$ for β/γ; $f = 0.7/0.4$ (for DST/SST waste); $Q_{rad} = 44.3$ kJ/mole
G-value Term, $G(H_2)$ (H_2 molecules/100 eV)	$G(H_2) = G_0(H_2) + G_{TOC}(H_2)$	$G(H_2) = G_0(H_2) + G_{TOC}(H_2)$	$G(H_2) = G_0(H_2) + G_{TOC}(H_2)$	$G(H_2)^{\alpha} = G_0(H_2)^{\alpha} + G_{TOC}(H_2)^{\alpha}$, $G(H_2)^{\beta/\gamma} = G_0(H_2)^{\beta/\gamma} + G_{TOC}(H_2)^{\beta/\gamma}$
Hydrogen Generation Rate from Radiolysis, HGR_{rad} (moles H_2/kg-day)	$CG(H_2)E_{abs}$	$CG(H_2)E_{abs}$	$CG(H_2)E_{abs}$	$C^{\alpha}G(H_2)^{\alpha}E_{abs}{}^{\alpha} + C^{\beta/\gamma}G(H_2)^{\beta/\gamma}E_{abs}{}^{\beta/\gamma}$
Hydrogen Generation Rate from Thermolysis, HGR_{therm} (moles H_2/kg-day)	$a_T[TOC][Al]\times\exp[-Q_T/R(1/T-1/304.7)]$ $a_T = 1.69\times10^{-7}$; $Q_T = 91{,}000 \pm 9{,}000$ J/mol	*Nominal:* $a_T[TOC][Al] \times \exp[-Q_T/R(1/T-1/304.7)]$ $a_T = 1.69 \times 10^{-7}$; $Q_T = 91{,}000$ J/mol *Upper Bound:* $a_T[TOC][Al] \times \exp[-Q_T/R(1/T-1/304.7)]$ $a_T = 1.93 \times 10^{-7}$; $Q_T = 100{,}000$ J/mol	*Nominal:* $a_T f[TOC][Al]^{0.4} \times \exp(-Q_T/RT)$ $a_T = 2.76 \times 10^9$; $f = 0.7/0.4$ (for DST/SST waste); $Q_T = 89.3\ (\pm 1.93)$ kJ/mole	***Nominal:*** $a_T f[TOC][Al]^{0.4} \times \exp(-Q_T/RT)$ $a_T = 2.76 \times 10^9$; $f = 0.7/0.4$ (for DST/SST waste); $Q_T = 89.3$ kJ/mole
Total Hydrogen Generation Rate, (w/o corrosion) (moles H_2/kg-day)	$HGR = HGR_{rad} + HGR_{therm}$			$HGR = HGR_{rad} + HGR_{therm}$ $HGR_{rad} = HGR^{\alpha} + HGR^{\beta/\gamma}$

Concentrations $[NO_2]$ and $[NO_3]$ are in moles/liter; [TOC] and [Al] are in wt.% and refer to dissolved species only. R = 8.314 J/K-mol is the gas constant. *T* is waste temperature in Kelvin. f_L denotes waste liquid fraction. *C* converts radiant energy absorption by waste (E_{abs}) into H_2 generation rate per waste mass. E_{abs} is proportional to the waste curie content.

Table 2 - Cases Evaluated in WEBPPS Mass Balance and Calculation of Hydrogen Generation Rate Calculation

Feed Stream	Case		
	A/D	B/D	C/D
LAW Feed Liquid Composition	SY-101 liquid at 10 M Na	AZ-102 Liquid at 5 M Na	AN-102 liquid at 10 M Na with TOC at Contract limit
LAW Feed Solid Composition	AZ-101 solids at 5 wt%	AZ-101 solids at 5 wt%	AN-102 solids at 5 wt%
HLW Feed Liquid Composition	SY-101 liquid at 10 M Na	AZ-102 Liquid at 5 M Na	No HLW stream assumed when Envelope C LAW Treated
HLW Feed Solid Composition	AZ-101 solids at 20 wt%	AZ-101 solids at 20 wt%	No HLW stream assumed when Envelope C LAW Treated
Note: Two Mass Balance production rate cases were considered. One at 80 MTG LAW and 6 MTG HLW and a second at 30 MTG LAW and 6 MTG HLW, except for Envelope C/D which was conducted at 30 MTG LAW and 6 MTG HLW.			

for further evaluation was defined. These feed definitions included waste feed batches from AN-102, AN-107, AY-102/C-106, AZ-101, AZ-102 and SY-101. The reference waste feed envelope compositions are presented in Table 2.

Completion of the WEBPPS Mass Balance and Calculation of Hydrogen Generation Rates: Using the waste feed definitions defined above as a guideline, mass balance estimates were made using the WTP Engineering Baseline Process Performance Software (WEBPPS) to estimate the chemical and radiochemical composition in each of the WTP process vessels. Two waste treatment cases were considered; one with 80 MTG LAW and 6 MTG HLW, and a second at 30 MTG LAW and 6 MTG HLW. Using the mass balance chemical and radiochemical composition results, combined with the maximum operating temperature the unit HGRs (gram mole H_2 /liter of solution per hour) were estimated using the WTP Hu Correlation for each of the process vessels for each of the mass balance cases and production rate cases identified. The results of this calculation are summarized in the calculation of HGRs (24590-WTP-M4C-V11T-00004) issued in March 2004.

- Engineering Scoping Evaluations to Assess Initial Results: Following the estimation of the unit HGRs, estimates were then made to determine the time to reach the LFL for H_2 for each of the process vessels for the Mass Balance cases identified above. Following the issuance of the "Calculation of the Hydrogen Generation Rates" (24590-WTP-M4C-V11T-00004), a question was asked by ORP as to whether BNI had determined if there are some outlier tank farm compositions, that, if eliminated from the calculaton, would result in a considerable reduction in predicted hydrogen generation rates (email from I. Papp to I. Tsang, March 18, 2004). Within the project the methods to reduce the HGRs were examined including basing the calculations on "as received" waste compositions and later on the preclusion of three tank wastes (AN-102, AN-107 and AZ-101) from the design feed basis. The elimination of the three tanks also initiated a study of processing techniques and potential impact to production rates and campaign time requirements.

- In parallel, the PJM working group was investigating the air requirements for the adaptation of the spargers in non-Newtonian vessels. The results of the PJM working group indicated that a reduction of the HGRs would also benefit the design associated with the back-up air compressor and the emergency diesel generator (EDG) design concept. The need to mimimize the design of sparging systems, and associated costs, to maintain acceptable operations following a design basis event provided further incentive to examine methods to reduce the HGR.

- Several analyses were performed during the Engineeeing Scoping Evaluation phase. First, HGRs were calculated assuming "as received" waste compositions. The evaluations determined that the HGR calculation still led to relatively short Times to LFL and would require continuous mixing of a number of vessels following a design basis event. The air requirements for PJM mixing and sparging under these conditions were determined to be too high, exceeding the exisiting compressor, EDG, and HVAC designs at that time. A second approach of decreasing the liquid level (and thereby increase the head space for H_2 accumulation) to increase Time to LFL was pursued. When it was determined that the air requirements for mixing were still higher than the design capability, the potential for tank waste exclusion was pursued.

  A ranking of the liquid waste based on "as received" data was performed to confirm the original ranking with the sodium molarity adjusted to the WTP Contract conditions (e.g. LAW Na at 10 M for envelope A/D and C/D and 5 M for Envelope B/D). The ranking indicated that with the use of processing controls on tanks AZ-101, AN-102 and AN-107, the resulting HGRs, and the corresponding Times to LFL, would be acceptable assuming the combination of the SY-101 liquid with the C-106 solids. The lowering of the DBE equilibrium temperatures by performing temperature transient analyses also provided additional benefit.

  Although some preliminary cost estimates were performed, the decision to control tank wastes from AZ-101, AN-102 and AN-107 was primarily based on the benefits of maintaining the existing air compressor sizing, EDG and HVAC design, which avoided equipment cost increases, as well as elimination of the schedule delay for design modifications.

- Decision to Deviate from the WTP Basis of Design: Recognizing the technical and project benefits for controlling tank wastes AN-102, AN-107 and AZ-101 during processing, the BNI engineering organization requested and obtained an internal approval to deviate from the Basis of Design. This action resulted in the preparation of a proposal to ORP to modify the feed basis for the HGR calculation (CCN: 092521).

- Completion of the time to LFL calculation for the WTP design: Following the approval of the decision to deviate from the Basis of Design, a formalized Time to LFL calculation (24590-WTP-M4C-V11T-00001) was prepared using the following major assumptions:

  - Waste feed is based upon an Envelope A/D feed composition only. Waste feeds from AN-102, AN-107 and AZ-101 are excluded from the analysis. These tank wastes could be managed in order to safely be processed through WTP.

  - The "as received" concentrations are used for analysis. The reference maximum feed vector comprised of SY-101 liquid (and C-106 for the solids) has a Na concentration of 6.2 M Na. The TOC level is still maintained at 0.5 mole TOC/mole Na.

The calculation results indicated that the vessels identified in Table 3 would have Time to LFL's of less than 240 hours, or ten days.

Table 3 - Vessels with Time to LFL less than 240 Hours

Vessel	Maximum Temperature °F	Time to LFL (hours)
HLP-VSL-00022	190	15
HLP-VSL-00027A/B	124	100
HLP-VSL-00028	123	100
UFP-VSL-00028	194	45
HFP-VSL-00001/5	140	33
HFP-VSL-00002/6	140	33
RLD-VSL-00008	140	230
CNP-EVAP-00001	140	200
TCP-VSL-00001	150	68
Note: Information abstracted from 24590-WTP-M4C-V11T-00001.		

Potential Conservatism in the Calculations used to Support HGR Estimates

A review and evaluation of the principal calculations used to estimate the HGR and Time to LFL in the WTP process vessels has determined that potential conservatism and corresponding over-estimation of the HGR remains. Further changes in the calculations will not likely change the design. However, potential operational benefits in terms of the treatability of waste feed can potentially be achieved. It is recognized that the two principal calculations; "Calculation of Hydrogen Generation Rates" (24590-WTP-M4C-V11T-00004) and, "Calculation of Time to Hydrogen Lower Flammability Limits" (24590-WTP-M4C-V11T-00001) are committed calculations and therefore have not been finalized as required for a "confirmed" status.

Summarized in Table 4 are the principal calculations, major assumptions used in the calculation, and the potential conservatism introduced by those major assumptions.

The appropriate strategy for the resolution of the issues associated with the HGR issues and the current exclusion of the 3 tank waste compositions from the design basis, and the programmatic desire to minimize the number of ITS systems in the WTP facilities is two-fold. This strategy should consider:

- Revision of the principal calculations to remove any unnecessary conservatism and inconsistencies in the feed basis, while maintaining an inherently safe design.

- Define operational strategies, if necessary to resolve any outstanding technical issues associated with the management and processing of the tank wastes (e.g. AN-102, AN-107 and AZ-101) in the WTP.

Conservatism Remaining in the HGR and Time to LFL Calculation

The revision to the assumptions for the principal calculations identified above provided additional realism to the calculations. These changes would still leave considerable conservatism (allowing for lower projection of HGR or increased time to reach LFL). The major areas of conservatism that remain in these calculations are summarized in Table 4. The remaining conservatisms may provide margin for uncertainties resulting from antifoam addition, leaching operations, and data quality (i.e., TFCOUP Revision 3A).

WTP Contractor Proposal on Modification of the WTP Feed Basis for H_2 Generation Rate Estimates

The WTP Contractor has recently (CCN: 099805) requested that the WTP feed basis be modified for the purposes of estimation of the H_2 generation rates. The change would be from the WTP Contract maximum feed definition (as used in the December 2003 calculations) to the "as received" composition of an Envelope A/D waste feed (as used in the June 2004 calculations). This approach, combined with the current set of HGR and Time to LFL calculations would place operational restrictions on the processing of the Envelope B/D and Envelope C/D waste feeds. The Envelope B/D feeds (e.g. tank waste AZ-101) would need to be processed either in reduced WTP vessel volume batches, or blended with lower decay heat containing wastes to ensure that the HGR can be effectively managed in post DBE conditions. The Envelope C/D wastes e.g tank waste AN-102/AN107) would be processed in reduced WTP vessel volume batches to ensure that the HGR can be effectively managed in post DBE conditions.

The Oversight Team believes that there is sufficient conservatism in the current HGR and Time to LFL calculations, such that when accounted for, in revised calculations, the processing of the Envelope C/D waste feeds can occur without operational restrictions. In addition, it is believed that the blending requirements in terms of reducing the average heat load for the Envelope B/D high heat tank waste (e.g. AZ-101) can be reduced. The Oversight Team believes that processing of the waste feeds, without operational restrictions and need for blending requirements, can be accomplished with sufficient conservatism remaining such that an inherently safe design is achievable.

Based upon the current status of the HGR and Time to LFL calculations, ORP and BNI have identified, and agreed to the following two recommendations:

Recommendation 1: Complete a short term evaluation to determine the impact of the primary technical assumptions on the results of the HGR and time to LFL calculations, and to establish the current design margins. The final assumptions to be used in the HGR and

Time to LFL calculations should be established based upon this evaluation. This evaluation should include assumptions on radioactive decay date, composition of the waste feeds, ratio of solids to liquids, and organic content of the process streams that currently exist in the calculations. The analysis should also assume that WTP will process the Cs/Sr capsules prior to 2028

Recommendation 2 Complete the final set of HGR and Time to LFL calculations that defines the waste feed basis, and uses assumptions identified in Recommendation 1. These calculations need to be expedited to ensure that the design and safety basis are brought into alignment.

Table 4 - Conservative Assumptions Remaining in the HGR and Time to LFL Calculations

Calculation	Key Assumptions	Recommended Evaluation of Conservatism	Basis
24590-WTP-M4C-V11T-00004, "*Calculation of Hydrogen Generation Rates*", March 18, 2004, Bechtel National Inc., Richland Washington.	Decay date for radionuclide is based upon TFCOUP Rev 3A at January 1, 1994.	Revise decay date to correspond to nominal start of production operations January 1, 2011.	Extending the decay date by 17 years will reduce the decay heat by ~40 to 45% and lower the anticipated HGR. This will have significant benefit to those waste compositions that do not contain significant concentrations of TOC.
	TOC concentrations for the tank waste envelopes are A/D-0.09 mole/mole Na, B/D~0.4 mole/mole Na and C~0.5 mole/mole Na.	Revise the TOC level for Envelope C to analytical results values that for AN-102 is ~0.21 mole TOC/mole Na at 10 M Na, and for AN-107 is ~0.34 mole TOC/mole Na at 10 M Na.	The use of analytical data to "modify" the design basis calculations is appropriate based upon the WTP Contact (Standard 2, a, 2, iv). The reduction in the TOC level for tanks wastes from AN-102 and AN-107 will lower the anticipated HGR.
	The TOC composition in the staged waste is static and does not change during storage.	The TOC concentration should be adjusted accounting for storage time, temperature based upon the Hu Correlation. A revised TOC concentration for the "high" TOC tank compositions should be estimated.	The TOC concentration in the staged waste will decay due to radiolysis and thermolysis. The Hu correlation is independent of TOC species. If the species is reactive, as assumed in the HGR calculation (e.g. assumed to be 89.9% EDTA) then decay will occur. *If the species is non reactive, then it* would have no impact on the HGR calculation.
	Mass balance is based upon "Contract Maximum" waste feeds.	Revise mass balance to account for "as received" waste feeds as defined in TFCOUP Rev 3A. Include a case based upon the contract maximum feed for comparison.	The change is expected to lower the HGR based upon scoping study results documented in scoping evaluation calculation.

Calculation	Key Assumptions	Recommended Evaluation of Conservatism	Basis
	The HGR calculation does not include use of "Anti-foam" reagents and dissolution of the Cs ion-exchange resins in the baseline calculation.	Incorporate organic concentration additions from the use of "Anti-foam" reagents and dissolution of the Cs ion-exchange resins. Use the chemical compositions for the Antifoam and ion-exchange resins in the analysis.	Additional organic added to the process system will increase the HGR estimates.
24590-WTP-M4C-V11T-00001, "Calculation of Time to Hydrogen Lower Flammability Limits", June 22, 2004, Bechtel National Inc., Richland Washington.	The LFL calculation is a bounding case calculation that assumes that: • The H_2 concentration in the vapor space decays to ~0% prior to an episodic release, and • All the generated H_2 is released upon initiation of mixing.	The LFL calculation should assume a finite composition in the vapor space due to breathing between the vessel and process vent system. The LFL calculation should be updated based upon the H_2 retention studies.	The revised assumption on the initial H_2 concentration in the vapor space will reduce the Time to LFL. However, this result should be offset by H_2 retention studies which suggest that an acute release of H_2 is not possible.
	The calculation is based upon waste feed envelopes for A/D only.	Update the calculation to address all three waste feed envelopes; A/D, B/D and C/D.	Needed to demonstrate the capability of the WTP and provide the basis for further safety assessments.
	The LFL calculation assumes that the fluids are efficiently mixed by the PJM sparger system and that there are no large particulate inclusions in or on the surface of the fluid.	The sensitivity of the vessel mixing requirements to the release of H_2 has not been determined and has been assumed to be instaneous. A slower than instaneous release rate, if technically defensible could significantly increase or prevent the Time to LFL conditions.	The project has not provided a technical basis for the assumption of instaneous release of H_2 from mixing.

Time Period of Concern

The current Preliminary Safety Analysis Report identifies a time period of concern of 3000 hours for H_2 accumulation process vessels. The time period of concern is a time estimate target, following a design basis event, in which normal plant systems are not assumed to function. Within the duration of the time period of concern, the H_2 concentration would not exceed the LFL.

A strong basis for the current Time Period of Concern does not exist (CCN: 096657) and thus the WTP Contractor is pursuing a reduced period of concern. While not approved by ORP, the reduced time period of concern could involve three separate periods:

- Vessels that reach the LFL in less than 336 hours. These vessels would be mixed by safety class systems. The systems and support systems would be automated and qualified for post seismic event operation.
- Vessels that reach the LFL between 336 and 672 hours. These vessels would be mixed with APC mixing systems and addressed via a TSR. The mechanical (piping) portions of the systems will be qualified for post seismic from the vessel and internals up through the PJM rack to an isolation point on the air supply to the rack.
- Vessels that reach the LFL in greater than 672 hours. These vessels would be mixing systems consistent with processing requirements and will be classified as APC.

Hydrogen Accumulation in Process Piping

The technical investigations associated with the accumulation and mitigation of H_2 in process vessels have led to questions associated with H_2 accumulation in process piping. Process piping includes; suction pipes from vessels, PJM air supply lines, sample piping and small vessels (e.g. separators and reverse-flow diverter charge vessels). In addition previous project reviews by ORP (e.g. 2 topical meetings in 1999 on Flammable Gases), questions on the Preliminary Safety Analysis Report related to flammable gas retention and accumulation in piping and ancillary equipment, and an open Condition of Acceptance (COA-PT SER Appendix B #5d) requires an evaluation of the potential for H_2 accumulation in piping systems and ancillary equipment and potential control strategies by December 31, 2005.

In response to the issues described above, the WTP Contractor is formulating a plan that uses a multidisciplinary team of safety operations and engineering representatives to identify and resolve the issues associated with H_2 accumulation in process piping. The plan will be prepared in October 2004. The review activity is envisioned to be completed by March 2005.

The Tank Farm Contractor has recently been approved to reduce unnecessary conservatisms in flammable gas generation, retention and gas release models (04-TED-088). The WTP Contractor should study and understand the conditions that lead to a modification of approved requirements in the planned assessments on hydrogen accumulation in process piping.

Based upon this assessment, ORP and the WTP Contactor have identified and agreed to the following Open Item.

Open Item 1 The WTP Contractor should provide the final plan and schedule for investigation of H_2 accumulation, and mitigation, for process piping and ancillary for the Pretreatment and HLW Vitrification facilities to ORP. An interim status of any findings should be provided to the ORP.

Objective 2: Determine to what extent vessels other than the nine vessels in the Pretreatment and HLW Vitrification facility acknowledged to process non-Newtonian slurries, experience non-Newtonian slurries under the following scenarios: 1) overflow; 2) misrouted transfers; 3) and receipt of Newtonian slurries in the HLW and LAW feed receipt vessels from the tank farms that upon solids settling may have the potential to create localized non-Newtonian conditions.

Current Status

BNI Corrective Action Report (24590-WTP-CAR-QA-03-226) identifies a number of scenarios that need to be evaluated as a result of new piping routes that could lead to potential hazardous conditions as a result of unanticipated hydrogen accumulation. These routes were not analyzed because "personnel did not recognize the effect of non-Newtonian waste on equipment performance in the FEP system because the impacts ... did not become known until later in the design process." Specific examples identified include:

- The misrouting of washed solids from UFP-VSL-00002A/B resulting in the accumulation of a flammable concentration of hydrogen in FEP-VSL-00017B.
- The inadvertent concentration of washed solids due to a misrouting from UFP-VSL-00002A/B to FEP-VSL-00017B resulting in the accumulation of a flammable concentration of hydrogen in FEP-SEP-00001B.

The CAR concludes that "other contingency and/or off normal routes exist in the Pretreatment design that could potentially introduce non-Newtonian wastes into vessels whose mixing systems have been only assessed for Newtonian wastes. Piping stub outs exist for future routes that have not been analyzed because characterization of other design information may not be currently available."

In "CAR-03-226, Identification of Contingency and Off-Normal Routes in PTF that may require further safety analysis," the WTP Contractor self identifies the actions to be taken to the implement the necessary corrective actions.

CAR-03-226 defines *off-normal routes* as "existing transfer routes that are not used as part of normal processing and are intended to be used infrequently (non-routinely)." *Contingency routes* are "those that are provided in the design to accommodate future processing capability which is not yet defined... These evaluations are presently considered 'on hold' because characterization or other design information may not be currently available."

The off-normal non-Newtonian routes that the WTP Contractor has identified that still need to be thoroughly evaluated are those that originate in non-Newtonian vessels in the PTF:

- UFP-VSL-00002A/B to TCP-VSL-00001;
- UFP-VSL-00002A/B overflow to PWD-VSL-00033;
- HLP-VSL-000027 A/B and HLP-VSL-00028 to tank farms; and
- HLP-VSL-000027 A/B and HLP-VSL-00028 overflow to PWD-VSL-00033

The contingency routes that the WTP Contractor has identified that need to be tracked as the design matures include:

- Reagent lines to UFP-VSL-00002A/B; and
- Cs/Sr capsule lines to HLP-VSL-00027B and HLP-VSL-00028.

The WTP Contractor has identified the potential for hazards arising from; 1) overflow; 2) misrouted transfers; 3) and receipt of Newtonian slurries in the HLW and LAW feed receipt vessels from the tank farms that upon solids settling may have the potential to create localized non-Newtonian conditions. However, because of the evolution of the design in the HLW facility, with the removal of the Concentrate Receipt Vessels, the contractor should confirm that all revised transfer routes should be re-examined to determine if they warrant further analysis. Likewise, in the PT facility, the above listed off-normal transfer routes need to be analyzed. The PT transfer routes that are classed as "contingency" routes need to be tracked and analyzed as the design of the facility evolves.

Completed Analyses:

The following analyses have been completed:

1. Transfers from HLP-VSL-00027 A/B to HFP-VSL-00001 have been analyzed in Integrated Safety Management (ISM) meetings.
2. Overflows have been addressed including recovery actions.
3. ITS level indication is provided at the PT facility to prevent overflows.

Based upon this assessment, ORP and the WTP Contractor have identified and agreed to the following Open Item

Open Item 2 Pretreatment and HLW Vitrification facility process piping transfer routes should be evaluated to ensure that non-Newtonian process fluids will not be accidentally transferred into vessels designed for the Newtonian process fluids. If necessary, operational strategies *should be identified to mitigate potential operational issues associated with the transfer of non-Newtonian fluids into Newtonian vessels. The WTP Contractor should complete and document the review of this issue considering both throughput and safety.*

Objective 3: Determine if a technical basis has been developed for the definition of Newtonian and non-Newtonian fluids (e.g. H_2 gas releasing versus gas retaining), and determine if this definition is reasonable and has been consistently applied in the design.

Non-Newtonian conditions are typical of colloids, clays, sugars and gels among other materials. Radioactive tank wastes are also known to exhibit non-Newtonian behavior in settled layers. A non-Newtonian waste fluid commonly undergoes a transformation from fluid behavior under an agitated environment due to mixing or pumping to a pseudo plastic–solid type behavior under quiescent conditions in which the waste is allowed to settle. In the pseudo solid-plastic state the non-Newtonian waste can become very thick and thus effectively trap hydrogen gas produced by radiolysis and thermolysis. On the other hand, under well mixed conditions, the non-Newtonian waste slurries behave as a liquid and allow steady release of gases.

The transformation to a pseudo plastic-solid state can be attributed to numerous factors including waste composition, especially in the presence of gelling agents such as phosphorous and/or alumina. The chemistry of non-Newtonian fluids is highly complex and dramatically affected by waste temperature, extent of waste agitation, and chemical composition. Further, tank farm studies suggest that rheology is also sensitive to solids particle size. Solids in the tank wastes contain agglomerates which, even in relatively high concentrations, produce slurries with yield strengths and apparent viscosities that show near-Newtonian characteristics under agitated conditions. However, when these agglomerates are subjected to high shear and processes such as washing and caustic leaching, they fall apart and form much finer particles which tend to develop characteristics of more homogeneous non-Newtonian slurries. This is at least one factor that explains why treated wastes (i.e., wastes that have been subjected to high shear in the ultrafilters, as well as washing and caustic leaching) have a more non-Newtonian characteristic relative to the untreated feed.

For select double shell tank wastes (AZ-101, AZ-102, C-104, and AY-102), BNI has determined, based on tank farm data, that only mild agitation is required to keep them in a Newtonian state when the "solids concentration" is below the contract maximum (200 g/liter). Above the contract maximum, the amount of agitation required to maintain solids in suspension increases as yield strength and apparent viscosity increase. However, the data indicate (see Figure 3) that even at very high solids concentrations (e.g., 600 g/l), the WTP feed slurries are only mildly non-Newtonian (i.e., yield strengths are below about 5 Pa).

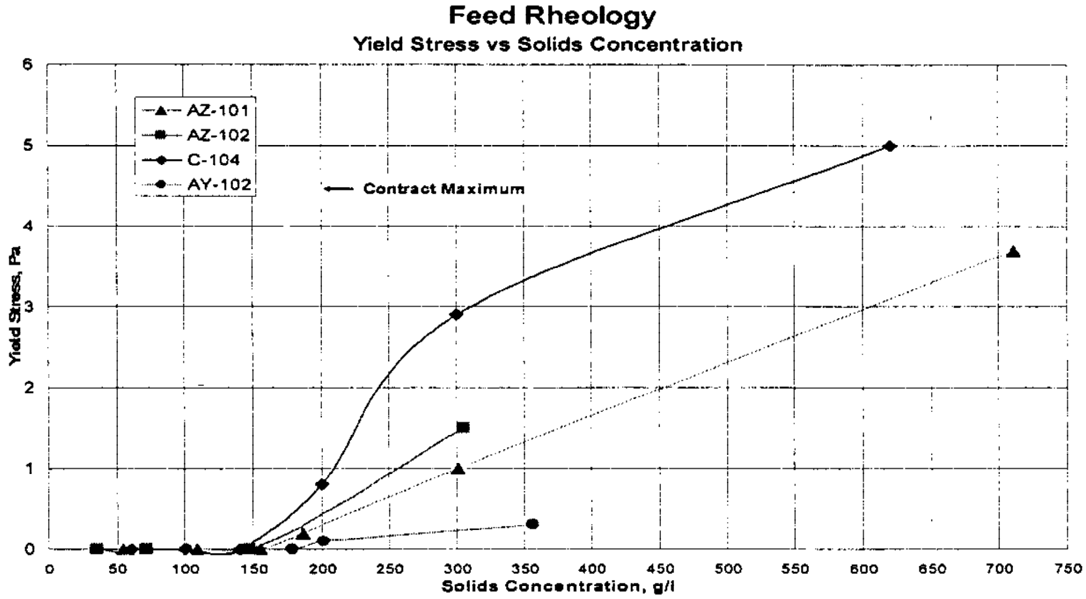


Figure 3 - Yield Stress of Selected HLW Waste Feeds to be Received in the WTP Pretreatment Facility

The WTP Contractor has also compiled tank farm data which indicates that the WTP feed wastes appear to undergo 3 phases of settling during periods when they are not being mixed. The rate of solids settling is dependent on the particle size, particle density, and fluid density, but, in general, within the first five hours, about 90% of settling takes place. Hindered settling occurs from about 5 hours to 15 hours and compaction and the development of shear strength occurs at a very slow rate beyond 15 hours. Thus, significant compaction and the development of very high shear strength is likely to occur over timeframes of months rather than hours or days.

R&T has conducted a number of gas retention and release studies. The results of these studies have been accounted for in estimating the time to the LFL in all vessels. As a result, ITS mixing is being provided for high solids vessels (such as HLP-VSL-00022) and where non-Newtonian conditions are expected. Because of the long times required for achieving a high degree of compaction and shear strength, Engineering has concluded that the pulse jet mixers will be able to re-suspend settled non-Newtonian slurry solids for release of trapped hydrogen.

Current Activities

Because prediction of the likelihood of non-Newtonian conditions is highly complex, the WTP Contractor is in the process of developing a plan to provide capability for conducting rheological analyses at the WTP Analytical Laboratory. The plan will:

1. Identify the sample points from which the samples would be potentially collected for rheological analysis. Rheological behavior is expected to change over the course of pretreatment because the wastes will be subjected to changes in temperature, pH, chemistry, solids concentration, and solids attrition. Therefore, the properties of a slurry may exhibit

non-Newtonian characteristics during the process even though the as-received waste does not;

2. Address the quantity and sample frequency;

3. Address the protocols, procedures, and determinations required of the rheological analyses;

4. Establish required turn-around times;

5. Identify any pre-requisites for sample characteristics received from the tank farms; and

6. Identify waste acceptance levels and mitigation strategies.

The WTP Contractor has proposed the use of anti-foaming reagents for application in the waste feed evaporators (FEP-SEP-01A/B). The application of an anti-foaming agent may also be required to counteract foaming resulting from sparging. However, the potential breakdown of organic anti-foams could contribute to the generation of hydrogen. The contribution to hydrogen production from the addition of anti-foaming agents is expected to be very small relative to the thermolysis of waste organics and radiolysis. An estimate of the potential anti-foam hydrogen generation contribution should be determined.

Anti-foaming agents could have an off-setting benefit as a rheology modifier. Rheology modifiers are widely used to reduce shear strength by orders of magnitude many cases in order to enhance the mixing and pumping of slurries. Consideration should be given to the selection of an anti-foam that exhibits the following properties: 1) has a minimal contribution to hydrogen generation (refractory organic); and 2) is a potential rheology modifier.

Based upon this assessment, ORP and the WTP Contractor have identified and agreed to the following Open Item

Open Item 3 The WTP Contactor should establish the strategy for sampling of the process fluids to determine the physical properties that are important to management of safety in the process facilities. Sample information should identify which compositions exhibit the potential for non-Newtonian behavior. The sampling strategy should identify the sample location and analyses to be completed (e.g. viscosity, percent solids, and chemical composition). The Sampling and Analysis Plan should be updated via ECCN or document revision to reflect the requirements to implement this strategy.

Objective 4: Determine if the ventilation system can adequately support the operation of the facilities to meet plant requirements and mission objectives for H_2 mitigation in normal operations considering recent R&T data.

Normal operation of the vessel ventilation system is being designed based on the calculated hydrogen generation rate.

Pulse Jet Mixers (PJMs) will be designed to operate in vessels to prevent hydrogen retention in non-Newtonian waste; remixing operation is conducted to preclude releases that exceed the Lower Flammability Limit (LFL) of hydrogen in vessel headspaces. PJM operation is staggered across separate vessels to maintain a reasonable pressure differential in the ventilation system (24590-G04T-F00G13, CCN: 088804, CCN: 088806). The PJMs in each vessel are operated cyclically, generally delivering mixing power for less than one minute in a three to four minute cycle.

The operations cycle time in each vessel is based on the calculated Time to LFL and the processing requirement for waste homogeneity. The conservatism in the hydrogen generation rate is carried over to the time to LFL calculation; more conservatism creates a shorter time to LFL, which consequently results in the PJMs being run more frequently. Reducing the conservatism in the HGR will allow the PJMs to be run less frequently.

The PJMs may also tax the ventilation system by the creep of aerosolizing particulates into the process ventilation system. ORP recognized that the R&T Program is currently evaluating this issue.

Air spargers have been designed to concurrently operate with PJMs in non-Newtonian vessels. PJMs elevate non-Newtonian waste suspensions; the action of spargers keeps the waste suspended and mixed. Spargers are also being designed to run in cycles, with on and off times based on the time to LFL. The sparger operation can also be tuned to the settling rate of the solids; spargers may be run even less frequently.

Engineering studies are in progress to determine the number of spargers installed to mix all areas of non-Newtonian vessels, the optimum use of spargers in number, and placement of the spargers in the vessels.

A Lessons-Learned memo (CCN: 036772) from design of the HVAC ventilation system of the DWPF treatment plant at Savannah River was obtained during the process of reviewing the off-gas ventilation system for the vessels. This document was discussed with BNI to ensure they are addressing these issues in the design of the Hanford facility for normal operations.

Objective 5: Determine if the ventilation system can adequately support the operation of the facilities to meet plant requirements and mission objectives for H_2 mitigation in <u>post Design Basis Event conditions</u> considering recent R&T data.

PJMs and air spargers are also run during post DBEs, but the operation time of each is less frequent than in normal operation. A three hour cycle has been proposed for spargers during normal operation (on 1 hour, off 2 hours) whereas a 12 hour cycle has been proposed for PDBE operation (off 12 hrs, on ~2 hrs). The 14 hour cycle is based on current LFL calculations and to maintain rheological stability. Power may be saved in this operation mode by increasing the operation cycle time to account for a more realistic hydrogen generation rate if rheological stability of waste are shown not to be an issue.

Testing is in progress in the Building 336 half scale test mock-up to evaluate the operation of the PJM's and the retention and release of H_2. During testing, (or during the early operational phase of the WTP) the following steps should be considered to provide a better understanding of the proposed operations of the PJMs and spargers:

- The June 2004 (or the revised) HGR calculations should be used to establish one of the bases for designing the H_2 retention and release tests;
- The required frequency and nozzle velocities of the PJMs should be calibrated in accordance with the revised Time to LFL calculations;
- The sparger rates should be calibrated in accordance with the revised Time to LFL calculations;
- Aerosolization testing should be conducted and based on the recalibrated operation of the mixing system; and
- Air and power requirements for the WTP process systems should be reviewed and as appropriate incorporate testing results.

Lessons learned from the DWPF HVAC system design are also being addressed for post DBE operation of the WTP facilities.

Based upon this assessment, ORP and the WTP Contractor have identified and agreed to the following Open Items

Open Item 4 The WTP Contractor should document the disposition of items identified in the DWPF HVAC system Lessons Learned (CCN: 036772)

Objective 6: Determine if the design has accounted for all locations within the WTP requiring management and monitoring of H_2 (e.g., plant wash and drains vessel, cesium eluent recovery process system, other)

The Contractor has identified design features that allow ready access for sampling and monitoring hydrogen gas. BNI recommends access primarily through spray headers and instrumentation ports throughout the WTP. Gas samples will be taken from existing connections provided for in the design. The preferred connections include the use of wash-down headers since gas samples can be taken from the spray header control racks located in the R2/C3 areas. Otherwise, samples will be taken from instrumentation lines that do not have automatic system control functions, and therefore, will not disrupt processing when H_2 monitoring is being performed

The Contractor considered both hard wired and portable equipment and is recommending portable systems for hydrogen monitoring. The Contractor has completed a preliminary survey of suppliers. The recommended portable systems are mounted on hand trucks and the portable systems provide the following features:

1. Sample extraction conditioning to remove water vapor and raise the relative humidity of the gas;

2. Gas filtering to remove particulates including radionuclide contamination; and

3. Hydrogen monitoring instrumentation and recording devices.

Since the gas sampling is intentionally introducing C5 materials into C3 space, appropriate ISM and ALARA reviews will be conducted, in accordance with 10CFR835 are required.

Because of conservatisms that are incorporated into the hydrogen generation rate and time to LFL calculations, and margins incorporated into the control design features of the WTP, it is highly likely that the actual H_2 concentrations will be much lower than design basis control concentrations. Based upon this assessment, ORP and the WTP Contractor have identified and agreed to the following Recommendation.

Recommendation 3 During Hot Commissioning, the portable, non ITS, hydrogen monitor systems should be used to demonstrate the conservatism of the HGR calculations and the H_2 control design features by monitoring the generation rate in selected points within the Pretreatment facility and the HLW facility. The following actions should be taken:

1. *Strategic sampling locations should be identified for verifying the hydrogen calculations;*

2. *The frequency of monitoring should be established based on the revised calculations; and*

3. *The Hot Commissioning verification process should be incorporated into the Sampling and Analysis Plan.*

Impact of Oversight Findings on the Anticipated Waste Treatment capacity of the WTP Facilities

The resolution of the Recommendations and Open Items identified and discussed in the previous section have the potential to impact the waste treatment capacity of the WTP process facilities. The relationship of these items to waste treatment capacity is described in this section.

- The current HGR and Time to LFL calculations place operational limitations on the treatment of the Envelope B/D and Envelope C/D tank wastes. These volume limitations may require that the design be modified to include an ITS liquid level that is lower that the currently planned L10 level in the vessels. The costs to accomplish this have not been factored into the operational limitation proposal (CCN: 099805). The operational limitation associated with the Envelope B/D waste feed may have an impact on plant production rate because of the inability to treat waste to maintain the HLW Vitrification rate of 480 canisters per year. A revision to the HGR and Time to LFL calculations as identified in Recommendation 1 and 2 should greatly mitigate the costs associated with the operational limitations and reduce the impact to waste treatment rates.

- The potential accumulation of hydrogen in piping identified as an emerging issue may place a burden on plant operations because pipes will have to be flushed after transfers of radioactive solids. If this can be accommodated by incorporating this function as a part of other routine operations then it is no added burden. However, if flushing is required that cannot otherwise be accommodated then it is an extra burden and will affect throughput.

Conclusions

This Design Oversight review was conducted while the HGR and Time to LFL calculations were in progress. In general, the Oversight Team concludes that the WTP Contractor is taking appropriate steps, in the design process, to reduce costs while ensuring safe operations. Based upon the review of the project information and discussions with BNI project staff the Oversight Team has concluded the following:

- The WTP Contractors approach to manage the design of the process ventilation system by the appropriate application of the assumptions used in the HGR and Time to LFL calculations is appropriate. This strategy has significantly reduced the cost of the WTP facilities and can result in a waste treatment capability that can support the WTP waste treatment mission needs.

- The June 2004 HGR and Time to LFL calculations use assumptions that appear to overestimate the HGR. The Oversight Team believes that when the calculations are revised with appropriate assumptions that the proposed operational restrictions[4] on vessel operating volume associated with treatment of Envelope C/D tank wastes will be eliminated, and that the blending requirements (or vessel volume operating limitations) for Envelope B/D will be reduced or eliminated.

- The WTP Contractor has acknowledged that a strong basis for the current time period of concern for H_2 generation, and response following a Design Basis Event (DBE) does not exist and are pursuing a reduced time period of concern. The results of these efforts which need to be subjected to a formal ISM review should result in a WTP facility that has better balance between process safety and the projected facility capital and operating costs compared to the current situation in which the time period of concern is 3000 hours.

- The HGR and Time to LFL calculations have a number of conservative assumptions that cannot be resolved in the near term and thus may not be able to be considered for potential reduction in conservatism. These assumptions include:

  - <u>HGR calculation</u>: The generation of H_2 is independent of the TOC composition; The TOC composition of the staged tank farm wastes will not change before processing in the WTP; and the tank waste composition will always have a unit heat generation rate near the design basis.

  - <u>Time to LFL Calculation</u>: The process solution will efficiently absorb H_2 and the H_2 will be instantly released of upon initiation of mixing.

- The ORP identified and the WTP Contractor has confirmed an issue associated with the accumulation of H_2 in process piping, cooling jackets, small vessels with ventilation dead

[4] BNI letter from J. P. Henschel to R. J. Schepens, "Information on Managing Feeds that Could Generate Large Amounts of Hydrogen," CCN: 099805, dated October 1, 2004.

zones. The potential outcome of these assessments may place additional operational restrictions or require design changes to the process piping systems. Thus ORP will continue to monitor the outcome of this issue.

- The WTP Contractor has identified the potential for hazards, and mitigation measures that could arise from the accidental transfer of non-Newtonian fluids into vessels which were designed for the management of Newtonian fluids. Final documentation of the operational strategies will formally close out these issues.

- The WTP Contractor is aware of the design capacity limitations of the process ventilation system and has been developing vessel operational strategies for normal and post DBE operations of this system. These proposed operations are integrated with the minimum operational requirements to evolve H_2 from the process fluids by mixing and sparging.

- The WTP Contractor has incorporated the applicable Lessons Learned from the design of the DWPF Ventilation System into the WTP HVAC design. Complete close-out of all Lessons Learned will occur following the commissioning of the WTP facilities. The WTP Contractors Lessons Learned program appears to be an effective system to manage insights from other DOE programs into the WTP project.

- Considerable thought has been given to a portable non-ITS hydrogen monitoring system than can be used to measure the H_2 concentrations in vessel head spaces. This system, if properly designed, can be effectively used to demonstrate the results of the HGR calculations and potentially reduce some of the conservatism in the operation of the WTP facilities.

- No design or operational issues were identified that would impact the waste treatment capacity of the WTP process facilities. The management of H_2 generated in process piping has the potential to impact the waste treatment capacity. Two potential situations exist: 1) if significant process fluids are generated to flush waste from the fluids and thereby diluting the process streams and 2) additional instrumentation of process piping is required that impacts the availability of the process systems due to monitoring and maintenance.

Recommendations and Open Items

Table 5 summaries three recommendations and four open items based upon an assessment of the information evaluated during this Design Oversight. The CARS action reference is also provided in Table 5.

Table 5 - Summary of Recommendations and Open Item s for the Hydrogen Mitigation Design Oversight

Item	CARS Reference	Recommendation or Open Item Summary
R-1	6616, #1	Complete a short term evaluation to determine the impact of the primary technical assumptions on the results of the HGR and time to LFL calculations, and to establish the current design margins. The final assumptions to be used in the HGR and Time to LFL calculations should be established based upon this evaluation. This evaluation should include assumptions on radioactive decay date, composition of the waste feeds, ratio of solids to liquids, and organic content of the process streams that currently exist in the calculations. The analysis should also assume that WTP will process the Cs/Sr capsules prior to 2028
R-2	6616, #2	Complete the final set of HGR and Time to LFL calculations that defines the waste feed basis, and uses assumptions identified in Recommendation 1. These calculations need to be expedited to ensure that the design and safety basis are brought into alignment.
R-3	6616, #3	During Hot Commissioning, the portable non ITS hydrogen monitor systems should be used to demonstrate the conservatism of the HGR calculations and the H_2 control design features by monitoring the generation rate in selected points within the Pretreatment facility and the HLW facility. The following actions should be taken: • Strategic sampling locations should be identified for verifying the hydrogen calculations; • The frequency of monitoring should be established based on the revised calculations; • The Hot Commissioning verification process should be incorporated into the Sampling and Analysis Plan.
OI-1	6616, #4	The WTP Contractor should provide the final plan and schedule for investigation of H_2 accumulation, and mitigation, for process piping and ancillary for the Pretreatment and HLW Vitrification facilities to ORP. An interim status of any findings should be provided to the ORP.
OI-2	6616, #5	Pretreatment and HLW Vitrification facility process piping transfer routes should be evaluated to ensure that non-Newtonian process fluids will not be accidentally transferred into vessels designed for the Newtonian process fluids. If necessary, operational strategies should be identified to mitigate potential operational issues associated with the transfer of non-Newtonian fluids into Newtonian vessels. The WTP Contractor should complete and document the review of this issue considering both throughput and safety.

Item	CARS Reference	Recommendation or Open Item Summary
OI-3	6616, #6	The WTP Contactor should establish the strategy for sampling of the process fluids to determine rhelogical properties that are important to management of safety in the process facilities. Sample information should identify which compositions exhibit the potential for non-Newtonian behavior. The sampling strategy should identify the sample location and analyses to be completed (e.g. viscosity, percent solids, chemical composition). The Sampling and Analysis Plan should be updated via ECCN or document revision to reflect the requirements to implement this strategy.
OI-4	6616, #7	The WTP Contractor should document the disposition of the items identified in the DWPF HVAC system Lessons Learned (CCN: 036772)
Note: All work products completed to close the Recommendations and Open Items should be informally submitted to ORP for review and evaluation prior to the completion of the BNI RITS closure package.		

References

1. CCN: 036772, "Lessons Learned on DWPF Ventilation Systems and Startup," August 14, 2002, Bechtel National Inc., Richland Washington.

2. CCN: 045320, "Maintaining Negative Pressure and Controlled Air Flow in the Pretreatment, HLW, and LAW Facilities," Bechtel National Inc., Richland Washington.

3. CCN: 053953, "WTP HVAC Zone Pressure Control Guidelines," March 13, 2004, Bechtel National Inc., Richland Washington.

4. CCN: 074567 "Rheology of 'As-Received' HLW Feed," December 15, 2003, Bechtel National Inc., Richland Washington.

5. CCN: 078291, LM Stock and DJ Sherwood, "Interim Report, Predicting Hydrogen Formulation in the Hanford Waste Treatment Plant with the Hu Correlation," December 19, 2003, Bechtel National Inc., Richland Washington.

6. CCN: 078580, "Safety Assessment to Support HFP Vessel Interlock ABAR 24590-WTP-SE-ENS-03-155, Reclassification of ITS HLW HFP/RLD Vessel Interlocks for Overflow Events," March 3, 2004, Bechtel National Inc., Richland Washington.

7. CCN: 078882, Memo Kevin Eager to Ivan Papp, "Selection of Feed for Waste Treatment Plant Process Performance Software Routine for Hydrogen Generation rate Calculation," January 12, 2004, Bechtel National Inc., Richland Washington.

8. CCN: 084809, "Hydrogen Generation Rate Curves," Memo Irving Tsang to Distribution, March 19, 2004, Bechtel National Inc., Richland Washington.

9. CCN: 085208, CAR-03-226, Identification of Contingency and Off-Normal Routes in PTF that Might Require Further Safety Analysis, May 18, 2004, Bechtel National Inc., Richland Washington.

10. CCN: 085544, "Planning for the Time to Lower Flammability Limit Calculation," Memo, Kevin Eager to Distribution, March 25, 2004, Bechtel National Inc., Richland Washington.

11. CCN: 085712, "Non Newtonian Safety Basis Review Team," Memo Richard Garrett to Distribution, April 1, 2004, Bechtel National Inc., Richland Washington.

12. CCN: 086556, Memo, IG Papp to GM Duncan, "Simple Analyses to Investigate Reducing Times to the Lower Flammability Limit of Hydrogen (LFL) in Certain Waste Treatment Plant Vessels," April 7, 2004, Bechtel National Inc., Richland Washington.

13. CCN: 088804, "Evaluation of Air Flow Balance Interaction of Pretreatment Vessel Vent Process System with the Vessel Overflow System," May 3, 2004, Bechtel National Inc., Richland Washington.

14. CCN: 088806, "Interaction of Pretreatment Vessel Vent Process System with the Vessel Overflow System During Full Sparging and Liquid Transfers," Bechtel National Inc., Richland Washington.

15. CCN: 092431, Memo Irving Tsang to Jack Yorgesen, "Request for Approval to Deviate from Basis of Design for Time to LFL Calculation," June 15, 2004, Bechtel National Inc., Richland Washington.

16. CCN: 092521, Memo Bret Yorgeson, to Rathini Pillai, "Hydrogen Generation Rates and Heat Loads," June 16, 2004, Bechtel National Inc., Richland Washington.

17. CCN: 096657, Memo Pete Lowry to Distribution, "PTF Hydrogen Mitigation Newtonian Vessels PJM Mixing," dated August 11, 2004, Bechtel National Inc., Richland Washington.

18. CCN: 099805, Letter JP Henschel to RJ Schepens, "Information on Managing Feeds that Could Generate Large Amounts of Hydrogen," dated October 1, 2004, Bechtel National Inc., Richland Washington.

19. 24590-WTP-M4C-V11T-00004, "Calculation of Hydrogen Generation Rates," March 18, 2004, Bechtel National Inc., Richland Washington.

20. 24590-WTP-M4C-V11T-00001, "Calculation of Time to Hydrogen Lower Flammability Limits," June 22, 2004, Bechtel National Inc., Richland Washington.

21. 24590-WTP-MRR-PT-02-010, Rev 0, Deng Y., "RPP Integrated System Plan Run 1C-Final Iteration Results," October 2002, Bechtel National Inc., Richland Washington.

22. 24590-PTF-RT-04-0003, Rev 0, "Hybrid Mixing System Test Data Supporting the Ultra-filtration Feed Process (UFP-VSL-00002A/2B), HLW Lag Storage (HLP-VSL-00027A/B), and HLW Blend (HLP-VSL-00028) Vessel Configurations," Bechtel National Inc., Richland Washington.

23. HNF-SD-WM-SP-012, Rev 3A, Kirkbride, R.A., et al, "Tank Farm Contactor Operation and Utilization Plan," September 2001, Numatec Hanford Corporation, Richland, Washington.

24. email from I. Papp to I. Tsang, "FW:PJM Meeting," March 18, 2004, Bechtel National Inc., Richland Washington.

25. 24590-WTP-ICD-MG-01-019, Rev. 3, "ICD-19- Interface Control Document for Waste Feed," August 15, 2003, Bechtel National Inc., Richland Washington.

26. 24590-G04T-F00G13 Rev 3, "System Description for the Pulse Jet Mixers and Supplemental Mixing Subsystems," May 17, 2004, Bechtel National Inc., Richland Washington.

27. 24590-WTP-PSAR-ESH-01-002-02, Rev 1a, "Preliminary Safety Analysis Report to Support Construction Authorization; PT Facility Specific Information," December 18, 2003, Bechtel National Inc., Richland Washington.

28. BNI "Statement of Work, HLW Vitrification Dynamic Pressure Modeling"

29. BNI Corrective Action Report, 24590-WTP-CAR-QA-03-226

30. 24590-HLW-Z0C-H01T-00002, "Design Basis Event HLW Process Vessel Overflow Calculations"

31. 04-TED-088, Letter R. J. Schepens (ORP) to E. S. Aromi (CHG), "Approval of HNF-3851, Empirical Rate Equation Model and Rate Calculations of Hydrogen Generation Rate for Hanford Waste, Revision 1," Office of River Protection, Richland, Washington.

Appendix A

DESIGN OVERSIGHT PLAN

REVIEW OF BNI HYDROGEN MITIGATION AND CONTROL SYSTEMS

August 30, 2004

U.S. Department of Energy, Office of River Protection

DESIGN OVERSIGHT PLAN

REVIEW OF BNI HYDROGEN MITIGATION AND CONTROL SYSTEMS

August 30, 2004

Design Oversight: D-04-DESIGN-CARS-6616

Team Lead: Don Alexander

Reviewer(s): Don Alexander

C K Liu

Langdon Holton

William Brasel

Jennifer Holland

Submitted by

Team Lead: ______________________ Date ______________

Concurrence:

WTP Engineering
Division Director: ______________________ Date ______________

Assistant Manager
Waste Treatment Plant: ______________________ Date ______________

1.0 Background, Purpose and Objectives

1.1 Background

The processing of tank wastes in the Waste Treatment Plant (WTP) facilities will be accompanied by the generation and release of hydrogen (H2) gas. In order to mitigate the potential for accumulations of H2 gas quantities that could lead to deflagrations or detonations, BNI has instituted a number of design constraints (e.g. waste mixing requirements and ventilation requirements) based on estimates of the "time to the lower flammability limit (LFL)." The assumptions used for, and the estimates of, the time to LFL have rapidly evolved over the last year. Therefore, a primary objective of this oversight is to review the uncertainties in the assumptions and calculated intervals to LFL. This review will not only attempt to verify that the assumptions and calculations are bounding, but will also attempt to determine if the assumptions and calculations are unnecessarily conservative and impact the operability of the WTP processes.

Hydrogen gas is believed to be readily released from Newtonian fluids. Substantial gas retention is believed to occur in non-Newtonian fluids (e.g. waste mixtures with solids concentrations greater than ~12 wt% solids) like those expected in nine key process vessels (e.g. UFP Feed Vessels, HLW Lag Storage Vessels, HLW Blend Vessel, HLW MFPV and HLW MFV vessels) within the Pretreatment facility. Based upon these key assumptions, an extensive R&T effort has been undertaken to provide a technical basis for mixing non-Newtonian fluids to assure that hydrogen gas is continuously released from the waste mixtures and will not exceed the LFL in these nine vessels. The appropriateness of these assumptions and the supporting R&T data will be evaluated.

Although the nine vessels in the Pretreatment and HLW Vitrification facility have long been acknowledged to process non-Newtonian slurries, other vessels may from time to time experience non-Newtonian (or H2 retaining) slurries under several remote scenarios: 1) overflow; 2) misrouted transfers; 3) and receipt of Newtonian slurries in the HLW and LAW feed receipt vessels from the tank farms that upon solids settling create localized non-Newtonian conditions.

Hydrogen monitoring and mitigation designs have also rapidly evolved for other Pretreatment systems, most notably the handling of hydrogen generated in the Cesium Ion Exchange (CXP) and Cesium Nitric Acid Recovery (CNP) systems. Other systems which handle hydrogen will be reviewed as a part of this oversight.

The development of a vessel mixing strategy for the final design for the non-Newtonian fluids was severely constrained by the capacity of the ventilation system. Therefore one of the objectives of this oversight will be to determine the adequacy of the ventilation systems of the WTP to continuously remove and maintain hydrogen from the headspace of the non-Newtonian vessels to levels below the LFL.

Finally, in a post-Design Basis Event (DBE) back-up air supply systems comprised largely of diesel generators and compressors will be relied upon to maintain and manage hydrogen accumulation below acceptable levels by providing active ventilation on the vessels and air sparging capability.

The oversight process will evaluate design calculations, R&T technical bases, operational planning, and the Integrated Safety Management Systems review process applied to the evaluation of hazards analysis to identify and quantify the operational strategies and procedures for hydrogen generation, accumulation and release.

1.2 Objectives

All of the following oversight objectives will be examined with respect to operability of the WTP and any impacts to WTP throughput:

1. Understand the requirements and assumptions for establishing the time to LFL for WTP normal-operations, and post-DBE conditions.

2. Determine to what extent might vessels other than the nine vessels in the Pretreatment and HLW Vitrification facility acknowledged to process non-Newtonian slurries, experience non-Newtonian slurries under the following scenarios: 1) overflow; 2) misrouted transfers; 3) and receipt of Newtonian slurries in the HLW and LAW feed receipt vessels from the tank farms that upon solids settling may have the potential to create localized non-Newtonian conditions.

3. Determine if a technical basis has been developed for the description of Newtonian and non-Newtonian fluids (e.g. H_2 gas releasing versus gas retaining), and determine if this definition is reasonable and has been consistently applied in the design.

4. Determine if the ventilation system can adequately support the operation of the facilities to meet plant requirements and mission objectives for H_2 mitigation in <u>normal operations</u> considering recent R&T data.

5. Determine if the ventilation system can adequately support the operation of the facilities to meet plant requirements and mission objectives for H_2 mitigation in <u>post Design Basis Event conditions</u> considering recent R&T data.

6. Determine if the design has accounted for all locations within the WTP requiring management and monitoring of H_2 (e.g., plant wash and drains vessel, cesium eluent recovery process system, other)

2.0 Process

This oversight shall be conducted shall be conducted within the guidelines of ORP PD 220.1X, Final Draft 2/5/03, "Conduct of Design Oversight."

2.1 Scope

This oversight shall include: 1) review of the time to LFL calculations; 2) review of "An Assessment of the Applicability of the Hu Model for Hydrogen Generation to the WTP" (Sherwood and Stock, 2004) especially with emphasis on the identification of system processes in the WTP flow sheet that must handle localized concentrations of hydrogen; and 3) system design descriptions. The emphasis of the design oversight shall be on the operability of the WTP and any impacts to WTP throughput.

2.2 Preparation

1. Identify the BNI Point of Contact for the Review

2. Review the calculations of "time to LFL" and how they are applied in the WTP design process.

3. Review background information as provided by BNI and identified through review of available design information.

4. Sample implementation of the program

5. Review current BNI open issues and the plans for and status of their resolution

In this regard, Table 1 lists information requested to be supplied by BNI to initiate this oversight.

2.3 Review and identify, resolve, or document issues

Evaluate the selected attributes and develop lines of inquiry and specific questions that are then explored with cognizant BNI personnel to meet the oversight objectives. This phase will be documented in summary tables as shown in Attachment 1, Appendix A. This effort will include participating in any applicable internal BNI reviews and discussions. The output from this phase of the oversight will be a completed summary table with BNI responses to the questions and lines of inquiry and a list of remaining open issues that need further evaluation by BNI for resolution.

2.4 Reporting

De-brief ORP and BNI management periodically as required and prepare a draft report that summarizes the activities, the results, conclusions and recommendations of the review. The draft report will be issued for review and comment of ORP management and cognizant BNI personnel. The final report will resolve comments received on the draft report.

3.0 Schedule of Activities

Table 2 summarizes the schedule for completion of this oversight.

4.0 Documentation

The final report of this task shall contain the sections and content as summarized in Attachment 1.

The open issues identified in this oversight shall be listed in the final report. Each open issue shall be assigned an item number and shall be tracked to resolution through CARS. These shall also be tracked to resolution by BNI through the CCN that will be assigned to the transmittal of the report from ORP to BNI. See Table 1, Attachment 1.

5.0 Closure

The Team Leader with concurrence of the Director shall confirm that the open items from this oversight are adequately resolved.

Table 1
Initial Information Requirements

1.	The process, procedures, and assumptions used in developing the calculation of "time to LFL" for normal operations and post-DBE's: • Process Vessels assumptions and calculations • CXP and CNP system assumptions and calculations • Determination of the occurrence of non-Newtonian conditions throughout the WTP
2.	Calculations of the "time to LFL" currently being used in the design of WTP systems, including vessels, process operations, and ventilation systems
3.	The technical bases for criteria used in the design of Hydrogen Mitigation and Control Systems (e.g., technical reports, testing results, vendor literature, industry experience).
4.	The analyses that provide a basis for the determination or lack thereof of non-Newtonian conditions throughout the WTP.
5.	Technical reports that assess the performance of selected systems to encourage the release hydrogen and removal of hydrogen.
6.	Calculations, testing, and engineering bases for the sizing of the ventilation systems to accommodate gas release in accordance with the "time to LFL" calculations."
7.	Roles and responsibilities for the management of Hydrogen Mitigation and Control Systems throughout the WTP.

Table 2
Schedule

Activity Description	Responsibility	Complete By
Develop Oversight Plan	Alexander	9/13/04
Identify Team members	Hamel/Alexander	9/13/04
Advise BNI of planned oversight and provide system oversight plan to identify needed BNI support	Hamel/Alexander	9/13/04
Meet with BNI Discipline Engineering Managers to outline objectives and become familiar with BNI design approach	Team	9/15//04
Obtain documents from BNI	Team	9/15/04
Review BNI documents, participate in relevant BNI internal meetings and meet with BNI as required	Team	9/29/04
Prepare Design Oversight Report	Team	10/6/04
ORP and BNI review of report	ORP and BNI	10/14/04
Resolve comments and issue final report including close out with BNI	Team	10/20/04

Attachment 1

Design Oversight Report Outline

The design oversight report should have the following sections, as appropriate:

Cover Page – The cover page includes dates of the design oversight, the report number, the names of the participating oversight reviewer(s) and the name of the ORP design oversight leader who reviewed and approved the report. See Attachment.

Executive Summary – The executive summary of this design oversight should describe the design products reviewed, review meetings attended and present the significant strengths and weaknesses. The summary should provide a conclusion on the adequacy of the design products/processes reviewed, identify significant open issues and the mechanism for tracking resolution of these issues by BNI.

Report Outline

1. INTRODUCTION

Summarizes the activity, schedule, purpose, scope and methods of review

2. BACKGROUND

Similar to the Background Section of the Design Oversight Plan

3. OBJECTIVES, SCOPE AND APPROACH

3.1 Objectives

Lists the objectives from the Design Oversight Plan

3.2 Scope

Summarizes the areas, systems, components, etc, reviewed in the oversight. This is similar to the Scope section of the Design Oversight Plan

3.3 Approach

In the same format as the Design Oversight Plan, summarizes the actual work performed as part of this oversight, e.g., documents reviewed (refers to references and Appendix A), actual meetings held with BNI, BNI meetings attended, preparation of preliminary draft for BNI review and comment, etc.

4. RESULTS

This section contains the significant results of the review including detailed description of the bases and recommendations for resolution of Open Issues identified in this review. The Open Issues *should be sequentially numbered in this discussion in the order listed in* Table 1, see below.

This section should be subdivided such that there is a subsection for each objective:

4.1 *Objective 1*

4.2 Objective 2

5. RECOMMENDATIONS

Summary of recommendations for action by BNI and ORP to ensure that open issues are resolved and plans for future oversight reviews.

6. REFERENCES

Principal references used in the oversight. Note that the majority of references will be contained in the reviewer summaries contained in Appendix A.

Table 1

Summary of Open Issues from the Design Oversight of the BNI Process for Selection of Materials of Construction

Item No[5]	CARS No	Open Issue Summary	Recommendation for Resolution
1.		*Summary of the Issue. This discussion should include the Section and item number reference where the detailed discussion of this issue is located within the main body of the report.*	*Summary of the recommended action to resolve the issue. This discussion should also include the Section and item number reference where the detailed discussion of the recommendation is located within the main body of the report.*

This table is the summary of Open Issues identified in the review and recommendations for BNI resolution of the issues. The listing of each open issue should include a short summary of the issue and the recommended action referenced back to the section of the report that contains the detailed discussion of the issue, e.g, Section 4.1.1, item a. Each item will be assigned an item number and CARS tracking number. It is expected that BNI will also track resolution of these issues via the CCN tracking number assigned to the transmittal of this report from ORP to BNI.

[5] Item No – Each item shall be identified with a unique number and entered into the CARS database for tracking to resolution.

APPENDIX A

(Note: This appendix contains the detailed results of the review. In addition to the responses to *the questions and lines of inquiry explored during the oversight this appendix may also contain* relevant minutes of meetings between BNI and ORP conducted as part of this review. This is typically a substantial document and is transmitted and handled as a separate document. The following is the format of this appendix.)

RESPONSES TO ORP QUESTIONS AND LINES OF INQUIRY
DESIGN OVERSIGHT
{System or area of review}

{Date}

The following questions (lines of inquiry) were developed by ORP as part of the design oversight of the process for selection of materials of construction (and the referenced documents). They are grouped into the following categories:

A. ...
B. ...

{Note: Categories of questions may include or pertain to, for example; Design Status Design Status, Design Requirements, System Descriptions, Calculations, System Descriptions, Modeling, R&T Program, Technical Performance, Additional Questions after the initial discussions with BNI, BNI Resolution of Action Items developed in Multi-Discipline Design Reviews or other meetings. Categories may also include minutes of meetings.}

The questions are arranged into tables and organized into five columns, which are:

Question - The question or line of inquiry raised by ORP.
Comment - Additional information supplied by ORP to clarify the question.
Response - The BNI response to the question.
Cognizant Discipline - The discipline within BNI that has the primary information on the response.
Group - Questions are categorized into three groups:

A. Questions that have complete responses.

B. Questions related to design information not yet available because of current status of the design. Dates for completion will be provided by {Date to be provided by BNI}.

C. Questions related to alternate system designs, off-design conditions, or actions outside the current scope of work. Partial responses have been provided. No additional work to resolve these questions is planned. Significant effort is expected to resolve these questions and may have significant project cost/schedule impacts.

A. {First category of question}

Question	Comment	Response	Cognizant Discipline	Group

B. {Second category of question}

Question	Comment	Response	Cognizant Discipline	Group

Attachment – Report Cover Page

U.S. Department of Energy, Office of River Protection

{Title of Oversight}
ORP Design Oversight Report

{Date}

Design Oversight: ______________________

Team Lead: ______________________
{Name}

Reviewers: ______________________
{Name}

____
{Name}

____
{Name}

____
{Name}

Concurrence: ______________________
William F. Hamel, Director
WTP Engineering Division

Approved: ______________________
John Eschenberg, Project Manager
Waste Treatment Plant

E-STARS™ Report
Task Detail Report
11/22/2004 0743

TASK INFORMATION

Task#	ORP-WTP-2004-0169		
Subject	CONCUR: (04-WED-063) TRANSMITTAL OF DOE ORP DESIGN OVERSIGHT REPORT ON HYDROGEN MITIGATION & CONTROL SYSTEMS, D-04-DESIGN-007		
Parent Task#		**Status**	CLOSED
Reference	04-WED-063/ CARS #6616	**Due**	
Originator	Almaraz, Angela	**Priority**	High
Originator Phone	(509) 376-9025	**Category**	None
Origination Date	10/14/2004 0751	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal

Instructions

Hard copy of the correspondence is being routed for concurrence. Once you have reviewed the correspondence, please approve or disapprove via E-STARS and route to the next person on the list. Thank you.

bcc:
MGR RDG File
WTP OFF File
J. J. Short, OPA
D. H. Alexander, WED
W. F. Hamel, WED
T. A. Shrader, WED
B. L. Nicoll, WPD
J. R. Eschenberg, WTP
CK Liu, WTP
L. F. Miller, WTP
S. J. Olinger, OEP

ROUTING LISTS

1 Route List — Inactive

- Hamel, William F - Review - Concur with comments - 11/04/2004 1108
- Eschenberg, John R - Review - Concur with comments - 11/19/2004 1447
- Schepens, Roy J - Approve - Approved - 11/22/2004 0728
- Alexander, Donald H - Review - Cancelled - 11/22/2004 0745

ATTACHMENTS

Attachments

1. 04-WED-063.LKH.Attachment.doc
2. 04-WED-063.LKH.Design Oversight.doc

COMMENTS

Poster Hamel, William F (Almaraz, Angela) - 11/04/2004 1111

Concur

Bill signed the hard copy on 10/25/04

Poster Eschenberg, John R (Almaraz, Angela) - 11/19/2004 0211

Concur

John signed the hard copy on 11/19/04

Poster Almaraz, Angela (Almaraz, Angela) - 11/22/2004 0711

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CLOSED

Don signed the hard copy on 10/14/04

TASK DUE DATE HISTORY

No Due Date History

SUB TASK HISTORY

No Subtasks

-- end of report --

E-STARS™ Report
Task Detail Report
10/14/2004 0930

TASK INFORMATION

Task#	ORP-WTP-2004-0169		
Subject	CONCUR: (04-WED-063) TRANSMITTAL OF DOE ORP DESIGN OVERSIGHT REPORT ON HYDROGEN MITIGATION & CONTROL SYSTEMS, D-04-DESIGN-007		
Parent Task#		**Status**	Open
Reference	04-WED-063/ CARS #6616	**Due**	
Originator	Almaraz, Angela	**Priority**	High
Originator Phone	(509) 376-9025	**Category**	None
Origination Date	10/14/2004 0751	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal

Instructions

Hard copy of the correspondence is being routed for concurrence. Once you have reviewed the correspondence, please approve or disapprove via E-STARS and route to the next person on the list. Thank you.

bcc:
MGR RDG File
WTP OFF File
J. J. Short, OPA
D. H. Alexander, WED
W. F. Hamel, WED
T. A. Shrader, WED
B. L. Nicoll, WPD
J. R. Eschenberg, WTP
CK Liu, WTP
L. F. Miller, WTP
S.J. Olinger, DEP

ROUTING LISTS

1 Route List — Active

- Hamel, William F - Review - Awaiting Response NP 10/25/04
- Eschenberg, John R - Review - Awaiting Response Comments (O4) 11/7 JY
- Schepens, Roy J - Approve - Awaiting Response
- Alexander, Donald H - Review - Awaiting Response DA 10/14/04

ATTACHMENTS

Attachments
1. 04-WED-063.LKH.Attachment.doc
2. 04-WED-063.LKH.Design Oversight.doc

COMMENTS

No Comments

TASK DUE DATE HISTORY

No Due Date History

SUB TASK HISTORY

No Subtasks

-- end of report --

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