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# ENGINEERING CHANGE NOTICE



1. ECN 664027

Proj. ECN

| 2. ECN Category (mark one) | 3. Originator's Name, Organization, MSIN, and Telephone No. | 4. USQ Required? | 5. Date |
|---|---|---|---|
| Supplemental [X] | W.H. Grams/Safety Analysis/ R1-44/373-7308 | [ ] Yes [X] No | November 15, 2000 |
| Direct Revision [ ] | 6. Project Title/No./Work Order No.: Interim Stabilization | 7. Bldg./Sys./Fac. No.: Salt Well Pumping | 8. Approval Designator: N/A |
| Change ECN [ ] | | | |
| Temporary [ ] | | | |
| Standby [ ] | 9. Document Numbers Changed by this ECN (includes sheet no. and rev.): RPP-6954, Rev. 0 | 10. Related ECN No(s).: N/A | 11. Related PO No.: N/A |
| Supersedure [ ] | | | |
| Cancel/Void [ ] | | | |

| 12a. Modification Work | 12b. Work Package No. | 12c. Modification Work Completed | 12d. Restored to Original Condition (Temp. or Standby ECNs only) |
|---|---|---|---|
| [ ] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d) | N/A | N/A — Design Authority/Cog. Engineer Signature & Date | N/A — Design Authority/Cog. Engineer Signature & Date |

13a. Description of Change — 13b. Design Baseline Document? [ ] Yes [X] No

This revision documents additional hazards identified when the scope was changed to include the Crane Chempump®. There were three hazardous conditions identified specific to the Crane Chempump®. Of these, one related to a flammable gas deflagration in the SST headspace had a high consequence but did not require any controls due to the low frequency. Another, related to a flammable gas deflagration in the transfer line, required no controls due to a low consequence and frequency. The third hazardous condition, related to the Fire in Contaminated Area accident, was found to bounded by the representative accident.

Also added by this revision is an evaluation of the gas generation in the Crane Chempump® presented in appendix D. Analyzed is gas generation caused by the reaction of caustic solutions or tank waste with the aluminum components of the rotor in the electric motor.

| 14a. Justification (mark one) | 14b. Justification Details |
|---|---|
| Criteria Change [X] | This change documents the hazard identification and evaluation related to new information concerning damaged rotor housings reacting chemically with caustic solutions and generating hydrogen gas. This change also documents the control allocation/decision process for these hazardous conditions. |
| Design Improvement [ ] | |
| Environmental [ ] | |
| Facility Deactivation [ ] | |
| As-Found [ ] | |
| Facilitate Const. [ ] | |
| Const. Error/Omission [ ] | |
| Design Error/Omission [ ] | |

| 15. Distribution (include name, MSIN, and no. of copies) | RELEASE STAMP |
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| See attached distribution sheet. | NOV 16 2000 DATE STA: 4 HANFORD RELEASE ID: 4 |

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1. ECN (use no. from pg. 1)

| 16. Design Verification Required | 17. Cost Impact — ENGINEERING | | 17. Cost Impact — CONSTRUCTION | | 18. Schedule Impact (days) | |
|---|---|---|---|---|---|---|
| ☐ Yes | Additional ☐ | $ | Additional ☐ | $ | Improvement ☐ | |
| ☒ No | Savings ☐ | $ | Savings ☐ | $ | Delay ☐ | |

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

| | | | | | |
|---|---|---|---|---|---|
| SDD/DD | ☐ | Seismic/Stress Analysis | ☐ | Tank Calibration Manual | ☐ |
| Functional Design Criteria | ☐ | Stress/Design Report | ☐ | Health Physics Procedure | ☐ |
| Operating Specification | ☐ | Interface Control Drawing | ☐ | Spares Multiple Unit Listing | ☐ |
| Criticality Specification | ☐ | Calibration Procedure | ☐ | Test Procedures/Specification | ☐ |
| Conceptual Design Report | ☐ | Installation Procedure | ☐ | Component Index | ☐ |
| Equipment Spec. | ☐ | Maintenance Procedure | ☐ | ASME Coded Item | ☐ |
| Const. Spec. | ☐ | Engineering Procedure | ☐ | Human Factor Consideration | ☐ |
| Procurement Spec. | ☐ | Operating Instruction | ☐ | Computer Software | ☐ |
| Vendor Information | ☐ | Operating Procedure | ☐ | Electric Circuit Schedule | ☐ |
| OM Manual | ☐ | Operational Safety Requirement | ☐ | ICRS Procedure | ☐ |
| FSAR/SAR | ☐ | IEFD Drawing | ☐ | Process Control Manual/Plan | ☐ |
| Safety Equipment List | ☐ | Cell Arrangement Drawing | ☐ | Process Flow Chart | ☐ |
| Radiation Work Permit | ☐ | Essential Material Specification | ☐ | Purchase Requisition | ☐ |
| Environmental Impact Statement | ☐ | Fac. Proc. Samp. Schedule | ☐ | Tickler File | ☐ |
| Environmental Report | ☐ | Inspection Plan | ☐ | | ☐ |
| Environmental Permit | ☐ | Inventory Adjustment Request | ☐ | | ☐ |

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

| Document Number/Revision | Document Number/Revision | Document Number/Revision |
|---|---|---|
| N/A | N/A | N/A |

21. Approvals

| | Signature | Date | | Signature | Date |
|---|---|---|---|---|---|
| Design Authority | | | Design Agent | | |
| Cog. Eng. | G.L. Jones, R1-44 [signature] | 11/15/00 | PE | | |
| Cog. Mgr. | R.J. Cash, R1-44 [signature] | 11/15/00 | QA | | |
| QA | | | Safety | | |
| Safety | | | Design | | |
| Environ. | | | Environ. | | |
| Other | | | Other | | |
| Safety Analysis | W.H. Grams R1-44 [signature] | 11/15/00 | | | |

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

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| To | From | Page 1 of 1 |
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| Distribution | W. H. Grams | Date November 15, 2000 |
| Project Title/Work Order | | EDT No. |
| RPP-6954, Rev.1, Hazard Evaluation for the Salt Well Chempump and a Salt Well Pump Design Using Service Water For Lube. and Cooling | | ECN No. 664027 |

| Name | MSIN | Text With All Attach. | Text Only | Attach./ Appendix Only | EDT/ECN Only |
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# HAZARD EVALUATION FOR THE SALT WELL CHEMPUMP® AND A SALT WELL CENTRIFUGAL PUMP DESIGN USING SERVICE WATER FOR LUBRICATION AND COOLING

**W. H. Grams**
CH2M HILL Hanford Group, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

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Key Words: Hazards, Hazard Analysis, Salt Well Pumping, Pump, Single-Shell Tanks, Authorization Basis, Tank Waste Remediation System, Crane Chempump

Abstract: This report documents results of a preliminary hazard anlaysis (PHA) covering the existing Crane Chempump and the new salt well pumping design. Three hazardous conditions were identified for the Chempump and ten hazardous conditions were identified for the new salt well pump design. Also presents the results of the control decision/allocation process. A backflow preventer and associated limiting condition for operation were assigned to one hazardous condition with the new design.



11/16/00

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RPP-6954
Revision 1

# Hazard Evaluation for the Salt Well Chempump® and a Salt Well Centrifugal Pump Design Using Service Water for Lubrication and Cooling

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
*Hanford Group, Inc.*
Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC06-99RL14047

RPP-6954
Revision 1

# Hazard Evaluation for the Salt Well Chempump® and a Salt Well Centrifugal Pump Design Using Service Water for Lubrication and Cooling

W. H. Grams
CH2M HILL Hanford Group, Inc.

Date Published
November 2000

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC06-99RL14047

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A-7320-005 (10/97)

# HAZARD EVALUATION
# FOR THE
# SALT WELL CHEMPUMP®
# AND A
# SALT WELL CENTRIFUGAL PUMP DESIGN
# USING SERVICE WATER FOR LUBRICATION AND COOLING

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## APPENDICES

## TABLES



## FIGURES

## TERMS

| | |
|---|---|
| AB | Authorization Basis |
| AC | Administrative Control |
| AIChE | American Institute of Chemical Engineers |
| AWF | aging waste facility |
| CAM | Continuous Air Monitor |
| Cat | category |
| Con | consequence |
| DCRT | Double-Contained Receiver Tank |
| DST | double-shell tank |
| Env | environmental |
| Freq | Frequency |
| FSAR | Final Safety Analysis Report |
| gal | gallon(s) |
| GRE | gas release event |
| Grp | group |
| HEPA | high efficiency particulate air [filter] |
| hr | hour |
| ID | identification |
| KPa | kilopascals |
| LCO | Limiting Condition for Operation |
| MAR | Material at Risk |
| Mit | mitigative |
| NC | No Controls |
| PA | Pennsylvania |
| P & ID | Piping and Instrumentation Diagram |
| PHA | Preliminary Hazards Analysis |
| Prev | preventive |
| psig | pounds per square inch gage |
| Rep Acc | representative accident |
| RPP | River Protection Project |
| SSC | structures, systems, and components |
| SST | single-shell tank |
| SWP | salt well pumping |
| TSR | Technical Safety Requirement |

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# 1.0 INTRODUCTION

## 1.1 PURPOSE

The River Protection Project (RPP) Authorization Basis (AB) Technical Safety Requirements (TSR) [CHG 2000a] contains controls that address salt well pumping and waste transfers. Currently, the design of salt well pumping (SWP) equipment uses a process lubricated centrifugal pump. The purpose of this document is to record the hazardous conditions identified during the Preliminary Hazards Analysis (PHA) of the existing Crane Chempump®[1] and a new SWP design and to evaluate the relationship to the hazardous conditions currently included in the AB as documented in the hazard analysis database (CHG 2000b). Also provided in this document is a description of the process and the results of the subsequent control decision/allocation meetings.

This document is not intended to authorize the activity. It documents the results of the hazard identification process and subsequent control decision process as defined in the AB. The hazard identification/evaluation process is used to determine the adequacy of controls and whether the proposed activity is within the AB. This hazard evaluation does not constitute an accident analysis.

## 1.2 BACKGROUND

The SWP process uses an integral motor/centrifugal pump and separate jet pump (foot valve). The motive power for the pumping process is provided by a centrifugal pump/induction motor unit that is located on top of the salt well screen assembly in an single-shell waste tank pump pit. The pump and motor assembly, as currently procured for SWP, is rated for, or otherwise qualifies for, service in Ignition Control Set 2 environments. The current design uses a series G, Chempump®manufactured by the Chempump® Division of Crane Pumps and Systems, Inc., Warrington, PA. This pump design is process fluid lubricated and cooled; i.e., the salt well liquid is circulated through the pump/motor to provide both lubrication and cooling. Recent SWP operations have been hampered by problems with this design. During SWP operations, the jet pump, foot valve, or other equipment may be clogged with salt crystals or other debris. One method of restarting pump flow is to place the SWP system into recirculation mode and then flush with a clean caustic solution. A recent attempt to restart flow using a caustic flush resulted in hydrogen gas being generated from the caustic reacting with internal aluminum components of the rotor. It was determined that waste salt crystallization in the pump caused a hydraulic imbalance allowing the rotor to exert significant force on the axial thrust surfaces. A hole wore through the stainless steel rotor canister end cap allowing the caustic solution to come in contact with the aluminum, which generated aluminum hydroxide and hydrogen gas. This was detected when pump pressure increased without the pump running. To remedy this situation the motor was locked out and the gas was allowed to bleed back to the tank. The new SWP centrifugal pump design addresses these problems.

[1] Chempump is a trademark of the Crane Co.

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# 2.0 DESCRIPTION OF SALT WELL PUMPS

## 2.1 DESCRIPTION OF CRANE CHEMPUMP®

The Crane Chempump® is a combination centrifugal pump and a squirrel cage induction electric motor, built together into a single hermetically sealed unit. The rotor assembly is a squirrel cage induction rotor consisting of a machined corrosion resistant shaft, laminated core with aluminum bars and end rings, two corrosion resistant end covers, and a corrosion resistant can. The rotor end covers are welded to the shaft and also to the rotor can which encapsulates and hermetically seals the rotor core from contact with the salt well liquid. The pump impeller is mounted on one end of the rotor shaft, which extends from the motor section into the pump casing. The rotor is submerged in the salt well fluid with the stainless steel can providing isolation from the fluid. Submersion of the rotating parts of the motor provide cooling and lubrication. A small portion of the salt well liquid is allowed to recirculate through the rotor cavity to cool the motor and lubricate the bearings. The Chempump® rotor rides on two bearings. During operation, the hydrodynamic forces center the rotor, keeping it away from the axial thrust surfaces. During SWP operations, the jet pump, foot valve, or other equipment may be clogged with salt crystals or other debris. One method of restarting pump flow is to place the SWP system into recirculation mode and then flush with caustic.

## 2.2 DESCRIPTION OF NEW CENTRIFUGAL PUMP

The replacement pump system utilizes a canned rotor pump, which is specifically designed to pump waste slurry. A piping and instrumentation diagram is shown in Figure 1 indicating equipment that changed from the previous design.

The new pumping system utilizes heated filtered water as bearing lubrication and motor cooling. The existing SWP dilution system is used to provide a source of heated, filtered water to the new design pump. Upgrades to the dilution system include adding a new design pump with a similar metering pump capable of developing higher pressures, and installation of a raw water filtering system upstream of the dilution tank to provide clean water to the new salt well pump. Additional instrumentation to support operation of the new salt well pump includes a remote bearing monitor, a pump power monitor, and stator winding resistance temperature detectors. A backflow preventer is installed to prevent backflow of tank waste into the pump flush water supply (service water system).

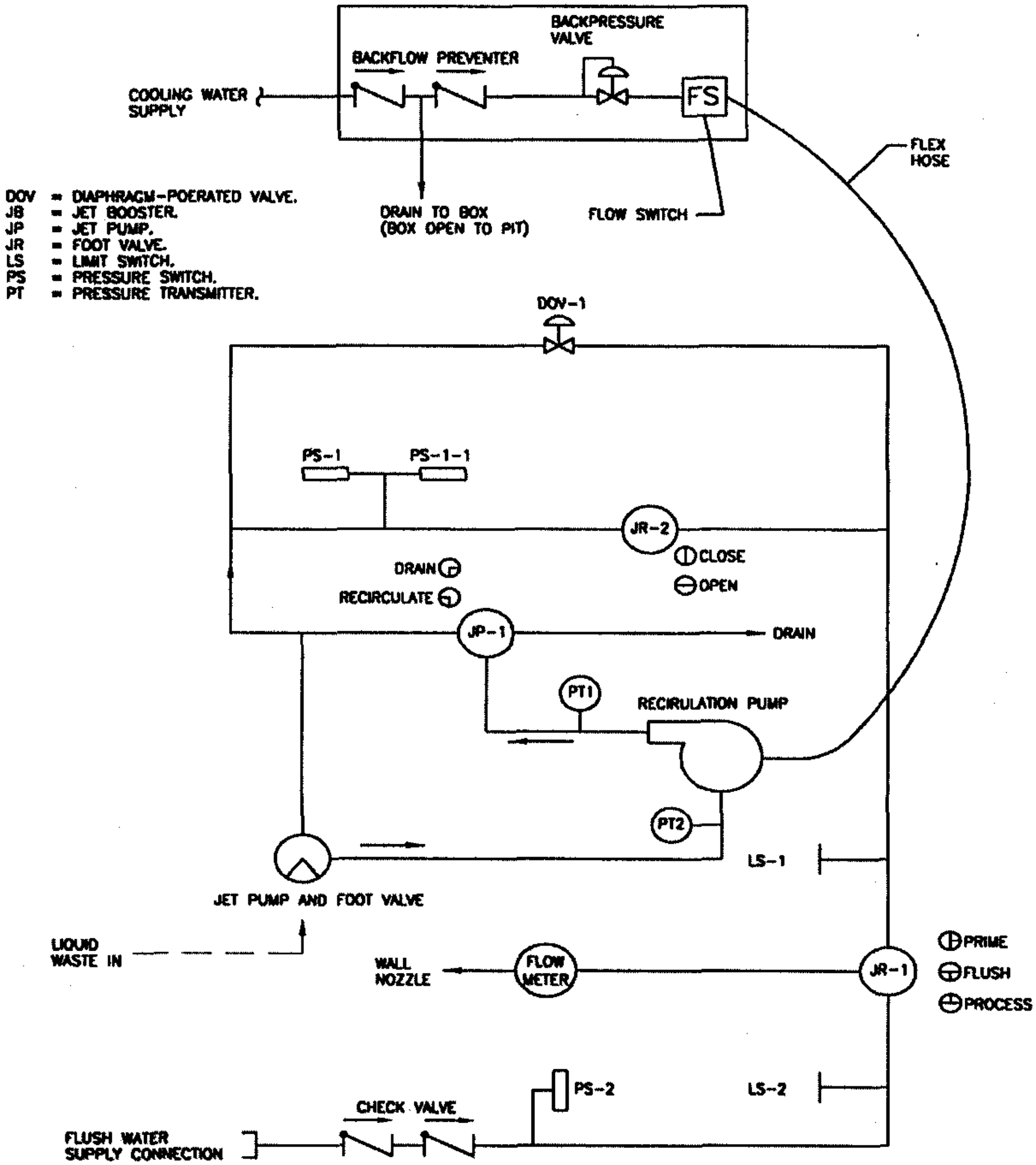
The following are the design attributes that were specifically evaluated in the hazard identification process:

The pump rotor has aluminum components and is fully encapsulated in stainless steel;

- The pump includes thrust washers which prevent shaft bearings from contacting the rotor can in the event of a thrust imbalance;
- The pump is cooled and lubricated with heated and filtered service water;

- The cooling fluid exits into the waste stream through the pump motor front bearing;
- The cooling water metering pump is capable of delivering 318 liters/hour (84 gal/hr) with normal injection rates of 1.14 to 2.27 liters/hour (0.3 to 0.6 gal/hr);
- The cooling water supply from the filter skid to the backflow preventer is SS, heat traced hard piping;
- The cooling line from the exit of the backflow preventer/back pressure valve assemble to the pump is flexible hose; and
- A relief valve is installed downstream of the new metering pump set to relieve at 1206 kPa (175 psig).

**Figure 1. Piping and Instrument Diagram for New Salt Well Pump.**




SALT WELL PUMP PIPING AND INSTRUMENT DIAGRAM

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## 3.0 HAZARD IDENTIFICATION AND EVALUATION

The hazards identification and evaluation of the new process water cooled and lubricated pump design for SWP used the Preliminary Hazards Analysis (PHA) method. The PHA consisted of a systematic brainstorming process, which included the following:

- Postulating hazards associated with the new pump design;
- Estimating the frequencies and consequences of the hazardous conditions; and
- Identifying the possible mitigative and preventive measures for each postulated hazardous condition.

The American Institute of Chemical Engineers in their publication "Guidelines for Hazard Evaluation Procedures," (AIChE 1992) recognizes the PHA process as a creditable method of hazard evaluation. A multi-disciplinary team records the results of this brainstorming process using a tabular format. The depth of the PHA is directly related to the experience and knowledge of the participants. A short resume of each team member is included in Appendix A to document the experience and knowledge of the PHA team.

### 3.1 METHODOLOGY

The PHA team met to develop the raw data. Initially, the team only considered the hazards associated with the new salt well pump design. The scope of the PHA was expanded and a PHA meeting was later reconvened to address the hazards associated with operation of the existing Chempump®. The information was recorded systematically in tabular format. The following sections describe the PHA table structure and details for recording information. The PHA was structured to ensure a systematic and thorough evaluation of the potential hazards. The PHA captured the following information:

- **Item ID:** The item identification (ID); used to record a unique identifier for the hazardous condition.

- **Location/Activity:** Specific point in the system or process where the deviation from the desired condition of a process variable is evaluated.

- **Hazardous Condition:** The hardware failures, operational faults, or conditions that could result in undesired consequences during waste transfer activities.

- **Candidate Causes:** The causes leading to the Hazardous Condition. Identifying causes is important when determining potential existing engineering and administrative features for significant hazardous conditions as well as potential consequences. In many cases, multiple hardware or operational faults are required to produce a hazardous condition. This column identifies the sequence of hardware and operational faults required to produce the postulated hazardous condition.

- **Material at Risk:** The material, which could be released in an associated accident.

- **Immediate Consequence:** The potential consequences that could result from the postulated hazardous condition.

- **Engineered Safety Features:** Existing engineered features (hardware items) identified by the PHA team that have the potential to mitigate or prevent the hazardous condition of concern. The engineered features are candidates for designation as Safety-Significant items for hazardous conditions that pose a significant threat to the health of facility workers and onsite personnel or Safety-Class for hazards that pose a significant threat to offsite individuals. These items should not be construed as being the "official" controls that would eventually be credited in the AB.

- **Administrative Safety Features:** Technical Safety Requirements and other existing controls identified by the PHA team that have the potential to mitigate or prevent the hazardous condition of concern. These items should not be construed as being the "official" administrative features that would eventually be credited in the AB.

- **Consequence Category No Controls (Con Cat NC):** The consequence ranking is a "first cut," qualitative estimate of the safety severity of the consequences assuming no controls are present. The following system is used:

| | |
|---|---|
| S0 | Negligible safety concerns for the facility worker. |
| S1 | Potential industrial injury, low radiological dose consequences or chemical exposure to the facility worker. |
| S2 | Potential significant radiological dose consequences or chemical exposure to onsite workers located outside the facility. |
| S3 | Potential significant radiological dose consequences or chemical exposure to the offsite population. |

- **Frequency Category No Controls (Freq Cat NC):** The frequency category is a "first cut," qualitative estimate of the likelihood of the hazardous condition assuming no controls are present. The following system is used:

| | |
|---|---|
| F3 | Events that are expected to occur one or more times during the lifetime of the facility, categorized as "anticipated" events. The frequency range associated with this category is greater than 1E-02/yr. |
| F2 | Events that could occur during the lifetime of the facility, but with low probability. Such events are categorized as "unlikely" and fall in the range of 1E-04/yr to 1E-02/yr. |
| F1 | Events not expected to occur during the lifetime of the facility, categorized as "extremely unlikely." The frequency range associated with this category is 1E-06/yr to 1E-04/yr. |
| F0 | Events categorized as "beyond extremely unlikely," with a frequency less than 1E-06/yr. Events in this category (such as a meteor strike) are so unlikely they generally do not require special controls. |

- **Environmental Category (Env Cat):** The environmental consequence ranking is a "first cut," qualitative estimate of the environmental severity of the hazardous condition assuming no controls are present. The following system is used:

| | |
|---|---|
| E0 | No significant environmental effect outside the facility confinement systems. |
| E1 | Limited environmental discharge of hazardous material outside the facility. |
| E2 | Large environmental discharge of hazardous material within the plant site boundary. |
| E3 | Significant environmental discharges of hazardous material outside the plant site boundary. |

- **Remarks:** Miscellaneous observations or clarifying comments for a given item.

## 3.2 MAJOR ASSUMPTIONS

The following assumptions were used during the hazard identification process:

- A rotor canister breach as well as a backflow of waste or flush solution is required to allow caustic solution to come in contact with aluminum components of the pump.
- The pump design is appropriate for use with tank waste.
- The aluminum/caustic reaction will develop sufficient pressure to cause hydrogen to escape in the recirculation (closed loop) mode.
- Cooling water (filtered service water) is limited to flows from 1.14 to 3.03 liters per minute (0.3 to 0.8 gpm) by the metering pump
- The cooling water metering pump is capable of a maximum delivery of 318 liters/hour (84 gal/hr).
- The operating pressures, approximately 345 kPa (50 psi) in the volute of the new salt well pump, are sufficient to allow backflow of waste through the cooling water supply line.
- SSTs suitable for salt well pumping are not likely to experience large gas release events.
- The throttle bushing (front near impeller) will restrict flow in the reverse direction.

## 3.3 EVALUATION

Ten hazardous conditions associated with the new SWP pump design and three hazardous conditions associated with the Chempump® were identified by the PHA team. These hazardous conditions are presented in Table 3-1. The table includes the following information: Item ID, Location/Activity, Hazardous Condition, Candidate Cause, Material at Risk, Immediate Consequence, Engineered Safety Features, Administrative Safety Features, Consequence Category No Control, Frequency Category No Control, and remarks. The qualitatively assigned consequence (severity) of the 10 hazardous conditions assigned by the PHA team resulted in the following totals for each consequence category:

| | |
|---|---|
| 0 | S0, Negligible safety concerns for the facility worker; |
| 1 | S1, Potential industrial injury, low radiological dose consequences or chemical exposure to the facility worker; |

6 S2, Potential significant radiological dose consequences or chemical exposure to onsite workers located outside the facility; and

3 S3, Potential significant radiological dose consequences or chemical exposure to the offsite population.

Following the initial PHA deliberations, a control decision/allocation team was impaneled. The control decision/allocation team roster and short resumes are presented in Appendix B. The initial step during the control decision meeting is to review the results of the PHA. This review identified three hazardous conditions where the frequency of occurrence was revised. The changes (see Table 3-1) that resulted from this review are:

- **ID# NEWSWP-01**: The frequency changed from F3 to F2 based on the need for multiple failures to initiate the hazardous condition.
- **ID# NEWSWP-02:** The frequency changed from F1 to F0 based on additional details of the design which revealed that the re-circulation loop could not be pressurized, eliminating the cause of a piping failure and subsequent release of flammable gas.
- **ID# NEWSWP-10:** The frequency changed from F2 to F0 based upon the team consensus that the failure of the backflow preventer, such that waste could leak to the surface, was not credible.

Table 3.2 lists hazardous conditions identified during the PHA as revised by the control allocation team. This listing is further sorted according to consequences in Table 3-3.

Table 3-4 provides a mapping of the hazardous conditions identified for the new SWP design to the analyzed representative accidents as described in the Tank Waste Remediation System Final Safety Analysis Report (FSAR) [CHG 2000c]. The information presented in this table includes the BIN, Item ID, Material at Risk, Hazardous Condition, Cause, Initial Frequency No Controls, Initial Safety Consequence No Controls, Cause Group, and Representative Accident. The information not previously defined is:

- **BIN**: A code that describes the release attributes for high Safety Consequences (S2 or S3) and Worker (S1) with anticipated frequency (F3) hazardous conditions.
- **Cause Group (Cause Grp):** – An alpha/numeric code used to permit sorting of data by the cause of the hazardous conditions.
- **Representative Accident (Rep Acc):** Representative Accident – An alpha/numeric code used to specify the analyzed accident in the FSAR. Only hazardous conditions with high Safety Consequence (S2 or S3) are assigned to representative accidents.

Included with the hazardous conditions identified for the new salt well pump design are the hazardous conditions identified as being represented by the analyzed accident. The breakdown for Table 3-4 shows:

2 hazardous conditions are related to Flammable Gas Deflagrations – SST (Rep Acc 05)

1 hazardous condition is related to Fire in Contaminated Area (Rep Acc 07)

1 hazardous condition is related to Tank Failure Due to Excessive Loads (Rep Acc 12)

1 hazardous condition is related to Waste Transfer Leak Into Structure (Rep Acc 33A)

4 hazardous conditions are related to Waste Transfer Leak Due To Misroute (Rep Acc 33D)

There was one hazardous condition related to worker safety (minor exposure or environmental release) that is not mapped to a representative accident.

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**Table 3-1. Salt Well Pumping New Pump Design Hazardous Conditions As Initially Identified. (7 pages)**

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-01 | SWP/New Pump | Release of toxic or radioactive aerosols to atmosphere from SST pump pit due to flammable gas deflagration in pit | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the pit with ignition source [Caustic Flush Activity] | SST Waste contamination in pump pit | Fire in pump pit burns paint and releases radioactive contaminants to atmosphere | Back-flow preventer in cooling water supply line<br><br>Flow switch interlock for cooling water supply system<br><br>Cooling water supply supplied at higher pressure than pump operation<br><br>High motor temperature trip interlock<br><br>Throttle bushing limits backflow into rotor area<br><br>Pump design has thrust washers that prevent rotor contact with pump bearings<br><br>Pump has bearing wear monitor and alarm | Procedures for pump operation (water supply on, motor temperature OK, backflow preventer verified, caustic only added when pump running, and continuous pump monitoring during caustic flush)<br><br>AC 5.10 Ignition Source Control Requirements<br><br>AC 5.11 Flammable Gas Monitoring | S2/E2 | F3 | A rotor canister breach is required to allow OH to come into contact with Al metal.<br><br>It is assumed that the pump design is appropriate for use with tank waste.<br><br>Al-OH reaction assumed to pressurize the line sufficiently to cause hydrogen escape.<br><br>Pump is not process cooled or lubricated (design feature). |

## Table 3-1. Salt Well Pumping New Pump Design Hazardous Conditions As Initially Identified. (7 pages)

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-02 | SWP/New Pump | Release of toxic or radioactive aerosols to atmosphere from SST tank headspace due to flammable gas deflagration in tank head space | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the tank headspace with ignition source [Caustic Flush Activity] | SST Waste | Fire/deflagration in SST with high energy release of toxic or radioactive material | Back-flow preventer in cooling water supply line<br><br>Flow switch interlock for cooling water supply system<br><br>Cooling water supply supplied at higher pressure than pump operation<br><br>High motor temperature trip interlock<br><br>Throttle bushing limits backflow into rotor area<br><br>Pump design has thrust washers that prevent rotor contact with pump bearings<br><br>Pump has bearing wear monitor and alarm | Procedures for pump operation (water supply on, motor temperature OK, backflow preventer verified, caustic only added when pump running, and continuous pump monitoring during caustic flush)<br><br>AC 5.10 Ignition Source Control Requirements<br><br>AC 5.11 Flammable Gas Monitoring | S3/E3 | F1 | A rotor canister breach is required to allow OH to come into contact with Al metal.<br><br>It is assumed that the pump design is appropriate for use with tank waste.<br><br>Al-OH reaction assumed to pressurize the line sufficiently to cause hydrogen escape.<br><br>Pump is not process cooled or lubricated (design feature). |
| NEW SWP-03 | SWP/New Pump | Release of radioactive/hazardous material to soil surface from SST due to overflow | Coolant leaks into tank until tank overflows | SST Waste | SST Waste (dilute form) released to soil surface | Metering pump design | AC 5.12 Material balance<br><br>AC 5.22 Service water intrusion monitoring | S2/E2 | F1 | Flow is intended to be limited to 0.3 to 0.8 gpm by metering pump.<br><br>Metering pump is capable of a maximum of 84 gallons/hour. |

## Table 3-1. Salt Well Pumping New Pump Design Hazardous Conditions As Initially Identified. (7 pages)

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-04 | SWP/New Pump | Release of waste to atmosphere from SST due to flammable gas fire/deflagration in tank | Coolant leak into tank induces a flammable gas release event | SST Waste | Fire/deflagration in salt well causes overpressure of HEPA filter releasing material on HEPA with continued release of contaminants released thereafter from active ventilation | | | S3/E2 | F0 | SSTs are not assumed to experience GRE events |
| NEW SWP-05 | SWP/New Pump | Release of waste to atmosphere from SST due to excessive weight causing dome collapse | Coolant line rupture causes flood on top of tank resulting in dome collapse due to excessive load | SST Waste | | | AC Service water intrusion monitoring | S3/E3 | F0 | None |
| NEW SWP-06 | SWP/New Pump | Release of waste to soil surface from SWP cooling line due to mistransfer of waste into salt well line | Mistransfer into SWP causes tank waste to backflow through the coolant line, backflow preventer failed | SST Waste | SST Waste leak to soil surface (without back flow preventer waste ends up in service water tank) | Back-flow preventer in cooling water supply line<br><br>Pit drain<br><br>Throttle bushing limits backflow into rotor area<br><br>JR-1 interlock<br><br>Metering pump has internal check valves that can prevent backflow through pump | AC 5.12 Waste Transfer Controls | S2/E2 | F3 | None |

**Table 3-1. Salt Well Pumping New Pump Design Hazardous Conditions As Initially Identified. (7 pages)**

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-07 | SWP/New Pump | Release of waste to soil surface from SWP cooling line due to backflow of waste through coolant line | Salt Well Pumping with backflow of waste through the cooling line with a leak outside the cover block | SST Waste | Pool of SST waste on soil surface | Throttle bushing restricts flow<br><br>Back flow preventer<br><br>Flow switch on cooling water supply shuts pump off if flow low<br><br>Power monitor interlock for high and low load<br><br>Pump motor high temperature shutoff | Operating procedure for salt well pump<br><br>Operator training | S2/E2 | F3 | This hazardous condition evaluates a design without a backflow preventer<br><br>The operating pressures across the pump are high enough to cause flow out of the cooling line.<br><br>Flow rates are assumed to be the driving pressure which is the differential pressure across the salt well pump (50 psig).<br><br>Throttle bushing will restrict flow rate.<br><br>The cooling supply line is stainless steel with heat tracing and supports.<br><br>The cooling supply line is hard piped from positive displacement pump to backflow preventer.<br><br>Hose will be used from the cover block extension to the back end of the pump. |

**Table 3-1. Salt Well Pumping New Pump Design Hazardous Conditions As Initially Identified. (7 pages)**

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-08 | SWP/New Pump | Release of waste to soil surface from pump pit caused by freezing and rupture of backflow preventer or coolant line | Freezing temperature ruptures backflow preventer or coolant line in pit (with plugged pit drain) causing a coolant leak which overflows pit | SST Waste Contamination in Pit | Dilute SST Waste on soil surface (pit drain plugged) | Leak detection system<br><br>Cooling line heat tracing and insulation<br><br>Cooling water flow switch | LCO and AC for leak detection | S1/E1 | F3 | None |
| NEW SWP-09 | SWP/New Pump | Release of SST waste to soil surface from pump pit caused by freezing and rupture of backflow preventer or coolant line | Freezing temperature ruptures backflow preventer or coolant line in pit (with plugged pit drain) causing a waste leak which overflows pit | SST Waste | SST Waste on soil surface (pit drain plugged) | Leak detection system<br><br>Cooling line heat tracing and insulation<br><br>Cooling water flow switch | LCO and AC for leak detection | S2/E1 | F3 | None |
| NEW SWP-10 | SWP/New Pump | Release of SST waste to soil surface from cooling water system due to failed backflow preventer (caused by high cooling water temperature) | Failures in cooling water heating system create high temperature water that damages backflow preventer AND backflow conditions exist | SST Waste | Backflow of SST waste into cooling water supply (no flow or dump into pit) | Design of the backflow preventer<br><br>Leak detection system | LCO and AC for leak detection | S2/E1 | F2 | This is an accident sequence that creates a preexisting condition of a failed backflow preventer.<br><br>This event captures concerns for backflow preventer failure causes. |

**Table 3-1. Salt Well Pumping New Pump Design Hazardous Conditions As Initially Identified. (7 pages)**

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| CHEMPM P-01 | SWP/ Chempump® | Release of toxic or radioactive aerosols to atmosphere from SST pump pit due to flammable gas deflagration in pit | Aluminum internal components in damaged rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the pit with ignition source [caustic flush activities] | SST Waste Contamination in Pit | Fire in pump pit burns paint and releases radioactive contaminants to atmosphere | None | AC 5.10 Ignition Source Control Requirements | S2/E2 | F2 | None |
| CHEMPM P-02 | SWP/ Chempump® | Release of toxic or radioactive aerosols to atmosphere from ruptured transfer line due to flammable gas deflagration in transfer line | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with tank waste during salt well pumping transfer to produce hydrogen which is concentrated in the transfer line high point with ignition source [salt well pumping] | SST Waste | Fire/deflagration in transfer line with high energy release of toxic or radioactive material | None | None | S1/E1 | F0 | None |

**Table 3-1. Salt Well Pumping New Pump Design Hazardous Conditions As Initially Identified. (7 pages)**

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| CHEMPMP-03 | SWP/ Chempump® | Release of toxic or radioactive aerosols to atmosphere from SST tank headspace due to flammable gas deflagration in tank head space | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the tank headspace with ignition source [caustic flushing activities] | SST Waste | Fire/deflagration in SST with high energy release of toxic or radioactive material | None | None | S3/E3 | F0 | None |

**Table 3-2. Salt Well Pumping New Pump Design Hazardous Conditions As Amended During Control Allocation. (7 pages)**

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-01 | SWP/New Pump | Release of toxic or radioactive aerosols to atmosphere from SST pump pit due to flammable gas deflagration in pit | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the pit with ignition source [Caustic Flush Activity] | SST Waste contamination in pump pit | Fire in pump pit burns paint and releases radioactive contaminants to atmosphere | Back-flow preventer in cooling water supply line<br><br>Flow switch interlock for cooling water supply system<br><br>Cooling water supply supplied at higher pressure than pump operation<br><br>High motor temperature trip interlock<br><br>Throttle bushing limits backflow into rotor area<br><br>Pump design has thrust washers that prevent rotor contact with pump bearings<br><br>Pump has bearing wear monitor and alarm | Procedures for pump operation (water supply on, motor temperature OK, backflow preventer verified, caustic only added when pump running, and continuous pump monitoring during caustic flush)<br><br>AC 5.10 Ignition Source Control Requirements<br><br>AC 5.11 Flammable Gas Monitoring | S2/E2 | F2 | A rotor canister breach is required to allow OH to come into contact with Al metal.<br><br>It is assumed that the pump design is appropriate for use with tank waste.<br><br>Al-OH reaction assumed to pressurize the line sufficiently to cause hydrogen escape.<br><br>Pump is not process cooled or lubricated (design feature). |

**Table 3-2. Salt Well Pumping New Pump Design Hazardous Conditions As Amended During Control Allocation. (7 pages)**

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-02 | SWP/New Pump | Release of toxic or radioactive aerosols to atmosphere from SST tank headspace due to flammable gas deflagration in tank head space | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the tank headspace with ignition source [Caustic Flush Activity] | SST Waste | Fire/deflagration in SST with high energy release of toxic or radioactive material | Back-flow preventer in cooling water supply line<br><br>Flow switch interlock for cooling water supply system<br><br>Cooling water supply supplied at higher pressure than pump operation<br><br>High motor temperature trip interlock<br><br>Throttle bushing limits backflow into rotor area<br><br>Pump design has thrust washers that prevent rotor contact with pump bearings<br><br>Pump has bearing wear monitor and alarm | Procedures for pump operation (water supply on, motor temperature OK, backflow preventer verified, caustic only added when pump running, and continuous pump monitoring during caustic flush)<br><br>AC 5.10 Ignition Source Control Requirements<br><br>AC 5.11 Flammable Gas Monitoring | S3/E3 | F0 | A rotor canister breach is required to allow OH to come into contact with Al metal.<br><br>It is assumed that the pump design is appropriate for use with tank waste.<br><br>Al-OH reaction assumed to pressurize the line sufficiently to cause hydrogen escape.<br><br>Pump is not process cooled or lubricated (design feature). |
| NEW SWP-03 | SWP/New Pump | Release of radioactive/hazardous material to soil surface from SST due to overflow | Coolant leaks into tank until tank overflows | SST Waste | SST Waste (dilute form) released to soil surface | Metering pump design | AC 5.12 Material balance<br><br>AC 5.22 Service water intrusion monitoring | S2/E2 | F1 | Flow is intended to be limited to 0.3 to 0.8 gpm by metering pump.<br><br>Metering pump is capable of a maximum of 84 gallons/hour. |

**Table 3-2. Salt Well Pumping New Pump Design Hazardous Conditions As Amended During Control Allocation. (7 pages)**

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-04 | SWP/New Pump | Release of waste to atmosphere from SST due to flammable gas fire/deflagration in tank | Coolant leak into tank induces a flammable gas release event | SST Waste | Fire/deflagration in salt well causes overpressure of HEPA filter releasing material on HEPA with continued release of contaminants released thereafter from active ventilation | | | S3/E2 | F0 | SSTs are not assumed to experience GRE events |
| NEW SWP-05 | SWP/New Pump | Release of waste to atmosphere from SST due to excessive weight causing dome collapse | Coolant line rupture causes flood on top of tank resulting in dome collapse due to excessive load | SST Waste | | | AC Service water intrusion monitoring | S3/E3 | F0 | None |
| NEW SWP-06 | SWP/New Pump | Release of waste to soil surface from SWP cooling line due to mistransfer of waste into salt well line | Mistransfer into SWP causes tank waste to backflow through the coolant line, backflow preventer failed | SST Waste | SST Waste leak to soil surface (without back flow preventer waste ends up in service water tank) | Back-flow preventer in cooling water supply line<br><br>Pit drain<br><br>Throttle bushing limits backflow into rotor area<br><br>JR-1 interlock<br><br>Metering pump has internal check valves that can prevent backflow through pump | AC 5.12 Waste Transfer Controls | S2/E2 | F3 | None |

**Table 3-2. Salt Well Pumping New Pump Design Hazardous Conditions As Amended During Control Allocation. (7 pages)**

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-07 | SWP/New Pump | Release of waste to soil surface from SWP cooling line due to backflow of waste through coolant line | Salt Well Pumping with backflow of waste through the cooling line with a leak outside the cover block | SST Waste | Pool of SST waste on soil surface | Throttle bushing restricts flow<br><br>Back flow preventer<br><br>Flow switch on cooling water supply shuts pump off if flow low<br><br>Power monitor interlock for high and low load<br><br>Pump motor high temperature shutoff | Operating procedure for salt well pump<br><br>Operator training | S2/E2 | F3 | This hazardous condition evaluates a design without a backflow preventer<br><br>The operating pressures across the pump are high enough to cause flow out of the cooling line.<br><br>Flow rates are assumed to be the driving pressure which is the differential pressure across the salt well pump (50 psig).<br><br>Throttle bushing will restrict flow rate.<br><br>The cooling supply line is stainless steel with heat tracing and supports.<br><br>The cooling supply line is hard piped from positive displacement pump to backflow preventer.<br><br>Hose will be used from the cover block extension to the back end of the pump. |

**Table 3-2. Salt Well Pumping New Pump Design Hazardous Conditions As Amended During Control Allocation. (7 pages)**

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-08 | SWP/New Pump | Release of waste to soil surface from pump pit caused by freezing and rupture of backflow preventer or coolant line | Freezing temperature ruptures backflow preventer or coolant line in pit (with plugged pit drain) causing a coolant leak which overflows pit | SST Waste Contamination in Pit | Dilute SST Waste on soil surface (pit drain plugged) | Leak detection system<br><br>Cooling line heat tracing and insulation<br><br>Cooling water flow switch | LCO and AC for leak detection | S1/E1 | F3 | None |
| NEW SWP-09 | SWP/New Pump | Release of SST waste to soil surface from pump pit caused by freezing and rupture of backflow preventer or coolant line | Freezing temperature ruptures backflow preventer or coolant line in pit (with plugged pit drain) causing a waste leak which overflows pit | SST Waste | SST Waste on soil surface (pit drain plugged) | Leak detection system<br><br>Cooling line heat tracing and insulation<br><br>Cooling water flow switch | LCO and AC for leak detection | S2/E1 | F3 | None |
| NEW SWP-10 | SWP/New Pump | Release of SST waste to soil surface from cooling water system due to failed backflow preventer (caused by high cooling water temperature) | Failures in cooling water heating system create high temperature water that damages backflow preventer AND backflow conditions exist | SST Waste | Backflow of SST waste into cooling water supply (no flow or dump into pit) | Design of the backflow preventer<br><br>Leak detection system | LCO and AC for leak detection | S2/E1 | F0 | This is an accident sequence that creates a preexisting condition of a failed backflow preventer.<br><br>This event captures concerns for backflow preventer failure causes. |

**Table 3-2. Salt Well Pumping New Pump Design Hazardous Conditions As Amended During Control Allocation. (7 pages)**

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| CHEMPM P-01 | SWP/ Chempump® | Release of toxic or radioactive aerosols to atmosphere from SST pump pit due to flammable gas deflagration in pit | Aluminum internal components in damaged rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the pit with ignition source [caustic flush activities] | SST Waste Contamination in Pit | Fire in pump pit burns paint and releases radioactive contaminants to atmosphere | None | AC 5.10 Ignition Source Control Requirements | S2/E2 | F2 | None |
| CHEMPM P-02 | SWP/ Chempump® | Release of toxic or radioactive aerosols to atmosphere from ruptured transfer line due to flammable gas deflagration in transfer line | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with tank waste during salt well pumping transfer to produce hydrogen which is concentrated in the transfer line high point with ignition source [salt well pumping] | SST Waste | Fire/deflagration in transfer line with high energy release of toxic or radioactive material | None | None | S1/E1 | F0 | None |

**Table 3-2. Salt Well Pumping New Pump Design Hazardous Conditions As Amended During Control Allocation. (7 pages)**

| Item ID | Location/ Activity | Hazardous Condition | Candidate Cause | Material at Risk | Immediate Consequence | Engineered Safety Features | Administrative Safety Features | Cons Cat NC | Freq Cat NC | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| CHEMPM P-03 | SWP/ Chempump® | Release of toxic or radioactive aerosols to atmosphere from SST tank headspace due to flammable gas deflagration in tank head space | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the tank headspace with ignition source [caustic flushing activities] | SST Waste | Fire/deflagration in SST with high energy release of toxic or radioactive material | None | None | S3/E3 | F0 | None |

**Table 3-3. Salt Well Pumping New Pump Design Hazardous Conditions Sorted According To Consequence. (2 pages)**

| Item ID | Hazardous Condition | Cause | Freq Cat | Env Cons |
|---|---|---|---|---|
| **Hazardous Conditions with Potentially Significant Facility worker Consequences (S1)** | | | | |
| CHEMPM P-02 | Release of toxic or radioactive aerosols to atmosphere from ruptured transfer line due to flammable gas deflagration in transfer line | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with tank waste during salt well pumping transfer to produce hydrogen which is concentrated in the transfer line high point with ignition source [salt well pumping] | F0 | E1 |
| NEW SWP-08 | Release of waste to soil surface from pump pit caused by freezing and rupture of backflow preventer or coolant line | Freezing temperature ruptures backflow preventer or coolant line in pit (with plugged pit drain) causing a coolant leak which overflows pit | F3 | E1 |
| **Hazardous Conditions with Potentially Significant On-site Worker Consequences (S2)** | | | | |
| NEW SWP-01 | Release of toxic or radioactive aerosols to atmosphere from SST pump pit due to flammable gas deflagration in pit | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in recirculation mode to produce hydrogen which escapes to the pit with ignition source [Caustic Flush Activity] | F2 | E2 |
| NEW SWP-03 | Release of radioactive/hazardous material to soil surface from SST due to overflow | Coolant leaks into tank until tank overflows | F1 | E2 |
| NEW SWP-06 | Release of waste to soil surface from SWP cooling line due to mistransfer of waste into salt well line | Mistransfer into SWP causes tank waste to backflow through the coolant line, backflow preventer failed | F3 | E2 |
| NEW SWP-07 | Release of waste to soil surface from SWP cooling line due to backflow of waste through coolant line | Salt Well Pumping with backflow of waste through the cooling line with a leak outside the cover block | F3 | E2 |
| NEW SWP-09 | Release of SST waste to soil surface from pump pit caused by freezing and rupture of backflow preventer or coolant line | Freezing temperature ruptures backflow preventer or coolant line in pit (with plugged pit drain) causing a waste leak which overflows pit | F3 | E2 |
| NEW SWP-10 | Release of SST waste to soil surface from cooling water system due to failed backflow preventer (caused by high cooling water temperature) | Failures in cooling water heating system create high temperature water that damages backflow preventer AND backflow conditions exist | F0 | E2 |

**Table 3-3. Salt Well Pumping New Pump Design Hazardous Conditions Sorted According To Consequence. (2 pages)**

| Item ID | Hazardous Condition | Cause | Freq Cat | Env Cons |
|---|---|---|---|---|
| CHEMPM P-01 | Release of toxic or radioactive aerosols to atmosphere from SST pump pit due to flammable gas deflagration in pit | Aluminum internal components in damaged rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the pit with ignition source [caustic flush activities] | F2 | E2 |
| **Hazardous Conditions with Potentially Significant Offsite Individual Consequences (S3)** | | | | |
| NEW SWP-02 | Release of toxic or radioactive aerosols to atmosphere from SST tank headspace due to flammable gas deflagration in tank head space | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in recirculation mode to produce hydrogen which escapes to the tank headspace with ignition source [Caustic Flush Activity | F0 | E3 |
| NEW SWP-04 | Release of waste to atmosphere from SST due to flammable gas fire/deflagration in tank | Coolant leak into tank induces a flammable gas release event | F0 | E3 |
| NEW SWP-05 | Release of waste to atmosphere from SST due to excessive weight causing dome collapse | Coolant line rupture causes flood on top of tank resulting in dome collapse due to excessive load | F0 | E3 |
| CHEMPM P-03 | Release of toxic or radioactive aerosols to atmosphere from SST tank headspace due to flammable gas deflagration in tank head space | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the tank headspace with ignition source [caustic flushing activities] | F0 | E3 |

**Table 3-4. New Salt Well Pump Design Hazardous Conditions Mapped to Analyzed Representative Accidents. (3 pages)**

| BIN | Item ID | Material at Risk | Hazardous Condition | Cause | Freq Cat | Cons Cat | Cause Grp | Rep Acc |
|---|---|---|---|---|---|---|---|---|
| **Analyzed Accident: Flammable Gas Deflagrations – SST (Rep Acc 05)** | | | | | | | | |
| A-1-a | XS-01-FLOW03 | SST and DCRT tank contents | Release of liquids, solids and/or vapors from single shell tank due to dome collapse and DCRT pressurization caused by flammable gas fire/explosion propagating from DCRT to single shell tank | Pipeline connecting single shell tank and DCRT fills with flammable gas; loss of ventilation flow in DCRT so that a flammable gas atmosphere is ignited by the ventilation outlet heater | F2 | S3 | B07 | 05 |
| **New Salt well Pump Design Represented Hazardous Conditions (Rep Acc 05)** | | | | | | | | |
| A-1-a | NEWSWP-02 | SST Waste | Release of toxic or radioactive aerosols to atmosphere from SST tank headspace due to flammable gas deflagration in tank head space | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in recirculation mode to produce hydrogen which escapes to the tank headspace with ignition source [Caustic Flush Activity | F0 | S3 | B08 | 05X |
| A-1-a | NEWSWP-04 | SST Waste | Release of waste to atmosphere from SST due to flammable gas fire/deflagration in tank | Coolant leak into tank induces a flammable gas release event | F0 | S3 | B08 | 05X |
| A-1-a | CHEMPMP-02 | SST Waste | Release of toxic or radioactive aerosols to atmosphere from ruptured transfer line due to flammable gas deflagration in transfer line | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with tank waste during salt well pumping transfer to produce hydrogen which is concentrated in the transfer line high point with ignition source [salt well pumping] | F0 | S1 | B08 | 05X |
| A-1-a | CHEMPMP-03 | SST Waste | Release of toxic or radioactive aerosols to atmosphere from SST tank headspace due to flammable gas deflagration in tank head space | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the tank headspace with ignition source [caustic flushing activities] | F0 | S3 | B08 | 05X |
| **Analyzed Accident: Fire in Contaminated Area (Rep Acc 07)** | | | | | | | | |
| A-1-a | CRN-05 | Pits and risers inventory | Release of radioactive and/or toxic materials from pits and risers due to fuel tank fire in crane or support vehicle (see In-Tank Equipment Installation for tank fires) | Human error in positioning crane load | F3 | S2 | B26 | 07 |

**Table 3-4. New Salt Well Pump Design Hazardous Conditions Mapped to Analyzed Representative Accidents. (3 pages)**

| BIN | Item ID | Material at Risk | Hazardous Condition | Cause | Freq Cat | Cons Cat | Cause Grp | Rep Acc |
|---|---|---|---|---|---|---|---|---|
| **New Salt well Pump Design Represented Hazardous Conditions (Rep Acc 07)** | | | | | | | | |
| A-1-a | NEWSWP-01 | SST Waste contamination in pump pit | Release of toxic or radioactive aerosols to atmosphere from SST pump pit due to flammable gas deflagration in pit | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in recirculation mode to produce hydrogen which escapes to the pit with ignition source [Caustic Flush Activity] | F2 | S2 | B08 | 07X |
| A-1-a | CHEMPMP-01 | SST Waste Contamination in Pit | Release of toxic or radioactive aerosols to atmosphere from SST pump pit due to flammable gas deflagration in pit | Aluminum internal components in damaged rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the pit with ignition source [caustic flush activities] | F2 | S2 | B26 | 07X |
| **Analyzed Accident: Tank Failure Due to Excessive Loads (Rep Acc 12)** | | | | | | | | |
| B-1-a | CRN-03 | Tank inventory | Release of radioactive and/or toxic materials from tank due to dome collapse | Human error results in excessive weight on dome | F3 | S3 | C10 | 12A |
| B-1-a | CRN-04 | Tank inventory | Release of radioactive and/or toxic materials from tank due to dome collapse | Crane or rigging failures drop load resulting in large impact to dome | F3 | S3 | C10 | 12B |
| B-1-a | CRN-11 | Tank inventory | Radioactive or toxic material release from tank due to boom failure and tank/equipment damage and dome collapse | Human error: improper load assembly, rigging, crane overloaded | F3 | S3 | C10 | 12C |
| **New Salt well Pump Design Represented Hazardous Conditions (Rep Acc 12)** | | | | | | | | |
| B-1-a | NEWSWP-05 | SST Waste | Release of waste to atmosphere from SST due to excessive weight causing dome collapse | Coolant line rupture causes flood on top of tank resulting in dome collapse due to excessive load | F0 | S3 | D10 | 12X |

**Table 3-4. New Salt Well Pump Design Hazardous Conditions Mapped to Analyzed Representative Accidents. (3 pages)**

| BIN | Item ID | Material at Risk | Hazardous Condition | Cause | Freq Cat | Cons Cat | Cause Grp | Rep Acc |
|---|---|---|---|---|---|---|---|---|
| **Analyzed Accident: Waste Transfer Leak into Structure (Rep Acc 33A)** | | | | | | | | |
| N/A | STOCHAS-01 | Liquid radioactive waste being transferred | Release of radioactive aerosols to the atmosphere or direct radiation exposure from waste transfer structures due to waste leaks into waste transfer structures (includes leaks in OGT leaks) | Corrosion, erosion, gasket or packing failure, jumper leaks, water hammer, high temperature waste, in-pipe flammable gas deflagration, or seismic events | F3 | S2 | N/A | 33A |
| **New Salt well Pump Design Represented Hazardous Conditions (Rep Acc 33A)** | | | | | | | | |
| C-2-b | NEWSWP-09 | SST Waste | Release of SST waste to soil surface from pump pit caused by freezing and rupture of backflow preventer or coolant line | Freezing temperature ruptures backflow preventer or coolant line in pit (with plugged pit drain) causing a waste leak which overflows pit | F3 | S2 | D24 | 33A X |
| **Analyzed Accident: Waste Transfer Leak due to Misroute (Rep Acc 33D)** | | | | | | | | |
| N/A | STOCHAS-04 | Liquid radioactive waste being transferred | Release of radioactive aerosols or direct radiation exposure from waste leaked on soil surface or into atmosphere due to waste leaks caused by misroute | Tank overflows (caused by misroutes, material balance errors, service water or fire water intrusion), backflow into clean systems, misroutes into pits, leaks into 204-AR, or pressurization of isolated portions of transfer systems | F3 | S2 | N/A | 33D |
| **New Salt well Pump Design Represented Hazardous Conditions (Rep Acc 33D)** | | | | | | | | |
| C-2-b | NEWSWP-03 | SST Waste | Release of radioactive/hazardous material to soil surface from SST due to overflow | Coolant leaks into tank until tank overflows | F1 | S2 | D06 | 33D X |
| C-2-b | NEWSWP-06 | SST Waste | Release of waste to soil surface from SWP cooling line due to mistransfer of waste into salt well line | Mistransfer into SWP causes tank waste to backflow through the coolant line, backflow preventer failed | F3 | S2 | D06 | 33D X |
| C-2-b | NEWSWP-07 | SST Waste | Release of waste to soil surface from SWP cooling line due to backflow of waste through coolant line | Salt Well Pumping with backflow of waste through the cooling line with a leak outside the cover block | F3 | S2 | D06 | 33D X |
| C-2-b | NEWSWP-10 | SST Waste | Release of SST waste to soil surface from cooling water system due to failed backflow preventer (caused by high cooling water temperature) | Failures in cooling water heating system create high temperature water that damages backflow preventer AND backflow conditions exist | F0 | S2 | D02 | 33D X |

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# 4.0 CONTROL ALLOCATION

## 4.1 METHODOLOGY

The control decision/allocation team first considered the results of the PHA. Prior to the meeting, the hazardous conditions identified during the PHA meeting were evaluated and then mapped to existing analyzed accidents. From this mapping, a suite of proposed controls was identified. This information was then reviewed for accuracy, with changes incorporated as necessary. The team then reviewed the proposed AB controls. Consensus was reached to determine if controls were adequate to prevent or mitigate the identified potential hazardous conditions or might introduce new hazards.

If existing controls were determined to adequately address the hazardous condition, the applicable controls were selected. If existing controls are not sufficient or inadequate for any reason, the control decision/allocation team proposed new or modified controls.

## 4.2 ALLOCATED CONTROLS

The result of the control decision/allocation meeting is presented in Table 4-1. The hazardous conditions identified for the new salt well pump are listed in ascending order of the representative accidents. In all but one case, existing controls for the representative accidents were found adequate to prevent or mitigate the hazardous condition. For one hazardous condition related to backflow of waste through the pump motor cooling line, ID # NEWSWP-07, a backflow preventer was determined to be required as a preventive SSC with a related LCO to ensure operability.

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## 5.0 CONCLUSIONS

There were 10 hazardous conditions identified specific to the new salt well pump design. Of these, one was a low consequence hazardous condition related to worker exposure to ionizing radiation and minor contamination events (spills or leaks). This is adequately addressed by the Tank Farms Radiation Protection Program.

The remaining hazardous conditions related to the new salt well pump design are associated with four representative accidents. There were two hazardous conditions related to Flammable Gas Deflagrations in an SST, one hazardous condition is related to the Fire in Contaminated Area accident, one hazardous condition is related to the Tank Failure Due to Excessive Loads accident, one hazardous condition is related to the Waste Transfer Leak Into Structure accident, and four hazardous conditions are related to the Waste Transfer Leak Due To Misroute accident. In all cases it was determined that the consequences of these hazardous conditions were bounded by the representative accident.

There were three hazardous conditions identified specific to the Crane Chempump®. Of these, one related to a flammable gas deflagration in the SST headspace had a high consequence but did not require any controls due to the low frequency. Another, related to a flammable gas deflagration in the transfer line, required no controls due to a low consequence and frequency. The third hazardous condition, related to the Fire in Contaminated Area accident, was found to bounded by the representative accident.

The controls allocated, for all but one hazardous condition, were existing controls currently allocated to the related representative accident. For the remaining hazardous condition, ID # NEWSWP-07, the control decision/allocation team determined that a backflow preventer was required to prevent a backflow of waste into the pump motor cooling line. The addition of this backflow preventer and a related LCO will require an amendment to the Authorization Basis.

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## Table 4-1. Control Allocation for the New Salt Well Pump Design Hazardous Conditions. (8 pages)

| Item ID | Material at Risk | Hazardous Condition | Cause | Prev SSC | Prev TSR | Mit SSC | Mit TSR | Control MEMO | Remarks | Cons Cat NC | Rep Acc |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-02 | SST Waste | Release of toxic or radioactive aerosols to atmosphere from SST tank headspace due to flammable gas deflagration in tank head space | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in recirculation mode to produce hydrogen which escapes to the tank headspace with ignition source [Caustic Flush Activity] | None required | None required | None required | None required | No controls required based on low accident frequency. | A rotor canister breach is required to allow OH to come into contact with Al metal.<br><br>It is assumed that the pump design is appropriate for use with tank waste.<br><br>Al-OH reaction assumed to pressurize the line sufficiently to cause hydrogen escape.<br><br>Pump is not process cooled or lubricated and cooling water will protect rotor from caustic (design feature).<br><br>The frequency of this event was determined to be F0 by the control decision board based on the limited amount of gas generated and inability to pressurize recirculation loop during caustic flush. | S3 | 05X |

## Table 4-1. Control Allocation for the New Salt Well Pump Design Hazardous Conditions. (8 pages)

| Item ID | Material at Risk | Hazardous Condition | Cause | Prev SSC | Prev TSR | Mit SSC | Mit TSR | Control MEMO | Remarks | Cons Cat NC | Rep Acc |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-04 | SST Waste | Release of waste to atmosphere from SST due to flammable gas fire/deflagration in tank | Coolant leak into tank induces a flammable gas release event | None required | None required | None required | None required | No controls required based on low accident frequency. | SSTs are not assumed to experience GRE events. | S3 | 05X |
| CHEMP MP-03 | SST Waste | Release of toxic or radioactive aerosols to atmosphere from SST tank headspace due to flammable gas deflagration in tank head space | Aluminum internal compontnets in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the tank headspace with ignition source [caustic flushing activities] | None Required | None Required | None Required | None Required | No controls required based on low accident frequency | | S3 | 05X |

**Table 4-1. Control Allocation for the New Salt Well Pump Design Hazardous Conditions. (8 pages)**

| Item ID | Material at Risk | Hazardous Condition | Cause | Prev SSC | Prev TSR | Mit SSC | Mit TSR | Control MEMO | Remarks | Cons Cat NC | Rep Acc |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-01 | SST Waste contamination in pump pit | Release of toxic or radioactive aerosols to atmosphere from SST pump pit due to flammable gas deflagration in pit | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in recirculation mode to produce hydrogen which escapes to the pit with ignition source [Caustic Flush Activity] | None required | AC: Ign Cntrls (Flam Gas)<br>AC: Flam Gas Mon Cntrls<br>AC: Process Instrument/ Measure/ Test Equip | None required | AC: Emergency Prep (Fire) | Controls based on accident analysis (Fire in Contaminated Area and Waste Transfer Leak due to Misroute). | A rotor canister breach is required to allow OH to come into contact with Al metal.<br><br>It is assumed that the pump design is appropriate for use with tank waste.<br><br>Al-OH reaction assumed to pressurize the line sufficiently to cause hydrogen escape.<br><br>Pump is not process cooled or lubricated (design feature).<br><br>The control decision board determined the frequency of the event to be F2 based on need to have a failed pump plus no cooling water plus inability to pressurize line during recirculation. | S2 | 07X |

## Table 4-1. Control Allocation for the New Salt Well Pump Design Hazardous Conditions. (8 pages)

| Item ID | Material at Risk | Hazardous Condition | Cause | Prev SSC | Prev TSR | Mit SSC | Mit TSR | Control MEMO | Remarks | Cons Cat NC | Rep Acc |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CHEMP MP-01 | SST Waste Contamination in Pit | Release of toxic or radioactive aerosols to atmosphere from SST pump pit due to flammable gas deflagration in pit | Aluminum internal components in damaged rotor (stainless steel can around rotor damaged) react with caustic solution during caustic flushing in re-circulation mode to produce hydrogen which escapes to the pit with ignition source [caustic flush activities] | None Required | AC: Ign Cntrls (Flam Gas)<br>AC: Flam Gas Mon Cntrls<br>AC: Process Instrument/ Measure/Test Equip | None Required | AC: Emergency Prep (Fire) | Controls based on accident analysis (Fire in Contaminated Area and Waste Transfer Leak due to Misroute). | None | S2 | 07X |
| NEW SWP-05 | SST Waste | Release of waste to atmosphere from SST due to excessive weight causing dome collapse | Coolant line rupture causes flood on top of tank resulting in dome collapse due to excessive load | None required | None required | None required | None required | No controls required based on low accident frequency. | None | S3 | 12X |
| NEW SWP-09 | SST Waste | Release of SST waste to soil surface from pump pit caused by freezing and rupture of backflow preventer or coolant line | Freezing temperature ruptures backflow preventer or coolant line in pit (with plugged pit drain) causing a waste leak which overflows pit | None required | None required | SS: Trans Leak Detect Syss<br>SS: Master Pump Shutdown Sys | LCO: Trans Leak Detect Syss<br>AC: Safety Management Programs<br>AC: Trans Cntrls<br>AC: Process Instrument/ Measure/Test Equip<br>AC: Emergency Prep | Controls based on accident analysis (Waste Transfer Leak) | None | S2 | 33AX |

**Table 4-1. Control Allocation for the New Salt Well Pump Design Hazardous Conditions. (8 pages)**

| Item ID | Material at Risk | Hazardous Condition | Cause | Prev SSC | Prev TSR | Mit SSC | Mit TSR | Control MEMO | Remarks | Cons Cat NC | Rep Acc |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-03 | SST Waste | Release of radioactive/hazardous material to soil surface from SST due to overflow | Coolant leaks into tank until tank overflows | None required | None required | None required | AC: Tank Service Water Intrusion Mon Program<br>AC: Process Instrument/ Measure/Test Equip<br>AC: Emergency Prep | Controls based on accident analysis (Waste Transfer Leak) | Flow is intended to be limited to 0.3 to 0.8 gpm by metering pump.<br>Metering pump is capable of a maximum of 84 gallons/hour. | S2 | 33DX |
| NEW SWP-06 | SST Waste | Release of waste to soil surface from SWP cooling line due to mistransfer of waste into salt well line | Mistransfer into SWP causes tank waste to backflow through the coolant line, backflow preventer failed | None required | AC: Trans Pump Admin Lock Cntrls | SS: Master Pump Shutdown Sys | AC: Trans Cntrls<br>AC: Process Instrument/ Measure/Test Equip<br>AC: Trans Sys Cover Removal Cntrls<br>AC: Safety Management Programs<br>AC: Emergency Prep | Controls based on accident analysis (Waste Transfer Leak) | None | S2 | 33DX |

**Table 4-1. Control Allocation for the New Salt Well Pump Design Hazardous Conditions. (8 pages)**

| Item ID | Material at Risk | Hazardous Condition | Cause | Prev SSC | Prev TSR | Mit SSC | Mit TSR | Control MEMO | Remarks | Cons Cat NC | Rep Acc |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-07 | SST Waste | Release of waste to soil surface from SWP cooling line due to backflow of waste through coolant line | Salt Well Pumping with backflow of waste through the cooling line with a leak outside the cover block | SS: Backflow Preventer | LCO: Backflow Prev Sys | None required | AC: Trans Cntrls<br><br>AC: Process Instrument/Measure/Test Equip<br>AC: Safety Management Programs<br>AC: Emergency Prep | Controls based on accident analysis (Waste Transfer Leak) | This hazardous condition evaluates a design without a backflow preventer.<br><br>The operating pressures across the pump are high enough to cause flow out of the cooling line.<br><br>Flow rates are assumed to be proportional to the driving pressure, which is the differential pressure across the salt well pump (50 psig).<br><br>Throttle bushing will restrict flow rate.<br><br>The cooling supply line is stainless steel with heat tracing and supports.<br><br>The cooling supply line is hard piped from positive displacement pump to backflow preventer.<br><br>Hose will be used from cover block extension to the back end of the pump. | S2 | 33DX |

## Table 4-1. Control Allocation for the New Salt Well Pump Design Hazardous Conditions. (8 pages)

| Item ID | Material at Risk | Hazardous Condition | Cause | Prev SSC | Prev TSR | Mit SSC | Mit TSR | Control MEMO | Remarks | Cons Cat NC | Rep Acc |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NEW SWP-10 | SST Waste | Release of SST waste to soil surface from cooling water system due to failed backflow preventer (caused by high cooling water temperature) | Failures in cooling water heating system create high temperature water that damages backflow preventer AND backflow conditions exist | None required | None required | None required | None required | No controls required based on low accident frequency. | This is an accident sequence that creates a preexisting condition of a failed backflow preventer.<br><br>This event captures concerns for backflow preventer failure causes.<br><br>The control decision board determined that the failure frequency of the backflow prevention device was F0 based on failure mode of backflow preventer where a backflow of waste to the supply line occurs (not a credible failure mode). | S2 | 33DX |

**Table 4-1. Control Allocation for the New Salt Well Pump Design Hazardous Conditions. (8 pages)**

| Item ID | Material at Risk | Hazardous Condition | Cause | Prev SSC | Prev TSR | Mit SSC | Mit TSR | Control MEMO | Remarks | Cons Cat NC | Rep Acc |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **S1-F0 Hazardous Conditions (No Controls Required)** | | | | | | | | | | | |
| CHEMP MP-02 | SST Waste | Release of toxic or radioactive aerosols to atmosphere from ruptured transfer line due to flammable gas deflagration in transfer line | Aluminum internal components in damaged pump rotor (stainless steel can around rotor damaged) react with tank waste during salt well pumping transfer to produce hydrogen which is concentrated in the transfer line high point with ignition source [salt well pumping] | None | None | None | None | No controls required | Frequency consistent with analysis for closure of the Flammable Gas USQ for DCRTs and Waste Transfer System | S1 | |
| **Control Allocation For S1-F3 Hazardous Conditions** | | | | | | | | | | | |
| NEW SWP-08 | SST Waste Contamination in Pit | Release of waste to soil surface from pump pit caused by freezing and rupture of backflow preventer or coolant line | Freezing temperature ruptures backflow preventer or coolant line in pit (with plugged pit drain) causing a coolant leak which overflows pit | None | None | None | AC: Safety Management Programs | Controls based on safety manageme nt program | None | S1 | |

## 6.0 REFERENCES

CHG 2000a, *Tank Waste Remediation System Technical Safety Requirements*, HNF-SD-WM-TSR-006, Rev. 1-L, CH2M HILL Hanford Group, Inc., Richland, Washington.

CHG 2000b, *Hazard Analysis Database Report*, HNF-SD-WM-TI-764, Rev. 2-F, CH2M HILL Hanford Group, Inc., Richland, Washington

CHG 2000c, *Tank Waste Remediation System Final Safety Analysis Report*, HNF-SD-WM-SAR-067, Rev. 1-M, CH2M HILL Hanford Group, Inc., Richland Washington.

AIChE, 1992, *Guidelines for Hazard Evaluation Procedures*, American Institute of Chemical Engineers, New York, New York.

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# APPENDIX A

# PRELIMINARY HAZARDS ANALYSIS TEAM BIOGRAPHICAL INFORMATION

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## APPENDIX A

## PRELIMINARY HAZARDS ANALYSIS TEAM BIOGRAPHICAL INFORMATION

James R. Bellomy III – Cognizant Engineer, Maintenance and Reliability Engineering. Mr. Bellomy has 20 years of engineering experience in design, construction, start-up and testing at both commercial and government owned reactor and non-reactor nuclear facilities. He has over 16 years experience at the Hanford Site supporting numerous Hanford construction projects and facility upgrades at N-Reactor and the 200 Area tank farms. He has experience in all aspects of systems design, fabrication, construction, and testing and has been involved in several hazard evaluations and safety assessments. Mr. Bellomy has been an Unreviewed Safety Question (USQ) Evaluator for the past 6 years and has provided support to several tank waste retrieval projects including tank 241-C-106 waste retrieval, tank 241-AZ-101 mixer pump testing, long length equipment removal, and salt well pumping.

William H. Grams – B.S. Mining Engineering, M.S. Mechanical Engineering. Mr. Grams has more than 20 years of experience in the nuclear industry, all of it with the disposal of high and low-level radioactive waste. He has over 15 years of experience at the Hanford Site including authorization basis (AB) assessments of new activities, accident analysis and release calculations, USQ screening and determinations, hazard assessments, and AB revisions. Other nuclear related experience includes low-level waste certification, waste management assessments and audits, preparation of characterization requirements for low-level waste, preparation of design requirements for waste tank retrieval systems, and identification of regulatory requirements.

Clifford E. Hampton – A.A. in Science. Mr. Hampton has more than 23 years of experience in the nuclear industry, most is in the Navy Nuclear field. He has over 20 years experience in the maintenance, testing, and operation of nuclear equipment. He was assigned as the Assistant Naval Reactor Representative (DOE oversight) for overhaul of nuclear submarines. He has three years of experience at Hanford working in the maintenance and shift operations areas. He is a certified Shift Manager, a Building Emergency Director and a USQ screener.

Grant W. Ryan, P.E. -- B.S. Physics, B.S. Nuclear Engineering, PE Mechanical Engineering. Ten years experience in nuclear facility safety analysis and general engineering support. Author of numerous documents at Hanford to support safe nuclear facility operations. These have included operating and alarm response procedures, safety analysis reports Tank Waste Remediation System Basis for Interim Operations (BIO), and the Final Safety Analysis Report (FSAR), calculation notes, topical reports, and engineering studies.

Milton V. Shultz Jr. – Fluor Federal Services Inc., Safety Analysis and Risk Assessment. B.S. Nuclear Engineering Technology. Scribe for salt well pump Process Hazard Analysis (PHA). More than 26 years experience in a broad range of engineering and technical assignments at the Hanford Site. Experience includes leading PHAs and HAZOPs for a variety of River Protection Project facilities, including several for the FSAR and BIO efforts, contributor to the hazards analysis work for the FSAR. Has performed independent nuclear safety evaluations of reactor plant design and operation at Hanford N Reactor.

Ryan D. Smith – B.S. Mechanical Engineering. Six years of experience at the Hanford Site with the last three years specific to Nuclear Safety and Licensing (NS&L) support. NS&L Engineer for the Interim Stabilization, Characterization, and Vadose Zone programs. Extensive knowledge in flammable gas related issues related to pumping waste to and from tank farm facilities. Key team member in establishing the AB for Interim Stabilization and reconciliation of the Los Alamos National Laboratory Safety Assessment with the BIO. Assisted in the transition of the BIO to the FSAR as well as ongoing AB maintenance and clarification support.

Michael A. White – B.S. in Mechanical Engineering. Mr. White has over 8 years of experience in the nuclear industry, all with the storage, treatment, handling, and transfer of radioactive liquid waste at the Hanford Site. His responsibilities have been focused in support of facility operations, including facility modification/upgrades, testing, and startup. Mr. White assisted in the development of the 242-A Evaporator/Liquid Effluent Retention Facility Safety Analysis Report, Safety Equipment List, and Part B Permit application, and has experience as a core USQ Evaluator.

William F. Zuroff – B.S. Degree, University of Idaho. Mr. Zuroff has more than 30 years of experience in the nuclear industry including nuclear operations, instrument maintenance, and plant engineering. He has over 15 years experience at the Hanford Site including equipment design, testing, operations, and USQ evaluations. Other nuclear related experience includes preparation of design requirements, and procurement specifications for nuclear monitoring systems.

# APPENDIX B

# CONTROL ALLOCATION TEAM BIOGRAPHICAL INFORMATION

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## APPENDIX B

## CONTROL ALLOCATION TEAM BIOGRAPHICAL INFORMATION

James R. Bellomy III – Cognizant Engineer, Maintenance and Reliability Engineering. Mr. Bellomy has 20 years of engineering experience in design, construction, start-up and testing at both commercial and government owned reactor and non-reactor nuclear facilities. He has over 16 years experience at the Hanford Site supporting numerous Hanford construction projects and facility upgrades at N-Reactor and the 200 Area tank farms. He has experience in all aspects of systems design, fabrication, construction, and testing and has been involved in several hazard evaluations and safety assessments. Mr. Bellomy has been an Unreviewed Safety Question (USQ) Evaluator for the past 6 years and has provided support to several tank waste retrieval projects including tank 241-C-106 waste retrieval, tank 241-AZ-101 mixer pump testing, long length equipment removal, and salt well pumping.

William H. Grams – B.S. Mining Engineering, M.S. Mechanical Engineering. Mr. Grams has more than 20 years of experience in the nuclear industry, all of it with the disposal of high and low-level radioactive waste. He has over 15 years of experience at the Hanford Site including authorization basis (AB) assessments of new activities, accident analysis and release calculations, USQ screening and determinations, hazard assessments, and AB revisions. Other nuclear related experience includes low-level waste certification, waste management assessments and audits, preparation of characterization requirements for low-level waste, preparation of design requirements for waste tank retrieval systems, and identification of regulatory requirements.

Gregory L. Jones – B.S. Nuclear Engineering Technology. Mr. Jones has over 23 years of experience in activities related to the safety of nuclear facilities. He has experience in nuclear plant licensing/safety evaluations (Probabilistic Risk Assessment (PRA) and deterministic), nuclear fuels reprocessing facility safety assessment, and plant/facility design and operational review. Areas of specialization in safety and licensing include: Safety Analysis Report (SAR) and Technical Specification/Operational Safety Requirements preparation for both nuclear power plants and fuels reprocessing facilities; USQ screenings and determinations; release and transport of radioactivity during normal, abnormal and accident conditions; evaluation of containment/confinement system capabilities for nonreactor risk assessment; dose consequence evaluations; natural forces design and accident evaluations; accident analysis, fault tree modeling, uncertainty/sensitivity analysis using CAFTA; and application of human reliability analysis. Other areas of specialization include project planning, program management engineering, peer review of PRA and deterministic analysis; and applied above specialties to over 20 Boiler Water Reactor and Pressurized Water Reactor FSAR updates.

Lawrence J. Kripps – B.S. and M.S. in Nuclear Engineering. Over twenty-six years experience managing and performing safety analyses and environmental assessments of U.S. Department of Energy and commercial nuclear and non-nuclear facilities. Provided technical direction and support in the development of the hazard and accident analyses and controls for the FSAR and the associated Technical Safety Requirements.

David J. Saueressig – B.S. in Mechanical Engineering. Mr. Saueressig has more than 13 years of experience in the nuclear industry, all of it with the storage, handling, and transfer of radioactive liquid waste. He has 13 years of experience at the Hanford Site including assignments in Process Engineering and Shift Operations Management. He is a certified Shift Manager within RPP, a Building Emergency Director, and USQ screener. He has spent six years on shift as a supervisor/manager supporting operations, including salt well pumping.

Ryan D. Smith – B.S. Mechanical Engineering. Six years of experience at the Hanford Site with the last three years specific to Nuclear Safety and Licensing (NS&L) support. NS&L Engineer for the Interim Stabilization, Characterization, and Vadose Zone programs. Extensive knowledge in flammable gas related issues related to pumping waste to and from tank farm facilities. Key team member in establishing the Authorization Basis (AB) for Interim Stabilization and reconciliation of the Los Alamos National Laboratory Safety Assessment with the BIO. Assisted in the transition of the BIO to the FSAR as well as ongoing AB maintenance and clarification support.

Michael A. White – B.S. in Mechanical Engineering. Mr. White has over 8 years of experience in the nuclear industry, all with the storage, treatment, handling and transfer of radioactive liquid waste at the Hanford Site. His responsibilities have been focused in support of facility operations, including facility modification/upgrades, testing, and startup. Mr. White assisted in the development of the 242-A Evaporator/Liquid Effluent Retention Facility Safety Analysis Report, Safety Equipment List, and Part B Permit application, and has experience as a core USQ Evaluator.

William F. Zuroff – B.S. Degree, University of Idaho. Mr. Zuroff has more than 30 years of experience in the nuclear industry including nuclear operations, instrument maintenance and plant engineering. He has over 15 years experience at the Hanford Site including equipment design, testing, operations, and USQ evaluations. Other nuclear related experience includes preparation of design requirements, and procurement specifications for nuclear monitoring systems.

## CONTROL DECISION MEETING ATTENDANCE SHEET

| Control Decision Meeting Attendance | | | |
|---|---|---|---|
| Name | Knowledge Area(s) Represented (see below) | Organization | Telephone Number |
| William H. Evans | 1, 2, 3, 8, 15, 16, 17 | NS&L | 373-7308 |
| [illegible] | 1, 2, 3, 8, 9, 15, 16, 17 | NS&L | 373-3255 |
| Lawrence J. Kripps | 15, 16 | NS&L | 376-1061 |
| William F. Zuroff | 3, 10, 15 | ESRPO | 373-1003 |
| Bellomy, James R | 3, 4, 5, 14, 20 | M&RE | 372-1673 |
| Saueressig, David J | 4, 5 | I/S OPS | 373-0183 |
| Smith, Ryan D | 1 | NS&L | 372-1383 |
| Mike White | 3, 4, 11, 14, 15, 20 | ESE | 3-5453 |
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Knowledge Areas:

1 Licensing Engineer
2 Hazard Analysis
3 Engineering
4 Operations
5 Project Management
6 Quality Assurance
7 Process Engineering
8 Safety Analyst
9 Accident Analysis
10 Design Authority
11 Design Agent
12 Radiological Control
13 Environmental Support
14 Equipment Engineering
15 Safety Structures, Systems, & Components
16 Technical Safety Requirements
17 Nuclear Safety & Licensing
18 Safety & Emergency Preparedness
19 Regulatory Compliance Support
20 Maintenance & Reliability Engineering
21 Other – Specify

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# APPENDIX C

# PRELIMINARY HAZARDS ANALYSIS AND CONTROL ALLOCATION PEER REVIEW

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# PRELIMINARY HAZARDS ANALYSIS AND CONTROL ALLOCATION PEER REVIEW FOR REVISION 0

**Practice 134 290 1112**
**Publication Date 22Nov99**
**Attachment 02 - Sheet 1 of 1**

**FLUOR DANIEL NORTHWEST**

**TECHNICAL PEER REVIEWS**

## CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-6954 DRAFT 2
Title: HAZARD EVALUATION FOR A SALT WELL CENTRIFUGAL PUMP DESIGN USING SERVICE WATER FOR LUBRICATION AND COOLING
Author: WILLIAM H. GRAMS
Date: DRAFT 2 SENT BY EMAIL ON 10/4/00
Scope of Review: MAIN BODY OF REPORT RELATED TO PRELIMINARY HAZARDS ANALYSIS BUT NOT RELATED TO CONTROL ALLOCATION

| Yes | No* | NA | |
|---|---|---|---|
| [ ] | [ ] | [X] ** | Previous reviews complete and cover analysis, up to scope of this review, with no gaps. |
| [X] | [ ] | [ ] | Problem completely defined. |
| [X] | [ ] | [ ] | Accident scenarios developed in a clear and logical manner. |
| [X] | [ ] | [ ] | Necessary assumptions explicitly stated and supported. |
| [ ] | [ ] | [X] | Computer codes and data files documented. |
| [ ] | [ ] | [X] | Data used in calculations explicitly stated in document. |
| [ ] | [ ] | [X] | Data checked for consistency with original source information as applicable. |
| [ ] | [ ] | [X] | Mathematical derivations checked including dimensional consistency of results. |
| [ ] | [ ] | [X] | Models appropriate and used within range of validity, or use outside range of established validity justified. |
| [ ] | [ ] | [X] | Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations. |
| [ ] | [ ] | [X] | Software input correct and consistent with document reviewed. |
| [ ] | [ ] | [X] | Software output consistent with input and with results reported in document reviewed. |
| [ ] | [ ] | [X] | Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references. |
| [ ] | [ ] | [X] | Safety margins consistent with good engineering practices. |
| [ ] | [ ] | [X] | Conclusions consistent with analytical results and applicable limits. |
| [X] | [ ] | [ ] | Results and conclusions address all points required in the problem statement. |
| [ ] | [ ] | [X] | Format consistent with applicable guides or other standards. |
| [ ] | | [X] ** | Review calculations, comments, and/or notes are attached. |
| [X] | [ ] | [ ] | Document approved (for example, the reviewer affirms the technical accuracy of the document). |

THOMAS B. POWERS *Thomas B. Powers* — 10/4/2000
Reviewer (printed name and signature) — Date

* All "no" responses must be explained below or on an additional sheet.

** Any calculations, comments, or notes generated as part of this review should be signed, dated, and attached to this checklist. The material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

NUCLEAR ENGINEERING

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## PRELIMINARY HAZARDS ANALYSIS AND CONTROL ALLOCATION PEER REVIEW FOR REVISION 1

### CHECKLIST FOR AB DOCUMENT CALCULATION TECHNICAL PEER REVIEW

Document and Section Reviewed: RPP-6954, Rev. 1, "Hazard Evaluation for the Salt Well Chempump and a Salt Well Centrifugal Pump Design Using Service Water for Lubrication and Cooling"

Scope of Review: The review is limited to the conduct and technical accuracy of the hazard identification and evaluation plus the control allocations.

| Yes | No | NA | |
|---|---|---|---|
| [✓] | [ ] | [ ] | Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps. |
| [✓] | [ ] | [ ] | Problem is completely defined. |
| [✓] | [ ] | [ ] | Accident scenarios are developed in a clear and logical manner. |
| [✓] | [ ] | [ ] | Necessary assumptions are explicitly stated and supported. |
| [ ] | [ ] | [ ] | Computer codes and data files are documented. |
| [ ] | [ ] | [✓] | Data used in calculations are explicitly stated. |
| [✓] | [ ] | [ ] | Data were checked for consistency with original source information as applicable. |
| [ ] | [ ] | [✓] | Mathematical derivations were checked including dimensional consistency of results. |
| [ ] | [ ] | [✓] | Models are appropriate and were used within their established range of validity, or adequate justification was provided for use outside their established range of validity. |
| [ ] | [ ] | [✓] | Spreadsheet results and all hand calculations were verified. |
| [ ] | [ ] | [✓] | Software input is correct and consistent with the document reviewed. |
| [ ] | [ ] | [✓] | Software output is consistent with the input and with the results reported in the document reviewed. |
| [✓] | [ ] | [ ] | Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. |
| [ ] | [ ] | [✓] | Safety margins are consistent with good engineering practices. |
| [✓] | [ ] | [ ] | Conclusions are consistent with analytical results and applicable limits. |
| [✓] | [ ] | [ ] | Results and conclusions address all points required in the purpose. |
| [✓] | [ ] | [ ] | **Concurrence** |

M. V. Shultz [signature] November 3, 2000
Reviewer (Printed Name and Signature) Date

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# APPENDIX D

## ANALYSIS OF GAS GENERATION BY CAUSTIC/ALUMINUM REACTION IN THE CRANE CHEMPUMP®

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# D1.0 GENERAL INFORMATION

## D1.1 ALUMINUM COMPONENTS OF THE CRANE CHEMPUMP®

The manufacturer of the salt well pump (Crane Chempump®) was contacted. They in turn contacted, General Electric, the manufacturer of the rotor, who declined to provide exact details of the rotor for proprietary reasons. However, they did provide the following general information:

The rotor is approximately 10.2 cm in diameter by 15.2 cm long (4 in. dia., 6 in. long). It is composed of a series of iron disks mounted on the stainless steel shaft. These disks have a series of tear drop shaped radial holes spaced equally about the disk. Tear drop shaped aluminum bars are inserted through the holes and aluminum disks, or end caps, are mounted on both ends of the assembly. This is then encapsulated in a welded stainless steel canister. The amount of aluminum in the rotor assembly for the Crane GB-3K Chempump® is 342 g (0.755 lb.).

## D1.2 ATTRIBUTES OF THE SALT WELL PUMPING SYSTEM DESIGNED TO PROTECT THE PUMP

The following are components of the salt well pumping system that are designed to protect the pump from conditions of high pressure or temperature:

1. Salt well rear bearing temperature Hi and Hi-Hi

   The system has an alarm and interlock to protect against running the pump with a plugged re-circulation line (no process lubricant/coolant). The hi alarm set point of 5.6° C (10° F) above the median waste temperature activates an alarm to alert salt well pump (SWP) operations of high pump temperatures. The Hi-Hi alarm/interlock set point of 11.1° C (20° F) above the median waste temperature activates an alarm and shuts down (de-energizes) the pump.

2. Transfer Pressure, Lo

   An interlock/alarm activates an alarm to alert SWP operations of a low pressure (loss of prime) condition and shuts down (de-energizes) the salt well pump if the discharge pressure drops below 103 kPa (15 psig) for more than 30 seconds.

3. Transfer Pressure, Hi

   An interlock/alarm activates an alarm to alert SWP operation of a high discharge pressure and shuts down (de-energizes) the salt well pump if the discharge pressure rises above 965 kPa (140 psig). This protects piping components from damage due to high pressures.

These alarms and interlocks will deactivate the pump at levels well below where gas generation would cause components to fail or to where temperature levels would be of concern.

# D2.0 ALUMINUM CAUSTIC REACTION

## D2.1 GAS GENERATION POTENTIAL

The reaction of aluminum and caustic produces 1 ½ moles of $H_2$ for every mole of aluminum. The balanced equation for the formation of hydrogen from Al in alkaline solution is

$$2NaOH + 2H_2O + 2Al = 3H_2 + 2NaAlO_2$$

The atomic mass of aluminum is 27. Therefore, there are:

342 g / 27 g/ mole Al = 12.7 moles of Aluminum

If all of this aluminum were to react, the amount of hydrogen produced would be:

12.7 moles Al * 1.5 moles $H_2$ / mole Al = 19 moles of $H_2$

19 moles $H_2$ * 22.4 liters/mole = 426 liters $H_2$ (15 $ft.^3$) at standard temperature and pressure (STP)

In the re-circulation mode, there is a total system volume of about 28.3 liters (1.0 $ft.^3$). The caustic flush used a 3 molar solution or 3 moles of NaOH per liter. The amount of caustic in the re-circulation loop would be:

28.3 liters * 3 moles/liter = 85 moles of caustic

It takes 1 mole of sodium hydroxide to react with each mole of aluminum. The amount of caustic in the system could react the following amount of aluminum:

85 moles caustic / (1 mole caustic/mole Al) = 85 moles Al

Therefore, given enough time there is an excess of caustic in the re-circulation loop to react with all of the aluminum in the rotor.

## D2.2 GAS GENERATION DURING NORMAL SALT WELL PUMPING

During normal transfers, a breach in the protective canister around the rotor would allow the tank waste to contact the aluminum parts. As tank waste has a relatively high pH, this would generate gas but not at the same rate as when pumping a 3 molar caustic solution. The aluminum is contained within the stainless steel encased rotor. It is unlikely that there would be a breach in the rotor encasement such that coolant would free flow through the assembly. More probable would be a single hole where coolant would enter. Thus the reaction would not progress as rapidly since the single hole would impede the ability to supply additional fluid. Initially, the reaction rate would be higher due to its attacking a fresh aluminum surface close to the breach in the rotor encasement. The reaction would then slow due to a longer flow path to additional aluminum. The gas would escape from the motor through the passage at the front bearing into the low pressure area of the volute near the center of the backside of the impeller. Gas would be entrained in the salt well liquid stream and transferred to the receiver tank. As hydrogen gas is a normal component of tank waste, the addition of a small amount into the stream would not be significant and may not be measurable beyond normal fluctuations when it reaches the receiver tank. The motor casing would not see increased pressure due to gas generation. The line pressure, due to the hydrogen generation, would not increase as the hydrogen generated would be an insignificant part of the overall transfer and would be carried along in the fluid through the transfer pipes to the receiver tank.

## D2.3 GAS GENERATION DURING LINE FLUSHING OPERATIONS

During line flushing activities using pH balanced service water, there would be some reaction of the flush water with the aluminum components. This is because the water pH is adjusted higher (on the basic side) to prevent waste tank corrosion. The water flush hydrogen generation would be similar to that of tank waste as discussed above. A line flush using a caustic solution would increase the hydrogen generation rate, however, this would not be significant since the maximum amount of hydrogen that could be generated is only 19 moles [426 liters $H_2$ (15 ft.$^3$) at STP] and venting would occur through the transfer line to the receiver tank.

## D2.4 GAS GENERATION IN RE-CIRCULATION MODE

When the pump is operating in the re-circulation mode, there is a total piping system volume of about 28.3 liters (1 ft.$^3$). A small amount of gas generation will cause a dramatic increase in pressure. The working pressure for SWP is less than 1000 kPa (140 psi). The pressure rise would eventually (depending on the generation rate) cause a failure of the piping causing a leak. Re-circulation could use either flush water, tank waste, or caustic solution. The pH balanced flush water and tank waste would generate hydrogen gas at a lower rate than would be produced by a caustic solution.

The results of the leak are dependent on where the leak occurred. The hydrogen that is generated in the rotor would escape into the process fluid cooling/lubrication stream and ultimately be injected at the eye of the impeller back into the flow loop. In re-circulation mode, the foot valve (an inlet check valve placed in the system to keep the pump primed) is a probable leak path. During re-circulation, this valve is closed because the amount of material going out the pump is the same as that going through the jet. When gas generation increases the line pressure, some of the fluid could leak past the check valve lowering the pressure. The foot valve is a metal-to-metal seal and historically has been shown to not be leak tight, making this a probable happening. The line would remain pressurized and tank waste would not enter into the line. Gas generation would continue, but at some point, the volume of gas would cause too much fluid to escape into the tank and pumping would degrade or even cease due to a loss of prime. The gas generation would continue until all the caustic in the rotor reacted with the aluminum.

A different result is postulated if the leak were to occur in one of the lines, valves, or in the pump/motor casing. In this case, fluid along with entrained gas would leak to either the pit or the salt well. If the gas generation rate is such that the pressure stays up in the line, no additional waste will enter the system and eventually the pump will lose prime and gas generation will cease as discussed in the paragraph above. If the overpressure caused a leak in excess of the gas generation rate, the foot valve would be opened and tank waste would be pulled into the loop, much like a normal transfer. The flow meter is not in the loop during this operation and would not detect any discrepancy between the pumped and received volumes. Thus, the pump will continue to run. A leak in the pit would eventually activate the leak detection system. A leak in the salt well would not be detected and the pump would run indefinitely with gas generation at the rate dictated by the waste. Eventually all the aluminum would be consumed and the gas generation would cease.

## D3.0 FLAMMABLE GAS IGNITION

### D3.1 ELEVATED TEMPERATURES IN THE PUMP INTERNAL PASSAGES

The reaction of aluminum and caustic is exothermic. Therefore, it can be assumed that the local temperature at the reaction interface could be elevated. During pump operation, the fluid is constantly pumped through the motor as a source of both cooling and lubrication. Areas within the pump could have temperatures higher than the fluid temperature; however, it is not expected that the wetted surfaces in the pump would exceed 93 °C (200 °F) and those areas could be locally hotter; e.g., a bearing or a place where the rotor was in contact with the thrust bushing. These would cool quickly upon de-energizing the pump. Ignition Source Control Set #2 states that the surface temperatures of heat-generating devices (this includes potential compression heating mechanisms and open flames) shall not exceed 416 °C (781 °F). It is unlikely that the surface temperatures of the pump would challenge this limit. The localized hot spots within the pump would not pose an ignition problem, since there would be only trace amounts of oxidizers entrained or dissolved in the fluid, but not enough to support combustion.

### D3.2 IGNITION OF FLAMMABLE GAS CAUSED BY CAUSTIC/ALUMINUM REACTION

#### D3.2.1 Ignition During Normal Salt Well Transfers and Line Flushing

During normal salt well transfers, the amount of gas that could be captured within the system would be in the motor only. As discussed above, gas generation will not cause pressure buildup. The pumping process continually provides fluid from the discharge of the pump to the motor for cooling and lubrication. Thus the generated gas would be entrained with the fluid and returned to the transfer line through the passage in the front bearing. The amount of gas in the system would be minimal. Gas could only be concentrated within the pump motor itself. The internal cavities of the motor are small as the motor is designed for maximum efficiency and thus the clearance between the rotor and stator is small. Thus the volume of gas present in the pump is conservatively estimated to be less than 1 liter (0.04 $ft.^3$) at line pressure. Most of this will be filled with fluid from the pump discharge. Therefore, the gas retention would, at the worst case, be a bubble in the motor down to the front bearing. Thus the amount of gas would be about one half of the estimated total volume or 0.5 liters (0.02 ft.$^3$). It would be unlikely that this small amount of gas could ignite as there is no reason to expect air or other oxidizers to be present in anything but trace amounts. In the unlikely event of ignition, the SWP lines in the pit would be filled with fluid. The overpressure due to ignition would cause the gas to escape through the small passages in the front bearing and rear bearing of the pump and enter the salt well transfer piping, which is liquid filled with no significant gas component. Thus, it is improbable that the ignition event would extend beyond that small volume of gas in the motor.

As discussed above, use of pH balanced water for line flushing would be analyzed similarly to a normal salt well transfer. Even less gas would be present since the water, unlike tank waste, would not include a gas component.

### D3.2.2 Ignition During Caustic Re-circulation

During caustic re-circulation, gas generation would cause a rapid buildup with a potential breach in the re-circulation lines. The amount of gas is dependent upon the rate of generation and size of the breach in the line. If the gas generation rate is sufficient to maintain pressure as material (gas and or caustic) escapes through the breach, then the pumping will continue until the gas volume replaces enough fluid to cause the pump to lose prime. At this point the volume in the system at line pressure would be the motor cavity [1 liter] plus the upper portion of the re-circulation loop (approximately 10 liters). Line pressure would be dependent on the size of the breach. The maximum pressure after line breach would occur with a very small hole. The maximum volume of pressurized gas would be the complete loop [28.3 liters] although the pump would probably lose prime well before that. In the unlikely event of ignition, the motor would be pressurized and the hot gases would either damage the motor casing and escape or exit into the line at two places, the volute and the pump discharge. At this point, the gas in the transfer line could ignite. The consequences of this event are described in the following section. Since the system is pressurized and the caustic solution would not contain any oxidizers, the fire triangle (heat/fuel/oxygen) is not complete and ignition would not be expected.

Where flammable gas escapes to the pit or tank headspace, an ignition source would need to be present to cause a gas burn. The portion of the pump with elevated temperatures would be a bearing and the internal portion of the rotor. The external portions of the pump in direct communication with the atmosphere in the pit would remain significantly cooler. It is unlikely that a hot bearing or rotor would cause the surface of the pump to exceed the limits of temperature imposed by the ignition controls (less than 416 °C [781 °F]). The ignition source remains within the motor.

## D3.3 CONSEQUENCE OF FLAMMABLE GAS IGNITION IN THE SALT WELL PUMP OR PIT

An analysis of the consequence of a flammable gas deflagration in a transfer line is documented in HNF-5334, *Hazard Evaluation for Waste Transfer System Piping Flammable Gas Hazards* (CHG 1999). This analysis considered full or essentially full piping as would be the case of the salt well loop from the pump to the jet and back to the pump. It also considered a deflagration in a partially full line since this would be the case for the salt well transfer lines beyond the re-circulation loop. This document concluded that there are no significant public (S3) or onsite worker (S2) consequences for any waste transfer line hazard. Consequences are limited from a deflagration by the diameter of the pipe (typically 7.6 cm [3 in] for encasements) and the inverse proportionality between the volume of flammable gas present and the source term available for release. Thus the pipes with the largest volume of headspace available for flammable gas accumulation will have the highest potential deflagration energy, but will have the least amount of waste available for release. The hazard analysis evaluated the ability of the piping to withstand flammable gas deflagrations or detonations. It determined that most primary piping and encasements would withstand the assumed detonation pressure of 2830 kPa absolute (411 psia). The piping most prone to failure is the older buried piping which, in the event of failure, would exhibit a mitigating effect by the several feet of soil covering the pipe. In summary, a deflagration of gas within a transfer line may cause a waste leak but the consequences will not exceed onsite or offsite limits.

The consequence of a deflagration within the motor and re-circulation loop would be similar to that analyzed for the transfer lines in HNF-5334 (CHG 1999) for a filled pipe. In the case of salt well pumping, the amount of piping is small (total volume of about 28.3 liters (1.0 $ft.^3$) with a relatively small amount of gas present. Additionally, most of this piping is contained within in the salt well with some in the pit. Thus the consequence would be bounded by that evaluated in the hazard analysis.

In the re-circulation mode, there is a possibility for gas to escape to the pit where Ignition Control Set #2 is required. If an ignition source were present, the consequence of a deflagration within a pit has been analyzed (CHG 1999) and was found to impact the onsite, co-located worker (S2).

## D4.0 SUMMARY

The aluminum components in the rotor of the Crane Chempump® can react with caustic solutions, or more slowly with tank waste, to produce hydrogen gas. The maximum amount of gas that could be generated is 19 moles or 426 liters (15 $ft.^3$) at STP. Hydrogen generation is not an immediate process, but occurs over a period of time (tens of minutes to hours, possibly days) depending on the caustic concentration and the size of the breach in the stainless steel canister around the rotor. During normal salt well transfers and line flushing, any gas generated is entrained in the waste stream and is ultimately transferred to the receiver tank. There would be no additional pressure build up and the small amounts of gas would be well within the range of that observed during normal salt well transfers when the pump is not damaged.

When in the re-circulation mode, the pump moves the fluids (caustic solutions or tank waste) in a closed loop having a total volume of approximately 28.3 liters (1 $ft.^3$). Gas generation could pressurize this loop and possibly cause a failure (breach) which would release liquid and gas into the tank (salt well) or pit. The internal components of the pump could have locally elevated temperatures, however, there would be insufficient oxidizer in the pump cavity to support combustion since only hydrogen would be generated in the loop. The exterior of the pump would experience minimal heating due to bearing friction or the reaction. Therefore, the addition of hydrogen into the pit is not expected to be a problem because Ignition Control Set #2 controls are required in the pit and it is unlikely that the flammability limit would be exceeded. Release of this amount of gas into the tank headspace may not even be measurable. The consequence of a flammable gas deflagration in the transfer lines, pit, or tank headspace, due to a reaction of caustic with the aluminum in the pump rotor, is bounded by the current analysis.

Although not evaluated, the design of the SWP system protects the pump. The pressure and temperature instrumentation and controls will shut down the system if pressures within the line or pump temperature exceed set limits.

This analysis was used in the evaluation of new information concerning gas generation in the salt well Chempump® (USQ Determination TF-00-0561, Revision 3).

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# PRELIMINARY HAZARDS ANALYSIS AND CONTROL ALLOCATION PEER REVIEW FOR APPENDIX D

## CHECKLIST FOR AB DOCUMENT CALCULATION TECHNICAL PEER REVIEW

Document and Section Reviewed: RPP-6954, Rev. 1, "Hazard Evaluation for the Salt Well Chempump and a Salt Well Centrifugal Pump Design Using Service Water for Lubrication and Cooling"

Scope of Review: The review is limited to the of RPP-6954, Rev. 1, Appendix D, *Analysis of Gas Generation by Caustic/Aluminum Reaction in the Crane Chempump®*.

| Yes | No | NA | |
|---|---|---|---|
| [X] | [ ] | [ ] | Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps. |
| [X] | [ ] | [ ] | Problem is completely defined. |
| [X] | [ ] | [ ] | Accident scenarios are developed in a clear and logical manner. |
| [X] | [ ] | [ ] | Necessary assumptions are explicitly stated and supported. |
| [ ] | [ ] | [X] | Computer codes and data files are documented. |
| [X] | [ ] | [ ] | Data used in calculations are explicitly stated. |
| [ ] | [ ] | [X] | Data were checked for consistency with original source information as applicable. |
| [X] | [ ] | [ ] | Mathematical derivations were checked including dimensional consistency of results. |
| [ ] | [ ] | [X] | Models are appropriate and were used within their established range of validity, or adequate justification was provided for use outside their established range of validity. |
| [ ] | [ ] | [X] | Spreadsheet results and all hand calculations were verified. |
| [ ] | [ ] | [X] | Software input is correct and consistent with the document reviewed. |
| [ ] | [ ] | [X] | Software output is consistent with the input and with the results reported in the document reviewed. |
| [ ] | [ ] | [X] | Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. |
| [X] | [ ] | [ ] | Safety margins are consistent with good engineering practices. |
| [X] | [ ] | [ ] | Conclusions are consistent with analytical results and applicable limits. |
| [X] | [ ] | [ ] | Results and conclusions address all points required in the purpose. |
| [X] | [ ] | [ ] | **Concurrence** |

W. L. Cowley (signature: W. L. Cowley)
Reviewer (Printed Name and Signature)

Date 11-8-00