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MAY 15 1995 Sta 31 #67

ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 603463

Proj. ECN N/A

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. Date
Supplemental [ ] Direct Revision [X] Change ECN [ ] Temporary [ ] Standby [ ] Supersedure [ ] Cancel/Void [ ]	ME Hughes, 7F220, B4-08, 373-5244	28 Dec 94

5. Project Title/No./Work Order No.	6. Bldg./Sys./Fac. No.	7. Approval Designator
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8. Document Numbers Changed by this ECN (includes sheet no. and rev.)	9. Related ECN No(s).	10. Related PO No.
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11a. Modification Work	11b. Work Package No.	11c. Modification Work Complete	11d. Restored to Original Condition (Temp. or Standby ECN only)
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ENGINEERING CHANGE NOTICE

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15. Design Verification Required	16. Cost Impact				17. Schedule Impact (days)	
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[] Yes	Additional	[] $ Ø	Additional	[] $	Improvement Ø	[]
[X] No	Savings	[] $	Savings	[] $	Delay	[]

18. 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 12. Enter the affected document number in Block 19.

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	[]		[]

19. 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		

20. Approvals

Signature	Date	Signature	Date
OPERATIONS AND ENGINEERING		ARCHITECT-ENGINEER	
Cog. Eng. SE Chalk for 26/Dec/94	12/30/94	PE	
Cog. Mgr. RL Fritz	28Dec94	QA	
QA TZ Anderson TZA	12/29/94	Safety	
Safety SE Chalk	12/30/94	Design	
Environ. N/A	X	Environ.	
Other	X	Other	
Nuclear Safety: PL Smith	1/16/95		
Environ Policy: JI Gould	1/30/95		
Engineering: BD Groth	2/9/95	DEPARTMENT OF ENERGY	
Risk Assessment: JM Siemer	2/8/95	Signature or a Control Number that tracks the Approval Signature	
		ADDITIONAL	

SUPPORTING DOCUMENT

1. Total Pages 131 ~~125~~ ~~109~~ 120

2. Title	3. Number	4. Rev No.
Hazard and Operability Study of the Multi-Function Waste Tank Facility	WHC-SD-W236A-PHA-001	1

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MWTF, TANKS, HAZOP, SAFETY, CONSTRUCTION PROJECTS	Name: JM Siemer Signature Organization/Charge Code 7F220

7. Abstract

Description of facility hazards that site personnel or the general public could potentially be exposed to during operation.

DISCLAIMER

8. RELEASE STAMP

RECORD OF REVISION	(1) Document Number WHC-SD-W236A-PHA-001 Rev.1	Page 1

(2) Title
Hazard and Operability Study of the Multi-Function Waste Tank Facility

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
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This document was reviewed following the procedures described in WHC-CM-3-4 and is:

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

VL Birkland — May 12, 1995

V.L. Birkland

WHC-SD-W236A-PHA-001
Rev. 1

Hazard and Operability Study

of the

Multi-Function Waste Tank Facility

Judith M. Siemer

November 1994

List of Terms

CAM	Continuous Air Monitor
DBE	Design Basis Earthquake
HazOp	Hazards and Operability
HEPA	High Efficiency Particulate Air
HWVP	Hanford Waste Vitrification Plant
MWTF	Multi-Function Waste Tank Facility
NACE	National Association of Cathodic Engineers
OSHA	Occupational Safety and Health Administration
PSAR	Preliminary Safety Analysis Report
psi	pounds per square inch
SSA	Systems Safety Analysis
WHC	Westinghouse Hanford Company

Table of Contents

1.0 INTRODUCTION

The Multi-Function Waste Tank Facility (MWTF) East site will be constructed on the west side of the 200E area and the MWTF West site will be constructed in the southwest quadrant of the 200W site in the Hanford area. Functional Design Criteria (Kendall, 1992); a Conceptual Design Report (Nicholson, 1992); an Advanced Conceptual Design Report (WHC, 1993) and a Preliminary Safety Evaluation (Kidder, 1991) have been issued for the project. A Preliminary Safety Analysis Report (PSAR) is scheduled to be completed in fiscal year 1995. The Westinghouse Hanford Company Safety Analysis and Engineering (SA&E) Department will be developing the PSAR; the Project Safety Analysis and Nuclear Engineering (SA&NE) unit of SA&E will have the primary role in performing the accident analyses for the PSAR.

The first step in performing an accident analysis is to identify and qualitatively assess the facility hazards. The results of the assessment are used to determine which abnormal events could initiate accidents with the potential to expose site personnel or the general public to radioactive or chemical hazards.

A number of systematic techniques for hazards identification are available; the technique chosen for the MWTF is the Hazards and Operability (HazOp) Study. The HazOp methodology was chosen because it is designed specifically for chemical processing and storage areas. It is also one of the most exhaustive techniques because it is designed to examine process deviations in exhaustive detail and because it utilizes a multi-discipline team of knowledgeable individuals in a systematic brainstorming effort. The HazOp results are being used as a scoping tool to determine which potential accident sequences must be analyzed in detail to demonstrate that the MWTF can be safely operated.

The results of Revision 1 to the HazOp Study will assist in the resolution of comments made by the DOE's Independent Review Group during the MWTF PSAR review . The subject comments were directed at obtaining a general quantification of hazards to the MWTF facility worker and estimating a frequency range for each of the various accident scenarios based on the collective engineering judgement of the HAZOP team members. The original HazOp methodology was not changed.

2.0 SCOPE

The HazOp covers equipment and facilities within the scope of Project W236-A which could contain quantities of hazardous (radiologically hazardous or toxic) materials with potential to cause significant consequences to site personnel or the general public. The assumed configuration was that documented in the draft "Advanced Conceptual Design Report for the Multi-Function Waste Tank Facility". In order to minimize duplication of effort, the HazOp covered typical equipment. For example, the tanks were represented by TK-103, since it was a "typical" tank, with the exception that drain piping

provides additional sources of liquid. The process pits were represented by the valve pit (considered typical); the flush pit was specifically considered because of the design differences from the other process pits. Areas with limited potential to cause consequences outside of the facility boundaries or initiate significant events in other parts of the facility (change rooms, etc) were not included in the scope of the HazOp.

Revision 1 of the study assigned one of four frequency ranges to the various hazards and assessed the hazards involving consequences to the facility worker.

3.0 ORGANIZATIONAL RESPONSIBILITIES

The HazOp was performed by Westinghouse Systems Safety Analysis and personnel designated by the MWTF project. Systems Safety Analysis (SSA) coordinated the effort by providing methodology, facilitation, recording services, and the final report. Other groups represented were the MWTF project, Kaiser Engineers Hanford design personnel, WHC Safety, and Tank Farm Operations. Information concerning the qualifications of the team members is included in Appendix C.

The Supplemental HazOp Study (Revision 1) was performed by WHC Safety Analysis and Engineering (SA&E) personnel and other personnel designated by the MWTF project. WHC SA&E coordinated the effort maintaining the original methodology. Other groups represented were the MWTF project, Kaiser Engineers Hanford design personnel, WHC Safety, and Tank Farm Operations. Most of the original HazOp team was retained.

4.0 METHODOLOGY

A Hazards and Operability study (described in detail in Appendix A) documents the effects of deviations from the design intent of the various "process" parameters. Flow diagrams were utilized to break the system into nodes. Each major piece of equipment involved in the process is a node, and the piping and/or instrument lines connecting the equipment are also nodes. Pertinent process parameters (guide words) such as flow, pressure, level, and temperature are chosen, and a series of questions are asked about each parameter. Each "question" concerns an abnormal condition of the parameter (for example, "no flow"). The team, based on design knowledge and operational experience, postulated the cause(s) and effects of the abnormal process condition. From this information, a qualitative estimate of the consequences of the abnormal condition was obtained. The estimate can then be used as a screening tool to determine the need for further analysis.

The HazOp product is a series of tables (Appendix B) showing the results of the team discussions. The results are further categorized to include a list of potential abnormal conditions which might cause consequences in the various categories, a list of accidents to be considered for analysis in the MWTF PSAR, and a list of comments and recommendations made by the team.

5.0 RESULTS

The summary of the results of the studies performed is included in this section.

The results of the HAZOP analyses were a number of postulated abnormal events which were ranked by the team members with respect to safety consequences. The first cut, qualitative, consensus estimates of the safety severity of the consequences were ranked by the following alphanumeric system:

S0 no effect outside the facility confinement systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1 potential industrial injury, radiological dose consequences or chemical exposure to the facility worker

S2 potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3 potential significant radiological dose consequences or chemical exposure to the offsite population

The following Table shows the number of events considered to have potential consequences in each category, for each study node. Note that the number of ranked abnormal events does not have a one-to-one correlation with the node deviations. In some cases, deviations of a parameter associated with one node would cause another deviation of a parameter associated with a second node. (For example, high flow through a feed line node might cause high level in the destination vessel.) In some cases an abnormal event caused by a particular deviation has more than one consequence ranking, depending upon the state of associated equipment or parameters. Because consequence calculations have not been performed for any abnormal event, some events have a dual (S1-S2 or S2-S3) ranking . These events are tabulated in both consequence categories. In some cases, the cause and consequences of a particular deviation at a node are identical to a deviation at another node. These are cross-referenced in the HazOp tables and not generally included in the count as separate ranked abnormal events. Thus, the count of abnormal events in the following table should simply be used as a guide to the severity of possible consequences in the MWTF. Only those abnormal events having a potential safety consequence of S2 or S3 will be considered for detailed accident analysis.

Table: HazOp Results Summary

Node	# S0	# S1	# S2	# S3	TOTAL
1. High level waste transfer lines (represented by spare line from diversion box to valve pit)	5	3	8	0	16
2. Flush jumper assembly	3	7	3	0	13
3. Piping from flush Pit to flush jumper (deviations encompassed by flush jumper assembly)	0	0	0	0	0
4. Process drain line from valve pit to drain pit to TK-103	4	0	0	0	4

Table: HazOp Results Summary

Node	# S0	# S1	# S2	# S3	TOTAL
5. Process waste jumper in valve pit	0	0	0	0	0
6. Valve pit	0	13	6	0	19
7. Valve pit drain line from valve pit to drain pit	0	1	0	0	1
8. Valve pit Exhaust line from valve pit to vent building	2	11	0	1	14
9. Process line encasement	3	3	1	0	11
10. Flush pit	0	7	1	0	12
11. Primary tank (TK-103)	10	9	9	3	31
12. Secondary tank (TK-103)	5	0	2	0	7
13. Sampler	5	9	0	0	14
14. Sampler pit	0	3	0	0	3
15. Sampler cell	0	18	0	0	18
16. Decontamination solution tanks	3	10	1	0	14
17. Mixer pump pit	3	7	2	0	12
18. Weather enclosure	9	19	3	2	33
19. Tanker load-in station	1	14	1	0	16
20. Piping from the load-in station to the chemical addition lines including piping within the pump station	12	12	0	0	24
21. Primary tank ventilation system air intake	0	7	0	0	7
22. Primary tank once-through exhaust	4	8	2	0	14
23. Combined exhaust tunnel and stack	0	0	2	0	2
24. Heat removal system on primary tank	1	6	0	0	7
25. Inlet to annulus ventilation system (basically the same as the primary ventilation system)	0	0	0	0	0

Table: HazOp Results Summary

Node	# S0	# S1	# S2	# S3	TOTAL
26. Annulus exhaust	0	4	0	0	4
27. Cross-over spool between annulus ventilation system and primary ventilation system	10	9	9	3	31

The HazOp tables are included in their entirety in Appendix B. Abnormal events having potential safety implications are summarized here. One hundred seventy-two deviations were postulated as having S1 (potential facility worker injury, radiation exposure, or exposure to toxic materials) consequences; many of these would be due to recovery actions necessitated by equipment failures or operating errors. The combined and summarized S1 deviations are:

1. Potential worker injury or exposure to radioactive contamination or toxic fumes during repair of process solution transfer piping or equipment

2. Potential high radiation exposure or industrial injury to operations/maintenance personnel during unplugging of process solution transfer lines due to loss of flush water flow or failure to flush a line segment due to misrouting of flush solution

3. Potential radiation exposure or industrial injury to operations/maintenance personnel due to repair of broken equipment in flush pit

4. Potential worker exposure to radioactive contamination due to flooding of flush pit

5. Potential high radiation exposure to personnel if process solution (feed for another waste tank) is erroneously transferred to flush pit

6. Worker chemical exposure due to transfer of wrong chemical to flush line

7. Possibility of overflowing waste tank due to wrong-time transfer of flush solution

8. Potential worker injury or exposure to radioactive contamination or toxic fumes during repair of equipment in valve pit

9. Unfiltered release of contaminated air from valve pit if pressurized due to chemical reaction, closed valve on vent line, pneumatic test failure, or via drain line to waste tank

10. Spray leak of process solution from valve pit piping spreading contamination which might be resuspended during contact maintenance/repair operations

11. Worker exposure to chemical fumes resulting from mistransfer of incompatible chemical solution to TK-103 via the flush line drain

12. Worker exposure to toxic gases due to chemical reaction in valve pit

13. Release of radioactive contamination from valve pit due to reverse flow to gas sampler building exhaust

14. Release of contaminated material to the environment due to broken process line encasement pipes (assumes that encasement is contaminated)

15. Environmental release of contaminated material due to failure of encasement piping during hydrotest (assumes that encasement is contaminated)

16. Leak of water from flush pit (S1 due to potential worker injury from repair. The flush pit is not ventilated, so confined space injuries might possibly occur.)

17. Leak of chemicals into flush pit potentially causing equipment damage and worker injury

18. Leak from primary tank causing increased worker radiation exposure due to recovery actions

19. Potential worker injury due to recovery actions from pumping out a tank at the wrong time

20. Potential worker injuries from recovery actions due to letting tank liquid level to go low enough to damage equipment

21. Structural damage to primary tanks due to high temperature from chemical reaction or ventilation failure

22. Contamination of sampler pit due to piping breaks or failure to install jumper (assumed worker exposure during maintenance)

23. Increased worker exposure because of difficulty in getting sample due to residual flush solution, decon solution or air in the sampler lines

24. Generation of toxic gas in sampler due to incompatibility of waste and decon solution

25. Contamination of sampler cell and casks due to leaks of process solution (could potentially spread to operating area and ventilation controls)

26. Spread of contamination from sampler cell due to ventilation failures

27. Spread of contamination from mixer pump pit if drain plugged

28. Resuspension and spread of contamination from mixer pump if motor fire or long-term loss of mixer pump motor cooling

29. Contamination spread due to dropping coverblocks into contaminated process pit

30. Contamination spread from weather enclosure fire starting either internal to the weather enclosure or external to the weather enclosure (range fire)

31. Worker heat exhaustion due to loss of weather enclosure air conditioning during periods of high ambient temperature

32. High temperature in sampler cell due to loss of air circulation during high ambient temperatures (worker heat exhaustion)

33. Spread of radioactive contamination due to fire in sampler cell

34. Potential worker injury from overflow of decontamination solution from decontamination solution storage tanks

35. Generation of small amounts of toxic gases in Tk-103 due to transfer of incompatible decontamination chemical to the tank via the decon area drain line

36. Release of hazardous material from decon solution tanks via tank vent stack due to solution overheating

37. Release of hazardous material into decon area from barrel pump if incompatible solution is transferred into decon tank

38. Increased worker radiation exposure due to inadvertent transfer of process solution to decon tank

39. Spread of contamination from process pit flooded by water from frozen utility pipes or fire protection water in the weather enclosure

40. Overflowing waste tanks from process pits draining water from frozen utility pipes or fire protection water into the tank

41. Contamination spread due to ventilation system problems caused by accumulation of windblown debris around cooling tower or ventilation intakes

42. Worker exposure to vehicle exhaust in weather enclosure due to failure of vehicle exhaust ventilation system

43. Worker injury due to spill or spray from chemical tank truck or associated piping

44. Worker injury due to reverse flow of steam from steam mixer to tanker load-in station

45. Worker exposed to hazardous chemicals due to failure of equipment in chemical addition system

46. Worker injury due to fuel fire in chemical supply truck

47. Chemical reaction in waste tank caused by mistransfer of incompatible chemical from truck load-in station resulting in tank pressurization or release of toxic gases

48. Worker radiation exposure due to suckback of contaminated tank atmosphere due to loss of steam in steam mixer

49. High differential pressure across once-through or annulus ventilation system due to excessive moisture in the air or transport of biota into intake (S1 rating due to hazards of filter changeout)

50. Contamination of inlet HEPA filter resulting from loss of ventilation outlet flow and subsequent reverse flow to inlet (S1 rating due to hazards of filter changeout)

51. Failure of inlet air heater control causing failure of inlet HEPA filter or damage to duct insulation (S1 due to hazards of recovery)

52. Contamination spread due to breach of inlet ductwork (could have normal stack flow with negative pressure not maintained in waste tank)

53. Contamination spread from inability to maintain annulus negative pressure with annulus crossover spool in place and open annulus riser (assumed that leak into annulus has occurred)

54. Steam from chemical addition system in tank vapor space causes plugging of exhaust HEPA filters (S1 ranking based on hazards of filter changeout)

55. Worker radiation exposure from replacement of equipment in exhaust system following fire in exhaust system

56. Worker radiation exposure resulting from repair of failed equipment on primary tank heat removal system

57. Transfer of corrosive flush solution to heat removal piping causing worker exposure during recovery

58. Release of propylene glycol due to heat removal system condenser failure

59. Transfer of propylene glycol to waste tank due to condenser failure (ranking depends on compatibility with contents of tank)

60. Release of contamination from annulus ventilation system due to pressurization

61. Release of process solution aerosol into annulus atmosphere due to small leak of primary tank

Forty deviations were postulated as having S2 (potential onsite worker exposure to airborne radioactivity or hazardous materials) consequences. The combined and summarized S2 deviations are:

1. Major environmental release of process solution due to the failure of both the primary and encasement piping

2. Major environmental release of process solution due to misrouting process solution to disconnected process line.

3. Major environmental release resulting from overflow of equipment due to reverse flow of process solution into equipment

4. Major environmental release from process lines damaged by chemical reaction of incompatible wastes, water hammer or steam addition from another facility (the latter considered very unlikely)

5. Major environmental release from equipment damaged by overpressure caused by operational problems with cross-site transfer line

(pressure design for cross site line is greater than MWTF equipment)

6. External leak from pressurized process pit resulting in release of contaminated air to environment due to incompatible chemical mixtures, closed valve on vent line, equipment failure during pneumatic test, or from tank event which might pressurize pit via the drain line.

7. Release to the environment of process solution due to structural failure of equipment and process pit liquid confinement

8. Environmental release of process solution inadvertently transferred to flush pit

9. Release of airborne radioactive contamination resulting from overfilling of primary waste tank combined with failure of the ventilation system to maintain confinement

10. Release of airborne radioactive contamination from pressurization of tank vapor space due to chemical reaction, high temperature, nuclear criticality

11. Release of toxic vapors from tank due to reaction of incompatible chemicals

12. Nuclear criticality due to excess fissile material non-homogeneously distributed (may not be credible)

13. Tank breach and airborne aerosol due to dropping heavy equipment (mixer pump or other) on tank floor

14. Potential for release of radionuclides or toxic material if incompatible waste transferred to tank via flush line.

15. Backup of process solution into flush pit with overflow and major environmental release

16. Hydrogen explosion in waste tank vapor space due to multiple mixer pump failures and ventilation failure

17. Release of airborne radioactive contamination resulting from overfilling of primary waste tank due to flooding of the weather enclosure by frozen pipes or discharge of the fire protection system combined with failure of the ventilation system to maintain confinement

18. Collapse of weather enclosure causing contamination spread from nearby structures

19. Potential for release of radionuclides or toxic material if incompatible chemical transferred to tank via chemical addition system.

20. Inadequate cooling of primary tank due to blockage of flow through once-through ventilation system (long-term effect)

21. Inadequate cooling of primary tank due to failure of heater control on ventilation inlet (once-through or annulus)

22. Fire in tank exhaust train causing unfiltered release of residual ventilation system contamination

23. High temperature causing release of residual contamination in primary tank exhaust from malfunction of electric exhaust heater.

24. Chemical reaction resulting from mixture of tank airstreams resulting in release of toxic emissions (current decision is not to combine airstreams)

25. Ammonium nitrate explosion resulting from buildup of ammonium nitrate on ventilation exhaust equipment due to mixing airstreams (current decision is not to combine airstreams)

Three deviations were postulated as having S3 (potential public exposure to airborne radioactivity or hazardous materials) consequences. The combined and summarized S3 deviations are:

1. Airborne release of contamination due to natural phenomena and external events in excess of the design basis (airplane crash, tornado, greater than design basis earthquake, etc)

2. Collapse of weather enclosure from greater than DBE or high wind resulting in damage to Safety Class 1 equipment

3. Spray leak from process piping not mitigated by process pit confinement system (cover blocks/ventilation)

Revision 1 added a column for the frequency range on the original HazOp study sheets. The column for "Rank" was modified to indicate consequence levels for the facility worker.

6.0 RECOMMENDATIONS/COMMENTS

The recommendations and comments on the design made by the team during the HazOp are listed; in some cases, the comments will have been resolved during the design review process. The recommendations and comments are as follows:

1. The team does not recommend use of submersible pumps for use in the sampling system, based on the experience of the team members with operational experience.

2. The team recommends a hose connection be provided in the truck load-in station to clean up minor spills during chemical load-in.

3. The team, based on this study, recommends the requirement for having forced air ventilation in the annulus be revisited.

4. Equipment connecting to the cross-site lines must be designed to the same pressure specification or must have code-approved device to limit pressure. Equipment to limit pressure to MWTF equipment is not yet provided by either the cross-site transfer project or the MWTF project. MWTF piping is designed to 400 psi.

5. Consideration should be given to special connectors for chemical couplings in the decontamination area. Normal chemicals assumed to be used are: sodium hydroxide, sodium nitrate, sodium nitrite, nitric acid, tartaric acid, and oxalic acid.

6. A design pressure for process pits should be specified.

7. OSHA confined space rules make the flush pit piping difficult to repair because it isn't ventilated.

8. Functional Design Criteria statement of pH 14 max. is inconsistent with general corrosion rates specified. An upper limit on pH is still being determined. Note that some tanks contain solutions with higher concentrations of caustics than that which corresponds to pH 14. Thus, the issue of caustic stress corrosion cracking must be carefully examined.

9. Is it necessary to use demineralized water for flushes, etc. due to chloride concentrations? This is primarily a consideration for transfer piping, but the team is uncertain about whether addition of flush water could be a problem in the tank.

10. It was noted that no specifications have been developed for acidified/neutral wastes in this tank farm.

11. The team felt that the effectiveness of the annulus CAM for leak detection may be less than adequate; verification of its effectiveness should be performed.

12. [redacted] on the ventilation system has established in the Functional Design Criteria.

13. The team assumes that cathodic protection has been provided for all appropriate equipment which meets National Association of Cathodic Engineers (NACE) code requirements.

14. The team assumes that since the weather enclosure design is according to national codes that air quality alarms may be required. The need for air quality alarms will be resolved during definitive design.

15. Analysis must be performed to determine the effects of collapse of the weather enclosure on safety class 1 equipment.

16. The team recommends that both vendor and WHC trucks should be sampled prior to chemical addition.

17. Elimination of stainless steel lining from design might eventually create difficulty in decontamination of the exhaust tunnel.

18. The team suggests that the compatibility of propylene glycol with stored waste be evaluated.

7.0 CONCLUSIONS

The results of the studies performed on the MWTF show a limited number of events with potential consequences which would impact the onsite worker or members of the general public. Based on a summary of abnormal events with consequences in the S2 and S3 categories, the following list of preliminary Design Basis Accidents has been developed:

1. Environmental release of process solution from a failure of both primary and secondary waste tanks; failure of both primary and encasement piping; or overflow of equipment or ancillary structures due to misrouting of process solutions.

2. Expulsion of contaminated air from pressurized contaminated process pit.

3. Release of airborne particulates or aerosols from pressurized tank dome.

4. Release of toxic vapors due to chemical reaction in the primary tank.

5. Nuclear criticality.

6. Unfiltered release of aerosol from a primary tank riser due to dropping of heavy equipment into solution in the tank during maintenance activities.

7. Combustible gas explosion (or other energetic event) in tank dome.

8. Design basis natural phenomena (winds, seismic event, range fire, ashfall) resulting in collapse of weather enclosure.

9. Tank bump from tank thermal gradients caused by loss of mixing pump and cooling systems.

10. Release of aerosols from tank resulting from heating the solution to boiling.

11. Spray leak from pressurized piping.

12. Release of radioactive particulates from heating of exhaust filters and contaminated exhaust paths (due to fire or electric heater malfunction).

13. Airborne release of contamination due to natural phenomena and external events in excess of the design basis (airplane crash, tornado, greater than design basis earthquake, etc.).

From this preliminary list of abnormal events, scoping calculations and/or a literature search of previous analyses will be performed to determine the bounding consequences from the listed abnormal events. Based on these calculations, some events may well be eliminated from detailed analysis because their consequences are not sufficiently severe to require safety class equipment for prevention and/or mitigation. Other events (such as a nuclear criticality or beyond design basis accidents) may not be credible, and will be eliminated from consideration if warranted.

8.0 REFERENCES

Kendall, B. A., 1992, *Functional Design Criteria Multi-Function Waste Tank Facility Project W-236*, WHC-SD-W236-FDC-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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Nicholson, J. R., 1992, *Conceptual Design Report for Multi-Function Waste Tank Facility Project W-236A*, WHC-SD-W236-CDR-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX A

HazOp DESCRIPTION

HazOp FORMS

A HazOp study consists of a detailed examination of the possible deviations of various process parameters from their design intent, with the causes and consequences of the deviation listed.

The HazOp process consists of subdividing system flow diagrams into segments known as study nodes. Each major piece of process equipment is a node, and all lines (piping, electrical, etc, connecting the equipment pieces can be divided into one or more nodes (usually at branch points). Process parameters of importance are designated for each node, and a series of appropriate "questions" are asked about the process parameters. Guide words, phrases or words used to describe process deviations, are used as question-asking tools to explore the means by which the process parameters might vary from their design intent. The causes and consequences of the deviations are examined, and the consequences ranked to determine possible safety significance.

Process parameters which may be examined include flow, temperature, pressure, viscosity, composition, phase, level, addition, reaction, maintenance, testing, instrumentation, sampling, etc. Guide words which are applied to process parameters and their meanings are listed below:

"No/none" --- negation of design intent
"More" --- quantitative increase
"Less" --- quantitative decrease
"As well as"--- qualitative increase
"Part of" --- qualitative decrease
"Reverse" --- logical opposite of intent
"Other than"--- complete substitution.

An example of the HazOp form to be used is shown in Figure 1. The form consists of the header (top of page) and several columns that make up the body of the text. The information in the header includes the date the work is performed, the location for which it is performed (area), the page number, and the names of the participants. Directly below this header is a sub-header that identifies the designated "Node". The Nodes are listed numerically and contain a "Description" of the plant location and functional description of the node.

The remainder of the form is the text body. The columns within the text body (of which there are 8) contain the information/data obtained from this HazOp study. The column titles, when reading from the left to the right, are:

Column 1 - **"Process Parameter"**; states which parameter is being analyzed.

Column 2 - **"Guide Word"**; is one of the guide words or a variant which applies to that node. Many of the nodes have a number of guide words for the various possible parameter deviations associated with the node.

Column 3 - **"Possible Cause(s)"**; lists the potential cause or causes of the deviation.

Column 4 - **"Detection"**; lists the means by which the parameter deviation could potentially be discovered or the potential consequences of the deviation mitigated.

Column 5 - **"Consequences"**; contains a qualitative estimate of the result of the deviation. Both the immediate consequence of the deviation (overflowing vessel, for example) and the potential release consequences are listed. The Consequence Ranking column is a "first cut", qualitative, consensus estimate of the safety and operational severity of the consequences.

Column 6 - **"Freq"** (frequency); the expectation of the consequence occurring during facility operating life. The alphanumeric system (key) is directly below.

FREQUENCIES (f)

F1 = Expected/Anticipated during facility lifetime (10^{-2}/yr < f < 1/yr)
F2 = Unlikey during lifetime of facility (10^{-4}/yr < f < 10^{-2}/yr)
F3 = Extremely Unlikely (10^{-6}/yr < f < 10^{-4}/yr)
F4 = Beyond Extremely Unlikely (f < 10^{-6}/yr)

Column 7 - **"Rank"**; identifies the overall severity of the consequence listed in column 5. A system has been developed to encode the severity level. This system assigns an alphanumeric identifier to a specific level of severity and rates each consequence with a certain level of risk. Included with this system is the predicted outcome/effect of a probable peril exposure to facility workers. If the level of severity has the potential for facility worker hazard an alpha identifier will be included with the severity level. This will distinguish the predicted effect or outcome of the hazard. The alphanumeric system (severity level and effect/outcome) keys are listed below:

SEVERITY LEVEL OF PROBABLE CONSEQUENCE

S0 = no effect outside the facility confinement systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1 = potential industrial injury, radiological dose consequences or chemical exposure to the facility worker

S2 = potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3 = potential significant radiological dose consequences or chemical exposure to the offsite population

FACILITY WORKER HAZARD PROBABLE CONSEQUENCE OUTCOME

S1-L = First Aid Case/Any Additional Dose
S1-M = Moderate Lost Time Injury/Exceeding Allowable Dose Guidelines
S1-H = Permanent Injury/Death

Column 8 - "**Remarks**"; contains information that the team judges requires documentation. This includes (but is not limited to) assumptions about facility operation or recommendations for changes in the planned design or operation.

MWTF HAZOP (RAW DATA)

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE (x): Description

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks

APPENDIX B

HazOp TABLES

Multi-Function Waste Tank Facility

Hazard and Operability Study

** STUDY SHEETS **

HAZOP TEAM MEMBERS

Name		Company	Subject Area
D. L. Bjorklund		Westinghouse Hanford	Tank Farm Operations
B. D. Groth		Westinghouse Hanford	Process Engineering
B. W. Hall		Westinghouse Hanford	Safety Analysis/Engineering
J. E. Hydzik		Kaiser Engineers Hanford	Piping Design
J. M. Siemer	(HAZOP Leader)	Westinghouse Hanford	Systems Safety Analysis
P. L. Smith		Westinghouse Hanford	Safety

HAZOP STUDY NODES

Node Number	Node Description	Date Examined
1	Spare Line from Diversion Box 2 Valve Pit	3/15/93 & 11/21/94
2	Flush Jumper Assembly	3/18/93 & 11/21/94
3	Piping from Flush Pit to Flush Jumper	3/18/93 & 11/21/94
4	Process Drain Line from Valve Pit to Drain Pit to TK-103	3/22/93 & 11/21/94
5	Process Waste Jumper in Valve Pit	3/22/93 & 11/21/94
6	Valve Pit	3/24/93 & 11/21/94
7	Valve Pit Drain Line from Valve Pit to Drain Pit	3/24/93 & 11/21/94
8	Valve Pit Exhaust Line from Valve Pit to Vent Building	3/24/93 & 11/21/94
9	Process Line Encasement	3/24/93, 3/25/93 & 11/21/94
10	Flush Pit	3/24/93, 3/25/93 & 11/21/94
11	Primary Tank (TK-103)	3/25/93 & 11/21/94
12	Secondary Tank (TK-103)	3/25/93 & 11/21/94
13	Sampler	3/29/93 & 11/21/94
14	Sampler Pit	3/29/93 & 11/21/94
15	Sampler Cell	3/29/93 & 11/22/94
16	Decontamination Solution Tanks	3/29/93 & 11/22/94
17	Mixer Pump Pit	3/31/93 & 11/22/94
18	Weather Enclosure	3/31/93 & 11/22/94
19	Tanker Load In Station	4/1/93 & 11/22/94

Node Number	Node Description	Date Examined
20	Piping from the Load In Station to the Chemical Addition including Piping Within the Pump Station	4/1/93 & 11/22/94
21	Primary Tank Ventilation System Air Intake	4/5/93 & 11/22/94
22	Primary Tank Once-Through Exhaust	4/7/93 & 11/22/94
23	Combined Exhaust Tunnel and Stack	4/8/93 & 11/22/94
24	Heat Removal System On Primary Tank	4/8/93 & 11/22/94
25	Inlet to Annulus Ventilation System	4/8/93 & 11/22/94
26	Annulus Exhaust	4/8/93 & 11/22/94
27	Cross-over Spool between Annulus Ventilation System and Primary Ventilation System	5/10/93 & 11/22/94

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 1: Spare Line from Diversion Box to Valve Pit
(Representative of Waste Transfer Lines)

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
Flow	No/None	Broken line	No change in level Material balance Pump amperage	Delay in transfer Major Environmental release if secondary pipe is broken	F1 F3	S0 S2 S1-L	Line assumed in use Line from HWVP may be dropped from scope (May be revisited) S1 (unless transfer needed for accident recovery) (transfers occur because something is needed)
		Not in use	Not applicable since line is assumed to be in use	Not applicable since line is assumed to be in use			
		Plugged line	No change in level Material balance Pump amperage	Delay in transfer	F1	S1-L	Same as broken line. Repair of plugged line would not necessarily result in an S1-consequence because plugs are generally cleared by repeated flushes.
		Failed pump	Same as above	Same as above		Same as above	Same as above
		Closed valve	Same as above	Same as above		Same as above	Same as above

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 1: Spare Line from Diversion Box to Valve Pit
(Representative of Waste Transfer Lines)

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
		Interlock actuation	Same as above, and Alarm (interlock actuation)	Same as above		Same as above	Same as above
		Misrouting	No change in level Material balance	Delay in transfer Major environmental release if undiscovered breaks in both primary and secondary pipe Misrouting could result in chemical/radionuclide incompatibility Major environmental release from misrouting due to interconnections	F3 F3 F2 F2	S0 S2 S0 S2	Same as above
	More	Flow exceeding design value due to high pressure (See high pressure on page 1-4)	Material balance (Administrative controls)	Potential line erosion	F2	S0	None
	Less	(See no flow on page 1-1)	(See no flow on page 1-1)	(See no flow on page 1-1)		(See no flow on page 1-1)	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 1: Spare Line from Diversion Box to Valve Pit
(Representative of Waste Transfer Lines)

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
	As Well As (Solids)	Sampling error or human error	(See no flow on page 1-1)	(See no flow on page 1-1)		(See no flow on page 1-1)	
	Part Of	N/A					
	Reverse	Syphoning	Material balance Radiation detector	Overfilling of equipment Material incompatibility	F3	S1-M	
	Other Than (Wrong Material)	Misrouting	(See no flow on page 1-1)	(See no flow on page 1-1) Chemical reaction	F3	S1-L	
	Other Than (Wrong Time)	Misrouting	(See no flow on page 1-1)	(See no flow on page 1-1) Chemical reaction	F3	S1-L	
Temperature	High (240°F Max)	Chemical reaction	Temperature monitoring at flow origination and destination points	Extensive damage to line due to excessive temperature	F3	S1-M	Note that temperature must be within limits before transfer occurs None of the transfer facilities can pump liquid > 240°F

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 1: Spare Line from Diversion Box to Valve Pit
(Representative of Waste Transfer Lines)

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
		Steam addition	Same as above	Same as above	F4	S2	Because of the distance from other facilities, it is highly unlikely that steam addition would cause damage
		Highly concentrated radionuclide inventory trapped in pipe	Same as above	Localized damage to line if excessive temperature	F3	S1-M	It is not believed that current tank or facility inventory could generate sufficient heat to cause overheating in this line
	Low	Low ambient temperatures in relation to high salt solutions freezing temperature can be 100°F or greater.	Same as no flow on page 1-1 (no flow due to freezing)	Same as no flow due to plugged line on page 1-1		Same as no flow due to plugged line on page 1-1	Piping designed for temperature transients

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 1: Spare Line from Diversion Box to Valve Pit
(Representative of Waste Transfer Lines)

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
Pressure	High	Operational problem with cross site transfer line (up to 2000 psi)	None	Exceeds pipelines' design envelope (See no flow on page 1-1)	F4	S2	Equipment connecting to the cross site lines must be designed to this specification or must have code - approved device to limit pressure. Equipment to limit pressure to MWTF equipment is not yet provided by the project. Lines are designed to 400 psi. (TBD issue) (pipelines are currently being designed for the same pressure criteria.)
		Water hammer	Audible Pressure gauges	Equipment damage	F3	S1-L	Water hammer outside facility control. Internally controlled by design (process lines are well-protected from water hammer).
		Chemical reaction	Pressure gauges Temperature gauges	Equipment damage	F3	S1-L	Chemical reactions controlled by procedures to avoid mistransfer and sampling

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 1: Spare Line from Diversion Box to Valve Pit
(Representative of Waste Transfer Lines)

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
	Low	(See low/no flow on page 1-1)	Draining line	(See no flow on page 1-1)		(See no flow on page 1-1)	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 2: Flush Jumper Assembly

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
Flow	No/None (Water) or Low	Broken pipe	Water meter (flow indicator) No pressure indication Material balance Interlock alarm	Plugged transfer line High radiation exposure to operations/maintenance personnel during repair/replacement	F2	S1-M S1-M	
		Supply valve closed in flush pit	Same as above plus Leak detection (liquid level) in pits Visual (Outside Pit)	Same as above		Same as above	Could be normal condition. It is assumed that flush was process intent.
		No water to farm	Same as above	Same as above		Same as above	
		Check valve stuck closed	Same as above	Same as above		Same as above	
		Plugged valve	Same as above	Same as above		Same as above	
		Interlocks (pressure switch and radiation detector)	Same as above	Same as above		Same as above	
		Misrouting	Same as above	Same as above		Same as above	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 2: Flush Jumper Assembly

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
	More	High pressure	Pressure switch (not in current design)	Exceed design rating of pipe	F2	S1-M	Assume that flush is occurring
	Less	Leak (broken pipe in pit or down stream)	Leak detection alarm and material balance	Flooding of flush pit	F2	SO	
		Jumper removed	Same as above	Same as above			
	AS WELL AS (feed for one of the other tanks)	Interlock failure	Alarm (Radiation or leak detector) Material balance	High exposure to personnel See no flow on page 2-1 Waste compatibility problems Exceeding operational limits on tanks inside and outside of the farms	F2	S1-M See no flow on page 2-1 S1-L SO - S2	Flush could involve 20,000 to 30,000 gallons
		Valves misaligned	Same as above	Same as above		Same as above	Same as above
	Part Of	N/A					

Codes

SO. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 2: Flush Jumper Assembly

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
	Reverse	Process solution backup because of higher pressure in transfer lines	Pressure switch Radiation detector Leak detector alarms	Over filling flush pit with major environmental contamination and onsite exposure See low /no flow on page 2-1 (line flush unsuccessful)	F1	S2 S1-M	There have been numerous incidents of flush pit contamination ; there have been near misses on overflowing. The tank farm is lower than the cross-site transfer line, so, even though valves and pumps can be shutoff by interlocks some hydraulic pressure remains.
		Low flush pressure	Same as above	Same as above		Same as above	
		Check valve fails	Same as above	Same as above		Same as above	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 2: Flush Jumper Assembly

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
		Valve misalignment	Same as above	Same as above		Same as above	
		Human error	Same as above	Same as above		Same as above	
	OTHER THAN (WRONG MATERIAL - chemicals and compressed air)	Human Error	Sampling Material balance Pressure Temperature Rise Procedures/Administrative controls Gas monitoring for effluents	Increased emissions Chemical reaction Heat Pressure Corrosion causing equipment damage Programmatic impact (off specification feed to HWVP)	F1	S1-M " " " " "	Chemical coupling should require special connectors. Normal chemicals used are: Sodium hydroxide, Sodium Nitrate, Sodium Nitrite, Nitric Acid, Tartaric Acid, Oxolic Acid Steam is N/A for this deviation

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 2: Flush Jumper Assembly

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
	OTHER THAN (WRONG TIME)	Human Error	Shutdown transfer(alarm) Material balance Tank high level alarm	Overfill a tank Plugged line if transfer shutdown Material out of specification	F3 F1	S1-M See low flow on page 2-1 S0	Overfilling a tank is very unlikely because of the time required to fill it.
	Other Than (Wrong Direction to drainline)	Valve misalignment (human error)	Material balance Flow elements in the drain lines	Overflow Tank 103 Programmatic impact because of increased waste volume	F3	S1-M S1-M	It is assumed that flow elements will be provided in the drain lines.
	Other Than Wrong Direction to Process Line Segment	Valve misalignment (human error)	Material balance	Procedure violation If this results in a failure to flush a line segment, see low flow plugged line on page 2-1	F2 F2	S0 S1-M	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 2: Flush Jumper Assembly

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
Pressure	High	(See node 1, pressure high on page 1-4)					
	Low	(See low flow on page 2-1)					
Temperature	High	(See node 1, temperature high on page 1-3)					
	Low	Low ambient temperature	(See no flow on page 2-1)	(See no flow on page 2-1)		(See no flow on page 2-1)	If weather enclosure is included in the design, this won't be an issue.

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

MWTF HAZOP (RAW DATA)

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, Siemer

NODE 3: Piping from Flush Pit to Flush Jumper

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
FLOW	NO/NONE	(See node 2, page 2-1)					
	MORE	(See node 2, page 2-2)					
	LESS	(See node 2, page 2-2)					
	Reverse	(See node 2, page 2-3)					
	Other Than (Wrong Time)	(See node 2, page 2-4)					
PRESSURE	HIGH	(See node 2, page 2-5)					
	LOW	(See node 2, page 2-5)					
TEMPERATURE	HIGH	(See node 2, page 2-5)					
	LOW	(See node 2, page 2-6)					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 4: Process Drain Line from Valve Pit to Drain Pit to TK-103

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
FLOW	NO/NONE	Closed valve	Pressure switch in the flush pit (drops) when line is draining Flow element if included	Won't be able to reset interlock in master pump system (delay in operation)	F2	S0	See remark for node 2 (Flow Other Than--Wrong Direction to Drain Line), page 2-5 concerning flow element.
		Plugged line	Same as above	Same as above	F2	S0	
		Jumper removed in pit	Same as above, and Pit leak detection	Same as above	F2	S0	
		Broken pipe	Same as above	Same as above, and Environmental release if encasement pipe is breached	F2	S0	
	MORE	See node 2, page 2-2 "More" for flush jumper					
	LESS	See node 2, page 2-1 "No/None Flow"					
	AS WELL AS	N/A					
	PART OF	N/A					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 4: Process Drain Line from Valve Pit to Drain Pit to TK-103

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
	REVERSE	N/A					
	OTHER THAN (WRONG MATERIAL)	See node 2, page 2-4					
	OTHER THAN (WRONG TIME)	See node 2, page 2-4					
PRESSURE	HIGH	See node 2, page 2-5					Drain lines need to be designed to same specification as process lines.
	LOW	See No/None Flow, page 4-1					
TEMPERATURE	HIGH	See node 2, page 2-5					
	LOW	See node 2, page 2-6					
	For other parameters see Flush Jumper Assembly						

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 5: Process Waste Jumper in Valve Pit

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
FLOW	NO/NONE	See node 1, page 1-1 and node 2, page 2-1					
	MORE	See node 1, page 1-2 and node 2, page 2-2					
	LESS	See node 1, page 1-2 and node 2, page 2-2					
	AS WELL AS	See node 1, page 1-3 and node 2, page 2-2					
	PART OF	N/A					
	REVERSE	See Other Than (Wrong Time), page 5-1					
	OTHER THAN (WRONG MATERIAL	See node 1, page 1-3					
	OTHER THAN (WRONG TIME)	See node 1, page 1-3					
PRESSURE	HIGH	See node 1, page 1-4					
	LOW	See node 1, page 1-5					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 5: Process Waste Jumper in Valve Pit

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
TEMPERATURE	HIGH	See node 1, page 1-3					
	LOW	See node 1, page 1-4					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 6: Valve Pit

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
Level (Liquid)	High	Leak (valve, jumper, and sources outside of pit leak in through pit cover) with pit drain plugged	Leak detection Other equipment failures Ventilation system behavior	If pit overflows, release of contamination to environment Equipment damage Personnel exposure Programmatic effect, inability to transfer until recovery complete.	F3 F2 F2 F2	S1-M S1-L S1-L S1-L	S2 only if pit is grossly contaminated
		Hose left running and pit drain plugged	Same as above	Same as above		Same as above	
		Disconnected jumper with flow being pumped and pit drain plugged	Same as above	Same as above		Same as above	
	Any Level (no plug in drain)	Source of liquid, Same as above	Leak detection Other equipment failures	Personnel exposure Programmatic effect, inability to transfer until recovery complete.	F1 F1	S1-L S1-L	
	Low	N/A					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 6: Valve Pit

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
Pressure	High (above atmospheric)	Motorized valve on vent line failed closed	Room CAM on weather enclosure If material leaked into pit, leak detector would detect it. Pressure indication in tank Seal pot in drain pit would prevent pressurization of drain line Administrative controls	Unfiltered airborne release of contaminated materials	F2	S1-M	Assume position/limit switch on motorized valve S2 if related circumstance grossly contaminates pit.
		High temperature in pit due to chemical reaction	Same as above	Same as above	F3	S1-M	S2 if related circumstance grossly contaminates pit.
		Pressurized via drainline from tank event	Same as above	Same as above	F3	S1-M	S2 if related circumstance grossly contaminates pit. Highly unlikely, if not incredible, due to seal pot design.

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 6: Valve Pit

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
		Pneumatic test of transfer line encasement	Same as above	Same as above	F3	S1-M	S2 if related circumstance grossly contaminates pit. Accidents potentially initiated by pneumatic testing will be analyzed in SAR
Pressure Continued	Low	N/A					
Temperature	High	See Pressure High on page 6-2					
	Low	Low ambient See Liquid Level High on page 6-1					
Structural Integrity	Leak (Liquid)	Rupture in stainless steel liner.	Visual integrity inspection every 5 years	Environmental contamination-ground contamination	F3	S1-M	Requires failure of primary barrier, large leak, drain needs to be plugged up in order to have any consequences. S2 if grossly contaminated

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 6: Valve Pit

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
		Corrosion and rupture.	Same as above	Same as above	F3	S1-L	Same as above
		Filling valve pit above liner and leak in concrete portion.	Same as above	Same as above	F3	S1-M	Same as above
		Seismic event	Same as above	Same as above	F3	S1-M	Same as above, and Seismic design is TBD
		Leak at nozzle penetration general weld seams.	Same as above	Same as above	F3	S1-M	Requires failure of primary barrier, large leak, drain needs to be plugged up in order to have any consequences. S2 if grossly contaminated
		Incompatible chemical mixtures	Same as above	Same as above	F3	S1-M	Same as above
		Jumper drop	Same as above	Same as above	F2	S1-L	Same as above

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 7: Valve Pit Drain Line from Valve to Pit TK-103

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
FLOW	NO/NONE	Plugging due to trash, plastic, equipment	Pit leak detection (can't reset alarm if liquid hasn't drained) Radiation detection if contaminated material Overflow of valve pit (worst case)	See node 6 high level on page 6-1		See node 6 high level on page 6-1	
		Small animals (not unless pit left open)-pits not left open anymore.	Same as above	See node 6 high level on page 6-1		See node 6 high level on page 6-1	
		Frozen line (not likely line about 8 or so feet underground)	Same as above	See node 6 high level on page 6-1		See node 6 high level on page 6-1	
	MORE	Disconnected process jumper (with flow)	Leak detector	See high level in node 6 on page 6-1		See high level in node 6 on page 6-1	
	LESS	Same as no flow.	Same as no flow.	Same as no flow.		Same as no flow	
		Vapor lock	Vapor lock would be hard to detect specifically.	Same as above		Same as above	
	AS WELL AS	N/A					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 7: Valve Pit Drain Line from Valve to Pit TK-103

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
	PART OF	N/A					
	REVERSE	High pressure in TK-103	See high level in node 6 on page 6-1 See High Pressure for node 6 on page 6-2	See high level in node 6 on page 6-1 See High Pressure for node 6 on page 6-2		See high level in node 6 on page 6-1 See High Pressure for node 6 on page 6-2	Due to the existence of the drain pit seal pot, a pressurization which would result in backflow to the valve pit is considered highly unlikely to incredible.
	OTHER THAN (WRONG MATERIAL)	Infiltration	Leak detector if quantity is large enough.	None not covered by other parameters.			
	OTHER THAN (WRONG TIME)	N/A					
TEMPERATURE	HIGH	Chemical reaction	None	Line damage.	F3	S1-M	Design temperature is 200°F S1 is based on repair activity
	LOW	Low ambient temperature (below solution solidification point)	See low/no flow on page 7-1	See low/no flow on page 7-1		See low/no flow on page 7-1	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 7: Valve Pit Drain Line from Valve to Pit TK-103

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
PRESSURE	HIGH	See temperature high on page 7-2	See temperature high on page 7-2	See temperature high on page 7-2		See temp high on page 7-2	Design pressure for process pits should be specified. See remark for reverse flow on page 7-2
	LOW	N/A					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, Siemer

NODE 8: Valve Pit Exhaust Line from Valve Pit to Ventilation Building

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
FLOW	NO/NONE	Fan failure	Alarms Pressure indication	System wide consequences for fan failure. Small potential for buildup/release of airborne contaminants.	F1 F1	S1-M S1-M	Note: No dentrainer on system, High dP fan shutdown. Elevation differential between filters and pit would limit the amount of aerosol carried to the filters.
		Butterfly valve failed shut.	Same as above and Flow indication Position switches on damper	Small potential for buildup/release of airborne contaminants.	F2	S1-M	Difficult to detect small amounts of flow
		Pit full of liquid and has vent blocked off.	Same as above	For pit full - see high level valve pit (node 6, page 6-1) Moisture entrainment clogs filters.		See high level valve pit, node 6, page 6-1	
		Infiltration paths plugged.	Same as above	Small potential for buildup/release of airborne contaminants.	F2	S1-M	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, Siemer

NODE 8: Valve Pit Exhaust Line from Valve Pit to Ventilation Building

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
		Broken ventilation pipe	Pressure indication Flow indication	Loss of vacuum on valve pit potentially resulting in release of airborne contaminants	F3	S1-M	
	MORE	Butterfly valve open too wide on inlet.	Periodic vent and balance	Wrong flow for this pit; no significant consequences	F1	S0	
		Other valves throttled down.	Same as above	Same as above		Same as above	Same as above
	LESS	Another pit is open with ventilation continuing to run	Periodic vent and balance.	See no flow on page 8-1.		See no flow on page 8-1.	Applicable section of HVAC should be shut off when pit is open
		See no flow on page 8-1.	Same as above	Same as above		Same as above	Same as above
	AS WELL AS (water), (process solution), (gases)	Spray leak of water or process solution.	Leak detectors in pit. Differential pressure increase. Stack monitor - only if filter failed or overloaded.	Contamination in pit, but no other significant consequences unless filters are breached or pit is open.	F2	S1-M	Unmitigated consequences of spray leak are S3. F3 for unmitigated spray leak.

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, Siemer

NODE 8: Valve Pit Exhaust Line from Valve Pit to Ventilation Building

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
		Liquid filling pit.	Same as above	See high level valve pit, node 6, page 6-1		See high level valve pit, node 6, page 6-1	
		Undefined chemical reaction gases.	Gas chromatograph in stack.	Potential occupational exposure	F2	S1-M	
		Boiling spilled material.	Leak detectors in pit. Differential pressure increase. Stack monitor - only if filter failed or overloaded.	Contamination in pit, but no other significant consequences unless filters are breached or pit is open.	F3	S1-M	
		Entrainment of dried particulate	Differential pressure increase. Stack monitor - only if filter failed or overloaded.	Contamination in pit, but no other significant consequences unless filters are breached or pit is open.	F2	S1-M	
	PART OF	N/A					
	REVERSE	Fan wired backwards	Valve position indicators	Potential contamination outside of pit	F4	S1-M	Wiring fan backwards is probably not credible due to fan design

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, Siemer

NODE 8: Valve Pit Exhaust Line from Valve Pit to Ventilation Building

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
		Closed inlet valves to filter banks with gas sampler building exhaust sampler running	Alarms on operational sequence for filter system (FCV)	Same as above	F3	S1-M	
	OTHER THAN (WRONG MATERIAL)	N/A					
	OTHER THAN (WRONG TIME)	N/A					
PRESSURE	HIGH	See valve pit high pressure (node 6, page 6-2).	See valve pit high pressure (node 6, page 6-2).	See valve pit high pressure (node 6, page 6-2).		See valve pit high pressure (node 6, page 6-2).	
		Blocked multiple vents.	Same as above	Same as above	F3	S0	
TEMPERATURE	HIGH	See node 6 Temperature high on page 6-3	See node 6 Temperature high on page 6-3	See node 6 Temperature high on page 6-3		See node 6 temp high on page 6-3	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, Siemer

NODE 8: Valve Pit Exhaust Line from Valve Pit to Ventilation Building

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
	LOW	Low ambient temperatures from outside air source (Doubtful)	See node 6 Temperature low on page 6-3	No flow if infiltration path blocked		See node 6 temp low on page 6-3	Doubtful if low temperatures would affect anything but infiltration. Should be considered as an overall ventilation system effect.

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 9: Process Line Encasement

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
Flow	No	Drain valve closed.	Leak detection in pit (doesn't alarm) cannot clear or reset encasement leak detector.	Inability to use line.	F2	S0	Assumed process intent is to drain encasement; otherwise normal condition
		Drain line plugged.	Same as above	Inability to use line.	F2	S0	
		Encasement line broken upstream of drain.	Same as above	Environmental release of liquid.	F3	S1-M	Repair of encasement would probably not be performed - only if spare line not available
		Frozen pipe	Same as above	Operational delay.	F2	S0	
	More	N/A					
	Less	N/A					
	As Well As	N/A					
	Part Of	N/A					
	Reverse	N/A					
	Other Than	Hydrotest water doesn't meet stress corrosion criteria.	Assume sampling if specifications are applicable	Decreased piping life.	F2	S1-L	Only if piping failed as a result.

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 9: Process Line Encasement

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
Temperature	High	See high temperature, node 1, on page 1-3.	See high temperature, node 1, on page 1-3.	See high temperature, node 1, on page 1-3.		See high temp., node 1, on page 1-3.	
	Low	See low temperature, node 1, on page 1-4.	See low temperature, node 1, on page 1-4.	See low temperature, node 1, on page 1-4.		See low temp., node 1, on page 1-4.	
Pressure	High	Human error during pressure test	Test assembly instrumentation/relief valve on test assembly.	Hydrotest: Broken pipe, environmental release of contaminated liquid. Pneumatic test: Shattered pipe and possibly primary line/worker injury or death, potential release of contaminated air.	F3 F3	S1-M S1-H	Only if encasement contaminated
		Faulty test equipment.	Same as above	Same as above		Same as above	These encasements are basically not contaminated, if so, this would indicate breach of primary line.

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 9: Process Line Encasement

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
	Low	N/A					Vacuum tests are currently not performed on encasement lines.

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 10: Flush Pit

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
Level	High	Leak of rainwater and plugged drain.	Leak/level detectors in pit (alarms in control room). Random visual observation if pit overflowed.	Contamination spread if overflow occurs. Contamination of pit.	F2	S1-L if process solution overflowed.	Note: There are no local alarms from leak detection. Note: leak detection is interlocked to transfer pumps. OSHA confined space rules make the piping difficult to repair because the flush pit isn't ventilated. Remark: The issue of coverblocks on pits is an issue being addressed in a company level committee.
		Leaky hose connection and plugged drain	Same as above	Same as above		Same as above	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 10: Flush Pit

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
		Leak from floor wash down and plugged drain	Same as above	Same as above		Same as above	
		Reverse flow of process solution and plugged drain	Same as above	Same as above		Same as above	
		Pipe leak/break while flushing or when pressurized during setup and plugged drain	Same as above	Same as above		Same as above	
	Low	N/A					
Composition	Process Waste	See reverse flow for flush jumper, node 2, page 2-3	Radiation instrumentation on flush line	See high level, page 10-1	F2	See high level, page 10-1	
	Chemicals	See other than for flush and leak of flush line jumper, node 2, page 2-4	Detection would be after the fact.	Worker injury and equipment damage		S1-M	
Level	Low	Failure to maintain seal water.	Level indicator fails high? (not sure what type of indicator will be used) Auditory (vacuum being pulled into line) Ventilation system degraded performance	Contamination of pit only if flow reversal in flush pit drain line.	F3	S1-M	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 10: Flush Pit

Process Parameter	Guide Word/ Deviation	Possible Causes	Detection	Consequence	Freq.	Rank	Remarks
		Human error	Same as above	Same as above	F1	S1-L	
		Level indicator failure	Same as above	Same as above	F1	S1-L	
Structural Integrity	Leak in pit structure	Natural phenomena	If in sump, the inability to maintain level, otherwise random visual inspection.	Environmental contamination if contaminated. Operational delay.	F3	S1-M S1-L	Likely no safety impact
		Corrosion	Same as above	Same as above		Same as above	
		Chemical attack	Same as above	Same as above		Same as above	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 11: Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Level	High	Human error	Level indication High level probe alarm Ventilation system problems if tank is grossly overfilled	Programmatic impacts. Potential to exceed structural design analysis parameters. Wetting filters and causing ventilation system failures - difficult with heat removal.	F3	S1-M	S2 ranking applies only if there are multiple failures in the ventilation system
		Misrouting	Same as above	Same as above	F3	S1-M	Same as above
		Failed level indication	Same as above	Same as above	F3	S1-M	Same as above
		Intrusion (leakage into pit and drainage to tank)	Same as above	Same as above	F3	S1-M	Same as above, and Leakage would have to continue for a long time (1 inch depth = about 2700 gallons)
	Low (less than minimum static head)	Leak	Annulus leak detection, liquid level indication in primary tank. Material balance and liquid level indication. Low level alarm Thermocouples	Programmatic impacts.	F3	S1-M	Check whether ventilation system could damage tank - see structural analysis Increased personnel exposure due to equipment repair or pumping out of annulus could cause S1 sequence

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 11: Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Level Continued	Low (less than minimum static head) Continued	Misrouting (ie. pumped material out of tank at wrong time)	Liquid level indication in primary tank. Mixer pump behavior. Material balance and liquid level indication. Transfer pump behavior (low amps) Low level alarm Thermocouples	Programmatic impacts Potential damage to tank Pump damage (mixing or transfer)	F3	S1-L	Same as above
		Long term evaporation of material due to ventilation system - material entrainment	Mixer pump behavior Material balance and liquid level indication Low level alarm Thermocouples	Programmatic impacts Potential damage to tank Pump damage (mixing or transfer)	F2	S1-L	Same as above

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 11: Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Level Continued	Low Continued	Liquid level instrumentation failure during transfer of material	Mixer pump behavior Material balance and liquid level indication Transfer pump behavior (low amps) Low level alarm Thermocouples	Programmatic impacts. Potential damage to tank Pump damage (mixing or transfer)	F2	S1-L	Same as above
Pressure	High (positive)	Loss of/inadequate ventilation system	Alarmed Pressure indication	Environmental release	F1	S1-M	S2 ranking considered very unlikely, S1 more probable
		Chemical reaction	Offgas Increased flow Increased temp	Same as above	F3	S1-M	Same as above
		High temp	Temp indication	Same as above	F2	S1-M	Same as above
		Nuclear criticality	Ventilation system behavior	Same as above	F4	S1-M	Same as above, and Criticality is not considered credible--Systems Safety Analysis will consult with criticality group

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 11: Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
		Temperature gradients		Same as above	F2	S1-M	S2 ranking considered very unlikely, S1 more probable
	High (static)	See High Pressure (positive)	See High Pressure (positive)	Operational impacts	F2	S0	
	Low (excessive vacuum)	Ventilation inlet blocked (closed damper or other cause)	Pressure alarms/indication	Structural damage if tank nearly empty	F2	S0	This event would have severe programmatic consequences.
		Equipment not sized right	Seal loop (vacuum breaker)	Same as above	F2	S0	Same as above
		Control instrumentation failures		Same as above	F2	S0	Same as above
Temperature	High (> than tank design temp)	Chemical reaction	Temp indication (Thermocouples)	equipment damage Damage to concrete structure Damage to tank If both tanks failed, then release of solution to environment	F3 F3 F3 F3	S1-L S1-L S1-L S1-M	Likelihood of exceeding temperature which would cause structural failure of tanks is very unlikely for currently stored wastes.
		Ineffective ventilation	Same as above, and dPs, flows, etc., on ventilation instrumentation	Same as above	F3	S1-M S2	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 11: Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Temperature Continued	High (> than tank design temp) Continued	Loss of cooling water	Temp indication Cooling tower instrumentation flows/temp pump alarms	Same as above		Same as above	
		Loss of primary and annulus exhaust with mixer pump continuing to run	Temp indication	Same as above		Same as above	
		Failure of temp indication instrumentation such that temp is not properly controlled	Ventilation instrumentation	Same as above		Same as above	
	Low (below solution "freezing point")	Low ambient temperature	Temperature indication Mixer pump behavior	Surface crystallization of solution	F3	S0	This would only have operational consequences; it would be expected to be surface crystallization only because of the large tank volume
		Solution composition	Temperature indication Mixer pump behavior	Surface crystallization of solution	F3	S0	Same as above

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 11: Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Composition (pH)	High (> than acceptable for general corrosion or stress corrosion cracking)	Improper characterization	Periodic sampling	Accelerated tank corrosion *Worst case: possible tank leak*	F3	S1-L See Level Low, on page 11-1	All streams are sampled prior to being introduced to the tank Functional Design Criteria statement of pH 14 max. is inconsistent with general corrosion rates specified. An upper limit on pH is still being determined.
		Misrouting	Temperature indication changes Gas sampling indication changes Corrosion probes	Same as above		Same as above	
		Failure to treat out of specification material	Same as above	Same as above		Same as above	
	Low (lower than acceptable for general corrosion)	Improper characterization	Same as for composition high on page 11-6	Same as for composition high on page 11-6	F3	Same as for composition high on page 11-6	Even though there is a lower limit on pH, tank damage from lower pH solution is unlikely for waste with nitrates. Sulfuric and hydrofluoric acids present other problems.

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 11: Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Composition (pH) Continued	Low (lower than acceptable for general corrosion) Continued	Misrouting	Same as for composition high on page 11-6	Same as for composition high on page 11-6		Same as for composition high on page 11-6	Same as above
		Failure to treat out of specification material (applicable to "new" or otherwise treated wastes)	Same as for composition high on page 11-6	Same as for composition high on page 11-6		Same as for composition high on page 11-6	Same as above
Composition (Halides)	Concentrations above stress-corrosion cracking limits (not a problem because tank is carbon steel).	Improper characterization	Sampling	Primary tank leak		See level low, on page 11-1	Note: corrosion probes not effective here Do we need to use demineralized water for flushes, etc.? This is primarily a consideration for transfer piping, but the team is uncertain about whether addition of flush water could be a problem in the tank.
		Misrouting	Same as above	Same as above		Same as above	

Codes

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S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 11: Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
		Failure to treat out of specification material	Same as above	Same as above		Same as above	
Composition (Solids)	More	Precipitation	Temperature profile Waste sampling Sludge level indicator detectors	Tank bump Difficulty in retrieving the waste	F3	S2 S0 S1-M	Tank bump (considered unlikely with current waste composition). This would require multiple failures of mixer pumps.
		Waste composition	Same as above	Same as above		Same as above	Same as above
		Waste temperature too low	Same as above	Same as above		Same as above	Same as above
		Misrouting could cause another problem which in turn would cause excessive solids	Same as above	Same as above		Same as above	Same as above
	Excess TRU and nonhomogeneous distribution of TRU material	Sampling errors (for excess case)	Sampling	Exceeding criticality limits/specifications Criticality in the worst case	F4	S0 S1-M	This assumes that TRU is precipitated in the solids. No specifications have been developed for acidified/neutral wastes in this tank farm.
		Misrouting (for excess case)	Record keeping if misrouting discovered	Same as above		Same as above	

Codes

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S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 11: Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Structural Integrity	Damage	Violation of load limit(s) on tank	Potential for leak - leak detection instrumentation Visual inspection - heavy vehicle parked on ground above tank.	Tank leak Loss of use of tank (programmatic)	F3 F2	See level low on page 11-1 S0	
		Overpressure	Analysis after the fact. Annulus inspection.	Tank leak	F2	See high pressure on page 11-3	
		High temperature	Analysis after the fact. Annulus inspection	Tank leak	F2	See high temp. on page 11-4	
		Natural phenomena (earthquake, tornado, meteorite)	Observation of phenomenon	Airborne release of contamination	F3	S1-H S2	Airborne release from meteorite, airplane crash, or greater than design basis seismic event is incredible or extremely low frequency event.
		Aircraft crash	Observation of phenomenon	Airborne release of contamination	F4	S1-H	Same as above
		Heavy equipment dropped on tank floor	Observation of phenomenon	Tank breach	F3	S1-M	Probable airborne release

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 11: Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, Siemer

NODE 12: Secondary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Liquid level	High (or any)	Leak of primary tank	Annulus leak detector Visual inspection of annulus with remote camera (not installed by the design), but performed by operations Liquid level low in primary tank Concrete and tank bottom temperatures Annulus CAM if radioactive leak	See Level low for primary tank, node 11, page 11-1	F3	S1-M See Level low for primary tank, node 11, page 11-1	Effectiveness of annulus CAM for leak detection may be less than adequate. If high liquid level, annulus ventilation will not function.
		Intrusion of liquid from other sources (entering through tank wall, open riser)	Same as above	If intrusion is sufficient and primary is mostly empty could possibly float the primary tank causing damage to the primary	F3	S1-M	
		Misrouting when intent is to pump out the annulus	Same as above	Same as above	F3	S1-M	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, Siemer

NODE 12: Secondary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Pressure	High	Annulus fan reversal with inlets closed (human error wiring fan)	Pressure monitoring instrumentation	See excessive vacuum for primary tank, node 11, page 11-4		See excessive vacuum for primary tank, node 11, page 11-4	The annulus is designed for a higher pressure than the primary tank.
	Low (excessive vacuum)	Intake valves closed, frozen, otherwise blocked	Pressure indication Valve position indication	No significant consequences If fan is capable of exceeding pressure limits - administrative impacts	F3	S0	Design limit = - 20 inches of water Is equipped with a vacuum breaker
		Liquid blocking air distribution system	Pressure indication	Same as above	F3	S0	
Temperature	High	See primary tank high temperature, node 11, page 11-4	Temperature indication	Concrete damage if temperature of greater than 350°F is transferred to concrete resulting programmatic consequences from loss of tank	F3	S0	Assumed that repair would not be attempted

Codes

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S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, Siemer

NODE 12: Secondary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Temperature Continued	Low	Low ambient temperature (cold air pulled in by ventilation system)	Temperature indication Pressure detection	Probably no structural damage Crystallization of material on outside of primary tank	F3	S0	No set limit for low temperature established in the Functional Design Criteria. Frost unlikely within weather enclosure
Structural Integrity	Damage	Exceeding load limits	Periodic inspections or inspections after the fact	Environmental release if primary tank leaks, otherwise no significant consequences	F3	S2	Tertiary leak detection has been removed from design.
		Dropping heavy equipment	Visual inspection	See above	F3	S2	Possible airborne release
		Natural phenomena (see discussion on primary tank, node 11, page 11-9)	Observation of phenomena	See above	F3	See above S3	See discussion on primary tank, node 11, page 11-9 for likelihoods of severe external events Failure of primary tank is given an S3 ranking
		Corrosion (see Composition on primary tank, node 11, page 11-6 for stress corrosion and general corrosion)	Visual inspection	No consequence unless primary tank leaks	F3	S0	

Codes

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S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 13: Sampler

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow	No	Blockage	Bottle not filling Pump ammeter not registering current Tank liquid level indication might tell if wrong probe is used	Inability to characterize tank contents Limit ability to transfer in and out of tank (programmatic)	F1	S0	S1 consequences might result from sampler repair
		Valve misalignment	Same as above	Same as above	F1	S0	Same as above
		Pump failure	Same as above	Same as above	F1	S0	Team does not recommend use of submersible pumps for this purpose
		Line break	Same as above, and Visual Leak detection	Potential to contaminate pit	F3	S1-M	
		Trying to draw a sample from nonsubmerged probe	No Sample	See blockage on page 13-1	F1	S0	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 13: Sampler

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
		Jumper not installed	Visual Leak detection	Contamination of pit	F2	S1-M	
		Material in tank could be too thick or too hot	Thermocouples No sample	See blockage on page 13-1 (Programmatic)	F2	S0	
Flow Continued	More (Too much)	N/A					
	Less	See no flow on page 13-1	See no flow on page 13-1	Increased worker exposure due to taking more time to get sample	F2	S1-L	
	As Well As (Air) (Flush water) (Decon. Soln)	Residual in lines	Lab results Visual inspection (for some) Radiation measurement results in no reading or much lower reading	Programmatic -- delay while adequate sample is taken False results could cause incompatibility problems when transfer occurs	F1	S1-L	S1 is based increased worker exposure from repeated sampling.
		Improper sampler operation	Same as above, and no sample	Same as above	F1	S1-L	Same as above

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 13: Sampler

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
	Part of (Non-representative sample)	Inadequate mixing of tank	Comparison of sample with lab results, engineering evaluation	Same as "As Well As" on page 13-2		Same as "As Well As" on page 13-2	Same as "As Well As" on page 13-2
Flow Continued	Reverse (Decon solutions)	Pumping wrong decon solution into a sampler (valve misaligned)	Levels in decon tanks Lab results Visual	Incompatibility of waste and decon solution	F2	S1-L	S1 based on generation of toxic gas NOTE; The sampler lines are small and the decon tanks are small compared to the waste tanks.
	Other than	See above	See above	See above	F2	S1-L	See above
Pressure	High	Chemical incompatibility from flush system	None obvious Difficulty in getting a sample	See no flow on page 13-1		See no flow on page 13-1	See no flow on page 13-1

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 13: Sampler

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
	Low	See no flow on page 13-1	See no flow on page 13-1	See no flow on page 13-1	F1	S1-L	See no flow on page 13-1
Temperature	High	Chemical reaction	No sample	Programmatic delays due to difficulty in taking a sample	F1	S1-L	See no flow on page 13-1
		High temperature waste	Thermocouples in tank	Same as above		Same as above	Same as above
	Low	Low ambient temperatures (below solution freezing point)	See no flow on page 13-1	See no flow on page 13-1		See no flow on page 13-1	Expected based on some solution characteristics

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 14: Sampler Pit

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq	Rank	Remark
Level	High (any liquid)	Leak and plugged drain	Pit leak or drain line leak detectors	Contamination of pit if leak involves process solution (primary tank waste)	F2	S1-L	Assuming worker exposure during maintenance
		Intrusion and plugged drain	Pit leak detector	Same as above	F2	S1-L	Same as above
		Jumper leak (see remark)	Same as above, and Flow meter in decon tank	Same as above	F1	S1-L	Flush from liquid sample room would be main source of liquid in leak. Unmitigated spray leak is S2 and F3
All other parameters and deviations are assumed similar to valve pit, node 6, page 6-1							

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 15: Sampler Cell

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Level	High (Spilled liquid)	Leaky sample line	Visual Leak detection	Contamination of the cell Contamination of sample casks Programmatic from equipment damage Potentially contaminate operating area and ventilation controls	F2	S1-L S1-M S1-L S1-M	Unmitigated spray leak is S2. S1-H F3
		Broken sample bottle	Same as above	Same as above	F1	S1-M	
		Overflow from bottle and plugged drain	Same as above	Same as above	F2	S1-M	Might be difficult to overflow bottle due to predetermined sample amount
		Leak from cell washdown system	Same as above	Same as above	F1	S1-L	
		Crane damage to piping	Same as above	Same as above	F2	S1-M	
		Natural phenomena	Same as above	Same as above	F3	S1-M	
		Leaky flush line	Same as above, and Decon tank level	Same as above	F2	S1-L	
	Low	N/A					

Codes

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S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 15: Sampler Cell

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Pressure	Loss of negative pressure	Fan failure (zone 1)	Alarms on fan Alarms on dP	Contamination spread if cell is contaminated	F1	S1-M	Possible only if pressure is positive
		Leak in ventilation duct	Same as above and Pressure drop in line	Same as above	F2	S1-M	
		Power failure	Observation of event	Same as above	F1	S1-M	This system will have standby power -- diesel generator
		Closed valve	Alarms on dP Pressure drop in line	Same as above	F1	S1-M	
		Loss of exhaust with supply continuing to run	Same as above	Same as above	F2	S1-M	
	Low	Supply fan off and damper closed and exhaust fan continues to run	Alarms Airlock door difficult to open	Operator cannot exit area easily	F2	S1-M	S1 based on operator spending too much time in the area and receiving increased exposure
Temperature	High	Loss of air circulation during high ambient temperatures	Tactile Temperature indications in room	Personnel heat exhaustion Lack of ability to sample (too hot for personnel comfort)	F2	S1-M	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 15: Sampler Cell

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Temperature Continued	High Continued	Fire	Fire detection system	Spread of contamination Loss of electrical equipment	F2	S1-M	
	Low (less than freezing point of solutions)	See low temperature, node 13, on page 13-3	See low temperature, node 13, on page 13-3	See low temperature, node 13, on page 13-3		See low temperature, node 13, on page 13-3	
	Low (less than 32 degrees F)	Low ambient temperatures and loss of heaters in ventilation supply	Temperature indication Flow alarms on fire system if frozen pipes caused leak Surveillance	Potentially freezing and bursting fire system piping causing flooding which if left undetected for a long time could overfill Tk-103.	F3	See high level in primary tank, node 11, page 11-1	Very unlikely in heated Ventilation Building
		Exhaust continues to run while supply is not heated	Same as above	Same as above		Same as above	Same as above

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 16: Decontamination Solution Tanks

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Level	High	Backflow from flush system	See Composition Process Solution on page 16-3	See Composition Process Solution on page 16-3		See Composition Process Solution on page 16-3	
		(Human error) Put too much solution in tank	Level instrumentation Visual Leak detection in overflow drain lines (leak detection is in the drain pit on TK-103)	Worker injury if spilled on floor when drain is blocked Transfer of incompatible chemical to TK-103 via the drain line	F2	S1-M S1-L	See Reverse Flow, node 13, page 13-3
		Leaky valve	Same as above	Same as above	F2	S1-M	
		Tank instrumentation faulty (does not indicate high level)	Visual Leak detection (in TK-103 drain pit)	Same as above	F2	S1-M	
	Low	(Human error) Forgot to fill tank	Level indication in tanks Attempted use of solution with insufficient solution to flush the system	Process delay		None	
		Drain valve failure	Same as above and Drain pit leak detection	Same as above, and See level high, page 16-1		See level high, page 16-1	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 16: Decontamination Solution Tanks

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Level Continued	Low Continued	Leak in tank or associated piping	Level instrumentation Alarms Visual inspection	Personnel exposure to decon chemicals if floor drain blocked	F3	S1-M	
Pressure	High	Over temperature of solution with plugged vent and overflow	Visual observation of vent stack	Release of hazardous material	F3	S1-M	
		Transfer of incompatible solution into tank (human error)	Tank temperature indication	If solution is being transferred with a barrel pump, solutions could backup into the room	F3	S1-M	
	Low	N/A					Passive vent to atmosphere
Temperature	High	Failure of heater control	Temperature gauge on tank Visual	See High pressure on page 16-2 for boiling		See high pressure on page 16-2	Team assumes no significant consequences unless tanks are boiling
		Chemical reaction	Same as above	Same as above		Same as above	
		Fire (external to tank)	Same as above and Fire detection in room	Equipment damage Personnel exposure to chemicals or contamination	F2 F2	S1-L S1-M	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 16: Decontamination Solution Tanks

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Temperature Continued	Low	See Temperature Low, node 15, page 15-3	See Temperature Low, node 15, page 15-3	See Temperature Low, node 15, page 15-3 and see Level Low, page 16-1		See Level Low, page 16-1	
Composition	Wrong Material	Human error	After the fact discovery Sampling	Incompatibility - bias in samples Chemical reaction in lines	F2	S0	Tanks are only 100 gallon capacity hence the team considers a reaction in the primary tank to be insignificant.
	Process Solution	Reverse flow due to valve mispositions/failures in flush line and Check valve failure	ARM Sampling Change in liquid level or temp. in decon tank Routine survey from rad protection	Increased worker exposure Potential rad airborne release through tank ventilation Process delay	F3	S1-M S1-M S0	
	Wrong Concentration	Human error	Discovery after the fact Sampling	Same as above	F2	S0	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 17: Mixer Pump

Process Parameter	Guide Word/ Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Temperature	High	Motor fire	Motor would quit Amperage indicator - automatic cutoff	Motor damage	F2	S1-L	See Node 18, p. 18-1, for weather enclosure fire - potentially initiated by motor fire. Repairs would be needed
		Cooling system inoperable for long period	Same as above	Same as above		Same as above	Same as above Motor would probably dump heat to tank
	Low	Low ambient temp	Observation of conditions	No significant consequences		S0	
Pressure	High	Ventilation system down/motor overheats	See Temperature High, page 17-2	See Temperature High, page 17-2		See Temperature High, page 17-2	See Temperature High, page 17-2
		See node 6, page 6-2 for ventilation system parameters causing high pressure	See node 6, Pressure High, page 6-2	See node 6, Pressure High, page 6-2		See node 6, Pressure High, page 6-2	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 17: Mixer Pump

Process Parameter	Guide Word/ Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
	Low	Blocked ventilation inlet with exhaust continuing to run	See node 6, Pressure Low, page 6-3	See node 6, Pressure Low, page 6-3		See node 6, Pressure Low, page 6-3	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 18: Weather Enclosure

Process Parameter	Guide Word/ Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Temperature	High	High ambient	Instrumentation	Worker exhaustion Programmatic impacts - loss of productivity	F1	S1-L S0	
		Fire Minor Fire - small equipment damage, hand extinguisher can be used. Major Fire - Fire department.	Fire detection system	Equipment damage - minor fire Potential personnel injury - minor fire Structural damage to pits and tanks from fire - major fire Structural damage to weather enclosure - major fire Damage to ventilation system - major fire	F2 F2 F3 F3 F3	S1-M S1-M S1-H S1-H S1-H	Contamination spread from REGULATED equipment in weather enclosure assuming the equipment is sufficiently contaminated.
		Air conditioning failure linked with high ambient temperature	Instrumentation	Worker exhaustion Programmatic impacts - loss of productivity	F1	S1-M S0	
		Initiated in weather enclosure (fuel or trash fire)	Fire detection system	See Fire above		See Fire above	Trash from potential poor housekeeping practices.
		Initiated in pits (fuel fire)	Same as above	Same as above		Same as above	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 18: Weather Enclosure

Process Parameter	Guide Word/ Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
		Range fire	Same as above	Same as above		Same as above	
	Low	Low ambient and heating system failure	Temperature indication Tactile	Leaks from frozen pipes (service piping)	F1	S1-L	Leaks from frozen pipe could cause intrusion into a tank.
				Worker discomfort/delays	F1	S1-M	Worker injury
				Frost buildup on ventilation intakes to tanks		See pressure low, node 11, page 11-4	Tank equipment may or may not be dependent on maintaining weather enclosure temperature.
				Inoperable fire system/frozen pipes/possible leak	F1	S1-M	See above for injury on ice Worst case: Flooding of process pit resulting in contamination spread.

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 18: Weather Enclosure

Process Parameter	Guide Word/ Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
		Steam outage	Same as above	Same as above		Same as above	Same as above
Inventory Contents	Contamination	Material released from pits and risers	CAM units and routine surveys	Worker exposure	F1	S1-M	
			Visual observation	Airborne contamination spread	F2	S1-M	
			Olfactory	Waste volume increase from cleanup	F1	S0	
			Ventilation system alarms	Process delay	F1	S0	
				Industrial hazards during cleanup	F1	S1-L	
		Dropped contaminated equipment	Observation and surveys	Same as above		Same as above	
		Failure of containment of contaminated equipment during maintenance	Surveys and/or CAMs Observation Visual	Same as above		Same as above	
	Poor housekeeping	Windstorm	Visual observation	Increased fire hazard	F1	S1-M	
				Ventilation problems with debris around intakes	F1	S0	
				Industrial hazard	F1	S1-M	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 18: Weather Enclosure

Process Parameter	Guide Word/ Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Inventory Contents Continued	Poor housekeeping Continued	Human error - not cleaning up tumbleweeds or trash, etc.	Same as above	Same as above		Same as above	
		Coexistence of construction and maintenance	Same as above	Same as above		Same as above	
Air Quality	Hazardous to Health	Vehicle exhaust ventilation failure	Olfactory	Worker injury	F2	S1-M	Note: Air quality alarms may be in the design Team assumes that since the design is according to national codes that air quality alarms may be required. The need for air quality alarms will be resolved during definitive design.
		Enclosure ventilation system failure	Alarms on system	Same as above	F2	S1-M	
		Fire	Fire alarms Visual	Equipment damage Worker injury or death		See previous discussion on fires	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 18: Weather Enclosure

Process Parameter	Guide Word/ Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Air Quality Continued	Hazardous to Health Continued	Open chemical containers/spills	Visual Olfactory	Same as above	F2	S1-M	Needs further evaluation by SSA. Still not evaluated.
Structural Integrity	Damage	Earthquake	Observation of phenomena	Collapse of weather enclosure potentially leading to damage of safety class 1 equipment	F2	S3	Analysis must be performed to determine the effects on safety class 1 equipment.
				Worker injury	F2	S1-H	
				Programmatic delays		S0	
				Potential to damage nearby structures if weather enclosure collapses	F2	S1-M	Programmatic delays would be caused while inspections are being performed.
		Windstorm - missile impact in excess of design basis	Same as above	Potential damage to weather enclosure, but building is designed to withstand UBC wind	F2	S2	Same as above
				Worker injury		S1-H	
				Programmatic delays		S0	
		Vehicle impact	Same as above	Same as above	F2	S1-H	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 18: Weather Enclosure

Process Parameter	Guide Word/ Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
		Aircraft impact	Same as above	See earthquake on page 18-5	F4	S1-M	Ranking may be more severe if contaminated equipment is damaged
Structural Integrity Continued	Damage Continued	Internal or external fire	Same as above	See previous discussion on fires on pages 18-1 and 18-4	F2	S1-M	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 19: Tanker Load In Station

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Contents	Liquid	Spill or spray from tanker or associated connections	Visual observation	Worker injury Disposal of hazardous material Airborne chemicals Environmental release if chemical overflowed curbed area	F1	S1-M S1-L S1-M S1-M	Put the above in here. The size of the curbed area will be determined during Title 1 design. Team recommends a hose connection in the load-in station to clean up minor spills during chemical load-in.
		Precipitation	Same as above	Disposal of material (may or not be hazardous material)	F1	S1-L	
		Leak of sanitary water	Same as above	Same as above	F1	S1-L	Industrial hazard potential
		Safety shower\eye wash left on	Visual Flow instrument	Same as above	F1	S1-L	Same as above
		Reverse flow from the service building (raw water, steam)	Visual Flow instrumentation	Same as above.	F2	S1-L	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 19: Tanker Load In Station

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Structural integrity	Damage	Truck impact	Visual inspection	Programmatic impact Potential environmental release	F1	S0 S1-M	S1 if hazardous material spread
		Acid spill	Same as above	Worker injury	F3	S1-M	Same as above. Acid not to be used.
		Natural phenomena	Same as above	See above Repairs needed	F2	S1-L S1-L	Same as above
		Fuel fire involving truck	Same as above	Worker injury	F2	S1-M	(worst case) Same as above
		Freeze damage	Same as above	See truck impact above	F1	S1-L	Same as above

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 20: Piping From Tanker Load In Station to Chemical Addition Including Piping Within the Pump Station

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence		Rank	Remark
Flow	No	Pump failure	Flow indication Pump amperage dP across pump Pressure gauge	Operational delay See node 1, page 1-1	F1	S1-L	S1 based on maintenance of pump
		Misvalving	See above	Operational delay Environmental release	F1	S0 S1-M	
		Pipe leak	See above Leak detector	Process delay Environmental release Worker injury See node 1, page 1-1	F3	S0 S1-M S1-M	
		Closed valve	See pump failure	Operational delay	F1	S0	
		Plugged line	See pump failure	Operational delay	F1	S0	
		See node 1, page 1-1, for other causes					
	More	N/A					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 20: Piping From Tanker Load In Station to Chemical Addition Including Piping Within the Pump Station

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence		Rank	Remark
Flow Continued	Less	See No Flow on page 20-1	See No Flow on page 20-1 and Sampling (for misvalving)	See No Flow on page 20-1, except that misvalving could cause a transfer of chemicals to the wrong tank		See No Flow on page 20-1 and composition of primary tank, node 11, page 11-6, 11-7	
	As Well As Raw water	Human error Misvalving	Tank sampling Flow indication on raw water line	Operational delay Tank material out of specification OSR violation if compliance with action statement was not timely	F2	S0 S1-L S0	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 20: Piping From Tanker Load In Station to Chemical Addition Including Piping Within the Pump Station

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence		Rank	Remark
	Part Of (low flow in piping from the load-in station to the pump station or low or no flow through the raw water line)	See no flow, page 20-1	Flow instrumentation Sampling Temperature	See no flow, page 20-1		See no flow, page 20-1	
	Reverse See load-in station, node 19, page 19-1 for discussion of reverse flow of water and steam through chemical lines						
Flow Continued	Reverse flow of chemicals through utility piping	Misvalving and check valve failure	Leak detection Visual inspection Damage to service piping	Worker injury	F2	S1-M	
	Other Than (Wrong Chemical)	Wrong truck	Sampling Manifest Temp increase or gas evolution in tank	Adverse chemical reaction Process delay Possible equipment damage	F2	S1-M S0 S1-L	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 20: Piping From Tanker Load In Station to Chemical Addition Including Piping Within the Pump Station

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence		Rank	Remark
		Wrong chemical in the truck	Same as above	Same as above		Same as above	Both vendor and WHC trucks should be sampled prior to chemical addition
		Wrong mixture in Add System (Trucks are parked in the wrong load-in stations; metering pumps set up for opposite mixture; metering pumps setup wrong)	Flow instrumentation and same as above	Same as above	F2	Same as above	Assuming inline mixing of chemicals via two load-in stations There is an outside possibility of violating corrosion specs.
Flow Continued	Other Than (Water)	No flow from chemical addition system with open water valves when diluting chemicals inline	Flow meters Liquid level in trucks Sample after the fact	Increased inventories and Same as above	F2	S0	
Pressure	High	Chemical reaction and closed valves	Temperature indication in line Valve lineup on computer	See Reverse Flow of Chemicals on page 20-4 Equipment damage	F2	S1-M	M9 pipe code per Advanced Conceptual Design Report (ACDR) does not cover chemical addition piping; no pressure requirements for such piping stated in ACDR.

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 20: Piping From Tanker Load In Station to Chemical Addition Including Piping Within the Pump Station

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence		Rank	Remark
	Low (less than desired pressure)	See Low Flow, on page 20-1					
Temperature	High	Chemical reaction	Temperature indication on addition line to distribution pit	Exceeding design parameters of piping	F3	S0	Design temp for this piping is not yet specified
Temperature Continued	Low	Cold weather	Temp indication	Inability to move solution Equipment damage	F2	S0 S1-L	Most of this piping is inside the weather enclosure

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 21: Primary Tank Ventilation System Air Intake

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow	No	Fan shutdown	General instrumentation Alarms	Inadequate cooling of primary tank Hydrogen buildup in primary tank atmosphere Possible contamination spread from primary tank	F3	S1-M S1-M S1-M	NOTE: General operating mode would be mixer pump shutdown on loss of primary ventilation S1 and S2 rankings are based on a longterm loss of primary ventilation.
		Filter plugged and fan still operating	dP High tank vacuum	No significant consequences if vacuum control system (seal loop) works as designed	F2	S1-M	Have redundant filter banks Ranking is based on the industrial hazards involved in a routine filter change out
		Backdraft damper shut	Damper Position indication	Same as above		Same as above	Damper repair may be needed
		Valve closed	Same as above	Same as above		Same as above	Valve repair may be needed
		Broken duct downstream of control dampers	Flow control instrumentation at stack Pressure indication on tank	Difficulty in maintaining tank vacuum		Same as above	Refer to node 11, Pressure/not enough vacuum on page 11-3
		Frost on the inlet	Same as valve closed	Same as valve closed	F1	Same as valve closed	Note: mitigated by the fact that vent inlet is inside the weather enclosure

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 21: Primary Tank Ventilation System Air Intake

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow Continued	More	Both fans running at the same time (Manual computer override)	Alarms Instrumentation	No effect on air intake system At worst could have high tank vacuum if speed control is overridden or failed		See node 11, high tank vacuum, page 11-4	Note: Multiple failure of controls would be required.
		Speed control failure and fan runs faster than normal	See above	See above		See above	
	Less	See no flow, page 21-1	See no flow, page 21-1	See no flow, page 21-1		See no flow, page 21-1	See no flow, page 21-1
	As Well As (Water)	Heater failure and/or excessive moisture in air (exceeding 70% relative humidity)	High dP across filters Temperature indication	High dP across filters	F3	S1-L	NOTE: The redundant intake train should start. Ranking due to industrial hazards of filter changeout
	As Well As (Biota)	Failure of bird screen and transfer of biota into weather enclosure	High dP indication	High dP across filters	F1	S1-L	Same as above.
	As Well As (Dust or dirt or foreign matter)	Windstorm	High dP indication Visual	Same as above		Same as above	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 21: Primary Tank Ventilation System Air Intake

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow Continued	As Well As (Dust or dirt or foreign matter) Continued	Human error	Same as above	Same as above		Same as above	
	Part Of	N/A					
	Reverse	Pressurization of tank when fans are shut down and valves misaligned	Alarms	Unless inlet HEPA failed, no significant consequences	F2	S1-L	Ranking due to industrial hazards from filter changeout; increased radiation exposure
	Other Than	N/A					
Pressure	High	See Reverse Flow, page 21-3	See Reverse Flow, page 21-3	See Reverse Flow, page 21-3		See Reverse Flow, page 21-3	See Reverse Flow, page 21-3

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 21: Primary Tank Ventilation System Air Intake

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Pressure Continued	Low (Excessive Vacuum)	See No and More Flow on pages 21-1 and 21-2 respectively	See No and More Flow on pages 21-1 and 21-2 respectively	See No and More Flow on pages 21-1 and 21-2 respectively		See No and More Flow on pages 21-1 and 21-2 respectively	See No and More Flow on pages 21-1 and 21-2 respectively
Temperature	High (Sufficient to cause cooling system problems)	Heater unit control failure	Temp indication	Worst case: fail HEPA Cause failure of duct insulation	F3	S1-L S1-L	Rankings due to industrial hazards involved in recovery
		Fire	Fire detection system in weather enclosure as well as above	Same as above	F3	Same as above	
	Low	See no flow, page 21-1	See no flow, page 21-1	See no flow, page 21-1		See no flow, page 21-1	See no flow, page 21-1

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 22: Primary Tank Ventilation System Air Exhaust

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow	No	Closed motor valve	Speed control Pressure drop Alarms on fan motor Temperature control	Tank temp increase Negative pressure regulations not met	F1	See node 11, temp high on page 11-4 and no flow intake on p. 21-1	NOTE: That redundant trains are provided with one train operated as normal and the other continually on standby.
		Filter plug	dP across HEPA	Same as above	F1	Same as above	
		Closed exhaust damper	Flow control indication Temp control	Same as above	F1	Same as above	
		Fan failure	Speed control Pressure drop indication Alarms on fan motor Temp control	Same as above	F1	Same as above	
		Duct failure (breach)	Event to cause duct failure would most likely be observed	Could have normal stack flow with tanks' negative pressure not maintained	F3	S1-L	Ducts are mostly underground and encased

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 22: Primary Tank Ventilation System Air Exhaust

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow *Continued*	No *Continued*	Gross overfilling of primary tank	Tank liquid level and remaining flow items above	See node 11, tank level high, page 11-1 and node 21, as well as (water), page 21-2		See node 11, tank level high, page 11-1	
	More	Over speed on fans	Fan speed control Flow control dP across fans	Equipment failure Bias stack sampling system by flow exceeding design	F1	S1-L S0	Pull too much vacuum on primary tank
		Both fans running at once	Flow control Alarms on motor Speed control dP across fans	Same as above		Same as above	
		Missing filter on inlet train and flow control failure	See above and dP across inlet filter	Unwanted particulate in tank Loss of tank negative pressure	F2	S0 S1-L	
		Annulus crossover spool in place with open annulus riser	Same as above	Inability to maintain annulus negative pressure	F3	S1-L	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 22: Primary Tank Ventilation System Air Exhaust

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow Continued	Less	See no flow, page 22-1	See no flow, page 22-1	See no flow, page 22-1		See no flow, page 22-1	
	As Well As (This deviation (involving steam) does not apply for node 26)		Tank temperature and liquid level increase				Ranking based on having to do a filter changeout.
	(toxic chemical)	Refer to primary tank (node 11, level high, page 11-1, and composition, page 11-6, 11-7) inlet piping and node 19, page 19-1, and node 20, page 20-1 (includes process solution and chemical)					
	Part of	N/A					
	Reverse	Fan failure with valves left open and recirculation system running and inlet plugged	Multiple indications	No significant consequences		None	Would require at least two unrelated failures. Team consensus is that very little reverse flow would be realized.
Flow Continued	Other Than	N/A					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 22: Primary Tank Ventilation System Air Exhaust

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Pressure	High (positive)	See high pressure in node 11, page 11-3	See high pressure in node 11, page 11-3	See high pressure in node 11, page 11-3		See high pressure in node 11, page 11-3	(pressure relief is to the pipe trench, but further analysis is needed to determine relief valve capacity, the ventilation capacity of the pipe trench and effects of emissions on pipe trench equipment)
	Excess Negative	See level high, node 11, page 11-1 and Blockage on inlet and fans continuing to run	See level high, node 11, page 11-1	See level high, node 11, page 11-1		See level high, node 11, page 11-1	
Temperature	High	Fire	Ventilation Building fire detection Temperature indication in pipe trench exhaust (for electrical fire in pipe trench) Visual observation in ventilation building	Worst case: Fire may damage filtration system resulting in unfiltered release Equipment damage Power failure	F3	S1-M S1-L S1-L	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 22: Primary Tank Ventilation System Air Exhaust

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Temperature Continued	High Continued	Chemical reaction in tank	Tank temperature indication See high temperature, node 11, page 11-4	See composition, node 11, page 11-6, 11-7		See composition, node 11, page 11-6, 11-7	
		Malfunction of electric heating coil (*This cause does not apply for node 24*)	Temp controller Temp indication in exhaust system	Equipment damage Release of residual contamination on filters	F3	S1-L S1-M	S2 is based on the loss of both filters in the system and no switching to the alternate system
		Failure of Recirculation system with mixer pump running	See high temp, node 11, page 11-4	Equipment damage		same as above	
		Failure of annulus exhaust cooling with mixer pumps running	Flow indication temp pressure alarms position indicators	Tank temperature increase Unavailability of secondary tank leak detection system	F3	S0 S0	Since the annulus ventilation system removes approximately 5% of the heat, the temperature increase should not be significant
	Low	N/A					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 23: Combined Exhaust Tunnel and Stack

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow	No	No flow from tank exhaust system	See no flow, node 22, page 22-1	See no flow, node 22, page 22-1		See no flow, node 22, page 22-1	
	More	See more flow, node 22, page 22-2	See more flow, node 22, page 22-2	See more flow, node 22, page 22-2		See more flow, node 22, page 22-2	
	As Well As	See As Well As, node 22, page 22-3	See As Well As, node 22, page 22-3	See As Well As, node 22, page 22-3		See As Well As, node 22, page 22-3	
	Part Of	See no flow, node 22, page 22-1	See no flow, node 22, page 22-1	See no flow, node 22, page 22-1		See no flow, node 22, page 22-1	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 23: Combined Exhaust Tunnel and Stack

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow Continued	Reverse	N/A					
	Other Than	Chemical reaction resulting from air stream mixtures which has undesirable product	Stack monitoring Visual Temp indication	Release of toxic emissions	F3	S1-M	Elimination of stainless steel lining from design might eventually create difficulty in decontamination of the exhaust tunnel.
Pressure and Temperature	See previous node 22, page 22-4						

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 24: Heat Removal System on Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
15 Flow	No (when needed)	Fan failure	alarms and instrumentation	inability to cool tank adequately		see tank temp high, node 11, page 11-4	
		seal loops not drained or full	seal loop level indication	same as above		same	
		plugged condenser or drain line	instrumentation system temp, vibration, flow, dP	same as above	F3	same	
		plugged drain in air/liquid separator unit which plugs the air path through the air/liquid separator	dP across unit plus other instrumentation	same as above		same	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 24: Heat Removal System on Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow Continued	No Continued	broken pipe and/or leaking flange connections	Detection is dependent on pipe break location dP variation tank temp cell pressure instrumentation if break was in cell if underground in tank farm would eventually plug line with dirt leak detection from cells or pipe gallery or pipe chase	cooling problems depending on location potential for airborne release into a cell minor soil contamination near underground section of piping Not able to maintain tank vacuum	F3	see tank temp high, node 11, page 11-4 S1-L S1-L S1-L	this cause may not be immediately detectable all ventilation lines are doubled encased lines
		tank level high plugged intake	see high level, node 11, page 11-1	a loss of tank cooling see high level, node 11, page 11-1		see temp high, node 11, page 11-4	
	more	fan overspeed	speed control on fan dP	none of significance		S0	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 24: Heat Removal System on Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow *Continued*	More *Continued*	both fans in operation with both seal loops drained	instrumentation	same as above		S0	
	less (when full flow needed)	speed controller failure	instrumentation	inadequate tank cooling see temp high, node 11, page 11-4		see temp high, node 11, page 11-4	This deviation would take longer to diagnose than no flow. There are redundant fans and would not expect faulty speed controllers on both.
		partial plug on system	same as above	same as above		Same as above	
		human error to override system	*same as above*	*same as above*		Same as above	
		see no flow, page 24-1	see no flow, page 24-1	see no flow, page 24-1		see no flow, page 24-1	
	As Well As (flush solution)	*Human error*	After the fact	*Transfer of wrong flush solution which would potentially cause accelerated corrosion in condenser or piping*	F2	S1-L	Ranking due to repairs being needed.

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 24: Heat Removal System on Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow Continued	As Well As (Propylene glycol)	Condenser tube failure	Liquid level on cooling side Delta T across condenser Increase in condensate flow to tank	Potential loss of tank heat removal if gross failure Potential incompatibility with tank contents	F2	S1-L Ranking depends on compatibility issue	Compatibility of propylene glycol with stored waste must be evaluated.
	Part of	N/A					
	Reverse	N/A					
	Other than	N/A					
Pressure	High	see high pressure, node 11, page 11-3	see high pressure, node 11, page 11-3	see high pressure, node 11, page 11-3		see high pressure, node 11, page 11-3	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 24: Heat Removal System on Primary Tank

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Pressure Continued	Low (too much vacuum)	Plugged condenser and fan continues to run	See no flow, page 24-1	Loss of tank heat removal	F2	S1-L based on condenser repair also see temp high, node 11, page 11-4	There is no vacuum specification on this pipe section from the condenser to the fan. The team believes the fan would be unable to produce enough vacuum to compromise piping structural integrity.
Temperature	High	See high temperature, node 22, page 22-4 except for heating coil	See high temperature, node 22, page 22-4 except for heating coil	See high temperature, node 22, page 22-4 except for heating coil		See high temperatu re, node 22, page 22-4 except for heating coil	
	Low	N/A					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

MWTF HAZOP (RAW DATA)

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 25: Inlet to Annulus Ventilation System
(Same as node 21)

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
							Everything here is the same as the primary inlet
Flow	no	same as primary inlet					annulus piping all goes to the center of the secondary tank and there could be a potential for blockage here
	more	same as primary inlet					
	part of	same as primary inlet					
	as well as	same as primary inlet					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 26: Annulus Exhaust

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
							The team, based on this study, recommends the requirement for having forced air ventilation in the annulus be revisited.
Flow	No	Same as primary exhaust (node 22, page 22-1) and Intrusion from either a primary tank leak or other source	Intake instrumentation Change in exhaust instrumentation	Lose part of leak detection capability in annulus Decreased cooling on primary tank	F2	S0 See high temp, node 11, page 11-4	Loss of annulus cooling is not expected to result in unacceptable temperatures in the primary tank.
	More	Open riser or risers (infiltration into tank)	Visual Reduced flow from intake system	Bias CAM reading Decreased heat removal	F2	S0 See high temp, node 11, page 11-4	Same as above
		See more flow, node 22, page 22-2	See more flow, node 22, page 22-2	See more flow, node 22, page 22-2		See more flow, node 22, page 22-2	
	less	See no flow, page 26-1	See no flow, page 26-1	See no flow, page 26-1		See no flow, page 26-1	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 26: Annulus Exhaust

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow Continued	As Well As (under primary tank leak condition)	See As Well As, node 22, page 22-3 except for steam	See As Well As, node 22, page 22-3 except for steam	See As Well As, node 22, page 22-3 except for steam		See As Well As, node 22, page 22-3 except for steam	
	Part of	N/A					
	Other Than	N/A					
Pressure	High	Plugged inlet and outlet plus heating of secondary tank atmosphere	Annulus temp detection Annulus pressure indication	Annulus atmosphere could be released unfiltered Loss of cooling Leak detection degradation	F3	S1-L See temp high, node 11, page 11-4 See no flow, page 26-1	
	Low (too much vacuum)	See Excessive Negative Pressure, node 22, page 22-4	See Excessive Negative Pressure, node 22, page 22-4	See Excessive Negative Pressure, node 22, page 22-4		See Excessive Negative Pressure, node 22, page 22-4	There is no vacuum relief on this system. Team assumes that the fan is self limiting.

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94

Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 26: Annulus Exhaust

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Temperature	High	High tank temp	Temp indication on filter trains	Same as High Temperature, node 22, page 22-4		Same as High Temperature, node 22, page 22-4	
		Fire	Same as High Temperature, node 22, page 22-4	Same as High Temperature, node 22, page 22-4		Same as High Temperature, node 22, page 22-4	
		Heater overheats	Same as High Temperature, node 22, page 22-4	Same as High Temperature, node 22, page 22-4		Same as High Temperature, node 22, page 22-4	
	Low	N/A					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 27: Cross-over Spool between Annulus Ventilation System and Primary Ventilation System

Process Parameter	Guide Word/Deviation	Cause	Detection	Consequence	Freq.	Rank	Remark
Flow	No	See no flow, node 22, page 22-1	See no flow, node 22, page 22-1	See no flow, node 22, page 22-1		See no flow, node 22, page 22-1	No flow through the spool is the normal condition.
		Incorrect installation of spool piece (human error)	Annulus dP	Loss of negative pressure in annulus	F2	S1-L	Same as above
	More	Infiltration from open riser or open pump pit	See more flow, node 22, page 22-2	Same as above	F2	S1-L	
	Less	See no flow, page 27-1	See no flow, page 27-1	See no flow, page 27-1		See no flow, page 27-1	See no flow, page 27-1

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 27: Cross-over Spool between Annulus Ventilation System and Primary Ventilation System

	As Well As (aerosols, toxic vapors, etc.)	Aerosol or toxic vapor present in annulus (see remark)	See liquid level low, node 11, page 11-1	Greater than normal aerosol levels in spool piece	F2	S1-M	This cause is based on the assumption that the primary tank is breached and its contents are leaking into the annulus. Aerosol and or vapor production could be caused by the leaked liquid impacting the wall of the annulus and the surface of the filling liquid. This mechanism would cease once the annulus liquid level was above the primary breach location.
Flow Continued	Reverse	See Reverse flow, node 22, page 22-3	Pressure indication in annulus	Contamination of pit if flange gasket leaked	F2	S1-M	
	Other Than	N/A					
Pressure	High (above atmospheric)	See High pressure, node 11, page 11-1 or node 12, page 12-2	See High pressure, node 11, page 11-1 or node 12, page 12-2	See High pressure, node 11, page 11-1 or node 12, page 12-2		See High pressure, node 11, page 11-1 or node 12, page 12-2	

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

Date of Study: 11/21/94 Team Members Present: Bjorklund, Hall, Hydzik, Groth, Smith, and Siemer

NODE 27: Cross-over Spool between Annulus Ventilation System and Primary Ventilation System

	Loss of negative pressure	See no flow, page 27-1	See no flow, page 27-1	See no flow, page 27-1		See no flow, page 27-1	
	Higher than required vacuum	See Excessive Negative Pressure, node 22, page 22-4	See Excessive Negative Pressure, node 22, page 22-4	See Excessive Negative Pressure, node 22, page 22-4		See Excessive Negative Pressure, node 22, page 22-4	
Temperature	High	N/A					
	Low	N/A					

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter).

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

APPENDIX C

HazOp TEAM QUALIFICATIONS

Codes

S0. no effect outside the facility confinement or containment systems and no safety concerns for the facility worker, the onsite worker, or members of the general public

S1. potential industrial injury, radiological dose consequences or chemical exposure to the facility worker (see additional breakdown of hazards to facility workers in attached cover letter)

S2. potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility

S3. potential significant radiological dose consequences or chemical exposure to the offsite population

N/A not applicable

The key members of the MWTF HazOp team, in alphabetical order, are

D. L. Bjorklund
B. D. Groth
B. W. Hall
J. E. Hydzik
J. M. Siemer
P. L. Smith

In addition to the key team members D.E. Bowers and B. Gilbert were in the initial HazOp meetings following reassignment to other duties.

The key members of the MWTF HazOp team brought to the study the following education and experience:

D. L. Bjorklund

Thirty two years experience at the Hanford site where the majority of time (17 years) was spent as a process operator at tank farms, B-Plant and PUREX. Also spent 12 years following the project design, construction, testing, safety documentation and readiness review. Has extensive knowledge of electrical systems from being an armed services instructor in the area of aircraft electrical systems. On the job training has been in the area of instrument controls, computer operation, and environmental law. Represented operations in the preparation of the Double-Shell Tank RCRA Part B permit.

B. D. Groth

B.S. Degrees in Math and Chemistry. Two and a half years experience in process support for Hanford Tank Farms. Involved in process support, minor equipment design, development of design criteria, maintenance, and operation of instrumentation, data acquisition, electrical, and mechanical systems in Nuclear Waste Storage Tank Farms. Primarily worked on developing, fabricating, installing and operating new gas monitoring systems for both process control and analytical purposes in special Watchlist Tanks.

B. W. Hall

B.S., Chemical Engineering. Over 4 years of experience at the Hanford Site in project safety analysis; 1 year in tank waste characterization. Experienced in hazards discovery analysis (e.g., HAZOP analysis, PHA, OHA), consequence analysis, safety class analysis, risk assessment, and atmospheric dispersion modelling. Mr. Hall co-authored Chapter 9 (Accident Analysis) of the Hanford Waste Vitrification Plant (HWVP) Preliminary Safety Analysis Report and provided safety oversight on the HWVP design effort for over 3 years. He also performed accident analysis to support the Cesium Demonstration Unit Preliminary Safety Evaluation and developed safety class requirements for various systems proposed to monitor and remediate watchlist tank 101-SY. Most recently, Mr. Hall developed a detailed safety equipment list for the MWTF.

J. E. Hydzik

B.S. Degree in Mechanical Engineering. Two years experience in mechanical engineering with current emphasis on piping and vessel systems. Involved in

the initial stages of the MWTF; provided input to system parameter definitions and preliminary calculations.

J. M. Siemer

B.S. Industrial and Management Engineering. Three years in the nuclear industry in the areas of Stress Analysis and Reliability and Risk Assessment; eight years in Safety Analysis for nuclear fuel reprocessing plants; and two years independent safety appraisal/review for nuclear fuel reprocessing plants and waste management. Experienced as a Hazard and Operability Study Team leader, Ms Siemer has received training on performing Hazards and Operability Studies from Science Applications International Corporation. Additional training courses completed include Management Oversight & Risk Tree Accident Investigation, Basic Risk Assessment Technology, System Reliability and Risk Assessment, Human Reliability in Engineered Systems, Advanced System Reliability and Risk Assessment, Probabilistic Safety Assessment, and Communicating Under Pressure--Dealing with Difficult People.

P. L. Smith

B.S. Degree in Engineering with emphasis in Civil Engineering, 8 graduate level courses in Mechanical Engineering, also completed a Criticality Safety Course. Over 40 years experience in engineering. Has received training in safety of nuclear facilities, risk evaluation, root cause analysis, radiation protection as well as other courses related to safety at WHC.