Assessment of Operational Readiness of the Safety Class
Double Shell Tank Primary Tank Ventilation System

Site: Office of River Protection Hanford

Facility: Tank Farms

System: Double Shell Tank (DST) Primary Tank Ventilation Systems

System Classification: Safety Class

System Safety Function:
1. Prevention of In-Tank Flammable Gas Deflagration (Safety Class Function)
2. Confinement Ventilation (Environmental Protection Function)

OBJECTIVE:

VSS-1 **This vital safety system is operational and personnel and processes are in place that ensures its continued operational readiness.**

VSS-1.1 VSS safety functions are defined and understood by responsible line managers, and supporting information/documentation is available and adequate. System testing is adequate to ensure operability. (Review Approach items 1, 2, 3 and 7)

Discussion of Results –

System Safety Functions

Prevention of In-Tank Flammable Gas Deflagration: The DST and AWF tank primary tank ventilation systems are identified as Safety-Class (SC) Systems, Structures, and Components (SSC) for the prevention of the Flammable Gas Deflagrations accident described in Section 3.4.2.2 of HNF-SD-WM-SAR-067, Rev. 2, *Tank Farms Final Safety Analysis Report* (FSAR). The safety function of the systems is to prevent the accumulation of flammable gases due to steady-state releases, thus decreasing the frequency of the accident. The accident analysis identified active ventilation systems as the primary means of maintaining DST and AWF tank vapor spaces below the flammability limit. Section 4.3.2 of the FSAR describes the system, its safety function and functional requirements, and Technical Safety Requirement (TSR) controls.

Confinement Ventilation: Environmental drivers require minimization of fugitive radioactive emission. Washington Administrative Code (WAC) 246-247, regulated by the Washington Department of Health, requires the utilization of As Low As Reasonably Achievable Control Technology (ALARACT) for the control of radioactive emissions. To satisfy the confinement function, the DST and AWF primary tank ventilation systems are intended to maintain a vacuum within the tank and provide High Efficiency Particulate Air (HEPA) filtration of the emissions.

Additionally, in-series redundancy of HEPA filtration is identified (in conjunction with HEPA filter differential pressure interlocks) as safety-significant[1] for the DST and AWF primary tank ventilation systems to prevent releases from exceeding the onsite risk guidelines as a result of the accident described in Section 3.3.2.4.2 of the FSAR, *HEPA Filter Failure – Exposure to High Temperature or Pressure*. The safety function of the ventilation system HEPA filters is to provide HEPA filtration of headspace gases before their release to the environment, thus reducing the likelihood of unfiltered releases due to partial HEPA filter release events associated with the accident. However, for the bounding scenario analyzed, the HEPA filters would likely fail because of the over-pressurization and, therefore, were not credited. Section 4.4.3 of the FSAR describes the system, its safety function and functional requirements, and Technical Safety Requirement (TSR) controls.

Conditions Under Which The Systems Are Intended To Perform Safety Function(s)

Prevention of In-Tank Flammable Gas Deflagration: The assumption in the analysis of the Flammable Gas Deflagration accident is that the ventilation systems are operable and operating during normal waste tank operations and will remain operable and operating during a tank waste Gas Release Event (GRE) that may occur in a tank. Specific controls (and their bases) are in place to protect the operability assumptions. Credit is not taken for the safety function performance during abnormal or accident situations.

Confinement Ventilation: Both DST and AWF primary tank ventilation and system exhaust HEPA filtration are intended to be operable during normal tank operating conditions; that is, while waste storage and waste transfers may be occurring. For the bounding scenario analyzed in the accident described in section 3.3.2.4.2 of the FSAR, the HEPA filters would likely fail as a result of an over-pressurization condition and, therefore, were not credited. However, in a less than bounding over-pressurization or over-temperature accident where the conditions are less severe, partial or full HEPA filter integrity may continue to exist, thus reducing the likelihood of unfiltered releases associated with the accident

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System Functional Requirements and Performance Criteria

Prevention of In-Tank Flammable Gas Deflagration:

Functional Requirements: The DST and AWF tank primary ventilation systems shall maintain vapor space pressures of all tanks <0 kPa (<0 in. WG relative to atmospheric pressure).

[1] NOTE: Safety-Significant (SS) and Defense-in Depth (DID) SSCs are to be addressed in a later CRAD submittal. However, confinement ventilation systems were to be addressed in this submittal. Therefore, periodic functional testing to confirm HEPA filter integrity and confinement performance will be presented here, but other SS and DID TSR controls (e.g., Stack CAM Interlock and HEPA Filter Differential Pressure Interlock) associated with a loss of filtration analyzed accident will be part of the next CRAD submittal.

Performance Criteria: Operability of the primary tank ventilation systems shall be verified daily to ensure compliance with the functional requirements. To ensure that the standby systems will operate in the event of a primary ventilation system failure, the standby systems are functionally tested on a periodic basis.

Confinement Ventilation:

Functional Requirements:

1. The DST and AWF tank primary ventilation systems shall maintain vapor space pressures of all tanks <0 kPa (<0 in. WG) relative to atmospheric pressure.
2. The DST and AWF ventilation system exhaust HEPA filter units shall remove at least 99.95% of particles of an approved challenge aerosol that are as small as 0.3 μm.

Performance Criteria:

1. Operability of the primary tank ventilation systems shall be verified daily to ensure compliance with the functional requirements. To ensure that the standby systems will operate in the event of a primary ventilation system failure, the standby systems are functionally tested on a periodic basis.
2. Per Administrative Control (AC) 5.18.2 (e) of HNF-SD-WM-TSR-006, Rev.2, *Tank Farm Technical Safety Requirements*, the HEPA filter nominal particulate removal efficiency shall be verified to be ≥99.95% by performing an aerosol test with the design air flow through the filter, according to the guidance in American Society of Mechanical Engineers (ASME) standard N510, *Testing of Nuclear Air Treatment Systems*, and Energy Research and Development Administration (ERDA) 76-21, *Nuclear Air Cleaning Handbook*. The aerosol test shall be performed after filter installation/replacement and every 12 months thereafter.

Surveillance Test Acceptance Criteria

Prevention of In-Tank Flammable Gas Deflagration: Limiting Condition of Operation (LCO) 3.2.1 of HNF-SD-WM-TSR-006, Rev.2, *Tank Farm Technical Safety Requirements* (TSR), provides the operability requirements for the exhausters for the primary tank ventilation system for DST and AWF waste tanks. Surveillance requirement (SR) 3.2.1.1 of the TSR requires verification that the active primary tank ventilation system is operable.

The preferred method is to confirm that the primary tank vapor space pressure is < 0 kPa (< 0 in. WG). Alternatively, monitoring of ventilation system airflow rate is an acceptable practice. Operability of the safety function is confirmed daily through use of the following Operator Surveillance Rounds:

- TF-OR-A-03, Rev. E-71, *AP and AW Tank Farms Daily Rounds.*
- TF-OR-EF-AN, Rev. C-41, *AN Tank Farm Rounds*.
- TF-OR-EF-AYAZ-D, Rev. C-67, *AY and AZ Tank Farms Daily Rounds*.

- TF-OR-EE-702AZ-D, Rev A-21, *702-AZ Primary Tank Ventilation System Operational Daily Rounds*.
- TF-OR-WST-01-D, Rev. C-27, *242-S, 244-S, 241-SY, 241-S and 241-SX Day and Night Shift Rounds*.

The acceptance criteria is confirmation that a vacuum exists in the primary tank vapor space or that the primary tank ventilation system exhaust fan(s) is operating.

Confinement Ventilation:

1. Verification that the confinement ventilation system is operable is conducted using operator daily surveillance rounds as described above.

2. Verification of the HEPA filter performance criteria of AC 5.18.2 (e) is conducted using maintenance procedure 3-VBP-156, Rev. B-9, *HEPA Filter In-Place Leak Test (Aerosol Test)* in conjunction with location specific datasheets. The test is in accordance with the guidance provided in ASME N510, *Testing of Nuclear Air Treatment Systems*, and Energy Research and Development Administration (ERDA) 76-21, *Nuclear Air Cleaning Handbook*. The test must demonstrate filter particulate removal efficiency to be ≥99.95% for particles are as small as 0.3μm at the design airflow rate.

Frequency of Surveillance Tests and Identification of Requirements

Prevention of In-Tank Flammable Gas Deflagration: Verification of both primary tank vacuum and primary tank ventilation exhaust fan operation is conducted once per shift per the operations surveillance procedures specified above ("Surveillance Test Acceptance Criteria"). This is a Surveillance Requirement required to support LCO 3.2.1 of the TSR.

Confinement Ventilation: Verification of both primary tank vacuum and primary tank ventilation exhaust fan operation is conducted once per shift per the operations surveillance procedures specified above ("Surveillance Test Acceptance Criteria").

Administrative Control (AC) 5.18.2 (e) requires the exhaust HEPA filter aerosol tests to be performed after filter installation/replacement and every 12 months thereafter. The activity is on a 330-day recall schedule in the Preventive Maintenance/Surveillance (PM/S) system.

Drawings That Document the System Configuration

Essential drawings and other design baseline drawings are readily available via microfilm at Document Control Centers or on the on-line Hanford Document Control System (HDCS). Outstanding and incorporated Engineering Change Notices (ECNs) to these documents are identified in HDCS, and are readily available in HDCS or at the document centers.

HDCS has the capability of identifying system cognizant engineers and system design authority engineers associated with the drawings.

The typical set of drawings used in daily operation of the DST ventilation system consist of; Piping and Instrument Diagrams, HVAC equipment schedules, electrical one-line diagrams and panelboard schedules, and HVAC equipment plans). A list of the drawings for the DST and AWF primary tank ventilation systems is included in Attachment F. This is not a complete listing of all the drawings for these systems, but it is a list of what is considered necessary for safe day-to-day operation and maintenance.

VSS-1.2 The backlog for surveillances, tests, inspections, maintenance, repair, upgrades, or other work on the system is managed and kept to an appropriate minimum. (Review Approach item 6)

Discussion of Results –

Current Maintenance, Testing, and Surveillance Backlog

The current backlog of Preventive Maintenance (PM), Corrective Maintenance (CM), and modification work packages for the DST and AWF primary tank ventilation systems is included in Attachment E. No backlog of surveillances, tests, or inspections has been identified. Backlog of corrective actions from recovery or corrective action plans will be identified separately from this document for all systems.

In the SY Tank Farm the backup exhauster aerosol test is overdue, because the motor on the exhauster has failed. A corrective maintenance work package is issued and the exhauster motor will be replaced. The aerosol test will occur subsequent to the successful motor replacement.

The SY Tank Farm Primary exhauster has had a problem with the demister/ de-entrainer. Water buildup within the exhaust filter system has caused higher differential pressure through the first stage HEPA filter. A replacement of the first stage HEPA filter was needed, due to this issue. A replacement demister/ de-entrainer for this exhaust unit needs to be procured and installed.

VSS-1.3 Configuration Management and Maintenance programs effectively ensure operational availability of the system. (Review Approach items 5, 8 and 9)

Discussion of Results –

Scheduled Maintenance, Walk downs, Inspections, and Assessments

Weekly, and monthly surveillance operator rounds are conducted to ensure tank farm operating equipment is functioning properly. These surveillances include items that are intended to ensure reliable performance of the DST and AWF primary tank ventilation systems. Applicable Operator Rounds include:

- TF-OR-A-03, Rev. E-71, *AP and AW Tank Farms Daily Rounds*.
- TF-OR-EF-AN, Rev. C-41, *AN Tank Farm Rounds*.
- TF-OR-EF-AYAZ-D, Rev. C-67, *AY and AZ Tank Farms Daily Rounds*.
- TF-OR-EE-702AZ-D, Rev A-21, *702-AZ Primary Tank Ventilation System Operational Daily Rounds*.
- TF-OR-WST-01-D, Rev. C-27, *242-S, 244-S, 241-SY, 241-S and 241-SX Day and Night Shift Rounds*.

Additionally, preventive maintenance and surveillance (PM/S) activities are regularly scheduled and conducted through the PM/S module of the Job Control System (JCS). These activities include the calibration, functional testing and other periodic maintenance items necessary for system components that assist operators in monitoring and controlling system operations, but are not necessarily tied directly to a safety-related function.

Regularly scheduled Environmental Surveillances and Compliance Inspections are conducted within the DST and AWF tank farms. Included in these surveillances are primary tank ventilation systems. Attachment C includes surveillance schedules and example checklists.

The Facility Excellence Program (FEP) as described in Section 5.8.3, “Identify and Implement Improvement Opportunities” of the “Integrated Environment, Safety, and Health Management System Description for the Tank Farm Contractor” (RPP-MP-003, Rev. 1), provides regularly scheduled self-assessments of different facilities by employees. Walk down assessments are informal, but equipment condition issues have been addressed in these walk downs. Attachment D contains schedules and a sample checklist for these activities.

VSS-1.4 The system is operable and available to fulfill its safety function when required. (Review Approach items 4 and 10)

Discussion of Results –

System Acceptance Test Failures: Last Three Years

Prevention of In-Tank Flammable Gas Deflagration: There is no maintenance testing or functional test intended to confirm operability. Operability of the safety function is confirmed daily through use of the Operator Surveillance Rounds as previously described in VSS-1.1 and VSS-1.3. The system is not required to be operable during planned shutdowns for maintenance, etc. Unplanned primary tank ventilation system shutdowns are typically detected in response to tank pressurization alarms or by operator rounds if pressurization alarms do not occur. Unplanned shutdowns are typically system failure on demand, and these are addressed in the next section (“System Failures in Response to Facility Conditions”).

Confinement Ventilation: During the three year period from 1998 to 2000, there were two events where HEPA filters failed to meet the annual (330 days) functional aerosol test acceptance criteria. Both of these failures were determined during the same work evolution (work package #2E-00-01475) on 10/26/00 at the 241-AP tank farm primary tank ventilation system.
One filter from each parallel exhaust train failed to meet the criteria during annual in-place testing of the filters. The filter component numbers are AP241-VTP-FLT-302 and -402. Both of these filters are the first stage filters of their respective dual-stage parallel filter train, so the confinement function of the filtration was not compromised because of the redundancy of filtration inherent in the design.

System Failures In Response to Facility Conditions: Last Three Years

Prevention of In-Tank Flammable Gas Deflagration: During the three year period from 1998 to 2000, there have been a total of 42 events where one of the five DST or AWF primary tank exhaust systems have experienced unplanned shutdowns (see Attachment A for details). Broken down by tank farm primary exhaust system, these are:

- 241-SY 21 Events Total time down: 99 hours, 51 minutes
- 241-AP 5 Events Total time down: 37 hours, 33 minutes
- 241-AW 4 Events Total time down: 16 hours, 51 minutes
- 241-AN 4 Events Total time down: 13 hours, 11 minutes
- 241-AY/AZ 8 Events Total time down: 13 hours, 47 minutes

Confinement Ventilation: The confinement ventilation function downtime is the same as presented above for the prevention of in-tank flammable gas deflagration accident. In other words, the exhausters must be operable to provide a vacuum in the primary tank to minimize the potential for unfiltered fugitive emissions through leak pathways.

There were no failures of HEPA filter integrity during the period, with the exception of the two 241-AP tank farm filters that failed the criteria of the in-place efficiency test. Because of the redundancy of in-series HEPA filters, these failures did not result in a loss of the confinement ventilation function. Because of the operability of the alternate safety control LCO 3.1.4 (Stack CAM Fan Interlock), the safety function to provide redundant in-series filtration in conjunction with LCO 3.1.8 (HEPA Filter dP Interlock) was not compromised.

Percentage of Time the System Was Not Capable Of Accomplishing Its Safety Function: Last Three Years

Prevention of In-Tank Flammable Gas Deflagration: When a DST or AWF primary tank ventilation system is discovered to be not operable to meet LCO 3.2.1 requirements, LCO actions are immediately entered to ensure safe operating configuration. While in LCO 3.2.1 action mode, the systems are not required to be operable, but immediate action is taken to restore the primary tank ventilation system to operable status as soon as possible.

The systems are not required to be operable during planned shutdowns for maintenance (LCO actions are entered). Additionally, should a ventilation system fail for any reason (unplanned shutdown), there is sufficient time for recovery before flammable gas concentrations in a tank might reach the Lower Flammability Level (LFL) necessary for minimum combustion.

It is determined in the accident analysis that a loss of active ventilation can result in an accumulation of flammable gases to Lower Flammability Level (LFL) conditions in 32 days for Tank 241-SY-101. The next shortest time to LFL is calculated to be 50 days for Tank 241-AN-107.

Twenty-one (21) of the 28 DSTs, based on current contents, cannot attain LFL conditions[2].

Nevertheless, for the purposes of this analysis, an estimate of percentage downtime and availability of the safety function for each DST/AWF tank farm primary tank ventilation system is provided based upon unplanned system shutdowns (see Attachment A for details):

- 241-AP Percentage downtime = 0.14% Availability: 99.86%
- 241-SY Percentage downtime = 0.38% Availability: 99.62%
- 241-AW Percentage downtime = 0.06% Availability: 99.94%
- 241-AN Percentage downtime = 0.05% Availability: 99.95%
- 241-AY/AZ Percentage downtime = 0.05% Availability: 99.95%

Confinement Ventilation: The confinement ventilation function requires that the exhausters be operable to provide a vacuum in the primary tank to minimize the potential for unfiltered fugitive emissions through leak pathways. There were no failures of primary tank ventilation exhaust HEPA filter systems during the analyzed period. Therefore, the estimated percentage of time that the system was not capable of providing this function when required to be operable is the same as presented above associated with ventilation system unplanned shutdown periods.

Supporting Systems/Equipment For Operation of the Vital Safety System

Electrical power is required for operation of the DST and AWF primary tank ventilation systems.

Although not essential to its operation (can operate in bypass), the 241-AY/AZ primary tank exhauster is supported by a moisture removal system (condenser) with cooling system (chiller and cooling tower) and an air recirculation module. The purpose of this system is to remove moisture from the air stream for return to the tanks, cool the air stream, and recirculate part of the air stream back to the tanks for waste tank cooling.

[2] Recent remediation efforts at Tank 241-SY-101 have reduced the gas generation rate by a factor of 7. Also, reanalysis of flammable gas generation rates in other tanks have extended the period to reach LFL concentrations. Approval of these new analyses into the FSAR is pending and in process.

This additional system is installed in the 241-AY/AZ primary tank exhausters because the four tanks in these two Aging Waste Facility tank farms contain waste with a high heat load.

CONCLUSIONS:

The DST and AWF Primary Tank Ventilation Systems serve two primary functions: (1) dilution and removal of flammable gas buildup for prevention of a potential in-tank flammable gas deflagration accident (safety-class function) and (2) provide confinement ventilation to minimize fugitive unfiltered emission (environmental function) by maintaining a vacuum within each tank. The systems are operable and available to perform their safety functions.

The systems are not required to be operable during planned shutdowns for maintenance. Additionally, should a ventilation system fail (unplanned shutdown) for any reason, there is sufficient time for recovery before flammable gas concentrations in a tank might reach the Lower Flammability Level (LFL) necessary for minimum combustion. It is determined in the accident analysis that a loss of active ventilation can result in an accumulation of flammable gases to Lower Flammability Level (LFL) conditions in 32 days for Tank 241-SY-101. The next shortest time to LFL is calculated to be 50 days for Tank 241-AN-107. Twenty-one (21) of the 28 DSTs, based on current contents, cannot attain LFL conditions[2].

Without regard to actual ventilation system recovery periods for prevention of an in-tank gas deflagration accident, the ventilation systems were analyzed for availability over the past three years based upon down time as a result of unplanned shutdowns. Availability of the systems to provide ventilation is greater than 99% for each of the five systems (ref. VSS-1.4).

The SY Tank Farm Primary exhauster has had a problem with the demister/de-entrainer. Water buildup within the exhaust filter system has caused higher differential pressure through the first stage HEPA filter. A replacement of the first stage HEPA filter was needed, due to this issue. A replacement demister/de-entrainer for this exhaust unit needs to be procured and installed.

The safety systems will need to have the role of each unique piece of equipment defined. These requirements need to be defined in an update to the RPP Safety Equipment List.

DOE employee who reviewed this assessment ___DOE Review Team_____ Date __2/28/01_
(*See below)

[2] Recent remediation efforts at Tank 241-SY-101 have reduced the gas generation rate by a factor of 7. Also, reanalysis of flammable gas generation rates in other tanks have extended the period to reach LFL concentrations. Approval of these new analyses into the FSAR is pending and in process.

Hours required for completing the assessment.

DOE: 40 Hrs.

Contractor: 240 Hrs.

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