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Action Plan for Response to Excessive Temperatures in Hanford Site High-Heat Waste Tank 241-C-106

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ACTION PLAN FOR RESPONSE TO EXCESSIVE TEMPERATURES IN HANFORD SITE HIGH-HEAT WASTE TANK 241-C-106

F. R. Hand

ABSTRACT

Tank 241-C-106 is a single shell tank at the Hanford Site in south central Washington State, and is the only tank on Hanford's High-Heat Tank Watch List. This action plan defines possible abnormal conditions (such as ventilation system failure or a leaking tank) that could lead to excessive temperature increases in tank 241-C-106, and documents pre-planned contingency actions that would effectively mitigate the consequences of such increased temperatures. Potential structural damage may result from high temperatures caused by inadequate cooling.

Tank 241-C-106 contains a significant amount of high-heat radioactive waste, mainly strontium, and requires forced ventilation combined with evaporation for adequate cooling. Forced ventilation at 2,400 ft^3/min, along with periodic water additions of approximately 6,000 gal/month, is currently maintaining the tank temperature within the required range. This action plan addresses high-heat concerns and corrective measures unique to tank 241-C-106 and to proposed sluicing activities in tank 241-C-106. Other general emergency actions for the 200 Area Tank Farms, such as those for fires and earthquakes, are described in WHC-CM-4-43, "Emergency Management Procedures" and are not included in this document.

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Tank 241-C-106 is presently a non-leaking tank. If tank 241-C-106 were to leak, maintaining current cooling water levels would result in continual water loss to the ground and further environmental damage. If cooling water additions to the tank are stopped should a leak occur, the sludge could heat to temperatures greater than established safety limits and could cause tank structural damage. A Tri-Party Agreement milestone and a Department of Energy Safety Initiative milestone have been established to start waste retrieval from tank 241-C-106 in October 1996..

Sluicing is scheduled to start October 1996 and is expected to be completed in six months. This contingency action plan will be followed until sluicing is completed.

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LIST OF TERMS

DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DST	double-shell tank
FIC	Food Instrument Corporation
FY	fiscal year
HEPA	high-efficiency particulate air (filter)
HLW	high level waste
LOW	Liquid Observation Well
OSD	Operating Specifications Document
OSR	Operational Safety Requirement
PUREX	Plutonium-Uranium Extraction (Facility at Hanford Site)
SST	single-shell tank
TC	thermocouple
TMACS	Tank Monitoring and Control System
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TWRS	Tank Waste Remediation System
WHC	Westinghouse Hanford Company
wg	water gauge
WRSS	Waste Retrieval Sluicing System

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ACTION PLAN FOR RESPONSE TO EXCESSIVE TEMPERATURES IN HANFORD SITE HIGH-HEAT WASTE TANK 241-C-106

1.0 INTRODUCTION

1.1 PURPOSE OF THE ACTION PLAN

Tank 241-C-106 is a single-shell tank (SST) and is a High-Heat Watch List Tank (Wang 1994, Hanlon 1996). The current waste inventory must be cooled to prevent overheating that could cause structural damage to the tank (RHO 1983). This action plan meets the requirements of Public Law 101-510 by providing an overview of the responses that will be implemented if excessive temperature increases or conditions that could lead to temperature increases are observed in tank 241-C-106. This plan summarizes:

- The criteria and specification limits required for ensuring that tank 241-C-106 is maintained in a safe condition
- Pre-planned response actions to prevent or mitigate safety concerns
- The conditions under which corrective action responses shall be initiated.

Preplanned actions in response to abnormal conditions that could result in excessive waste temperature increases provide further assurance that the waste in tank 241-C-106 will be stored and handled safely until waste retrieval is completed.

1.2 SCOPE OF THE ACTION PLAN

The information included in this action plan applies specifically to high-heat tank 241-C-106. Tank 241-C-106 contains high-heat source materials and requires cooling. This is currently provided by forced ventilation and evaporative cooling. Under certain abnormal conditions heat removal capability may be impaired. This action plan defines possible abnormal conditions, that could lead to excessive temperature increases in tank 241-C-106 and documents pre-planned contingency actions that would effectively mitigate the consequences of such an event. Potential conditions that could lead to excessive temperature increases are ventilation system failure or a leaking tank. Excessive temperature increase is defined in Section 5.1.

The majority of the waste in tank 241-C-106 is scheduled to be retrieved by sluicing. Project W-320 covers the design and construction phases in preparation for the sluicing activity. East Tank Farm Transition Project will perform the sluicing operational phase of the sluicing project. This action plan will be followed until sluicing is completed.

Other general emergency actions for the Hanford Site, such as those for fire and earthquake, are described in *Westinghouse Hanford Company Emergency Management Procedures* (WHC-CM-4-43), as required by the *Tank Farms Emergency Response Guides* (WHC-IP-0839-TF), and are not specifically included in the scope of this action plan.

This action plan is administered and controlled at the 200 East Area for tank 241-C-106. However, if a developing event has the potential to impact a larger area, emergency actions provided by WHC-IP-0839-TF and WHC-CM-4-43 for the involved site(s) shall be followed as appropriate. WHC-IP-0839-TF includes an emergency preparedness plan, that is in compliance with applicable U.S. Department of Energy (DOE) orders and Westinghouse Hanford Company (WHC) policies, to protect onsite personnel, public health and safety, and the environment in the event of operational, natural phenomena, and/or safeguards and security events at WHC facilities. WHC-CM-4-43 provides more specific emergency management procedures for key WHC facilities; it also provides procedural steps to be taken in the event of an emergency, such as notification, activation of the Emergency Management Center, event command, and recovery actions. A specific emergency response plan for use in response to a fire or explosion event is addressed in WHC-SD-PRP-TI-001 (Marsh 1991). East Tank Farm Transition Project is responsible for the interfacing of these plans and procedures associated with tank 241-C-106 depending on the type and degree of a developing accident and the extent of the potentially affected area.

In accordance with the requirements of Public Law 101-510, Section 3137, this action plan identifies the conditions for tank 241-C-106 that could lead to temperature increases if not corrected, and the pre-planned responses that would be taken to correct excessive temperature increases. This action plan also identifies the conditions under which corrective action responses shall be initiated.

The requirement of Public Law 101-510 to respond to excessive pressure is not relevant to tank 241-C-106 as discussed in Section 2.5.

This action plan also addresses releases caused by a leaking tank and summarizes the pre-planned responses that are also available to East Tank Farm Transition Projects. The responses to more general non-defined release accidents are addressed in the *TWRS Emergency Response Guides* (WHC-IP-0839-TF), *Westinghouse Hanford Company Emergency Management Procedures* (WHC-CM-4-43), and the *Tank Farm Stabilization Plan for Emergency Response* (Marsh 1991).

2.0 BACKGROUND

2.1 BACKGROUND TO THE ACTION PLAN

Subsection (b) of Public Law 101-510, Section 3137, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation," requires the Secretary of Energy to take the following actions with regard to any Hanford Site SST or double-shell tank (DST) that has been identified, under Subsection (a) of the law, as having a serious potential for release of high-level waste:

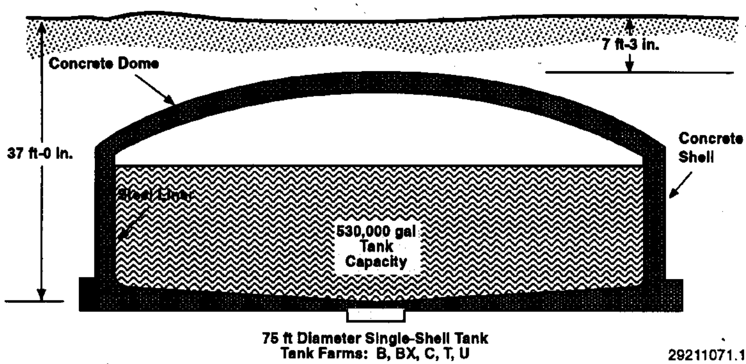
- Identify those tanks that "may have a serious potential for release of high-level waste due to uncontrolled increases in temperature or pressure..."
- Ensure that "continuous monitoring to detect a release or excessive temperature or pressure..." is being carried out
- Develop "action plans to respond to excessive temperature or pressure or a release from any tank identified..."
- Restrict additions of high-level nuclear wastes to the identified tanks unless no safer alternative exists or the serious potential for a release of high-level nuclear waste is no longer a threat.

All Watch List tanks have been identified pursuant to Subsection (a) and are categorized by tank contents (Hanlon 1996). Categories include those tanks that 1) have the potential for flammable gas generation, 2) contain ferrocyanide compounds, 3) contain organics, or 4) have high heat loads (heat load exceeds 11.7 kW [40,000 Btu/hr] and requires water addition for cooling). This action plan addresses pre-planned response actions to prevent or mitigate safety concerns that are caused by the high heat load of SST 241-C-106.

2.2 PHYSICAL DESCRIPTION OF TANK 241-C-106

Tank 241-C-106 is a 2,000-m^3-(530,000-gal)-capacity SST located in the Hanford Site C Tank Farm at 200 East Area (Figure 2-1). The C Tank Farm is one of the four original tank farms (B, C, T, and U) that were constructed at the Hanford Site 200 areas during 1944 and 1945. The C Tank Farm has four 210-m^3 (55,000-gal) tanks and twelve 2,000-m^3 (530,000-gal) tanks. The 2,000-m^3 (530,000-gal) tanks are constructed of reinforced concrete and have welded carbon steel liners on their bottoms and sides. Each tank has a 0.3-m (1-ft) dished bottom and a usable waste depth of approximately 4.9 m (16 ft) at the sidewall. The bottom of each tank consists of a 15-cm (6-in.) layer of reinforced concrete that is covered with a 5-cm (2-in.) layer of grout and a 1-cm (3/8-in.) steel plate liner. The knuckle (transition section from bottom to sidewall) is made from 1-cm-(3/8-in.-) thick steel plate. The tank sides are 33-cm-(13-in.-) thick reinforced concrete. The steel liner extends 5.5 m (18 ft) up the straight side of the tank and varies in

Figure 2-1. Diagram of Single-Shell 530,000-Gallon Tanks in Hanford Site C Tank Farm.



thickness from 0.6 to 1 cm (1/4 to 3/8 in.). An asphalt composition material was placed between the steel liner and the reinforced concrete during construction to seal the outer surface of the steel liner and to provide a moisture barrier. The top of the steel liner is covered with lead flashing to prevent moisture from entering between the liner and concrete wall. The dome is constructed of 38-cm (15-in.)-thick reinforced concrete. The tanks were constructed with five 10-cm (4-in.) risers, five 30-cm (12-in.) risers, a condenser hatchway connected to the tank by a 30-cm (12-in.) duct, and two 107-cm (42-in.) manholes (see drawings H-2-37006 [WHC 1972] and H-2-70496 through H-2-70504 [WHC 1976], and Figure 2-2).

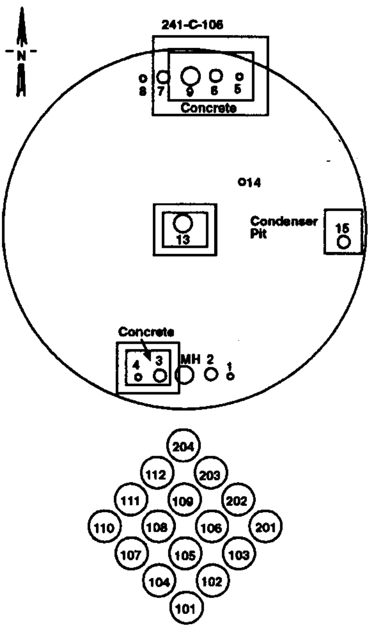
2.3 BACKGROUND TO TANK 241-C-106

Tank 241-C-106 has been used for radioactive waste storage since mid-1947. The operating records and sluicing history (Rodenhizer 1987) for tank 241-C-106 recognizes three distinct waste layers.

From 1947 to 1954 tank 241-C-106 received metal waste from the bismuth phosphate process. The metal waste was sluiced in 1953 to recover uranium, leaving behind a waste heel of approximately 90,720 L (24,000 gal), which was either not sluiceable or was not economical to retrieve to meet recovery needs at the time. Fill and sample records show this bottom layer has since remained stratified during subsequent fill operations (Weiss 1991). The heat load for tank 241-C-106 stayed below 11.7 kW (40,000 Btu/h) from 1947 until the tank was used for decanting strontium based waste during the late 1960's.

From 1954 to 1969, tank 241-C-106 was used as the metal waste supernatant blend tank in the Farm for receiving U Plant waste and PUREX HLW. During the late 1960s, a program was instituted at the Hanford Site to recover strontium and cesium from aging waste stored in the 241-A and 241-AX boiling waste tank farms. A sludge washing and decanting process took place in the 244-AR vault, requiring the washing of accumulated slurry with water to remove soluble constituents. The original intent was to decant the wash solution (PUREX sludge supernate) from the solids by settling the solids and then pumping off the supernate (the liquid portion of a solid-liquid separation process) to tank 241-C-106. The decanting step proved to be ineffective, however, and strontium solids were drawn into and transferred with the wash solution to tank 241-C-106 where they accumulated. By mid-1971, it became obvious that unacceptable quantities of strontium had been transferred with the PUREX sludge supernate when temperatures in excess of 100°C (212°F) were observed in tank 241-C-106. Because the SSTs in the C Farm were not designed and equipped for storage of self-boiling waste, transfers of PUREX sludge supernate to tank 241-C-106 were halted and tank 241-C-106 was immediately placed on an active ventilation system. These campaigns resulted in a second layer consisting of approximately 310,404 L (82,000 gal) of sludge, containing high-heat production materials, primarily ^{137}Cs and ^{90}Sr. Since mid-1971, water has also been added periodically to the tank to keep the sludge wet and to promote heat transfer through evaporation.

Figure 2-2. Riser Locations for Tank 241-C-106.



241-C Farm Layout

241-C-106

No.	Dia. (in.)	Description and Comments
1	4	Enraf, Pressure Gauge, BM
2	12	Exhauster Riser
3	12	Sluicer, Chiller Cond. Drain
4	4	Recirculating Dip Leg WC
5	4	Open
6	12	Old Transfer Pump
7	12	Closed-circuit TV*
8	4	B-221 Temperature Probe
9	36	Slurry Pump*
13	26	Distributor Jet WC
14	4	Temperature Probe
15	12	Air Inlet Filter, Cooling Coil

Legend:

3 1/2 in. circle is tank outline

Risers

36 in.

12 in. (in proportion to size)

4 in.

1, 2, 3, etc. Riser number - may not agree with field ID

Various size rectangles are pits - may have label

Double rectangle indicates weather covered pit unless otherwise identified.

MH Manhole at dome top - no riser to surface

* Planned additions in risers 7 & 9

29210056.5

From 1971 to 1979, the tank received low-level complexant waste from strontium recovery in B Plant. This third layer contains approximately 344,472 L (91,000 gal) of sludge. In 1979 the tank was declared inactive, and was left in a partially isolated condition in August 1983.

The total sludge volume for all three layers, including the compaction of the second layer, was approximately 757,082 L (200,000 gal) at the end of 1979.

2.4 CONFIGURATION OF TANK 241-C-106

Before construction activities associated with Project W-320, tank 241-C-106 was inactive, partially isolated, and actively ventilated. Partial isolation since 1979 prevented the introduction of any additional material into the tank except for cooling water additions. Partial isolation measures on this tank included 1) all pits were weather covered with urethane foam to minimize moisture intrusion, 2) air and water lines to the pits were cut and sealed, and 3) all process lines to the tank and pits were capped or sealed in the CR-153 and C-151 diversion boxes. These measures were taken to comply with the requirements of U.S. Department of Energy, Richland Operations Office (DOE-RL) Order 5820.2A (DOE-RL 1990). The tank is only partially isolated because cooling water is frequently added to the tank to replace water that is removed by the evaporative cooling process. The pump pit still contains the jumpers and pump used to remove material from the tank, and the sluice pit still contains the jumpers and drop legs used to add material to the tanks. Some additional isolation work began in fiscal year (FY) 1993 and included removal and modification of weather covers in preparation for sludge removal. Project W-320 construction activities are described in Section 2.8.

Tank 241-C-106 now contains as much as 181,699 L (48,000 gal) of drainable liquids and 745,723 L (197,000 gal) of sludge (Wang 1994). The heat generation rate is estimated to be 110,000 $\pm$ 20,000 Btu/hr (32 $\pm$ 5.9 kW) (Bander 1993a) with an upper bound heat generation rate of 132,400 Btu/h (38.8 kW) (Fryer and Thurgood, 1995). Forced ventilation at 1.1 m^3/sec (2,400 ft^3/min) along with water addition is being administered currently to maintain cooling of the tank. Waste temperatures are given in Section 2.6. The condition of this tank is currently categorized as sound (i.e., not leaking) (Bailey 1993).

Water additions to tank 241-C-106 are made approximately every 4 to 8 weeks. Starting in November 1993, water treated with Dearborn-66 additive and with a pH value between 10 and 11 for corrosion control has been added to tank 241-C-106. The water is added from a tank truck through the pump pit drain. To keep the sludge wet and to facilitate evaporative cooling, the supernate liquid layer above the sludge is controlled between the 2.0 and 1.9-m (79 and 74.5-in.) levels. When the liquid level is close to the minimum level of 1.9 m (74.5 in.), water is added to raise it close to the maximum level of 2.0 m (79 in.). Approximately 22,700 L (6,000 gal) of water with a nominal temperature of 32 °C (90 °F) (Bander and Thurgood 1995) are added for each occurrence.

2.5 RECENT STUDIES AND THE HIGH-HEAT SAFETY ISSUE

Based on a stabilization evaluation of tank 241-C-106 in 1987 (Pauley and Torgerson 1987), it was concluded that tank 241-C-106 could not be cooled solely by forced-air until approximately the year 2045, when the radioactive strontium would sufficiently decay. A significant environmental concern has been generated by the need to continue water additions until the radiogenic heat of decay will be less than 11.7 kW (40,000 Btu/hr). If cooling water additions were interrupted by a tank leak, the sludge temperatures would exceed established limits and could cause structural damage to the tank concrete, which would allow HLW to leak from the tank. Should water additions continue into a leaking tank, the leakage would contaminate the soil column.

This concern has resulted in several tests, studies, or analyses of alternate cooling methods, sludge retrieval, and tank operating history. These studies are of interest because, until retrieval is completed, they will form the technical basis for which cooling methods will be used should the need arise.

The exhauster fan on the ventilation system was out of service from January 25 to June 7, 1992 (Hanlon 1993). During this time, the bulk waste temperature increased approximately 5 °C/month (9 °F/month) without any pressure increase. No water additions were required during this timeframe because water loss through evaporation was minimal. Additional temperature transients are discussed in Section 2.7.

Parametric thermal studies (Bander 1993c) investigated the feasibility to reduce the drainable liquid in the tank, to minimize any soil contamination should a leak occur, by stopping water additions and allowing the liquid in the tank to evaporate. The study determined the thermal conditions in the tank as the tank dries out for various ventilation air temperatures (4, 12, and 31 °C [40, 53, and 88 °F]) at the inlet of the tank and flow rates (0, 1.1, and 2.8 m^3/sec [0, 2400, and 6000 ft^3/min]). The study concluded that under certain conditions (primarily cooler ventilation inlet air) it is possible to maintain the tank below temperatures that would cause structural damage without water additions. A design study of an alternative cooling method using an air-chiller and sprinkler system (Rensink and Kriskovich 1995) is based on this work.

A process test, Tri-Party Agreement Milestone M-40-05, was conducted between March 10 and June 15, 1994 to determine if water additions could be reduced to establish a lower liquid level in the tank (to minimize potential leakage volume). A test plan (Sutey 1994), a test report (Bander 1995), and a subsequent analysis report (Bander and Thurgood 1995) were issued. Water additions to the tank were discontinued to allow the liquid level to decrease through evaporation, at a rate of approximately 5 to 8 cm (2 to 3 in) or 20,800 to 31,400 L (5,500 to 8,300 gal) per month. The test ended June 15, 1994, after approximately 18 cm (7 in) of water on top of the waste was allowed to evaporate. This test revealed that saturated conditions (a steam zone) existed in the central waste layer during the warmer seasons of the year, based on fluctuating temperature readings at the thermocouples (TCs) in riser R14, located midway between the center of the tank and the tank wall. Riser R14 indicated temperatures increased from 52 to 103 °C (125 to 217 °F). Temperatures at the TCs in riser R8, nearer to the tank wall, had a slight increase consistent with seasonal norms.

Because of concerns surrounding this saturated zone, a study was commissioned to determine the possibility of the steam rising and flashing at the surface of the waste without condensing, with resultant pressurization of the tank vapor space and waste release to the atmosphere (Bander et al. 1994). This study concluded that a steam bump event would not occur during quiescent tank storage.

Rensink and Kriskovich (1995) discuss the possibility of a leak resulting in water entering small voids between the liner and the concrete, or below the concrete bottom of the tank. If these regions are initially at atmospheric pressure and are above saturation temperature, it would result in the formation of steam under the liner (or below the concrete bottom of the tank). It was concluded that although there is no clear cut scenario resulting in damage to the tank, the conditions in place for preventing this occurrence are marginal; therefore, reducing or eliminating the saturation zone; i.e., region of higher temperatures in the tank structure, should be initiated at the earliest possible date.

A further study was needed to determine a method to reduce or eliminate the saturated region of the waste to allow for waste disturbance without causing a tank steam bump event. Initially, this study (Thurgood and Odgen 1995) used the 2-D thermal model created during the 1994 process test to verify that the waste in the central bottom of the tank reached saturation temperature, estimated to be 109 °C (228 °F). Then, the study evaluated the effectiveness of an inlet air chiller under various conditions in reducing or eliminating the steam void. This study concluded that chilled ventilation air (4 °C [40 °F] at 100% relative humidity and 1.1 m^3/sec [2400 ft^3/min]) and full or reduced evaporative cooling would maintain the highest waste temperature at the bottom of the tank below the local saturation temperature. The analysis also concluded that chilled ventilation air without evaporative cooling would maintain the tank below temperatures that would cause structural damage.

Closure of the high-heat safety issue is planned for FY 1997 when waste in tank 241-C-106 is retrieved through Project W-320 and the Waste Retrieval Sluicing System (WRSS). Project W-320 and the WRSS are to retrieve and transfer high-heat waste from tank 241-C-106 to double-shell tank 241-AY-102 by means of a closed-loop, continuous sluicing process. A Tri-Party Agreement milestone (M-45-03A) and a Department of Energy Safety Initiative milestone have been established to start waste retrieval from tank 241-C-106 in October 1996. Cool-down of the saturated region in the waste is a prerequisite for waste retrieval.

2.6 INSTRUMENTATION

Instrumentation for tank 241-C-106 consists of an ENRAF liquid level gauge mounted in riser R1, two TC trees mounted in risers R8 and R14, and a tank pressure/vacuum gage mounted on riser R1 (Figure 2-2). Riser R7 is equipped with a multi-port assembly for installing more than one instrument or other types of equipment, such as an in-tank video camera. Before 1994, a Food Instrument Corporation (FIC) gauge transmitted liquid-level data to the Computer Automated Surveillance System (a continuously online-monitored computer system) and to the Surveillance Analysis Computer System (an off-line database and data analysis system). The temperatures and tank pressure/vacuum had to be read locally at the C Farm. In 1994, all the liquid level, temperature, and pressure instruments were connected to the Tank Monitoring and Control System (TMACS), which makes continuous monitoring possible.

Six drywells are associated with tank 241-C-106. These drywells are vertical steel casings in the ground that range in depth from approximately 30 to 40 m (100 to 130 ft). Gamma and neutron detection probes are lowered into these wells to monitor for possible leaks, which are shown through an increase in radiation profiles (gamma detector) or moisture levels (neutron probes). The radiation scan data in all six of the drywells around tank 241-C-106 are normal to date. The readings have remained consistent with the reference baselines established for these wells in 1975.

Table 2-1 summarizes the current monitoring practice for tank 241-C-106. The practice meets or exceeds the requirements specified in the Operational Safety Requirement (OSR) (Dougherty 1994) and Operating Specifications Document (OSD) (WHC 1996c) for single-shell tanks.

Table 2-1. Tank 241-C-106 Monitoring Requirements and Current Practice

	Temperature	Liquid Level	Domespace pressure	Airborne Radiation
Requirements	Monthly[1]	Daily[2]	Every 36 hrs[1]	Instantaneous[3] Weekly Average Annual Average
Current Practice	CM*	CM*	CM*	Same as Requirements

*CM = Continuous Monitoring (TMACS)
(1) Per WHC-SD-0SR-005 (Dougherty 1994)
(2) Per WHC-OSD-T-151-00031 (WHC 1996c)
(3) Per WHC-CM-7-5

Instrumentation for liquid surface level measurements consist of an ENRAF liquid-level gauge mounted in riser R1. A FIC liquid-level gauge was mounted in riser R1 until April 1996 when it was removed in preparation for sluicing. At that time the ENRAF gauge was moved from riser R7 to R1. In 1994 all the liquid-level instruments were connected to the

TMACS, which makes continuous monitoring possible. The FIC gauge recorded data between 1981 and 1994. The more sensitive ENRAF gauge has been recording since October 1994. The ENRAF gauge has a manufacturer-reported accuracy of ± 0.10 cm (0.04 in) under ideal conditions. The FIC gauge has an accuracy of ± 0.25 cm (0.1 in) under ideal conditions. Actual field experience indicates errors can be significantly higher. A measurement precision of ± 0.63 cm (0.25 in) was empirically established for the FIC, with a specification limit of ± 1.3 cm (0.50 in) (Schofield 1994).

According to Bander and Thurgood (1995), the operating liquid level since 1981 has been nominally between 190 and 200 cm (75 and 79 in.), although on rare occasions the level has dropped to 189 cm (74.5 in). Figure 2-3 shows the liquid surface level as measured by the FIC gauge from 1981 through 1988. The height reported is measured in inches from the knuckle of the tank which (due to the dished bottom of the tank) is 30.5 cm (12 in) above the bottom center of the tank. The data were taken on a weekly basis during this time period. Figure 2-4 shows the liquid surface level as measured by the FIC and ENRAF gauges from 1989 through July 1995. These data were taken on a daily basis beginning the middle of 1989. The ventilation system was not operating toward the end of 1990 for about one month and at the beginning of 1992 for about 4 1/2 months. These outages are reflected by surface level rises. The surface level data (Crea and Bander 1994) show that the addition of water initially suppresses the evaporation rate to about half of the long term rate for about 1 to 2 weeks. This can be observed in Figure 2-4 by the change in slope of the surface level data. There is also a seasonal effect that shows more evaporation toward the end of summer and less evaporation toward the end of winter (Barrington 1995).

Temperature measurements are obtained from two TC trees mounted in risers R8 and R14. The R8 tree has 6 TCs and is located near the tank wall. The R14 tree has 8 TCs (#7 TC is not operational) and is located midway between the center of the tank and the wall. Both trees have three TCs immersed in the sludge. In 1994 the temperature instruments were connected to the TMACS, which makes continuous monitoring possible. Figure 2-5 shows the TC data in risers R8 and R14 for TCs 1, 2, and 3 (numbering from the bottom of the tree) for 1993 through July 1995. Data were collected weekly before April 1994 and subsequently on a daily basis. The water additions during this period are shown by plotting the surface level, scaled to fit on the figure. The periodic increases in temperature in riser R14 are correlated with water additions as can be seen by comparing the level data curve with the TC curves for riser R14. A convective gap closure model (Thurgood et al. 1995) was developed for simulating the oscillating temperatures at the TC tree in riser R14. According to this model, the baseline readings from in-waste TCs at riser R14 preceding water additions are lower than the actual waste temperature, due to free liquid convection in an existing gap in the sludge surrounding the TC tree. The peak readings are more indicative of actual waste temperature, as convective heat transfer is disrupted and the sludge is brought into contact with the TCs briefly following water additions.

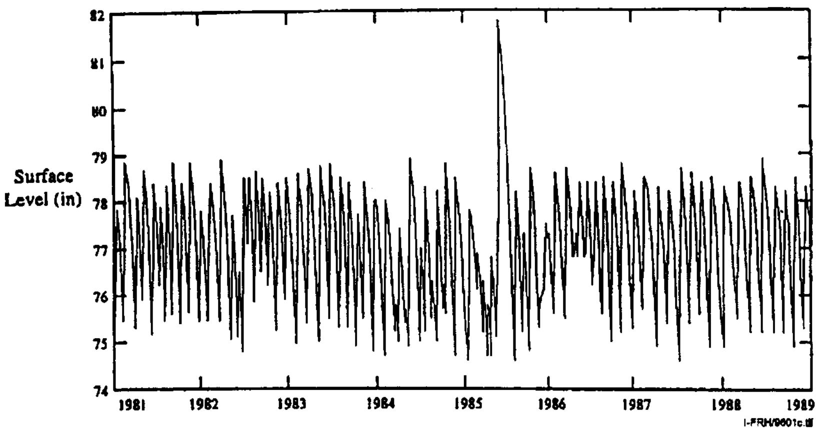


Figure 2-3. Historical FIC Liquid Surface Level Data 1981 through 1989

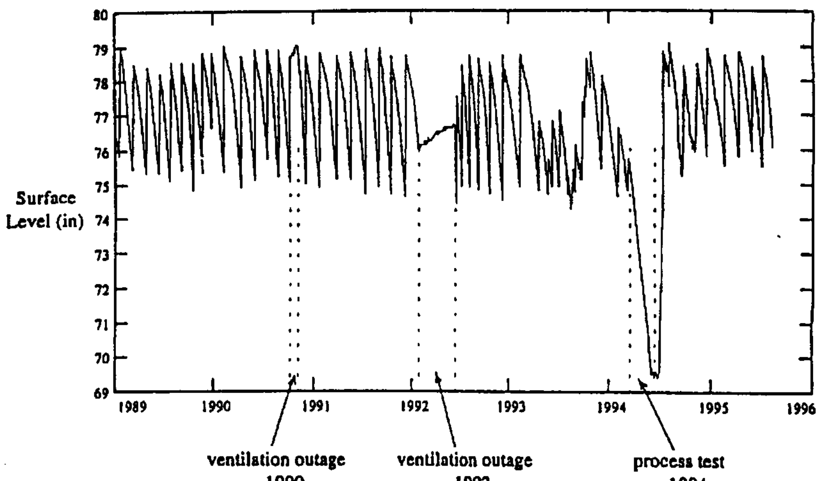


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Figure 2-4. Historical FIC and ENRAF Liquid Surface Level Data 1989 through July 1995

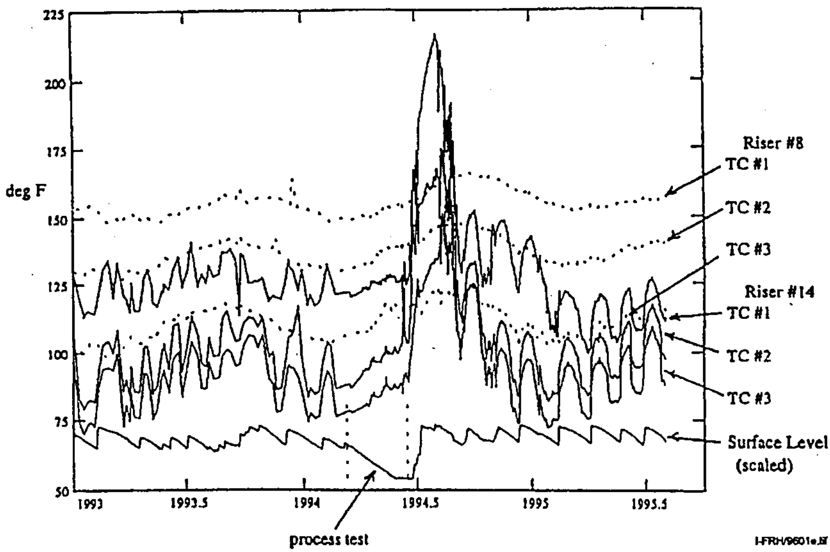

Figure 2-5. Measured Temperatures in Tank 241-C-106, Riser R8 and R14

Following the 1994 process test, TCs on the tree in riser R14 began to indicate significantly higher temperatures in the waste sludge than the typically low temperatures observed at this location. This is illustrated in Figure 2-5. Temperatures increased at the bottom TC in riser R14 from about 52 to 103 °C (125 to 217 °F) following the process test. Temperatures at the TCs in riser R8 became only slightly elevated during 1994, relative to seasonal norms, as illustrated in Figure 2-5. This can be accounted for by the above-average summer temperatures in 1994.

Riser R8 has historically been used for reference temperatures for monitoring the thermal behavior of the tank, because riser R14 temperature readings are not representative (lower than expected) of the waste temperatures for the reasons given below. A thermal model (Bander 1993a) predicted that the steady-state maximum temperature at riser R8 is 77 °C (170 °F) and at riser R14 is 104 °C (220 °F). The corresponding centerline maximum temperature is 110 °C (230 °F). Unfortunately, riser R14 temperature readings have not been representative of the local waste temperatures that the model predicted. Typical temperature readings at riser R14 have been between 49 °C and 66 °C (120 °F to 150 °F) and sometimes rise above 93 °C (200 °F) when TC probes are believed to be in direct contact with sludge waste. Historically, the riser R14 TC tree was ignored as suspect, and only occasional readings were taken.

The riser R14 TC tree was installed in 1978, using the "water-lancing" technique. Although the TC tree is only about 5.1 cm (2 in.) in diameter, a hole larger than 7.6 cm (3 in.) in diameter was drilled in the waste. The "well" was suspected to never have been entirely filled up, and the liquid gap between the waste and the tree caused low temperature readings due to local "narrow-gap" convection. With this understanding, riser R8 TC readings (in combination with the thermal model results) are used for monitoring waste temperatures in tank 241-C-106.

In 1993 an extensive verification effort was performed on all TCs on the TC tree in riser R14. Verification of internal resistance concluded that all 8 riser R14 TCs but one (the 7th TC probe in the domespace) were reading correctly. The fact that the R14 TC tree read lower temperatures than the thermal model predicted generated great interest and spawned many theories. This issue was studied by WHC and outside experts from Pacific Northwest National Laboratory and Los Alamos National Laboratory. The internal resistances in the TC probes were within specification; the contacts between the probes and the waste were determined to be at fault. The temperature readings in the riser R14 TC tree do not represent the local waste temperature because the TC tree is sitting in a liquid well. The thin liquid gap between the TC probe and the waste plays an important role in the way riser R14 TC probes read the surrounding temperatures. This phenomenon was sometimes referred to as the "chimney effect" (Agnew 1993) and later as a "convective gap" (Thurgood et al. 1995). The liquid gap condition caused fluctuation of the temperature reading in riser R14 from 54 °C (130 °F) to about 104 °C (220 °F) during the massive water addition after a liquid-reduction process test (Bander 1995) was completed in 1994. Fluctuation of temperature readings in riser R14 proved that the local waste temperature at that location was indeed as high as 104 °C (220 °F) (Thurgood et al., 1995) (see Figure 2-5).

The temperature of the sludge in tank 241-C-106 normally fluctuates slightly because of changes in ambient conditions. The daily fluctuation is usually insignificant, but the seasonal fluctuation can be from 6 °C to 11 °C (10 °F to 20 °F) depending on the summer/winter meteorological conditions. According to the TC readings at riser R8 over the last few years, the maximum waste temperature at riser R8 can reach above 74 °C (165 °F) after summer and below 68 °C (155 °F) following winter.

2.7 VENTILATION

The exhauster used to ventilate tank 241-C-106 has been changed several times since the tank was placed on an active ventilation system. The tank is currently ventilated by the 296-P-16 exhauster. The 296-P-16 exhauster is a portable unit of nominal 3.3 m^3/second (7,000 ft^3/min) capacity. Nominal exhaust flow rates are 0.57 m^3/second (1,200 ft^3/min) and 1.1 m^3/second (2,400 ft^3/min) from tanks 241-C-105 and 241-C-106, respectively.

Air is drawn into the tanks through inlets equipped with high-efficiency particulate air (HEPA) filters. The exhaust air is passed through a deentrainment section (to remove entrained water) and then through a bank of HEPA filters. Deentrained moisture drains back to riser R2 on tank 241-C-106.

From January 25, 1992 to June 7, 1992, ventilation in tank 241-C-106 was not operational due to failed equipment. The recorded maximum waste temperature at the riser R8 TC tree increased from 72 °C (161 °F) to 92 °C (198 °F) and domespace air temperature increased from 29 °C (80 °F) to 67 °C (153 °F) (Figure 2-6). It is estimated that riser R14 and tank center experienced a similar temperature increase of approximately 21 °C (37 °F) during this period. Therefore, it is important that ventilation equipment be fixed as soon as possible.

To provide additional cooling before the start of sluicing operations, a cooling coil has been installed in the tank 241-C-106 inlet. When it becomes operational, the new coil will be capable of cooling the incoming air to approximately 4 °C (40 °F). A recirculating ventilation system to be operated during sluicing operations is also planned. The recirculating ventilation system serves two functions: 1) cool the tank, and 2) maintain the tank at a negative pressure relative to atmosphere while discharging a decontaminated ventilation stream to the atmosphere. The system is a combination recirculation and exhaust system. The recirculation portion of the system is used to provide the needed cooling. The exhaust portion of the system maintains the required negative pressure in the tank.

Figure 2-7 shows schematically the three configurations: the system as presently configured; the present system with a new cooling coil installed; and the recirculating ventilation system. The recirculating system will be installed in such a way that the present system, as modified with a new cooling coil, will remain operational but both can not be operated simultaneously.

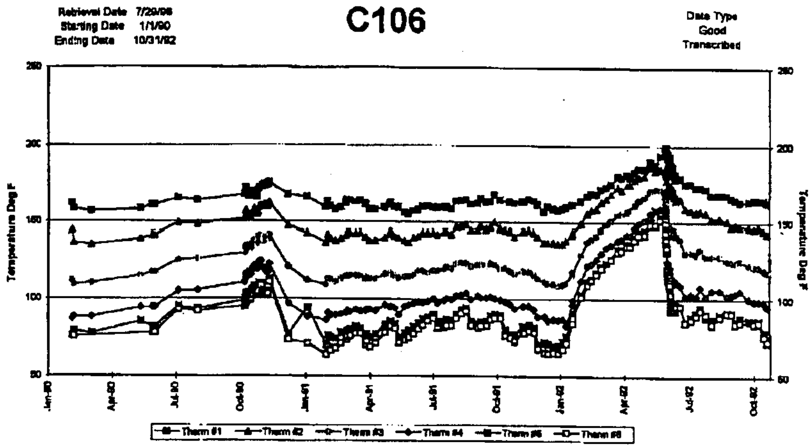

Figure 2-6. Thermocouple Tree 8 Temperature Curve for Tank 241-C-106 from January 1990 to October 1992

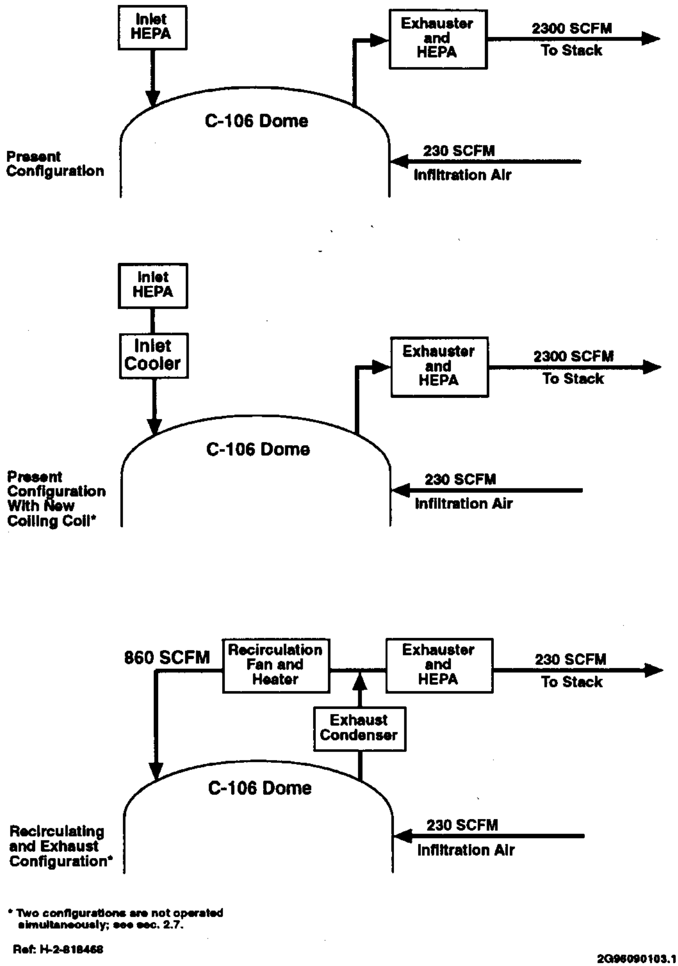

Figure 2-7. Ventilation System Configurations.

2.8 W-320 CONSTRUCTION

In addition to the recirculating ventilation system described above, construction activities planned in conjunction with Project W-320 include the installation of a sluicing system and a slurry return system. The two systems are similar since each will have a submersible pump and a booster pump. The sluicing system submersible pump will be installed in tank 241-AY-102 and will draw supernate from near the surface of the tank. A nearby booster pump will provide the necessary pressure to transfer the liquid to the sluicer system in tank 241-C-106 through a double-encased pipeline. The slurry system submersible pump will be in tank 241-C-106 and its booster pump will be nearby. Transfer of the slurry to tank 241-AY-102 will also be via a double-encased pipeline. The two system are depicted schematically in Figure 2-8.

2.9 SLUICING OPERATIONS

Prior to the start of liquid transfer operations, the present ventilation system with the new inlet cooling coil will be operated continuously for a period of several months to pre-cool the tank waste solids below the limits outlined in WHC-SD-WM-SAD-024. At the end of the pre-cooling period, actual transfer operations will begin. During sluicing operations, the new recirculation/exhaust system will be operated continuously and the sluicing and slurry systems will be operated as required to maintain a reasonable balance of liquid level between the two tanks as outlined in WHC-SD-WM-SAD-024.

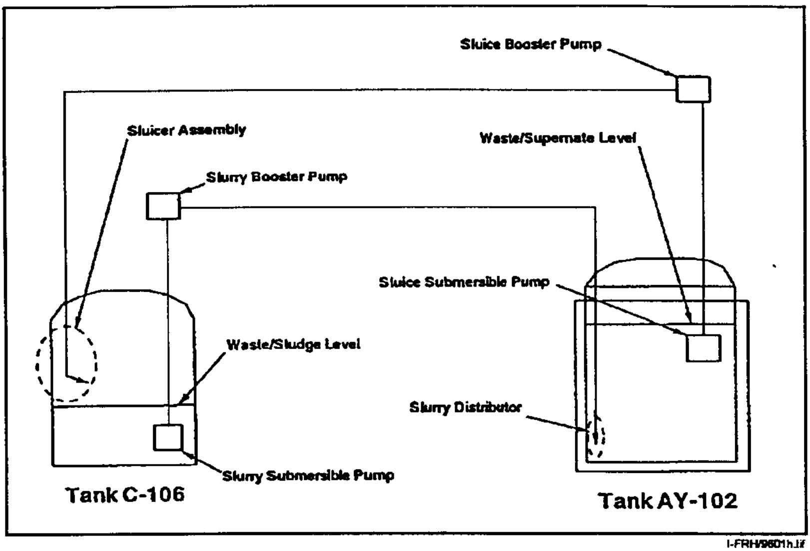

Figure 2-8. Sluice System Block Diagram

3.0 MONITORING AND RESPONSE OF KEY PARAMETERS

This chapter summarizes the administrative controls, operating specification criteria, required monitoring frequencies, and reporting requirements for safety-related parameters. For high-heat tank 241-C-106, safety-related parameters include waste and domespace temperatures, tank pressure, airborne radiation level, leak detection, and ventilation system operability.

Administrative requirements and other documents are in place to ensure proper responses to anomalous situations in tank 241-C-106. These documents and procedures are:

- Safety analysis reports for SSTs including tank 241-C-106 (Smith 1986a; Smith 1986b; Boyles 1989).
- Westinghouse Hanford Management Requirements and Procedures (WHC-CM-1-3), *Hanford Site Radiological Control Manual* (HSRCM-1), *Tank Farms Emergency Response Guides* (WHC-IP-0839-TF), and *TWRS Administration* (WHC-IP-0842), which implement administrative and technical controls derived from DOE directives.
- *Operating Specifications for Single-Shell Waste Storage Tanks*, OSD-T-151-00013 (WHC 1996a), and *Operating Specifications for Watch List Tanks*, OSD-T-ISI-00030, (WHC 1996b), which establish or detail SST surveillance limits, including those for tank 241-C-106.
- *Operating Specifications for Tank Farm Leak Detection*, OSD-T-151-00031 (WHC 1996c), which contains specific SST leak detection surveillance requirements, including those for tank 241-C-106.
- Procedures for occurrence reporting and processing of operations information (WHC-CM-1-5, Sec. 7.1), which specify occurrence reporting system requirements.
- DOE Orders 5484.1 (DOE 1981), 5481.1B (DOE 1986b), 5480.1B (DOE 1986a), 6430.1A (DOE 1989), 5820.2A (DOE-RL-1990), 5700.6C (DOE 1991), and 5480.23 (DOE1992), which provide overall administrative guidance.
- *Safety Assessment for Tank 241-C-106 Waste Retrieval Project W-320* (WHC-SD-WM-SAD-024), which outlines the sluicing operations and associated administrative controls.

In addition to the above, criteria and response actions specific to tank 241-C-106 are identified in this action plan (Section 5.0).

3.1 TEMPERATURE MONITORING AND RESPONSE

Temperature readings are obtained from the TCs on the two TC trees in risers R8 and R14. These TCs and their history are discussed in Section 2.6. The readings are monitored and recorded by TMACS.

3.1.1 Administrative Controls

Administrative documents and procedures are in place to ensure that corrective responses take place before any tank temperature readings exceed the criteria specified in Section 3.1.2. The documents and procedures are identified in Section 3.0.

3.1.2 Tank Temperature Criteria

Tank 241-C-106 waste and domespace temperatures are monitored. The data are used to determine if a trend of increasing temperatures exists from the established baseline. Waste temperature in tank 241-C-106 is a key parameter for safety control.

Temperature criteria are specified in *Operating Specifications for Single-Shell Waste Storage Tanks*, OSD-T-151-00013 (WHC 1996a). These limits are:

- Temperature

  1. The temperature of the waste shall not exceed 149 °C (300 °F).

  2. The temperature of the tank domespace vapor shall not exceed 121 °C (250 °F).

  3. The maximum temperature change in the waste shall be 11 °C (20 °F) per day. This requirement does not apply to the thermocouple readings in riser R14 (WHC 1996a).

- Thermocouple trees

  Thermocouple (TC) trees shall be installed in any SST containing a demonstrated heat load greater than 11.7 kW (40,000 Btu/h). If two or more probes on a TC tree fail, operability shall be restored as soon as practical. Tank 241-C-106 has two TC trees at risers R8 and R14. For reasons described in Section 2.6, riser R8 TC tree is used for monitoring purposes.

The safety analysis report (Smith 1986b) concluded that heat loads less than 11.7 kW (40,000 Btu/h) would not result in waste temperatures greater than 177 °C (350 °F) under any circumstances. The OSD (WHC 1996a) further lowered the maximum operational limit of the waste temperature to 149 °C (300 °F), with an additional 28 °C (50 °F) safety margin.

The temperature change criterion [11 °C (20 °F) per day] is intended to prevent structural damage. The criterion is expected to be easily satisfied due to the large thermal inertia of the waste and the low heat load. Note that this requirement does not apply to the thermocouple readings in riser R14 because of the non-representative readings at that location (see Section 2.6). Thermal studies (Jimenez 1991) have indicated that the expected temperature change per day, should forced cooling be stopped, would be considerably less than the criteria limit. The slow heatup rate was confirmed in FY 1992 during a period when the forced cooling was inoperable for four months. During those four months, the heatup rate was approximately 5 °C (9 °F) per month at the bottom two TCs in riser R8.

3.1.3 Monitoring Frequencies

Sludge temperature readings, in accordance with WHC-SD-OSR-005 (Dougherty 1994), are required at least monthly for tank 241-C-106. Currently sludge temperature readings are recorded continuously by the TMACS. The TMACS alarms on high temperature.

3.1.4 Reporting Requirements

The following reporting requirements are specified in OSD-T-151-00013 (WHC 1996a).

- Failure to monitor a high-heat-load tank within the prescribed frequency is reportable as an OSD violation.

- Exceeding the waste temperature criteria of 149 °C (300 °F) maximum and/or 11 °C (20 °F) daily variation are reportable as OSD violations.

- When two or more TCs on the same TC tree fail, it is reportable as an OSD violation if operability is not restored per requirements in OSD-T-151-00013 (WHC 1996a).

- Waste temperatures shall be monitored in tanks containing waste with a heat load of greater than 11.7 kW (40,000 Btu/h). Temperature data shall be analyzed at least quarterly to determine if any trends have occurred that show waste temperatures increasing (Smith 1986b).

- Other surveillance anomalies (e.g., an anomaly in data that has not exceeded any other criteria, such as temperature) that are inconsistent with the historical norm of the tank will result in generation of a discrepancy report by Tank Farm Surveillance Analysis (WHC-IP-0842). Other anomalies may also result in issuance of a discrepancy report.

3.2 TANK PRESSURE MONITORING AND RESPONSE

Tank pressure monitoring for tank 241-C-106 is performed mainly to monitor the performance of the ventilation system, which is an important element in maintaining temperatures within normal conditions. Significant pressure transients for tank 241-C-106 is not expected. Pressure readings are obtained from the domespace pressure gauge installed in riser R1 (previously installed in riser R7 until April 1996) and other gauges installed in the 296-P-16 exhauster system. The readings are monitored and recorded by TMACS.

3.2.1 Administrative Controls

Administrative documents and procedures are in place to ensure that corrective responses take place before any tank pressure readings exceed the criteria specified in Section 3.2.2. The documents and procedures are identified in Section 3.0.

3.2.2 Tank Pressure Monitoring Criteria

Applicable tank pressure criteria are specified in the safety analysis reports (Smith 1986a, 1986b; Boyles 1989), including tank 241-C-106.

Specific operating parameters are listed in the *Operating Specifications for Single-Shell Waste Storage Tanks* (WHC 1996a). These requirements include the following:

- Ventilation operating pressure

  Operating pressure ranges between -0.1 and -5.9 in. water gauge (wg)

- HEPA filter differential pressure

First filter in a series	0.05 in. wg to 5.9 in. wg
Other filter in a series	0.05 in. wg to 4.0 in. wg
Total series of filters	0.05 in. wg to 5.9 in. wg

3.2.3 Monitoring Frequencies

The waste tank shall have tank pressures monitored every 36 hours (Dougherty 1994). Per Operating Procedure TO-060-050, *Portable Exhauster Operation for TK-105-C and TK-106-C*, (WHC 1996e) the ventilation system (including vacuum in the tank and pressure drop across the HEPA filters) is required to be checked daily, and operational data to be logged daily. The domespace pressure is monitored continuously by TMACS.

3.2.4 Reporting Requirements

Discrepancy and occurrence reporting requirements are applicable to ventilation system pressures outside specified limits (WHC-IP-0842 and WHC-CM-1-5).

3.3 AIRBORNE RADIATION-LEVEL MONITORING AND RESPONSE

In the context of this action plan, airborne radiation levels relate directly to the performance of the ventilation system for tank 241-C-106, which is an important element in maintaining tank 241-C-106 temperatures within safety limits.

3.3.1 Administrative Controls

Administrative documents and procedures are in place to ensure that corrective responses take place before any airborne radiation-level readings exceed the criteria in Section 3.3.2. The documents and procedures are presented in Section 3.0, with the following additions:

- Emergency responses and reporting guidelines are specified in the *Environmental Compliance Manual* (WHC-CM-7-5)

- Radiation protection control standards, requirements, and guidelines are specified in the *Hanford Site Radiological Control Manual* (HSRCM-1).

Should additional radiation monitoring systems be added to the tank, this action plan will be revised to reflect changes in configuration, criteria, and controls. Monitoring systems are installed on the current 296-P-16 exhauster and will be installed on the new Project W-320 recirculation ventilation system.

3.3.2 Airborne Radiation-Level Monitoring Criteria

Airborne radiation-level criteria are specified in the *Hanford Site Radiological Control Manual* (HSRCM-1). Gaseous effluent concentrations are specified for annual and weekly averages and instantaneous concentrations are measured at the exhaust stack (WHC-CM-7-5). Airborne radiation-level criteria are as follows:

- The annual average concentration of radionuclides released to the environment in airborne effluents shall not exceed the derived concentration guides specified in Attachment A of the *Environmental Compliance Manual* (WHC-CM-7-5).

- The weekly average concentration of radionuclides released to the environment in airborne effluents shall not exceed four times the derived concentration guides specified in Attachment A of the *Environmental Compliance Manual* (WHC-CM-7-5).

- The maximum instantaneous concentration of radionuclides released to the environment in airborne effluents shall not exceed 5,000 times the derived concentration guides specified in Attachment A of the *Environmental Compliance Manual* (WHC-CM-7-5).

3.3.3 Monitoring Frequencies

A continuous air monitor with an alarm capability is located on the 296-P-16 exhauster stack. Monitors and alarms for all active exhaust stacks shall be functionally tested monthly (WHC-CM-7-5).

3.3.4 Reporting Requirements

WHC discrepancy and occurrence reporting requirements are applicable to unexpected increases in airborne radiation levels (WHC-IP-0842 and WHC-CM-1-5).

Non-routine releases are reported to DOE and WHC environmental personnel in accordance with the "Occurrence Reporting and Processing of Operations Information," WHC-CM-1-5, Section 7.1, and DOE Order 5000.3B (DOE 1993). If a "reportable" release is confirmed per DOE Order 5000.3B, procedure requirements to notify the National Response Center and the Washington State Department of Ecology are outlined in WHC-CM-7-5.

3.4 LIQUID-LEVEL AND LEAK DETECTION MONITORING AND RESPONSE

Cooling water additions are currently used to control the temperature of tank 241-C-106 and thereby maintain the integrity of the tank's concrete structure. In the event of a leak, the ability to continue to cool the waste sufficiently and also minimize environmental impact would become a primary concern. If a leak is identified for this tank, the location and size of the leak and the time the leak occurs with respect to planned or ongoing sluicing activities would effect the corrective actions taken, but would not effect the reporting response described here.

3.4.1 Administrative Controls

Administrative documents and procedures are in place to ensure that corrective responses take place both before and after any liquid-level readings violate the criteria in Section 3.4.2. The controlling documents and procedures are identified in Section 3.0. Specific SST technical criteria limits and controls for leak detection, including those for tank 241-C-106, are contained in the following documents:

- WHC-OSD-T-151-00031, *Operational Specifications for Tank Farm Leak Detection* (WHC 1996c)
- WHC-SD-WM-TI-573, *Technical Basis for Operational Specifications Document* (WHC 1995)
- WHC-IP-0842, *TWRS Administration*, Volume II, Section 5.2, "Liquid Level Data Review"

3.4.2 Waste Tank Leak-Detection Criteria

3.4.2.1 Waste Tank Liquid-Level Monitoring Criteria. Liquid-level criteria are specified in WHC-OSD-T-151-00031 (WHC 1996c) and WHC-SD-WM-TI-573 (WHC 1995). The supernate level is controlled between 2.0 and 1.9 m (79 and 74.5 in. levels) to maintain a liquid layer above the solids surface to keep the sludge wet and facilitate evaporative cooling. The surface level measurements are accurate to ±0.6 cm (±1/4 in., which is approximately 2,650 L [700 gal]). The periodic behavior of the surface level is logged and manually analyzed for anomalies.

The primary method for leak detection for tank 241-C-106 is to calculate the evaporation rate (based on water additions and surface level change) on a monthly basis and compare the monthly evaporation rate to a baseline evaporation rate (based on historical average evaporation rates). Departure from the baseline evaporation rate by more than two standard deviations will result in an engineering evaluation of the status of tank 241-C-106. The leak detection criteria is three standard deviations below the evaporation baseline. Dry well scans are used to provide backup leak detection monitoring.

Additional liquid-level and leak detection activities conducted during sluicing are described in WHC-SD-WM-SAD-024.

3.4.2.2 Dry Well Monitoring Criteria. Dry well radiation criteria are specified in WHC-OSD-T-151-00031 (WHC 1996c). Action criteria for monitoring using a Scintillation Probe require a doubling of radiation levels above the baseline, and greater than 200 c/s. Action criteria for monitoring using a Geiger Mueller Probe require either

1) a tripling in radiation levels for baseline values less than 1,000 c/s, or
2) a doubling of radiation levels above the baseline for baselines above 1,000 c/s.

3.4.3 Monitoring Frequencies

3.4.3.1 Waste Tank Liquid-Level Monitoring Frequencies. Liquid levels are monitored within the tank farm facilities as specified in the *Operational Specifications for Tank Farm Leak Detection* (WHC 1996c). The levels in tank 241-C-106 are required to be monitored on a daily basis. Currently, TMACS records the liquid level for tank 241-C-106 continuously.

3.4.3.2 Drywell Monitoring Frequencies. WHC-OSD-T-151-00031 (WHC 1996c) specifies the drywell levels within the tank farm facilities are to be monitored monthly. Six drywells are associated with tank 241-C-106. These wells are scanned at least monthly.

3.4.4 Reporting Requirements

WHC discrepancy and occurrence reporting requirements are applicable to unexpected changes in waste tank liquid levels (WHC-IP-0842 and WHC-CM-1-5).

Non-routine releases are reported to DOE and WHC environmental personnel in accordance with the "Occurrence Reporting and Processing of Operations Information," WHC-CM-1-5, Section 7.1, and DOE Order 5000.3B (DOE 1993). If a "reportable" release is confirmed per DOE Order 5000.3B, procedure requirements to notify the National Response Center and Ecology are given in WHC-CM-7-5.

3.5 WASTE TANK FORCED VENTILATION FAILURE AND RESPONSE

Forced ventilation is necessary to maintain adequate cooling for tank 241-C-106. If the forced ventilation system for tank 241-C-106 is not operational, then the temperature of the tank waste will start rising. Three different ventilation system configurations will be in use between now and the completion of sluicing.

3.5.1 Administrative Controls

If the tank 241-C-106 ventilation system becomes non-operational, the East Tank Farm Transition Project will initiate a "corrective maintenance work package."

3.5.2 Monitoring Requirements

The operational status of the ventilation system is monitored indirectly by the pressure gauges in the dome space and in the 296-P-16 exhauster. Currently temperature and liquid level are monitored continuously by TMACS. The ENRAF level data trend will continue to be monitored on a continuous basis by TMACS, to ensure that cooling water remains over the waste surface. In case of TMACS failure, manual readings will be implemented at frequencies specified by Procedure (see Section 2.6).

3.5.3 Reporting Requirements

Appropriate occurrence reports will be issued if waste temperature criteria are exceeded (see Section 3.1.4).

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4.0 RESPONSIBILITIES

The WHC Tank Waste Remediation System organization is responsible for day-to-day tank farm operations (WHC-IP-0842). The responsibilities for response to excessive temperature or pressure, or a release from tank 241-C-106, are assigned as follows.

- East Tank Farm Transition Project shall be responsible for the safety of tank 241-C-106 and for routine monitoring of the tank. Initial screening of monitoring data shall also be performed by East Tank Farm Transition Project and TWRS Engineering.

- Surveillance Analysis and Data Acquisition receives temperature data and shall be responsible for 1) reviewing trending to predict when limits would be exceeded, 2) permanent logging (recordkeeping), and 3) reporting data. Additionally, Tank Farm Surveillance Analysis shall have the responsibility for reporting data anomalies and initiating response actions (WHC-IP-0842).

- TWRS Nuclear Safety Support shall be responsible for providing independent safety review of all activities related to waste tank safety.

- The Manager of East Tank Farm Transition Project shall be responsible for conducting assessment activities and determining appropriate corrective actions.

- Corrective actions shall be defined by TWRS Engineering and implemented in the field by East Tank Farm Transition Project and other organizations as appropriate.

- TWRS Program Quality Assurance shall be responsible for verifying that activities affecting quality have been performed in accordance with appropriate procedures.

- Safety Issue Resolution shall be responsible for implementing safety-related programs for safe storage of the waste.

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5.0 CORRECTIVE ACTIONS

Possible corrective actions for potential abnormal conditions in tank 241-C-106 are summarized in this section. The immediate goals of any corrective action are to maintain the tank in a safe condition, resolve the abnormal condition, and reduce or eliminate any environmental consequences. In addition the long range goals of any corrective action are to maintain the tank in a condition that will facilitate waste retrieval. Three stages of operation exist -- 1) the current system of passive waste storage, 2) the system in cool down mode in preparation for sluicing, with the cooling coil installed and operating in the ventilation system, and 3) the system ready for sluicing or while sluicing is actively ongoing. The response to the same abnormal condition may be different depending upon the stage of operation of tank 241-C-106. This is due to a different set of waste conditions existing at each stage of operation and to different equipment and systems being available for immediate use in responding. In the following sections, corrective actions are identified and discussed based on these operational stages. For simplicity, the three stages of operation are referred to as -- pre-cool down mode, cool down mode, and sluicing mode.

5.1 TEMPERATURE INCREASES

Excessive temperature increase is defined as

1. A violation of an OSD temperature limit.

2. Any other temperature anomaly, at the discretion of the Manager of East Tank Farm Transition Project.

For an excessive temperature increase in tank 241-C-106, the goals of the corrective actions are to regain temperature control of the tank and to maintain thermal conditions below the temperature criteria described in Section 3.1.2. Possible corrective actions are summarized in Table 5.1 and are discussed individually following the table. One or more of these corrective actions or other appropriate action will be taken at the direction of the Manager of East Tank Farm Transition Project.

Table 5-1. Temperature Increase Corrective Actions.

Tank is in		
Pre Cooldown Mode	Cooldown Mode	Sluicing Mode
Restore ventilation	Restore ventilation	Restore ventilation
Increase ventilation	Increase ventilation	Turn off heater
Install air-chiller	Use cooling coil	Alternate ventilation systems
Add water	Add water	Switch from recirculation to cooling coil ventilation system
Accelerate sludge retrieval	Accelerate sludge retrieval	Add sluice water
Install recirculation lines w/ tank 241-AY-102	Install recirculation lines w/ tank 241-AY-102	Initiate or continue sluicing
		Stop sluicing, recirculate w/ tank 241-AY-102

- **Restore Ventilation.** This assumes that there is a ventilation outage and that the temperature increase is due to the lack of ventilation. Restore the ventilation capacity as soon as possible by repairing the at-fault ventilation system, switching to the other system (at certain stages the cooling coil system and the recirculation system will both be installed), or using a portable exhauster.

- **Increase Ventilation.** Tanks 241-C-105 and 241-C-106 share a common exhauster. In 1994, tank 241-C-105 was confirmed not to be a high-heat tank (i.e., less than 11.7 kW [40,000 Btu/hr] heat generation); therefore forced ventilation is not required. The system valve from tank 241-C-105 can be reduced in order to increase ventilation to 241-C-106, if so directed by East Tank Farm Transition Project. The 296-P-16 exhauster has a nominal 3.3 m^3/second (7,000 ft^3/min) capacity. The exhauster throughput could be increased.

- **Install Air-chiller**. Colder ventilation air, all other things being equal, will increase the tank waste cooling rate. The effectiveness of colder ventilation air is discussed in Thurgood et. al (1995). An air-chiller design study addressing emergency and normal operating conditions is documented in a design summary report (Rensink 1995). A cooling coil has been installed in the present ventilation system as part of Project W-320 and will be operational before sluicing commences.

- **Add Water.** Water (even if the tank is leaking) must be added in quantities sufficient to prevent excessive temperature increase. Water can be added through the existing pump pit, through a proposed sprinkler system (Rensink 1995), or through the sluice line from tank 241-AY-102. Corrective actions for leaking tanks are summarized in Section 5.2.

- **Accelerate Sludge Retrieval.** Engineering activities have been initiated to remove the waste from tank C-106 (Project W-320). The conditions for early retrieval on a non-emergency basis are discussed in an engineering study (Squires et al. 1991) and the *Tank C-106 Early Retrieval Plan* (Henderson 1993). Under emergency conditions, the early retrieval plan could be further accelerated.

- **Install Recirculation Lines with Tank 241-AY-102.** Project W-320 will install sluice and slurry lines between tanks 241-C-106 and 241-AY-102. Prior to sluicing, these lines could be used to recirculate the liquids in the two tanks to equalize their temperatures and cool tank 241-C-106.

- **Use Cooling Coil.** Project W-320 installed a cooling coil in the current ventilation system. The installed system will supply 1.1 m^3/second (2,400 ft^3/min) of air at 4 °C (40 °F) when it becomes operational.

- **Turn Off Heater.** The recirculating ventilation system used during sluicing activities has a 30 kW heater, which will be used on a intermittent basis, to help control fog in the tank. Turning off this heat source will reduce the tank heat load. (For comparison purposes, the estimated radiogenic heat generation rate is 32 kW [110,000 Btu/hr].)

- **Alternate Ventilation Systems.** Currently the recirculation ventilation system is required to be operating while sluicing is active and the other system (current system with cooling coil installed) is required to be off. Both systems have a cooling capacity but the recirculating system has a smaller capacity. Alternating between systems, on a frequent basis, would allow the larger cooling capacity to be used (e.g., off shift) and for sluicing to proceed (e.g., on shift) on an alternating basis.

- **Switch from Recirculation to Cooling Coil System.** The recirculation ventilation system has a limited cooling capacity that is considerably less than the cooling coil ventilation system capacity.

- **Add Sluice Water.** The water level during sluicing can be increased. The added water (either from tank 241-AY-102 or standard makeup water for tank 241-C-106) will act as a heat sink. This is a short term solution, but only a short term solution is required because continued sluicing will solve the long term problem.

- **Initiate or Continue Sluicing.** Sluicing will remove the high-heat sludge that is the driving force behind the temperature increase.

- **Stop Sluicing and Recirculate with Tank 241-AY-102.** This assumes that the major source of the temperature increase is due to sludge disturbance. Temporarily stop sluicing activities but continue to recirculate water with tank 241-AY-102. This will allow tank 241-AY-102 to act as a heat sink. Resume sluicing once the temperature stabilizes.

5.2 LEAKING TANK

Abnormal changes in tank liquid levels or dry well radiation levels could indicate that a leak has occurred and that the normal cooling method (water addition) may have to be modified. The goals of the corrective actions will be 1) to monitor the tank to determine the extent of the leak, 2) to control or limit the leak, 3) to control the tank temperature, and 4) if possible to maintain the tank in such a configuration that sluicing may proceed.

Some actions will be taken to monitor the tank, and others to control the tank. The immediate and long term monitoring actions are summarized in Table 5-2 and are discussed individually following the table. One or more of these corrective actions will be taken at the direction of the Manager of East Tank Farm Transition Project.

There are three primary leak scenarios based on leak location and size. These are 1) a liquid-vapor interface leak, 2) a below liquid-vapor interface leak, and 3) a large leak. Possible corrective actions for these three leak scenarios coupled with the three operating modes are summarized in Table 5-3 and are discussed individually following the table. One or more of these corrective actions or other appropriate action will be taken at the direction of the Manager of East Tank Farm Transition Project. Corrective actions associated with the sluicing/sludge retrieval operating mode are also discussed in WHC-SD-WM-SAD-024. The key assumptions for the three leak scenarios are as follows.

- **Liquid-vapor Interface Leak.** The leak is assumed to be at or near the liquid-vapor interface but above the sludge level. With this leak location it is possible to lower the liquid level in the tank and still maintain a liquid pool over the sludge without leaking. The size of the leak is small to moderate implying that enough water could be added to maintain any desired liquid level while allowing the tank to leak. This further implies that "full wet" sluicing could physically proceed if desired.

- **Below Liquid-vapor Interface Leak.** The leak is assumed to be below the sludge level. With this leak location it is not possible to lower the liquid level in the tank and still maintain a liquid pool over the sludge without leaking. The size of the leak is small to moderate implying that enough water could be added maintain any desired liquid level while allowing the tank to leak. This further implies that "full wet" sluicing could physically proceed if desired.

- **Large Leak.** The leak is assumed to be below the sludge level. The size of the leak is large implying that enough water cannot be added to maintain any desired liquid level while allowing the tank to leak. This further implies that "full wet" sluicing is not physically possible, but that other techniques may allow sluicing to take place.

It should be kept in mind that the elevation of the sludge which differentiates the liquid-vapor interface and below liquid-vapor interface leak, will be continuously changing while sluicing takes place. In that context this becomes a floating interface.

Table 5-2. Leaking Tank Immediate and Long-Term Monitoring Corrective Actions.

Immediate	Long Term
Install in-tank video	Monitor soil temperatures
Increase required surveillance	Install liquid observation well
	Install thermocouples

- **Install In-Tank Video.** During leak investigation, an in-tank video may be installed to assist in leak verification. The new video may be compared with old videos taken in 1994. The comparison may help identify the leak location. If the leak location can be identified to be above the hard crust (liquid vapor interface leak as used herein), a new high liquid level operating limit may be set below the leak location. The liquid cover may then be reestablished to maintain cooling and normal operations would be resumed. If no leak location can be pinpointed, temperature control will be used to determine the need for minimum water addition.

- **Increase Required Surveillance.** Required surveillance frequencies may be increased for parameters monitored on tank 241-C-106. East Tank Farm Transition Project will analyze the data and modify tank operations in accordance with WHC-IP-0842.

Table 5-3. Leaking Tank Corrective Actions

Tank is in		
Pre Cooldown Mode	Cooldown Mode	Sluicing Mode
Liquid-vapor Interface Leak		
Allow tank to drain	Allow tank to drain	Allow tank to drain
Control liquid level	Control liquid level	Sluice to drop level
Increase ventilation	Increase ventilation	Control temperature as needed
Install air-chiller	Use cooling coil	
Install sprinkler	Install sprinkler	Accelerate sludge retrieval
Install recirculation lines with tank 241-AY-102	Install recirculation lines with tank 241-AY-102	
Below Liquid-vapor Interface Leak		
Allow tank to drain	Allow tank to drain	Allow tank to drain
Increase ventilation	Increase ventilation	Sluice to drop level
Install air-chiller	Use cooling coil	Control temperature as needed
Install sprinkler	Install sprinkler	Accelerate sludge retrieval
Large Leak		
Allow tank to drain	Allow tank to drain	Allow tank to drain
Increase ventilation	Increase ventilation	Sluice to drop level
Install air-chiller	Use cooling coil	Stop sluicing
Install sprinkler	Install sprinkler	Control temperature as needed
		Accelerate sludge retrieval

- **Monitor Soil Temperatures.** A significant leak from tank 241-C-106 would be expected to raise soil temperatures. Soil temperatures may be monitored through the drywell in the area of expected migration, along with dry well radiation scanning if deemed necessary by TWRS Engineering.

- **Install Liquid Observation Well.** If liquid level could not be detected above the crust, a liquid observation well (LOW) may be installed in tank 241-C-106. If a LOW is deemed necessary by engineering and waste conditions will permit, its location will be determined by engineering.

- **Install Thermocouples.** Additional thermocouples may be installed in tank 241-C-106 in locations determined by engineering staff, if deemed necessary by TWRS Engineering and Safety Issue Resolution.

- **Allow Tank to Drain.** This is a passive response to a tank leak because 1) no actions are taken to halt or limit the leak, nor to identify or characterize the leak, 2) all water additions are stopped, and 3) the tank is simply allowed to drain as it will. Tank 241-C-106 currently contains an estimated 181,699 L (48,000 gal) of drainable liquids as free liquid above the sludge and as interstitial liquid within the sludge. Therefore, only 181,699 L (48,000 gal) of liquid are at risk if all water additions are stopped. The environment consequences will be limited to a maximum release of 181,699 L (48,000 gal). This response assumes that any direct action to control or investigate the leak or to retrieve the waste may lead to a release of more than 181,699 L (48,000 gal) with ensuing greater environmental consequences. Thermal studies (Thurgood et. al 1995) indicate that a drained tank with chilled ventilation air (1.1 m^3/sec [2400 ft^3/min] at 4 °C [40 °F]) will maintain moist sludge (via a sprinkler or other means) in a cool state (below all OSR and OSD limits) and will maintain dry sludge (no moist top surface to aid in evaporative cooling) below the OSR limit (177 °C [350 °F]) but above the OSD limit (149 °C [300 °F])).

- **Control Liquid Level.** During a leak, the liquid level is expected to drop faster than the normal evaporation rate of 5,678 L (1,500 gal)/week (or 1.5 cm [0.6 in.]/week based on 10,410 L [2,750 gal] equivalent to 2.5 cm [1 in.] in tank 241-C-106). If a leak at the liquid vapor interface is confirmed (by in-tank video or level measurement), the liquid level can be lowered to the 183 to 188-cm (72 to 74-in.) level depending on the leak location. Also, smaller (less than 22,700 L [6000 gal] at a time) but more frequent water additions could be made to control the liquid level within an even tighter band. If the location of the leak cannot be determined, water additions shall be kept to the minimum to maintain adequate long-term waste temperature control.

- **Increase Ventilation.** Controlling the temperature in the tank is a major concern. Increasing the ventilation flow, as discussed in Section 5.1, is an option.

- **Install Air-chiller.** Controlling the temperature in the tank is a major concern. A cooling coil was installed in the present ventilation system as part of Project W-320 (see Section 5.1).

- **Install Sprinkler.** A sprinkler system may be installed for cooling with minimum water addition. Water addition may or may not be needed depending on the long-term temperature control. A sprinkler system design study addressing emergency and normal operating conditions is documented in a design summary report (Rensink 1994, 1995). The sluicer could be used for these water additions.

- **Accelerate Sludge Retrieval.** Water is needed to help cool the sludge. Retrieving the sludge eliminates the need for the cooling water. See discussion in Section 5.1.

- **Install Recirculation Lines with Tank 241-AY-102.** A liquid-vapor interface leak assumes that there is still a liquid pool above all of the sludge surface. This liquid could be recirculated with tank 241-AY-102, as discussed in Section 5.1, for additional cooling capacity. The recirculation line would also allow for elevation control of the liquid level.

- **Use Cooling Coil.** Controlling the temperature in the tank is a major concern. Using the installed cooling coil, as discussed in Section 5.1, is an option.

- **Sluice to Drop Level.** Because sluicing is actively ongoing, continue sluicing to drop the level of the liquid in the tank below the leak elevation as quickly as possible. This assumes that the benefit to be gained by sluicing the remaining sludge is greater than the resulting contamination to the environment. The tank will continue to leak while this sluicing is done, but the total volume leaked may be less than the volume leaked if sluicing is stopped and other actions are taken. Once the liquid level is below the leak, normal sluicing operations can resume.

- **Stop Sluicing.** This assumes that the benefit to be gained by sluicing the remaining sludge is less than the resulting contamination to the environment. If sluicing activities are almost complete, then the amount of sludge that will be left is not large and the heat load can be handled by other means (i.e., dry sludge with air-chiller), even though it may be above 11.7 kW (40,000 Btu/h). If sluicing activities have not yet started or have just started, then the amount of sludge that will be left is large and another solution to the heat problem is required.

- **Control Temperature as Needed.** Because sluicing is actively ongoing, the need to control temperature is a short term requirement that needs to be evaluated based on how long it will take to complete sluicing versus how long it will take to control the temperature if sluicing is stopped. Most temperature control measures are slow and a lengthy cooldown time is required. This lengthy cooldown time could exacerbate any consequences due to leaking. Any of the methods that will reduce the temperature may be used, but the most expedient measure may be to accelerate sluicing.

5.3 VENTILATION SYSTEM ANOMALIES

Abnormal ventilation system conditions (plugged or failed HEPA filters, mechanical failure of the ventilation equipment, etc.) would be detected by anomalous ventilation duct pressures, and/or an increase in airborne radiation levels. The response to these conditions would be to restore the ventilation system to its normal operational condition as soon as practicable. A portable exhauster may be installed if deemed appropriate by TWRS Engineering and East Tank Farm Transition Project.

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