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High-Heat Tank Safety Issue Resolution Program Plan

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Title: **HIGH-HEAT TANK SAFETY ISSUE RESOLUTION PROGRAM PLAN**

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HIGH-HEAT TANK SAFETY ISSUE RESOLUTION PROGRAM PLAN

EXECUTIVE SUMMARY

The purpose of this program plan is to provide a guide for selecting corrective actions that will mitigate and/or remediate the high-heat waste tank safety issue for single-shell tank 241-C-106. This program plan also outlines the logic for selecting approaches and tasks to mitigate and resolve the high-heat safety issue.

The identified "safety issue" for high-heat tank 241-C-106 involves the potential release of nuclear waste to the environment as the result of heat-induced structural damage to the tank's concrete, if forced cooling is interrupted for an extended period of time. The heat source of approximately 110,000 Btu/hr is the radioactive decay of the stored waste material (primarily ^{90}Sr) inadvertently transferred into the tank in the late 1960s. To mitigate the high-heat safety issue, an effective cooling method must be designed and implemented to maintain low waste and tank temperature. Currently, forced ventilation, with added water to promote thermal conductivity and evaporation cooling, is used for heat removal. The method is very effective and economical. Alternative cooling methods, such as air chillers, have also been evaluated. The "safe" concrete temperature limit has been determined conservatively to be 177 °C (350 °F) in the Safety Analysis Report/Operating Safety Requirements. The Operating Safety Document states that the operating waste temperature should be less than 149 °C (300 °F). At this time, the only viable solution identified to permanently resolve this

safety issue is the removal of heat-generating waste in the tank. This solution is being aggressively pursued as the only remediation method to this safety issue, and tank 241-C-106 has been selected as the first single-shell tank for retrieval. The current cooling method and other alternatives are addressed in this program as means to mitigate this safety issue before retrieval.

A computer thermal model for predicting the thermal response of the high-heat waste tank has been developed. The model has been "fine-tuned" using past operating data and is expected to help optimize the selected system upgrades and alternative mitigation methods. Paralleling this effort, an updated structural analysis has been developed for tank 241-C-106. The computer structural model takes the output from the thermal analysis as a boundary condition and conservatively confirms that an adequate safety margin for retrieval will be maintained at least through 2002 (retrieval schedule will begin in 1996).

As previously mentioned, cooling the high-heat tank to prevent waste temperatures from exceeding the 149 °C (300 °F) operating limit is currently accomplished by forced ventilation through high-efficiency particulate air filters, with added water to promote thermal conductivity and evaporative cooling. Water is periodically added to maintain a liquid cover over the waste sludge/crust deposit and to enhance thermal conductivity and evaporation for heat transfer. At the current ventilation level (71 m^3/min [2,500 ft^3/min]), the recorded maximum waste temperature at Riser 8 is approximately 71 °C (160 °F). According to a homogeneous thermal model, the corresponding maximum waste temperature at the center bottom of the waste is 110 °C (230 °F). Based on this temperature distribution, a small *saturation zone is believed to exist at this region. Such a saturation zone could grow seasonally during the summer and completely disappear during the winter; it could be eliminated by installing an air chiller for additional heat removal. An engineering study is being conducted to assess the effectiveness of an air chiller; the study is expected to recommend installation of an air chiller.*

The liquid that is in the tank to promote cooling exceeds the interstitial holdup capacity of the tank's sludge; the liquid content exceeding the interstitial holdup capacity is called the drainable liquid. Under the current cooling method, if a leak were to occur, significant environmental concern would result. This program plan also identifies contingency actions and associated tasks to deal with this concern.

This program plan has three parts. The first part establishes program objectives and defines safety issues, drivers, and resolution criteria and strategy. The second part evaluates the high-heat safety issue and its mitigation and remediation methods and other alternatives according to resolution logic. The third part identifies major tasks and alternatives for mitigation and resolution of the safety issue. A table of best-estimate schedules for the key tasks is also included in this program plan.

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LIST OF TERMS

DOE-RL	U.S. Department of Energy Richland Operations Office
EM	U.S. Department of Energy Headquarters Environmental Restoration and Waste Management
FIC	Food Instrument Corporation
FY	Fiscal Year
OSD	Operating Safety Document
OSR	Operating Safety Requirements
PNL	Pacific Northwest Laboratory
SEG	Scientific Ecology Group, Inc.
SST	Single-Shell Tank
TC	Thermocouple
TMACS	Tank Monitoring and Control System
TWRS	Tank Waste Remediation System
WHC	Westinghouse Hanford Company

HIGH-HEAT TANK SAFETY ISSUE RESOLUTION PROGRAM PLAN

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this program plan is to provide a guide for developing resolution logic and to identify major tasks for mitigating and resolving the safety issue* for high-heat tank 241-C-106. The plan outlines the steps necessary to complete the identified tasks. Proper contingency actions in the event of a leaking tank are also addressed.

1.2 HIGH-HEAT SAFETY ISSUE

A "high-heat" waste tank at the Hanford Site is defined as a single-shell tank (SST) with total heat generated at a rate of 40,000 British thermal units per hour (Btu/hr) or more. In 1994, eight SSTs were listed as high-heat tanks (Bander 1994). Only tank 241-C-106 requires more than active ventilation to maintain adequate cooling. Tank 241-C-106 is the only Watch List tank in the high-heat category (Harmon 1991).

The safety issue for high-heat tank 241-C-106 involves the potential release of high-level nuclear waste as a result of tank structural damage caused by overheating of the tank concrete. The heat is generated by the radioactive decay of waste material stored in the tank. For tanks that may overheat, the temperature of the waste is maintained by an active cooling system in accordance with the following Operating Safety Document (OSD) requirements (OSD-T-151-00013) (Wodrich 1992):

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*Definitions for terms used in the Tank Waste Remediation System (TWRS) program, including the Waste Tank Safety Program, are critical for clear and concise communications and for achieving consistent integrated planning. These definitions are as follows:

- <u>Mitigation:</u> The action taken to reduce the severity of tank safety issues.
- <u>Resolution:</u> The elimination of a tank safety issue by physical, chemical, analytical, and/or administrative methods.
- <u>Remediation</u>: The actions taken to safely store, maintain, treat, and dispose of tank waste forms.

- Maximum 149 °C (300 °F) for the waste
- Maximum of 121 °C (250 °F) for the dome
- Maximum change of 11 °C (20 °F) per day.

1.3 BACKGROUND

Between 1969 and 1971, high-heat sludge was water-sluiced from aging waste stored in SSTs in the 241-A and 241-AX Tank Farms to recover ^{137}Cs and ^{90}Sr. The sludge washing/decanting step of the process did not function as planned, and strontium-rich solids were transferred to SST 241-C-106. This tank now contains as much as 181,699 L (48,000 gal) of drainable liquids and 745,723 L (197,000 gal) of sludge. There is no saltcake in the tank. As of 1988, the waste in tank 241-C-106 was estimated to generate heat from 61,550 to 176,000 Btu/hr with a conservative estimate of 158,000 Btu/hr (Pauly and Torgerson 1987). More recent estimates in 1993 place the heat rate at 110,000 ± 20,000 Btu/hr (Bander 1993a).

Tank 241-C-106 is a 2,000-m^3 (530,000-gal)-capacity SST located in the Hanford Site C Tank Farm (Figure 1-1). 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. Tank 241-C-106 has been used for radioactive waste storage since mid-1947.

In mid-1971, when waste temperatures in excess of 99 °C (210 °F) at Riser 8 (see Figure 1-2) were observed in tank 241-C-106, the tank was immediately placed on forced-air ventilation. Since mid-1971, filtered raw water has been added to the tank regularly to cover the sludge solids in order to promote heat transfer and evaporative cooling, and to permit accurate in-tank liquid-level measurements using Food Instrument Corporation (FIC) gauges. The tank is sound (nonleaking) and has been on inactive status since 1979. The added liquid has averaged approximately 22,700 L/month (6,000 gal/month) over the last five years. When the liquid level in the tank decreases to a preestablished level, water is added to reestablish a predetermined upper liquid level. The decrease in water level is thought to be caused by evaporation only. The liquid level data recorded in 1992 (when the ventilation was down) support a "sound tank" theory. Since November 1993, treated water with pH value between 10 and 11 has been introduced to replace raw corrosion control. Because of the 22-year-long raw water addition, a thick layer of mineral scale (estimated to be 6 in. thick) has been deposited on top of the heat-generating sludge. In 1994, an Enraf device (an improved surface level measuring device using a buoyancy/tension wire gauge) was installed to replace the FIC.

Routine surveillance of the tanks for leak detection is maintained by surface-level measurements and drywell radiation scan readings. Any departure from historical periodic behavior of surface measurements results in an immediate investigation. The radiation scan data from the drywells around tank 241-C-106 are consistent with a non-leaking tank, and they have remained consistent with reference baselines established in 1975. The liquid level has been consistent with past performance, and the drywells have shown no indications of radiation migration. During the period January to June 1992, the water level remained constant for five months when the ventilation system was out-of-service. Water was not added during that period. All these facts support the conclusion that tank 241-C-106 is structurally sound.

Single-shell tank 241-C-106 is the only high-heat tank that requires more than active ventilation to keep the temperature below 149 °C (300 °F) (Pauly and Torgerson 1987). Active ventilation was not functioning for a five-month period from January to June 1992. During that time, tank waste temperatures increased approximately 22 °C (40 °F) with the maximum temperature recorded at Riser 8 rising from 72 to 93 °C (161 °F to 199 °F) without the addition of water. The heatup transient during that period was not very rapid even without active ventilation and water addition. The heatup rate was less than 5 °C (8 °F) per month.

The liquid currently maintained in tank 241-C-106 to promote cooling exceeds the interstitial holdup of the tank's sludge. The fraction of the liquid content exceeding the interstitial holdup in a tank is called drainable liquid. A primary operational concern is the possibility of drainable liquid spilling into the ground if a leak were to occur. The practice of maintaining drainable liquid in the tank presents a dilemma for a leaking tank. The dilemma is whether water should be added to make up for the leak and control the temperature within limits, or whether waste should be allowed to heat up and potentially result in structural damage. Elimination of the need for maintaining drainable liquid in the event of a leak is addressed in this program as the contingency plan.

Several studies, including one completed in 1987, examined cooling options in support of in situ stabilization (Pauly and Torgerson 1987). The study concluded that no viable alternative exists to retrieving all or part of the tank's contents in order to resolve the high heat safety issue. The study recommended that retrieval of the tank's contents be pursued as soon as practical. If the thermal conductivity of dry sludge were demonstrated to be greater than 0.25 Btu/hr-ft-°F, then other acceptable cooling alternatives could exist for tank 241-C-106. To date no determination of the actual thermal conductivity has been made, although laboratory efforts to investigate thermal conductivity for simulated sludge were initiated. A planned core-sampling activity is being pursued in Fiscal Year (FY) 1995. The thermal conductivity of the dry sludge is one of the key characteristics to be determined in the laboratory.

In January 1991, in accordance with the *National Defense Authorization Act for Fiscal Year 1991*, Public Law 101-510, Section 3137 (Wyden Amendment), tank 241-C-106 was identified as a high-level waste tank that "may have a serious potential for release of high-level waste due to uncontrolled increases of temperature or pressure." All 53 tanks so identified were designated as "Watch List" tanks at that time, and documented in a letter from Westinghouse Hanford Company (WHC) to the U.S. Department of Energy Richland Operations Office (DOE-RL) dated January 8, 1991. Tank 241-C-106 was placed on the Watch List mainly because if drainable liquid is not maintained in the tank, an uncontrolled increase in temperature could result in structural damage to the tank's concrete, with a potential subsequent release of high-level waste.

A Tri-Party Agreement milestone (M-40-05) requested a study to evaluate the possibility of minimizing liquid inventory and water additions to tank 241-C-106. The purpose of the study is to minimize potential environmental impact if a leak were to develop. The completion date of this Tri-Party Agreement milestone was scheduled for October 1995. An accelerated schedule was later mandated by U.S. Department of Energy (DOE) Safety Initiative 2x to complete the same task by June 1995.

To carry out this study, a liquid reduction process test (Sutey 1993) was completed in FY 1994, and determined that a lower liquid inventory level is possible if a leak develops due to coast-line corrosion. During water addition after the process test, local temperature readings at Riser 14 rose from 60 to 102 °C (140 to 215 °F) from June to August 1994, while Riser 8 temperatures remained unchanged. Studies concluded that the indicated temperature changes were localized to Riser 14 (Eyler 1994, Thurgood 1994). These changes are believed to be caused by intermittent contact of the thermocouples (Tcs) in Riser 14 and the surrounding waste. The TC tree was placed in Riser 14 in 1978 using the "water lancing" method. As a result, the space between the TC tree and the waste has never been properly closed. Recognizing the problem, the temperature readings from the Riser 8 TC tree have been used historically as reference parameters for monitoring purposes. The average maximum temperature reading at the Riser 8 TC tree is about 71 °C (160 °F). A thermal analysis (Bander 1993a) using uniform heat distribution concluded that the maximum waste temperature at the center bottom of the tank should be around 110 °C (230 °F). Based on this analysis and the process test experience, a "saturation zone" is believed to exist. All the safety analyses and safety program planning are based on the assumption that a "saturation zone" exists in tank 241-C-106. Therefore, the installation of an air chiller to eliminate the assumed saturation zone is a high-priority task in the high-heat safety program.

Engineering studies on retrieval concepts for tank 241-C-106 (Esvelt 1990, Squires et al. 1991) identified costs in excess of $150,000,000, with eight to nine years required to implement the project using the preferred long-reach-arm confined sluicing system. Two later evaluations concluded that past-practice sluicing is an acceptable method for retrieval of tank 241-C-106 (Henderson 1993, Bailey 1993). As a result, past-practice sluicing is Westinghouse Hanford Company's recommendation for earliest resolution of the high-heat tank safety issue and to meet the requirement to initiate the demonstration of SST waste retrieval for Tri-Party Agreement Milestone M-07-00. The DOE has identified tank 241-C-106 as the M-07-00 retrieval demonstration tank, and the Washington State Department of Ecology has concurred.

Project W-320 (Tank 241-C-106 Sluicing) will carry out the 241-C-106 waste retrieval using the past-practice sluicing method. This project uses the tank-to-tank retrieval system, involving injection of controlled quantities of pressurized water or liquid into the tank through two spray nozzles. The water dislodges the sludge and forms a slurry that is pumped from the tank to a double-shell receiver tank for safe storage. The past-practice sluicing method is expected to remove a sufficient amount of the heat-generating sludge so that tank 241-C-106 will no longer be a high-heat tank.

1.4 PROGRAM PLAN SUMMARY

This program plan has been established to address the high-heat safety issue resulting from excessive heat generated in the waste tank. The current method and other alternatives selected to mitigate/resolve the safety issue are discussed. Funding for this activity is provided by the DOE Headquarters Environmental Restoration and Waste Management (EM) Activity Data Sheet 1110-0 (Waste Tank Safety Program). Retrieval of the tank waste, aggressively pursued as a DOE safety initiative (DOE 1993), is funded by the Waste Retrieval Program (Activity Data Sheet 1210).

The current need to maintain drainable water in tank 241-C-106 for cooling remains a potential environmental concern if a tank leak were to occur. Another potential safety concern is the existence of a saturated zone in the center of the waste. Although past operating experience suggests that the potential risk from these concerns is small, this program plan addresses recommended options and alternatives that are available to resolve the concerns.

Section 2.0 provides safety issue resolution criteria, drivers, and strategy for resolving this safety concern. Program objectives and key programmatic assumptions also are provided. Section 3.0 describes the safety issue resolution logic for the program plan. Section 4.0 describes the scope of work for the major tasks in the program logic, and Section 5.0 provides schedules for the identified major tasks.

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

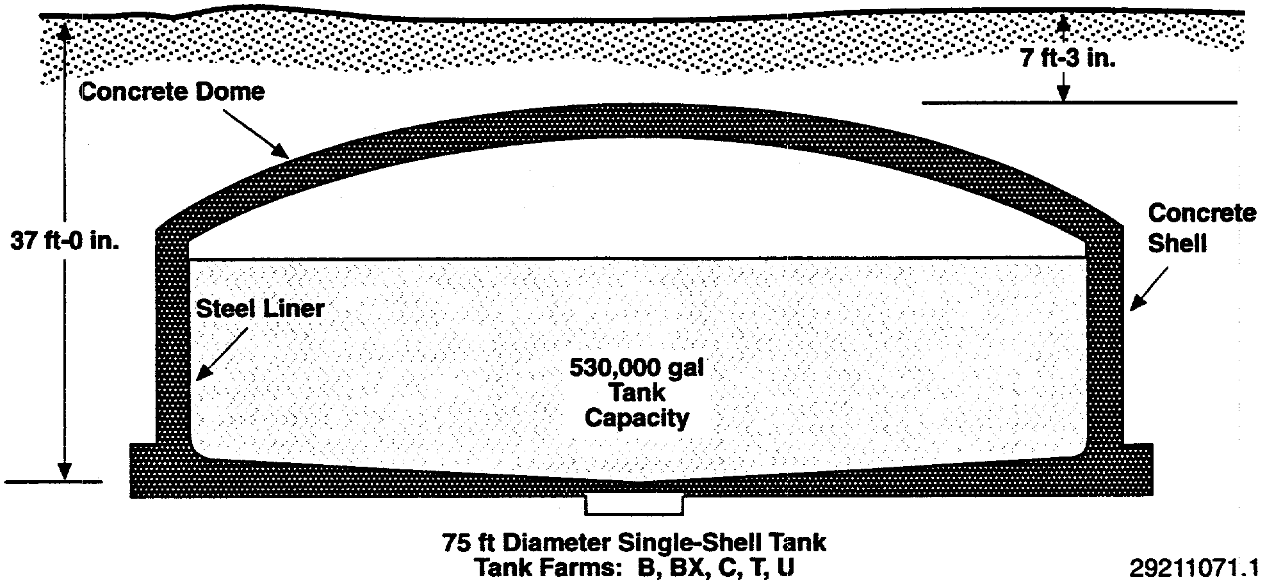
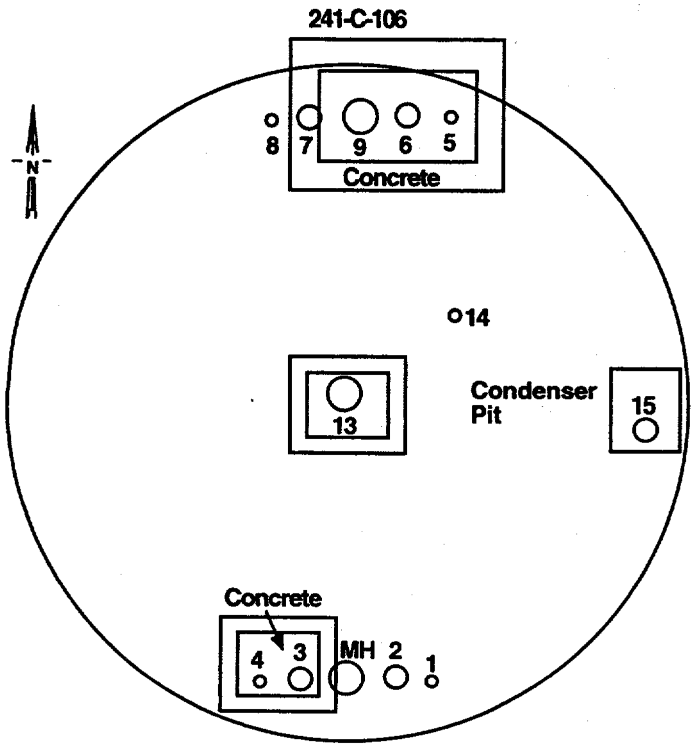
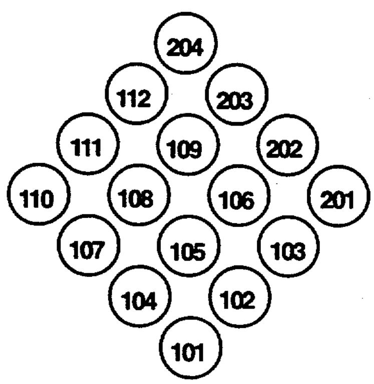


Figure 1-2. Riser Locations for Tank 241-C-106.



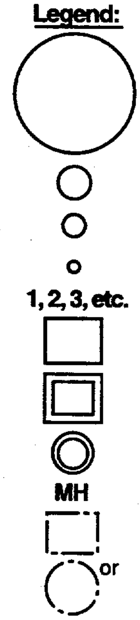


241-C Farm Layout

241-C-106

No.	Dia.	Elev.	Description and Comments
1	4"	646.15	FIC, BM
2	12"	646.18	Exhauster Riser
3	12"	647.24	Lead Covered WC
4	4"		Recirculating Dip Leg WC
5	4"		Recirculating Dip Leg WC
6	12"	646.01	Sluicing Access/Flange
7	12"	646.48	OBSV Port/Press. Gauge
8	4"	645.66	B-221 Temperature Probe
9	42"		Sludge Pump
13	26"		Distributor Jet WC
14	4"	645.5	Temperature Probe
15	12"		Air Inlet Filter

Legend:



3 1/2 in. circle is tank outline

Risers

42"

12" in proportion to size

4

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.

Caisson (USU 72" dia.) - covered

A 42" manhole at dome top - no riser to surface

29210056.5

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2.0 PROGRAM OVERVIEW

2.1 SAFETY ISSUE RESOLUTION CRITERIA

The safety issue for high-heat tank 241-C-106 is the potential release of high-level nuclear waste as a result of structural damage caused by overheating the tank concrete. The criteria to resolve the safety issue must provide for control of the temperature below a level that will ensure structural integrity of the tank. This can be achieved by accomplishing either of the following:

- Heat-generating waste in the tank must be removed to a quantity less than 40,000 Btu/hr equivalent.
- If sufficient waste is not removed, acceptable cooling methods must be developed to remove the heat generated in the tank. This is considered an interim solution.

These criteria are used to guide the high-heat safety issue resolution logic and tasks. The programmatic logic and selected tasks to mitigate/remediate this safety issue are summarized in Sections 3.0 and 4.0.

The DOE planning base case for the Tank Waste Remediation System (TWRS) has been changed recently to include retrieval of all SST waste. Tank 241-C-106 has been selected as the demonstration SST in order to provide permanent closure of the safety issue. Consequently, retrieval activities are being pursued aggressively as the only long-term remediation method to resolve the high-heat safety issue.

2.2 DRIVERS

Two drivers push the resolution of the tank 241-C-106 safety issue. The first driver is that this issue is one of four Priority 1 waste tank safety issues. It has been identified (in accordance with the Wyden Amendment [Public Law 101-510]) as having serious potential for release of high-level waste because of an uncontrolled high-temperature increase if active cooling is not maintained in the tank. The second driver is the assumption that structural damage to a waste tank is unacceptable. Permanent resolution of the high-heat waste tank safety issue can be achieved by retrieving some or all of the waste from tank 241-C-106; at this time, accelerated early retrieval is being planned as part of the safety initiative sponsored by the DOE to meet Tri-Party Agreement milestone M-07-00 requirements (DOE 1993).

2.3 STRATEGY

Because of high heat generation in tank 241-C-106, permanent resolution of the safety issue is not expected until retrieval in FY 1997. The program strategy is to continue to cool the waste in the tank with the minimum required water addition as well as to accommodate scheduled pre-retrieval activities.

The current cooling method poses a risk to the environment if a leak were to develop, and alternative means of cooling for a leaking condition are being studied. The awareness of the environmental impact should a leak occur, combined with the lead time for waste retrieval, has generated interest in near-term, low-cost alternative mitigating concepts. The low-cost alternative cooling concepts and designs, such as an air chiller and in-tank sprinkler systems, are discussed in Sections 3.0 and 4.0. Together these constitute a stand-by contingency plan that will be implemented if a leak occurs before scheduled retrieval.

The overall resolution strategy for the high-heat safety issue is to continue with the current cooling method with a "standby" contingency plan. The contingency plan is to complete an engineering study of alternative cooling methods as soon as possible; then the field implementation, if called for, can be completed within three months after a tank leak is confirmed. The study of contingency plan and alternative cooling methods depend on a credible simulation model calibrated by field data and waste characterization. Two sources of data are being collected to support model development for the safety program: one from the upcoming core-sampling activity scheduled for FY 1995; and the other from data collected during routine operation and non-routine activities, such as process tests and off-normal events. Data taken from these sources continue to be used for upgrading the computerized thermal model for tank 241-C-106.

Two milestones related to the high-heat safety program are listed below:

1. Tri-Party Agreement Milestone M-40-05 requested completion of a study of minimizing liquid inventory in, and water additions to, tank 241-C-106 by September 1995. To further accelerate the schedule, DOE Safety Initiative 2x (DOE 1993) accelerated the completion date to June 1995.

2. DOE Safety Initiative 6e requested initiating waste retrieval from tank 241-C-106 in October 1996. This is an accelerated schedule for completion of the Tri-Party Agreement full-scale retrieval demonstration milestone M-07-00 scheduled for October 1997 (Ecology et al. 1990 and 1991).

2.4 PROGRAM OBJECTIVES

The overall objective of this program is to resolve the high-heat safety issue associated with tank 241-C-106; the interim objective is to provide adequate cooling in the tank. Another interim objective is to resolve the potential environmental concern associated with the current cooling method if a leak should occur. All objectives will be achieved in compliance with state and federal laws and regulations and will be consistent with company procedures and guidelines. The program plan provides the resolution logic and technical bases to explain how and why recommendations are made and tasks are selected. The program plan will be implemented safely, with minimum environmental impact and at reasonable cost.

2.5 SCOPE

The scope of the high-heat program includes the assessment of the safety issue, the evaluation of the current cooling method, the logic for selecting mitigation/remediation methods and tasks, the identification and strategy of contingency action plans, and the safe storage and monitoring of waste until waste retrieval is completed.

An accelerated schedule has been implemented to retrieve the waste from tank 241-C-106 in FY 97. This program plan focuses on the short-term cooling of the tank until all or a sufficient amount of the waste is retrieved, and on the contingency cooling alternatives if a leak should occur before retrieval. Preparations for waste retrieval are currently underway, and will be carried out through Project W-320.

2.6 KEY ASSUMPTIONS

The following key assumptions are used for development of this program.

- Structural damage to the concrete of any SST is unacceptable for any reason or at any foreseeable time (even if it does not lead to significant release of high-level waste).
- Tank wall corrosion will be actively controlled by adding treated water with a pH value between 10 and 11, a practice that will substantially delay or prevent leaking.
- The current cooling method is effective and will be used until retrieval is started. If a tank leak occurs before retrieval, alternative cooling methods will be implemented.
- A saturation zone is assumed to exist according to the available thermal analyses.
- The program plan accommodates scheduled pre-retrieval activities, such as removal of in-tank instruments and equipment.
- The Waste Tank Safety Program (WTSP) will respond to potential future project and program modifications, and make appropriate changes accordingly.

- Core sampling and analysis costs will be paid for by the Characterization Program (Activity Data Sheet 1130).

- Retrieval planning and implementation costs for tank 241-C-106 will be paid by Project W-320.

3.0 HIGH-HEAT SAFETY ISSUE RESOLUTION LOGIC

The logic for resolving the high-heat waste tank safety issue is consistent with the "Planning Exercise for the Resolution of High Level Waste Tank Safety Issues" issued on December 23, 1991 by Science Applications International Corporation for DOE Headquarters in Washington, D.C. The logic is generic, and is used for mitigation/remediation of all Hanford Site Priority 1 safety issues. The generic DOE logic is designed for chemical reaction-based safety issues, and not every step is appropriate for addressing every waste tank safety issue; for example, high-heat tanks. Some minor variations exist because of the dissimilarity between chemical reaction-based safety issues for the other Watch List tanks and the thermal reaction-based safety issue for high-heat tank 241-C-106. This section only addresses logic steps relevant to the high-heat safety issue (see Figures 3-1, 3-2, and 3-3).

3.1 EVALUATE THE PROBLEM

This part of the logic focuses on a better understanding of the extent and severity of the "problem" or "safety issue" in individual waste tanks. Unlike other safety issues at the Hanford Site, the high-heat safety issue involves only one tank, 241-C-106, at this time. Therefore, some of the steps included in the generic logic are not required. This part of the logic diagram is shown in Figure 3-1.

The safety issue for tank 241-C-106 is defined as "the potential release of high-level nuclear waste as a result of waste tank damage due to overheating the concrete structure of the waste tank." To mitigate or resolve this issue, selected methods must be identified and implemented for safe operation and remediation of the waste tank.

3.1.1 Establish and Refine the Hypothesis/Model

This logic step (see Figure 3-1, logic 1.1 and 1.3) involves investigating the mechanisms producing the "problem" and the "solution." Understanding the heat generation rate and thermal properties and their distributions within the waste is a part of understanding the problem. Understanding the heat transfer process from the waste and out of the tank is a part of understanding the solution. The first mechanism (part of understanding the problem) is evaluated in this section, and the second mechanism (part of understanding the solution) is evaluated in Section 3.2.1.

The heat produced within the waste is transported to a heat transfer device for removal from the tank. That device may be air at the top of the waste, or it may be the walls of the tank. The efficiency of the heat transfer is affected primarily by thermal conductivity and, to a lesser degree, by other thermal properties (heat capacity and density) of the waste. To keep the waste temperature within the safety limit, it may be necessary to maintain a moisture level within the waste to enhance thermal conductivity and to provide latent heat removal.

The thermal conductivity of waste is one of the key characteristics to be determined in the laboratory. In addition, the thermal conductivity of the waste under varying moisture levels will also be determined as part of the core-sampling analysis plan. The thermal conductivity for the waste in tank 241-C-106 is estimated to be about 0.5 to 1.0 Btu/hr-ft-°F for wet sludge, and 0.25 to 0.5 Btu/hr-ft-°F for dry sludge (Bander 1992).

A model for predicting the thermal response of the waste in tank 241-C-106 has been developed and is being upgraded as more data become available. In FY 1995, the thermal properties of the waste will be measured from the planned core-sampling analysis. The current model was verified in FY 1993 (Bander 1993a) using the temperature data recorded from January to June 1992 when the ventilation system was down.

The thermal model is expected to project conservative results of conceptual alternative designs. The projection will assist in validating and selecting alternative mitigation and remediation methods. Using the existing model, the results of "unmitigated consequence" for tank 241-C-106 can be estimated conservatively. In the absence of any mitigation measures, such as forced ventilation, the maximum final waste temperature was predicted to be 260 °C (500 °F) (see Figure 3-4) for dry waste using 0.25 Btu/hr-ft-°F as a representative thermal conductivity. In order to meet the safety criteria of 149 °C (300 °F), it is obvious that the high-heat condition in tank 241-C-106 must be mitigated for safe storage of high-heat waste.

3.1.2 Define Tank Safety Criteria

This logic step defines the safety acceptance criteria of a high-heat SST (see Figure 3-1, logic 1.4). This section includes evaluation of the impact of high temperature on the structural integrity of the tank.

A postulated waste tank safety issue, defined as a nuclear release from a waste tank to the atmosphere as a result of a tank structural damage, can be prevented by any one of the following: containing high-level nuclear waste after structural damage, removing high-level waste from the tank, or removing heat from the waste and out to the environment.

For this program plan, it has been assumed that structural damage to any SST at the Hanford Site is unacceptable for any reason. The risk associated with heat-induced structural damage to tank 241-C-106 is related to the residual strength of the tank's concrete after the accumulation of almost half-a-century of operation*. Any future degradation of the

*The degradation of the structural strength of concrete as a function of temperature is inelastic (i.e., for given temperature the degradation is permanent, and further temperature-caused degradation will not occur unless and until a higher temperature is established). Tank 241-C-106 has already been known to have reached the currently established OSD limit of 149 °C (300 °F).

structural strength of the concrete can be prevented by keeping the temperature of the tank waste below any sustained temperatures seen to date.

A thermal-structural analysis was performed (Julyk 1994) to determine the residual structural strength for tank 241-C-106 in anticipation of potential remediation retrieval equipment loadings. A best-estimate and upper-bound thermal analysis was performed to characterize the temporal and spatial temperature distribution of the 241-C-106 tank from initial operation in 1947 to 2002. The calculated residual strength is greater than that required for potential retrieval needs or any other requirements (such as seismic resistance). The analysis suggests that a temperature safety criterion higher than the current Operating Safety Requirements (OSR)/OSD limit is justified. Increasing the operating temperature limit above 149 °C (300 °F), however, is not being considered at this time. The results of the thermal-structural evaluation show an adequate safety margin left in the tank after the exposure to the actual and projected thermal exposure from 1947 through 2002 (at which time the bulk of the waste is expected to be retrieved even under the most pessimistic schedule).

3.1.3 Applying Criteria to Data

Data needed to resolve or mitigate the safety issue are collected for tank 241-C-106 from historical operating experience and planned core-sampling analysis (see Figure 3-1, logic 1.5). All known historical thermal data, including the 1992 ventilation-failure event and the 1994 Riser 14 temperature transient event, have been incorporated in the current analytical model. It is expected that data from the planned core-sampling analysis will be incorporated in the thermal model in 1995. The core sample data will enable better predictions of the thermal responses and effectiveness of alternative designs.

3.1.4 Evaluate Results

This logic step is shown in Figure 3.1, logic 1.7. The unmitigated consequence was evaluated in the early 1970s, and the result was considered unacceptable. A cooling method of forced ventilation with water added was implemented at that time. The same cooling practice is still in use.

A similar assessment for this program plan was performed in 1993. The updated model predicted that tank 241-C-106 would still exceed the limiting operating temperature of 149 °C (300 °F), if it were left alone (see Figure 3-4). Therefore, mitigative measures are required to safely maintain tank 241-C-106 before retrieval. However, other alternatives, such as use of an air chiller, that might not have been adequate in the 1970s (because of higher decay heat), are being reevaluated as backup or contingency options. This is addressed in Section 3.2. Figure 3-4 shows that the maximum waste temperature in tank 241-C-106 could reach 260 °C (500 °F) in an unmitigated condition. The corresponding maximum TC recording at Riser 8 is projected to be about 204 °C (400 °F).

3.2 MITIGATION/REMEDIATION

This logic step focuses on identifying, evaluating, selecting, and implementing mitigation and/or remediation measures if the evaluation in Section 3.1.4 indicates that mitigation and/or remediation are required. This part of the logic diagram is shown in Figure 3-2.

3.2.1 Identify the Pathway to Hazard

An understanding of the hazard and the pathway leading to the hazard is required to define the problem so that corrective action can be determined. It is necessary to know exactly what is needed to prevent hazardous consequences from occurring and how to provide it. Identifying the hazard will dictate the path or approach for preventing a hazardous consequence..

For high-heat tanks, the hazard is the high heat generation that could lead to waste tank structural failure and potential release of nuclear waste to the environment. The path is the failure to remove the heat from the waste and out of the tank.

According to past thermal analyses (Bander 1992, Bander 1993a, Bander 1993b, Bander 1994), approximately 10 to 15% of the heat is transferred through tank walls, and the balance of the heat (85 to 90%) is removed from the waste surface and out of the tank by evaporation, convection, conduction, and radiation. Therefore, it is obvious that alternative cooling methods must focus on surface removal of the heat.

3.2.2 Determine Approaches to Preempt Hazard

This logic step (Figure 3-2, logic 2.2) identifies all possible ways to reduce or eliminate the severity of the hazard. Although forced ventilation with water added has been effectively used for mitigation, several other approaches have also been considered. It is important to reassess the alternative options again because the total heat load has been decreased by at least 40% since 1970 due to radioactive decay. It is possible that options previously considered unsatisfactory may become valid now or in the immediate future (See Sections 3.2.4 and 3.2.5). The mitigating/remediating options under consideration are summarized below:

1. Forced ventilation with water added. This method, used for more than 20 years, is a very effective cooling method. However, the effectiveness of this method in a leaking tank condition is questionable. Therefore, more backup or contingency methods must be studied.

2. Forced ventilation alone. The ventilation level can be adjusted from the current level of 71 m^3/min (2,500 ft^3/min) up to 170 m^3/min (6,000 ft^3/min). The effectiveness of this method may not be acceptable for adequate cooling. A thermal analysis (Bander 1993b) concluded that the maximum waste temperature would exceed the 177 °C (350 °F) OSR safety limit as shown in Figure 3-5 with forced ventilation alone.

3. Refrigerated ventilation (air chiller). In parallel with an air chiller design activity, a series of conservative thermal analyses (Bander 1993b) concluded that the maximum waste temperature would be less than the 177 °C (350 °F) OSR safety limit as shown in Figure 3-5.

4. Waste retrieval. Total waste retrieval is the only remediation method identified for the high-heat tank 241-C-106. Even partial retrieval is an effective way to mitigate the high-heat safety issue. According to the recent DOE safety initiatives schedule, the retrieval of tank 241-C-106 will take place in FY 1997.

3.2.3 Define Selection Criteria

This logic step is shown in Figure 3-2, logic 2.3. In general, selection criteria should take into account safety, cost, implementation time, potential for success, collateral disadvantages or benefits, etc. The existing cooling method, implemented in the 1970s, is very effective. It is important to reevaluate the alternative options listed in Section 3.2.2 using a set of updated selection criteria. Updated selection criteria account for updated, known future plans that are very different from those considered in the 1970s. The criteria include the following:

1. The selected options must be compatible with retrieval-related activities. Early retrieval of tank 241-C-106 in FY 1997 is one of the Hanford Site Tank Waste Remediation System safety initiatives fully supported by Westinghouse Hanford Company and DOE. The high-heat safety program plan will accommodate all phases of the retrieval activities. The retrieval project has expressed the following preferences.

    - Wet sludge is preferred.

    - Installation of any new in-tank instruments is undesirable.

    - Rinse water will be added to tank 241-C-106 during equipment removal starting in FY 1994.

    - Lower liquid level with more flexible level control is desirable.

2. The considered mitigation/remediation options must meet the safety criteria (see Section 3.1.2).

3. If necessary, relative cost versus benefit for all proposed options should be evaluated.

4. The secondary hazards resulting from viable options must be evaluated and resolved.

3.2.4 Evaluate Approaches by Criteria

The planned accelerated retrieval in FY 1997 was proposed as one of DOE's Hanford Site Safety Initiatives. It is expected that the high-heat safety issue will be permanently resolved shortly after retrieval is initiated. The focus of this safety program plan is on safe, low-cost, interim storage of the high-heat waste until retrieval in FY 1997. This logic step is shown in Figure 3-2, logic 2.4.

The current method of cooling waste in tank 241-C-106 was initiated in the 1970s. Although the selection was made before this safety program logic was developed, the method is very effective and economical. A "retrofit" comparison of the advantages and disadvantages for the current approach and other competing alternatives is summarized in this section. All approaches identified here show promise in mitigating the safety issue. A series of thermal analyses (Bander 1993b) were performed to determine the relative effectiveness of these options.

Forced ventilation with water added. This is the current cooling method. The predicted conservative maximum waste temperature is 110 °C (230 °F). This corresponds to the maximum temperature of 71 °C (160 °F) recorded at Riser 8 TC tree (Bander 1993a). The thick liquid layer (about 0.3 m [1 ft]) on top of the sludge provides effective evaporation cooling and enhanced thermal conductivity. The water also guarantees wet sludge for uncomplicated retrieval. The only identified secondary hazard is the potential environmental impact if a tank leak were to occur.

To minimize the secondary hazard, a thermal analysis has been performed to explore adding a limited amount of water through an above-surface sprinkler system. The purpose is to wet the sludge by providing interstitial liquid to maintain high thermal conductivity. According to a recent thermal analysis (Bander 1993b), the maximum waste temperature is conservatively estimated to be about 121 °C (250 °F). The increase is due to the effect of reduced evaporation. This modified method will be an alternative approach to the contingency plan if a tank leak occurs. This modified method may not have been sufficiently effective when the high-heat problem surfaced in 1970. An above-surface sprinkler system is being designed by the Waste Tank Engineering (Mechanical Systems) organization for use as a contingency.

Other methods to minimize this secondary hazard are also being studied. One method uses CRYOCELL technology proposed by Scientific Ecology Group, Inc. (SEG Proposal No. WS-9108-418) to provide a freezing underground catcher. However, it is considered too expensive ($6,000,000 plus operating costs) and might cause freezing damage to the concrete. Also, there are concerns about safety and cost for long-term clean-up. This proposal has been declined for tank 241-C-106 application.

Forced ventilation alone. If water is not added, forced ventilation will eventually dry up the waste and degrade the thermal conductivity. As a result, the maximum waste temperature would rise above 177 °C (350 °F) as predicted by a recent thermal analysis (Bander 1993b) using 0.25 Btu/hr-ft-°F thermal conductivity. The predicted temperature exceeds the OSR safety limit for tank 241-C-106. Consequently, this option should not be considered if retrieval will take place in FY 1997.

Refrigerated ventilation. A refrigerated ventilation system (open or closed) is being studied as an alternative or contingency cooling method. A conservative thermal analysis (Bander 1993b) concluded that, with refrigerated ventilation, the maximum waste temperatures are predicted to be less than the OSR safety limit of 177 °C (350 °F) (Figure 3-5). A detailed study of an air chiller is being performed by the Mechanical Systems organization under Tank Waste Remediation System.

Waste retrieval. This method is the most expensive option, but it is identified as the only remediation method. Past-practice sluicing is Westinghouse Hanford Company's recommendation for earliest resolution of the high-heat safety issue and for meeting the requirement to initiate the demonstration of SST waste retrieval for Tri-Party Agreement Milestone M-07-00 (Project W-320, "Tank 241-C-106 Sluicing"). Past-practice sluicing is anticipated to remove at least 70% of the heat-generating sludge, allowing addition of cooling water to cease, resulting in tank 241-C-106 being safe and stabilized. Project W-320's schedule has been accelerated in accordance with the requirement of DOE Safety Initiative 6e.

By comparison, it is obvious that the current method (water added with forced ventilation) is the most effective and economical means to remove heat from the tank. The only induced secondary hazard is the potential environmental impact if a tank leak were to occur. This hazard can be safely and effectively controlled by installing an air chiller system. An above-surface sprinkler system is also considered as backup to the air chiller system as a contingency method. More detailed plans and tasks are described in Section 4.0.

3.2.5 Implement the Mitigation/Remediation Option

This logic step is shown in Figure 3-2, logic 2.5. Based on the evaluation described in Section 3.2.4, the current practice remains the most economical and effective method of cooling the waste. Although there is a secondary hazard if a leak occurs, the hazard can be safely controlled by implementing contingency actions (i.e., air chiller and/or sprinkler system). Before the waste is retrieved in FY 1997, the current cooling method is expected to continue. In case of a confirmed leak, contingency actions to install an air chiller and/or above-surface sprinkler system will be initiated immediately.

All other alternatives to reduce the severity or to eliminate the safety issue are identified in Section 3.2.4. The logic described here is consistent with the remediation recommendation documented in the *Hanford Defense Waste Environmental Impact Statement* (DOE 1987).

3.3 MAINTAIN REQUIRED MONITORING

The safety of tank 241-C-106 can be confirmed and achieved with existing monitoring systems. Although repair and replacement may be performed as needed, no enhanced monitoring systems or instruments are required. This part of the logic diagram is displayed in Figure 3-3.

3.3.1 Identify Parameters to Monitor

This logic step is shown in Figure 3-3, logic 3.1. The waste temperature is directly related to the safety status of the high-heat tank. Therefore, it is logical to monitor the waste temperature to ensure tank safety. Although liquid level is also monitored, the primary purpose of the liquid level monitoring is to confirm whether the tank is sound or leaking. Based on past operating history, it has been established that waste temperature varies seasonally within a narrow band if a liquid level is maintained at the current cooling configuration.

3.3.2 Develop Monitoring Plan

This logic step is shown in Figure 3-3, logic 3.2. The monitoring of waste temperature and liquid level for tank 241-C-106 is required weekly (Welty and Vermeulen 1991). Although ventilation and psychrometric parameters are also monitored, waste temperature and liquid level are directly related to the high-heat safety issue.

3.3.3 Determine Control Limit

This logic step is shown in Figure 3-3, logic 3.4. The upper control limit for waste temperature is 149 °C (300 °F) according to the OSD (Wodrich 1992). The control band for the liquid level measured from the side bottom of the tank is between 189 and 201 cm (74.5 to 79 in.).

3.3.4 Develop Contingency Plans

This logic step is shown in Figure 3-3, logic 3.5. The contingency plan is addressed in WHC-EP-0473, *Action Plan for Response to Excessive Temperature in High Heat Source Waste Tank 241-C-106 at the Hanford Site* (DeFigh-Price and Wang 1993). An updated contingency plan will be issued in February 1995. There are two thermocouple trees in tank 241-C-106; only one (Riser 8) records representative temperatures. The TC probes on Riser 14 do not record representative waste temperature most of the time because of poor contact. If two probes, or the bottom probe alone, in the Riser 8 tree fail, operability of the tree will be restored as soon as possible. The liquid surface measurement is performed using both Enraf and Food Instrument Corporation (FIC) devices. If both devices are inoperational, manual measurement shall be performed at the same required frequencies.

3.4 SCHEDULE IMPLICATIONS

The schedule for the major tasks (see Section 4.0) supporting the high-heat safety program plan is summarized in Section 5.0.

Figure 3-1. High-Heat Tank Safety Issue Resolution Logic (Evaluate the Problem).

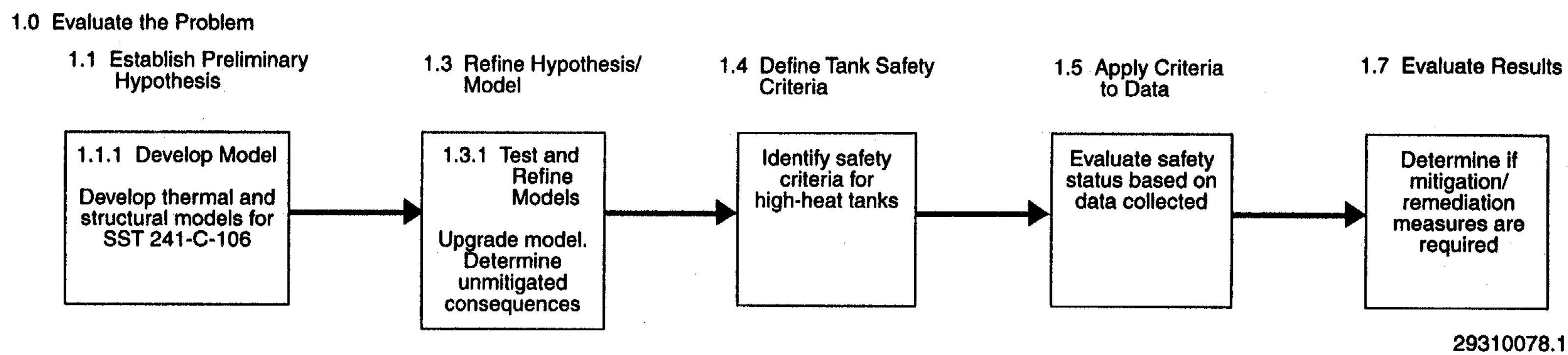


Figure 3-2. High-Heat Tank Safety Issue Resolution Logic (Mitigation/Remediation).

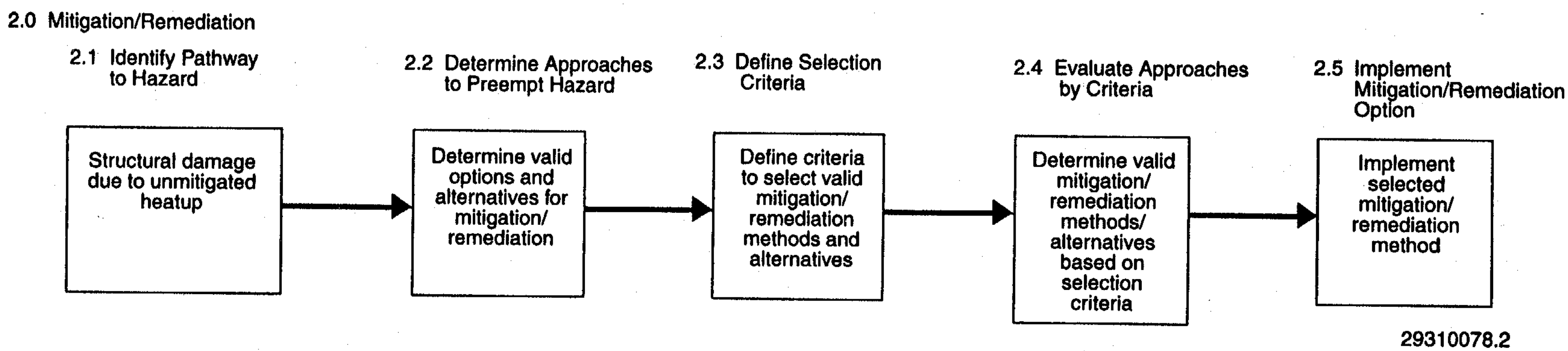


Figure 3-3. High Heat Tank Safety Issue Resolution Logic (Maintain Required Monitoring).

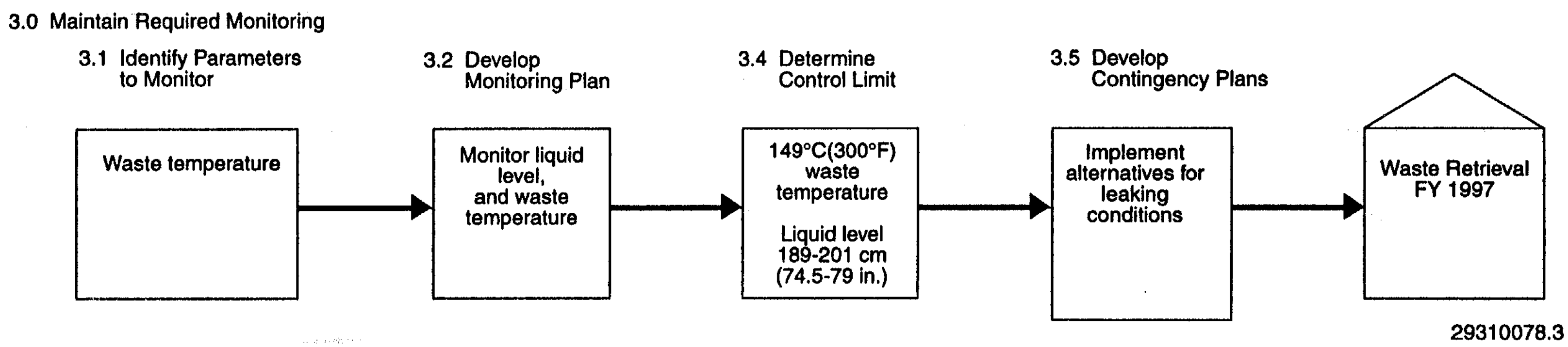


Figure 3-4. Unmitigated Consequence for 241-C-106 Heatup.

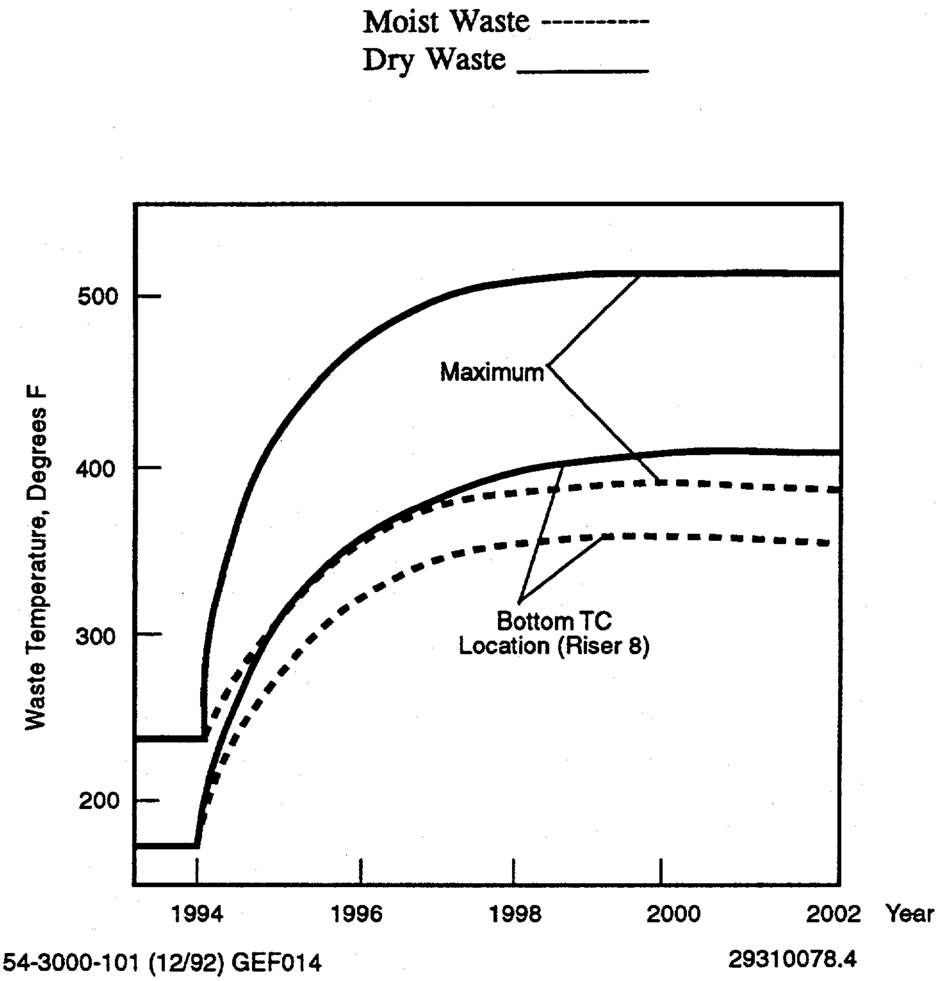
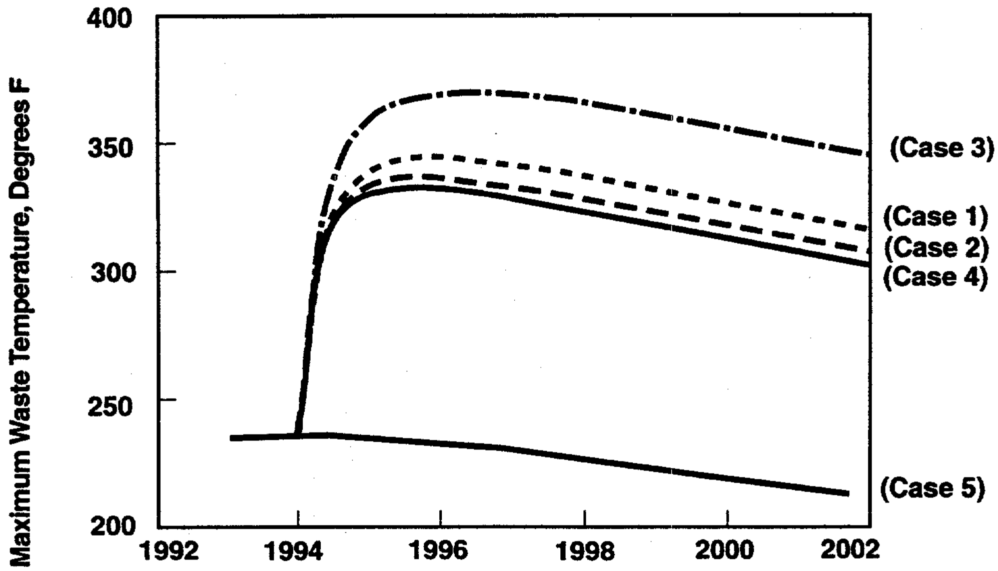


Figure 3-5. Maximum Calculated Temperatures for Tank 241-C-106.



Case 1. Dry waste, inlet air of 2,400 cfm at 12°C (53°F)

Case 2. Dry waste, inlet air of 2,400 cfm at 4°C (40°F)

Case 3. Dry waste, inlet air of 2,400 cfm at 31°C (88°F)

Case 4. Dry waste, inlet air of 6,000 cfm at 12°C (53°F)

Case 5. Moist waste, inlet air of 2,400 cfm at 12°C (53°F)

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4.0 HIGH-HEAT SAFETY ISSUE RESOLUTION MAJOR TASKS

This section of the high-heat safety issue resolution program plan provides task descriptions and identifies deliverables for each major task and proposal consistent with the logic in Section 3.0. The identified tasks and proposals are categorized into the following five groups:

1. Completed tasks
2. Ongoing tasks
3. Scheduled tasks
4. Proposals only
5. Tasks without firm schedules to be initiated immediately as an integral part of the contingency action plan.

Tasks in categories (4) and (5) do not have schedules and completion dates.

4.1 EVALUATE THE PROBLEM

The tasks in this section are related to evaluating and defining the high-heat safety issue.

4.1.1 Establish and Refine the Hypothesis/Model

This subsection describes the major tasks in developing thermal and structural models. All the tasks related to this subsection were completed before FY 1995.

4.1.2 Develop Thermal Model for Tank 241-C-106

A simplified conservative model for tank 241-C-106 was developed in 1992 (Bander 1992) based on steady-state thermal data recorded in the past. The estimated heat generation rate was 150,000 Btu/hr based on 1989 decay heat.

Between January 25 to June 7, 1992, the exhauster fan on the ventilation system was out of service, and very little evaporation took place. During this period, no heat was removed from the tank, thus providing valuable transient heatup data for calibrating the earlier simplified model. The transient data were used for performing an upgraded thermal analysis (Bander 1993a), and a revised heat load of 118,300 Btu/hr (based on 1989 decay heat) was calculated.

It has been observed that thermocouple tree in Riser 14 recorded erratic temperature readings in the past. Since 1982, maximum temperature readings from 38 °C to 104 °C (100 °F to 220 °F) have been recorded by TC #1 (bottom probe) in Riser 14. Most of the time, the thermocouple tree in Riser 14, which is 6 m (20 ft) from the tank center, read lower waste temperatures than the tree in Riser 8, which is 9 m (30 ft) from the tank center. Field tests verified that all the TC probes in Riser 14 were sound. Consequently, two theories were developed by the thermal analysts. One theory was that the contact between the heat-generating waste and the TC probes at Riser 14 was poor, due to a variety of reasons. The poor contact yielded lower than normal temperature readings. This theory was sometimes referred to as the "chimney effect." The second theory speculated that a "liquid core" was responsible for the low temperature readings at Riser 14 because of enhanced local convective heat transfer.

In 1994, many studies were performed after a post-process-test unusual occurrence involving Riser 14 temperature anomalies. The process test was designed to reduce the liquid inventory in tank 241-C-106. The temperature fluctuation between 49 °C and 104 °C (120 °F and 220 °F) proved that the first theory is correct. The conclusion was documented in a number of 1994 studies (Thurgood 1994, Alumkal 1994, and Eyler 1994). The same thermal model has been used for a number of sensitivity studies on the effect of ventilation rate, evaporation cooling, inlet air temperature, etc. A planned core-sampling analysis to be completed in FY 1995 will provide actual thermal conductivity and permeability data for the waste at various moisture levels.

TASKS:

1. Develop and update a thermal model for tank 241-C-106 and predict total heat load and long-term thermal responses based on current operating conditions and sensitivity study of key parameters.

   Deliverable:
   1. WHC-SD-WM-ER-200, *Revised Thermal History of Tank 241-C-106.*
   2. WHC-SD-WM-ER-290, *Tank 241-C-106 Parametric Studies in Support of Safety Alternative Process.*

   Status: Completed.
   1. Bander 1993a.
   2. Bander 1993b.

4.1.3 Develop Structural Analysis Model for Tank 241-C-106

A structural model, which accurately reflects concrete properties as a function of time and temperature exposures based on the revised thermal analysis (Bander 1993a), has been developed for tank 241-C-106. This model accounts for concrete property response temperature and also considers dead, live, and thermal loads into the twenty first century.

The model calculates the expected residual strength based on a detailed past thermal and waste load history. It also determines whether the tank can meet all natural forces requirements for DOE Order 6430.1 (DOE 1989) through the year 2002. (This work was funded by the Waste Retrieval Program.)

TASKS:

1. Evaluate the structural response of tank 241-C-106 and safety margin (residual strength) for scheduled retrieval based on the revised thermal history.

   Deliverable: WHC-SD-W320-ANAL-001, *Tank 241-C-106 Structural Integrity Evaluation for In Situ Conditions.*

   Status: Completed (Julyk 1994).

4.1.4 Define Tank Safety Criteria

For this program plan, it is assumed that concrete structural damage of the tank is unacceptable for any reason or at any foreseeable time (even if it does not lead to a significant release of high-level waste). Based on this assumption, a maximum waste temperature limit of 177 °C (350 °F) was given as a conservative OSR safety limit. In turn, an even more conservative maximum waste temperature of 149 °C (300 °F) has been used as the OSD operating limit.

The Tank Waste Remediation System (TWRS) Waste Retrieval Program investigated the residual structural strength of the load-bearing structure as a result of past-practice thermal loading (Julyk 1994). According to the investigation report, the residual strength was demonstrated to be greater than required for potential retrieval needs or any other requirements such as natural forces resistance. Therefore, the maximum temperature for the waste could be increased, which would allow a greater reduction or even the elimination of cooling liquid. Based on the current retrieval schedule of FY 1997, this proposal is not needed for interim storage and eventual remediation of tank 241-C-106.

According to the current thermal model, the maximum waste temperature is a few inches from the bottom toward the center of the tank. A concern over the "bumping" effect on the steel liner and the concrete is being investigated. The phenomenon of "bumping" is defined as the local vaporization effect at a hot region of the waste when the waste temperature exceeds the boiling point. The result of the investigation has been documented in a Pacific Northwest Laboratory (PNL) report, and will provide guidance for contingency actions for a leaking tank.

TASKS:

1. Investigate possible effects on structural integrity due to "thermal bumping."

   Deliverable: A PNL letter report on Tank 241-C-106 Hardpan Studies.

   Status: Completed (Friley 1994).

4.1.5 Apply Criteria to Data

Data from the 1992 ventilation failure event were applied to upgrade the thermal model in 1993 (Bander 1993a). Although the model has been much improved, a better understanding of the behavior of the thermal properties of the waste (such as thermal conductivity and specific heat at dry and wet conditions) is required. The following three tasks have been identified.

TASKS:

1. Upgrade the thermal model and analyses using the transient data collected from the 1992 ventilation failure event.

   Deliverable: WHC-SD-WM-ER-200, *Revised Thermal History of Tank 241-C-106.*

   Status: Completed (Bander 1993a).

2. Obtain core sample and its analytical results to provide laboratory measured data (thermal conductivity, specific heat, etc.) for upgrading thermal analyses.

   Deliverable: Laboratory report documenting thermal properties.

   Status: The best-estimate schedule for obtaining two rotary-mode sample cores is May 1995. It takes another six months for the laboratory to analyze and issue the sampling report. It is expected the final laboratory report will be issued in November 1995.

3. Upgrade the thermal model and analyses using data obtained from the scheduled core-sample analysis.

   Deliverable: A technical report (WHC-SD-WM-ER-*xxx*) documenting the updated thermal analyses.

   Status: Complete thermal analysis report in February 1996.

4.1.6 Evaluate Results

The predictions of unmitigated consequences have been obtained using the updated thermal model. The results are presented in Figure 3-4 for simulated wet and dry waste, respectively.

TASKS:

1. Predict unmitigated consequences for high-heat tank 241-C-106.

   Deliverable: WHC-SD-WM-ER-290, *Parametric Studies in Support of Safety Alternative Process.*

   Status: Completed (Bander 1993b).

4.2 MITIGATION/REMEDIATION

As described in Section 3.2, the selected methods to mitigate and/or remediate the high-heat safety issue include ventilation, adding water, refrigerated air, waste retrieval, or a combination of the above. The implementation of these options and the resolution of identified secondary hazards resulting from these processes are delineated in this section.

4.2.1 Ventilation/Added Water

This is the current method of cooling the waste in tank 241-C-106. The cooling method of forced ventilation with water added has been used since the 1970s and is very effective. The current ventilation level is about 71 m^3/min (2,500 ft^3/min) (exhauster capacity is 170 m^3/min [6,000 ft^3/min]), and the water addition rate is approximately 5,700 L (1,500 gal) per week. Since November 1993, "treated water" has been used to replace raw water. The chemical additive for the treated water is mainly sodium sulfite (brand name Dearborn-66). The pH value of the treated water is between 10 and 11. The purpose of adding treated water is to reduce coast-line corrosion.

As mentioned in Section 3.2, the only identified drawback to this cooling method is the potential environmental impact in the event of a tank leak . If a leak were to occur, either the waste would be allowed to heat up, or cooling water would be added to make up for the leak. A number of tasks are identified to mitigate or remediate the environmental impact of a leaking tank. These tasks are being studied as part of the backup or contingency action plan.

TASKS:

1. Perform a thermal analysis with ventilation cooling alone. The purpose is to simulate a leaking tank without water addition. A sensitivity study is included to estimate the effects of wet and dry waste and at various ventilation levels from 71 m^3/min to 170 m^3/min (2,500 to 6,000 ft^3/min). The results of this task will help determine the best action to take if a tank leak were to occur.

   Deliverable: A WHC-SD-WM-ER-290, *Parametric Studies in Support of Safety Alternative Process.*

   Status: Completed (Bander 1993b). The results are shown in Figure 3-5. It can be concluded that ventilation alone without water addition (dry waste simulation) would not maintain the maximum waste temperature under the 177 °C (350 °F) OSR safety limit. However, with air chiller installation (reduced air inlet temperature), it is possible to maintain maximum waste temperatures below the 177 °C (350 °F) OSR limit.

2. Develop a method to add treated water (pH = 10 to 11) to tank 241-C-106. The purpose is to reduce the corrosion rate of the steel liner so that potential leaks can be prevented or delayed.

   Deliverable: Develop a recipe and procedures to add treated water to tank 241-C-106.

   Status: Completed. A recipe of treated water was developed in October 1993. A Process Charge Authorization (ETF-94-008) to add treated water to tank 241-C-106 was approved in October 1993. Since November 1993, treated cooling water has been used for routine water addition to tank 241-C-106.

3. Design an in-tank sprinkler system. If analysis indicates that significant degradation in thermal conductivity exists for dry waste, an in-tank sprinkler system is recommended to provide adequate moisture in the waste if a tank leak were to occur. The moisture level is controlled through maintaining an optimum amount of interstitial liquid that will not leak out. The proposed sprinkler system can also be used as a backup to an air chiller design.

   Deliverable: Conceptual design report.

Status: Completed (Rensink 1994). Installation of the system will not take place unless a leaking tank condition is confirmed. It is estimated that implementation of an in-tank sprinkler system will take less than three months from the time a tank leak is confirmed.

4. Conduct a process test to minimize liquid inventory. The purpose of the process test is to reduce hydraulic head and liquid inventory in tank 241-C-106 so that environmental impact can be minimized for a leaking tank.

   Deliverable: Complete Safety Alternate Process Test in high-heat tank 241-C-106 and issue report to DOE-RL.

   Status: Completed (Payne 1994). A process test plan was prepared (Sutey 1993); the process test was initiated in March 1994 and ended in June 1994. This is the first half of the requirement specified in Tri-Party Agreement Milestone M-40-05 (due date: September 1995). The second half of the Milestone is specified in 4.2.3. The same Tri-Party Agreement Milestone has been accelerated by DOE's Safety Initiative 2x for June 1995 completion.

5. Update contingency plan WHC-EP-0473 to deal with possible tank leak situations.

   Deliverable: Revision to WHC-EP-0473, *Action Plan Response to Excessive Temperature in High Heat Source Waste Tank 241-C-106 at the Hanford Site*.

   Status: The high-heat action plan (WHC-EP-0473) is being revised and will be issued as Revision 2 in February 1995.

6. Update thermal analyses with the data obtained from the waste sample analysis. The updated results will be used for verification of past thermal/safety analyses and possible modification of system designs for contingency actions.

   Deliverable: A WHC-SD-WM-ER-*xxx* report documenting updated analyses.

   Status: Scheduled to be completed in February 1996 (assume that two push-mode core samples will be available by May 1995, and the laboratory report will be issued by November 1995).

7. A CRYOCELL frozen barrier technology was proposed by Scientific Ecology Group, Inc. (SEG Proposal No. WS-9108-418) to "catch" leaking waste, if needed.

Deliverable: None.

Status: The SEG proposal was reviewed and put on hold as a low-priority option because of the high cost (more than $6,000,000 initial installation plus an unspecified annual operating cost) and the possible negative impact of the freezing effect on concrete.

4.2.2 Ventilation

The ventilation alone option was evaluated in Section 3.2.4. The conclusion was that this method was not adequate for safe cooling of tank 241-C-106 for interim waste storage at this time. No specific tasks are planned for this option.

4.2.3 Refrigerated Ventilation

Based on the results of a conservative thermal analysis (Bander 1993b), the refrigerated ventilation (air chiller) method appeared very promising. The following two tasks are identified for this option.

TASKS:

1. Perform a thermal analysis to simulate refrigerated ventilation cooling. A sensitivity study is performed for ventilation levels ranging from the current 71 m^3/min (2,500 ft^3/min) to the design maximum of 170 m^3/min (6,000 ft^3/min) and for inlet air temperatures varying from 5 to 12 °C (40 to 53 °F).

   Deliverable: WHC-SD-WM-ER-290, *Parametric Studies in Support of Safety Alternative Process.*

   Status: Completed (Bander 1993b).

2. Perform engineering studies to select the best air chiller option for emergency conditions as well as enhanced operating conditions.

   Deliverable:
   1. WHC-SD-WM-ES-279, *Air Cooling/Heat Removal from Tank 241-C-106.*
   2. An engineering study or letter report on air chiller selection and recommended installation option.

   Status:
   1. Completed (Kriskovich and Brodsky 1993).

2. An engineering study is being performed to evaluate three options of air chiller designs and installations. The study will be completed in February 1995. This is the second half of the requirement specified in Tri-Party Agreement Milestone M-40-05 (due date: September 1996). The same Tri-Party Agreement Milestone has been accelerated by DOE's Safety Initiative 2x for June 1995 completion. A chiller designed for Project W-320 is expected to be installed and operational by 10/95.

4.2.4 Retrieval of Waste

To completely resolve the high-heat safety issue, retrieval is identified as the only remediation method. This task is being aggressively pursued as Project W-320, which will incorporate the past-practice sluicing method to retrieve waste from tank 241-C-106. This task is funded by Tank Waste Project W-320. Completion of this task will meet the requirement to initiate the demonstration of SST waste retrieval (tank 241-C-106 is selected as the demonstration tank) for Tri-Party Agreement Milestone M-07-00 scheduled for completion by September 1997. To accelerate the schedule, DOE further requested that early retrieval be initiated in October 1996 through DOE's Safety Initiative 6e (DOE 1993).

4.3 MAINTAIN REQUIRED MONITORING

The existing liquid level and temperature monitoring systems for monitoring tank 241-C-106 are adequate. No additional monitoring capability, except repair and maintenance, is anticipated at this time. Although ventilation and psychrometric data are also monitored, waste temperature and liquid level are required monitoring parameters per OSR (Wodrich 1992). However, the following tasks are being considered for future applications.

TASKS:

1. The FIC in tank 241-C-106 has not been reliable in FY 1993. Replacement/repair of the FIC is scheduled for FY 1994.

   Deliverable: Replacement/repair of FIC.

   Status: Completed. The existing FIC was repaired in September 1994. Also, an Enraf device (an improved surface level measuring device using a buoyancy/tension wire gauge) was installed in October 1994. Tank 241-C-106 was one of 21 tanks scheduled to have Enrafs installed in 1994 as a safety initiative to upgrade leak detection equipment for SSTs with liquid surfaces. This work was performed by Tank Farm Upgrades.

2. Both TC trees and the FIC in tank 241-C-106 are to be connected to the Tank Monitoring and Control System (TMACS) in FY 1994.

   Deliverable: Connect TC trees and FIC to TMACS.

   Status: Completed. Both TC trees and FIC, as well as Enraf, were connected to TMACS in FY 1994.

3. Conduct an in-tank video survey of the wall condition to verify visual structural integrity.

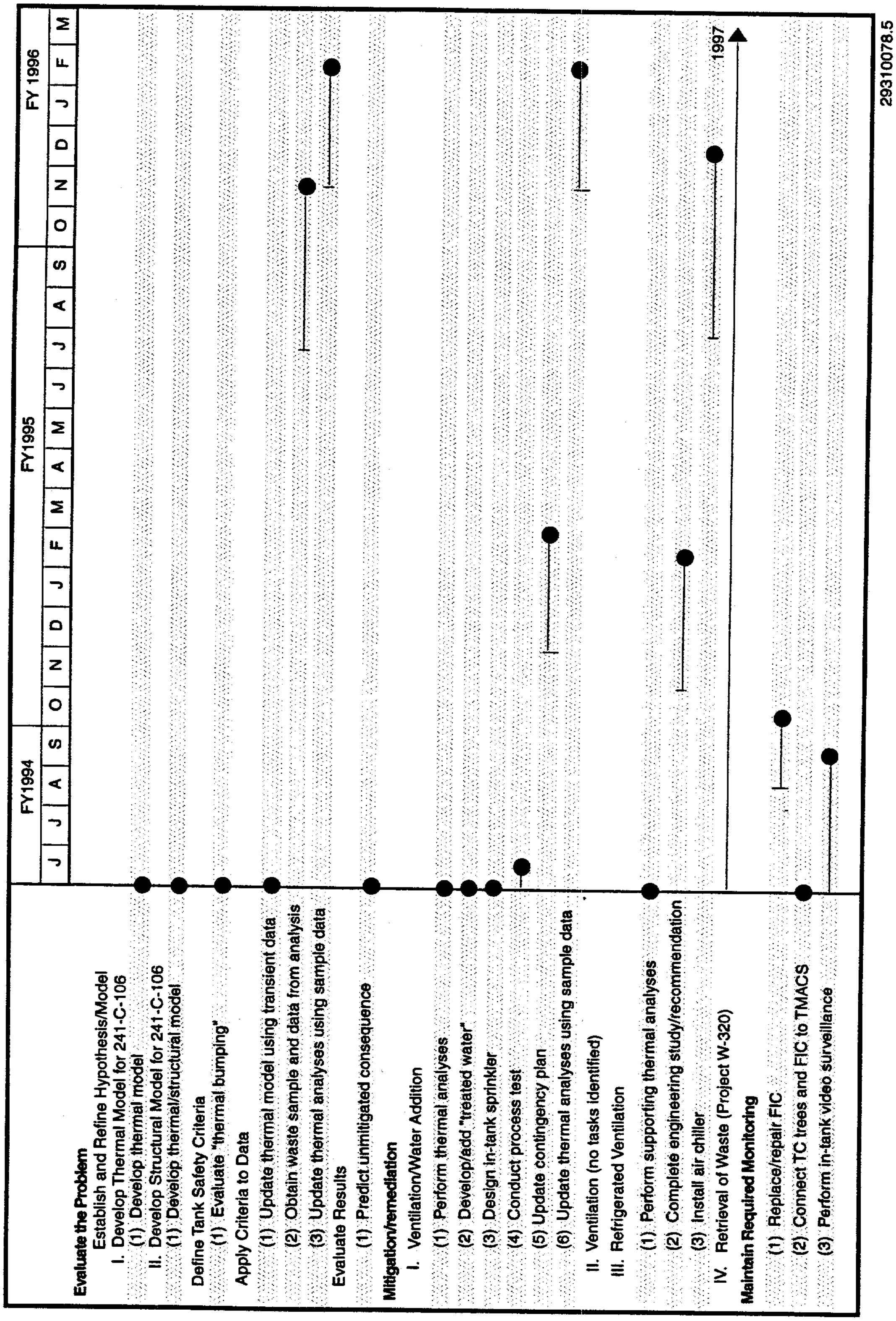
   Deliverable: In-tank video surveillance.

   Status: Completed. Half a dozen entries were performed in FY 1994 for in-tank video activities. Visual inspection of the tank structural integrity was satisfactory. No apparent structural damages were observed.

5.0 PROGRAM SCHEDULE

Figure 5-1 is the schedule supporting implementation of the high-heat safety issue resolution program at the level of funding established by the DOE *Fiscal Year 1994 Five-Year Plan* (activity data sheet 1110-0; task description document 1110-0-AF). The schedule is subject to modification depending on changes to funding levels and supporting activities.

Figure 5-1. High-Heat Tank Safety Issue Resolution Program Schedule Summary for Fiscal Years 1993, 1994 and 1995.



6.0 REFERENCES

Alumkal, W. T., 1994, *Lessons Learned and Action Plan Resulting from Unexpected Temperature Changes in Tank 241-C-106*, (letter report 9457194 to T. R. Sheridan, DOE-RL, November 7), Westinghouse Hanford Company, Richland, Washington.

Bailey, J. W., 1993, *Tank 241-C-106 Leak Study*, WHC-SD-WM-ES-218, Westinghouse Hanford Company, Richland, Washington.

Bander, T. J., 1992, *Thermal History of Tank 241-C-106*, WHC-SD-WM-ER-161, Westinghouse Hanford Company, Richland, Washington.

Bander, T. J., 1993a, *Revised Thermal History of Tank 241-C-106*, WHC-SD-WM-ER-200, Westinghouse Hanford Company, Richland, Washington.

Bander, T. J., 1993b, *Tank 241-C-106: Parametric Studies in Support of Safety Alternative Process*, WHC-SD-WM-ER-290, Westinghouse Hanford Company, Richland, Washington.

Bander, T. J., 1994, *Evaluation of Heat Sources in High-Heat Single Shell Tanks*, WHC-SD-WM-ER-333, Westinghouse Hanford Company, Richland, Washington.

DeFigh-Price, C., and O. S. Wang, 1993, *Action Plan for Response to Excessive Temperature in High Heat Source Waste Tank 241-C-106 at the Hanford Site*, WHC-EP-0473, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

DOE, 1987, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Waste (HDW-EIS)*, 1987, Hanford Site, Richland, Washington.

DOE, 1993, *TWRS Safety Initiatives*, Hazel R. O'Leary, Secretary of Energy, U.S. Department of Energy, Washington, D. C., September 1993.

DOE-RL, 1989, Hanford Plant Standards, "Standard Design Criteria," Rev. 11, DOE-RL Order 6430.1B, DOE-Richland Operations Office, Richland, Washington

Ecology, EPA, and DOE, 1991, *Hanford Federal Facility Agreement and Consent Order*, Vol. 1, "Second Amendment, September 1991," Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Vol. 2, "Calendar Year 1990 Annual Update," Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Esvelt, C. A., 1990, *Interim Stabilization of Tank 106-C Engineering Study*, WHC-SD-W139-ES-001, Westinghouse Hanford Company, Richland, Washington.

Eyler, L. L., 1994, *Assessment of Tank 241-C-106 Temperature Response Indication*, ASD/LLE-94-003, Rev. 2, Battelle Pacific Northwest Laboratory, Richland, Washington.

Friley J. R., 1994, *Report on Tank 106-C Hardpan Studies*, Letter Report A&MS/JRF-002/94, Battelle Pacific Northwest Laboratory, Richland, Washington.

Harmon, H. D., 1991, *Safety Measures for Waste Tanks at the Hanford Site, Richland, Washington* (letter to R. E. Gerton, DOE-RL, January 8), Westinghouse Hanford Company, Richland, Washington.

Henderson, J. M., 1993, *Tank 106-C Sluicing Letter Report* (letter report 935041 to N. L. Nichol, January 15), Westinghouse Hanford Company, Richland, Washington.

Julyk, L. J., 1994, *Tank 241-C-106 Structural Integrity Evaluation for In Situ Conditions*, WHC-SD-W320-ANAL-001, Westinghouse Hanford Company, Richland, Washington.

Kriskovich, J. R. and K. Brodsky, 1993, *Air Cooling/Heat Removal from Tank 241-C-106*, WHC-SD-WM-ES-279, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Pauly, T. R., and M. M. Torgerson, 1987, *Tanks 105-C and 106-C Stabilization Study*, RHO-RE-EV-97, Rockwell Hanford Operations, Richland, Washington.

Payne, M. A., 1994, *High Heat Safety Program: FY 1994 Milestone for High-Heat Tank 241-C-106* (leter report 9456500 to R. E. Gerton, DOE-RL, September 30), Westinghouse Hanford Company, Richland, Washington.

Public Law 101-510, Section 1317, *National Defense Authorization Act for Fiscal Year 1991*, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation," U.S. Congress, Washington, D.C. [Also referred to as the Wyden Amendment]

Rensink, G. E., 1994, *Tank 241-C-106 Sprinkler Syatem and Cooling System Report*, WHC-SD-WM-RPT-089, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Squires, K. G., G. A. Barnes, T. R. Benegas, R. R. Cruz, J. M. Henderson, E. L. Kunkler, J. D. Ludowise, and S. W. Shaw, 1991, *Engineering Study for Partial Retrieval of Tank 241-C-106,* Westinghouse Hanford Company, Richland, Washington.

Sutey, M. J., 1993, *Process Test Plan: Tank 241-C-106*, WHC-SD-WM-PTP-026, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Thurgood, M. J., B. C. Fryer, S. W. Claybrook, D. M. Ogden, S. A. Wood, K. Sathyanarayana, 1994, *Tank 106-C Thermal Hydraulics Analysis Related to the March 10-June 15, 1994 Process Test and Temperature Rise of Riser 14 Thermocouples*, NAI-940708-1, Numerical Applications, Inc., Richland, Washington.

Welty, R. K. and N. J. Vermeulen, 1991, *Waste Storage Tank Status and Leak Detection Criteria*, WHC-SD-WM-TI-357, Rev. 1G, Westinghouse Hanford Company, Richland, Washington.

Wodrich, D. D., 1992, *Operating Specification of Single-Shell Waste Storage Tanks*, OSD-T-151-00013, Westinghouse Hanford Company, Richland, WA.

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