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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 (SST) 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 extended periods. The heat is generated from the radioactive decay of waste material (primarily ^{90}Sr) inadvertently transferred into the tank in the late 1960s. To mitigate this 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 to cool the waste. The method is very effective. Other alternatives are also evaluated. The "safe" concrete temperature limit has been determined conservatively to be 177 °C (350 °F) in the Safety Analysis Report/Operating Safety Requirements (SAR/OSR). The Operating Safety Document (OSD) states that the waste temperature should be less than 149 °C (300 °F). Although justification for a higher limit can be made, there is no need or plan to increase this temperature limit.

At this time, the only viable solution identified to resolve this safety issue is the removal of heat generating waste in the tank. This solution is being aggressively pursued as the permanent solution to this safety issue and also to support the present waste retrieval plan. Tank 241-C-106 has been selected as the first SST for retrieval. The current cooling method and other alternatives addressed in this program plan are the mitigating means to 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 exceeding the 149 °C (300 °F) operating limit is currently accomplished by evaporative cooling through High-Efficiency Particulate Air (HEPA) filtered active ventilation. Cooling is supported by periodically adding water to maintain a liquid cover over the sludge and for enhanced thermal conductivity and evaporation for heat transfer. At the current ventilation level (71 cubic meters per minute or 2,500 cubic feet per minute), the recorded maximum waste temperature is approximately 71 °C (160 °F). The liquid in the tank to promote cooling definitely exceeds the interstitial holdup of the tank's sludge. The fraction of the liquid *content exceeding the interstitial holdup liquid capacity is defined as the drainable liquid. If a leak occurs, environmental concern would result from the current cooling method. This program plan also identifies contingency actions and tasks to deal with this concern.*

The 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 alternatives according to resolution logic. The third part identifies major tasks and alternatives for mitigation and resolution of the safety issue. Selected tasks and best-estimate schedules are also summarized in the program plan.

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LIST OF TERMS

DST	Double-Shell Tank
EM	U.S. Department of Energy Headquarters Environmental Restoration and Waste Management
FIC	Food Instrument Corporation
FY	Fiscal Year
HEPA	High-Efficiency Particulate Air
OSD	Operating Safety Document
OSR	Operating Safety Requirements
RR	Restoration and Remediation
SAR	Safety Analysis Report
SST	Single-Shell Tank
TC	Thermocouple
TMACS	Tank Monitoring and Control System
TPA	Tri-Party Agreement
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/h) or more. In 1993, 11 SSTs were listed as high-heat tanks (Hanlon 1993). 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 (Letter from H. D. Harmon, Westinghouse Hanford Company to DOE-RL, January 8, 1991).

The safety issue for high-heat tank 241-C-106 involves the potential release of high-level nuclear waste as a result of waste tank structural damage caused by the overheating of the waste tank concrete structure. The heat is generated from the radioactive decay of waste material stored in the tank. For tanks that may overheat, the temperature of the waste is

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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:

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

maintained by an active cooling system in accordance with the following Operating Safety Document (OSD) requirements (OSD-T-151-00013) (Wodrich 1992):

- 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/h with a conservative estimate of 158,000 Btu/h (Pauly and Torgerson 1987). More recent estimates in 1993 place the heat rate at 110,000 $\pm$ 20,000 Btu/h (Bander 1993a).

In mid-1971, when waste temperatures in excess of 99 °C (210 °F) were observed in tank 241-C-106, the tank was immediately placed on forced-air ventilation. Since mid-1971, water has been added to the tank periodically 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 placed on inactive status since 1979. The added liquid has averaged approximately 22,700 L per month (6,000 gal per 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 this theory.

Routine surveillance of the tanks for leak detection is maintained by surface-level measurements and drywell radiation scan readings. The surface-level measurements are accurate to $\pm$ 0.63 cm ($\pm$0.25 in.) or about 2,650 L (700 gal). Any departure from historical periodic behavior of surface measurements results in an 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 not shown any indications of radiation migration. From 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 from January to June 1992. During that time, tank waste heated from 72 to 93 °C (161 °F to 199 °F) without adding water. The heatup transient during that period was not very rapid even without active ventilation and adding water (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 in a tank exceeding the interstitial holdup is defined as drainable liquid. A primary operational concern is the possibility of drainable liquid spilling into the ground if a leak occurs. 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. The 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 there is no viable alternative 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 was demonstrated to be greater than 0.25 Btu/h-ft-°F, then there could be other acceptable cooling alternatives 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) 1994. The thermal conductivity of the dry sludge is one of the key characteristics to be determined in the laboratory. At the same time, the retrieval option for stabilizing tank 241-C-106 continues to be developed.

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 are designated as "Watch List" tanks. See Letter from Westinghouse Hanford Company (WHC) to DOE-RL dated January 8, 1991.) Tank 241-C-106 was placed on the Watch List 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.

Engineering studies focusing on retrieval concepts for tank 241-C-106 (Esvelt 1990; Squires et al 1991) as well as a preconceptual engineering review in late FY 1991 identified costs in excess of $150,000,000 with eight to nine years to implement (based on the use of the preferred long reach arm confined sluicing system and with tank 241-C-106 being the only one to use this retrieval system). Two evaluations concluded that past-practice sluicing is an acceptable method for retrieval of tank 241-C-106: Tank Sluicing Letter Report 1993; and Tank 241-C-106 Leak Study (Bailey 1993). As a result, past-practice sluicing is WHCs recommendation for the 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 (TPA) Milestone M-07-00. The Department of Energy has identified tank 241-C-106 as the M-07-00 retrieval demonstration tank and the Washington Department of Ecology has concurred.

Project W-320 (Tank 241-C-106 Sluicing) will incorporate past-practice sluicing. It uses the tank-to-tank retrieval system, involving injection of controlled quantities of low pressure (150 psi) water 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 (DST) for interim storage, subsequent pretreatment, and eventual disposal. The heavy solids will settle in the DST, and the lighter supernatant will recirculate as sluicing liquid back to tank 241-C-106. It is anticipated that the past-sluicing method will remove a sufficient amount of the heat-generating sludge so that it will not be necessary to continue adding water and so that tank 241-C-106 will be stabilized.

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. Methods and alternatives selected to mitigate/resolve the safety issue are discussed. Funding for this activity is covered as part of the DOE Headquarters Environmental Restoration and Waste Management (EM) Activity Data Sheet 1110-0. Retrieval of the tank waste, aggressively pursued as a DOE safety initiative (DOE 1993), is funded by the Tank Disposal Program (ADS 1210).

The current need to maintain drainable water in tank 241-C-106 for cooling remains a potential environmental concern if a tank leak occurs. The program plan also addresses the options and alternatives that are available to resolve this concern by developing means to minimize drainable liquid that could leak.

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.

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 structure. 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 and accomplish either of the following:

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

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

The DOE planning base case for the Tank Waste Remediation Systems (TWRS) has been changed recently to retrieve 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 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) 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. It has been concluded that the permanent resolution of the high-heat waste tank safety issue is to retrieve some or all 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 Department of Energy to meet TPA 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 occurs. Alternative means of cooling for a leaking condition is being studied as a contingency plan. 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 mitigating concepts. The low-cost alternative cooling concepts and designs, such as air chiller and in-tank sprinkler systems, are discussed in Chapters 3.0 and 4.0. Together these constitute a stand-by contingency plan which will be implemented if a leak occurs before scheduled retrieval (DeFigh-Price and Wang 1993).

The overall resolution strategy for the high-heat safety issue is to continue with the current cooling method with a "stand-by" contingency plan. The contingency plan is to complete the conceptual designs 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 system designs 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 1994; 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.

A number of milestones related to the high-heat safety program include the following: the DOE safety initiative (DOE 1993) schedule to complete the process test for minimizing the liquid level in tank 241-C-106 by June 1995 (also TPA milestone M-40-05); the DOE safety initiative to start retrieving waste from tank 241-C-106 in FY 1997; and the TPA full-scale retrieval demonstration milestone M-07-00 by 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. A second interim objective is to resolve the potential environmental concern associated with the current cooling method if a leak should occur. All objectives will be in compliance with state and federal laws and regulations and will be consistent with company rules 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 realization of the safety issue, the evaluation of the current cooling method, the logic for selecting mitigation/resolution methods and tasks, the identification and strategy of contingency action plans, and the safe storage and monitoring of waste until waste retrieval is completed.

A decision has been made to retrieve the waste from tank 241-C-106 in FY 97. The 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.

2.6 KEY ASSUMPTIONS

The following key assumptions are associated with 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 9 to 10, 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, selected alternative cooling methods will be implemented as part of the contingency plan. The early completion of the alternative system design will minimize lead time for installation if a leak occurs.

- The program plan accommodates scheduled pre-retrieval activities, such as removal of in-tank instruments and equipment.

- The Waste Tank Safety Program will ensure that integrated plans are established and adhered to for the High-Heat Tank Safety Issue Resolution Program. Other projects and programs may also fund and implement the integrated plans.

- Core sampling and analysis costs will be paid by the Tank Waste Characterization Program.

- Retrieval planning and implementation costs for tank 241-C-106 will be paid by the Waste Tank Project W-320 (single-shell Tank Retrieval Project).

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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-HQ. The logic is generic, and it is used for the mitigation/resolution of all the Hanford Site Priority 1 safety issues. The generic DOE logic is designed for chemical reaction-based safety issues; 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 chapter 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 Hanford, the high-heat safety issue involves only 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, 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/h-ft-°F for wet sludge, and 0.25 to 0.5 Btu/h-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 becomes available. In FY 1994, 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 ventilation was down.

Because tank 241-C-105 received the same type of waste in lesser volumes as 241-C-106, it has similar thermal properties. A thermal analysis performed for tank 241-C-105 predicted the total heat generation rate was no more than 25,000 Btu/h. A process test, based on the recommendations of the thermal analysis and conducted since July 1993, has resulted in no water being added to tank 241-C-105. The liquid level and temperature response are being monitored throughout the test period which will last about a year. The process results will also be used for calibrating the analytical model for tank 241-C-106.

The model is expected to project conservative results of conceptual alternative designs. The projection will assist in validating and selecting alternative mitigation and resolution 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/h-ft-°F as representative thermal conductivity. In order to meet the safety criteria of 149 °C (300 °F), it is obvious that the safety issue 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 more than 45 years of operation*. Any future degradation of the structural strength of the concrete can be prevented by keeping the temperature of the tank waste to below any sustained temperatures seen to date.

A thermal-structural analysis was performed (July 1993) 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 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, have been incorporated in the current analytical model. It is expected that data from the planned core-sampling analysis will be inserted in the thermal model in FY 1994. This 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 practice is still used.

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*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).

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 still required to safely maintain the tank 241-C-106. However, other alternatives, such as air chiller, that might not have been effective in the 1970s should be 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 thermocouple (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 remediation measures if the evaluation in Section 3.1.4 indicates that mitigation and 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 to prevent from occurring and how to prevent it. Identifying the hazard will dictate the path or approach for preventing a hazard.

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.

The second heat transfer mechanism, that is, transferring heat out of the tank, (see Section 3.1.1) is of interest in this logic step logic. According to past thermal analyses, approximately 10 to 15 percent of the heat is transferred through tank walls, and the balance of the heat 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 used for mitigation, several other approaches have been considered. It is important to reassess the alternative options again because the total heat load has been decreased by at least 40 percent since 1970 due to radioactive decay. It is possible that options considered unsatisfactory previously may become valid now or in the immediate future. (See Section 3.2.4.) The mitigating/remediating options under consideration are summarized below:

1. Forced ventilation with water added: This method, used for more than twenty years, is a very effective cooling method.

2. Forced ventilation alone: The ventilation level can be adjusted from the current level of 2,500 up to 6,000 ft^3/min. The effectiveness of this method is being evaluated using a series of thermal analyses.

3. Refrigerated ventilation (air chiller): In parallel with an air-chiller design activity, a series of thermal analyses are being performed to support the design and evaluate the effectiveness of this alternative.

4. Waste retrieval: Even partial waste retrieval is an effective way to mitigate the high-heat safety issue. This approach is considered the only remediation method to resolve the high-heat safety issue permanently. 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 still a valuable exercise to reevaluate the alternative options listed above using a set of updated selection criteria. Updated selection criteria account for known future plans, and they are different from those considered in the 1970s. They 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 Tank Waste Remediation System safety initiatives fully supported by 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 Safety Initiatives. It is expected that the high-heat safety issue will be permanently resolved at that time. The focus of this safety program plan is on safe, short-term, low cost temporary storage 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 are being 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 104 °C (220 °F). This corresponds to the maximum temperature of 77 °C (170 °F) recorded at Riser 8 TC tree. The thick liquid layer (about 0.3 m or 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 occurs.

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 1993c), 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. Besides, there are additional concerns over safety and cost for long-term clean-up. This proposal has been declined for tank 241-C-106.

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 raise above 177 °C (350 °F) as predicted by a recent thermal analysis using 0.25 Btu/h-ft-°F thermal conductivity. The predicted temperature exceeds the safety limit for tank 241-C-106 (Bander 1993c). In addition, the resulting dry waste is not desirable for the planned retrieval project. Based on this evaluation, this option should not be considered if retrieval will take place in FY 1997. However, this option may be considered as a backup alternative in case a tank leak occurs.

Refrigerated ventilation. A refrigerated ventilation system (open or closed) is being studied as an alternative method. If the system is effective, and moisture can be maintained in the tank, this method would satisfy all the selection criteria. A scoping study along with supporting thermal analyses is being performed by the Mechanical Systems and Thermal-Hydraulic Analysis organizations.

Waste retrieval. This method is the most expensive option, but it is identified as the only remediation method. Past-practice sluicing is the WHC's recommendation for the 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"). It is anticipated that past-practice sluicing will remove at least 70 percent of the heat-generating sludge to allow adding cooling water to cease, resulting in tank 241-C-106 being safe and stabilized.

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 occurs. This hazard can be safely and effectively controlled by installing an in-tank, above-surface sprinkler system or a chilled air system. More detailed plans and tasks are in Chapter 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 (Section 3.2.4), the current method 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 safety controlled by implementing contingency actions.

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 above-surface sprinkler system or a chilled air 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. Based on the amount of heat removal required to control the waste tank temperature (safety criteria) and other selection criteria, the alternatives will be evaluated based on 1993 knowledge. 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 (WHC 1992a). 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 1992). An updated contingency plan will be issued in FY 1994. There are two thermocouple trees in tank 241-C-106. According to the OSD, only one is required. If two or more probes in a tree fail, operability of the tree will be restored as soon as possible. The liquid surface measurement is performed using a Food Instrument Corporation (FIC) device. If the FIC is inoperational, manual measurement shall be performed at the same required frequencies.

3.4 SCHEDULE IMPLICATIONS

The schedule for the major tasks supporting the high-heat safety program plan is summarized in Chapter 5.0.

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

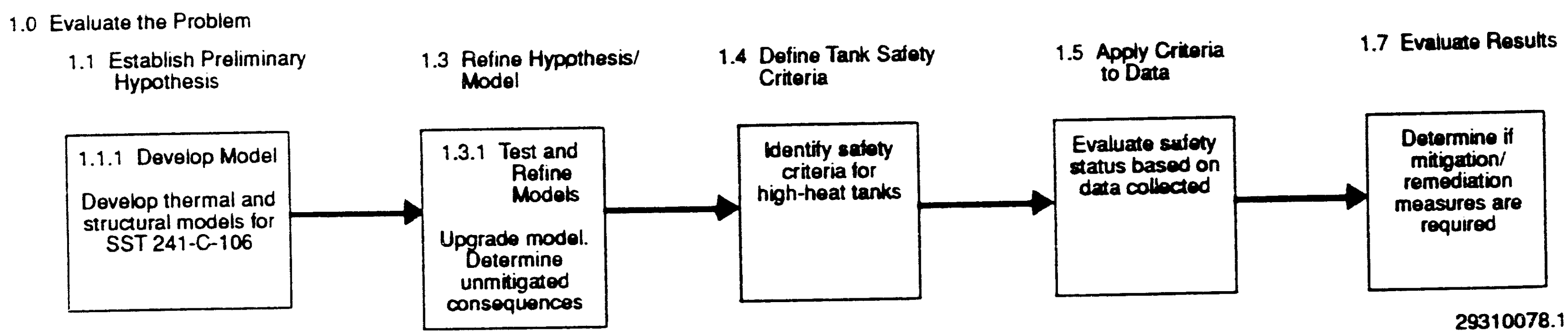


Figure 3-2. High-Heat Tank Safety Issue Resolution Logic (Mitigation/Remediation).

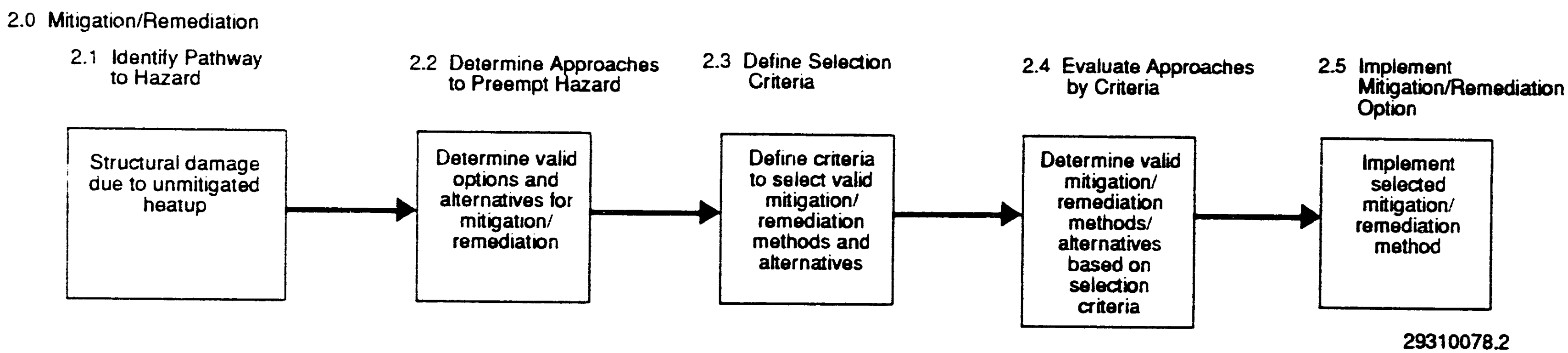


Figure 3-3. High Heat Tank Safety Issue Resolution Logic (Maintain Required Monitoring).

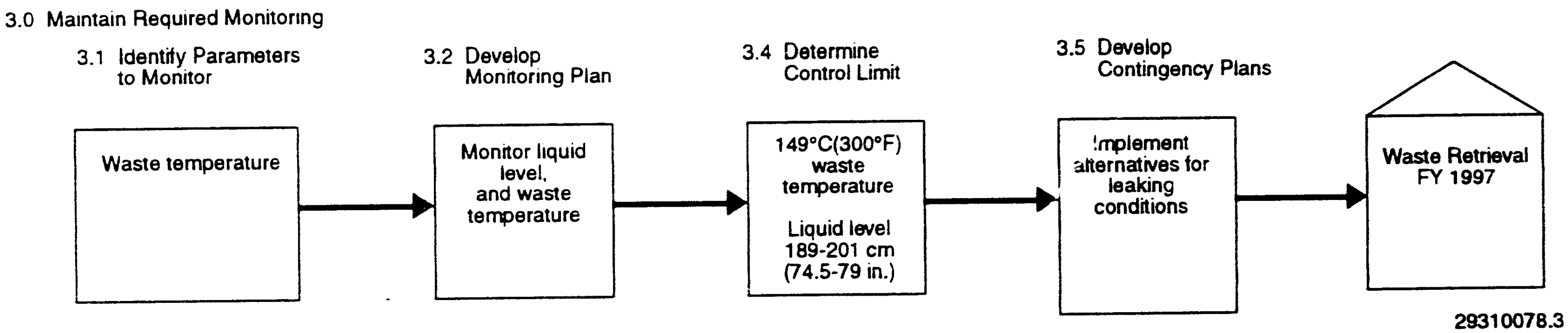
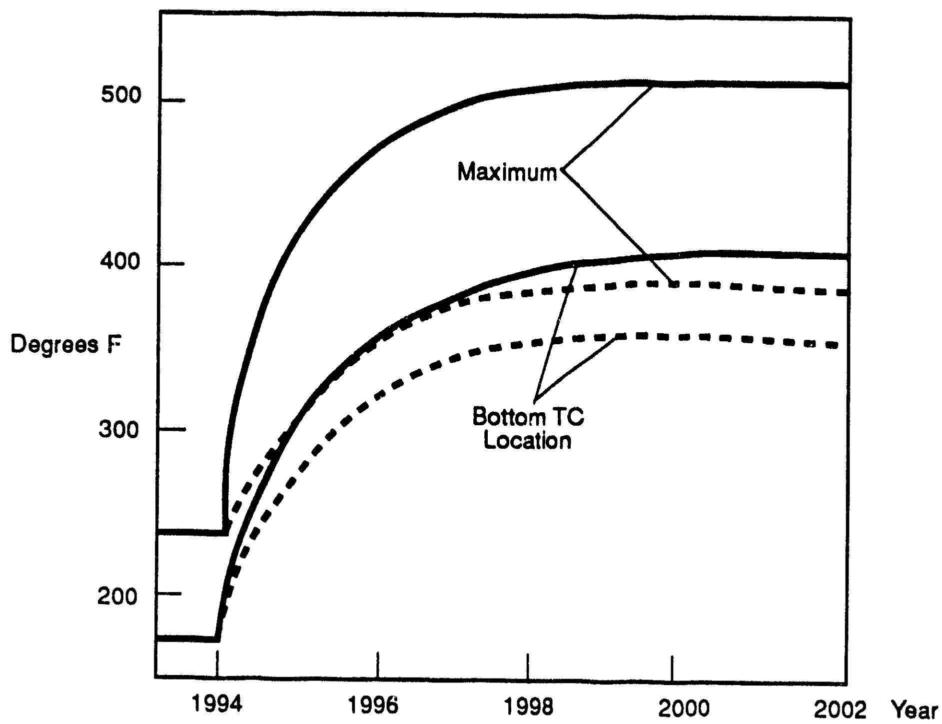


Figure 3-4. Unmitigated Consequence for 241-C-106 Heatup.

Moist Waste ----------
Dry Waste ________



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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. On-going 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.

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/h (based on 1989 decay heat). In the period 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 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/h (based on 1989 decay heat) was predicted.

In 1993, an anomaly was observed when thermocouple tree in Riser 14 (6 m [20 ft] from the center) indicated lower waste temperatures than the tree in Riser 8 (9 m [30 ft] from the center). This observation was later verified by a series of field tests and thermal analyses which varied thermal conductivity and heat generation distribution in the radial direction (Bander 1993b). The same thermal analyses implied that the total heat load in tank 241-C-106 may be less than the previously predicted 118,300 Btu/h heat load.

However, for this safety program, a heat load of 118,300 Btu/h (in 1989) with uniform thermal conductivity and heat generation distribution is used as the design basis for system upgrade and decision-making.

The same model is being 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 1994 will provide the 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.

   Deliverable: WHC-SD-WM-ER-200, *Revised Thermal History of Tank 241-C-106*, June 1993 (Bander 1993a).

   Status: Completed.

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), is being 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 will calculate the expected residual strength based on a detailed past thermal and waste load history. It will use data output to determine 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 Tank Disposal 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*, 1993.

   Status: Final draft completed. The report will be available in December 1993.

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) Retrieval Program is investigating the residual structural strength of the load-bearing structure as a result of past-practice thermal loading. If the residual strength is greater than required for potential retrieval needs or any other requirements such as natural forces resistance, then 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 safe temporary storage and eventual remediation of tank 241-C-106.

According to the current thermal model the maximum waste temperature is approximately 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 a "bumping" is defined as the local vaporization effect at a hot region of the waste when waste temperature exceeds boiling point. The results of the investigation will provide guidance for a contingency plan.

TASKS:

1. Reassess the maximum waste temperature criteria for tank 241-C-106 to prevent structural damage. The methodology could also apply to other SSTs.

   Deliverable: None.

   Status: A thermal/structural analysis to estimate safety margins for planned retrieval activities is being completed (July 1993). The stress analysis is funded by the Waste Retrieval Program, and the thermal analysis is funded by the Waste Tank Safety Program. The results concluded that a higher waste temperature may be allowed. However with the scheduled retrieval in FY 1997, the task is not necessary.

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

   Deliverable: A PNL letter report.

   Status: A work order to PNL is being prepared. The work will start in December 1993 and end in March 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, 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 in June 1993.

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

   Deliverable: Laboratory report documenting thermal properties.

   Status: The best-estimate schedule for obtaining a sample core is February 1994. It takes six months for the laboratory to analyze and issue the sampling report. It is expected the report will be issued in August 1994.

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 November 1994.

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 (Bander 1993c)

   Status: Complete in November 1993.

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 2,500 ft^3/min (exhauster capacity is 6,000 ft^3/min), and the water addition rate is approximately 5,700 L (1,500 gal) per week. Since August 1993, "treated water" has been used to replace raw water. The chemical additive for the treated water is mainly sodium sulfite (also called Dearborn-66). The pH value of the treated water is between 9 to 10. The purpose of adding treated water is to reduce corrosion.

As mentioned in Section 3.2, the only identified drawback about this cooling method is the potential environmental impact if a tank leak occurs. If a leak occurs, 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 resolve hazard of a leaking tank. These tasks will be studied but not implemented unless a tank leak actually occurs.

TASKS:

1. Perform a thermal analysis with ventilation cooling alone. This is would simulate a leaking tank without water added. A sensitivity study is included to estimate the effects of wet and dry waste and various ventilation levels (2,500 to 6,000 ft^3/min). The results of this task will help determine the minimum water required if a tank leak occurs.

   Deliverable: A WHC-SD-WM-ER-290 (Bander 1993c).

   Status: Analyses are being performed. The report will be issued in November 1993.

2. Develop a method to add treated water (pH = 9 to 10) 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 until after 1997 (scheduled retrieval).

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

 <u>Status</u>: A recipe of treated water was developed in the last quarter of FY 1993. A Process Charge Authorization (ETF-94-008) to add cold treated water to tank 241-C-106 was implemented in October 1993. The task is completed.

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 occurs. The moisture level is controlled through maintaining an optimum amount of interstitial liquid which will not leak out.

 <u>Deliverable</u>: Definitive design report.

 <u>Status</u>: The conceptual design and definitive design of an in-tank sprinkler system is scheduled to be completed in December 1993 and April 1994, respectively. The installation will not take place unless a leaking tank is confirmed. It is estimated that implementation of an in-tank sprinkler system will take approximately three months from the time a tank leak is confirmed.

4. Conduct a process test to minimize liquid inventory. The purposes include the following: reducing hydraulic head as well as liquid inventory, maintaining current heat-removal configuration, and facilitating scheduled waste retrieval in 1997.

 <u>Deliverable</u>: Complete Safety Alternate Process Test in high-heat tank 241-C-106 and issue report to Ecology and EPA by September 1995 is TPA Milestone M-40-05.

 <u>Status</u>: The process test is scheduled to begin in April 1994 and end in September 1994. To accommodate pre-retrieval activities, the completion date may be delayed due to adding rinse water to clean up removed equipment. Completing the test by June 1995 is a safety initiative action.

5. Update contingency plan WHC-EP-0473 to deal with possible tank leak situations and in the appropriate time frame.

   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 in February 1994.

6. Update thermal analyses with the data obtained from the waste sample analysis. The updated results will be used for verification of past 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 November 1994 (as long as core sample analysis is available in August 1994).

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 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 at this time. Also, the resulting dry waste is not desirable for sluicing retrieval of the waste. No specific tasks are planned for this option.

4.2.3 Refrigerated Ventilation

Based on the preliminary results of a recent thermal analysis (Bander 1993c), 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 will be performed for ventilation levels ranging from the current 2,500 ft^3/min to the design maximum of 6,000 ft^3/min and for inlet air temperatures varying from 0 to 7 °C (32 to 45 °F).

   Deliverable: A WHC-SD-WM-ER-290 (Bander 1993c) report documenting the results.

   Status: The technical report is scheduled to be issued in November 1993.

2. Design a refrigerated ventilation unit.

   Deliverable: Definitive design report.

   Status: The capacity and effectiveness of a refrigerated ventilation system is being designed by the Mechanical Systems organization. The definitive design is scheduled to be completed in April 1994. The installation will not take place unless a tank leak actually occurs. It is estimated that implementation of a refrigerated ventilation unit will take approximately three months from the time a tank leak is confirmed.

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 past-practice sluicing method to retrieve waste from tank 241-C-106. This task is funded by Tank Waste Project. 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. The retrieval of tank 241-C-106 is also identified as a recent DOE safety initiative (DOE 1993) which authorized accelerated early retrieval in FY 1997.

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 or reporting is anticipated at this time.

Although ventilation and psychrometric data are also monitored, waste temperature and liquid level are required monitoring parameters. 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: The FIC is scheduled to be replaced or repaired in FY 1994. Tank 241-C-106 is one of 21 tanks scheduled to have a new improved surface-level measuring device (buoyancy/tension wire gauge) installed by December 1994 as a safety initiative to upgrade leak detection equipment for SSTs with liquid surfaces. This work will be performed by Tank Farm Upgrades.

2. Both TC trees and FIC in tank 241-C-106 are to be connected to TMACS in FY 1994.

   Deliverable: Connect TC trees and FIC to TMACS.

   Status: The TC trees and FIC will be connected to TMACS in April 1994.

3. Conduct an in-tank video survey of the wall condition to verify visual structural integrity. During the survey, a couple of TC probes will be inserted into the waste to record temperature profiles in the waste.

   Deliverable: In-tank video surveillance.

   Status: This task is scheduled to be completed in the second quarter of FY 1994.

   A "temperature anomalies" phenomenon was observed in March 1993. The phenomenon was explained with a thermal analysis (Bander 1993b). Additional field verification using TC probes is proposed along with the in-tank video activity.

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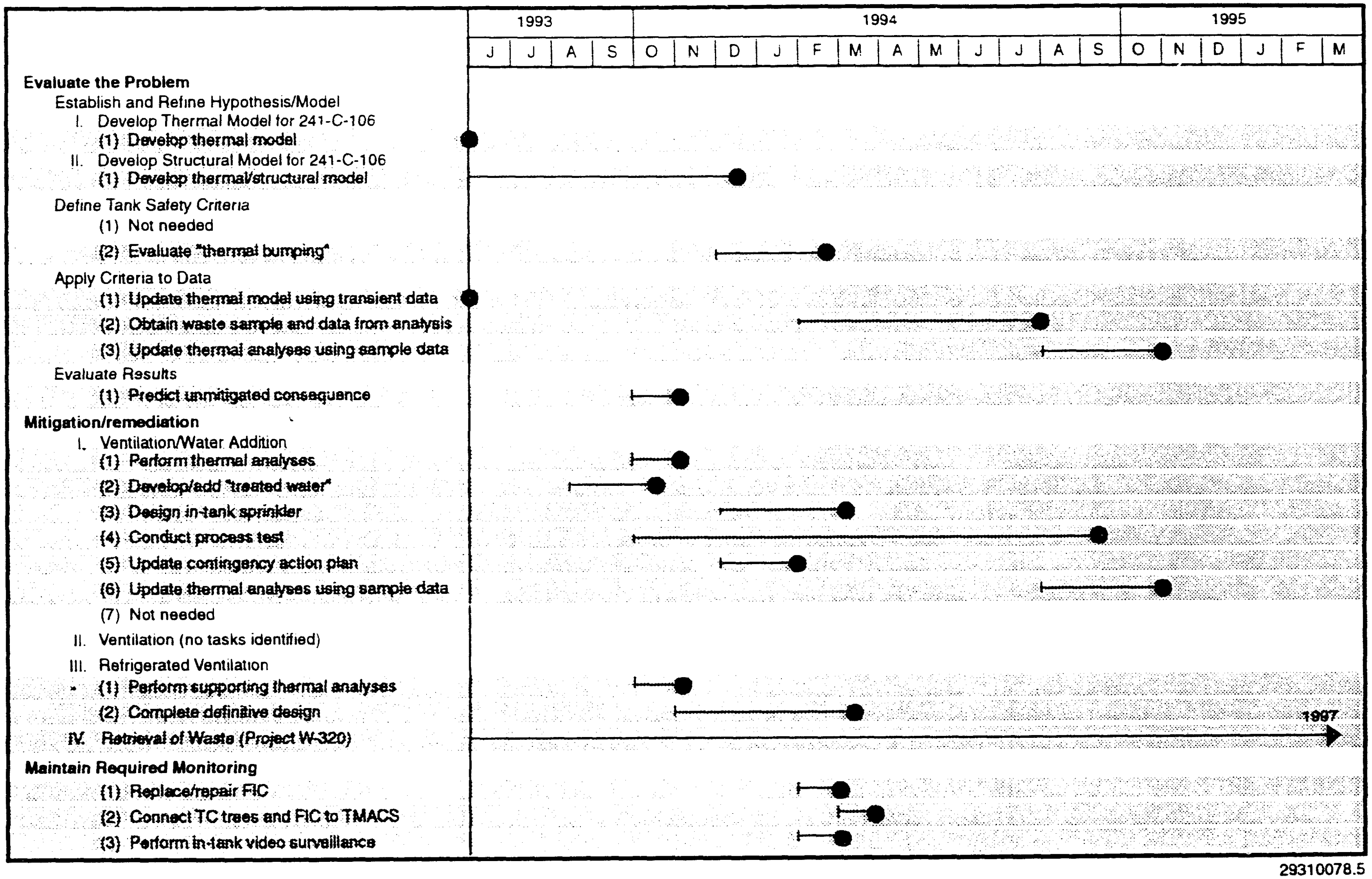
5.0 PROGRAM SCHEDULE

Figure 5-1 is the schedule supporting the 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 availability of new technical data. Figure 5-1 does not include tasks associated with the proposed contingency plan and programs that are identified only as proposals.

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



6.0 REFERENCES

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

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

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

Bander, T. J., September 1993b, *Tank 241-C-106: Radial Variation of Thermal Conductivity and Heat Generation*, WHC-SD-WM-ER-217, Westinghouse Hanford Company, Richland, Washington.

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

DeFigh-Price, C. and O. S. Wang, 1992, *Action Plan for Response to Excessive Temperature is High Heat Source Waste Tank 241-C-106 at the Hanford Site*, WHC-EP-0473, 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, 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.

Ellis, S. H., 1992, *Waste Tank Project Administration*, WHC-IP-0842, Westinghouse Hanford Company, Richland, Washington.

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

Hanlon, B. M., 1993, *Tank Farm Surveillance and Waste Status Summary Report for May 1993*, WHC-EP-0182-62, Westinghouse Hanford Company, Richland, Washington.

July, L. J., 1993, *Tank 241-C-106 Structural Integrity Evaluation for In Situ Conditions*, WHC-SD-W320-ANAL-001, Westinghouse Hanford Company, Richland, Washington.

Letter from H. D. Harmon, Westinghouse Hanford Company, to R. E. Gerton, U.S. Department of Energy, Richland Field Office, *Safety Measures for Waste Tanks at Hanford Site, Richland, Washington*, January 8, 1991.

Mares, E. M., 1991, *Waste Tank Safety, Operations, and Remediation (WTSOR) Project Management Plan* (PMP), WHC-SD-WM-PMP-004, Westinghouse Hanford Company, Richland, Washington.

National Defense Authorization Act for Fiscal Year 1991, Public Law 101-510, "Safety Measures for Waste tanks at Hanford Nuclear Reservation," Section 3137 (Wyden Amendment).

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.

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.

Tank 106-C Sluicing Letter Report, 1993, from J. M. Henderson to N. L. Nichol, 935041, January 15, 1993, Westinghouse Hanford Company, 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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