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HANFORD WASTE TANK SAFETY ISSUES: A PROGRAM OVERVIEW

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ABSTRACT

This paper presents an overview of the potential high-activity waste safety issues in the 177 underground radioactive waste storage tanks at the Hanford Site. Also, included is a discussion of the strategy and plans to remedy hazardous conditions and remove other deficiencies related to the operation of the tanks. A three-pronged multimillion dollar integrated program has been initiated that (1) assesses and, on an as needed basis, defines remediation and/or mitigation actions to allow interim stabilization of high risk waste tanks; (2) upgrades existing facilities and instrumentation to meet current nuclear facility operations standards; and (3) addresses and upgrades the conduct of operations. For tanks that are considered at risk, extensive management controls presently are employed to ensure that the tanks continue to be maintained in a safe manner. In addition, comprehensive monitoring, characterization and applied research, and engineering efforts have been initiated to support resolution of safety issues. A key element of the Westinghouse Hanford Company effort is preventing future problems associated with creating potentially incompatible wastes as part of waste management activities associated with the planned disposal of the wastes in these storage tanks. Such efforts also will provide the basis for safe near future remediation of tanks and define and maintain the envelope of safety to support the ultimate disposal of all high-activity waste in Hanford Site tanks.

INTRODUCTION

This paper lists the 23 safety issues related to storing high-activity mixed tank waste at the Hanford Site. A summary discussion of seven of the safety issues follows. This paper serves as an introduction to the Environmental Restoration 1991 conferences special session "Hanford Tank Operations and Safety Issues." Initiatives are underway for evaluating the technical issues leading to solving waste tank safety issues. Initially, high priority efforts being focused on are the hydrogen and ferrocyanide tanks because they represent unreviewed safety questions. The logic underlying the Waste Tank Safety, Operations and Remediation Program at the Hanford Site will be presented.

BACKGROUND

The radioactive waste stored in Hanford Site underground tanks has come from (1) three different processes for recovering plutonium and uranium from approximately 100,000 metric tons of uranium of fuel; (2) from three different processes that recovered radionuclides from the waste; (3) from miscellaneous other sources such as laboratories and reactor decontamination solutions; and (4) from production and waste management operations. The wastes were neutralized before entering the storage tanks and, over the years, the wastes have been concentrated as a result of water evaporation. The major chemicals in the tanks include sodium nitrate/nitrite, sodium hydroxide, sodium aluminate, and sodium phosphate. Also, there are large amounts of organics. The waste tank radionuclide inventory is approximately 210 million curies, and is stored in single-shell and double-shell tanks.

Between 1943 and 1964, 149 single-shell tanks (total capacity 94-million gallons) were built for storing liquid radioactive wastes at the Hanford Site. These single-shell tanks consist of reinforced concrete with a carbon-steel liner. Single-shell tank capacities range from 208 cubic meters (55,000 gallons) to 3,785 cubic meters (1 million gallons). Today, the tanks hold about 168,205 cubic meters (37 million gallons) of liquids and solids from a variety of reprocessing and waste processing activities. No wastes have been added to any of these tanks since November 1980. Sixty-six of the single-shell tanks have either leaked or are suspected to have leaked.

Between 1968 and 1986, 28 double-shell tanks were built for storing liquid radioactive wastes at the Hanford Site. The double-shell tanks consist of a carbon-steel tank within a steel-lined concrete tank. The double-shell tanks have a nominal capacity of 3,785 cubic meters (1 million gallons). The total capacity of the double-shell tanks is about 113,562 cubic meters (30-million gallons). The double-shell tanks were placed into service beginning in 1973. They presently contain about 104,560 cubic meters (23 million gallons) of liquid radioactive waste. The double-shell tanks have a built-in leak detection capability: none of the double-shell tanks have leaked.

In 1968, a program to remove pumpable liquids from single-shell tanks was started to prevent or diminish future impacts from possible leaks. Pumpable interstitial liquid and supernatant wastes are being removed from single-shell tanks and transferred to double-shell tanks. The remaining 51 tanks are scheduled to be pumped by September 1996. Not all liquid can be pumped from the single-shell tanks because some liquid is bound interstitially in the tank solids and the remainder drains too slowly to pump effectively.

The tanks and the instrumentation and equipment associated with the tanks reflect the engineering practices of the times that the tanks were built or installed. The more stringent application of nuclear facility standards, by the Department of Energy, to waste management facilities will require an extensive upgrade program, as well as the construction of new facilities. Additional double-shell tank capacity also is needed to accommodate potential mitigation/remediation actions associated with higher risk tanks, and to support pretreatment activities associated with the disposal of existing double-shell tank wastes.

Concerned about waste tank safety at the Hanford Site, Congressman Wyden (Oregon) introduced an amendment to the *National Defense Authorization Act for Fiscal Year 1991*, Public Law 101-510, Section 3137. The amendment requires that the secretary of the U.S. Department of Energy report to the U.S. Congress on actions taken to promote high-level radioactive waste tank safety at the Hanford Site. In compliance with Public Law 101-510, a report was written (DOE 1991) that also addresses the secretary's timetable for resolving outstanding safety issues at the Hanford Site. The report addresses the identified safety issues, and describes the planned studies and remediation actions. In addition, the report presents a schedule for resolving the safety issues. Table I contains the list of Hanford Waste Tank Safety Issues.

The four Priority 1 issues and three of the Priority 2 issues are discussed in the following sections.

STRATEGY FOR RESOLVING SAFETY ISSUES

Resolving all safety issues will take many years, and as the tanks receive further evaluation it is anticipated that more issues may be identified. A Waste Tank Safety Program has been established to conduct this work and a series of charts have been developed to describe the program logic. Detailed plans also are being developed for each of the major activities. Program logic charts, which show relationships of the major activities and the steps necessary to resolve the issues, were developed. Based on new information, improvements will be made in the logic as the program proceeds.

The Waste Tank Safety Program is summarized in Figure 1. The major activities shown are: evaluation, remediation/mitigation, verification and upgrades. The 23 potential safety issues have been divided into 3 priorities to aid further evaluation, in response to Public Law 101-501 by the U.S. Department of Energy. The four Priority 1 tanks that have been selected for accelerated evaluation are introduced in the following section. Three of the Priority 1 tanks will be discussed in greater detail in later papers in this session. Three other Priority 2 issues that play a pivotal role in ensuring the success of the accelerated evaluation program, or in ensuring safe operation also are described in following sections.

Evaluation will determine that some tanks require remediation/mitigation to close the safety concern (such as tanks 241-SY-101 and 241-C-106) while the evaluation of other tanks may determine that there is not a safety issue. For those tanks requiring remediation or mitigation, this activity includes collecting data, developing the remediation method, and installing and conducting the remediation.

Tank safety verification is a parallel, long-term activity that includes an in-depth review of the physical condition, as well as contents of the tanks. The end result is documented verification of each tank's capability to safely store waste until the waste can be disposed of.

The tank farm upgrades activity provides a broad range of improvements that have safety implications; such as improved configuration control and conduct of operations, improved maintenance, new instrumentation, upgraded equipment and facilities, and upgraded safety documentation. These upgrades are needed to close some of the safety issues as well as enable the tank farms to be operated to today's standards.

Successful completion of the Waste Tank Safety Project will ensure that wastes are safely stored until the Waste Disposal Program(s) can be carried out.

Table I. Hanford Site Waste Tank Safety Issues.
(Sheet 1 of 2)

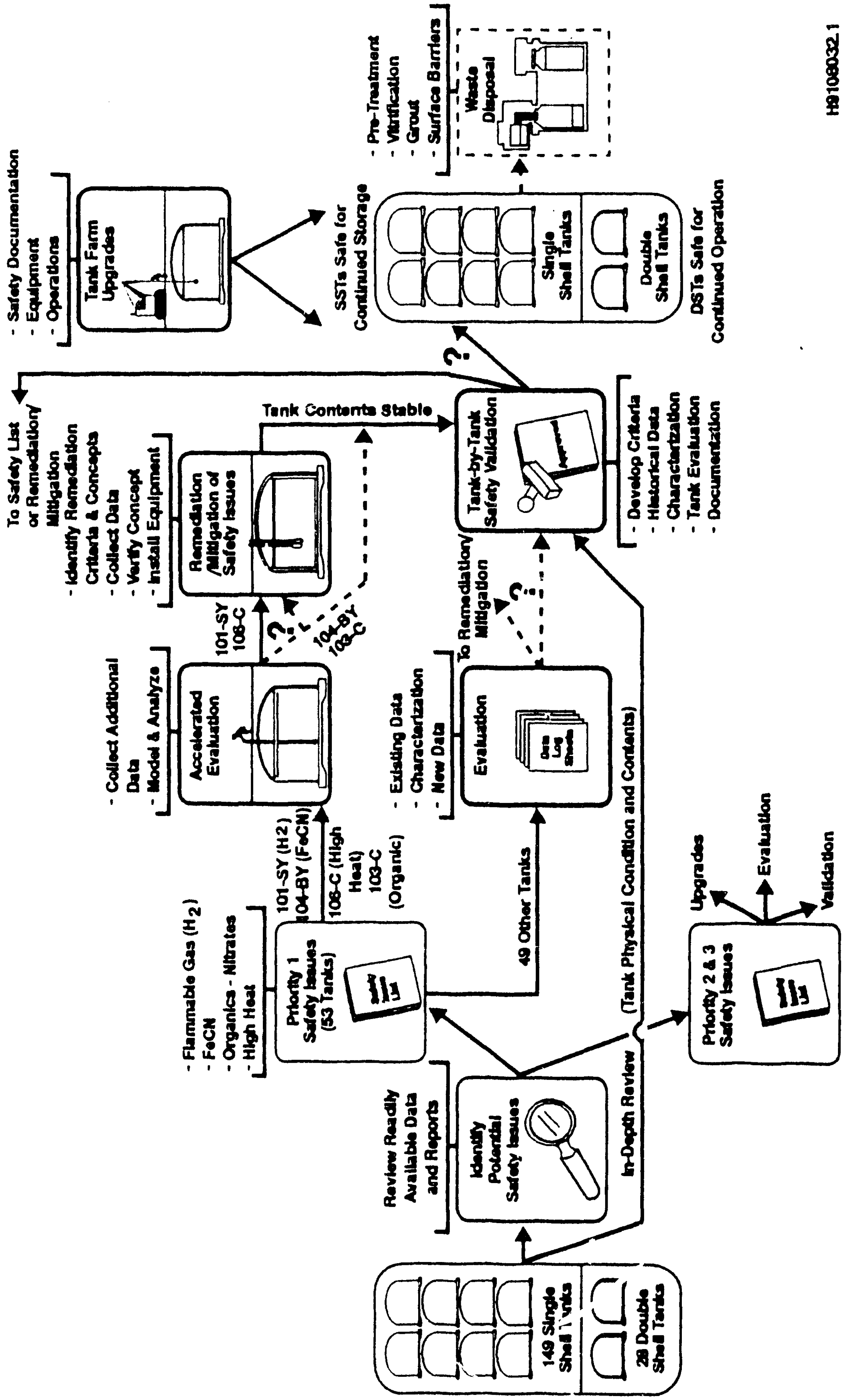
Safety issues description	Number of tanks		
	DST	SST	Total
Priority 1			
1. Flammable gas generation in Tank 241-SY-101 and other tanks	5	18	23
2. Potential explosive mixtures of ferrocyanide in tanks	--	24	24
3. Potential organic-nitrate reactions in tanks	--	8	8
4. Continued cooling required for high-heat generation in Tank 241-C-106	--	1	1
Priority 2			
1. Insufficient tank contents characterization to support evaluations	All	All	177
2. Inadequate safety documentation	All	All	177
3. Tank safe operating life	All	All	177
4. DST space requirements	All	All	177
5. Upgrading of operations, equipment, and facilities			
a. Improvement in conduct of operations	All	All	177
b. Lack of plant-essential drawings	All	All	177
c. Maintenance and upgrades of tank farm facilities and equipment	All	All	177
d. Instrument upgrades in SST and DSTs	All	All	177
e. Tank toxic vapor releases	All	All	177
f. Leaking S-302-A catch	tank	383	86
g. Inadequate single-shell tank leak-detection systems	--	All	149
h. SST emergency pumping	--	17	17
i. Response to a leaking DST	All	--	28

Table I. Hanford Site Waste Tank Safety Issues.
(Sheet 2 of 2)

Safety issues description	Number of tanks		
	DST	SST	Total
Priority 3			
1. SST sealing to prevent intrusions	--	All	149
2. DST safety upgrades	All	All	All
a. Transfer line concrete encasement integrity and secondary containment compliance	All	All	All
b. AZ Tank Farm ventilation line	2	--	2
c. Excessive hydroxide consumption in Tank 241-AN-107	1	--	1
d. Improved leak detection in DSTs	All	00	28
e. Intertank ventilation connections	All	19	47

DST = double-shell tank.
SST = single-shell tank.

Fig. 1. Waste Tank Safety Program.



PRIORITY 1 SAFETY ISSUES

This section provides an overview of the four Priority 1 safety issues associated with single-shell and double-shell tanks and their potential impact on pretreatment before disposal. Issues of concern to potential treatment strategies include cyclic hydrogen (flammable gas mixture) release, ferrocyanide accumulation, the presence of organic chemicals mixed with nitrate-nitrite salts, and the requirement to add cooling water to single-shell Tank 241-C-106.

Safety issues are the present focus of the Waste Tank Safety Program whose task is to ensure the safety of the single-shell tank and double-shell tank systems until appropriate treatment and disposal of tank contents can take place. To ensure interim safety, extensive management and technical controls are employed to ensure that safety issues related to tanks will continue to be maintained in a safe manner. In addition, there is an ongoing requirement (established by the Department of Energy) for a broad-based peer review of all planning and safety documentation by high-level groups established by the U.S. Department of Energy-Headquarters. Approval of all actions relating to the flammable gas and ferrocyanide tanks by U.S. Department of Energy-Headquarters, before all intrusive acts, is required also.

The hazardous characteristics of the existing wastes, leading to identification and control, were estimated on the basis of general information from the chemical literature, expert peer judgement, and limited historical and actual sampling data. Mitigating factors, which would serve to reduce risk, such as moisture content, presence of inert diluents (e.g., sodium carbonate, sodium aluminate, and/or sodium phosphate), and conditions that could lead to a lack of reactivity of the wastes were purposely understated.

Scenarios of significant concern associated with waste in tanks include the following.

- The potential for ignition of flammable gases such as hydrogen-air, hydrogen-nitrous oxide and or air-organic vapor mixtures.
- The potential for secondary ignition of organic-air and/or organic-nitrate mixtures initiated by the burning of flammable gases.
- The potential for ignition of organic-nitrate and/or ferrocyanide-nitrate mixtures initiated by the radiolytic or chemical heating of dry salt cake or by localized heating.
- The potential for a leak from a tank causing release of contaminants into the environment while having to meet a requirement to add cooling water to that tank to maintain its structural integrity.

Administrative and technical controls associated with the conduct of operations are in place to restrict activities that could cause undesirable exothermic reactions. For example, pumping of interstitial liquid from ferrocyanide tanks has been stopped to maintain present moisture levels (e.g., to maintain present thermal conductivity and heat capacities). Nonsparking tools and use of electrical bonding techniques on instrumentation are used around hydrogen tanks. So-called "normal" activities for tanks at issue are limited to surveillance. Special safety analysis documents, which are extensively peer reviewed, are prepared for all work inside the tank.

In addition, comprehensive monitoring, characterization, and applied research efforts have been initiated to support resolution of issues and to prevent creation of future problems associated with potentially incompatible wastes or actions related to the planned treatment and disposal of the wastes in these storage tanks. Such efforts also will provide the basis for safe near future remediation of tanks and define the envelope of safety to support the disposal of all high-activity waste in Hanford Site tanks. A review of these and other safety issues was presented recently at the Waste Management 1991 Conference (Babad 1991).

Flammable Gas Generating Tanks

Some of the double- and single-shell tanks generate, store, and periodically appear to release significant quantities of flammable gas, primarily mixtures of hydrogen and nitrous oxide. If a spark were to be present, this gas mixture could ignite and burn; thus, potentially causing filters in the vent system to fail resulting with a spread of contamination.

Hydrogen gas generation in Tank 241-SY-101 is a top priority waste tank safety issue at the Hanford Site because average peak concentrations above the lower flammability limit for hydrogen occur periodically. Such venting of gases is expected to keep reoccurring until some form of remediation is taken. In addition, it is likely that a greater-than-lower flammability limit for concentration sometimes exists within the waste. In the unlikely event an ignition source was to be present during these periods, a hydrogen burn or explosion could occur with a possible release of nuclear waste to onsite and offsite personnel.

There are 22 other tanks also suspected of potentially containing smaller accumulations of hydrogen. However, there is a significant difference in severity of behavior between those tanks and Tank 241-SY-101. Evidence of venting, surface level behavior, and knowledge of the other tank contents suggests a much lower likelihood of potentially dangerous gas concentrations in these other tanks.

Potentially Explosive Mixture of Ferrocyanide in Tanks

Twenty-four tanks contain insoluble ferrocyanide salts in quantities greater than 1,000 gram/moles mixed in a sodium nitrate/sodium nitrite matrix. If subjected to high temperatures, these materials could become explosive. However, there is a low probability for any heating mechanism to occur.

Ferrocyanide tanks were identified as a safety issue because it is not known whether concentrations and distribution of ferrocyanide and nitrate-nitrite materials in the tanks would allow an uncontrolled exothermic reaction or explosion if tank contents were allowed to heat up. Although the measured tank temperatures [57 °C (135 °F)] are far below the temperature [285 °C (545 °F)] required to cause an exothermic reaction, the consequences of an event could be at a level potentially exceeding the safety envelope defined in the Environmental Impact Statement (DOE 1987; GAO 1990).

A recent review of the practice of drying out single-shell tanks to avoid potential leakage of radioactive and hazardous materials into the soil disclosed that additional analysis of this practice is needed for tanks containing ferrocyanide. For tanks that contain large quantities of ignitable materials (tanks containing ferrocyanide and organics), pumping has been discontinued until additional safety evaluations of liquid removal can be completed.

Potential Organic-Nitrate Reactions in Tanks

Eight tanks contain organic chemicals at a concentrations believed to be potentially hazardous. Concentrations of organics that may be present in some tanks could cause an exothermic reaction given a sufficient driving force, such as high temperatures. However, the difference between ignition temperatures and actual tank temperatures measured, as discussed previously for the ferrocyanide tanks, is so large that the probability of such a reaction is considered to be very low. The tank temperatures in the organic tanks do not exceed 65 °C (149 °F).

The postulated high concentrations of organic compounds have been inferred (from tank transfer, flow sheet records, and limited analytical data) in eight single-shell tanks. Many organic chemicals, if present in concentrations above 10 dry weight percent (sodium acetate equivalent), have the potential to react with nitrate-nitrites constituents at temperatures above 220 °C (392 °F) in an exothermic manner. The consequences of the postulated reaction are about the same as that postulated for a secondary crust ignition after ignition of hydrogen in a tank. Although work on this issue is just beginning, consideration of hazards associated with heating nitrate-nitrite mixtures containing organic materials is an integral part of both the hydrogen and ferrocyanide tank efforts. Because the concentrations of organic materials in the listed single-shell tanks and their chemical identity are not accurately known at present, a tank sampling program has been planned to provide more information on the contents of these tanks and to serve as a basis for laboratory testing and safety evaluations.

Evaluation of the records related to material transfers to the remaining single-shell tanks and double-shell tanks continues, and may uncover additional tanks that meet the organic concentration requirements, placing them on "watch list" status.

Continued Cooling Required for High-Heat Generation in Tank 241-C-106

One single-shell tank requires periodic addition of water to maintain its temperature within the permissible limits determined by structural considerations. Single-shell Tank 241-C-106 (530,000 gallon capacity), has been used for radioactive waste storage since mid-1947 and currently contains about 250,000 gallons of waste. During the late 1960s, a program to recover strontium and cesium from aging stored waste in the A and AX Tank Farms was started at the Hanford Site. Sludge washing/decanting steps in this process inadvertently transferred heat-generating strontium-rich sludge to Tank 241-C-106.

Tank 241-C-106 generates enough heat that periodically water is added to prevent overheating. Continued cooling by adding water is required to prevent exceeding tank operating limits; thereby, possibly causing structural damage to Tank 241-C-106. This tank is currently considered to be sound. If the current methods of cooling Tank 241-C-106 are stopped, the sludge will heat to temperatures greater than established tank limits and may cause tank structural problems. This type of behavior is an anomaly among the single-shell tanks. In the event of a leak, the need for adding cooling water to the tank would remain. Because cooling water is needed to keep the tank within operating limits, existing interstitial liquid could not be pumped from the tank, which is the usual practice.

EXAMPLES OF PRIORITY 2 SAFETY ISSUES

Insufficient Tank Contents Characterization to Support Evaluations

For many tanks, there are sufficient uncertainties in tank chemistry, a possible source of a yet unidentified hazard. Based on flow sheet considerations, the probability of additional hazardous chemical combinations occurring is believed to be low. The nature of the chemicals used in past chemical processing, the waste management operations leading to the waste in the tanks, and the alkaline condition of the tanks appears to limit the range of new possibilities. The actual composition and distribution of chemicals in most tanks is not well characterized. Process records suggest that most tanks contain appreciable oxidants (mostly sodium nitrate and sodium nitrite) and some tanks contain flammable or potentially explosive materials. This situation creates a need for enhanced characterization data to support safety analysis and the definition of the risk.

In general, knowledge of the contents of the single-shell tanks and double-shell tanks is necessary to ensure appropriate safety precautions and preventative measures are taken in operating the tank farms. Characterization is required to assess the flammable and/or explosive potential and the chemical and radiological hazards that may be present in the tanks for continued storage and final disposal. For operating tanks, it is imperative to know what is in the tank and how that waste will interact with other wastes before they are mixed. A multi-programmatically funded detailed characterization program of the contents of Hanford Site high-activity waste tanks is underway.

Upgrading of Operations, Equipment and Facilities (Monitoring and Control Systems)

Many of the waste tank farm facilities are old, degraded, and unreliable. For example, the electrical distribution equipment needs upgrades to provide a reliable source of power as well as backup power. Ventilation systems are wearing out and require high maintenance, which results in outages that are longer than desirable. Instrumentation, such as liquid-level gauges, leak-detection systems in process pits, and radiation monitors require high maintenance and are out of service or fail often. Spare parts for older equipment are unavailable. In addition, many of the waste tank farm facilities do not meet current design requirements. One example would include the lack of redundant high-efficiency particulate air filtration in many facility ventilation systems.

A major upgrade (repair and/or replace) effort is required to return existing equipment to an acceptable condition, as well as bringing all equipment and facilities into compliance with current regulatory requirements. The instrumentation to monitor and control tank temperature or to detect the presence of flammable gases is old, and needs to be updated to current waste management design requirements.

Tank Safe Operating Life

The single-shell tanks at the Hanford Site have exceeded their original operating life and the early double-shell tanks are fast approaching their operating life (20 years). However, all these tanks will be required to contain chemical and radioactive materials beyond their suggested design lives (50 years), under present operational and disposal plans. About half of the single-shell tanks already have leaked or are presumed leakers. No double-shell tank containment liner has leaked to date, but original corrosion specifications would suggest that the possibility exists that a liner could start leaking before disposal operations are completed. Thus, a determination of the safe operating life of the single- and double-shell tanks needs to be made to assess their ability to safely store wastes until waste disposal decisions are implemented (estimated to be 25-30 years)

The condition of the single-shell tank concrete structure was evaluated in the late 1970s and early 1980s, to determine structural conditions. At that time, it was concluded that the single-shell tank concrete structure was adequate to support the disposal plans, although the tanks could not be expected to contain any liquid materials. In the 1970s and 1980s, it was expected that the single-shell tanks were to be disposed of by the late 1990s. The cleanup of the single-shell tanks is now scheduled to be completed by the year 2018 (Ecology et al. 1990).

The single-shell tanks were designed using industry standard codes in the 1940s and 1950s. The ability of the single-shell tanks to safely store solid waste contents, particularly the ability to withstand natural forces and the added stresses due to contained waste forms and planned remediation activities, will be reevaluated.

The double-shell tanks at the Hanford Site may need to remain operational past the year 2030 to support site cleanup, including the disposal of single-shell tank wastes. The double-shell tanks were designed in the 1960s, 1970s, and 1980s to existing design codes and standards. The condition of the tanks will be reviewed to determine their capacity to support the extended cleanup mission.

SUMMARY

Evaluating the safety issues identified previously, defining appropriate remedial action to correct these safety concerns, and implementing facilities upgrades to bring facilities associated with the aging waste tanks closer to modern nuclear standards is being actively pursued at the highest possible priority. Risk to the operating staff, the Hanford Site environment, and to the general public appears to be low and is being reaffirmed. Work is underway to both quantify the risk and to take appropriate corrective actions to support continued safe storage of the waste as well as the eventual permanent disposal of Hanford's single-shell tanks and double-shell tanks.

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