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RESLOUTION OF SAFETY ISSUES ASSOCIATED WITH THE STORAGE OF HIGH-LEVEL RADIOACTIVE WASTE AT THE HANFORD SITE

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Resolution of Safety Issues Associated with the Storage of High-Level Radioactive Waste at the Hanford Site.

SPEAKER AND AUTHORS, WITH AFFILIATIONS AND COMPLETE MAILING ADDRESSES

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ABSTRACT

A number of high-level radioactive waste (HLW) safety issues have been identified at the Hanford Site in southeastern Washington State. Resolution of these issues is one of the Highest Priorities of the U.S. Department of Energy. The most urgent issues are the potential for explosions in certain tanks (due to periodic venting of large quantities of flammable gases, or the presence of substantial quantities of ferrocyanide and/or organic compounds in combination with nitrates-nitrites). Other safety issues have been identified as well, such as the requirement for periodic water additions to one tank to control its temperature and the release of noxious vapors from a number of tanks. Substantial progress has been made toward safety issue resolution. Potential mechanisms have been identified for the generation, retention and periodic venting of flammable gas mixtures; potential methods for controlling the periodic release behavior have been identified and in-tank testing will be initiated in 1992. Research is being conducted to determine the initiation temperatures, energetics, reaction sequences and effects of catalysts and initiators on ferrocyanide-nitrate/nitrite reactions; waste characterization on a tank-by-tank basis will be required to identify whether ferrocyanide-containing wastes are safe to store as-is or will require further treatment to eliminate safety concerns. Resolution of all of the Hanford Site HLW safety issues will be accomplished as an integral part of the Hanford Tank Waste Remediation System that has been established to manage the storage of these wastes and their preparation for disposal.

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Resolution of Safety Issues Associated with the Storage of High-Level Radioactive Waste at the Hanford Site.

G. B. Mellinger and J. C. Tseng

INTRODUCTION

Approximately 230,000 m^3 of radioactive wastes are stored in tanks at the U.S. Department of Energy (DOE) Hanford Site (Hanford) located in southeastern Washington State. The majority of this waste (140,000 m^3) is stored in 149 single-shell tanks (SSTs); the remainder of the waste is stored in 28 double-shell tanks (DSTs).

In mid-1990 two safety issues (termed Unreviewed Safety Questions or USQs) were identified associated with the storage of these radioactive wastes at Hanford. These USQs dealt with the potential for explosions in certain storage tanks due the periodic venting of large volumes of flammable gases or the presence of substantial quantities of ferrocyanide (a fuel) in combination with nitrates/nitrites (oxidizers).

Admiral Watkins, the Secretary of Energy, and Mr. Leo Duffy, the Assistant Secretary for Environmental Restoration and Waste Management immediately initiated an aggressive program to resolve these two USQs and to improve the overall safety posture of HLW storage. This paper will discuss the DOE's efforts to identify and resolve safety issues at Hanford.

IDENTIFICATION OF SAFETY ISSUES

In addition to the flammable gas and ferrocyanide USQs, additional safety issues and system deficiencies have been identified associated with tank waste storage at the Hanford Site. In the context of this report, a safety issue is defined as an event or condition that can lead to either an uncontrolled release of radioactivity or exposure to radiation; or a loss of primary or secondary containment. Safety issues are divided into three levels:

Level 1 Safety Issues (those that contain <u>most</u> of the conditions that could lead to a release of radioactivity or other health hazard);

Level 2 Safety Issues (those that contain <u>some</u> of the conditions that could lead to a release of radioactivity or other health hazard);

Level 3 Safety Issues (those that could lead to future releases of radioactivity or other health hazards if the tanks are to be used for intermediate - 5 to 30 year - waste storage).

System deficiencies are defined as situations, for which there is a lack of sufficient information, hardware, administrative controls, or qualified staff to properly identify safety hazards or to ensure the continued safe operation of the facility. The safety issues and system deficiencies that have been identified for tank waste storage at Hanford are shown in Tables 1 and 2.[1]

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[1]Draft document "Department of Energy High-Level Waste Storage Tank Safety Issues Report" Prepared for DOE High-Level Waste Tank Working Group, dated October 14, 1991.

The Westinghouse Hanford Company (the operating contractor at Hanford) has a program in place to address these and any other Safety Issues that may be identified in the future (e.g. criticality safety which was recently identified as a USQ) (Gasper 1991).

The focus of this paper is five of the highest priority waste tank Safety Issues at Hanford. These include the four Level 1 Safety Issues shown in Table 1. One of the Level 2 Safety Issues "Tank Toxic Vapor Release" is also addressed as this issue is now receiving increased emphasis. In addition to the two initial USQs (flammable gas and ferrocyanide) these safety issues include:

the potential for runaway reactions in certain tanks due to the presence of substantial quantities of organic compounds in combination with nitrates/nitrites (Organic-Containing Wastes);

the need for periodic water additions to an SST to control its temperature (High-Heat Tank); and

the release of noxious vapors from a number of tanks (Noxious Vapors).

HIGH PRIORITY SAFETY ISSUES

In this section our current understanding of these safety issues will be described as will our current approach for Safety Issue mitigation (ensuring that these wastes can be safely stored until the safety issues can be

resolved). Safety Issue resolution will likely require the retrieval and treatment of these wastes.

Flammable Gas

Although this safety issue affects five DSTs and eighteen SSTs, the majority of the work related to this issue has focused on the most active of these tanks, Tank 241-SY-101. Tank 241-SY-101 releases substantial quantities of gas at approximately 110 day intervals. The composition of the released gas is approximately 36% H_2, 28.5% N_2O, and 37%N_2 (plus minor amounts of H_2O, NH_3, CO_2, CH_4, CO) (Babad 1991). It is important to note that this mixture contains both a fuel and an oxidizer; atmospheric oxygen is not required for the released gas to be flammable. During a large release (the largest release to date has been approximately 280 m^3), the lower flammability limit (approximately 4% hydrogen for these mixtures) may be exceeded in the tank dome space for a brief period of time (minutes).

Between release events, Tank 241-SY-101 exhibits a uniform temperature profile in the upper portion of the tank and a characteristic temperature "bulge" in the lower portion which "grows" between events (the primary heat source is the decay of Cs-137 in this waste). Typical tank temperature profiles are shown in Figure 1. Between events, the volume of the waste increases; this is observed as an increase in the height of surface of the waste. These behaviors are understood to be due to the presence of an upper convecting region and a lower non-convecting region in the waste (the presence of these two layers was confirmed by data obtained from the characterization of two full length core

samples obtained from the tank in 1991 - the non-convecting region contains a much higher solids concentration and is much more viscous). It is thought that gases are produced throughout the waste, but that those gases generated in the convecting region are released at approximately the same rate as they are generated while those produced in the non-convecting region are trapped as very small bubbles).

During release events, the surface of the waste drops. Decreases of up to approximately 26 cm have been observed for large release events (Babad 1991). Concurrent with the gas release, the temperature in the lower portion of the tank decreases and a temperature increase is measured at the top surface of the waste. This change is shown in Figure 1. It is thought that a gas release event occurs when portions of the waste detach from the non-convecting region, float to the surface of the waste and release some portion of the trapped gas. The mechanisms responsible for gas entrapment, gas release, and the initiation of gas release events have been evaluated but the specific mechanisms are not understood in detail (Alleman 1991 and Alleman 1992).

Based on studies conducted using synthetic waste simulants, radiolytic and thermal processes appear to be the primary contributors to the gas generation in Tank 241-SY-101 (Babad 1991). Tank corrosion is not thought to be a major mechanism for hydrogen generation; if corrosion was the major hydrogen generation mechanism it might be expected that other Hanford tanks would behave similarly to this tank which is clearly not the case (Ashby 1992). In addition to providing insight into the behavior of Tank 241-SY-101, the synthetic waste studies will be used to obtain information needed to help

ensure that future waste transfers will not result in the formation of other wastes that exhibit behavior similar to the wastes in Tank 241-SY-101.

Final resolution of this safety issue will require that hydrogen generation be eliminated. This, however, will likely require that the waste be removed from the tank and treated chemically or thermally to eliminate the organic compounds present. Because the required treatment capability does not currently exist at Hanford, near term efforts are focused on mitigation of the safety issue (putting the tank in a safe condition until resolution can be accomplished).

Current mitigation efforts are directed toward eliminating large gas releases. If smaller, more frequent releases can be induced, safe storage may be assured. A number of techniques for accomplishing this objective were identified. Based on a preliminary evaluation of these techniques, four were selected for further evaluation and testing (Babad 1992). These include pumping/stirring (to substantially reduce or eliminate a cohesive non-convective region), heating (which would reduce the amount of solids present in the non-convective region and reduce its viscosity), dilution (which would have the same effect as heating), and ultrasonic agitation (which may induce the trapped bubbles to release in a controlled fashion).

Plans are being developed for in-tank testing of these four mitigation techniques in Tank 101-SY starting in late 1992. In-tank testing is required due to the difficulty associated with attempting to physically simulate the complex behavior of the waste present in Tank 101-SY. Numerical and physical

modeling are being used, however, to support the design of these experiments and to support the safety analyses that must be performed prior to this testing.

The initial in-tank test, scheduled to be initiated in late 1992, will evaluate the ability of jet mixing to prevent the accumulation of gases generated in the non-convective slurry layer of Tank 101-SY. In addition to providing information on the effectiveness of the jet mixing in releasing gas, the test will be utilized to evaluate the waste and tank hardware response to the mixing pump operation. For example, the extent of waste heating and foaming are of concern as are the hydraulic loads imposed on in-tank hardware (e.g., instrument trees). Information obtained from the test will be utilized to determine whether jet mixing is a viable mitigation concept and, if so, data obtained from the test will be utilized in the design of the long-term mixing equipment.

The jet mixing apparatus is shown schematically in Figure 2. It incorporates a 110 kW slurry pump. Success criteria have been established for the test. These include 1) whether the rate rise of the waste level decreases (historically, the rate of rise has been approximately 0.19 cm/d), 2) whether the hydrogen concentration in the tank dome space increases, 3) whether the temperature profile in the non-convective region changes, and 4) whether more uniform waste densities are achieved. These parameters will be measured using instrumentation that will be installed in the tank to monitor the experiment. In order to assess whether success is achieved, the values of these parameters will need to be compared with baseline data to be obtained prior to the test.

Of particular interest will be dome space gas compositions (especially H_2, N_2O, and NH_3) and current rate of rise of the waste level.

Abort criteria have also been established for the test. If any of these criteria are met the test will be aborted by immediately securing the pump. These criteria generally deal with improper pump behavior (e.g., vibration) and unanticipated changes in tank condition such as waste temperature, tank level, and hydrogen concentrations in the dome space.

A combined test is also planned. The primary objective of this test, which is currently scheduled to take place in early 1993, will be to evaluate each of the four mitigation concepts, ultrasonics, heating, dilution, and mixing, individually and in combination. The ability of these techniques to effect controlled release of gas from the non-convective region and also to enhance the movement of resulting gas bubbles through the waste column with subsequent expulsion from the waste surface into the gas space will be tested. Another objective of this test will be to attempt to determine the mechanism(s) by which gas is retained in the non-convecting waste layer and to determine whether any of these potential mitigation concepts will cause enhanced gas retention.

A schematic diagram of the test apparatus is shown in Figure 3. In order to ensure that the testing impacts only a limited volume of the waste in the tank, the testing will be conducted within a test chamber lowered into the waste. Success criteria similar to those for the jet mixing test will be applied to this test. Abort criteria will also be developed.

Ferrocyanide-Containing Wastes

The ferrocyanide compounds present in Hanford waste tanks resulted from processes used to scavenge radioactive cesium from waste liquids. The predominant ferrocyanide precipitate is probably a compound that approaches $Na_2NiFe(CN)_6$. Concentrated mixtures of ferrocyanide salts in the presence of nitrate and/or nitrite constituents can be made to react or explode under certain conditions. The Hanford ferrocyanide tanks contain from 210 to 17,700 kg of ferrocyanide (Babad 1992 b).

Although the probability of a ferrocyanide explosion may be low (the currently measured maximum temperature in a ferrocyanide tank is 55°C, substantially below the minimum temperature, 180°C, at which exothermic behavior has been seen in laboratory samples) the possibility of such an event cannot be dismissed.

As is the case for the flammable gas tanks, resolution of this safety issue will likely require retrieval and treatment of tank wastes. The approach for mitigating this safety issue involves a number of steps:

Identify the conditions (e.g., temperature, ferrocyanide concentration, water content) under which ferrocyanide-containing wastes can be safely stored prior to removal for treatment and disposal;

Evaluate each ferrocyanide tank to determine whether the conditions required for assuring safe storage can be assured for that tank and the required monitoring to ensure that those conditions are maintained;

Conduct the required monitoring for those tanks for which continued storage is appropriate;

Expedite retrieval and treatment of any wastes for which safe storage cannot be assured.

Substantial progress has been made toward identifying the conditions under which ferrocyanide containing wastes can be safely stored. Minimum reaction temperatures have been evaluated based on testing with synthetic ferrocyanide waste mixtures. These studies have evaluated the effects of parameters such as fuel to oxidant ratio, potential catalysts and initiators, and variations in ferrocyanide species (testing of Cs and K as well as Na forms, testing of ferricyanide as well as ferrocyainde compounds). These materials can be made to explode only under conditions of dryness and favorable stoichiometry; under these conditions, high temperatures (>220°C) or high-energy sparks are required to initiate an explosion. The effects of water content and ferrocyanide concentrations are also being evaluated as part of the effort to determine the compositional boundaries of reactive ferrocyanide mixtures.

The process of sampling and characterizing ferrocyanide tanks has also been initiated. Surface samples have been obtained from Tank 241-BY-104. Full length core samples have recently been obtained from Tank 241-C-112, a tank

which contains waste that is expected to have among the highest ferrocyanide concentrations. The waste in Tank 241-C-112 was found to have a very high water content (approximately 50 wt%) and its reactivity was found to be approximately a factor of ten less reactive than comparable synthetic wastes. An integrated program for sampling and characterization of all Hanford waste tanks (including ferrocyanide tanks) is being developed. Although this program emphasizes core sample characterization, techniques for in situ waste characterization are also being evaluated (e.g. the use of laser Raman spectroscopic methods for ferrocyanide determinations).

Ensuring the safe storage of ferrocyanide-containing wastes (both in those tanks that can be stored safely and those tanks awaiting retrieval prior to remediation) will likely require that a minimum moisture content is maintained. This, in turn will require that the moisture in these tanks be monitored (preferably in situ). A number of moisture monitoring methods have been considered including neutron probes, eddy current, spectroscopic (IR), and sonic/ultrasonic, and microwave techniques. The two favored methodologies at this time include neutron probes and spectroscopic techniques. Neutron probes have the advantage of being a mature technology. However, these probes only provide localized information and their use requires a drywell in the waste. In-tank sensor/instrumentation development will be required before the spectroscopic technique can be used. However, this technique could be used to view large areas of the waste's surface and might be used in conjunction with neutron probes to provide a more complete picture of the moisture content of the waste.

Ensuring that ferrocyanide containing wastes can be safely stored will also require that adequate temperature monitoring capability be present. To help meet this need, additional thermocouple trees are being installed in ferrocyanide tanks. Although thermal analyses have indicated that the presence of "hot spots" is unlikely, the use of infrared measurements for surface temperature mapping is also being evaluated.

Organic-Containing Wastes

The issue associated with the organic-containing wastes is essentially the same as that associated with ferrocyanide tanks and the general approach to mitigating and resolving this issue is expected to be similar. After determining the conditions under which organic-containing wastes can be safely stored, the organic tanks will be evaluated on a tank-by-tank basis to determine whether these conditions are present. If not, expedited retrieval and treatment will be implemented. For those wastes that can be safely stored, monitoring programs will be put in place to assure that the conditions required for safe storage are maintained.

Work on this Safety Issue is in the planning stages. At the current time Hanford is reevaluating the current criterion for organic tanks (3.0 % total organic carbon). The types of testing required to estimate minimum reaction initiation and propagation temperatures are being identified. The required characterization of organic-containing wastes is also being identified. The program will also evaluate other factors, such as whether processes can be

identified that might lead to regions of enhanced organic concentration and whether "hot spots" may be present.

High-Heat Tank

Tank 241-C-106 contains a waste sludge with a high Sr-90 content (the heat loading in this tank was estimated to be 46 kW in 1987, primarily due to the decay of Sr-90). To ensure waste tank structural integrity the temperature limit for waste in single shell tanks, such as Tank 241-C-106, has been set at 150°C. Evaporative cooling is required to assure that this temperature limit is not exceeded; periodic water additions (approximately 20 m^3 per month) must be made. The practice of adding cooling water will present a dilemma in the event that a leak occurs. Heat transfer analyses have shown that the temperature of the sludge in the tank would exceed 230°C within one year if water addition was stopped.

Efforts related to high-heat Tank 241-C-106 are focused on ensuring that the waste can be safely stored until it is retrieved. Structural integrity evaluations are being performed to ensure that waste retrieval operations can be safely implemented. Studies are also underway to determine the minimum water additions required to ensure that established temperature limits are not exceeded. Also, water additions are compared with calculated evaporative losses to provide assurance that the tank is not leaking.

Noxious Vapors

Numerous informal reportings of vapors and odors in Hanford Tank Farms have occurred over the past decade. Since 1987 there have been sixteen first-aid cases, with the last case on January 1992. Currently, workers are required to wear respiratory equipment in a number of the tank farms. This requirement is reducing worker efficiency and may impact the ability to meet certain deadlines for resolving other safety issues. Also, concerns have been raised about whether flammable or explosive concentrations of organic vapors may be present in Tank 241-C-103.

Mitigation of this safety issue will require that appropriate means of controlling these emissions be identified and implemented. The first step in this process is the determination of the identities and sources of these emissions. A strategy for this activity is being developed. This strategy will include both area monitoring and characterization of the dome space vapors in certain waste tanks such as 241-C-103.

ISSUE RESOLUTION

Final resolution of each of these safety issues will likely require retrieval and treatment of these wastes. This treatment will be accomplished as an integral part of the Tank Waste Remediation System (TWRS). The scope of the TWRS includes all programs, projects and activities for receiving, safely storing, maintaining, treating, and disposing on-site or packaging for off-site disposal all Hanford tank waste.

Current TWRS plans call for waste treatment for safety issue resolution to be included in the initial phase of waste pretreatment. This treatment will include organic destruction to resolve the Flammable Gas, Organic-Containing Waste, and Noxious Vapor Safety Issues; and ferrocyanide destruction to resolve the Ferrocyanide-Containing Waste Safety Issue. Resolution of the High-Heat Tank Safety Issue will be accomplished through retrieval of the waste from Tank 241-C-106 and treatment of this waste for disposal.

CONCLUSIONS

The DOE has identified a number of Safety Issues associated with the storage of radioactive wastes in tanks at the Hanford Site. Initial efforts have focused on the most urgent needs and aggressive programs are in place for their mitigation and resolution. As these initial issues are addressed, the effort will shift to the remaining Safety Issues and System Deficiencies. Mitigation and resolution of these Safety Issues will be accomplished as an integral part of the overall program for closure of the Hanford waste tanks. Mitigation and resolution will be implemented as expeditiously as possible, but only in a safe, environmentally sound, and technically appropriate manner.

REFERENCES

Alleman, R. T., Z. I. Antoniak, J. R. Friley, C. E. Haines, L. M. Liljegren, and S. Somasundaram. 1991. Mechanistic Analysis of Double-Shell Tank Gas Release: Progress Report - November 1990. PNL-7657, Pacific Northwest Laboratory, Richland, Washington.

Alleman, R. T., Z. I. Antoniak, L. L. Eiler, and L. M. Liljegren. 1992. Conceptual Models for Waste Tank Mechanistic Analysis: Status Report - January 1991. PNL-8011, Pacific Northwest Laboratory, Richland, Washington.

Ashby, E. C., C. Jonah, D. Meisel, L. R. Pederson, and D. M. Strachan. 1992. Gas Generation and Retention in Tank 101-SY: A Summary of Laboratory Studies, Tank Data and Information Needs. PNL-8124, Pacific Northwest Laboratory, Richland, Washington.

Babad, H., G. D. Johnson, J. A. Lechelt, D. A. Reynolds, L. R. Pederson, D. M. Strachan, D. Meisel, C. Jonah, and E. C. Ashby. 1991. Evaluation of the Generation and Release of Flammable Gases in Tank 241-SY-101. WHC-EP-0517, Westinghouse Hanford Company, Richland, Washington.

Babad, H., J. L. Deichman, B. M. Johnson, D. K. Lemon, and D. M. Strachan. 1992. Mitigation/Remediation Concepts for Hanford Site Flammable Gas Generating Waste Tanks. WHC-EP-0516, Westinghouse Hanford Company, Richland, Washington.

Babad, H., R. J. Cash, J. L. Deichman, and G. D. Johnson. 1992. High Priority Hanford Site Radioactive Waste Storage Tank Issues: An Overview. WHC-SA-1539-FP, Westinghouse Hanford Company, Richland, Washington.

K. A Gasper and I. E. Reep. 1991. Waste Tank Safety Programs Overview Plan: W1W End Function. WHC-EP-0426, Westinghouse Hanford Company, Richland, Washington.

TABLE 1 SAFETY ISSUES

LEVEL	ISSUE	ISSUE TITLE
1	1	High Flammable Gas Concentrations
	2	Potentially Explosive Mixtures of Ferrocyanide
	3	Potential For Runaway Organic Nitrate Reactions
	4	Water Additions Needed to Cool Single-Shell Tank
2	1	Inadequate SST Leak Detection
	2	Storage of HLW in Tanks That Have Leaked
	3	Inability of Waste Tanks and Ancillary Equipment to Withstand a Design Basis Earthquake
	4	SST Emergency Pumping Capability Inadequate
	5	Tank Toxic Vapor Release
	6	Inadequate Response Time to a Leaking DST
	7	Storage of High-Level Waste in Tanks With No Secondary Containment
3	1	Insufficient Spare Tank Volume to Handle Waste Resulting from Resolution of Other Safety Issues
	2	Cracked Tank Farm Ventilation Lines
	3	Insufficient Hydroxide Concentration in Tanks
	4	Inadequate Sealing of SSTs to Prevent Intrusions that Could Then Leak Contamination Out of Tank
	5	Possible Inadequacies in Waste Transfer Line Leak Detection
	6	Excessive Unfiltered Airflow Passages into Tanks
	7	Potential for Formation of Explosive Deposits
	8	Uncharacterized Corrosion of HLW Tanks
	9	Questionable Integrity of HLW Tank Vaults

TABLE 2 SYSTEM DEFICIENCIES

DEFICIENCY	DEFICIENCY TITLE
1	Insufficient Tank Contents Characterization
2	Inadequate Safety Documentation
3	Deficient Maintenance and Upgrade of Facilities
4	Deficient Instrument Upgrades in SSTs and DSTs
5	Questionable Tank Safe Operating Life
6	Conduct of Operations Deficient
7	Lack of Plant-Essential Drawings
8	Questionable Transfer Line Concrete Encasement Integrity
9	Inadequate Leak Detection in DSTs

Figure 1. Tank Temperature Pofile Comparison Before, During, and After Gas Release Event.

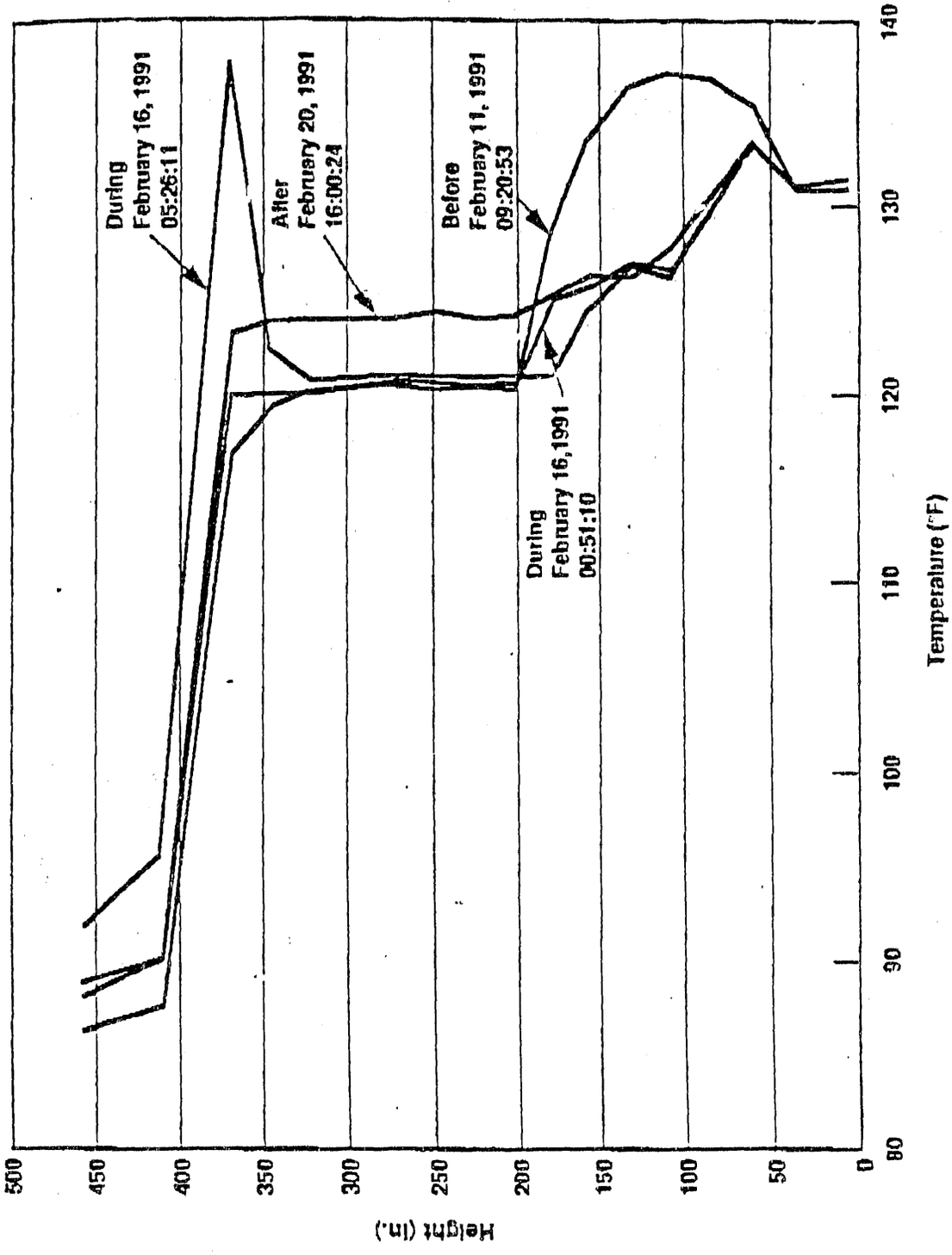


Figure 2. Schematic of Horizontal Jet Mixing Pump Apparatus.

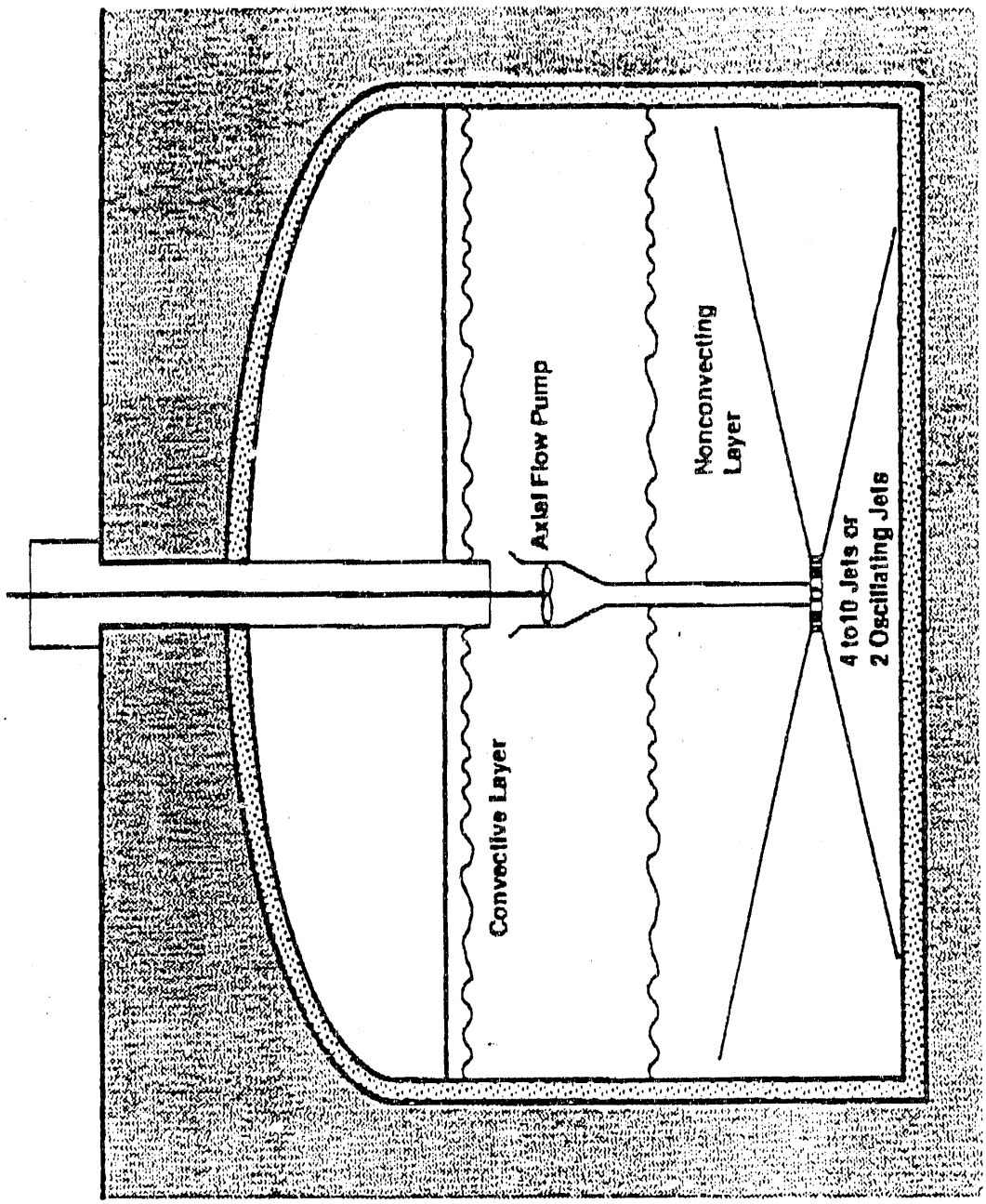
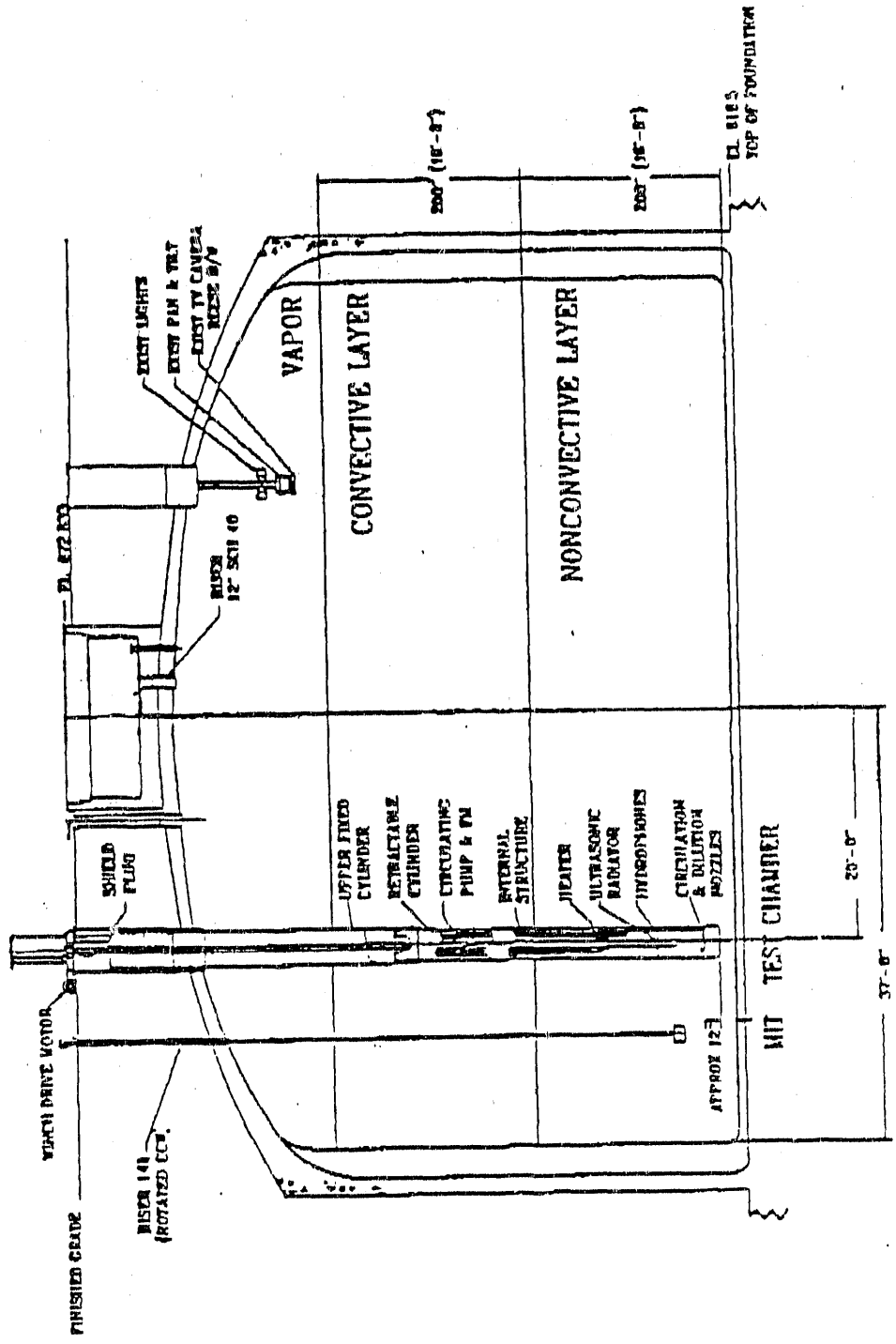


Figure 3. Schematic of Combined Mitigation Test Apparatus.



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