

MAY 23 1997

ENGINEERING DATA TRANSMITTAL

Page 1 of 1  
1. EDT 620271

|   |  |  |  |  |  |
|---|--|--|--|--|--|
| 2. To: (Receiving Organization)<br>Distribution   |  | 3. From: (Originating Organization)<br>Safety Issue Resolution |  | 4. Related EDT No.:<br>NA                |  |
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| 11. Receiver Remarks:    11A. Design Baseline Document? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |  |  |  | 12. Major Assm. Dwg. No.:<br>NA          |  |
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| 1                    | HNF-SD-WM-ER-680         | A11           | 0            | Strategy for Resolution of the Flammable Gas Safety Issue | NA                  |                        |                        |                      |

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# Strategy For Resolution of The Flammable Gas Safety Issue

**GD Johnson**

DESH, Richland, WA 99352

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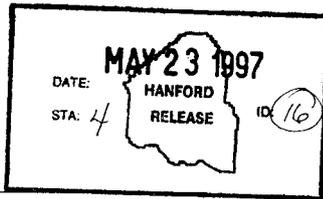
Abstract: This document provides a strategy for resolution of the Flammable Gas Safety Issue. It defines the key elements required for the following.

- Closing the Flammable Gas Unreviewed Safety Question (USQ).
- Providing the administrative basis for resolving the safety issue.
- Defining the data needed to support these activities, and
- Providing the technical and administrative path for removing tanks from the Watch List.

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HNF-SD-WM-ER-680, Rev. 0

**STRATEGY FOR RESOLUTION  
OF THE  
FLAMMABLE GAS  
SAFETY ISSUE**

May 1997

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**TERMS**

|                     |   |
|---------------------|---|
| AWF                 | aging waste facilities  |
| CERCLA              | <i>Comprehensive Environmental Response, Compensation and Liability Act of 1980</i> |
| CIP                 | compliance implementation plan  |
| DCRT                | double-contained receiver tank  |
| DNFSB               | Defense Nuclear Facilities Safety Board   |
| DOE                 | U.S. Department of Energy   |
| DOE-HQ              | U.S. Department of Energy, Headquarters   |
| DST                 | double-shell tank   |
| FAST                | function analysis system technique  |
| FGWL                | Flammable Gas Watch List  |
| FY                  | fiscal year   |
| HWMA                | <i>Washington State Hazardous Waste Management Act</i>                              |
| IMUST               | inactive miscellaneous underground storage tank                                     |
| JCO                 | justification for continued operation   |
| RCRA                | <i>Resource Conservation and Recovery Act of 1976</i>                               |
| SST                 | single-shell tank   |
| Tri-Party Agreement | <i>Hanford Federal Facility Agreement and Consent Order</i>                         |
| USQ                 | Unreviewed Safety Question  |
| WBS                 | work breakdown structure  |
| WHC                 | Westinghouse Hanford Company  |

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## **STRATEGY FOR RESOLUTION OF THE FLAMMABLE GAS SAFETY ISSUE**

### **1.0 INTRODUCTION**

This document provides a strategy for resolution of the Flammable Gas Safety Issue. It defines the key elements required for the following:

- Closing the Flammable Gas Unreviewed Safety Question (USQ),
- Providing the administrative basis for resolving the safety issue,
- Defining the data needed to support these activities, and
- Providing the technical and administrative path for removing tanks from the Watch List.

The strategy provided by this document supersedes the guidance given by WHC-SD-WM-TI-691, Rev. 0, "Strategy for Resolution of the Flammable Gas Safety Issue," dated April 18, 1995.

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## **2.0 MISSION STATEMENT, DEFINITIONS AND OBJECTIVES**

### **2.1 MISSION STATEMENT**

The mission of the Flammable Gas Project is as follows:

- Provide the technical basis for monitoring high-level waste tanks for safe storage
- Provide the technical basis for closure of the USQ and for the upgrade of the Tank Farms Authorization Basis
- Provide the technical basis for resolving the Flammable Gas Safety Issue.

### **2.2 PROJECT DRIVERS**

Several requirements, or drivers, have been established for conducting the Flammable Gas Project. They are briefly described in Sections 2.2.1 through 2.2.4.

#### **2.2.1 Safety Measures Law**

The safety of the high-level waste tanks at the Hanford Site is a public safety concern. The U.S. Congress passed Public Law 101-510, Section 3137, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation," in 1990. Appendix A contains the complete wording of this law, which requires the identification and monitoring of tanks of concern.

#### **2.2.2 Unreviewed Safety Question**

The issue of flammable gases within the waste tanks was first identified as a USQ by U.S. Department of Energy (DOE) Order 5480.5 (DOE 1986) in 1990. The USQ was redefined in 1996 to address additional situations and facilities. The DOE Order that currently addresses USQs is 5480.21 (DOE 1991).

#### **2.2.3 Defense Nuclear Facilities Safety Board**

The Defense Nuclear Facilities Safety Board (DNFSB) was created to provide advice and formal recommendations to the President and Secretary of Energy regarding public health and safety issues at DOE-owned nuclear facilities. DNFSB reviews operating practices and occurrences at these facilities and makes appropriate recommendations to DOE. Recommendation 93-5 made in 1993 identified the following two items:

- Insufficient tank waste technical information exists and the pace of acquiring additional information is too slow to ensure that waste can be stored and operations conducted safely
- Insufficient tank waste technical information exists and the pace of acquiring additional information is too slow to ensure that future disposal program data requirements can be met.

A significant portion of the implementation plan that DOE issued in response to Recommendation 93-5 dealt with the Flammable Gas Safety Issue (DOE 1996).

### **2.2.4 Hanford Federal Facility Agreement and Consent Order**

The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology 1996) was established between the Washington State Department of Ecology, the U.S. Environmental Protection Agency and the DOE in 1989. The Tri-Party Agreement binds DOE to actions to comply with the *Resource Conservation and Recovery Act of 1976* (RCRA), the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA), and the Washington State *Hazardous Waste Management Act* (HWMA). It also establishes major milestones for dealing with the safety issues.

## **2.3 TECHNICAL OBJECTIVES**

Considerable information is needed to address the nature and behavior of flammable gases in the high-level waste tanks. The technical objectives for the Flammable Gas Project can be defined in a problem statement. The problem statement developed for the Flammable Gas Project during a recent facilitated workshop was

"The potential may exist for uncontrolled flammable gas ignition which could result in unacceptable consequences."

The following specific technical tasks are associated with this problem statement and the mission statement:

- Develop an understanding of gas generation, retention, and release
- Collect data to develop an understanding of the behavior of the various waste types and tank configurations
- Assess the potential hazards posed by the presence of flammable gas and potential ignition sources

- Develop and implement appropriate means to monitor the tanks and mitigate, if required, the accumulation and release of unacceptable quantities of flammable gas and the potential ignition sources.

The information obtained from activities supporting the technical objectives must be assembled into appropriate documents to support closure of the USQ and resolution of the safety issue.

## 2.4 OVERVIEW OF THE FLAMMABLE GAS SAFETY ISSUE AND USQ

### 2.4.1 The Safety Issue

Public Law 101-510, Section 3137, addressed safety issues concerning the handling of high-level nuclear waste in storage tanks at the Hanford Site. This law required identifying tanks of concern, establishing appropriate monitoring for the tanks, developing action plans, and restricting waste additions to the subject tanks. In January 1991, a list of tanks subject to this law was submitted to DOE (Harmon 1991a). This list became the "Watch List." In February 1991, a method for selecting flammable gas tanks was defined (Harmon 1991b).

Public Law 101-510 also required that the DOE report to Congress on actions taken to promote tank safety, including actions specifically taken pursuant to the law and the timetable for resolving the outstanding issues. A plan for dealing with the waste tank safety issues was issued in 1991 (Wilson 1991). The plan identified 23 safety issues at the Hanford Site tank farm facilities. These safety issues were sorted into the following three categories.

- **Priority 1.** Issues and/or situations that contain **most** of the necessary conditions that could lead to onsite (worker) or offsite radiation exposure through an uncontrolled release of radioactive waste.
- **Priority 2.** Issues and/or situations that present or contain **some** of the necessary conditions that could lead to an uncontrolled release of radioactive waste using extreme assumptions.
- **Priority 3.** Issues and/or situations that could lead to the future release of fission products if the tanks are viewed as intermediate storage (5-30 years) of high-level nuclear waste. These issues include corrosion and/or leakage, operating practices, buried single-wall transfer lines, etc.

Four Priority 1 safety issues were identified. They were flammable gas generation, the potential for an explosive mixture of ferrocyanide in tanks, the potential for organic-nitrate reactions in tanks, and the continued cooling required to mitigate heat generation in tank 241-C-106.

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#### 2.4.2 The Flammable Gas Watch List and Selection Criteria

In August 1994, *Criteria for Flammable Gas Watch List Tanks* was issued (Hopkins 1994). In October 1994, DOE-Headquarters (DOE-HQ) issued a memorandum providing guidance on modifying the Hanford Site High-Level Waste Tanks Watch List (Lytle 1994). This memorandum stated that no laws or DOE Orders exist that establish the process or criteria for modifying the Watch List. The memorandum further established that the Office of Environmental Management is the approval authority for Watch List modifications. Guidance was given that the U.S. Department of Energy, Richland Operations Office (RL) will discuss any proposed Watch List modifications with appropriate stakeholders.

The current selection criterion for the Flammable Gas Watch List is as follows:

*"Any tank that can have a flammable gas volume in the domespace that, when ignited, would result in pressure above a containment-related tank design limit will be categorized as a Flammable Gas Watch List tank."*

This criterion is quite similar to the problem statement provided in Section 2.3.

The criterion for removing tanks from the Flammable Gas Watch List is as follows:

*"Any tank that no longer satisfies the selection criterion for the Flammable Gas Watch List will be removed from the Watch List."*

These criteria have been approved by DOE and replace those given in Hopkins (1994).

#### 2.4.3 The Flammable Gas Unreviewed Safety Question

In 1990, the apparent release of large quantities of flammable gases in 241-SY-101 waste was recognized as a situation requiring special attention and control. In April 1990, administrative controls were implemented to control activities in 241-SY-101 and in 22 other tanks that potentially had similar behavior (Bracken 1990). In May 1990, RL determined that hydrogen and nitrous oxide build-up in certain waste tanks and the possibility of their ignition constituted an USQ (Lawrence 1990). The USQ was applied to tanks identified as tanks of concern in Bracken (1990).

As a result of evaluating additional tank data, two tanks were added to the Flammable Gas USQ and Watch List in 1992 and 1993 that brought the total to 25 tanks. Appendix B lists the 6 double-shell tanks (DST) and 19 single-shell tanks (SST) on the Watch List.

The original Flammable Gas USQ was updated in July 1996 and consolidated earlier determinations into one overall Flammable Gas USQ determination that was adopted by RL on November 1, 1996. This expanded the USQ in flammable gas composition; applicability

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to additional structures; methods of gas generation, retention, and release; location of hazard; and energetics and characteristics of burns. The Flammable Gas USQ now applies to 149 SSTs and 27 DSTs, 7 double-contained receiver tanks (DCRT), 4 vaults, 13 catch tanks, 36 inactive miscellaneous underground storage tanks (IMUSTs) and 2 deactivated evaporators. It is noteworthy that 241-SY-101, the tank that initiated the entire process, was dropped from the USQ as having an adequate authorization basis.

A justification for continued operation (JCO) was submitted at the same time as the expanded Flammable Gas USQ. The JCO provides detailed descriptions and data for the flammable gas hazards identified in the Flammable Gas USQ. Work controls and equipment requirements were developed and documented. Facilities affected by the Flammable Gas USQ have been divided into three facility groups (Appendix C) to allow for grading of controls without undue complexity for implementation. The controls and requirements include adaptations, expansions, and refinements to existing Authorization Basis controls and other administrative practices used to manage the flammable gas hazard. The JCO is under review by RL; however, standing orders have been approved that provide the controls outlined in the JCO (Wagoner 1996) for ventilation, ignition source, and monitoring. The controls are to be applied to the tanks on a graded basis for both waste- and nonwaste-intrusive operations.

## **2.5 SCHEDULAR OBJECTIVES**

The major milestones for the Flammable Gas Project as classified by agency (Tri-Party Agreement, DNFSB, and DOE) are summarized below beginning with Fiscal Year (FY) 1997.

### **2.5.1 Tri-Party Agreement Milestones**

It should be noted that for the TPA milestones, closure of the USQ and resolution of the safety issue applies only to the 25 tanks listed on the Flammable Gas Watch List (Appendix B). However, it is the intent of the Flammable Gas Project to close the USQ for all 149 single-shell and 27 double-shell tanks by September 30, 1998.

Appendix D of the Tri-Party Agreement describes the following milestones (Ecology 1996).

- Complete Vapor Space Monitoring for All Flammable Gas Generating Tanks (M-40-10): January 31, 1997.
- Close All Unreviewed Safety Questions for Double-Shell and Single-Shell Tanks (M-40-09): September 30, 1998.
- Mitigate/Resolve Tank Safety Issues for High Priority Watch List Tanks (M-40-00): September 30, 2001.

### **2.5.2 DNFSB Milestones (93-5 Implementation Plan)**

- Letter Reporting Completion of AN Tank Farm Ventilation Upgrade (5.4.3.5f): November 1996.
- Letter Reporting Completion of Flammable Gas Safety Screening of Remaining Passively Ventilated SSTs to Determine if Steady State Vapors are Less Than 25% of the LFL (5.4.3.5g): November 1996.
- Letter Reporting Completion of Supporting Technical Document on Flammable Gas Safety Issue (5.4.3.5h): December 1996.
- Letter Reporting That External Equipment Spark Sources in Flammable Gas Tanks have been Managed by Controls or the Equipment has been modified (5.4.3.5i): December 1996.
- Letter Reporting Completion of Voidmeter and Viscometer Readings in Tanks AN-103, AN-105, and AN-105 (5.4.3.5j): December 1996.
- Letter Reporting Completion of Retained Gas Sampling in Tanks AW-101, AN-103, AN-104, AN-104 and A-101 (5.4.3.5k): March 1997.
- Letter Reporting Refinement of Flammable Gas Generation/Retention Models Using Voidmeter and Retained Gas Sampling Data (5.4.3.5l): May 1997.

### **2.5.3 DOE Milestones**

- Issue Updated Strategy Document for Resolution of the Flammable Gas Safety Issue (T22-97-109): May 30, 1997.
- Issue SST Gas Generation Report (T22-97-106): August 4, 1997.
- Submit USQ Closure Package for JCO Facility Group 3A Interim Stabilized Tanks (T22-97-147): August 15, 1997.
- Issue Flammable Gas DST Summary Report (T22-97-108): August 29, 1997.
- Issue FY 1997 Annual Report on Vapor Space Monitoring of Flammable Gas Tanks (T22-97-107): September 30, 1997.
- Provide 5 Portable Exhausters for Flammable Gas SSTs (T22-97-145): September 30, 1997.

- Submit USQ Closure Package for JCO Facility Group 3B Non-Interim Stabilized Tanks (T22-97-148): September 30, 1997.
- Complete Flammable Gas Safety Project Support to Tank 241-SY-101 (T22-97-111): September 30, 1997.
- Complete Installation of SHMSs on Additional Flammable Gas Tanks (T22-97-003): September 30, 1997.
- Issue Final Ammonia Report (T22-97-105): September 30, 1997.
- Complete RGS Data Analysis for 4 of 4 Flammable Gas SSTs (T22-97-006): December 31, 1997.
- Submit USQ Closure Package for JCO Facility Group 2 Single-Shell Tanks (T22-98-111): June 30, 1998.
- Submit USQ Closure Package for JCO Facility Group 1 and 2 Double-Shell Tanks and Aging Waste Facility Tanks (T22-98-112): July 31, 1998.
- Complete Flammable Gas Mechanism Studies (T22-98-103): September 30, 1998.
- Complete Ventilation Upgrades for Flammable Gas DSTs (T22-98-002): September 30, 1998.
- Complete Safety Issue Models for Flammable Gas Tanks (T22-98-001): September 30, 1998.
- Issue Flammable Gas SST Data Status Report (T22-99-101): March 31, 1999.
- Complete Monitoring Upgrades for Flammable Gas Tanks (T22-99-102): September 30, 1999.
- Complete Data Analysis for Flammable Gas Tanks (T22-000-001): September 29, 2000.

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### 3.0 STRATEGY

#### 3.1 THE NATURE OF THE FLAMMABLE GAS SAFETY ISSUE

The key phenomena for the Flammable Gas Safety Issue are gas generation, gas retention, and mechanisms that cause release of the gas from the waste. An understanding of the mechanisms for these processes is required for final resolution of the safety issue. Central to this understanding is gathering of information from historical records, tank sampling, tank process data (temperatures, ventilation rates, etc.), and results of laboratory evaluations conducted on tank waste samples.

Gas generation processes must be understood well enough to estimate the generation rate and relative gas compositions as a function of the different waste types in the tanks. Generation rates of the major fuel (hydrogen, ammonia, and methane) and diluent species (nitrogen) determine the minimum tank ventilation rate required to prevent a buildup of flammable gas mixtures in the domespace of a tank. A knowledge of gas generation processes also aids the assessment of the long term behavior of tank wastes and supports analyses of potential changes in waste storage conditions. Finally knowledge of the composition is needed to assess the severity of potential deflagrations. The presence of gases such as ammonia, methane, and nitrous oxide can have a significant influence on the burn characteristics of a gas mixture.

Retention of gases is generally affected by hydrostatic and mechanical forces. Actual mechanisms will vary with the waste type (double-shell slurry, sludge, or saltcake). Extensive analyses conducted for tank 241-SY-101 have shown that the relative densities of solid and liquid phases, as well as the shear strength of gas retaining layers are important factors. Viscosities of the fluids and slurries are also important for evaluating the trapping and release of the gas. Current research is directed toward a better understanding of the physics of gas retention and release.

To date, evaluation of the stored gas has been through analysis of tank-level data, temperature profiles, and detailed modeling activities. In-situ measurements appear to be the most promising approach for characterization of stored gas. Void fraction measurements have been conducted on double-shell tanks, but this method most likely will not work for the single-shell tanks where the waste is either sludge or saltcake. The retained gas sampler is being used in selected SSTs to determine feasibility of the approach.

Gas can be released spontaneously or as a result of waste intrusive activities. Understanding gas release mechanisms sufficiently to estimate release rates, volumes, and frequencies and to relate each of these parameters to tank waste configurations and properties is necessary to evaluate the consequences of a postulated gas mixture ignition. This information also supports development of work controls and ventilation requirements. Modeling efforts are needed to assess the mixing and removal of gases from tank domespaces and tests and instrumentation upgrades are needed to provide basic data.

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Resolution of the Flammable Gas Safety Issue will require evaluation of tank conditions relating to the distribution of gas both in the domespace and within the waste. The waste tanks will continue to generate gases until the waste is retrieved. Thus, it is necessary to establish monitoring criteria, methods for implementing the monitoring (e.g., specific types of gas monitors), and actions or decisions based on the results of such monitoring. This information is developed as part of required updates to the tank farm authorization basis. Verification that monitoring criteria and work controls are indeed effective is needed for resolution of the safety issue.

Specific project tasks established to obtain the requisite knowledge discussed in this section are described in Appendix F.

### **3.2 STRATEGY/LOGIC FOR ISSUE RESOLUTION**

The high-level strategy for closing the Flammable Gas USQ and resolving the Flammable Gas Safety Issue will follow the approach that was successfully used for the Ferrocyanide Safety Issue (Grumbly 1993). This strategy (see Figure 3-1) uncoupled closure of the Ferrocyanide USQ from final resolution of the Ferrocyanide Safety Issue by noting that "closure" of the USQ is an early intermediate step in the process of "safety issue resolution." For the Ferrocyanide Safety Issue, the strategy contained two key steps.

- Development of criteria for three safety categories that rank the hazard for each tank and thus allow for closure of the Ferrocyanide USQ, and
- Confirmation and final placement of each tank into one of the categories based on core sampling and analyses of the tank contents, as noted in Figure 3-1.

To apply this approach to the Flammable Gas Safety Issue, Figure 3-1 has been changed as shown in Figure 3-2. The problem statement given in Section 2.3 was "The potential may exist for uncontrolled flammable gas ignition which could result in unacceptable consequences." The criteria for safety issue resolution were developed at a facilitated workshop and are discussed in this section. The process by which the Flammable Gas USQ will be closed is summarized in Section 3.2.3 and described in detail in Appendix D. The rest of this section focuses on a description of and logic for resolving the safety issue.

The approach for resolving the Flammable Gas Safety Issue was developed at facilitated workshops held on February 19-20 and March 4, 1997. Various Hanford contractors, Pacific Northwest National Laboratory (PNNL), Los Alamos National Laboratory (LANL), Sandia National Laboratory (SNL), and DOE participated. (See Appendix E for a complete list of participants).

### 3.2.1 Function Analysis System Technique

Figure 3-3 is the function analysis system technique (FAST) diagram developed to resolve the Flammable Gas Safety Issue. FAST diagraming is a logic tool most commonly used in value engineering and analysis studies. The logic begins when a team of people identifies function statements (i.e. active verb and measurable noun) and arranges those functions by asking "how" for each function from left to right, starting with the higher-order function. The team validates the logic by asking "why" for each function from right to left. During the process of developing the critical path in both the how and the why directions, "when" and "all-the-time" functions are identified.

"When" functions result from a critical path function. "When" functions are vertically aligned with the corresponding critical path function. "All-the-time" functions happen more than once, or all the time, throughout the critical path. "All-the-time" functions are stand-alone functions grouped separately from the critical path to identify their uniqueness. The FAST diagram is complete when the team is satisfied that all the functions within the scope have been identified and arranged in order from the highest to lowest, including any applicable "when" and "all-the-time" functions.

Figure 3-3 shows the "how" functions starting at the left side of the diagram.

"How is the safety issue resolved?

It is resolved by demonstrating control effectiveness and by closing the USQ.

"How do you demonstrate control effectiveness?

It is demonstrated by mitigating or eliminating the hazard.

"How do you mitigate/eliminate the hazard and close the USQ?

This is done by revising the authorization basis."

In considering the "why" aspect, one starts at the right side of the diagram.

"Why do we want to understand flammable gas behavior?

We want to understand flammable gas behavior so we can identify the hazards.

"Why do we identify the hazards?

The hazards are identified so we can model the accidents."

For the "when" part of the process, an example is as follows:

"When we revise the authorization basis we document the technical basis, develop the Compliance Implementation Plan and obtain DOE approval."

Figure 3-1. Strategy for Ferrocyanide Safety Issue Resolution.

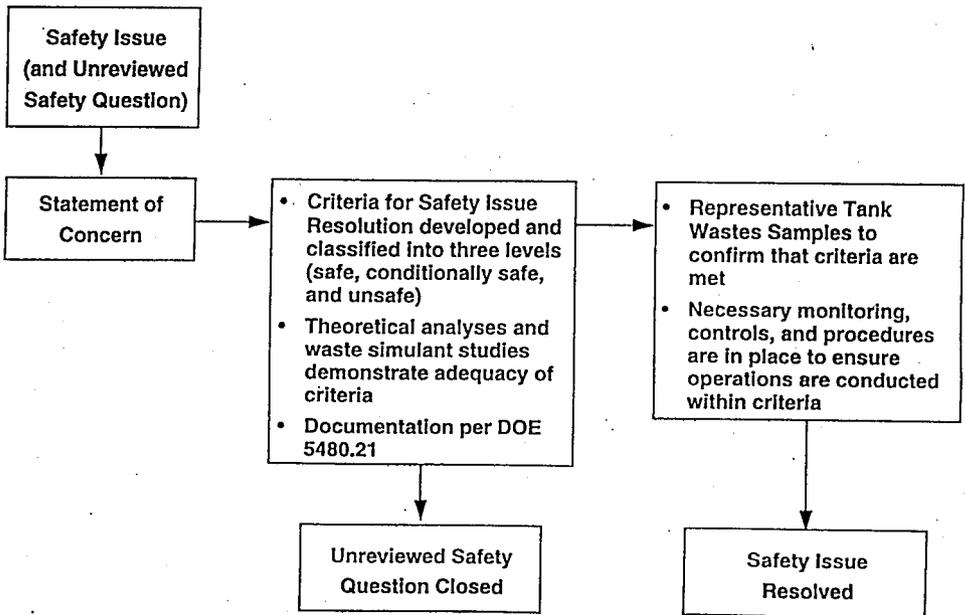


Figure 3-2. Strategy for Resolution of the Flammable Gas Safety Issue.

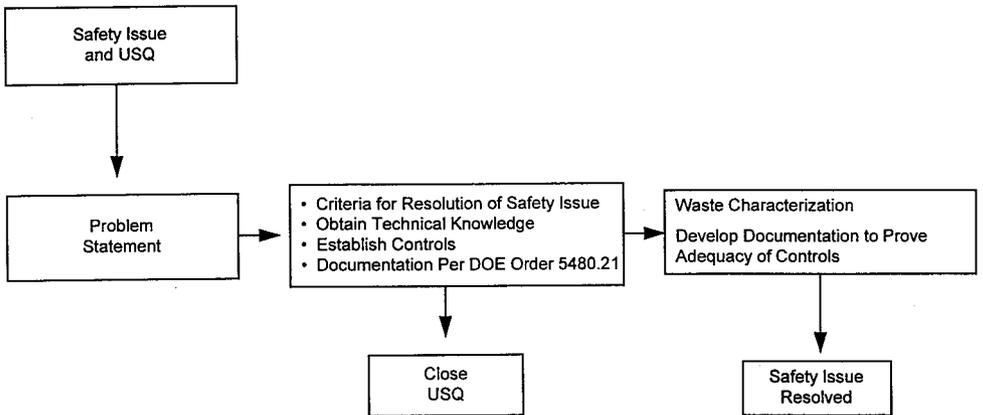
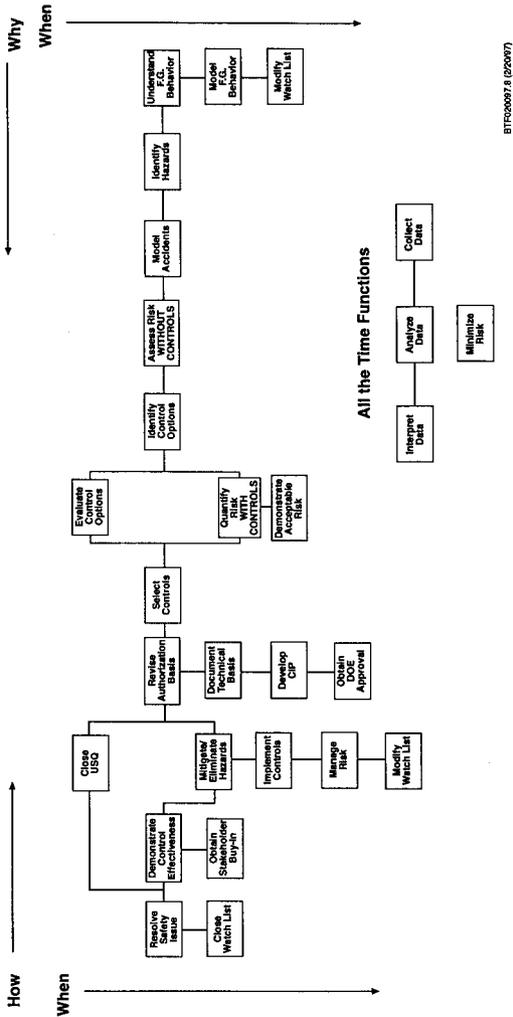


Figure 3-3. F.A.S.T. Diagram - Flammable Gas Issue Resolution Strategy.



### 3.2.2 Logic Diagram for Resolution of the Safety Issue

The FAST diagram from Figure 3-3 was used to develop a logic or flow diagram for resolving the Flammable Gas Safety Issue. In this diagram, the starting point is at the left and the end point is at the right side of the diagram. Figure 3-4 shows the diagram developed at the facilitated workshop. In this figure, each functional rectangular block, where appropriate, has an associated list of activities and products. The diamond-shaped blocks call for decisions.

A key item evaluated at the workshop was to determine the exact role of the Flammable Gas Watch List (FGWL) with respect to closure of the safety issue. Resolution of the safety issue is a Tri-Party Agreement milestone. For this milestone, the FGWL only identifies the tanks for which resolution is required. The requirements of the milestone do not involve removing tanks from the Watch List or final closure of the Watch List. As noted in the flow diagram, the two main requirements for resolving the safety issue are closure of the USQ and implementation of the updated safety authorization basis. When these have been done, submitting the basis for removing a tank, or tanks, from the Watch List to DOE is appropriate. Finally, it should be noted that in the activities beneath the block for "resolve safety issue," an activity is included for removing a tank from the Watch List.

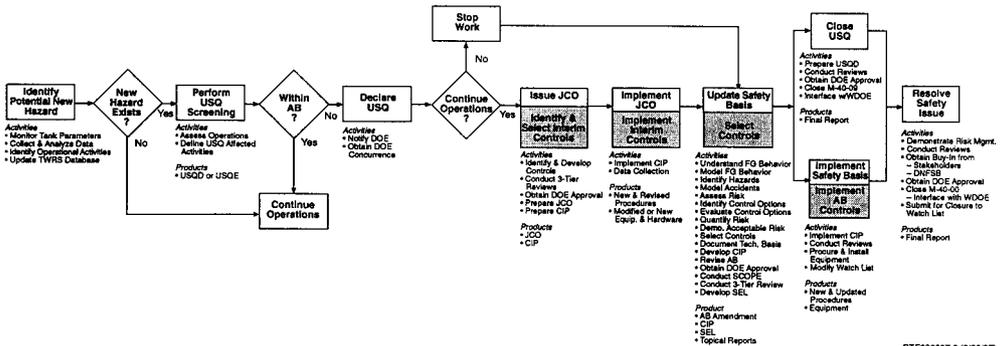
The flow diagram is driven by the steps and information required to ensure that the required authorization basis is in place. This is key to resolving the safety issue. It is also driven by DOE Orders. Most Flammable Gas Project activities support the block labeled "Update Safety Basis." Note that most of the activities listed for this block are also the functions shown on the FAST diagram in Figure 3-3.

The left half of the diagram has essentially been completed. As noted in Section 2.4.3, an updated Flammable Gas USQ has been approved and a JCO has been submitted to DOE along with a compliance implementation plan (CIP). Efforts are now directed at updating the safety basis and developing the information for closing the USQ, which is discussed in the next section.

### 3.2.3 Closure of the Flammable Gas USQ

Closure of the Flammable Gas USQ has been a complex issue and, as noted in Section 2.4.3, the Flammable Gas USQ now covers all 149 single-shell tanks, 27 double-shell tanks, and a variety of miscellaneous tanks and facilities. Even though the USQ has been closed for tank 241-SY-101, application of this process on a tank-by-tank basis has not been successful. Some reasons for this are that the existence and extent of the hazard and the necessity and effectiveness of controls have been subject to much debate. Furthermore, elimination of uncertainties in many of the technical parameters needed for hazard analyses is not likely to be achieved in the near term.

Figure 3-4. Flammable Gas Issue Resolution Strategy Flow Diagram.



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The general requirements for closure of a USQ involve defining the hazard, identifying when and where the hazard occurs, evaluating and quantifying the risk, identifying a means to control the risks, quantifying the effectiveness of proposed controls, revising the authorization basis, implementing the controls, and providing a means to keep the USQ closed.

The approach for closing the Flammable Gas USQ will rely on applying expert elicitation methods to quantify the uncertainty of technical parameters of highest doubt and consequence. This approach is based on the recognition that the fundamental building blocks of responsible hazard management are specific, concrete decisions about what hazard control strategies are appropriate for a tank or facility. In order to provide the requisite information for selecting the controls, the process will start with a systematic approach to phenomenological uncertainty. Expert elicitation will allow for a quantitative treatment of uncertainty. Workshops will be held with nationally recognized experts to collect their estimates of ranges of required parameters. Once this information has been obtained and agreed with, it will be used in an analysis of the hazards and corresponding control options. When the control options have been defined, the process for closing the USQ can then proceed.

A detailed description of the process for closing the Flammable Gas USQ for 149 SSTs and 27 DSTs is provided in Appendix D.

An approach for closing the Flammable Gas USQ for DCRTs, vaults, catch tanks, IMUSTs, evaporators, transfer lines, and pits is being developed. Closure for transfer lines, pits, and evaporators should not be too involved and the required documentation will be prepared in FY 1998. Facilities such as the DCRTs, vaults, and catch tanks may be able to use the Analysis Tool developed for the SSTs (Appendix D). Some sampling and design modifications may be needed. Closure of the USQ for the IMUSTs might be difficult since little is known about these tanks. On the other hand since many of the IMUSTs are sealed and there are no operations being performed, restricted access might be the best approach for the near term. These options along with others are being evaluated and a more detailed plan will be available in the next few months.

The Tri-Party Agreement milestone date for closure of the Flammable Gas USQ is September 30, 1998. As noted earlier, the approach for USQ closure utilizes "expert elicitation" in the development of the basis for making decisions about the required controls for the hazards. It is anticipated that this approach would also benefit the process for resolution of the safety issue.

#### **3.2.4 Disposition the Watch List**

The final step in resolution of the Flammable Gas Safety Issue is to close out the Watch List. As noted in the introduction to Section 3, the DOE had noted that closure of the USQ was only a part of the overall process for issue resolution. This view was reflected in

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Figures 3-1 and 3-2. Resolution of the safety issue rests with demonstrating that sufficient knowledge exists about the phenomena so that application of the appropriate controls ensures that any given tank will not become an issue with respect to flammable gas.

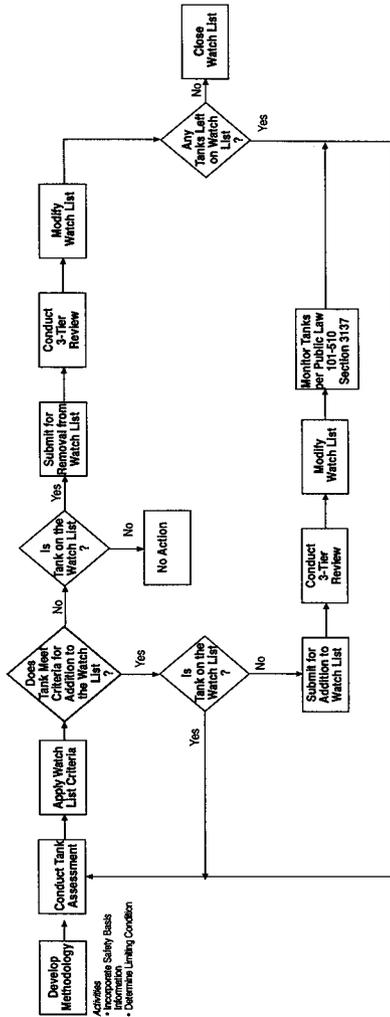
Criteria for placing tanks on and removing tanks from the Watch List have been issued (See Section 2.4.2). Another part of the facilitated workshop (Appendix E) provided some general agreement about the criterion for placing tanks on the FGWL. The workshop participants discussed the meaning of the word "can" in the criterion: "Any tank that *can* have a flammable gas volume in the domespace that, when ignited, would result in pressure above a containment-related tank design limit will be categorized as a Flammable Gas Watch List tank."

The participants agreed that it should be interpreted as meaning "to have a significant potential for an unacceptable risk from a spontaneous release of flammable gas."

Also as a result of the workshop, the criterion for removing a tank from the Watch List ("Any tank that no longer satisfies the selection criterion for the Flammable Gas Watch List will be removed from the Watch List") was interpreted to mean (1) a tank that cannot spontaneously release enough flammable gas to the domespace "which, if ignited.....tank design limit" has **acceptable risk** from the perspective of the Watch List, and (2) compliance with DOE orders in implementing an approved authorization basis is a measure of demonstrating acceptable risk.

Finally, the workshop produced a flow diagram, shown in Figure 3-5, for modifying the FGWL. A key item in this process is to have an evaluation methodology that correctly reflects the conditions in the various waste tanks. The current methodology has been subject to much criticism (Johnson 1996) and efforts are underway to improve it. Once this has been put in place, then assessments can be conducted on a tank by tank basis. Proposed additions or removals will be subjected to review, and final approval of the changes to the Watch List will reside with DOE-HQ.

Figure 3-5. Flow Diagram for Modification of the Flammable Gas Watch List.



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## **4.0 MANAGEMENT APPROACH**

### **4.1 PROGRAM STRUCTURE**

The Flammable Gas Project is an activity (WBS Element 1.1.1.2.2.1) within the Safety Issue Resolution End Function. Details of the work breakdown structure (WBS), baseline schedule, and costs are provided in the FY 1997 Multi-Year Work Plan (WHC-SP-1101, Rev. 2). This project uses a multi-disciplined approach involving Hanford Site contractors, national laboratories, universities, and consultants. The WBS activity has the following four cost accounts.

- Safety Issue Models for Flammable Gas Tanks
- Flammable Gas Tank Data Collection and Analysis
- Flammable Gas Safety Basis
- Monitoring and Mitigation Equipment for Flammable Gas Tanks.

### **4.2 PROJECT TASKS**

Table 4-1 summarizes the tasks and performing organizations for each cost account. Appendix F contains summary descriptions of the tasks.

Table 4-2 summarizes the relationship of the tasks to the FAST diagram (Figure 3-3) for resolving the safety issue. Each task is listed as a primary function or a secondary function. For example the gas generation task is a primary function to the understand flammable gas behavior function from the FAST diagram, while the CRS support task is a secondary function to understanding flammable gas behavior. A number of the functional blocks in the FAST diagram will be conducted by other parts of the Tank Waste Remediation System (TWRS) organization; these are not noted in Table 4-2, which only shows the tasks for the Flammable Gas Project.

### **4.3 TRANSITION STRATEGY**

Assuming that the Tri-Party Agreement milestone is successfully completed, the activities of the Flammable Gas Project will transition to Tank Farm Operations in FY 2002. The transition process for any remaining activities will be formulated in future updates to this document.

Table 4-1. Flammable Gas Project Cost Accounts. (2 Sheets)

| Task  | Performer     |
|---|---------------|
| Safety Issue Models for Flammable Gas Tanks     |               |
| Gas generation                                  | PNNL/NHC      |
| Gas retention                                   | PNNL          |
| Ammonia studies                                 | PNNL/NHC      |
| Physics/chemistry integration                   | PNNL          |
| Domespace modeling                              | PNNL/NHC      |
| Flammability tests                              | CIT/LANL      |
| Deflagration analyses                           | LANL          |
| PNNL project management                         | PNNL          |
| Flammable Gas Tank Data Collection and Analysis |               |
| Retained gas sampling/analysis                  | PNNL/NHC/LMHC |
| Vapor analysis                                  | PNNL/LMHC     |
| Waste behavior analysis                         | PNNL          |
| Domespace breathing analysis                    | PNNL          |
| Data reconciliation                             | LANL          |
| Data evaluation                                 | LMHC          |
| Voidmeter tests/analysis                        | LMHC/PNNL     |
| SY-101 data reports                             | PNNL          |

Table 4-1. Flammable Gas Project Cost Accounts. (2 Sheets)

| Task   | Performer      |
|--|----------------|
| <b>Flammable Gas Safety Basis</b>                                  |                |
| USQ closure  | DESH           |
| Safety basis support   | DESH           |
| Scope  | SNL            |
| Safety support   | LANL           |
| Compatibility criterion  | LANL           |
| Program planning/control   | DESH           |
| Project management   | DESH           |
| CRS support  | DOE            |
| <b>Monitoring and Mitigation Equipment for Flammable Gas Tanks</b> |                |
| Ventilation upgrades   | SESC           |
| Gas monitoring equipment   | SESC           |
| TMACS support  | LMHC/FDNW      |
| Video equipment  | LMHC           |
| SY-101 mitigation support  | SESC/LMHC/LANL |
| Portable exhausters  | LMHC           |
| Equipment coordination   | LMHC           |
| Pressure gauges  | LMHC           |

CIT California Institute of Technology  
 DESH Duke Engineering & Services Hanford  
 DOE Department of Energy  
 LANL Los Alamos National Laboratory  
 LMHC Lockheed Martin Hanford Company  
 NHC NUMATEC Hanford Company  
 PNNL Pacific Northwest National Laboratory  
 SESC SGN Eurisys Services Company  
 SNL Sandia National Laboratories

Table 4-2. F.A.S.T Functions.

| F.A.S.T FUNCTIONS                    | Understand Flammable Gas Behavior | Model Flammable Gas Behavior | Modify Watch List | Identify Hazards | Model Accidents | Assess Risk without Controls | Identify Control Options | Evaluate Control Options | Quantify Risk with Controls | Demonstrate Acceptable Risk | Select Control | Reverse Augmentation Basis | Document Technical Basis | Develop CIP | Obtain DOE Approval | Close USD | Mitigate/Eliminate Hazards | Implement Controls | Manage Risk | Modify Watch List | Demonstrate Control Effectiveness | Obtain Stakeholder Buy-In | Resolve Safety Issue | Closed Watch List | Collect Data | Analyze Data | Interpret Data | Minimize Risk |
|--------------------------------------|-----------------------------------|------------------------------|-------------------|------------------|-----------------|------------------------------|--------------------------|--------------------------|-----------------------------|-----------------------------|----------------|----------------------------|--------------------------|-------------|---------------------|-----------|----------------------------|--------------------|-------------|-------------------|-----------------------------------|---------------------------|----------------------|-------------------|--------------|--------------|----------------|---------------|
| FLAMMABLE GAS PROJECT TASKS          |                                   |                              |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 1-1 Gas Generation                   | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 1-2 Gas Retention/Release            | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 1-3 Airborne Studies                 | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 2                 | 2            | 1            |                |               |
| 1-4 Physics/Chemistry Integration    | 1                                 | 1                            | 2                 |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 1-5 Flammability Testing             | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 1-6 Flammability Tests               | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 1-7 Delegation Analysis              | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 2                 | 2            | 2            |                |               |
| 1-8 PNNL Project Mgmt                | 2                                 | 2                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 2-1 Reduced Gas Sampling & Analysis  | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 2-2 Vapor Sampling & Analysis        | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 2-3 Waste Behavior Analysis          | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 2-4 Headspace Breathing Analysis     | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 2-5 Data Reconciliation              | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 2-6 Data Error Investigation         | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 2-7 Data Error Prevention & Analysis | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 2-8 SY-101 Data Reports              | 1                                 | 1                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      | 1                 | 1            | 1            |                |               |
| 3-1 USD Closure                      |                                   |                              |                   | 2                |                 | 1                            | 2                        | 2                        | 1                           | 2                           | 1              | 1                          | 1                        | 2           |                     | 1         |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 3-2 Safety Basis Support             |                                   |                              |                   | 2                |                 | 1                            | 2                        | 2                        | 1                           | 2                           | 1              | 1                          | 1                        | 2           |                     | 1         |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 3-3 Safety Basis Support             |                                   |                              |                   | 2                |                 | 1                            | 2                        | 2                        | 1                           | 2                           | 1              | 1                          | 1                        | 2           |                     | 1         |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 3-4 USQ/Safety Support               |                                   |                              |                   | 2                |                 | 1                            | 2                        | 2                        | 1                           | 2                           | 1              | 1                          | 1                        | 2           |                     | 1         |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 3-5 Compatibility Criteria           |                                   |                              |                   | 2                |                 | 1                            | 2                        | 2                        | 1                           | 2                           | 1              | 1                          | 1                        | 2           |                     | 1         |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 3-6 Program Planning/Control         | 2                                 | 2                            | 1                 |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 3-7 Project Management               | 2                                 | 2                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 3-8 CDS Support                      | 2                                 | 2                            |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 4-1 Ventilation Upgrades             |                                   |                              |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 4-2 Gas Monitoring Equipment         |                                   |                              |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 4-3 TMACS Support                    |                                   |                              |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 4-4 TMACS Support                    |                                   |                              |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 4-5 SY-101 Mitigation Support        |                                   |                              |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 4-6 Portable Exhausts                |                                   |                              |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 4-7 Equipment Coordination           |                                   |                              |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| 4-8 Pressure Gauges                  |                                   |                              |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| Primary Function - 1                 |                                   |                              |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |
| Support Function - 2                 |                                   |                              |                   |                  |                 |                              |                          |                          |                             |                             |                |                            |                          |             |                     |           |                            |                    |             |                   |                                   |                           |                      |                   |              |              |                |               |

Table 4-3. Ten-Year Plan Guidance.

|   |   | A           | B                    | C                       | D           |
|---|---|-------------|----------------------|-------------------------|-------------|
| <b>LIKELIHOOD</b> - defined as either:    | <i>Probability that event (i.e., exposure) occurs within a year, leading to adverse impacts; or</i>   | 1           | < 1;<br>> 0.1        | <= 0.1;<br>> 0.01       | <= 0.01     |
|   | <i>Time until event (i.e., exposure) leading to adverse impacts is expected to occur</i>  | < 1 year    | >= 1 yr;<br>< 10 yrs | >= 10 yrs;<br>< 100 yrs | >= 100 yrs  |
| <b>IMPACTS - Public Safety and Health</b> |   |             |                      |                         |             |
| 1   | <i>Death or injuries/illnesses involving permanent, irreversible effects such as permanent total disability or chronic diseases. Extreme overexposures</i>  | Urgent (1A) | High (1B)            | Medium (1C)             | Medium (1D) |
| 2   | <i>Injuries/illnesses involving permanent partial disability or temporary total disability &gt; 3 months, or overexposure</i>   | High (2A)   | Medium (2B)          | Medium (2C)             | Low (2D)    |
| 3   | <i>Injuries/illness that result in temporary, reversible impacts. Disability may be total but of &lt; 3 months duration or small over exposure exceedence</i>                                       | Medium (3A) | Low (3B)             | Low (3C)                | Low (3D)    |
| 4   | <i>Injuries/illness that result in partial or temporary reversible impacts or exposures at or below regulatory levels</i>   | Low (4A)    | N/A*                 | N/A                     | N/A         |
| <b>IMPACTS - Worker Safety and Health</b> |   |             |                      |                         |             |
| 1   | <i>Death or injuries or illnesses resulting in permanent total disability, chronic or irreversible illnesses, or extreme overexposure</i>   | Urgent (1A) | High (1B)            | Medium (1C)             | Medium (1D) |
| 2   | <i>Injuries or illnesses resulting in permanent partial disability or temporary total disability &gt; 3 months, or serious overexposure</i>   | High (2A)   | High (2B)            | Medium (2C)             | Low (2D)    |
| 3   | <i>Injuries or illnesses resulting in hospitalization, temporary, reversible illnesses with a variable but limited period of disability of &lt; 3 months, or overexposure</i>                       | Medium (3A) | Medium (3B)          | Low (3C)                | Low (3D)    |
| 4   | <i>Injuries or illnesses not resulting in hospitalization, temporary reversible illnesses requiring minor supportive treatment or cumulative exposures above limits that have no lasting effect</i> | N/A         | N/A                  | N/A                     | N/A         |
| <b>IMPACTS - Environmental Health</b>     |   |             |                      |                         |             |
| 1   | <i>Catastrophic damage (irreversible loss of unique or sensitive environment, or very poor biological condition, or a wide geographic impact or &gt; 20 years to recovery)</i>                      | Urgent (1A) | High (1B)            | High (1C)               | High (1D)   |
| 2   | <i>Significant damage (poor biological condition, or intermediate geographic impact or 5-20 years to recovery)</i>  | High (2A)   | High (2B)            | Medium (2C)             | Medium (2D) |
| 3   | <i>Moderate Damage (fair biological condition, or small geographic impact or 2-5 years to recovery)</i>   | Medium (3A) | Medium (3B)          | Low (3C)                | Low (3D)    |
| 4   | <i>Minor damage (good biological condition, and negligible geographic impact or &lt; 2 years to recovery)</i>   | N/A         | N/A                  | N/A                     | N/A         |

\* While "N/A" is used in this table to indicate risk levels near background, it may also be used to designate projects unrelated to risk reduction, such as administration, management, or research.

#### 4.4 RISK MANAGEMENT

Preparation of project activities for FY 1998 and beyond included a risk evaluation that addressed risks to workers, the public, and the environment. For each category, the level of risk is defined by the intersection of impact and likelihood as shown in Table 4-3.

The public health and safety risks, worker health and safety risks, and environmental protection risks associated with the Flammable Gas Safety Issue Resolution Project are considered to be **High** during interim storage, decrease to **Medium** during remediation activities assuming planned tank safety issue resolution activities have been performed, and decrease to **Low** after the waste is retrieved from the tanks. Table 4-4 summarizes the risk evaluation that was done for the interim storage period. The items "1B-H," "1C-M," etc. shown in Table 4-4 are derived from Table 4-3.

Table 4-4. Health and Safety Risk Summary by Year.

| Table 4-3   | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|-------------|------|------|------|------|------|------|
| Public      | 1B-H | 1B-H | 1C-M | 1C-M | 1C-M | T    |
| Worker      | 1B-H | 1B-H | 1C-M | 1C-M | 1C-M | T    |
| Environment | 1B-H | 1B-H | 2C-M | 2C-M | 2C-M | T    |

T = all aspects of this project transition to Operations at the beginning of FY 2002.

Failure to perform activities to resolve the Flammable Gas Safety Issue can significantly increase risks during interim storage and remediation. Risks that are currently classified as High and Medium would increase to Urgent and High. The worst case scenarios during interim storage and waste retrieval activities involve the buildup and ignition of flammable gases, with a subsequent fire or explosion in a tank. The accident scenario results in the eventual release of respirable-sized radiological and toxicological contaminants to the atmosphere. This release would have severe and permanent effects on worker health and safety, significant radiological exposure to the public, and widespread environmental contamination. However, as presently planned at the time of transition of this project to the Operations function, the risk will have been quantified and the effectiveness of work controls will have been demonstrated to the point that the Flammable Gas Safety Issue has been resolved and the risks reduced.

Sources of risk for flammable gas tanks potentially include as many as 149 SSTs, 28 DSTs (includes the aging waste facilities [AWF]), 7 DCRTs, and 12 catch tanks. Representative values for describing the risk were developed by Van Vleet (1996). The potential flammable gas burn volumes range from a fraction of 1 m<sup>3</sup> up to the bounding quantity of approximately 600 m<sup>3</sup>. The frequency of a gas release event of sufficient magnitude to challenge the dome structure coupled with an ignition source is unlikely, i.e., 10<sup>2</sup> to 10<sup>-4</sup> per year. The consequences for these events also range over a spectrum. Small burns will not adversely

affect the tank and the HEPA filter will remain intact, thus the consequence would be negligible. Burns large enough to challenge the dome structure have potential onsite consequences of 0.19 Sv (DST), 0.044 Sv (AWF), 0.72 Sv (DST burn while removing a mixer pump), and 6.5 Sv (SST). The offsite consequences would be 0.00016 Sv (DST), 0.00004 Sv (AWF), 0.00062 Sv (DST burn while removing a mixer pump), and 0.0057 Sv (SST). Note that 1 Sv is equal to 100 rem. Detonations could result in higher consequences of 39 Sv (SST) and 2.7 Sv (DCRT) for the onsite receptor at 100 m and 0.034 Sv (SST) and 0.0024 Sv (DCRT) for the offsite receptor.

Long-term health risks are proportional to the number of tanks that may contain flammable gases in concentrations capable of supporting a burn coupled with the likelihood that an ignition source could be introduced. The likelihood of exposure depends in part on how close public access will be at that time. Because final access levels and the time schedules for implementation have not been determined, it must be assumed that the public will have access to the boundary of the 200 area within decades. At the closure point for the Flammable Gas USQ, the risks will have been appropriately managed through an effective control strategy thereby reducing the risks.

Project activities are focused on developing the technical basis for closing the Flammable Gas USQ affecting 27 DSTs and 149 SSTs, removing 25 tanks from the Flammable Gas Watch List and resolving the Flammable Gas Safety Issue. Scope includes updating the authorization basis for monitoring for safe operations of the tank farms and continued safe storage of the tank contents.

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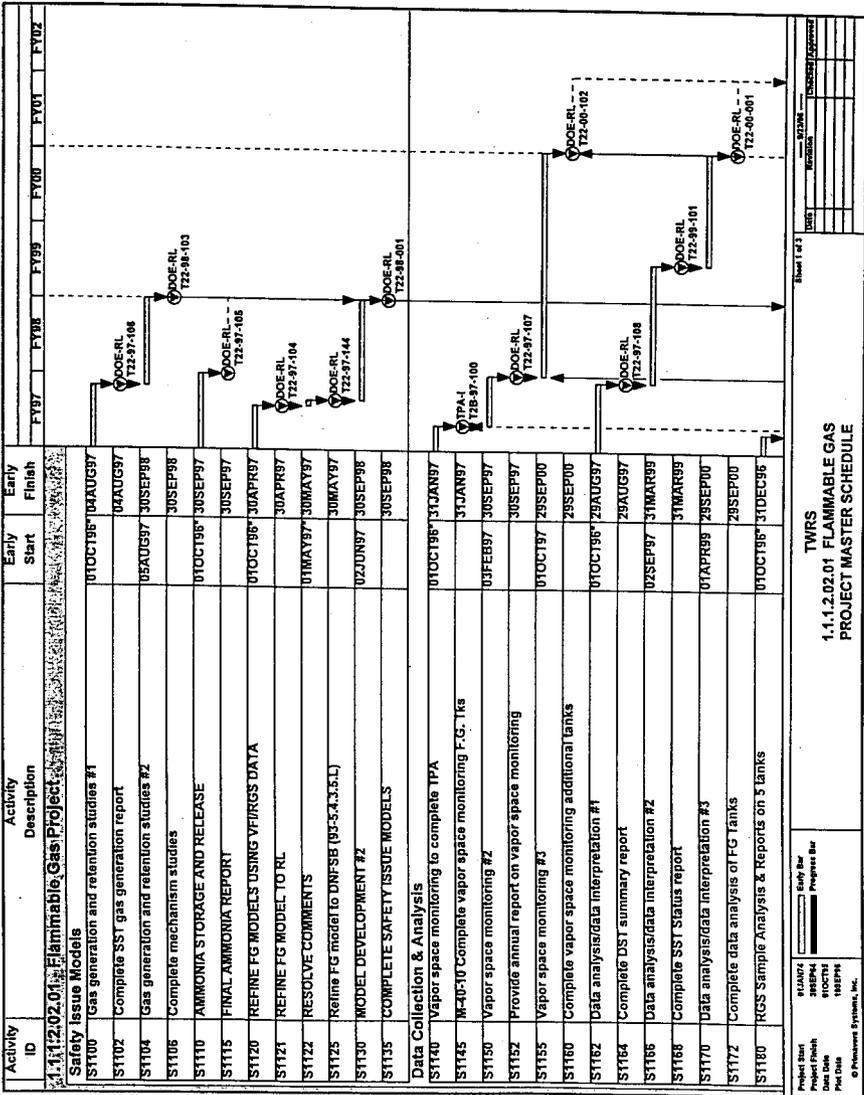
**5.0 SCHEDULE AND RESOURCES**

The project schedule developed for the Multi-Year Work Plan (MYWP) is shown in Figure 5-1. The Flammable Gas Project funding associated with this schedule is summarized in Table 5-1. The MYWP is updated each year, and as such, priorities for various tasks may change as a result of new technical information, updated information for the Authorization Basis, changes in Tank Waste Remediation System program priorities, or as a result of direction from RL. As a result specific tasks may be added or deleted and, thus some of the details of the funding and scheduling of specific tasks could change; such changes will be noted in the MYWP.

Table 5-1. Flammable Gas Project Funding.

| Fiscal year | Funding (\$000) |
|-------------|-----------------|
| 1997        | 24,962          |
| 1998        | 29,516          |
| 1999        | 14,132          |
| 2000        | 8,684           |
| 2001        | 4,123           |

Figure 5-1. Flammable Gas Project Schedule. (Sheet 1 of 3)



Sheet 1 of 3

|       |          |         |          |
|-------|----------|---------|----------|
| Units | Revision | Checked | Approved |
|       |          |         |          |

TWRS  
1.1.1.2.02.01 FLAMMABLE GAS  
PROJECT MASTER SCHEDULE

|                |         |              |
|----------------|---------|--------------|
| Project Start  | 8/14/92 | Early Bar    |
| Project Finish | 28SEP94 | Progress Bar |
| Date Date      | 8/10/93 |              |
| Plot Date      | 10SEP94 |              |

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Figure 5-1. Flammable Gas Project Schedule. (Sheet 2 of 3)

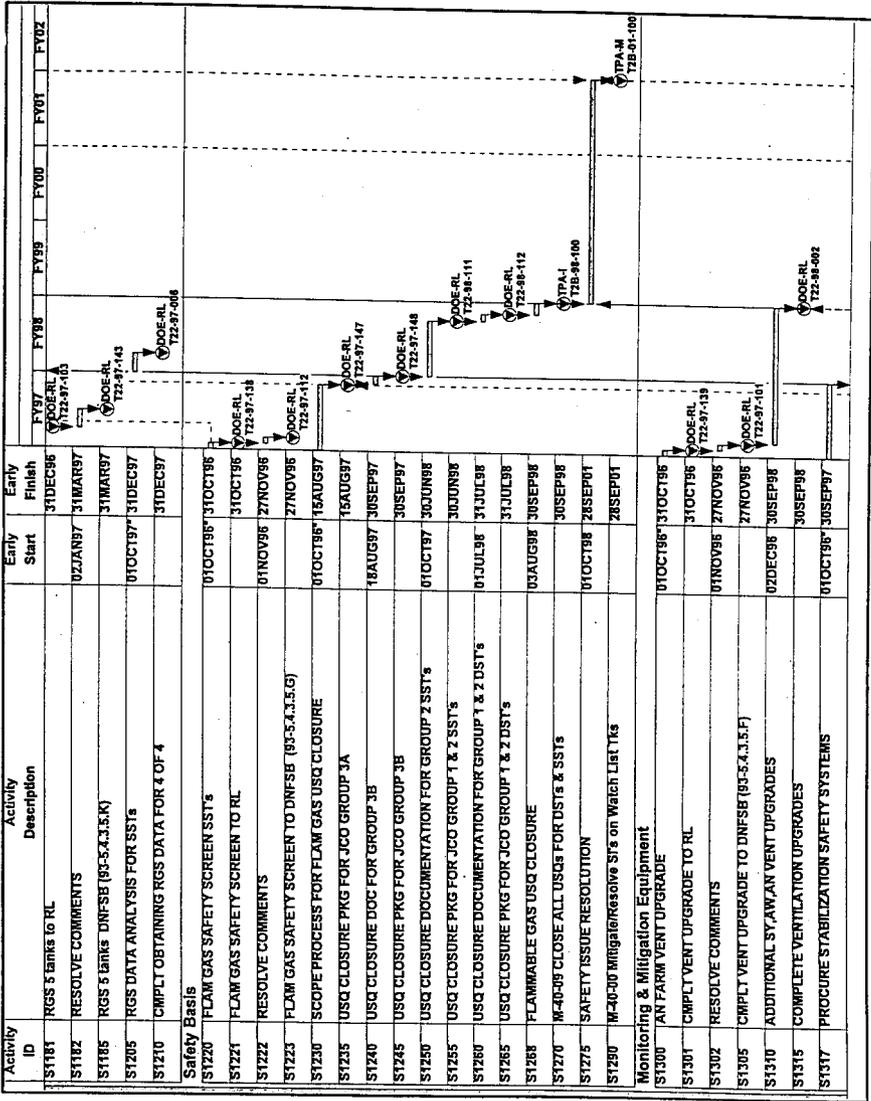
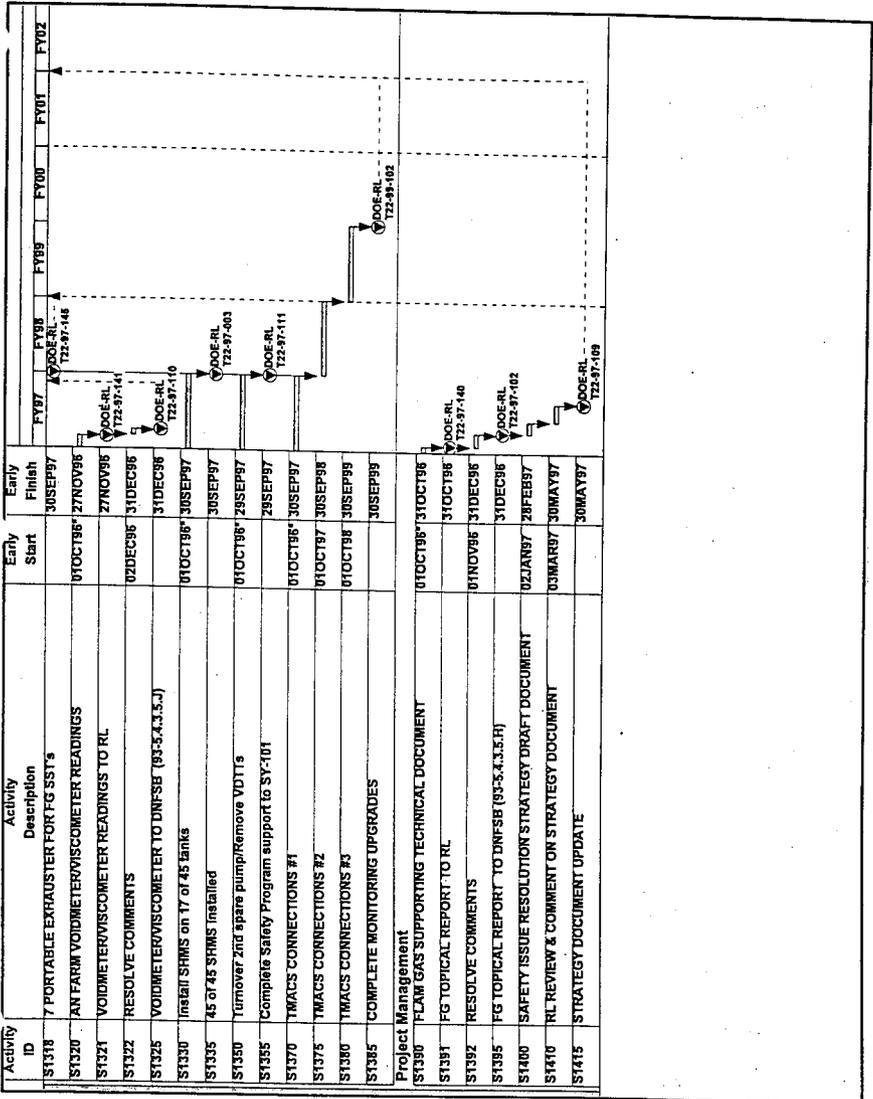


Figure 5-1. Flammable Gas Project Schedule. (Sheet 3 of 3)



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**APPENDIX A**

**PUBLIC LAW 101-510 (H.R. 4739), NOVEMBER 1990,  
NATIONAL DEFENSE AUTHORIZATION ACT FOR  
FISCAL YEAR 1991**

**Section 3137: Safety Measures for  
Waste Tanks at Hanford  
Nuclear Reservation**

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**APPENDIX A**

**PUBLIC LAW 101-510 (H.R. 4739), NOVEMBER 1990,  
NATIONAL DEFENSE AUTHORIZATION ACT FOR  
FISCAL YEAR 1991**

**Section 3137: Safety Measures for  
Waste Tanks at Hanford  
Nuclear Reservation**

**(a) Identification and Monitoring of Tanks.** Within 90 days after the date of the enactment of this Act, the Secretary of Energy shall identify which single-shelled or double-shelled high-level nuclear waste tanks at the Hanford Nuclear Reservation, Richland, Washington, may have a serious potential for release of high-level waste due to uncontrolled increases in temperature or pressure. After completing such identification, the Secretary shall determine whether continuous monitoring is being carried out to detect a release or excessive temperature or pressure at each tank so identified. If such monitoring is not being carried out, as soon as practicable the Secretary shall install such monitoring, but only if a type of monitoring that does not itself increase the danger of a release can be installed.

**(b) Action Plans.** Within 120 days after the date of the enactment of this Act, the Secretary of Energy shall develop action plans to respond to excessive temperature or pressure or a release from any tank identified under subsection (a).

**(c) Prohibition.** Beginning 120 days after the date of the enactment of this Act, no additional high-level nuclear waste (except for small amounts removed and returned to a tank for analysis) may be added to a tank identified under subsection (a) unless the Secretary determines that no safer alternative than adding such waste to the tank currently exists or that the tank does not pose a serious potential for release of high-level nuclear waste.

**(d) Report.** Within six months after the date of the enactment of this Act, the Secretary shall submit to Congress a report on actions taken to promote tank safety, including actions taken pursuant to this section, and the Secretary's timetable for resolving outstanding issues on how to handle the waste in such tanks.

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**APPENDIX B**  
**FLAMMABLE GAS WATCH LIST TANKS**

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**APPENDIX B**

**FLAMMABLE GAS WATCH LIST TANKS**

| Single-Shell Tanks |        | Double-Shell Tanks |
|--------------------|--------|--------------------|
| 101-A              | 105-SX | 103-AN             |
| 101-AX             | 106-SX | 104-AN             |
| 103-AX             | 109-SX | 105-AN             |
| 102-S              | 110-T  | 101-AW             |
| 111-S              | 103-U  | 101-SY             |
| 112-S              | 105-U  | 103-SY             |
| 101-SX             | 107-U  |                    |
| 102-SX             | 108-U  |                    |
| 103-SX             | 109-U  |                    |
| 104-SX             |        |                    |

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**APPENDIX C**  
**FACILITY GROUPS**

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## APPENDIX C

### FACILITY GROUPS

Tank Waste Remediation System (TWRS)-managed facilities affected by the Flammable Gas Unreviewed Safety Question (USQ) have been divided into three facility groups to allow for grading of controls without undue complexity for implementation in the field. Control grading addresses the fact that flammable gas hazards are widely variable among individual tank farm facilities. Three Facility Groups have associated controls that are logically based on the variable degrees of flammable gas hazards observed and postulated for the TWRS facilities. Limiting the control grading to three levels is a deliberate strategy to minimize operational complexity. At the same time, the use of three broad groups is an acknowledgement that technical uncertainties prevent "knife-edge" determinations regarding the hazard potentials of each individual facility.

#### Facility Group One

Facility Group 1 consists of those facilities that are acknowledged with little or no controversy to be of the greatest concern with respect to the flammable gas hazard. Specifically, the five tanks (241-AN-103, 241-AN-104, 241-AN-105, 241-AW-101, and 241-SY-103) that have undergone observed, significant gas release events (GRE) are conservatively postulated to have the potential for large spontaneous and large induced GREs. The level of rigor selected for these tanks is judged to be the maximum possible to simultaneously manage the risk, perform essential waste storage functions, and meet planned TWRS mission objectives.

#### Facility Group Two

If a tank is postulated to have the potential for a large induced GRE but only a small spontaneous GRE, it is placed in Facility Group 2. The single-shell tanks (SST) that fail the GRE evaluation (Hodgson 1996) (i.e., are estimated to retain gas amounts sufficient to cause the domespace concentration to exceed 25% of the LFL, if 25% of the gas is released) are considered to have the potential for large induced releases. However, as stated previously, SSTs are not postulated to undergo large spontaneous releases.

The definition of Facility Group 2 is a reflection of the uncertainty that remains in fully understanding tank flammable gas hazards and characterizing specific tank contents and behaviors. Facility Group 2 contains all double-shell tanks (DST) and aging waste facilities (AWF) not listed in Facility Group 1 plus all SSTs that are documented to "fail" the GRE evaluation.

The balance of the DSTs and AWFs are all within their design life and are integral to the safe waste storage and disposal mission. They will receive some amount of new waste from other Hanford Site facilities and will undergo liquid reductions, waste consolidation, multiple transfers, and mixing. Procedures are in place to minimize the likelihood that these operations would create conditions resulting in large spontaneous gas release behavior. However, some of these operations may result in increased gas generation and retention capability. Therefore, it is appropriate to categorize these facilities in Group 2 or higher. In the unlikely event that significant GRE behavior develops, tank monitoring results will provide an indication and the category of the facility will be changed to Group 1.

### **Facility Group Three**

The most lenient (least restrictive) set of controls is applied to those facilities assigned to Facility Group 3, which includes all of the tanks not assigned to either Facility Group 1 or 2. The controls for Facility Group 3 reflect the widely accepted judgement that many SSTs, particularly those that have been interim stabilized, pose a significantly lower risk from the standpoint of flammable gas hazards than those in either Facility Group 1 or Facility Group 2.

### **DEFINITIONS OF TERMS**

**Gas Release Events.** Gas release events are flammable gas releases that occur at a relatively high rate. The released gas must include gas that has been generated, then retained in the waste, as the gas release rates far exceed the gas generation rates. These gas release events are distinctive events although in some tanks such releases may be a part of a larger series of such events (i.e., episodic). These gas release events are generally described by a sudden onset, a sharp increase in gas release rate above steady-state rates, and a short duration compared to the ventilation dilution time constants. Gas release events may occur spontaneously, be caused by outside natural phenomena such as seismic events, or be induced by operations or activity related to disturbances of the waste. The release rate can be sufficiently high that dilution by mixing with vapor space air and dilution with ventilation cannot prevent flammable conditions from occurring, at least for some duration of time, in some portion of the vapor space.

**Steady-State Releases.** Steady-state release describes the ongoing release of generated flammable gases such that the rate of release changes only negligibly over time. The release rates are relatively slow (compared to gas release events) because the generation rates are relatively low. These releases are a concern only if the released gases are allowed to accumulate to flammable concentrations in tank system vapor spaces. Such an accumulation takes a relatively long time (hours to months) and can be managed by dilution using ventilation. All of the radioactive tank waste generates flammable gases on an ongoing basis; therefore these releases and their potential accumulation are a chronic problem for all waste-containing vessels.

**APPENDIX D**  
**APPROACH FOR RESOLUTION OF THE USQ**

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## APPENDIX D

### APPROACH FOR RESOLUTION OF THE USQ

At present, the Tank Waste Remediation System's (TWRS) operations are constrained and complicated by the existence of the Flammable Gas Unreviewed Safety Question (USQ) covering flammable gas generation, retention, release, and combustion in the waste tanks and associated facilities. The U.S. Department of Energy (DOE) is committed to closure of this USQ by September 1998--to meet a date called out in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) Milestone M-40-09. Fluor Daniel Hanford (FDH) and the Project Hanford Management Contractors (PHMC), which manage the Hanford Site for DOE, have formulated a technical and programmatic approach that will allow the U.S. Department of Energy, Richland Operations Office (RL) to achieve that milestone. This appendix summarizes the approach.

The logic of this approach is straightforward. In Section D.1, an analysis is presented on why the Flammable Gas (FG) USQ has been resistant to closure. This analysis has led to a new approach for dealing with technical uncertainty, an approach based on methods used by RL and U.S. Nuclear Regulatory Commission to address other issues, but adapted for the Hanford Site flammable gas issue. The new approach (Section D.2) to uncertainty is designated "SCOPE: Safety Controls Optimization by Performance Evaluation." Section D.4 illustrates in concrete terms how the SCOPE methodology will simplify decision making for hazard controls for specific TWRS facilities. Section D.5 describes at a higher level how the information from the specific facility analyses will be captured in submittal packages to RL in three phases corresponding to natural groupings of the tanks. Section D.6 summarizes the programmatic elements of the approach FDH and its PHMC subcontractors are taking and identifies the roles of key organizations in the activities. Of particular importance is the discussion of RL's role as a participant, either as an overseer, reviewer, or decision-maker, throughout the entire two-year process.

#### D.1 CHALLENGES POSED BY THE FLAMMABLE GAS USQ AND IMPLICATIONS FOR A PATH FORWARD

##### D.1.1 USQ Declaration

Following a 1990 investigation into flammable gas generation, retention and release mechanisms within Hanford Site waste tanks, it was concluded that flammable gas hazards were not adequately evaluated in existing TWRS authorization basis documentation and a USQ was declared as noted in Section 2.4.3. This declaration was based primarily on the fact that generation of nitrous oxide and the retention (slurry growth) and periodic release of flammable gases within the waste matrix were not fully considered in the development of safety documentation for the waste tanks.

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The 1990 flammable gas USQ was originally applied to 23 tanks. The knowledge base for understanding flammable gas phenomena has grown since the original USQ was declared, and the scope of the USQ has subsequently been expanded. The generation of flammable gases other than hydrogen was recognized for ammonia and methane.

In 1996, the flammable gas USQs were consolidated into a single USQ (Wagoner 1996), based on TF-96-0433, Revision 1, which also refined and expanded the flammable gas phenomena considered to be within the scope of the USQ. Further, this USQ determination expanded the USQ coverage to single-shell tanks (SST), double-shell tanks (DST), and any engineered container or receiver managed and operated by TWRS that may store or contain Hanford Site high-level waste in a condition that permits generation, accumulation, retention, and/or release of flammable gas.

### **D.1.2 Interim Management of Flammable Gas Hazards**

In response to USQ TF-96-0433, Revision 1, FDH and its PHMC subcontractors have developed a flammable gas management strategy to prevent flammable gas ignition in the affected facilities and structures and has issued standing orders to manage operational activities (Dodd et al. 1997). The strategy is to manage the risk associated with steady-state gas accumulation by requiring either passive or active ventilation for all tanks. To manage the risks associated with retained gases and GREs, specific ignition source controls and continuing monitoring requirements are applied on a graded basis to the facility groups depending on the work performed.

Facility groups were developed based on the assumption that facilities exhibiting similar characteristics pose similar hazards. The tanks are grouped according to those that are postulated to be subject to large versus small GREs.

### **D.1.3 Efforts to Date Toward Closing the Flammable Gas USQ**

The approach for closing the flammable gas USQ has previously been based on characterization, evaluation, and closure for individual tanks. This approach is not presently considered effective, because the USQ definition has expanded greatly and closure for individual tanks has been accomplished for only one tank (241-SY-101) and this just occurred in June 1996. Considerable characterization and analysis were required and mitigation of the flammable gas hazard is provided by a costly approach (i.e., mixer pump) that would not be practical to extend to many other tanks if the pump's only purpose is to mitigate the flammable gas retention hazard. The original strategy of tank-by-tank closure was abandoned because this approach had the potential to lead to a very complicated authorization basis with many varying control strategies. The tank-by-tank approach would be expensive, especially given the expanded scope of the USQ. The approach to closure described herein provides for closure based on a logical approach to the problem, resulting in facility groupings to which a consistent and defensible control strategy will be applied.

#### **D.1.4 Relevance of Recent Safety Analysis Efforts**

Recent hazard and safety analysis efforts including the Justification for Continued Operations (JCO) (Grigsby and Leach 1997) and the Basis for Interim Operation (BIO) (WHC 1996) have refined the safety control strategy, but will not close the USQ. In general, it has been beyond the established scope of these efforts to do so.

The JCO (Grigsby and Leach 1997) presents a qualitative description of the flammable gas hazards and an accident prevention control strategy. The JCO by its very nature, however, does not quantify baseline risk or the effectiveness of controls.

The BIO (WHC 1996) only quantifies uncontrolled risk and only for a few "representative" scenarios. The effectiveness of the controls is not quantitatively evaluated. The BIO has not quantitatively established that all prudent risk management actions have been taken.

The FSAR quantifies uncontrolled and controlled risk for a few "representative" scenarios. The effectiveness of controls is estimated within the resolution possible given the simplicity and conservative approach used. The results do not establish that all prudent risk management actions have been taken. Analysis results are shown to be above guidelines, but why no further reduction is possible or prudent is not established.

Requiring activity- and facility-specific safety analyses on a case-by-case basis is not a cost-effective method to address the full scope of the flammable gas hazard. For example, each different analysis may result in different control requirements and different safety analysis results, making field implementation difficult and confusing to operators. Moreover, the effectiveness of specific control measures generally cannot be related to specific scenarios or the safety analysis results.

#### **D.1.5 The Unique Challenge Presented by the Flammable Gas USQ**

Since the USQ was first declared in 1990, new information and a vastly improved technical understanding of the flammable gas generation, retention, and release mechanisms has been developed. Despite the additional knowledge, the flammable gas USQ has still not been closed after more than 6 years. In the intervening time other USQs were declared, reviewed, and closed. The following provides a clear understanding of what makes the flammable gas issue different from other safety issues.

- Detailed modeling and sample analyses have demonstrated that the Flammable Gas Safety Issue is a genuine safety concern, whereas analyses for other USQs have often indicated that the original hypothetical safety issues were not serious concerns.
- Flammable gases and the possibility of ignition cannot be readily eliminated. No realistic approach has been identified that can reduce combustible gas or oxygen concentrations to negligible levels, or to completely eliminate potential ignition sources.

- Phenomenological uncertainties strongly affect bounding safety analysis consequence calculations and drive results to large consequence determinations. Attempts to deal with the uncertainties have not been totally successful. Several safety analysis documents have been produced since the Flammable Gas USQ was declared including the following:
  - Justification for Continued Operation (Grigsby and Leach 1997)
  - Basis for Interim Operation (WHC 1996)
  - Standing Order 97-01 (Dodd et al. 1997)
- Numerous field measurements and sample analyses have been performed to characterize the conditions in the tanks. Many physical, chemical, and mathematical modeling investigations have also been done on flammable gas topics since the flammable gas USQ was declared. Despite the amount of resources directed at understanding phenomenology controlling the flammable gas issue, the uncertainties associated with the key parameters controlling the issue have not been substantially reduced. If the work to date has not substantially reduced these key uncertainties, continued expenditures of resources are highly unlikely to reduce them any time soon.
- The conventional safety analysis approach of "bounding" the potential consequences and demonstrating that the results are acceptable does not work for flammable gases because unacceptable consequences are calculated. There is great economy and ease of analysis gained when parameters that are highly uncertain can be replaced with specific values that are "conservative" or "bounding." This approach gives the analyst a strong technical basis to confidently state that the consequences of any actual event would be less than the computed consequences. When the computed consequences and frequency of an event are acceptable, the actual risk is inferred to be acceptable. This approach has been so successful in the past that there has been no need to develop alternate approaches to safety analyses. For the flammable gas issue, "bounding" safety analysis conclude that Hanford Site personnel and the public may receive exposures in excess of the established risk guidelines, even if prudent and feasible mitigating actions are taken. To date, no other method has been used to accommodate high phenomenological uncertainties. Thus, presently no alternative exists to the "unacceptable" conclusions of the "bounding" analyses. Also, there is no general agreement on what is acceptable in a safety analysis that is less than "bounding."
- Conservative frequency estimates used in "bounding" safety analyses conclude that a serious accident is not unlikely.
- Bounding safety analyses are not useful for assessing the effectiveness of controls on reducing risk. Because the consequences depend on an accident being initiated, the bulk of the analysis work is independent of the influence of controls designed to prevent an accident in the first place.

Any one of these factors represents a major obstacle for the successful application of traditional methods for closing the Flammable Gas USQ. Taken together, they represent a formidable barrier and provide a good explanation of why progress has been slow. Insights from this analysis have guided FDH and its PHMC subcontractors in developing a path to USQ closure that has a much higher likelihood for success.

## **D.2 SAFETY CONTROLS OPTIMIZATION BY PERFORMANCE EVALUATION**

Other fields of technology policy have been faced with the need to make concrete decisions in the face of high phenomenological uncertainty and have used methods developed in the behavioral sciences to deal with this uncertainty. In particular, methods have been developed that use expert elicitation to quantify phenomenological uncertainty and incorporate the results into decision processes in a scrutable and defensible manner. For example, the U.S. Nuclear Regulatory Commission used expert elicitation in a study of risk and uncertainty at commercial nuclear power plants (USNRC 1990). In a quite different application, the DOE used expert elicitation to develop design requirements for the new production reactor (Bergeron 1992).

The proposed strategy for closing the Flammable Gas USQ relies on applying similar expert elicitation methods to uncertainties about gas production, release, and combustion. The approach is based on the recognition that the fundamental building blocks of responsible hazard management are specific, concrete decisions about what hazard control strategies are appropriate for each tank or other component of TWRS. The approach also is guided by the contrasting understanding that, because of the common issues among the TWRS components, independent tank-by-tank decision processes are wasteful in both time and money. A tank-by-tank approach would also lead to inconsistencies in hazard management across the Hanford Site.

- The proposed closure strategy is based on the use of a decision support system that will allow Hanford Site personnel to quantitatively estimate the effects of various alternative control strategies on the safety of a facility configuration. The process for developing such a decision support system is called Safety Controls Optimization by Performance Evaluation (SCOPE). Several key features should be highlighted to explain the role of SCOPE in allowing DOE to close the flammable gas USQ.
- The process emphasizes the timely review of existing analyses and data (rather than large, new analysis efforts) and the consideration of divergent technical views by experts who provide quantified parameter uncertainty distributions. The participating experts document the basis for their specific elicitation values, so the source for all of the values impacting the results can be traced.

- The process accommodates early and meaningful stakeholder involvement by (1) including stakeholders in the process for selecting panel experts for panels, (2) including stakeholder-selected subject matter experts to provide topic-specific information for panel members to consider, and (3) providing open proceedings and documentation to allow continual monitoring and review throughout the process. All meetings of the experts and all technical presentations to the panels of experts are open meetings that can be observed by independent reviewers and stakeholders.
- The basic element of Hanford Site management with respect to flammable gas hazards is the analysis of specific facilities and the development of recommendations by the responsible Hanford Site subcontractor for appropriate controls. The SCOPE products make this possible without requiring the Hanford Site engineers performing these analyses to be experts on flammable gas phenomenology.

### **D.3 RATIONALE FOR PROPOSED APPROACH TO USQ CLOSURE**

There are two requirements that underlie RL's commitment to close the Flammable Gas USQ by September 1998. The first is to follow established DOE Order 5480.23 governing USQ management. The second is to satisfy the spirit as well as the letter of the language of the Tri-Party Agreement.

The SCOPE process and results will permit DOE to exercise discretion and judgment in carrying out the requirements of DOE Order 5480.23 in that (1) the understanding of risk determined by the SCOPE process will be adequate for prudent management of safety at the Hanford Site, and (2) the appropriate amount of conservatism and control can be determined at the discretion of DOE at the end of the process in light of the knowledge regarding the marginal utility of additional risk management controls. These judgments will be used in a rigorous and well documented manner, demonstrating that all prudent risk management actions have been taken.

Tri-Party Agreement Milestone M-40-09, "Close all Unreviewed Safety Questions (USQ) for Double-Shell and Single-Shell Tanks," states that the USQ closure process is comprised of the following:

"Data will be collected and safety documentation, including new operating safety envelopes and appropriate work controls will be submitted for approval. This will be followed by a USQ screening and evaluation submitted for approval, followed by a recommendation for USQ closure."

The various activities and deliverables associated with this strategy to USQ closure are described in Section 3.5. Taken together, these deliverables will achieve the requirements necessary for DOE to close the USQ.

#### **D.4 FLAMMABLE GAS HAZARD MANAGEMENT: FACILITY ANALYSIS AND CONTROLS SELECTION**

One of the key elements of the closure strategy is that FDH and its subcontractors will develop and implement a technically defensible basis for deciding on what hazard controls are appropriate for specific TWRS facilities. The method will bear a strong relationship to traditional hazard control decision-making, but differs in how technical uncertainty is treated. As discussed above, the use of highly conservative or bounding analyses of TWRS facilities has often been ineffective or impractical from the perspective of practical engineering decisions about hazard controls. This approach incorporates conservatism, but it is a calibrated conservatism--the "degree of belief" in the calculated results is quantified.

The details of how technical uncertainty is quantified and factored into hazard analysis have been described by Sandia National Laboratories (Bergeron 1996). To adequately explain the essence of the closure strategy, a description of how the facility analysis process differs from traditional approaches is needed. An example of the proposed method for hazard analysis and controls selection for a particular TWRS facility is provided. It is not intended to be complete or detailed, but rather to capture in concrete terms what is different about the new approach.

The responsibility for performing systematic analyses of hazards for a particular facility begins with an analysis team consisting of one or more PHMC subcontractor engineers. The deliverable will be a document called a "Controls Selection Analysis" that presents, in a standard format, the following information:

- Description of current configuration of the facility: The facility is described in flammable gas hazard management terms that reflect the database for the facility, including:
  - Tank type (SST, DST, AWF)
  - JCO/BIO/FSAR Facility Group
  - Ventilation configuration
  - Waste contents (sludge, saltcake, supernate, interstitial liquid)
- Range of activities covered: The types and rough number of activities planned for the tank are summarized. These are described in terms of location and waste disturbing nature including ex-tank intrusive, domespace intrusive, or waste intrusive locations and globally or locally waste disturbing in nature. Special cases such as saltwell pumping are described in terms of the pump type and expected duration. Major planned modification or operations are described in more detail such as retrieval demonstration, mixer pump operation, novel characterization activities. The general long-term role in the TWRS mission is summarized, such as use for sludge washing, consolidation tanks, staging tanks for cross-site transfers, evaporator feed or receiver tanks.

- Description of alternative control strategies: Examples of control strategies would include:
  - Ventilation system upgrades, including electrical equipment design (relative to ignition source controls) and performance improvements (e.g., flowrate, tank vacuum levels, domespace mixing provided, etc.);
  - Domespace inerting;
  - Flammable gas monitoring locations, set points, and actions;
  - GRE mitigation (e.g., mixer pumps, waste dilution, agitation, changes to sludge/supernatant configuration);
  - Ignition source control rigor (e.g., NEC Class I, Division 1 versus Division 2); and
  - Additional lightning protection.
- Calculations of several safety metrics including quantified uncertainty: These calculations are the principal output of the SCOPE Analysis Tool. The metrics considered will include traditional calculations of dose to workers or to the public as well and toxicological exposures. In addition, other quantities such as whether a burn occurred or a containment component failure (e.g., HEPA filters or tank dome) will be presented. All these metrics will be presented not as bounding results, but at selected values of confidence and expressed as a percentile of an uncertainty distribution.
- Other information relevant to controls selection: Additional information such as capital cost of a facility retrofit, impacts on operating costs and impacts on mission schedule or ALARA will be presented by the analysis team, as appropriate.
- Recommended controls: The team's primary recommendation for hazard controls for a particular facility will be presented and the justification of the recommendation will be summarized. In the case of a close judgment call between two nearly equal alternatives, the second alternative will also be described.

There are several new concepts that appear in this list relative to traditional hazard controls selection. First, the metrics that will be used to characterize hazards include both traditional ones, such as dose, and non-traditional ones, such as HEPA failure. The reason for the new metrics is to provide better resolution of the effectiveness of controls for events that generate only a small source term, but are nonetheless legitimate causes for concern.

Second, information is provided that will allow tradeoffs between safety benefits and other factors such as cost or worker risk during implementation of the controls. Because the TWRS facilities and flammable gas hazards already exist, the risk management actions are largely a retrofit. As such, the practicality of their implementation must be considered to

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ensure that actions are prudent. Therefore, the information used to judge the adequacy and prudence of risk management actions must be expanded beyond radiological consequence and toxicological exposures, including cost and mission schedule impact. Concurrence that cost and mission schedule impacts are important, which will be considered by RL in final technical safety requirement (TSR) selection, is critical to success of this closure process.

Third, and most important from the perspective of Flammable Gas USQ closure, quantitative information on technical uncertainty is provided. Figure D-1 illustrates the basic concepts, and will be used in the discussion that follows to convey not only how the new approach is different from traditional safety analysis methods, but also how it is consistent with traditional methods.

The figure shows the results of a number of calculations using the SCOPE Analysis Tool (AT). The key points about it are that it embodies the collective judgments of expert panels made up of nationally recognized specialists about flammable gas issues and it combines the experts' quantitative input about uncertainty with specific and well-documented information about the TWRS facilities and available hazard control strategies to assess the impact of the control strategies on baseline risk.

While some aspects of the SCOPE-AT analysis are new, the analysis strongly resembles traditional safety evaluation approaches. There are five hypothetical accident events addressed in Figure D-1, denoted A, B, C, D, and E. These are stylized scenarios that represent the kind of challenges that safety features are intended to deal with. An example might be a gas release event into the domespace of a tank.

Like traditional analysis methods, quantities such as radioactive dose at the Hanford Site boundary or to a worker at a specified distance from the release are calculated (Figure D-1 is intended to represent such a metric). What is different is that the consequence metric, in this case "dose," is calculated at varying degrees of confidence. Three values are shown for each scenario. The highest value represents the 95th percentile of the uncertainty distribution (i.e., there is a 95% confidence that the true value is not higher than the quantity in the figure). The middle value is the median of the distribution (the best estimate with respect to flammable gas uncertainties). The lowest value on the figure is the converse of the top value (based on expert judgment); i.e., there is only a 5% probability that the true value will be less than that shown.

The key difference between information shown in Figure D-1 and that available with traditional safety analysis methods is that the metrics in the figure display a quantitative representation of the degree of conservatism. This allows the analysis team to see the range of possible effects of alternative choices of hazard controls and to make recommendations in the light of the uncertainty of the predictions.

The hypothetical situation represented by Figure D-1 compares two alternative hazard control strategies. Normally, the team would consider more than two, but the comparison shown here might be the "runoff" between the two leading options. One strategy might require

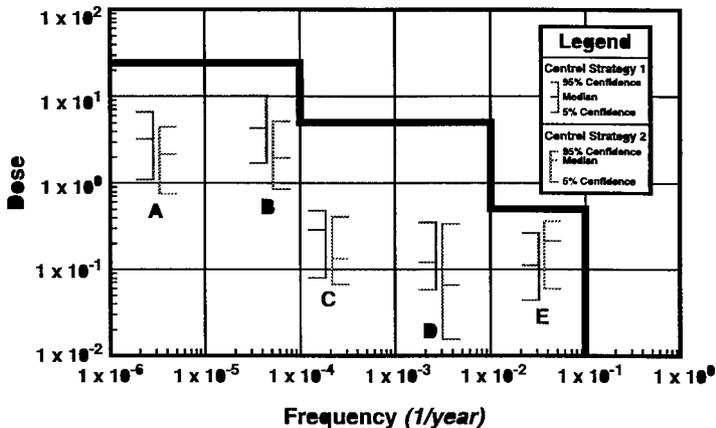


Figure D-1. Hypothetical Results from the SCOPE Analysis Tool for Two Alternative Control Strategies.

installing a domespace ventilation system with specified performance parameters. The second strategy might require instituting more stringent spark controls. On consideration of the results presented in Figure D-1, the analysis team would note that both control strategies result in not exceeding the risk guidelines (indicated by the solid line) for all three confidence levels (95%, 50%, 5%). No doubt this is a desirable attribute of the control strategies, although current safety guidelines state that this is neither necessary nor a sufficient reason for choosing a particular control strategy.

The case illustrated in Figure D-1 would represent a closecall in terms of the analysis team's recommendation for a preferred strategy. Careful evaluation of the results shown in the figure might suggest that Option 2 is the front runner, but the analysis team will bring many other factors into the decision process. For example, Option 1 may be significantly less expensive than Option 2. With the results on consequence metrics calculated by SCOPE being so similar, the cost consideration would carry the weight of the decision and the team would recommend Option 1. Other factors considered by the analysis team might include as low as reasonably achievable (ALARA) concerns with installation and/or maintenance of the hazard control configuration, impacts on mission schedule, or other practical considerations.

The case represented in Figure D-1 is only one possible pattern. Another is that all reasonable options exceed, at the 95th percentile, the risk guidelines for one or more of the events analyzed. Depending on how far the guidelines are exceeded, it may still be straightforward for the analysis team to recommend a control strategy alternative based on

the SCOPE calculations and the other types of information about the alternatives. The key point is that the risk guidelines have not been established as absolute requirements; they provide a reference point for relative degrees of risk for various alternatives.

It is important to note that the Controls Selection Analysis is essentially a recommendation for a specific control strategy in relation to several specific alternatives, along with a clearly documented justification for the recommendation. That recommendation and justification will naturally be reviewed and approved at appropriate levels within FDH and its PHMC subcontractor organizations before being submitted to RL, and must meet with RL concurrence before the controls are implemented. What is important about the Controls Selection Analysis document is that the recommendation can consider the effectiveness of controls for particular challenges at specific levels of conservatism, such as the median (best estimate) of the uncertainty distribution or at the 95th percentile.

At this point in the development of the new concept, an appropriate quantitative degree of conservatism has not been specified. There is precedent for focusing on the 95th percentile and that is why it was used in the example. However, it is desirable for RL to be directly involved in the decision about which points on the uncertainty distribution should be considered for the Controls Selection Analyses. One of the interfaces of the program with RL is to select the standard.

This systematic, quantitative analysis method to factor in a broader range of practical considerations will be a substantial improvement to the decision-making process. It is important to note that the element of judgment has not been removed. It is expected that most of the analysis team recommendations will be straightforward and that the preferred strategy will be obvious from the analysis and the supporting information. Review and approval should also be straightforward. However, inevitably some cases will have two or more equally acceptable alternatives. In that case, the analysis team would identify the recommended option as well as the alternates.

The description of the hypothetical analysis team recommendations for a particular TWRS facility illustrates how the SCOPE process will assist with the basic building blocks of Hanford Site hazard management. Overall Hanford Site management and the USQ closure path involves more than is described here. In particular, the way that the individual facility analyses are combined to address appropriate controls for facility groups (in the form of TSRs) requires explanation (see Section D.5).

The important point of this discussion of specific facility assessments is that the proposed approach to hazard controls decision-making does not remove the elements of responsibility and judgment from either FDH and its subcontractors or RL. Instead, it creates a framework in which the basis for appropriate decisions is understood by all the responsible parties and the decision-makers do not have to be experts on flammable gas phenomenology. If this goal is accomplished, the barrier to closing the flammable gas USQ will have been removed.

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## D.5 CONTENT OF USQ CLOSURE PACKAGES

### D.5.1 FACILITY GROUPINGS AND PHASED CLOSURE APPROACH

The USQ closure project has been scheduled in three phases. The phases are based on tank groupings that are meaningful from a flammable-gas-phenomena and control-strategy standpoint. The phased approach allows for demonstrable progress toward USQ closure while allowing for the development of an increasing level of sophistication in terms of analysis and controls. The groupings and phases are as follows:

- Phase I: SSTs that have been saltwell pumped and show little gas retention. These are the JCO/BIO Facility Group 3 tanks that have been saltwell pumped and are called Group 3A tanks in the USQ closure project. Having had all of the supernatant and much of the interstitial liquids removed, gas retention and GRE potential are expected to be the lowest for the tanks. Planned operations and activities are at a minimum; therefore, control strategies are also expected to be the simplest of the groupings. USQ Closure for Group 3A Tanks is a proposed FY 1998 Performance Agreement.
- Phase II: SSTs that have not yet been saltwell pumped but also show little gas retention. These are the JCO/BIO Facility Group 3 tanks that have not been saltwell pumped and are called Group 3B tanks in the USQ closure project. These tanks may contain small amounts of supernatant and are generally saturated with interstitial liquids, which is expected to result in different gas retention and GRE behavior from saltwell pumped tanks. In addition, activities and operations associated with saltwell pumping will be addressed. Because of these differences from Group 3A tanks, control strategies are anticipated to cover a broader range of options. USQ Closure for Group 3B tanks is a proposed FY 1998 Performance Agreement.
- Phase III: Tanks that appear to retain significant amounts of flammable gas and those that have exhibited spontaneous GRE behavior (5 DSTs) make up the third phase. These tanks require the most sophisticated modeling and elicitation, as well as the broadest range of control strategies. This group includes JCO/BIO Facility Group 1 and 2 tanks, which includes a number of SSTs and all of the DSTs/AWF tanks. Addressing these tanks in the third phase allows for more complete development of control strategies and the addition of more sophisticated modeling and elicitation structures. USQ closure of Facility Groups 1 and 2 will be accomplished by late FY 1998.

Figure D-2 shows a logic diagram for the steps involved in the closure of the USQ for Facility Groups 3A and 3B.

Categorizing the tanks and other TWRS facilities into groups for hazard management purposes is a fundamental simplifying element of the current approach to the authorization basis (AB) and the proposed approach to USQ closure. The results of the expert elicitation

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process and the results of SCOPE evaluations for specific tanks (documented in the controls selection analysis documents) will influence the final decisions about further division into subgroups to address the actual population of the major groups and subgroups.

As noted in Section 3.2.3, efforts are in progress for developing a plan for closure of the USQ for DCRTs, vaults, catch tanks, IMUSTs, evaporators, transfer lines and pits. At this point it appears that some of these could be processed for USQ closure in the near term. Others could follow shortly after the SSTs and DSTs. The most difficult group is the IMUSTs since little is known about the tank contents. It is anticipated that the plan for these facilities will be ready in a few months.

#### **D.5.2 USQ CLOSURE PACKAGES**

Each USQ closure package will constitute a change to the TWRS Authorization Basis (AB). All of the existing TWRS AB documents affected by the change will be modified to reflect the proposed AB amendment and submitted to RL as a complete package for review and approval. Three such packages will be submitted for closure of the flammable gas USQ. Each package will contain the following elements.

- Cover letter - The cover letter will describe package contents, scope of the package and any conditions specific to the submittal, and the nature of the requested action by RL.
- USQ - A copy of the USQ (TF-96-0433, Rev. 1) for which closure is requested.

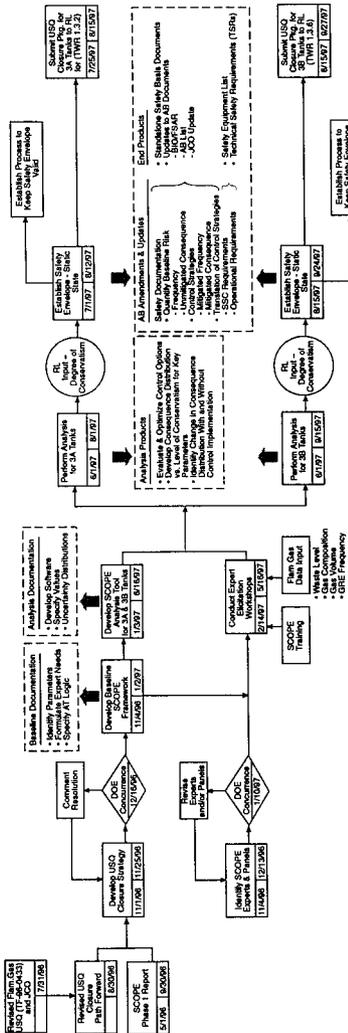
**Controls Selection Analysis Document.** The controls selection analysis document and appendices that apply to the specific facility groups will be submitted as a supporting document to the AB documents. Revision of the BIO/FSAR. The appropriate sections of the BIO or FSAR, depending on which document is in force, because an AB document will be revised to reflect the results of the controls selection analysis. The appropriate revision will be submitted for approval.

**Revision of TSRs.** Revisions to existing TSRs or new TSRs that reflect the recommended controls will be submitted as a revision to the TSR document.

**Revision of the JCO.** The appropriate sections of the flammable gas JCO will be revised to accommodate the control strategy for the submitted group of tanks.

**Compliance Implementation Plan.** The cost and schedule for implementing the controls for the submitted group of tanks will be provided.

Figure D-2. Logic Diagram for Performance Agreement 1.3.2.



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## **D.6 PROGRAM STRATEGY TO ACCOMPLISH USQ CLOSURE**

### **D.6.1 Overview of Program Strategy**

The evaluation by the team of experts of tank conditions and phenomena important to potential flammable gas accidents, their development and approval of a risk assessment model, and their quantification of the uncertainty associated with key parameters constitutes the formal technical review required for eventual USQ closure. That review is done in the Safety Controls Optimization by the Performance Evaluation (SCOPE) project. The resulting SCOPE analysis establishes the technical basis for estimating the expected risk, the impact of uncertainty on computed risk, and the impact on margin between expected risk and risk guidelines for each tank caused by selecting increasing conservatism (factors of safety). Approval of a flammable gas control option to reach a specified level of risk establishes the condition for DOE to close the USQ on that tank. Successful implementation of the approved controls establishes the condition for DOE to close the safety issue on that tank.

The above description of the USQ closure strategy is independent of type (SST or DST). The SCOPE project is initially limited to SSTs. The technical analysis is somewhat more straightforward for SSTs because a SCOPE analysis does not have to address potential additions of waste and more complex future waste configurations in those tanks. Stakeholder understanding and confidence in the risk assessment methodology used in SCOPE (i.e., explicit tracking of uncertainty, the use of expert judgment to quantify uncertainty for key parameters, evaluation of impact of conservatism, etc.) is also more quickly and easily established if the initial scope of the work is limited. A direct extension of SCOPE from SSTs to DSTs will be applied.

Three expert elicitation workshops are currently planned in FY 1997 to elicit results for the technical parameters of highest uncertainty and consequence. The information and analysis needed to address SSTs is a subset of that needed for DSTs. A limited number of expert elicitation workshops will be conducted in FY 1998 specific to DSTs. The information obtained to develop the DST analysis is added to that for the SST analyses; the SST analysis is not replaced or made obsolete by the DST analysis.

Most importantly, the accuracy and robustness of the SCOPE analysis for DSTs will be substantially improved by the following:

- Use of the SST results to compute the expected risk and calibrate results with existing safety analyses and other risk evaluations,
- Determination of the parameters that have the most controlling influence on risk, and
- Evaluation of the sensitivity of the results to the level of complexity of the models used to study specific phenomena.

These results will provide invaluable guidance in extending the SCOPE analyses to DSTs. The importance of several potential sources of risk is contentiously debated because predicting their real impact on risk a priori is impossible. Because SSTs are, in general, thought to have much lower risk than many DSTs, the initial analysis framework can be conservatively, and thus confidently, simplified to evaluate the importance of those potential risk sources. If the results are insensitive to the particular sources, there is no need to expend the resources required to develop a more accurate and detailed, but therefore less conservative, model. Opposite results would justify the effort to further refine the relevant components of the risk assessment model when expanding the analyses to include DSTs so that better determination can be made of the impact of controls and uncertainty in key parameters on risk.

The general approach to closure of the flammable gas USQ for both SSTs and DSTs tanks is as follows:

1. Assemble a diverse team of nationally recognized experts to participate in formal technical reviews of tank conditions and phenomena relevant to the initiation and progression of hypothetical flammable gas accidents in the Hanford Site tanks.
2. Assemble physical phenomena-based models into a complete risk assessment model that tracks the impact of potential flammable gas controls on accident behaviors and resultant risk.
3. Have the team of experts modify and approve the risk assessment model, assess model uncertainties, and quantify uncertainty associated with key physical parameters.
4. For each tank, use the approved risk model to compute the risk associated with operations and how that risk would be affected by different flammable gas controls.
5. Using computations, track how parameter uncertainty affects confidence associated with computed risk and computed change in risk resulting from installing controls. Conduct studies to assess the sensitivity of results to the physical models within the risk assessment model. Compare results to risk guidelines.
6. Separate from determining the impact of controls on risk, FDH and its PHMC subcontractors will evaluate a variety of potential control strategies and estimates cost (dollars, schedule impact, worker exposures) and benefit (risk reduction) for each. FDH and its PHMC subcontractors also determine the trade-offs of meeting increasing risk margins relative to risk guidelines that result from increasing safety factors applied to the analysis.
7. FDH and its PHMC subcontractors will present to DOE a range of control options with the estimates of cost, schedule, and worker exposure for each to reach the safety margins computed for each option. FDH and its PHMC subcontractors will request approval on a recommended option; DOE reviews the options and approves the

recommended option or approves another option based on different priorities for risk reduction, cost control, schedule maintenance, and worker exposure goals.

### **D.6.2 Development of the SCOPE Decision Support System**

**Development of Analysis Framework.** An early step in the SCOPE process is to specify the quantities that have high uncertainty and are important to the calculations. This will be the purpose of the ongoing expert elicitation process. Other information will be assembled from existing sources (see Section 3.6.2). This sorting into categories, the crafting of the questions to be posed to the experts, and the mathematical process that will combine the output of the expert elicitation with other data to produce metrics is collectively called the analysis framework. A strawman Analysis Framework has been developed and is currently being refined within the ongoing expert elicitation workshops.

**Assembly of Expert Panels.** Eleven organizations have been approached with a request to nominate qualified experts for the panels. A procedure has been developed to objectively review the qualifications of these individuals and to ensure that the important technical fields will be covered by the panel membership. A proposal for the membership of the panels was submitted to RL in January 1997. After preliminary RL review, the final membership list has been approved by RL.

**Expert Panel Workshops.** The expert panels will meet in a series of workshops that allows them to be exposed to a broad range of relevant technical information from specialists and to share viewpoints. This activity will be open to observers and will also include opportunities for stakeholders to present their technical viewpoints to the panel members. The goal is to foster consensus, but not at the expense of the individual perspectives of the panelists. A series of three meetings is scheduled in FY 1997 to address SSTs. Information from these workshops feeds into the two FY 1997 Performance Agreement deliverables. A second series of workshops will be conducted in FY 1998 to address DSTs, feeding into the corresponding closure process for the remaining TWRS facilities.

**Expert Elicitation.** The culmination of each series of workshops is to conduct intensive interviews of each individual expert by a specialist in expert elicitation. The result is a set of simple curves that express that expert's "degree of belief" about the uncertain quantities called for in the analysis framework. The curves from the set of experts are aggregated to give a single curve representing the perspective of the entire panel. These aggregate curves are embedded into the SCOPE Analysis Tool that is later used by analysis teams to evaluate the effectiveness of hazard controls for specific facilities.

**Completion of Analysis Tool.** The SCOPE-AT will be a software package that can be used by analysts to calculate various metrics at specified confidence levels, as described in Section D.4. A working version, suitable for training purposes, will be available before the workshops end. However, the final version will not be completed until the aggregated uncertainty distributions from the expert panels are incorporated into the AT. Concurrent

with the tool's development, technical documentation will be prepared on the use of the software and its technical basis.

### **D.6.3 Controls Selection and Closure Documentation**

**Scope AT "Pedigreed" Data Gathering and Management.** A number of data needed to perform control selection analyses are certain or fairly certain. These include tank configuration, current equipment attributes, and current waste configuration. Such "pedigreed" data do not need to be addressed as uncertain values or distributions, but must represent the best known value. Required data items are identified as the AT framework is developed. Examples of needed data include the following:

- Tank number, empty volume, and diameter
- Number of connected pits and normally open risers
- Installed equipment including type (e.g., electrical, electrostatic discharge capable, mechanical spark capable), location (ex-tank, domespace, waste intrusive), and indicators of its spark-generating potential
- Waste configuration including sludge volume, saltcake volume, supernatant volume and specific gravity, and interstitial liquid volume
- Ventilation system configuration and performance data including flowrate, tank vacuum levels, and location of mixing points

Data that must be maintained as a quality record will be identified. The data will be verified as the best available information and will be managed accordingly. Data will be gathered from the best known, existing sources such as the FSAR verified data sources (e.g., Information Verification Forms), Flammable Gas Equipment Advisory Board findings and records, tank characterization reports (TCR). Data not gathered from existing quality record sources will be verified by review and approval from the cognizant TWRS organization. Such data and its verification will be documented on Information Verification Forms. The source for all certain data will be recorded as part of database management.

**Control Option and Mitigation Strategy Concept Development Results.** A key to USQ closure is the selection of effective and efficient controls including possible GRE mitigation. The selection process requires information related to these options that are useable in the controls selection analysis. For example, ventilation options need to be described in terms of flow rate, vacuum level, and domespace mixing time constants. Mitigation options need to be described in terms of waste volume affected and residual gas retention levels. Ignition controls need to be described in terms of spark frequency reduction. The effects and costs of

implementing the concepts need to be realistic. Therefore, control options will be described in concept development reports and proposals that will address the following:

- Key design features
- Problems with existing systems
  - Benefits and downside
  - Effectiveness of option in AT attribute format
  - Cost and feasibility.

**Controls Selection Analysis.** Using the SCOPE AT, an analysis and selection of control strategies will be conducted for each portion of the project. Control strategies will be analyzed for each tank grouping. Tanks in Groups 3A and 3B will be analyzed in late 1997, and tanks in Groups 1 and 2 are tentatively scheduled to be analyzed in 1998.

**SCOPE Results Report and Appendices.** Following the analysis efforts, a final SCOPE results report will be prepared. The report will describe the overall process and the results of the expert elicitation. Appendices will be prepared that present the results of the controls selection analysis for each tank grouping and control strategy recommendations. The main body of the report and appendices for Tank Groups 3A and 3B will be prepared during July 1997. The appendices for Tank Groups 1 and 2 will be prepared during May 1998.

**Authorization Basis Amendment Packages.** Each USQ closure package will constitute a change to the TWRS Authorization Basis (AB). All of the AB documents affected by the change will be modified to reflect the proposed modification and submitted to RL as a complete package for review and approval. Contents of the AB amendment package were described in Section D.5.2.

## REFERENCES

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- Dodd, R. A., J. G. Burton, and J. H. Wicks, 1997, *Tank Farms Standing Order 97-01, Compensatory Actions for Open Discovery Unreviewed Safety Questions*, Lockheed Martin Hanford Company, Richland, Washington.
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- USNRC, 1990, *Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants*, NUREG-1150, U.S. Nuclear Regulatory Commission, Washington, D.C.
- WHC, 1996, *Tank Waste Remediation System Basis for Interim Operation*, WHC-SD-WM-BIO-001, Rev. E, Westinghouse Hanford Company, Richland, Washington.
- Wagoner, J. D., 1996, *Definition and Declaration of Flammable Gas Unreviewed Safety Question (USQ)*, (letter 96-WSD-283 to H. J. Hatch, Fluor Daniel Hanford, Inc., November 1), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

**APPENDIX E**  
**SUMMARY OF WORKSHOP ATTENDEES**

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**APPENDIX E**

**SUMMARY OF WORKSHOP ATTENDEES**

Two facilitated workshops were held to develop the logic and flow diagrams for this document. The first meeting was held on February 19-20, 1997 and the second one was held on March 4, 1997.

Attendees at February 19-20, 1997 workshop were as follows:

|                  |        |
|------------------|--------|
| W. B. Barton     | LMHC   |
| R. E. Bauer      | DESH   |
| D. R. Bratzel    | DESH   |
| J. W. Brothers   | PNNL   |
| R. J. Cash       | DESH   |
| S. W. Eisenhower | LANL   |
| C. A. Groendyke  | DOE-RL |
| K. M. Hall       | LMHC   |
| R. A. Harrington | LMHC   |
| G. D. Johnson    | DESH   |
| E. J. Lipke      | DESH   |
| R. M. Marusich   | FDNW   |
| S. E. Slezak     | SNL    |
| C. W. Stewart    | PNNL   |
| J. R. White      | LANL   |
| J. Young         | MSI    |

Attendees at March 4, 1997 workshop were as follows:

|                  |        |
|------------------|--------|
| W. B. Barton     | LMHC   |
| R. E. Bauer      | DESH   |
| J. W. Brothers   | PNNL   |
| H. Calley        | DOE-HQ |
| J. M. Grigsby    | G&P    |
| C. A. Groendyke  | DOE-RL |
| R. A. Harrington | LMHC   |
| G. D. Johnson    | DESH   |
| E. J. Lipke      | DESH   |
| R. M. Marusich   | FDNW   |
| C. W. Stewart    | PNNL   |
| J. R. White      | LANL   |
| J. Young         | MSI    |

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**APPENDIX F**  
**TASK SUMMARIES**

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TASK SUMMARY SHEET  
SET 1

TASK TITLE: Gas Generation

PERFORMER(S): PNNL/NHC

PURPOSE/NEED: Experimental evaluations are conducted to determine the mechanisms for gas generation, the amount of gas produced, and the species produced. This information is used to (1) support evaluation of ventilation requirements, (2) provide assessment of the long-term behavior of wastes, (3) provide compositional data for assessment of deflagrations, and (4) support analyses of changes in waste storage conditions.

APPROACH/BASIS: This task will measure the identity and stoichiometry of degradation products formed in actual tank waste by thermal and radiolytic processes. Specifically, this task will accurately measure the activation parameters for the thermal and radiolytic production (E, and G- values) for hydrogen, nitrous oxide, nitrogen and other gases generated from the actual waste. These parameters are needed to adequately calculate the gas generation capacity of the waste under actual tank storage and retrieval conditions. Waste gas generation rates under controlled laboratory conditions and the analysis of gas composition are valuable to predict the effect of tank operations on the actual gas production, composition, and disposition (dissolve from bubbles, release, react, etc.).

CURRENT STATUS: Evaluations have been completed for 241-SY-101 and 241-SY-103. Tests are under way on waste samples from tanks 241-S-102 and 241-AN-105.

REMAINING WORK: Information is needed on the types of gases and the rates at which they are produced to describe the behavior of the tanks. Tests need to be applied to tank waste samples representing carefully selected waste types to validate the concepts derived from the work on simulants and to achieve a predictive capability for the key types of wastes. Tanks selected for conducting tests on waste samples are: 241-AW-101, 241-U-105, 241-U-103, and most likely a tank from the SX and S group of tanks.

ESTIMATED COMPLETION DATE: September 30, 1998

KEY REFERENCES:

Bryan, S. A., C. M. King, L. R. Pederson, S. V. Forbes, and R. L. Sell, 1996, *Gas Generation from Tank 241-SY-103 Waste*, PNNL-10978, Pacific Northwest National Laboratory, Richland, Washington.

Pederson, L. R., and S. A. Bryan, 1996, *Status and Integration of Studies of Gas Generation in Hanford Wastes*, PNNL-11297, Pacific Northwest National Laboratory, Richland, Washington.

TASK SUMMARY SHEET  
SET 1

Person, J. C., 1996, *Effects of Oxygen Cover Gas and NaOH Dilution on Gas Generation in Tank 241-SY-101 Waste*, WHC-SD-WM-DTR-043, Westinghouse Hanford Company, Richland, Washington.

TASK SUMMARY SHEET  
SET 1

TASK TITLE: Gas Retention and Release

PERFORMER(S): PNNL

PURPOSE/NEED: Evaluations of the amount and nature of stored gas are needed to (1) support the assessment of the consequences of a deflagration, (2) support the evaluations of the facility grouping of tanks for selection of work controls and, (3) to assist in the evaluations for safety assessments of proposed operations (i.e., saltwell pumping, waste transfers, retrievals, etc.).

APPROACH/BASIS: This task is divided into two main activities. The first addresses the mechanisms of gas bubble retention and the release of bubbles through laboratory-scale experiments and scaling to extrapolate the result to the tank scale. The objective of the laboratory-scale studies is to quantify the pertinent mechanisms of gas bubble retention and release by measuring and observing the retention of gas bubbles and the release of these bubbles in actual waste samples. The objective of the SST gas release studies is to quantify the most important SST gas release issues. These studies emphasize gas release behavior at the scale of the entire tank and will address the release of small gas plumes, the release of gas caused by seismic activity, and the release of gas during and after salt-well pumping.

CURRENT STATUS: Laboratory studies on both waste simulants and tank waste have provided a basis for retention mechanisms (waste strength, capillary forces, and attachment to particles). In situ volumes have been determined for five DSTs and one SST. An approach for assessing the maximum retention capability of wastes has been established.

REMAINING WORK:

- Conduct bubble retention experiments on selected additional waste samples that cover the range of waste types important to the flammable gas safety issue.
- Conduct a large-scale, long-term experiment to validate the current model of gas retention.
- Operate the RGS to provide
  - the retained gas volume, composition, and distribution in high-priority SSTs
  - the retained gas volume, composition, and distribution before and after salt-well pumping in representative tanks
  - the concentration of dissolved ammonia in the liquid.

TASK SUMMARY SHEET  
SET 1

- Continue modeling and experimental studies of salt-well pumping focused on understanding ammonia (soluble gas) release. Interpret data from appropriately monitored tanks during pumping

ESTIMATED COMPLETION DATE: September 30, 1998

KEY REFERENCES:

- Gauglitz, P. A., S. D. Rassat, M. R. Powell, R. R. Shah, and L. A. Mahoney, 1995, *Gas Bubble Retention and its Effect on Waste Properties: Retention Mechanisms, Viscosity, and Tensile and Shear Strength*, PNL-10740, Pacific Northwest Laboratory, Richland, Washington.
- Gauglitz, P. A., P. R. Bredt, J. H. Konyonenbelt, D. P. Mendoza, S. D. Rassat, and S. M. Tingey, 1996, *Mechanisms of Gas Retention and Release: Results for Hanford Waste Tanks 241-S-102 and 241-SY-103 and Single-Shell tank simulants*, PNNL-11298, Pacific Northwest National Laboratory, Richland, Washington.
- Stewart, C. W., J. M. Alzheimer, M. E. Brewster, G. Chen, R. E. Mendoza, H. C. Reid, C. L. Shepard, and G. Terrones, 1996a, *In Situ Rheology and Gas Volume in Hanford Double-Shell Waste Tanks*, PNNL-11296, Pacific Northwest National Laboratory, Richland, Washington.
- Stewart, C. W., M. E. Brewster, P. A. Gauglitz, L. A. Mahoney, P. A. Meyer, K. P. Recknagle, and H.C. Reid, 1996b, *Gas Retention and Release Behavior in Hanford Single-Shell Waste Tanks*, PNNL-11391, Pacific Northwest National Laboratory, Richland, Washington.

TASK SUMMARY SHEET  
SET 1

TASK TITLE: Ammonia Studies

PERFORMER(S): PNNL/NHC

PURPOSE/NEED: The solubility of ammonia in tank waste is sufficient to permit the storage of large amounts of ammonia. If a sudden release were to occur, this would present a hazard to worker safety (toxicity) and for flammability concerns.

APPROACH/BASIS: Develop an understanding of the chemistry of ammonia in the highly basic waste forms. Support the RGS effort for ammonia analyses.

CURRENT STATUS: Mechanism for ammonia storage and release have been documented. A review of historical data has been completed. Data have been obtained on the ammonia concentration as a function of depth on several tanks; models were developed and are being applied to each tank data set.

REMAINING WORK:

- Complete documentation of potential mechanisms for the production of ammonia, and
- Complete analysis of RGS data

ESTIMATED COMPLETION DATE: September 30, 1997

KEY REFERENCES:

Palmer, B. J., C. M. Anderson, G. Chen, J. M. Cuta, T. A. Ferryman, and G. Terrones, 1996, *Evaluation of the Potential for Significant Ammonia Releases from Hanford Waste Tanks*, PNNL-11237, Pacific Northwest National Laboratory, Richland, Washington.

TASK SUMMARY SHEET  
SET 1

TASK TITLE: Physics/Chemistry Integration

PERFORMER(S): PNNL

**PURPOSE/NEED:** A technical integrating function will be performed in this task for the purpose of bringing understanding to the physics and chemical issues, being investigated by experiments and analysis of characterization, and monitoring data. The integrating function will provide independent assessments, as well as on-request support to the Flammable Gas Project Management, resulting in consultation, presentations, and letter and formal reports.

**APPROACH/BASIS:** Using the knowledge and experience of Flammable Gas issues and of ongoing work to identify where new or additional work should be directed and places where major knowledge gains can be made via combining results from several sources.

Resolution of the Flammable Gas Safety Issue depends on well-understood and well-ascribed flammable gas physics and chemistry. Flammable gas safety issues depend on sensitive parameters and characteristics that can be collected from related work and the literature, and described for decision makers.

**CURRENT STATUS:** In the chemistry portion, a report was issued that reviewed recent progress made in determining the chemical mechanisms, kinetics, and stoichiometry of gas generation in Hanford Site waste tanks. Information was gathered from the results of laboratory studies with simulated wastes, laboratory studies using actual waste core samples (Tanks 241-SY-101 and 241-SY-103), studies of thermal and radiolytic reactions in the gas phase, and gas solubility evaluations.

For the physics integration, the task has produced an overview of the current understanding of flammable gas retention and release in Hanford Site single-shell waste tanks based on theory, experimental results, and observed tank behavior. The credible mechanisms for significant flammable gas releases were described, and release volumes and rates were quantified as much as possible. The only mechanism demonstrably capable of producing large (~100m<sup>3</sup>) spontaneous gas releases is buoyant displacement, which occurs only in tanks with a relatively deep layer of supernatant liquid. Only the double-shell tanks currently satisfy this condition, all release mechanisms believed plausible in single-shell tanks have been investigated, and none has the potential for a large spontaneous gas release. Only small spontaneous gas releases of several cubic meters are likely by these mechanisms.

**REMAINING WORK:** The needs remaining to understand gas release deal less with the large, catastrophic release and focus more on the common, small releases that are of operational concern.

TASK SUMMARY SHEET  
SET 1

- Develop the capability to predict whether buoyant displacement will occur in a “new” tank created by transfer of existing waste,
- Relate the small gas releases from SSTs observed in SHMS data to waste configuration and properties in the context of the gas retention and release mechanisms,
- Develop a predictive parametric model for the volume of a small, plume-type release that is actually flammable as a function of elapsed time after release, and
- Develop and understanding of the gas distribution (soluble and insoluble) relating domespace composition to gas composition within the waste. Relate this to generation mechanisms.

ESTIMATED COMPLETION DATE: September 30, 1998

KEY REFERENCES:

- Pederson, L. R., and S. A. Bryan, 1996, *Status and Integration of Studies of Gas Generation in Hanford Wastes*, PNNL-11297, Pacific Northwest National Laboratory, Richland, Washington.
- Stewart, C. W., M. E. Brewster, P. A. Gauglitz, L. A. Mahoney, P. A. Meyer, K. P. Recknagle, and H. C. Reid, 1996, *Gas Retention and Release Behavior in Hanford Single-Shell Waste Tanks*, PNNL-11391, Pacific Northwest National Laboratory, Richland, Washington.

TASK SUMMARY SHEET  
SET 1

**TASK TITLE:** Deflagration Analysis

**PERFORMER(S):** LANL

**PURPOSE/NEED:** The major hazard for the flammable gas issue is a deflagration of the gas mixture in the domespace of a tank. Analyses of the burns of gas mixtures and the corresponding structural response is needed to support the update effort in the Tank Farms Authorization Basis.

**APPROACH/BASIS:** The finite-elements models developed by Westinghouse Hanford Company (WHC) for static analysis will be used with the necessary modifications. Using those input models, transient analysis will be performed and the failure modes will be identified. The implications on the dome collapse scenario and the consequence analyses will be quantified.

This part will emphasize the analysis of postulated plume residence times. The likelihood and consequences of such burns will be quantified. The effect of active ventilation on the likelihood of plume burns will be emphasized.

**CURRENT STATUS:** The WHC models were developed and seismic induced motion analysis started.

**REMAINING WORK:** Complete analysis and reporting of results

**ESTIMATED COMPLETION DATE:** September 30, 1997

**KEY REFERENCES:** Not Applicable

TASK SUMMARY SHEET  
SET 1

TASK TITLE: PNNL Project Management

PERFORMER(S): PNNL

PURPOSE/NEED: Plan, coordinate, and monitor the activities within PNNL's Flammable Gas Project.

APPROACH/BASIS: Activities include preparing and issuing a project statement of work, preparing and issuing a project management plan as necessary, preparing a project quality assurance (QA) plan as necessary with support from PNNL QA staff, managing costs and schedules and maintaining liaison with client projects. Work produced by PNNL is reviewed by project management for applicability to the agreed upon scope and client needs, quality, cost, and timeliness. Monthly highlight reports will be prepared and submitted to the client that contain a description of the previous month's technical progress, the status of milestones, and expenditure information.

The program management work breakdown structure element (WBS) will control and track progress toward completion of milestones to ensure timely, reviewed project deliverables and coordinate the preparation of required planning documents including statements of work, project budgets, and schedules.

CURRENT STATUS: Ongoing effort.

REMAINING WORK: Continue task until end of program.

ESTIMATED COMPLETION DATE: September 30, 2000

KEY REFERENCES: Not Applicable

TASK SUMMARY SHEET  
SET 2

TASK TITLE: Retained Gas Sampling (RGS) and Analysis

PERFORMER(S): PNNL/NHC/LMHC

PURPOSE/NEED: Provide for direct determination of the amount and composition of stored gas. The information is needed to support analyses being conducted to close the Flammable Gas Unreviewed Safety Question (USQ) and Flammable Gas Safety Issue.

APPROACH/BASIS: The RGS is a modified version of the universal core sampler designed to be absolutely leak tight. RGSs are loaded into the drill string during normal push-mode core sampling. After capturing a waste sample and recovering it from the drill string, the sampler is x-rayed to determine whether a full sample was captured and then transported to the 222-S Laboratory. In the laboratory, the sample is extruded into an extraction vessel where the waste gas is removed for analysis by a combination of stirring, vacuum pumping, and heating. Samples of the gas are taken at each stage of the extraction process and sent to PNNL for mass spectrometry. Measurements of ammonia content are also made from samples and data obtained during the extraction process. The extraction process results are analyzed to calculate total gas inventories and phase distributions. The results are documented in formal reports.

CURRENT STATUS: Evaluations have been completed for 241-AW-101, 241-AN-103, 241-AN-104, 241-AN-105, and 241-A-101.

REMAINING WORK: Conduct sampling and analysis of selected single-shell tanks 241-U-103, 241-C-106, 241-BY-101, 241-BY-109.

ESTIMATED COMPLETION DATE: September 30, 1998

KEY REFERENCES:

Cannon, N. S., and R. C. Knight, 1995, *Retained Gas Sampler System Acceptance Test Report*, WHC-SD-WM-ATR-137, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Shekarriz, A., D. R. Rector, N. S. Cannon, L. A. Mahoney, B. E. Hey, M. A. Chieda, C. G. Linschooten, J. M. Bates, F. J. Reitz, R. E. Bauer, and E. R. Siciliano, 1997, *Composition and Quantities of Retained Gas Measured in Hanford Waste Tanks 241-AW-101, A-101, AN-105, AN-104, and AN-103*, PNNL-11450, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington.

TASK SUMMARY SHEET  
SET 2

TASK TITLE: Vapor Analysis

PERFORMER(S): PNNL/LMHC

PURPOSE/NEED:

- Monitor flammable gas tanks to determine the frequency of gas release events and composition of gas released, and
- Gather data required to support development of work controls, closure of the Flammable Gas USQ, and resolution of the Flammable Gas Safety Issue.

APPROACH/BASIS: Obtain data from Watch List and selected tanks through the use of grab samples, Standard Hydrogen Monitoring Systems (SHMS), and gas characterization systems (CGS).

CURRENT STATUS: Gas release events (GREs) have been characterized for double-shell tanks. No significant GREs have been observed in SSTs. Data has been used to estimate compositions and ventilation rates.

SHMS, are installed on 30 tanks and GCSs are installed on three tanks. Installation of additional monitoring systems are planned for FY 1997 and FY 1998.

REMAINING WORK: Continue to monitor tanks, issue annual reports. Support installation and operations of additional monitoring instruments.

ESTIMATED COMPLETION DATE: September 30, 2001

KEY REFERENCES:

Wilkins, N. E., R. E. Bauer, and D. M. Ogden, 1996, *Results of Vapor Space Monitoring of Flammable Gas Watch List Tanks*, WHC-SD-WM-TI-797, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

TASK SUMMARY SHEET  
SET 2

TASK TITLE: Waste Behavior Analysis

PERFORMER(S): PNNL

PURPOSE/NEED: Development of an analytical method for estimating the amount of stored gases is needed to support the assessment of individual tanks, to enhance the overall understanding of the behavior of gases in wastes, and to support safety analysis.

APPROACH/BASIS:

- Evaluate the response of changes in waste level caused by changes in atmospheric pressure considering identified issues, and
- Establish an analytical approach to evaluating tanks for trapped gas.

CURRENT STATUS: Assessments have been made for 177 high-level waste tanks. A number of issues were identified with the data and model used for this analysis that would affect the amount of stored gas.

REMAINING WORK:

- Complete evaluation of individual waste tanks,
- Provide experimental validation of  $dL/dP$  as a method to quantify the volume of trapped gas,
- Evaluate the effects of the strength of waste forms on the amount of stored gas, and
- Evaluate sources of long-term changes on level that affect estimates of stored gas.

ESTIMATED COMPLETION DATE: September 1997

KEY REFERENCES:

Whitney, P. D., 1995, *Screening the Hanford Tanks for Trapped Gas*, PNL-10821, Pacific Northwest Laboratory, Richland, Washington.

Whitney, P. D., P. A. Meyer, N. E. Meyer, N. E. Wilkins, F. Gao, and A. G. Wood, 1996, *Flammable Gas Data Evaluation Progress Report*, PNNL-11373, Pacific Northwest National Laboratory, Richland, Washington.

TASK SUMMARY SHEET  
SET 2

Johnson, G. D., 1996, *Evaluation of Recommendation for Addition of Tanks to the Flammable Gas Watch List*, WHC-SD-WM-ER-599, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

TASK SUMMARY SHEET  
SET 2

TASK TITLE: Domespace Breathing Analysis

PERFORMER(S): PNNL

PURPOSE/NEED: Tank domespace ventilation rates are needed by the Flammable Gas Project and the Organic Tanks Project for resolution of safety issues. The flammable gas concentration in a passively ventilated waste tank is a function of the rate at which gases are released from the waste and the rate at which these gases are vented to the atmosphere. Current estimates of the flammable gas generation and release rates are consistent with calculated ventilation rates that are dominated by buoyancy-driven venting. Contrary to this, the Organic Tank Project is using domespace vapor sampling and the assumption that domespace ventilation is dominated by barometric pressure fluctuations to determine which tanks may have significant pools of organic solvents. If the higher ventilation rates calculated by the Flammable Gas Project are correct, the methods used by the Organic Tank Project will not correctly identify tanks with significant organic solvent pools. Both programs need actual measurements of ventilation rates.

APPROACH/BASIS: Inject helium and sulphur hexafluoride into selected tanks and measure the concentration of each gas at various time intervals. Analyze data to determine effective ventilation rates.

CURRENT STATUS: The method has been verified for tank 241-S-102; the ventilation rate for this tank is 2 cfm.

REMAINING WORK: Conduct tests in other selected SSTs.

ESTIMATED COMPLETION DATE: September 30, 1998

KEY REFERENCES: Not Applicable

TASK SUMMARY SHEET  
SET 2

**TASK TITLE:** Data Reconciliation

**PERFORMER(S):** LANL

**PURPOSE/NEED:** Provide comprehensive reports on double-shell tanks that provide the current understanding of the state of the tank. The information is needed to support closure of the Flammable Gas USQ and resolution of the Flammable Gas Safety Issue.

**APPROACH/BASIS:** This task involves generating data reconciliation reports for six tanks. The task involves reconciling the available data and the models to determine the expected values and standard deviations for the parameters important to the Flammable Gas Project. The data that will be analyzed include voidmeter, viscometer, retained gas sampler, barometric pressure vs level, temperature, domespace pressure, waste level, waste samples, vapor grab samples, domespace gas concentration measurements, and fill history. These data will be reconciled with the available gas generation, gas retention, and gas release models.

**CURRENT STATUS:** A preliminary report has been issued for 241-AW-101.

**REMAINING WORK:** Complete reports for 241-AN-103, 241-AN-104, and 241-AN-105 and Facility Group 2 tanks.

**ESTIMATED COMPLETION DATE:** September 30, 1997

**KEY REFERENCES:** Not Applicable

TASK SUMMARY SHEET  
SET 2

TASK TITLE: Data Evaluation

PERFORMER(S): LMHC

PURPOSE/NEED: Provide assessments of tank behavior. Develop a methodology for identifying potential Watch List tanks. Provide a reference set of parameters (gas composition, gas volume, etc.) for use on Safety Analyses.

APPROACH/BASIS: Develop a methodology to be used in screening all tanks for potential inclusion on the Watch List. Perform a screening of all tanks using this methodology and the previously approved evaluation criteria. This task is also to collect all available information on flammable gas tanks to provide interpretive reports on tank behavior. This task is to review and analyze tank data collected from a variety of sources (gas concentration, tank level, tank pressure, temperature, etc.) to support development of tank models and understanding of tank behavior. The end product will be a compilation of tank information that will be the source for subsequent safety analysis and engineering work.

CURRENT STATUS:

- Gas monitoring data collection is on going,
- Remainder of tasks to be started, and
- Draft methodology for Watch List tank identification complete.

REMAINING WORK:

- Improve/streamline data collection capabilities,
- Develop framework for technical manual,
- Perform analysis and reporting to support technical manual publication, and
- Complete methodology and screen tanks.

ESTIMATED COMPLETION DATE: September 30, 2001

KEY REFERENCES: Not Applicable

TASK SUMMARY SHEET  
SET 2

TASK TITLE: Domespace Modeling

PERFORMER(S): NHC/PNNL

PURPOSE/NEED: Provide analysis of single-shell tank ventilation rates for use in understanding of tank behavior and application in safety analysis. This work will also support the Organic Project by determining SSTs breathing rates to support organic pool size estimates.

APPROACH/BASIS: Analysis shall pursue three separate paths:

- Develop and validate (using data from 2 & 3) a general model to be used for estimating SSTs breathing rate,
- Estimate breathing rates from SHMS hydrogen "decay" data following induced GRES for SSTs, and
- Evaluate breathing rate data obtained by the tracer injection method.

CURRENT STATUS:

- Simple model has been proposed,
- SHMS method has been demonstrated,
- 241-S-102 test of breathing rate by tracer injection completed, and
- Tracer injection test in tanks 241-U-103, 241-C-107, and 241-AX-103 initiated.

REMAINING WORK:

- Complete model development and validation,
- Analyze tracer injection test results, and
- Support development of continuous tracer gas monitoring method development.

ESTIMATED COMPLETION DATE: October 1998

TASK SUMMARY SHEET  
SET 2

KEY REFERENCES:

- Huckaby, J. L., 1997, *Preliminary Letter Report on Tank 241-S-102 Tracer Gas Testing*, PNNL TWSFG97.29, March 17, Pacific Northwest National Laboratory, Richland, Washington.
- Barnes, G. A., 1996, *Test Plan for Measuring the Breathing Rate of Tank 241-S-102 by Use of Tracer Gases*, WHC-SD-WM-TP-492, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Andersen, J. A., 1997, *Tank Plan for Determining Breathing Rates in Single-Shell Tanks Using Tracer Gases*, HNF-SD-TWR-ETP-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

TASK SUMMARY SHEET  
SET 2

TASK TITLE: Voidmeter Tests/Analysis

PERFORMER(S): LMHC/PNNL

PURPOSE/NEED: A Key parameter in the analyses of the flammable gas hazard is the amount and distribution of gas bubbles that are retained in the waste.

APPROACH/BASIS: The basic approach is to perform in situ measurements of the stored gas by evaluating the compressibility of the waste at various depths. The voidmeter was developed for this purpose for use in DSTs.

CURRENT STATUS: Tests have been completed and reported for tanks 241-SY-101, 241-SY-103, 241-AW-101, 241-AN-103, 241-AN-104, and 241-AN-105. Data are being used to update the models used to estimate the amount of retained gas.

REMAINING WORK: Tests will be conducted in tanks 241-AN-107 and 241-AN-105. Data for 241-AN-107 is needed to support operation of the mixing pump for caustic addition. Earlier tests in 241-AN-105 did not obtain data for the lower 6 feet of waste because of some equipment problems; a retest will be done to obtain the data for the bottom portion of the tank and to investigate temporal variations in void fraction.

ESTIMATED COMPLETION DATE: Tests to be completed and a report will be issued by September 1997.

KEY REFERENCES:

Stewart, C. W., J. M. Alzheimer, M. E. Brewster, G. Chen, R. E. Mendoza, H. C. Reid, C. L. Shepard, and G. Terrones, 1996, *In Situ Rheology and Gas Volume in Hanford Double-Shell Tanks*, PNNL-11296, Pacific Northwest National Laboratory, Richland, Washington.

TASK SUMMARY SHEET  
SET 2

**TASK TITLE:** 241-SY-101 Data Reports

**PERFORMER(S):** PNNL

**PURPOSE/NEED:** Provide summary reports on the data for tank 241-SY-101 to support assessments of the effectiveness of the mixer pump to mitigate episodic releases of gas.

**APPROACH/BASIS:** Monitor the day-to-day operation of the mixer pump in Tank 241-SY-101. Daily review the DACS recorded data and assess what changes if any are occurring in the tank waste. Immediately notify the client of any deleterious changes. Prepare and issue a brief monthly data report to the client and the West Area Tank Farm Operations Manager. Prepare and issue a quarterly report containing tank, pump, and waste data, plus a current description of the waste and assessment of any change over the last quarter.

**CURRENT STATUS:** Reports have been issued quarterly. The mixer pump continues to be a highly effective means to mitigate the flammable gas hazard.

**REMAINING WORK:** Continue to collect, analyze, and report the data for 241-SY-101. Facilitate transfer of responsibility for this activity to LMHC and Tank Farm Operations.

**ESTIMATED COMPLETION DATE:** September 30, 1997

**KEY REFERENCES:** Not Applicable

TASK SUMMARY SHEET  
SET 3

TASK TITLE: Flammable Gas USQ Closure

PERFORMER(S): DES&H

PURPOSE/NEED: A Flammable Gas USQ has been declared on 149 SSTs and 27 DSTs. Closure of this USQ is a TPA milestone. This task provides for the overall planning and implementation for activities for closure of the USQ.

APPROACH/BASIS:

- The proposed closure strategy is based on the use of a decision support system that will allow Hanford Site personnel to quantitatively estimate the effects of various alternative control strategies on the safety of a facility configuration. The process for developing such a decision support system is called Safety Controls Optimization by Performance Evaluation (SCOPE). Several key features should be highlighted to explain the role of SCOPE in allowing DOE to close the Flammable Gas USQ.
- The process emphasizes the timely review of existing analyses and data (rather than large, new analysis efforts) and the consideration of divergent technical views by experts who provide quantified parameter uncertainty distributions. The participating experts document the basis for their specific elicitation values, so that the source for all of the values impacting the results can be traced.
- The process accommodates early and meaningful stakeholder involvements by (1) including stakeholders in the process for selecting panel experts for panels, (2) including stakeholder-selected subject-matter experts to provide topic-specific information for panel members to consider, and (3) providing open proceedings and documentation to allow continual monitoring and review throughout the process. All meetings of the experts and all technical presentations to the panels of experts are open meetings that can be observed by independent reviewers and stakeholders.
- The basic element of Hanford Site management with respect to flammable gas hazards is the analysis of specific facilities and the development of recommendations of appropriate controls by the responsible Hanford Site subcontractor. The SCOPE products make this possible without requiring the Hanford Site engineers performing these analyses to be experts on flammable gas phenomenology.

The SCOPE process and results will permit DOE to exercise discretion and judgment in carrying out the requirements of Order 5480.21 in that (1) the understanding of risk determined by the SCOPE process will be adequate for prudent management of safety at the Hanford Site and (2) the appropriate amount of conservatism and control can be determined

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TASK SUMMARY SHEET  
SET 3

at the discretion of DOE at the end of the process in light of the knowledge regarding the marginal utility of additional risk management controls. These judgments will be utilized in a rigorous and well-documented manner, demonstrating that all prudent risk management actions have been taken.

**CURRENT STATUS:** RL has essentially accepted the approach for closure of the Flammable Gas USQ. The first major activity is to implement the SCOPE process (see SCOPE Task Sheet).

**REMAINING WORK:** Close the Flammable Gas USQ for Facility Groups 1, 2, and 3.

**ESTIMATED COMPLETION DATE:** September 30, 1998

**KEY REFERENCES:**

Funderburke, W. M., 1996, *Flammable Gas Project: Memorandum of Understanding on the Strategy for Closure of the Flammable Gas Unreviewed Safety Question to Meet Performance Agreement TWRI.3.2 and 1.3.6*, (letter 9655781 to S. Marchetti, Fluor Daniel Hanford, Inc., November 29), Lockheed Martin Hanford Corporation, Richland, Washington.

Sohn, C. L., 1997, *Qualified Acceptance of the Memorandum of Understanding (MOU) on the Strategy for Closure of the Flammable Gas Unreviewed Safety Question*, (letter 96-WSD-356 to H. J. Hatch, Fluor Daniel Hanford, Inc., January 13), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

TASK SUMMARY SHEET  
SET 3

TASK TITLE: Safety Basis Support

PERFORMER(S): DES&H

PURPOSE/NEED: This task provides support for closure of the Flammable Gas USQ and other SCOPE tasks.

APPROACH/ BASIS: Prepare documentation packages for closure of the Flammable Gas USQ. These packages will contain (1) a transmittal letter; (2) a USQE; (3) a controls Selection Analysis Document; (4) revisions to the BIO/FSAR; (5) revisions of the TSRs; and (6) a compliance Implementation Plan.

CURRENT STATUS: Ongoing activity.

REMAINING WORK: Prepare packages for Facility Groups

ESTIMATED COMPLETION DATE: September 30, 1998

KEY REFERENCES: Not Applicable

TASK SUMMARY SHEET  
SET 3

TASK TITLE: SCOPE

PERFORMER(S): Sandia National Laboratories (SNL)

**PURPOSE/NEED:** Under this program, Sandia National Laboratories will develop and implement a process that will assist the Tank Waste Remediation System (TWRS) in making decisions about cost-effective safety controls related to flammable gas hazards. The concept for this process is called Safety Controls Optimization by Process Evaluation (SCOPE). A key focus of the work is to support the Hanford Site's approach to close the Flammable Gas USQ within the timeframe specified by the Tri-Party Agreement (September 1998).

**APPROACH/BASIS:** Sandia National Laboratories will define the concept, convene the necessary panels of experts for the expert elicitation process, create a Decision Support System (DSS), and provide technical assistance to Hanford Site personnel who will apply this methodology to develop flammable gas control strategies. The work is organized into five tasks:

**Task 1: Project Management**

This task covers oversight and integration of all technical activities. Quality Assurance oversight is also covered, including interfaces with the TWRS Quality Assurance Program. Work associated with cost and schedule tracking and periodic reporting to the Project Hanford Management Contractor are also included in this task.

**Task 2: Process Development**

The phase 1 final report lays out in some detail the many elements of the process that lead to the SCOPE DSS. This task covers the final design of the process and the specification of the details of how the elicitation will be carried out. One of the key elements of the scope DSS is the Analysis Tool, which is a computer-based system that combines the output of the expert elicitation with data about the tanks and specific hazard control systems to produce estimates of the relative benefits of alternative controls. Development and maintenance of the Analysis Tool is covered by this task.

**Task 3: Elicitation Process**

There are several elements of the elicitation process task. First, the experts that will participate on the panels must be selected by following a predetermined evaluation process. Second, a core technical information library will be evaluated, selected, and assembled to provide the experts with a common basis for discussions. Third, several workshops with the expert panels will be conducted to develop consensus, as well as to preserve legitimate

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**TASK SUMMARY SHEET**  
**SET 3**

technical difference of opinion, culminating in the actual elicitation that produces the data needed for the Analysis Tool. Finally, the entire elicitation process will be thoroughly documented in order to provide a clear audit trail for decisions that may emerge from use of the SCOPE DSS.

**Task 4: Application Support**

The actual application of the SCOPE DSS to specific TWRS facilities will be carried out under other projects. This task provides a limited level of support to those activities including user documentation, troubleshooting of the software, and responses to safety analysts' questions that arise during the use of the DSS.

**Task 5: Programmatic Interfaces**

Acceptance of hazard control decisions that are supported by the SCOPE DSS will depend in part on the credibility of the process to various stakeholders. Under this task communication and coordination with key stakeholders will be supported. Of particular importance is the involvement of RL in decision processes, and in an oversight role. In addition, it is important to take advantage of the large body of existing and ongoing work related to flammable gas hazards at the Hanford Site; this task will support the integration of this information into the SCOPE process.

**CURRENT STATUS:** The Phase I report has been issued and the Analysis Framework document was sent out for review. Expert elicitation workshops have been setup for March, April, and May 1997.

**REMAINING WORK:**

**1997**

Complete workshops  
Apply Analysis Tool (AT) to Facility Group 3

**1998**

Conduct workshops and AT evaluations for Facility Groups 1, 2, and 3

**ESTIMATED COMPLETION DATE:** July 1998

TASK SUMMARY SHEET  
SET 3

KEY REFERENCES:

Bergeron, K. D., D. C. Williams, S. E. Slezak, M. L. Young, C. E. Leach, M. G. Plys, B. Malinovic, and J. M. Grigsby, 1996, *SCOPE: Safety Controls Optimization by Performance Evaluation: a Systematic Approach for Safety-Related Decisions at the Hanford Tank Waste Remediation System*, SAND96-2927, Sandia National Laboratories, Albuquerque, New Mexico.

TASK SUMMARY SHEET  
SET 3

TASK TITLE: Safety Support

PERFORMER(S): Los Alamos National Laboratory (LANL)

PURPOSE/NEED: This task covers LANL activities in support of the closure of the Flammable Gas USQ.

APPROACH/BASIS: The following activities will be conducted:

- Complete the Flammable Gas USQ closure guideline documents by incorporating the comments,
- Finalize the Risk Ranking methodology document submitted as DRAFT in FY 1996, and
- Participation in the form of expert opinions, modeling support, presentation of previous SA work, and peer review to the Safety Controls Optimization by Performance Evaluation (SCOPE) team.

CURRENT STATUS: Ongoing activity

REMAINING WORK:

ESTIMATED COMPLETION DATE: September 30, 1998

KEY REFERENCES: Not Applicable

TASK SUMMARY SHEET  
SET 3

**TASK TITLE:** Compatibility Criterion

**PERFORMER(S):** Los Alamos National Laboratory (LANL)

**PURPOSE/NEED:** The objective is to develop a criterion for waste compatibility and measurable waste parameters in order to avoid creating another flammable gas tank similar to 241-SY-101. The issue is a major concern, especially with the urgency in saltwell pumping flammable gas single-shell tanks into double-shell tanks and other similar transfers from single-shell tanks (e.g. Project W320).

**APPROACH/BASIS:** The approach comprises of reviewing the available data from DSTs with known or anticipated GRE behavior and casting the data into models or dimensionless groups to determine the parameters that are responsible for the GRE behavior. Based on the results of the data analyses, develop reasonably conservative criteria to be imposed on waste transfers in order to minimize the likelihood of creating another flammable gas tank. The requirements of the criterion may be met by analyses or by compatibility tests that can be run by real waste samples once the parameters that need quantification are determined.

**CURRENT STATUS:** The review of existing data and models continues. A master logic diagram is generated and various branches are being quantified.

**REMAINING WORK:** Complete the quantification of all GRE mechanisms and the associated uncertainties. Identify and quantify the range of measurable parameters.

**ESTIMATED COMPLETION DATE:** End of FY 1997.

**KEY REFERENCES:** Not Applicable

TASK SUMMARY SHEET  
SET 3

TASK TITLE: Project Management

PERFORMER(S): Duke Engineering and Services Hanford

PURPOSE/NEED: This task provides for the planning and monitoring of all aspects of the Flammable Gas Project.

APPROACH/BASIS:

- Prepare program plans, including budget and schedule,
- Conduct regular reviews of all program tasks including all reports,
- Prepare reports to status the performance of all work,
- Interface with FDH and its PHMC Subcontractors, and the U.S. Department of Energy to ensure an effective approach is used for meeting milestones and commitments, and
- Develop and implement strategies for closure of the Flammable Gas USQ and resolution of the Flammable Gas Safety Issue.

CURRENT STATUS: Ongoing activity

REMAINING WORK: N/A

ESTIMATED COMPLETION DATE: September 30, 2001

KEY REFERENCES: This document.

TASK SUMMARY SHEET  
SET 3

TASK TITLE: Program Planning/Control

PERFORMER(S): Duke Engineering and Services Hanford

PURPOSE/NEED: This task provides for the baseline planning and control of the Flammable Gas Project.

APPROACH/BASIS:

- Assist Project Manager with all aspects of baseline planning and control,
- Prepare Multi-Year Work Plan (baseline) and Project Baseline Summary (budget submittal),
- Prepare activity-based cost estimates and resource-loaded schedules,
- Maintain baseline and implement change control,
- Perform monthly status and reporting, and
- Control execution of work (issue charge codes, work orders, purchase orders, letters of instruction, etc.).

CURRENT STATUS: Ongoing activity.

REMAINING WORK: N/A

ESTIMATED COMPLETION DATE: September 28, 2001

KEY REFERENCES: Multi-Year Work Plan

TASK SUMMARY SHEET  
SET 3

**TASK TITLE:** Chemical Reactions Sub-Tanks Advisory Panel (CRS) Support

**PERFORMER(S):** U.S. Department of Energy

**PURPOSE/NEED:** This task provides funding for the Chemical Reactions Sub-Panel

**APPROACH/BASIS:** The CRS has been requested by the U.S. Department of Energy to review various project documents. Comments from the CRS are transmitted to FDH and its PHMC subcontractors for evaluation.

**CURRENT STATUS:** Ongoing activity

**REMAINING WORK:** N/A

**ESTIMATED COMPLETION DATE:** September 30, 2001

**KEY REFERENCES:** Not Applicable

TASK SUMMARY SHEET  
SET 4

**TASK TITLE:** Ventilation Upgrades

**PERFORMER(S):** SESC

**PURPOSE/NEED:** Ensure that adequate ventilation exists in flammable gas tanks so as to prevent chronic releases from exceeding 25% of the lower flammability level (LFL) and to minimize the time at risk for episodic releases of gases.

**APPROACH/BASIS:** Farms such as AN and AW have a ventilation system, but do not have an effective means for control and balance of the system. The first step is to provide each tank in farm with an inlet filter system. This has been completed for the SY Farm. With each tank having a controlled inlet for air it is possible to set and maintain a flow for each tank. Recent experience with the AN and AW Farms has shown that some of the flammable gas tanks have had virtually no flow. This lead to unacceptable levels of hydrogen. A constant flow control device also being developed for use with the inlet filter; this unit will ensure that designated minimum flow is always present. The approach for controlling ignition sources has lead to insuring that potential spark sources will be estimated; thus, spark resistant fans will be installed in the ventilation systems.

**CURRENT STATUS:** Inlet filters and flow controllers have been completed for the AN and AW Farms. Inlet filters have been installed in the SY Farm and an intrinsically safe exhauster was installed in the SY Farm.

**REMAINING WORK:**

- Install flow controllers in the SY Farm,
- Install spark resistant fans in the AN and AW exhausters, and
- Install flow monitors in six DSTs.

**ESTIMATED COMPLETION DATE:** September 30, 1998

**KEY REFERENCES:** Engineering Task Plans (Internal Documents)

TASK SUMMARY SHEET  
SET 4

TASK TITLE: Gas Monitoring Equipment

PERFORMER(S): SESC

PURPOSE/NEED: Provide for the design, fabrication and installation of gas monitoring equipment. This equipment will be used to assess the gas release behavior of tanks that are being salt well pumped, retrieved, as an integral part of the work control strategy

APPROACH/BASIS: A gas monitor called the Standard Hydrogen Monitoring System (SHMS) was developed to provide on-line measurements of hydrogen levels in Watch List tanks. In addition the SHMS has been upgraded to include the capability to extract samples of gas for detailed laboratory analyses of other gases.

Enhancements to the SHMS include the use of gas chromatograph and infrared analyzers.

CURRENT STATUS: Thirteen additional systems are being installed in FY 1997 as outlined in the referenced letter.

REMAINING WORK: Four more systems to be completed in FY 1998.

ESTIMATED COMPLETION DATE: September 30, 1998

KEY REFERENCES:

Cash, R. J., 1996, *Flammable Gas Project: Revised Strategy for Continuous Monitoring*, (letter 9654881 to S. Marchetti, Fluor Daniel Hanford, Inc., October 15), Duke Engineering and Services, Hanford, Inc., Richland, Washington.

TASK SUMMARY SHEET  
SET 4

TASK TITLE: TMACS Support

PERFORMER(S): LMHC/FDNW

PURPOSE/NEED: Provide for automatic data recording and storage for SHMS, level gauges, pressure monitors and waste thermocouples.

APPROACH/BASIS: Tank Farms is installing a Tank Monitoring and Control System (TMACS) in all tank farms. The Flammable Gas Project is supporting this activity so that SHMS, surface-level gauges, flow meter, and pressure gauges can be connected to the TMACS.

CURRENT STATUS: Work in progress.

REMAINING WORK:

ESTIMATED COMPLETION DATE: September 30, 1997

KEY REFERENCES: Engineering Task Plans (Internal Documents)

TASK SUMMARY SHEET  
SET 4

TASK TITLE: Video Equipment

PERFORMER(S): LMHC

PURPOSE/NEED: Television cameras monitor intrusive activities in the Flammable Gas Watch List tanks because, waste in tank 241-SY-101 exhibited considerable movement prior to gas release events, waste observations with cameras will provide early warning of a gas release event. Television images also enable operators monitor activities such as insertion of a MIT or core drill string, as well as identify of problems or obstructions that might be encountered during these types of activities.

APPROACH/BASIS: Develop and install intrinsically safe video and auxiliary systems in tanks that exhibit episodic releases of gas.

CURRENT STATUS: TV Systems have been installed and are in operation for 241-SY-101, 241-SY-103, 241-AW-101, 241-AN-103, 241-AN-104, and 241-AN-105. Portable systems have been prepared for use in SSTs.

REMAINING WORK: Operate and maintain existing video systems.

ESTIMATED COMPLETION DATE: September 30, 1999

KEY REFERENCES: Not Applicable

TASK SUMMARY SHEET  
SET 4

TASK TITLE: 241-SY-101 Mitigation Support

PERFORMER(S): SESC/LMHC/LANL

PURPOSE/NEED: Mitigation of tank 241-SY-101 has been accomplished by the installation and operation of a mixer pump, and the Flammable Gas USQ for tank 241-SY-101 was closed June 21, 1996. It is anticipated that the Flammable Gas Safety Project support to this tank can be completed in FY 1997. Remaining scope includes (1) completing and turning over to Operations a second spare pump (including future pump replacement activities and associated hardware), (2) updating the safety assessment, and (3) removing two VDDTs from within 241-SY-101.

APPROACH/BASIS:

- Update the safety assessment to the spare pump and removal of the VDDTs,
- Complete miscellaneous hardware items for the second spare pump, and
- Provide level of effort (LOE) engineering support for the operation of the Data Acquisition and Control System (DACS).

CURRENT STATUS: Ongoing effort.

REMAINING WORK:

ESTIMATED COMPLETION DATE: 1998

KEY REFERENCES:

Sullivan, L. H., 1995, *A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington*, LA-UR-92-3196, Rev. 14, Los Alamos National Laboratory, Los Alamos, New Mexico.

TASK SUMMARY SHEET  
SET 4

**TASK TITLE:** Portable Exhauster

**PERFORMER(S):** LMHC

**PURPOSE/NEED:** In accordance with safety assessment requirements, provide portable exhausters for tanks that will be salt well pumped.

**APPROACH/BASIS:** Most of the SSTs do not have an active ventilation system, while others have exhausters that have reached the end of their design life. Recent safety analyses have shown that some of the tanks have high flammable gas concentrations. To ensure that flammable gas concentrations remain within safety limits it is necessary to have an active ventilation system on the tank while doing intrusive activities. Portable exhausters that meet NEC/NFPA requirements for flammable atmospheres is needed.

**CURRENT STATUS:** Five portable exhausters are being fabricated to support salt well pumping of single-shell tanks.

**REMAINING WORK:** Complete fabrication and acceptance of the exhausters.

**ESTIMATED COMPLETION DATE:** September 30, 1997

**KEY REFERENCES:** Engineering Task Plans (Internal Documents)

TASK SUMMARY SHEET  
SET 4

TASK TITLE: Equipment Coordination

PERFORMER(S): LMHC

PURPOSE/NEED: This task provides for the coordination cost control, scheduling, and management of all activities for the design fabrication and installation of equipment. It also supports the Flammable Gas Equipment Advisory Board.

APPROACH/BASIS: Project management and scheduling and construction coordination for all engineering and field installation activities.

CURRENT STATUS: Ongoing effort.

REMAINING WORK: Complete installation of equipment as noted on other task sheets.

ESTIMATED COMPLETION DATE: September 30, 1999

KEY REFERENCES: Not Applicable

TASK SUMMARY SHEET  
SET 4

TASK TITLE: Pressure Gauges

PERFORMER(S): LMHC

PURPOSE/NEED: Installation of pressure gauges was a requirement of Public Law 101-510, Section 3137 for Watch List tanks. These gauges will augment the monitoring of SSTs for gas release events. Data may also aid in the evaluation of the effective ventilation rate.

CURRENT STATUS: Gauges have been installed, ongoing work directed at connection to TMACS.

REMAINING WORK: Complete TMACS connections

ESTIMATED COMPLETION DATE: September 30, 1997

KEY REFERENCES: Engineering Task Plans (Internal Documents)

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