HANFORD SITE RADIOACTIVE WASTE STORAGE TANK SAFETY ISSUES: THE PATH TO RESOLUTION

D. D. Wodrich and J. L. Deichman
Westinghouse Hanford Company
Richland, WA 99352

ABSTRACT

High-level radioactive waste has been stored in large underground storage tanks at the U.S. Department of Energy's (DOE) Hanford Site in Eastern Washington State since 1944. Since then, more than 227,000 m^3 (60 Mgal) of waste have been accumulated in 177 tanks. These caustic wastes consist of many different chemicals. The waste forms include liquids, slurries, salt cakes, and sludges. A number of safety issues have been raised about these wastes, and resolution of these issues is a top priority of DOE. A Waste Tank Safety Program has been established and a series of logic charts have been developed that show relationships of the major activities and the steps necessary to resolve the issues. The path to safety issue resolution has been defined, and the effort is well underway.

INTRODUCTION

High-level radioactive waste has been stored in large underground storage tanks at the U.S. Department of Energy's (DOE) Hanford Site in Eastern Washington State since 1944. Approximately 227,000 m^3 (60 Mgal) of waste have been accumulated in 177 tanks. These caustic wastes consist of many different chemicals. The waste forms include liquids, slurries, saltcakes, and sludges. A number of safety issues have been raised about these wastes, and resolution of these issues is a top priority of DOE. This paper describes the program logic steps being followed at the Hanford Site to resolve the safety issues.

BACKGROUND

The radioactive waste stored in underground tanks at the Hanford Site has come from various sources: (1) three different plutonium and uranium recovery processes from approximately 100,000 Mtu of irradiated fuel, (2) three different radionuclide recovery processes from waste, and (3) miscellaneous sources (e.g., laboratories and reactor decontamination solutions). The neutralized wastes include sodium nitrate/nitrite, sodium hydroxide, sodium aluminate, sodium phosphate, large amounts of organics, and approximately 775×10^{16} Bq (210 MCi) of radionuclides.

The wastes are stored in 149 single-shell tanks (SST) and 28 double-shell tanks. The SSTs consist of a reinforced concrete tank with a carbon steel liner and have capacities ranging from 208 m^3 (55,000 gal) to 3,785 m^3 (1 Mgal). The double-shell tanks consist of a carbon steel tank within a steel-lined concrete tank; each has a nominal capacity of 3,785 m^3 (1 Mgal) as shown in Fig. 1. Sixty-six of the older SSTs have leaked or are suspected to have leaked approximately 3,785 m^3 (1 Mgal). No waste has been added to these tanks since 1980, and the pumpable liquids are being removed so that the remaining waste will be mostly sludge and saltcake. The solids remaining in one of those pumped tanks is shown in Fig. 2. None of the newer double-shell tanks, the first one placed in service in 1970, have leaked.

SAFETY ISSUES IDENTIFIED

Safety studies and evaluations have been conducted periodically as new waste-producing processes were developed and waste conditions changed. However, delaying permanent waste disposal, continual pressure of waste generation on limited storage space, and aging facilities have resulted in several current safety issues.

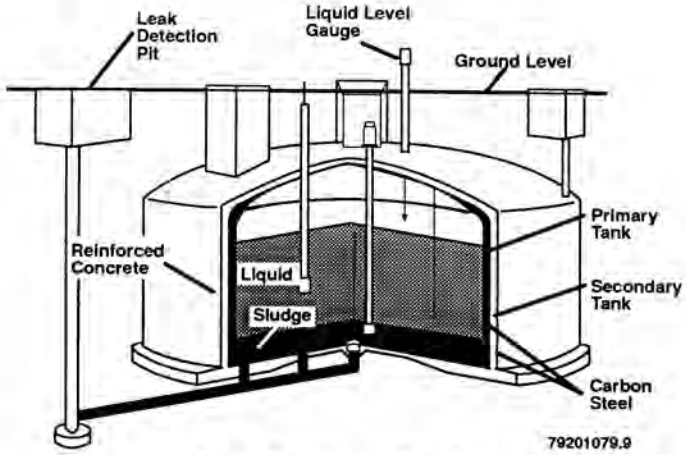

Fig. 1. Double-shell tank.

Over the past 2 1/2 years, 23 safety issues have been identified by reviewing waste tank facilities, operations, anomalies, and investigations. These issues range from episodic flammable gas releases to failed monitoring instruments. The 23 safety issues, divided into three priorities based on their significance, are listed in Table I.

Congress also has expressed concern about Hanford Site tank safety in Section 3137 of Public Law 101-510. Section 3137 specifically directs the Secretary of DOE to take the following actions:

- Identify those tanks at Hanford that "...may have a serious potential for release of high-level waste due to uncontrolled increases in temperature or pressure..."
- Determine whether "...continuous monitoring to detect a release or excessive temperature or pressure..." at each identified tank is being carried out and, if not, to install such monitoring as soon as possible if installing such monitoring does not increase the danger of a release
- "...develop action plans to respond to excessive temperature or pressure or a release from any tank identified..." as having a serious potential for release of

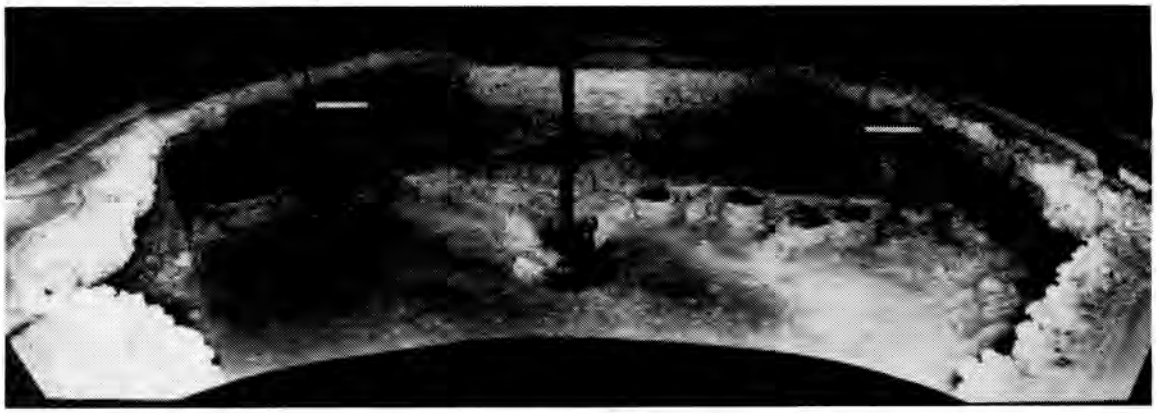

Fig. 2. Saltcake in an underground tank.

TABLE I

Waste Tank Safety Issues Safety Issues Description

Priority 1
1. Flammable gas generation in Tank 101-SY and other tanks
2. Potential explosive mixture of ferrocyanide in tanks
3. Potential organic-nitrate reactions in tanks
4. Continued cooling required for high heat generation in Tank 106-C
Priority 2
5. Insufficient tank contents characterization to support evaluation
6. Inadequate safety documentation
7. Maintenance and upgrade of tank farm facilities and equipment
8. Inadequate SST leak detection systems
9. Instrument upgraded in SSTs and DSTs
10. Tank safety operating life
11. SST emergency pumping
12. Leaking S-302-A catch tank
13. Tank toxic vapor releases
14. Improvement in conduct of operations
15. Lack of plant essential drawings
16. DST space requirements
17. Response to a leaking DST
Priority 3
18. Transfer line concrete encasement integrity and secondary containment compliance
19. AZ Tank Farm ventilation line
20. Excessing hydroxide consumption in Tank 107-AN
21. Sealing of SSTs to prevent intrusions
22. Improved leak detection in DSTs
23. Intertank ventalization connections
DST = double-shell tank.
SST = single-shell tank.

high-level waste due to uncontrolled increases in temperature or pressure

- Prohibit additions of high-level radioactive wastes to the identified tanks except for small amounts to be removed and returned to a tank for analysis unless the Secretary determines that no safer alternative exists or that the tank does not pose a serious potential for a release of high-level radioactive waste.

Additionally, Section 3137 directs that the Secretary of the DOE report to the United States Congress "...on actions taken to promote tank safety, including actions specifically taken pursuant to this section of the law, and the Secretary's timetable for resolving the outstanding issues on how to handle the waste in such tanks."

As required by Subsection 3137(a), the DOE has identified 53 high-level radioactive waste tanks that "...may have a serious potential for release of high-level waste due to uncontrolled increases in temperature or pressure." Fifty-two of these tanks were identified because they contain chemical materials that, at temperatures much higher than that

measured in any Hanford Site tanks, may produce an exothermic reaction. One other tank also was identified because it is the only SST that requires the periodic addition of water for evaporative cooling to prevent tank structural failure and a subsequent release of radioactive waste to the environment.

RESOLUTION OF SAFETY ISSUES

Resolution of all the safety issues will take many years. As the tanks receive further evaluation, it is anticipated that more issues may be identified. A Waste Tank Safety Program has been established to conduct this work, and an overview plan for implementing remediation of waste tank safety issues was prepared. Detailed plans also are being developed for each of the major activities. Because the program is complex, top-level program logic charts showing relationships of the major activities and the steps necessary to resolve the issues have been quite useful in explaining and coordinating the program. These logic charts are used in this paper to describe the Waste Tank Safety Program and the steps leading to safety issue resolution. It is anticipated that the logic can be improved as the program proceeds.

The Waste Tank Safety Program logic is summarized in Fig. 3. The plan is to evaluate all 177 tanks (shown on the left), correct any deficiencies, and conclude the program when the tanks are verified as safe for storing the waste until it can be disposed. The major activities are: Evaluation, Remediation/Mitigation, Verification, and Upgrades.

Four of the tank contents safety issues that affect 53 tanks were classified as Priority 1 and are getting the most attention. The other 19 are classified as Priority 2 and 3, one of which has been resolved. Of the 53 priority 1 tanks, four have been selected for accelerated evaluation. Tank 101-SY is of the greatest concern because of flammable gas, while 104-BY has the largest amount of ferrocyanide. Tank 106-C is an SST that requires the addition of water to keep it cool, and 103-C has a separable organic layer floating on top of the aqueous waste.

Evaluation will determine that some tanks require remediation/mitigation to close the safety concern (i.e., Tanks 101-SY and 106-C), while the evaluation of others will determine that safety is not an issue. The evaluation task logic is shown in Fig. 4.

Because data collection is an expensive and time consuming-effort, it is extremely important to state the safety issues clearly so everyone understands them and to develop the criteria that, when met, would resolve the issue. Then the deliverables, which will be used to show the criteria are met, can be defined. With these in place, the data needed can be identified by listing the questions that need to be answered. The data sources to answer the questions include taking waste samples from the tank; monitoring the tank instrumentation; laboratory or engineering test; and historical records, modeling, and analysis. The specific data to be acquired also must be defined; that is, a chemical analysis of the waste must specify what chemicals should be analyzed. As the data are collected and analyzed, it is likely that the data need will be adjusted.

Data evaluation, which may include modeling and laboratory tests, will determine whether the safety issue needs some corrective action to remediate it or whether the tanks are safe in their present condition. Safety issue resolution will require a significant amount of documentation that will be approved by other oversight groups.

The logic for safety issue remediation/mitigation is shown in Fig. 5. Remediation means the problem is corrected, while mitigation means it is made less severe. The first, very

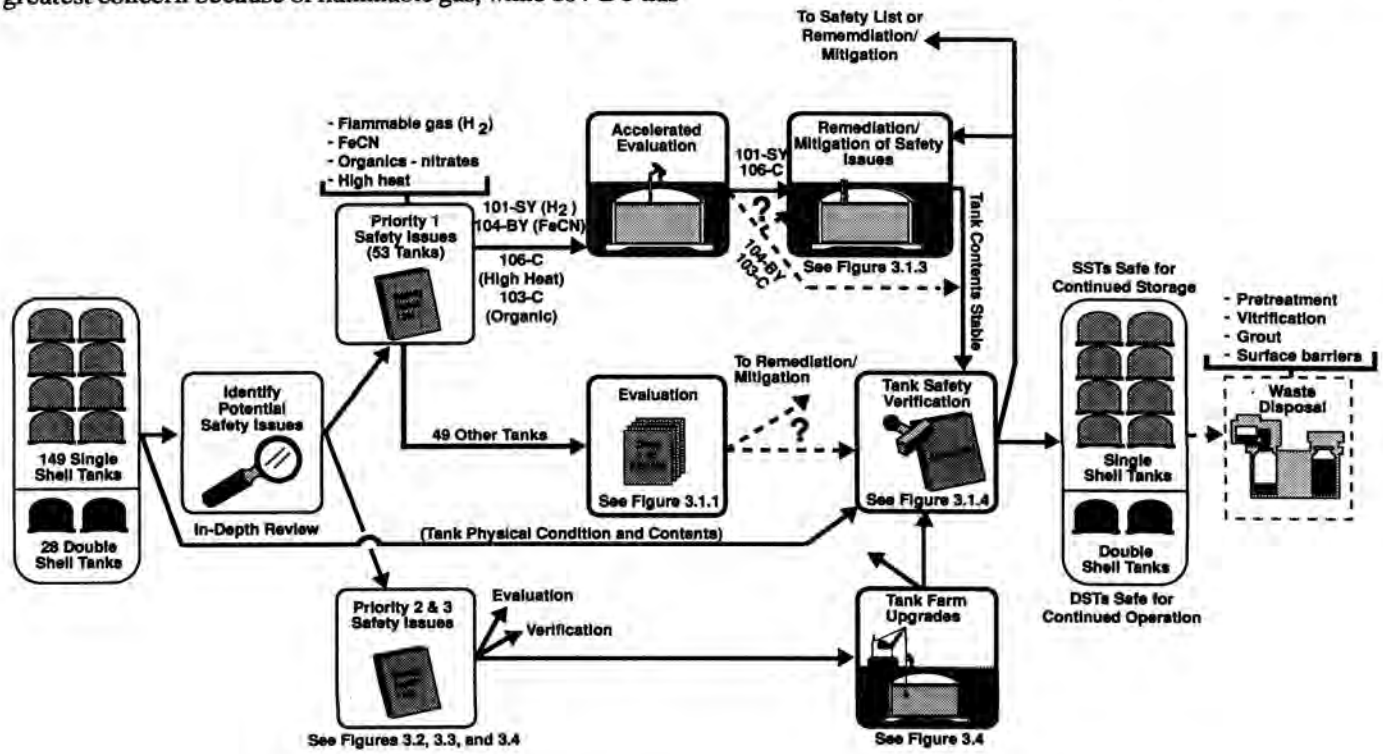

Fig. 3. Waste tank safety program.

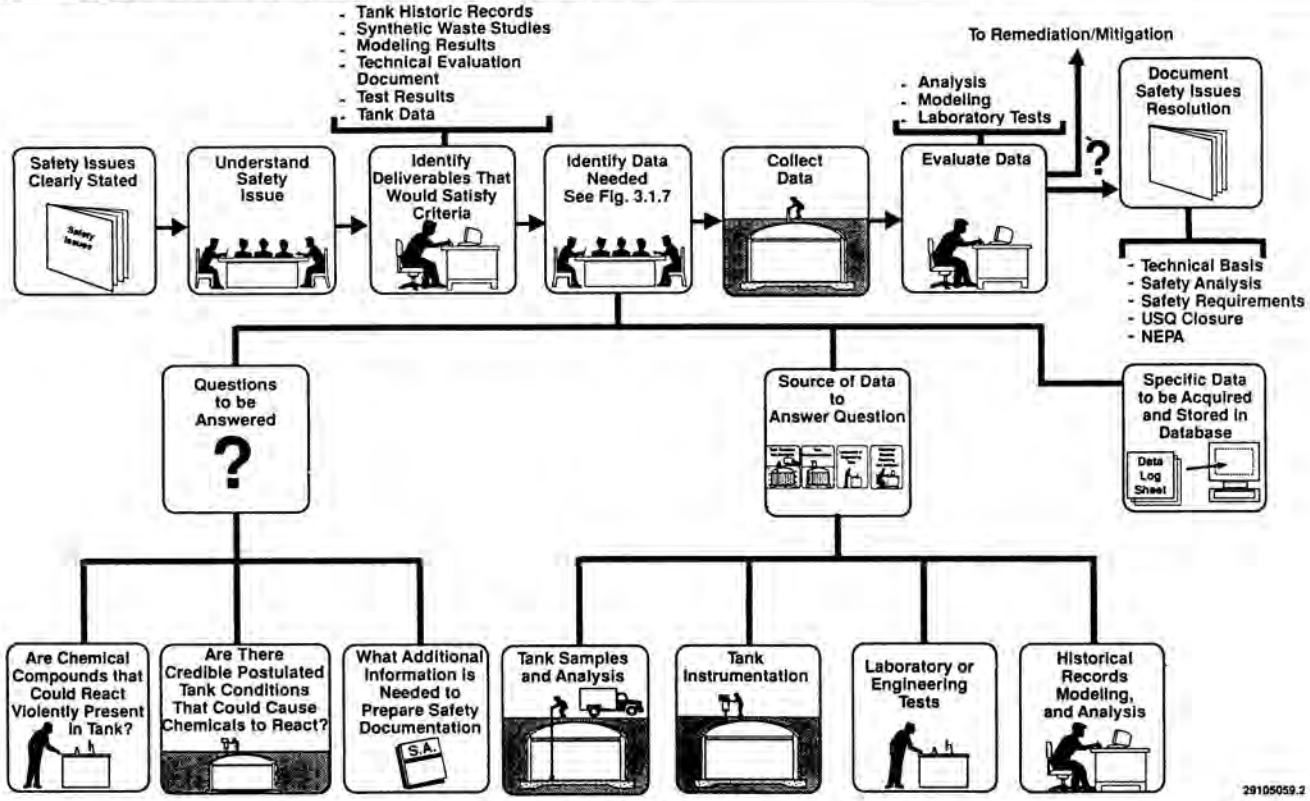

Fig. 4. Evaluation.

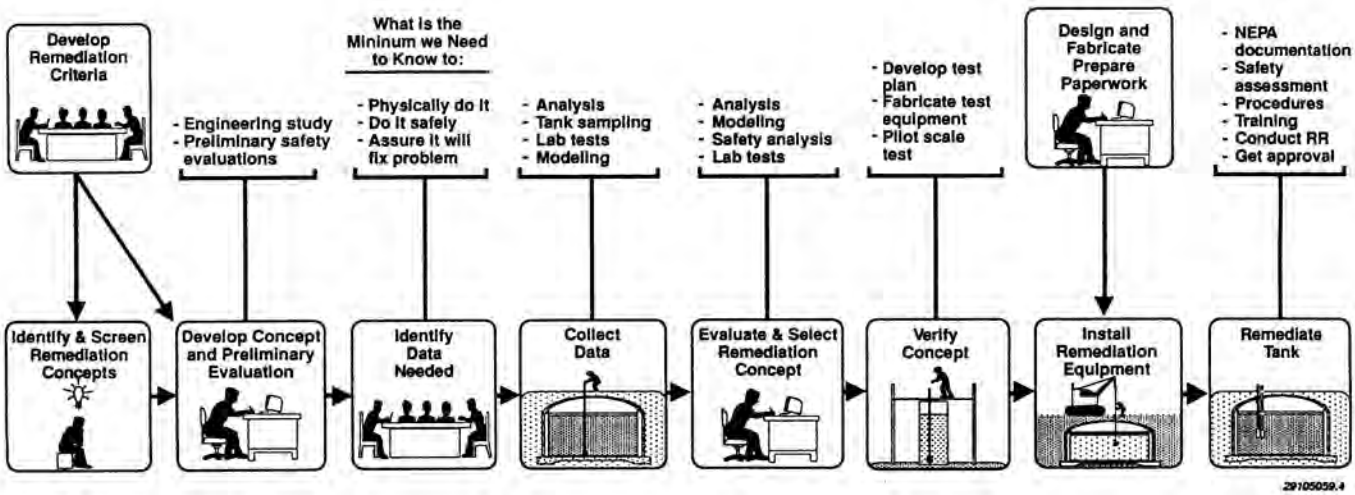

Fig. 5. Remediation/mitigation of safety issues.

important step is to develop criteria that, when met, means the issue is resolved. These criteria must be measurable.

The next step is to brainstorm concepts that would fix the problem. These might include such things as mixing or diluting the waste, destroying the organic waste, or purging the tank with inert gas. The most promising concepts should be developed and evaluated more fully. Based on these concepts, the data needed to implement the concept safely and to assure it will work can be identified. The steps for identifying data needed are the same as shown on the evaluation logic chart in Fig. 4, except the questions to be answered are different.

As the data are collected and evaluated, a remediation concept can be selected and developed. It is likely the concept will need to be verified through testing before there is enough confidence to proceed with design, fabrication, and installation. Actual remediation will require significant preparation in addition to developing the method and equipment. This includes such things as safety assessments, operating procedures, personnel training, and readiness review.

Because the tank waste will not be disposed for tens of years, the waste storage system must provide safe storage until then. The tank safety verification activity, shown in Fig. 6, will evaluate the tank contents, tank physical condition, and supporting systems systematically to verify that they are safe for continuous use. One of the tasks is to collect and assemble the large amount of existing tank and waste information in a controlled database so that it can be used in the evaluations. Additional data needs also will be identified as the evaluations proceed. The evaluations will be documented and the findings will determine if a safety issue requires remediation/mitigation or if the tank is safe. Those evaluations also will provide technical input to upgrading the safety analysis reports, which will be the key documents in the tank safety verification process. The end result of this activity will be a documented verification that the tanks are safe for continued operation or storage.

The last major activity is tank farm upgrade. Deficiencies in the tank farm facilities, equipment, and infrastructure have safety implications, and upgrades are needed to close some of the safety issues. The upgrades include:

- Configuration control by field-verifying drawings, making system drawings, labeling equipment, and developing master component lists.
- Improved conduct of operations through operator training and certification, user-friendly procedures, and qualified technical support.
- Upgraded operational safety requirements and safety analysis reports.
- Improved maintenance by removing unused alarms, repairing out-of-service equipment, removing asbestos, reducing maintenance backlog, and better housekeeping.
- New facilities and equipment such as additional tanks, tank ventilation systems, double-encased pipelines, tank monitoring instruments, and automated data collection.
- New support facilities such as change rooms and portal radiation monitoring at each tank farm, additional office space and shops to collocate and house increased staff, and test facilities for verifying safety issue remediation methods.
- Reduced radiation exposure by removing obsolete contaminated equipment, cleaning up contaminated surface soil, and stabilizing blowing sand.

CONCLUSION

The Hanford Site's Waste Tank Safety Program is large, complex, and has high priority within the DOE. The road to resolving the safety issues has been mapped out, and although it will be a journey of many years, we are well on our way.

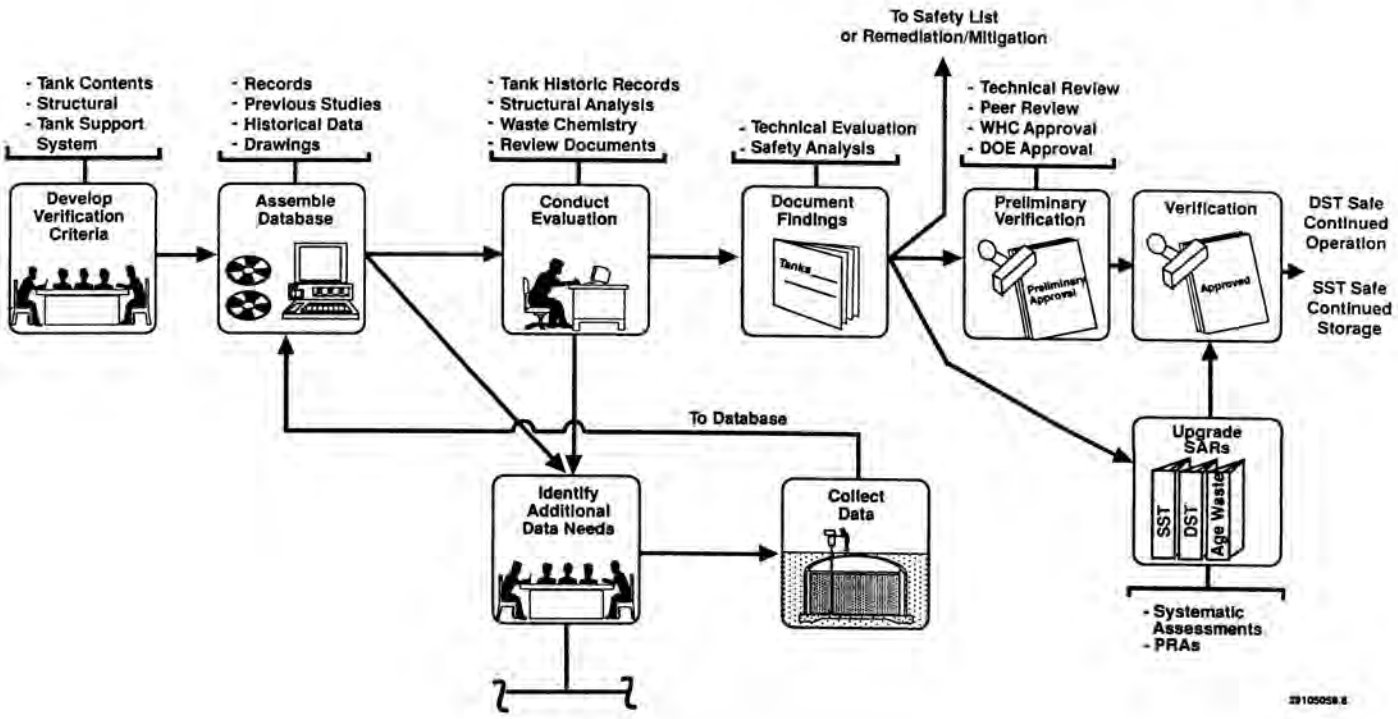

Fig. 6. Tank safety verification.