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**Structural Integrity Assessments for the Category C
Liquid Low-Level Waste Tank Systems
at the Oak Ridge National Laboratory**

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Energy Systems Environmental Restoration Program
ORNL Environmental Restoration Program

**Structural Integrity Assessments for the Category C
Liquid Low-Level Waste Tank Systems
at the Oak Ridge National Laboratory**

Date Issued—September 1995

Prepared for
U.S. Department of Energy
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LOCKHEED MARTIN ENERGY SYSTEMS, INC.
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**PART II - STRUCTURAL INTEGRITY ASSESSMENTS FOR THE CATEGORY C
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PART I
SUPPLEMENTAL INFORMATION

SUPPLEMENTAL INFORMATION

Part II provides the Structural Integrity Assessments for the Category C LLLW Tank Systems. These assessments of the structural integrity of the singly contained LLLW tanks and associated piping were conducted in accordance with Section IX.F and Appendix F of the Federal Facility Agreement (FFA). Part II is composed of a section for each of the 14 Category C tank system assessments and provides certification for each tank system component as warranted.

The following provides a summary of the findings of the structural integrity assessments. For the general types of system components which have not been certified, supplemental information is provided which describes the impact of the lack of certification. In addition, further detail is included for the HFIR (High Flux Isotopes Reactor) Tank System.

SUMMARY OF ASSESSMENT FINDINGS

Assessments were performed to determine the structural integrity of 14 tanks and their associated piping. The certifications of each component in the structural integrity assessments were based on the results of leak tests, a review of design drawings, and a qualitative corrosion assessment. A summary of the assessment findings for tanks and pipelines follows.

Tanks

Of the 14 tanks which were assessed, 11 were certified as having sufficient structural integrity to contain liquids up to the maximum levels achieved during leak testing. One tank, Tank F-201, is no longer used and is in the process of being transferred to Category D classification. Two tanks, HFIR and WC-10, did not pass leak tests due to inflows into the respective tanks. A discussion of the HFIR Tank System is included below. Field investigations completed over the last two years indicate that inflows to Tank WC-10 are entering the tank via a gravity drain line and that the source of the inflows appear to be non-LLLW from the Isotopes Circle area.

The certification statement for each tank that routinely passed monthly leak testing addresses a level up to which the tank has sufficient structural integrity to contain the liquids. This level is based on the highest level at which the tank passed leak testing. Based on an examination of the highest level reached in the tank over the assessment period and the highest level at which the tank passed leak testing, the testing program has been successful at testing at the volumes routinely reached in each tank. Monthly testing will be continued for the Category C tanks during the next annual re-assessment period. The monthly testing will continue to be conducted routinely on the first weekend of each month. Therefore, the tanks will be tested at the liquid level achieved during normal usage. It should be noted that there are safety limits set for each tank which are not exceeded.

Pipelines

There are 91 line segments which were identified as part of the Category C tank systems. Of these 91 line segments, 71 segments are currently in use. These segments in use are approximately

15,803 feet in total length. Of this total length, 76%, or 12,002 feet, was tested and therefore certified. The remaining lines were untestable. The untestable lines were discussed in the Detailed Leak Detection Test Plan and Schedule for Pipelines at ORNL, DOE/OR/01-1167&D2. The pipelines which could not be tested were generally untestable due to one or more of the following circumstances:

1. Line is inaccessible (One end of the line cannot be accessed in order to pump water into the line for a volume balancing test.)
2. Line cannot be isolated (There are no isolation valves at the end of one or more segments of a piping system to permit a gas pressure decay test.)
3. Tank level measurement is inadequate to provide the accuracy and precision needed for an enhanced volume balancing leak test. When this situation has occurred, it has been due to uncontrolled inflows into the tank which prevent a conclusive volume balancing test. However, volume balancing tests were performed (inlet line to Tank WC-10 and inlet line to HFIR Tank) in order to qualitatively assess the line condition.

The untestable pipelines generally include one or more of the following characteristics which indicate a mitigation of the risk of release to the environment or risk to the health and safety of workers or the public:

1. Line is a suction leg (additionally, in cases where there is an associated pump, the pump primes, indicating that the line is intact).
2. Line is not used.
3. Line is fully contained by a vault or runs through a vault for a portion of its length.
4. Line is short (often the untestable line is a segment of line existing between an isolation valve of a testable pipeline and a tank, pump, or steam jet).

The structural integrity assessments for each tank system list all of the line segments associated with each system. The assessment for each tank system discusses whether the lines are used or not, and the tank system diagram and tables provide information on length and type of line.

HFIR TANK SYSTEM

The HFIR Tank is currently used to collect LLLW from the ion exchange columns in the HFIR reactor building during re-generations. The tank also collects filter pit condensate and rain water infiltration into the filter pits. The HFIR Tank is scheduled to go out of service in September 1997. However, the HFIR portion of the Melton Valley LLLW Collection and Transfer Line Item construction project is currently scheduled to be complete by the Second Quarter FY 96. This project will eliminate the primary need for the tank, the drain lines from the filter pit and HFIR building to the tank and the pressurized line from the tank to the Diversion Box at Tanks T-1 and T-2. The filter pit contributes unsteady inflows into the tank and prevents the conclusive testing of the tank and the main portion of the gravity drain line from the building to the tank. The HFIR

system Environmental Safety and Health (ES&H) exemption is discussed in the FFA Plans and Schedules (ES/ER-17&D1). The HFIR cannot be operated without access to the tank system.

HFIR is a primary producer of medical radioisotopes used in diagnosing and treating cancer throughout the United States. Many of these isotopes are short-lived, and continuity of production is vital. For example, HFIR is the sole provider of palladium-103, which is used in the treatment of prostate cancer. Palladium has a half-life of only 17 days, thus production interruptions would severely impact its availability. HFIR is the western world's sole provider of transuranium isotopes, such as californium-252. Used in the treatment of cervical cancer, californium-252 has become an increasingly important medical tool over the last few years.

HFIR is also a key producer of rhenium-188, which is used for radiolabeling antibodies for cancer treatment, and osmium-191/iridium-191m, which is used in evaluating heart disease. Although alternate sources can produce these isotopes, no other reactors can produce them efficiently, and without HFIR, the availability of these isotopes would be severely limited.

In addition to medical radioisotopes, isotopes for safety-related purposes are produced at HFIR. Californium-252 is used as the thermal neutron source in monitors that detect hidden explosives in luggage and packages. These monitors have been installed in several major airports in the United States and in Europe. No direct replacement for the californium source is available. Also, systems designed by Los Alamos National Laboratory for assaying transuranic waste require a californium source. Numerous international research projects depend upon continued availability of the HFIR reactor. These include the Magnetic Fusion Energy Materials Program, a joint United States/Japan project in which the United States has committed to irradiate several experiments. In addition, the United States, together with Japan, Russia, and the European Community, is engaged in a program in which HFIR is used to determine the effects of irradiation on candidate first-wall, shield, and insulator materials for the International Thermonuclear Experimental Reactor. Loss of the HFIR for support of these and other international projects would be costly and could potentially damage United States relations in the international community.

The shutdown of the HFIR would cause greater adverse societal impacts than would the benefits gained from the slightly decreased risk of environmental insult. The HFIR Tank has not been certified because variable inflows prevented successful leak testing, however, there are no indications that there are any outflows from the tank. The leak test on the drain line from the HFIR Building to the tank was inconclusive also due to the variable inflows. The majority of the pressurized discharge piping between HFIR Tank and the Diversion Box at T-1 and T-2 (1947 feet out of 1985 feet) was successfully tested and certified. In addition, there are mitigating features of the piping not tested which lessens the impacts of a potential leak. A discussion of each untested segment follows.

1. Line Segment 38 -- This line segment is the suction piping for Pump A in the HFIR Tank Pump Pit and is 38 feet in length. The pump is capable of being primed prior to transfers indicating that the line is intact. In addition, the line is in the tank or in the concrete vault containing the pumps for approximately 25 feet out of the total pipe length of 38 feet.
2. Line Segment 39 -- This line segment is the suction piping for Pump B in the HFIR Tank Pump Pit and is 38 feet in length. The pump is capable of being primed prior to transfers indicating that the line is intact. In addition, the line is in the tank or in the concrete vault containing the pumps for approximately 25 feet out of the total pipe length of 38 feet.

3. Line Segment 76 -- This line segment is a gravity drain line connecting the filter pit for Building 7920 to the drain line (line segment 75) to the filter pit for the HFIR (Building 7913) and is 20 feet in length. There is no access to either end of the line, rendering the line untestable by the enhanced volume balancing method or the gas pressure decay method.
4. Line Segment 75 -- This line segment is a gravity drain line which connects the Building 7911 Stack to the Filter Pit (Building 7913) and is 22 feet in length. The line is inaccessible at each end, therefore it cannot be tested by the EVB or GPD method.
5. Line Segment 121 and Line Segment 77 -- These line segments are connected in series and form the gravity drain line which connects the Filter Pit (Building 7913) to the HFIR Building and eventually to the HFIR Tank. The lines are 152 feet in length total. The lines are inaccessible and therefore, cannot be tested by the EVB or GPD method.

CONCLUSION

In summary, it is DOE's belief that, with the exception of Tank F-201 which is being transferred to Category D, the structural integrity assessments included in Part II of this document meet the intent of the FFA for allowing Category C tank systems to remain in service.

PART II

**STRUCTURAL INTEGRITY ASSESSMENTS
FOR THE CATEGORY C
LLLW TANK SYSTEMS**

STRUCTURAL INTEGRITY ASSESSMENTS FOR THE CATEGORY C LLLW TANK SYSTEMS

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September 8, 1995

EXECUTIVE SUMMARY

This document provides a report of the efforts made to satisfy the Federal Facility Agreement (FFA) for the structural integrity certification of 14 Category C Liquid Low Level Waste (LLLW) Tank Systems on the Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee.

Within this document, each tank system is described including the associated pipeline segments evaluated as a part of those tank systems. A separate structural integrity assessment was conducted for each of the LLLW Tank Systems, four of which are located in Melton Valley, and ten of which are located in Bethel Valley. The results of the structural integrity assessments are reported herein. The assessments are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and primarily (3) leak testing program results.

Design plans and specifications were reviewed for a general description of the tanks and associated pipelines. Information of primary significance included tank age, material of construction, tank design and construction specifications. Design plans were also reviewed for the layouts and materials of pipeline constructions, and ages of pipelines.

Next, a generic corrosion assessment was conducted for each tank system. Information was gathered, when available, related to the historical use of the tank and the likely contents. The corrosion assessments included a qualitative evaluation of the walls of each tank and pipelines associated with each tank, as well as the welds and joints of the systems. A general discussion of the stainless steel types encountered is included in Section 4.0 of this report. The potential for soils to have caused corrosion is also evaluated within the sections on the individual tank systems.

The final set of information used to certify the tank systems are the results of a leak testing program performed on the tank systems. Category C tanks were tested monthly between December, 1993 and August, 1995. Annual leak testing of pipelines was conducted between December, 1993 and August, 1995. The results of these leak tests are presented in Section 7.0 of this report, in tank-specific subsections of Section 7.0. A discussion of the untestable portion of the lines is included in this section also.

This assessment has determined that all of the tank systems were generally designed and constructed with materials and methods appropriate to their intended usage. With the exception of one tank system, it was determined that corrosion is likely not to be a significant factor in the integrity of the systems. Thirteen of the 14 Category C tanks have been leak tested; one that has not been tested is not being used. Of the 13 that have been tested, eleven routinely pass leak testing and have been certified. Two tanks experience a persistent inflow from nonprogrammatic sources which prevent PASS test results from being achieved. None of the tanks give any indication of an outflow, or leak. Most of the pipelines that require leak testing, and that can be leak tested, have been tested and have been certified.

Certification results for each specific tank system are presented in the tank-specific subsections of Section 7.0. Certification for each specific tank system is provided at the end of each tank section.

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LIST OF ACRONYMS

ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CVR	Compensated volume rate
DOE	Department of Energy
DP	Differential pressure
EPA	Environmental Protection Agency
EVB	Enhanced volume balancing
FFA	Federal Facility Agreement
GPD	Gas pressure decay
H/V	Height to volume
HOG	Hot off-gas
LLLW	Liquid low level waste
MDP	Modified differential pressure
MIC	Microbiologically influenced corrosion
NPS	Nominal pipe size
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
P _D	Probability of detection
P _{FA}	Probability of false alarm
SARA	Superfund Amendment and Reauthorization Act
SCC	Stress corrosion cracking
SIA	Structural integrity assessment
SS	Stainless steel
TDEC	Tennessee Department of Environment and Conservation
UST	Underground Storage Tank
VDP	Volumetric differential pressure methods
WOCC	Waste Operations Control Center

1.0 INTRODUCTION

The active portion of the Oak Ridge National Laboratory (ORNL) Liquid Low Level Waste (LLLW) System, largely designed in the 1950s, consists of 41 tanks with associated pipelines and ancillary equipment such as pumps and valves. The system is distributed between the Bethel Valley and Melton Valley areas of the ORR. These tanks range in capacity from 40 to 50,000 gallons and are used to collect, neutralize, concentrate, and store liquid wastes prior to disposal. The active, singly contained portion of the LLLW system consists of 14 tanks ranging in size from 40 to 15,000 gallons. These tank locations are shown in Figures 1 and 1A.

The Superfund Amendment and Reauthorization Act (SARA) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) required the Department of Energy (DOE) to execute a Federal Facility Agreement (FFA) with the Environmental Protection Agency (EPA) and the Tennessee Department of Environment and Conservation (TDEC) for the ORR.

The FFA distinguishes four categories of tank and pipeline systems:

- New systems (Category A),
- Doubly contained systems (Category B),
- Singly contained systems (Category C), and
- Inactive systems (Category D).

Section IX.F of the FFA specifically requires structural integrity assessments of the Category C LLLW Systems. Results of the structural integrity assessments are to be submitted to the EPA Region IV and the TDEC to enable the continued use of the Category C Tank Systems, until next reassessment or removal from service, in accordance with FFA requirements.

Figure 1A. Melton Valley Category C LLW Tank Systems

2.0 PURPOSE

This report presents the results of a series of evaluations to determine if the individual Category C tank systems retain sufficient structural integrity to continue in use. The approach used to reach the final certification/conclusion consisted of three phases, including:

- Review of the original engineering design drawings and construction materials to determine whether the tank and line systems were capable of containing liquids without leaking (and also to check that the construction materials were compatible with liquids that might have been placed in these systems). While drawings copied here in this report may be of poor quality, they are copies of the best available originals.
- Performance of a qualitative corrosion assessment that further evaluated both the potential internal corrosion effects of materials in the tank and in the potential external corrosion effects of the backfill and native soil at the Oak Ridge National Laboratory (ORNL).
- Performance of monthly leak tests on the tanks and annual leak tests on associated testable pipelines. This task was judged to be the most important criteria for determining structural integrity.

3.0 DESIGN DRAWING EVALUATION

Available Design drawings and as-built drawings of the tanks were reviewed for the 14 Category C Tanks. In some cases, design drawings were generic for several tanks, and in some cases design drawings and/or as-builts were not available.

The drawings were reviewed for materials of construction, specifications, and any codes that were met by the tanks at the time of installation. Types of welds and the presence or absence of any extra flanges or ports were also noted. The information gained from review of the available drawings was used during the certification process for determining whether the tanks were suitable to contain LLLW at the time of installation, and to note any circumstances which may have contributed to deterioration of a tank's structural integrity.

4.0 GENERAL CORROSION ASSESSMENT OF THE CATEGORY C TANK SYSTEMS

Most of the waste tanks and associated piping at ORNL are constructed of types 347 and 304L stainless steel (SS). Both of these SS alloys nominally contain 18% chromium and 8% nickel and exhibit good corrosion resistance in many environments, particularly oxidizing ones. The corrosion resistance of 347 SS is very similar to that of 304L SS. The carbon content in 347 SS can be as high as 0.08%, whereas in 304L it is a maximum of 0.03%. Both have an austenitic crystal structure and are easy to weld. Type 347 SS is welded with 347 weld rod, and type 304L SS is welded with 308L rod. The compositions of both weld rods are essentially the same as the base metal except that the chromium content is somewhat greater to compensate for chromium vaporization during welding. Generally, the corrosion resistance of the cast weld structure closely matches that of the base metal.

The stainless steels owe their stainless character to the presence of chromium. Depending on the environment, a minimum chromium content of 12 to 14% is required to produce a stainless alloy. In the temperature range of 480 to 870°C (900 to 1600°F), the carbon in stainless steels that is in excess of 0.03% diffuses to grain boundaries, where it is precipitated as chromium carbide. Since the solid state diffusion rate of chromium is much less than carbon, the chromium content in a very thin layer at the edges of the grains is reduced to below the 12 to 14% level, and the metal in that thin layer is no longer a stainless steel. Stainless steel in such a condition is said to be sensitized, and in such conditions corrosion manifests itself by attacking along grain boundaries (intergranular corrosion) in some environments. If the alloy contains sufficient niobium (10 times the carbon content), as in 347 SS, niobium carbide forms in preference to chromium carbide. The edges of the grains retain their chromium and the alloy is not subject to intergranular attack. Because of the niobium addition, 347 SS is said to be stabilized; 304L SS is stabilized by virtue of its low carbon content.

4.1 Corrosion by Waste Solutions

The ORNL waste solutions have varied compositions, and under some conditions may be highly corrosive to stainless steels. The corrosiveness of these solutions can be greatly reduced by adding caustic to make the solutions alkaline so that the pH is 13 to 14. This is the current and past practice for most of the ORNL tanks, but there were unspecified periods when caustic was not added.

Corrosion failures seldom occur because of uniform attack (general wall thinning) but are much more likely to result from some form of localized attack. Several localized failure modes are briefly discussed below. None of these forms of attack are likely to occur if the solution pH is high; however, during periods when caustic was not added in the past or if the tank solutions are allowed to become only slightly alkaline or acidic in the future, localized attack may result. For the storage tanks, it is assumed that the temperature has never exceeded 25°C (77°F), that the concentration of radiolysis products in solution is insufficient to influence corrosion reactions, and that the solution composition is uniform throughout the tank.

4.1.1 Stress Corrosion Cracking (SCC)

Austenitic stainless steels under tensile stress are susceptible to stress corrosion cracking (SCC) in the presence of chloride ions, but the minimum temperature required for cracking to occur is 50 to 60°C (122 to 140°F), well above the assumed maximum temperature of the waste systems. Other agents can also produce SCC in stainless steel (e.g., caustic solutions, fluoride ions, and polythionic acids) but these require either higher temperature or fully sensitized microstructures which do not exist in the ORNL waste systems. Consequently, SCC does not represent a potential failure mode for these systems.

4.1.2 Pitting Corrosion

The austenitic stainless steels are subject to pitting in the presence of chloride ions. Under some conditions, chloride ions can initiate very localized corrosion on passive surfaces and at these sites pits may form. Once formed, a pit may continue to grow or spontaneously passivate. For a pit to form and continue to grow, the electrochemical potential of the metal must be above some minimum value which becomes lower as the chloride concentration and temperature increase. In addition, the presence of the other anions in solution inhibits the pitting process [Lechkie 1966]. As an example, the minimum hydroxide ion concentration to prevent pitting of SS in a solution with a given chloride concentration at 25°C (77°F) is given by the following equation:

$$\log[C1^-] = 1.62\log[OH^-] + 1.84$$

Similar relationships are given for other anions.

When a pit develops, the base of the pit is the anode and the surrounding area is the cathode of the corrosion cell. The solution within the pit is significantly different from the bulk solution and has a lower pH than the bulk solution. An active pit usually deepens at an appreciable rate, leading to relatively rapid penetration of vessel walls.

The alkaline solutions that presently exist in most ORNL waste tanks and the expected low chloride concentrations make growth of existing pits or formation of new ones very unlikely. However, if the pH of the solutions is allowed to become only slightly alkaline or acidic, pitting could lead to failure.

4.1.3 Crevice Corrosion

Crevice corrosion may occur under deposits, between metal flanges and in other confined regions where the small volume of solution cannot readily mix with the bulk solution. Crevice corrosion often starts as a differential aeration cell, where corrosion processes consume the dissolved oxygen in the solution within the crevice and the potential of the metal in that region becomes more active than the surfaces outside of the crevice. Thus, an electrochemical cell is formed with the metal in the crevice region serving as anode. Once initiated, pitting and crevice corrosion proceeds by the same mechanism.

Crevice corrosion is very improbable in solutions with pH values of 13, but in only slightly alkaline or acidic solutions it represents a potential failure mode. A properly constructed system, however, without significant solids in the bottom, should provide few locations for crevice corrosion to begin.

4.1.4 Intergranular-Knife Line Attack

Since neither 347 nor 304L SS are subject to chromium carbide grain boundary precipitation, conventional intergranular attack is not to be expected. However, the niobium stabilization of 347 SS produces one detrimental effect during welding that sometimes leads to "knife-line attack" [Shreir 1994, 3:56]. The metal immediately adjoining the fusion zone is subject to very high temperatures during welding, causing precipitated niobium carbide to go into solution. On reheating, as in multipass welding, carbide, possibly containing some chromium, may form. Thus, a very narrow band adjacent to the weld may be susceptible to intergranular attack in some environments. In contrast to knife-line attack, "weld decay" or "heat affected zone" corrosion that results from welding unstabilized SS occurs a slight distance (~2mm) from the weld. In even moderately acidic and in alkaline solutions knife-line attack of 347 SS at 250°C is improbable.

4.1.5 Microbiologically Influenced Corrosion (MIC)

It has only been in the last 10 to 20 years that the influence of microorganisms on corrosion processes has been recognized and understood by most corrosion engineers. There are many different microorganisms that can influence corrosion. Some operate under anaerobic conditions while others thrive in aerated environments. Under favorable conditions doubling times of 60 to 120 minutes are possible, so a small number of microorganisms originally present can form large colonies in relatively short times [Sherier 1994, 2:87-97]. Before MIC can begin, the microorganisms must colonize on a metal surface. Colonization is not possible when the solution flows rapidly past a metal surface; however, metals exposed to slow-moving or stagnant solutions are prime candidates for MIC.

While there is presently no evidence that MIC has been involved in corrosion of either the interior or exterior surfaces of the LLLW waste system, MIC appears possible and needs to be considered a possible failure mechanism in slightly acid, neutral, or slightly alkaline solutions; however, at a pH of 13, MIC is highly improbable.

4.2 Soil Side Corrosion of ORNL Waste Systems

Many of the ORNL waste tanks and essentially all associated piping are buried directly in soil. These tanks and pipes were not coated, nor has cathodic protection been applied on any of the tanks or much of the singly contained piping. Consequently, there is concern about the condition of the SS after more than 40 years in the soil. There are two reports of testing programs and experience at the Savannah River Plant, however, that suggest damage is probably not severe at ORNL.

The most extensive study of SS corrosion by soils was conducted by Romanoff of the National Bureau of Standards [Romanoff]. Pipe sections of 304 SS (0.05 and 0.08% carbon) were buried for up to 14 years in different soils across the United States. Chloride, sulfate, and pH values ranged from zero to 10,000 ppm, 12 to 10,500 ppm, and 4.8 to 9.4 respectively. In all cases uniform attack was negligible and in soils containing low concentrations of chloride and sulfate, such as at ORNL, maximum pit depths were 0.006 in. in 14 years. In a subsequent study, many 304 SS specimens (0.05 and 0.06% C) were exposed in different soils for up to eight years. Only a few very shallow (unmeasured) pits were reported [Gerhold 1981].

There are many underground stainless steel pipelines at the Savannah River Plant that are neither coated nor cathodically protected. These lines were installed in the early 1950s, and as of about four years ago, not a single failure had been observed [Ondrejcin 1991]. On the other hand, underground SS lines at the Hanford Reservation, installed during World War II, began leaking in 1947. Penetrations were caused by localized pitting which was probably initiated by MIC [Bucholz 1960]. Installation of cathodic protection on all buried lines stopped the failures. One major difference between the soils at Hanford and Savannah River (and ORNL) is the porosity. Hanford has an alluvial soil with about 30% porosity, whereas the porosity at Savannah River and ORNL is much less.

In spite of the Hanford experience, the data obtained by Romanoff and the observation at Savannah River, combined with the apparent lack of failure in the ORNL waste system after more than 40 years, implies that SS corrosion by ORNL soils is minimal and is unlikely to contribute significantly to any possible future failures. Evidence to support this theory was found when a section of stainless steel piping installed as a part of the WC-16 system in 1951 was purposely unearthed in May 1995. The section had sustained very little external corrosion or damage and appeared to be structurally sound.

5.0 INTRODUCTION TO LEAK TESTING

The LLLW Tank Systems are comprised of several components, including the tanks and several different types of pipelines. Different types of components, or similar components with significantly different volume capacities or other characteristics, require different leak testing methods. This is a consequence of the existing instrumentation or performance requirements, actual configuration of the system, environmental effects, operational constraints, or a combination of these factors.

The Category C LLLW system can be divided into three distinct types of components: tanks, pressurized pipelines, and gravity-fed pipelines. The pipelines can be further divided according to whether they are capable of being isolated from the remainder of the system (i.e., whether they are valved or unvalved). Each component type and their subdivisions presents distinctly different technical problems for leak testing. Four different release detection methods are commonly used to test underground storage tank systems for leaks. These methods are: volumetric, non-volumetric, inventory control, and leak-effects monitoring. In the first three methods, tests are conducted through measurements made inside the tank or pipeline, while leak-effects monitoring is an external procedure. The sections below provide information about the leak detection methods used for each component type.

The pipelines at ORNL were divided into two classifications based on the mode of transportation of the liquids within the pipelines: pressurized and gravity-fed. None of the gravity-fed lines could be isolated from the remainder of the system, and therefore they could not be pressurized. Enhanced Volume Balancing (EVB) was employed as the test method for these gravity fed lines. This method uses a controlled addition of minimal volumes of water to the line being tested. The pressurized pipelines were tested by a volumetric gas pressure decay (GPD) method (followed by a tracer technique when required). The choice of method for a given line depended upon whether that line could be isolated by means of valves.

The LLLW tanks are tested using another volumetric method. This method precisely measures the change in liquid volume over time. The protocol for using this method is slightly different depending upon the size of the tank; for the larger tanks (over 3,000 gallons in capacity) the volume data is collected over a longer period of time, to improve the precision of the method.

Singly contained tanks with volumes between 3,000 gallons and 15,000 gallons (referred to as large tanks) were tested by a method based upon the differential-pressure sensors, but using a modified test protocol. The large tanks are distinguished from the small tanks by their height-to-volume (H/V) ratios. The tanks considered to be large have H/V ratios in excess of 100 gal/in. (at mid-tank), while the small tanks have H/V ratios significantly less than 100 gal/in. Tank Systems T-1, T-2, HFIR, and WC-20 are classified as large tanks in this report, with the remainder of the 14 tank systems classified as small tanks.

The LLLW tanks are tested monthly, while the pipelines are tested annually. The performance of all of the leak testing methods employed at ORNL has been evaluated, and all meet the basic performance requirements described in the Underground Storage Tank (UST) regulations. The tank methods have been shown to be capable of detecting a leak of 0.2 gal/hr with a probability of detection (PD) of at least 95%, and with a probability of false alarm (PFA) of no more than 5%. The pipeline methods have a performance sufficient to detect leaks that are full-use equivalent to 0.1 gal/hr, with a PD of at least 95% and a PFA of no more than 5%.

As part of the certification process, the leak test methods, protocol, and evaluation procedures and documents were examined for accuracy and applicability to ORNL's LLLW system. These efforts showed that the methods used were consistent with the LLLW components tested, that the methods used were consistent with the evaluation approach, and that leak tests at ORNL were conducted in accordance with the test procedures and protocols appropriate to the method used.

These leak tests resulted in one of several test decisions. A PASS decision indicates that the absolute value of the measured volume rate of the component tested was less than a specified test threshold value. A FAIL decision indicates a negative volume rate that exceeded the threshold, suggesting a leak in the system. An INCONCLUSIVE result indicates that the data quality was too poor to make a decision, or that there were known factors rendering the test unreliable. For the LLLW tanks, two other test decisions are possible, EMPTY and INFLOW. An EMPTY result indicates that the liquid level is at or below the bottom of the dip leg of the level sensor and therefore the liquid level cannot be recorded. An INFLOW result occurs when the measured rate of volume change is greater than expected, suggesting that liquid is flowing into the tank from external sources.

Because the vault sumps in some of the tank pits collect runoff during rainfall events, data collected during rain events during leak tests were analyzed to determine whether rainfall affected the test. Suspected inflows due to rain cause an INCONCLUSIVE or INFLOW test result.

5.1 Leak Testing Methods for Tanks

All Category C tanks were tested using existing liquid level sensors. The existing level sensor, together with temperature measurements of the sensor, is identified as the primary instruments used in the release detection method. To allow cost-effective use of the existing instruments, this method utilized (1) algorithms sufficient to compensate for any environmental effects that might influence the measurements and (2) a leak testing protocol governing the data collection and analysis steps. The LLLW tanks were tested on a monthly schedule; the release detection method was evaluated to ensure detection of a 0.2-gal/hr leak, with a probability of detection (PD) of at least 95% and a probability of false alarm (PFA) of no more than 5%.

The tanks were tested by a method based upon differential pressure (DP) measurement of the liquid level in the tank, using an instrument called a DP cell. The DP cell measures liquid level by sensing the head pressure produced by the liquid with respect to the pressure in the vapor space of the tank. As the liquid depth increases, the pressure increases. The output of the DP cell is

proportional to the measured pressure. The liquid level can be determined from a measurement of the output with a calibrated sensor.

As configured at ORNL, the DP cell infers the tank liquid level by measuring the mass of the liquid in a vertical column above the outlet of a bubbler tube that is placed into the tank. In a container with constant cross-sectional area, and where the bubbler tube extends to the bottom of the container, the output of the DP cell is independent of level (volume) changes that result from thermally induced expansion and contraction of the liquid. That is, the DP cell is self-compensating for thermally produced volume changes in the liquid, and eliminates the need to compensate for the liquid volume changes due to temperature fluctuations.

Before a leak test is initiated, it is important to minimize external factors that can affect the test results. Accordingly, the testing protocol begins with a waiting period, during which all tank activity is suspended until after the end of the leak test. During this period, the operators/owners using the tank are asked to suspend additions to and transfers from the tank. In addition, outside activities such as air sparging to clear the level gauge air lines, are also suspended. This waiting period gives the tank and its contents an opportunity to stabilize, thereby maximizing the quality of the leak test data.

After the waiting period, a data collection period is initiated. Tanks with volumes less than 3,000 gallons were tested for one or two consecutive trial periods of 24 hours each. Tanks with volumes between 3,000 and 15,000 gallons were tested for one or two single trial periods of 48 hours each. Data from these trials were used to derive a decision on the leak tests. If the decision is inconclusive or indicates that the tank is empty or experiencing an inflow, another test is scheduled as soon as possible.

5.2 Leak Testing Methods for Pipelines

The gravity-fed pipelines generally transport only small volumes of waste (e.g., fractions of a gallon to a few tens of gallons) at any given time, carrying the liquid from a hot cell to a collection tank. The gravity-fed lines typically contain no liquid other than during a deliberate transfer of waste or when liquids accumulate in low spots at the bottom of a horizontally oriented pipe. Such transfers are infrequent and none of these lines could be isolated from the tank for a pressure test. These lines were tested using a variation of the volume balancing method, in which a known volume of liquid introduced into a pipeline is compared to the volume that actually reaches the collection tank.

The pressurized pipelines generally carry a larger volume than do gravity-fed lines. Some of the pressurized lines could be isolated from their respective tanks by valves and were therefore pressure tested. The remainder of the pressurized lines could not be isolated, due to lack of isolation valves, and were not pressure tested.

5.2.1 Leak Detection Method for Gravity-Fed Pipelines

Gravity-fed pipelines were tested using a variation of the volume balancing method. Traditional volume balancing methods were not used to test gravity lines at ORNL because the lines are used infrequently and tend to dry out between uses (and are likely to be dry before a test). With dry pipes, an unknown portion of an added volume is lost due to "wetting" of the walls of the pipe, and some additional unknown portion can "pool" or accumulate in low spots in the line. Thus, the volume added to the line and the volume received by the tank would generally never balance, and it would not be known if the volume loss was due to wetting and pooling or to a leak in the line. A further difficulty with traditional volume balancing is that it requires that a large volume of liquid be added at the inlet end of the line so that, in the case of a small leak, the observed volume difference will be large enough to be measured accurately with the existing sensors. This creates additional waste liquids that must be processed and is therefore not encouraged.

These problems were addressed at ORNL through a variation on the traditional volume balancing method, in which the *rate of flow* of liquid added at the inlet end of the line is compared to the *rate of flow* of liquid collected in the tank. This is referred to as an "enhanced volume balancing" method, or EVB. Once a steady rate of flow has been established at the inlet and another steady rate of flow is observed in the collection tank, the line has been wetted and low spots have been filled. After known environmental effects have been compensated for, and within the uncertainties of the method, the difference between the flow rate at which liquid is being added to the line and the flow rate being recorded in the tank is a direct measure of the leak rate of the pipeline.

Successful use of the EVB method requires: (1) that the collection tank be nonleaking (so any measured volume rate can be attributed to the pipeline), (2) that the precision of the pump used to add water at the inlet be at least an order of magnitude better than the leak rate to be detected, and (3) that the height-to-volume ratio of the collection tank be known precisely. These requirements are met by (1) ensuring that the collection tank is tight prior to leak testing the pipeline, (2) using a precise and calibrated metering pump, together with a closed loop pump speed controller, and (3) measuring the height-to-volume correction factor as part of the EVB test protocol.

5.2.2 Leak Testing Methods for Pressurized Pipelines

The LLLW pressurized were tested using a gas pressure decay (GPD) method, followed by a helium tracer technique if necessary.

In the GPD test, the pipeline is first drained or purged of liquid and then pressurized with nitrogen (or air) and isolated from the pressure source while the line pressure is monitored and recorded for a specified period of time. After a short waiting period to allow adiabatic effects to subside, the recorded data are processed in such a way that the rate of change of pressure in the line is converted into an equivalent liquid loss rate; the data are then compared to a detection threshold. Within the allowable noise of the method, a pressure drop in the line can be attributable to losses in the line caused by either a "hole" in the line or poorly seated valves that allow the gas to pass through

the internal piping of the valve into the downstream piping. If a GPD test results in a PASS decision, the line is considered tight. If the GPD test results in a FAIL decision, a helium tracer technique is employed so that the failure can either be verified (and the leak located or localized) or the GPD result can be declared a false alarm.

When the helium tracer technique is employed following a GPD test, a helium purge is first used to ensure a 100% helium atmosphere in the pipeline. Following the helium purge, the line is pressurized with helium and continuous pressure is maintained for the duration of the measurement period. After a short waiting period (which allows helium to begin to diffuse upward from the buried line, if a hole in the line exists), a helium detector is walked along the surface of the ground directly above and parallel to the surveyed location of the pipeline. Gas samples are collected at frequent intervals along the line, from small accumulator locations that have been "punched" into the soil (or drilled into the roadway); these data are then recorded. This is repeated so that the helium has sufficient time to reach the surface, even in soils with low permeability.

Successful helium tracing of the pressurized line requires that: (1) the isolation valves can be closed sufficiently to enable pressure buildup, (2) the location of the line be well known, (3) frequent sample intervals are used to maximize the chance of detecting any helium that might be escaping from a hole in the line, and (4) escaping helium remain confined within a few feet laterally of the pipeline. At ORNL, these requirements are met by (1) replacing valves that are not operable, (2) surveying the location of the line from the "as built" drawings, backed up with the line locator measurement, (3) punching or drilling helium accumulator pockets at eight to ten foot intervals along the surveyed location. The fourth requirement should be met because of the expectation that leaking helium will remain within the confines of the pipeline trench.

5.3 Determination of Expected Error Values for the Untestable Pipelines

Although some pipelines in the LLLW system cannot be tested for leaks, a rough assessment of their integrity can be inferred if liquid transfers are made through these lines during the assessment period, and if the volumes "sent" from the sending tank and the volumes "received" by the receiving tank are recorded for each transfer. This assessment can be made by subjecting the difference between the two volumes to an *error analysis* based upon the errors expected to be observed, given the measuring instruments and other factors. The sources of error included in this analysis are: (1) the precision of the level sensor and (2) the accuracy of the measurement, which depends on strapping table error, signal conditioning accuracy, level sensor accuracy, and the influence of temperature changes in the liquid that are not compensated for. The foregoing sources of error are quantified either through estimates provided in the manufacturer's specifications or through analysis of the data. The resulting numbers are then combined statistically to obtain a numerical value for the expected error. The discrepancy between the input and output volumes is considered significant if its absolute value is greater than the expected error. Sources likely to contribute to this error were considered, and are presented in Figure 2.

Precision of the level sensor. The first step is to determine the precision of the level sensor, P_R , for each tank. P_R is based on the noise observed in the data, an example of which is shown in the accompanying figure. The process can be expressed by

$$P_R = \sqrt{(2 * \sigma^2)}$$

where σ is the standard deviation. It is assumed that σ before transfer $\approx \sigma$ after transfer $= \sigma$.

Accuracy of the measurement. The accuracy of the measurement, P_A , is then determined for each tank. There are four components to P_A .

- **S (strapping table error).** $S = 0.5\%$ of full scale, based upon an engineering estimate made from manufacturer specifications.
- **G (Action Pak accuracy).** $G = 0.1\%$ of full scale, based on manufacturer specifications.
- **A (sensor accuracy).** $A = 0.2\%$ of full scale, based on manufacturer specifications for the 823 DP cell.
- **U (uncompensated temperature influence).** $U = 0.1\%$ of full scale, as determined from the data.

The values of S, G, A and U, once calculated, are converted to volume (in gallons) based on the height-to-volume ratios at the two levels (before and after a transfer). In the horizontal tanks, P_A may vary between transfers due to the fact that a tank's height-to-volume ratio can vary according to the level of liquid. The numbers are then combined statistically, according to

$$P_A = (1/3) \sqrt{S_{level\ 1}^2 + G_{level\ 1}^2 + A_{level\ 1}^2 + U_{level\ 1}^2 + S_{level\ 2}^2 + G_{level\ 2}^2 + A_{level\ 2}^2 + U_{level\ 2}^2}$$

(These are all 3σ numbers, so the $1/3$ factor converts each to a 1σ number.)

When the errors from all the above sources have been considered, the error for an individual tank, P (a 1σ number), can be determined. Since the P_A values are all given as a percent of full scale, they are dependent on the volume transferred:

$$P = \sqrt{2 * (P_R)^2 + \left(\frac{V_T}{V_{FS}}\right)^2 * (P_A^2 - P_R^2)}$$

where V_T is the volume transferred and V_{FS} is the total volume capacity of the tank. In this scenario, as one approaches zero volume transferred,

$$P \rightarrow \sqrt{2 * P_R^2}$$

and as one approaches full volume transferred,

$$P \rightarrow \sqrt{P_R^2 + P_A^2}$$

Based on the following equation, the expected error (a 3σ number) can now be calculated for a specific transfer between two tanks:

$$\text{Expected Error} = 3 * \sqrt{P_{tank\ 1}^2 + P_{tank\ 2}^2}$$

Figure 2 Potential Error Sources

6.0 BASIS FOR TANK SYSTEM CERTIFICATION

Tank certification in this effort was based on three specific areas where data were available. Design drawings for each tank system were available for review. A corrosion evaluation of each system provided limited, but useful, information concerning remaining structural integrity. The major data set upon which the structural integrity assessment was based was the leak test information. For example, a leak test with a pass result is sufficient to determine that the remaining structural integrity of the tank is adequate to hold the liquid, at the time of the test.

Line tests provide a similar method by which the remaining integrity of the line can be assessed and a determination made concerning the ability of the line to contain fluid. However, for gravity lines, this certification is valid only up to the flow rate under which the EVB was conducted and for the date and time of testing. GPD testing provides sufficient information to certify the entire pressurized line segment at full capacity for the date and time of testing.

With such a significant reliance on leak detection methods to certify the tank and its ability to successfully retain liquids, it is important that the testing results meet the agreed upon requirements, which have their foundation in 40 CFR Part 280. Included are the requirements of greater than 95% Pd of detecting a leak of 0.2 gal/hr and less than 5% PFA. Results which successfully demonstrate that they meet or exceed these requirements are accepted as a pass and used as a basis for certification of the tank. Certification applies only to that portion of the tank which was wetted during the leak test. This limiting value can either be stated as a depth of liquid in the tank or as a percent of total tank capacity. In many cases each tank has been tested on multiple occasions. The successful test with the greatest depth or percent of total capacity is accepted as the certification limit. If a future leak test is conducted with a greater volume in the tank and the result is pass, certification may be extended to the greater volume upon reevaluation.

A review of the design drawings for each of the tank systems must demonstrate and validate that the tank systems were properly designed to retain the liquid wastes placed in them. Each tank and its associated lines were evaluated. The resultant certification, based on available data, should not be construed as a guarantee that leaks have not occurred in the tank or lines, in the past, nor that they will not leak in the future.

7.0 TANK SYSTEM ASSESSMENTS

This section of the report details the actual leak testing performed, and the corresponding certification results, for each of the 14 Category C LLLW Tank Systems. Throughout this section, individual pipelines are referred to using a unique "line segment number" and "index number". These line segment and index numbers are in accordance with previous numbering in "Detailed Leak Detection Test Plan and Schedule for the Oak Ridge National Laboratory Liquid Low-Level Waste Active Pipelines" [DOE/OR/01-1167&D2]. While each pipeline has a line segment number, only testable lines were assigned index numbers.

7.1 2026A Tank System

The 2026A Tank System is located near the southeast corner of Building 2026 where radioactive materials are analyzed, as shown in Figure 1. The 2026A Tank System receives LLLW from Building 2026 using three gravity-fed lines. The tank discharges to Valve Box VB-1A. The tank system is operational, and there are occasional transfers through the discharge piping. The 2026A Tank System includes Tank 2026A and eight line segments connected to the system. Some associated pipelines are doubly contained, however, since the tank and most lines are singly contained, the system has been classified as Category C.

7.1.1 2026A Tank Description

Tank 2026A, also known as Tank F-401, is a 500-gallon tank located in a concrete vault. The tank is located near the southeast corner of Building 2026. Installed in 1965, 2026A is mounted vertically, supported on a concrete pad conforming to the shape of the flanged dished head. The tank is constructed of Hastelloy "C" SS with an unknown wall thickness and ASME standard 304L SS flanged dished heads. The tank has an outside dia of 48", and a length of 78". The design drawing for Tank 2026A is provided as Figure 3.

The tank is equipped with one 3" dia Schedule 40 nozzle, two 2" dia Schedule 40 SS nozzles, one 1½" dia Schedule 40 SS nozzle, two ¼" dia Schedule 40 NPS nozzles, three ⅜" dia Schedule 40 NPS nozzles, one ½" dia Schedule 40 nozzle, one 1½" dia jet suction nozzle, one 2" dia Schedule 40 overflow nozzle, and one 6" dia Schedule 40 inspection nozzle. The jet suction nozzle is located 8" from the center of the tank, and the inspection nozzle is located 16" from the center of the tank. The remaining nozzles are located around a 19½" radius of the tank center. The overflow nozzle is located on the side of the tank, 5" down from the top. All pipe flanges are beveled welding type.

The tank is located in a concrete vault having outside dimensions of 8'-0" x 8'-0" with 6" walls. The top of the vault contains a removable cone cover used for inspection and maintenance.

Tank 2026A is capable of receiving material from three different lines originating in Building 2026, where analysis of radioactive materials is conducted. A schematic of the tank system and numbered line segments is provided in Figure 4.

SEE DRAWING FOR WELDING

NO.	SERVICE	SIZE & DESCRIPTION
1	2 INLET	2" SCH. 40 PIPE 90
2	1 WASH JET SUCT	1 1/2" SCH. 40 PIPE 90
3	1 OVERFLOW	2" SCH. 40 PIPE 90
4	1 JET SUCT	1 1/2" SCH. 40 PIPE 90
5	1 WIPER NOZZ	6" SCH. 40 / 180° BEND FLG.
6	2 L.S. LEVEL PROBES	1/4" NPS - 2000' COUP.
7	3 OVERFLOW PROBES	1/4" NPS - 2000' COUP.
8	1 INLET	2" SCH. 40 PIPE 90
9	1 B.C.D. VIB. DRAIN	1/2" SCH. 40 PIPE 90

NOTE: ALL MATL. TO BE HASTELLOY "C" EXCEPT TOP HEAD TO BE TYPE 304L ST. STL.

F-401
RCD-WASTE MONITOR TK.
 MATL. - HASTELLOY "C" SHEET 1 OF 1-0"
 1000

Figure 3. 2026A (F-401) Tank Design Drawing

Figure 4. 2026A Tank System

7.1.2 2026A Pipeline Descriptions

Eight line segments make up the portion of the LLLW pipeline system belonging to Tank 2026A. Characteristics of these eight lines are listed in Table 1, and line segments are shown in Figure 4. Pipelines associated with the 2026A Tank System are constructed of 304L SS or Hastelloy "C" and were installed in 1965. As shown in Figure 4, 2026A has three pipeline inlets, one discharge pipeline, as well as one gravity-fed overflow line.

The testable pipelines are the three SS gravity-fed lines leading to the tank from Building 2026. The first, Line Segment 67, is a 55' long section of 2" dia pipe (node 5 to node 6 in Figure 4). The second, Line Segment 69, is a 90' long section of 2" dia pipe (node 3 to node 4). The third gravity-fed inlet, Line Segment 65, is 308' long with a 3" dia (node 1 to node 2).

The 2026A discharge and overflow line could not be tested due to a lack of physical access and a lack of isolation valves. This untestable line is separated into two elements. The first is a 15' long element that includes a vertical suction line serving the steam-jet transfer pump and a return segment that appears to drain from a tank overflow into the outlet piping. This element is comprised of three individual segments: Line Segment 188 (node 7 to node 8); Line Segment 184 (node 8 to node 9); and Line Segment 174 (node 13 to node 9). The second untestable element is comprised of two serial segments in the transfer line: Line Segment 68 (node 9 to node 10) is 300' long, and Line Segment 66 (node 10 to node 11) is 77' long. Line Segments 184 and 68 are constructed of Hastelloy "C", while all other lines are SS. The type of SS could not be identified.

Table 1 Characteristics of Line Segments Evaluated as a Part of Tank System 2026A

Line Segment	65	67	69	66	68	174	188	184
Node Numbers	1 to 2	5 to 6	3 to 4	10 to 11	9 to 10	13 to 9	7 to 8	8 to 9
Index Number	G25	G24	G23					
Diameter (in)	3	2	2	3	2	2	1	2
Material	SS	SS	SS	SS	Hastelloy C	SS	SS	Hastelloy C
Length (ft)	308	55	90	77	300	5	6	4
Volume (gal)	118	10	16	29	52	1	1	1
Transfer Method	G	G	G	SJ	SJ	G	SJ Suct.	SJ
Install Date	1965	1965	1965	1965	1965	1965	1965	1965
G Gravity SJ Steam jet pump Suct. Suction SS Stainless Steel								

7.1.3 Corrosion Assessment of the 2026A Tank System

The tank bottom and sides are constructed of Hastelloy C, but the head is constructed of 304L SS. The drain lines from the building to the tank are also Hastelloy "C". Waste solutions contain many different chemicals including acids such as nitric and hydrochloric. When only small volumes of acid are disposed of, they are not neutralized before entering the tank, but relatively large volumes are neutralized before disposal in the tank. A strong caustic solution is added to the tank each time the tank is emptied to keep the pH of the tank solution near 13 at all times.

Hastelloy "C" is an alloy containing about 55% nickel, 15% molybdenum, 15% chromium and lesser amounts of iron and tungsten and has excellent corrosion resistance to room temperature acids and most other chemicals. Thus, even if the waste solutions were not neutralized, very little attack on the Hastelloy "C" would be expected. Since the 304L SS head is above the liquid level, no significant corrosion should occur on it.

There is essentially no corrosion expected on the outside of the tank since it is located in a concrete vault. Similarly, the underground Hastelloy "C" lines should be free of any damaging corrosion.

7.1.4 Results of Leak Tests on the 2026A System

This section summarizes the results of the leak detection tests conducted on the 2026A Tank System. Each element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for tank methods; 0.1 gal/hr for pipeline methods) with a probability of detection (PD) no less than 95% and a probability of false alarm (PFA) no greater than 5%. The method used for each component is shown in Section 7.1.4.3

7.1.4.1 Tank

Leak testing of Tank 2026A began in March 1994, and continued at a minimum monthly interval through January 1995, with a total of 13 leak tests performed on the tank. The results are summarized in Table 2, which shows date of each test, the volume of LLLW in the tank at the time of the test, the percent of Tank 2026A's total volume the test volume represented¹, the test result, and, where appropriate, comments pertinent to particular tests. The table shows that, although one test suffered from data quality problems and resulted in an INCONCLUSIVE test decision, Tank 2026A passed the other 12 leak tests. The maximum capacity for which the tank passed the leak testing was 55.4% of the total tank volume, or 310 gallons.

¹The look up table used by the tank liquid level monitoring system uses a capacity of 560 gallons for Tank 2026A, while the documentation and drawings show a 500 gallon capacity. Since the leak tests are based upon data from the level monitoring system, the percent of capacity here is based on a 560 gallon capacity.

Table 2 Summary of Leak Tests Conducted on Tank 2026A

Date	# of Gallons	% Capacity	Test Result	Comments
3/4/94	191	34.0	PASS	No comment
3/11/94	200	35.7	INCONCLUSIVE	High noise in data
4/1/94	235	42.0	PASS	No comment
5/6/94	275	49.1	PASS	No comment
6/3/94	280	50.0	PASS	No comment
7/1/94	310	55.4	PASS	No comment
8/5/94	59	10.5	PASS	No comment
9/2/94	74	13.2	PASS	No comment
9/30/94	85	15.2	PASS	No comment
10/7/94	96	17.1	PASS	No comment
11/4/94	103	18.4	PASS	No comment
12/2/94	123	22.0	PASS	No comment
1/6/95	132	23.5	PASS	No comment

The compensated volume rate (CVR) data from these leak tests was analyzed to (1) to verify that the test method was performing properly in this application and (2) to confirm that during this assessment period the leak testing process had remained stable; that is, that the performance of the method as applied to this particular tank was not deteriorating. This analysis included a comparison of the 2026A CVRs with the test results originally used to evaluate the performance of the test method, as well as other statistical tests. This analysis, described below, showed that the data obtained from 2026A are consistent with the results of the performance evaluation. The analysis also showed that the leak testing process remained stable during the assessment period.

7.1.4.2 Pipelines

The results of the leak detection tests on the testable 2026A pipelines are summarized in Section 7.1.4.2.1. An assessment of the 2026A pipelines that cannot be tested for leaks with existing approved methods is summarized in Section 7.1.4.2.2.

7.1.4.2.1 Testable Pipelines

The testable portion of the 2026A Tank System consists of the three gravity-fed inlet lines from Building 2026 to Tank 2026A (see Figure 4). All three of the lines were tested in February 1995. Table 3 summarizes these results, describing each line in terms of its index number (which defines the testable element or component), the line segment numbers which make up each testable element, the test date, the test result, and any relevant comments. Two of the lines passed the leak

test and are thus considered free of leaks. The third line (index number G23) generated an INCONCLUSIVE test result due to a partial blockage that interfered with the free flow of liquid through that line and into the tank. This line will not be reused until the blockage has been removed. At that time, the line would be retested.

Table 3 Summary of Leak Test Results for the 2026A Testable Lines

Index No.	Line Segment	Test Date	Test Result	Comment
G25	65	2/2/95	PASS	No comment
G24	67	2/7/95	PASS	No comment
G23	69	2/9/95	INCONCLUSIVE	Partial line blockage

7.1.4.2.2 Untestable Pipelines

The untestable portion of the 2026A system (Line Segments 66, 68, 174, 184 and 188) is the discharge and overflow line from Tank 2026A to Valve Box 1A. This line carries transfers from Tank 2026A through Valve Box 1A. From Valve Box 1A, LLLW is transferred through Valve Box No.1 to Tank W-22 via doubly contained pipelines. These lines are covered in the Design Demonstrations for Category B Tank Systems Piping at Oak Ridge National Laboratories, Oak Ridge, Tennessee, DOE/OR/03-1195&D2. The volume in both Tank 2026A and Tank W-22 is measured and recorded by the Waste Operations Control Center (WOCC). Transfer logs show that during the period from January through December 1994 two transfers were made from 2026A to W-22. These transfers are summarized in the first four columns of Table 4. The difference between the volume sent (Column 3) and the volume received (Column 4) for each transfer is shown in Column 5.

Table 4 Summary of Transfers between 2026A and W-22 During 1994

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum Expected Error (Gal)	Is difference greater than expected error?
2/15/94	2026A - W-22	301	401	100	141	No
7/21/94	2026A - W-22	280	352	72	141	No

For the 2026A to W-22 transfers, given the pre-transfer and post-transfer levels of liquid in the two tanks at the time each transfer occurred, the expected error was 141 gallons. Both recorded transfers showed input/output-volume differences less than the maximum expected error; therefore, it is concluded that there were no significant differences during this assessment period.

7.1.4.3 Analysis of Leak Test Data

During the period between March 1994 and January 1995 a total of 13 leak tests were conducted on Tank 2026A. There was one INCONCLUSIVE test decision and 12 PASS decisions. Figure 5 shows a time series plot of the CVR data obtained from each of the 12 usable test results. It is seen that all 12 of the CVR values are well within the decision thresholds and are thus consistent with the PASS results. In addition, with the exception of the first test, the CVRs appear to vary in a stable manner over time and to be more or less randomly scattered about a small positive mean value.

Figure 5 Time Series Plot of Leak Test CVRs from Tank 2026A

In Figure 6, the CVR data obtained from Tank 2026A are compared to the scaled method evaluation data. The smooth curve is a normal probability density function calculated from the mean and standard deviation of the evaluation data, scaled by the appropriate height-to-volume (H/V) ratio. This normal curve indicates that, had the evaluation been performed in a tank the size of 2026A, all of the method error values would lie approximately between -0.02 and +0.02 gal/h. A visual comparison of the normal curve with the superimposed histogram of the 2026A CVR data shows that the latter appears to be well contained within the envelope of the expected-results curve.

Figure 6 A Comparison of 2026A CVRs (Histogram) and Scaled Evaluation CVR Errors (Normal Curve)

An analysis was performed on the 2026A data to determine whether the data shown above was consistent with data expected from a non-leaking tank, with the evaluated performance of a calibrated leak testing method used as the comparator. This analysis examined the distributions of the data. An F-test [Summers, 1977] was performed on the variance of the CVR data to determine whether the spread of the data was consistent with expectations as determined from the evaluation data. Similarly, a Student's T-test [Mendenhall, 1992] was also performed to determine whether the mean of the CVR data was consistent with expectations.

As shown above, there were 12 usable CVR results, having a mean of 0.007 gal/h and a standard deviation of 0.009 gal/h. The statistical tests can be performed using these values, together with the scaled evaluation mean of 0.019 gal/h and standard deviation of 0.022 gal/h. Table 5 summarizes the results of this analysis. Column 1 describes which test is being used, column 2 shows the test statistic, and column 3 shows the test critical value (for a 1% level of significance). The inference drawn from the test is shown in column 4. If the test statistic is greater than the corresponding test critical value, it means that, with only a 1% chance of error, the two data sets are from different variance populations.²

² To the extent that an F-statistic is much smaller than the F-critical value, an inverse F-test (F^{-1}) may be used to show that the test data are from a different population than the evaluation data. In this case, the test data would be interpreted as being significantly better (i.e., less noisy) than the evaluation data; this finding, however, has no value in this analysis and is not considered further.

Table 5 Summary of Statistical Comparisons Between Evaluation and 2026A CVR Data

Test	Test Statistic	Test Critical Value	Inference
F-test	1.51	2.96	Not different
T-test	2.95	3.11	Not different

The results shown in Table 5 show that, at a 1% level of significance, the variance of the 2026A data is no different than the variance of the evaluation data. The T-test also shows that, at a 1% level of significance, the mean of the 2026A data is no different than the mean of the evaluation data. Based upon this analysis, it is concluded that the leak testing process as applied to 2026A is stable and that the leak test data obtained from 2026A are substantially consistent with those expected from a non-leaking tank.

7.1.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines.

Review of the design drawings indicated that the tank was designed in accordance with acceptable practices defined by ASTM and ASME. One concern noted was an abundance of nozzles into the tank that were not connected to pipelines. However, because the unused nozzles are located on the top of the tank, there is no concern that leakage could occur at those location as long as the tank is operating at less than full capacity. The design drawings revealed a sound design of the 2026A Tank.

The corrosion assessment determined that, with the present use of the tank system, all forms of corrosion on the interior walls of the tank and associated piping should be non-existent. Corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. Furthermore, an analysis of the general aspects of corrosion at ORNL revealed that corrosion of SS by ORNL soil is not believed to be severe.

Leak testing of Tank 2026A was completed by the Volumetric DP method in 13 tests. The tank passed 12 of the tests and had INCONCLUSIVE results in one test. The INCONCLUSIVE result was explained by excessive noise in the liquid level measurement device.

Two of three testable line segments passed leak testing by EPA approved methods. The other testable line segment resulted in an INCONCLUSIVE result due to a partial blockage of the line. Although, a limited evaluation of the untestable pipelines can be made using transfer logs, this method of assessment is not deemed valid for certification purposes, because of limited accuracy.

All of these factors were considered in determining certification of the 2026A Tank System components. Table 6 summarizes the elements of the tank system which were certified and the conditional limits on their certifications.

Transfer logs were used to qualitatively assess the pipelines which are untestable by currently approved methods. Transfer logs reveal that two transfers were made, during the period between January 1994 and December 1994. The difference between the measured volume sent from Tank 2026A and the measured volume received in Tank W-22 were less than the maximum expected errors in both of the transfers. The volume of these transfers along with the latest qualitative assessment of the pipelines are reported to EPA and TDEC in the "Quarterly Highlights for LLLW Tank System Activities". The volume of these transfers along with the latest qualitative assessment of the pipelines are reported to EPA and TDEC in the "Quarterly Highlights for LLLW Tank System Activities". Although a limited evaluation of the untestable pipelines can be made using transfer logs, this method is not deemed valid for certification purposes, because of limited accuracy.

Table 6 Summary of 2026A Tank System Testing and Certification

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank 2026A		Yes	DP	PASS	Yes	55.4%
LS-65	308	Yes	EVB	PASS	Yes	32 gph
LS-66	77	No	N/T*	N/A	No	N/A
LS-67	55	Yes	EVB	PASS	Yes	32 gph
LS-68	300	No	N/T*	N/A	No	N/A
LS-69	90	Yes	EVB	INCONCLUSIVE	No	N/A
LS-174	5	No	N/T*	N/A	No	N/A
LS-184	4	No	N/T*	N/A	No	N/A
LS-188	6	No	N/T*	N/A	No	N/A
* Transfer records available DP Differential Pressure EVB Enhanced volume balancing gph Gallons per hour LS Line segment N/T Not testable N/A Not applicable						

7.1.6 Certification

Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that Tank 2026A retains sufficient structural integrity to contain liquids at operating levels up to the maximum level which achieved a PASS during the testing program. Also, based upon the results of the pipeline tests, it is my professional opinion that Line Segments 65 and 67 retain sufficient integrity to contain liquids up to a flow rate of 32 gph. Table 6 provides a summary description of the certifications for the 2026A Tank System. If future testing is conducted at larger pipeline flows and greater tank levels, then certification levels may also increase.

It is recommended that leak detection and line testing using EPA and TDEC approved methods be continued, to support annual certification, until this system has been removed from operation or replaced.

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7.2 F-201 Tank System

The F-201 Tank System is located in the Bethel Valley area in a vault adjacent to Building 3525, as shown in Figure 1. The F-201 system collects cleaning liquids from Building 3525. The tank system is made up of Tank F-201 and two pipeline segments. Because the lines and tank are singly contained, the tank system has been classified as Category C, according to the FFA.

7.2.1 F-201 Tank Description

Tank F-201 is a 40-gallon, singly contained, vertically oriented tank located in a concrete vault adjacent to Building 3525. Installed in 1962, Tank F-201 is mounted vertically on three carbon steel 36" x 2" x 1/4" L legs anchored to 4" x 4" x 3/8" plates. The tank is constructed of 304L rolled SS plate with an unknown wall thickness and ASME standard 304L SST flanged dish heads. The outside dia of the tank is 18", with a length of 36". The operating volume of the tank is 20 gallons. The design drawing of Tank F-201 is provided as Figure 7.

The top of the tank is equipped with six nozzles and one 1" dia nozzle. The six 1 1/2" dia nozzles are located around a 6" radius from the center of the tank and the 1" dia nozzle is located at the center of the tank. All nozzles are constructed of Schedule 40S. Three lifting lugs are positioned symmetrically around the top of the flanged dish head.

The tank is located in a reinforced concrete vault with inside dimensions of 4'-5" x 5'-6" with 12" thick walls. The top of the vault is constructed to receive inwardly stepped plugs used for inspection and maintenance. The floor of the vault is sloped to a 1'-0" x 1'-0" x 1'-0" sump in the southwest corner.

Tank F-201 is capable of receiving material from two sources, each originating in Building 3525. A schematic of the tank system with numbered line segments is shown in Figure 8.

7.2.2 F-201 Pipeline Descriptions

The F-201 pipeline system consists of two gravity-fed inlet lines from Building 3525 to Tank F-201. The first, Line Segment 72 (node 1 to node 2 in Figure 8) is 58' long, 1 1/2" dia, and is constructed of 304L SS. This line originates at four drain headers from a charging area within Building 3525. The second, Line Segment 73 (node 3 to node 4), is 65' long, and is made of 304L SS. Line Segment 73 is connected to off-gas drain pots located inside Building 3525. Characteristics of these two line segments are shown in Table 7. Each of these line segments were untestable due to the lack of accurate liquid level measurement devices in the tank.

Figure 7. F-201 Tank Design Drawing

Figure 8. F-201 Tank System

Table 7 Characteristics of Line Segments Evaluated as a Part of Tank System F-201

Line Segment	72	73
Node Numbers	1 to 2	3 to 4
Index Number		
Diameter (in.)	1.5	1.5
Material	304L	304L
Length (ft)	58	65
Volume (gal.)	6	7
Transfer Method	G	G
Install Date	1962	1962
G Gravity		

7.2.3 Corrosion Assessment of F-201 Tank System

This tank has been on standby since January 1992 and presently contains mostly rain water and possibly some decontamination solution (detergents) and wash water. Originally, this tank served Building 3525 and collected waste solutions from processing irradiated material. Since there was never any effort made to control the pH of the solution at a high value, some significant corrosion damage, particularly pitting and crevice corrosion, may have occurred during its lifetime. During the last three years corrosion damage should not have been very significant even without a high pH, although pitting is possible if even low levels of halide ions are present.

Since the tank is located in a concrete vault, external corrosion is not a concern. Some of the SS piping associated with the tank is buried and is subject to soil-side corrosion. However, from information cited in Section 4, it is unlikely that soil-side corrosion is severe.

7.2.4 Results of Leak Tests on the F-201 System

Due to the lack of liquid level measurement equipment suitable for conducting a leak test on Tank F-201 no leak tests were conducted on this tank system. The unsuitable tank measurement equipment, coupled with a lack of isolation valves in the pipelines, prevented leak testing of both lines associated with Tank F-201.

7.2.4.1 Untestable Pipelines

In the case of the F-201 Tank System, no liquid levels are capable of being recorded and therefore, transfers for this tank system are not recorded by the Waste Operation Control Center (WOCC), and an evaluation of the untestable pipeline segments is not possible.

7.2.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, and (2) a qualitative assessment of corrosion on the tank and pipelines.

Review of the design drawings indicated that the tank was designed in accordance with acceptable practices defined by ASTM and ASME. The design drawings revealed a sound design of the F-201 Tank.

The corrosion assessment determined that with the present use of the tank system, corrosion on the interior walls of the tank and associated piping may be significant. However, corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. Tank F-201 is located within a concrete vault so exterior corrosion should be negligible.

None of the F-201 Tank System components could be tested using current approved methods, therefore no determination could be made of the current structural integrity of the tank and piping.

All of these factors were considered in determining certification of the F-201 Tank System components. Table 8 summarizes the tank system elements which were and were not certified and the conditional limits on their certifications.

Table 8 Summary of F-201 Tank System Testing and Certification

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank F-201		No	N/T	N/A	No	N/A
LS-72	58	No	N/T	N/A	No	N/A
LS-73	65	No	N/T	N/A	No	N/A
EVB Enhanced Volume Balancing gph Gallons Per Hour LS Line Segment N/T Not Testable N/A Not Applicable						

7.2.6 Certification

The F-201 Tank System cannot be certified at this time.

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a Division of Environmental Systems Corporation

7.3 F-501 Tank System

The F-501 Tank System is located just south of Building 3525, as shown in Figure 1. The system collects LLLW from Building 3525 and discharges to Tank W-12. The tank system is made up of Tank F-501 and three pipelines connected to the system. Because the lines and tank do not meet the requirements for secondary containment, the tank system has been given the classification of Category C, according to the FFA.

7.3.1 F-501 Tank Description

Tank F-501 is a 400 gallon tank located in an unlined, reinforced concrete vault. Installed in 1962, Tank F-501 is mounted vertically on four 3" x 3" x 5/16" L legs anchored to the floor of the vault. The tank is constructed of 304L SS and has a wall thickness of 1/4" with ASME standard 304L SS flanged dished heads. The outside dia of the tank is 48" with a length of 46". The working volume of the tank is stated as 192 gallons. The drawing for Tank F-501 is provided as Figure 9.

The tank is equipped with four 1" dia nozzles, two 2" dia nozzles, and one 3" dia flanged on the top of the tank. Six of the nozzles are located around an 18" radius from the center of the tank. The flanged nozzle is located 12" from the center of the tank with a 1" offset from the tank centerline. One 4" dia nozzle is located on the side of the tank, 4 1/2" below the weld of the top flanged dished head. Another 3" dia nozzle is located 6-1/5" below the weld of the top flanged dished head on the opposite side of the tank of the 4" dia nozzle. All nozzles are 304L SS. Two lifting lugs are positioned on opposite edges of the top flanged dish head.

The unlined reinforced concrete vault has an interior dimensions of 7'-6" x 6'-6" and walls 12" thick. The top of the vault is constructed to receive inwardly stepped plugs used to allow inspection and maintenance. The floor of the vault is sloped to a 1'-0" x 1'-0" x 1'-0" sump. The outside of the vault has a membrane waterproofing followed by a 1/2" fiber board to within 4'-0" of the top of the vault.

Tank F-501 is capable of receiving material from two sources. The sources originate in Building 3525 and Tank F-201. The liquids generated in Building 3525 are gravity-fed into Tank F-501. A schematic of the tank system with numbered line segments is shown in Figure 10.

Figure 10. F-501 Tank System

7.3.2 F-501 Pipeline Descriptions

The F-501 system has three pipelines, each of which is made up of multiple line segments. The first pipeline, identified as Index No. G30 (node 12 to node 7 in Figure 10), has 2" and 4" dia segments, and is constructed of 304L SS. This line, made up of two line segments, is a gravity-fed line connecting a cell header in Building 3525 with Tank F-501. The first segment, Line Segment 149, is a 12' long segment that leaves the cell header in Building 3525 as a 2" dia line constructed of 304L SS (node 12 to node 13). The second segment, Line Segment 74, is a 4" dia line, and is 9' long (node 6 to node 7).

The second pipeline is a portion of the transfer line connecting Tank F-201 to Tank F-501. This segment, Line Segment 154, is 18' long, with a 1½" dia, and is constructed of 304L SS. This segment extends from Tank F-201 to the 4" dia segment described above as Line Segment 74 (node 6 to node 7).

The third element of the F-501 Tank System is the matrix of discharge transfer lines leading from Tank F-501 to Tank W-12. This element is comprised of three line segments, all constructed of 304L SS. The first, Line Segment 189 (node 8 to node 9), is 8' long, has a 1" dia. This segment transfers liquid from Tank F-501, via steam jet to Line Segment 61 which leads to Tank W-12. The second, Line Segment 194 (node 10 to node 11), is 7' long, with a 1" dia. Segment 194 also transfers liquids from Tank F-501, via steam jet to Line Segment 61. The third, Line Segment 61 (node 9 to node 2), is 202' long, with a 3" dia. Table 9 contains a summary of the F-501 Tank System pipeline characteristics.

Table 9 Characteristics of Line Segments Evaluated as a Part of Tank System F-501

Line Segment	61	74	149	154	189	194
Node Numbers	9 to 2	6 to 7	12 to 13	6 to 7	8 to 9	10 to 11
Index Number	*	G30	G30		*	•
Diameter (in)	3	4	2	1.5	1	1
Material	304L SS	304L SS	304L SS	304L SS	304L SS	304L SS
Length (ft)	202	9	12	18	8	7
Volume (gal)	78	6	2	2	<1	<1
Transfer Method	SJ	G	G	SJ & SJ Suct.	SJ & SJ Suct.	SJ & SJ Suct.
Install Date	1962	1962	1962	1962	1962	1962
* Transfer records available G Gravity SJ Steam jet pump SS Stainless steel Suct. Suction						

7.3.3 Corrosion Assessment of F-501 Tank System

Tank F-501 is an active tank used to collect liquid waste from Building 3525. Solutions collected in the tank include acids (including HCl and HF), bases, salts, and detergent solutions used for decontamination. No effort is made to maintain the tank solution at a high pH, and the solution may have a high or low pH depending on what was most recently added to the tank.

Because of the unknown and variable composition of the tank solution, pitting and crevice corrosion as well as a high general corrosion rate must be considered possible. It is not possible to estimate the present condition of the tank.

Since the tank is situated in a concrete vault, external corrosion is not a concern. Some of the SS piping is buried and is subject to corrosion by soil. However, based on information cited in Section 4.0, corrosion of SS by ORNL soil is not believed to be severe.

7.3.4 Results of Leak Tests on the F-501 System

This section summarizes the results of the leak detection tests conducted on Tank System F-501. Each element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for tank methods; 0.1 gal/hr for pipeline methods) with a P_D no less than 95% and a P_{FA} no greater than 5%. The method used for each component of the system is shown in Section 7.3.5.

7.3.4.1 Tank

For purposes of this report, leak testing of Tank F-501 was conducted from September 1994 through January 1995, with a total of six tests conducted on the tank. The results are summarized in Table 10, showing the date of each test, the volume in the tank during the test, the percent of the tank's capacity represented by the specified volume³, the test result, and, where appropriate, comments pertinent to particular tests. Table 10 shows that Tank F-501 passed all six tests.

³The look-up table used by the tank liquid level monitoring system uses a capacity of 192 gallons for F-501, while the documentation and drawings show a 400 gallon capacity. Since the leak tests are based upon data from the level monitoring system, the percent of capacity here is based on a 192 gallon capacity.

Table 10 Summary of Leak Tests Conducted on Tank F-501

Date	# of Gallons	% Capacity	Test Result	Comments
9/23/94	76	39.6	PASS	No comment
9/30/94	78	40.6	PASS	No comment
10/7/94	133	69.3	PASS	No comment
11/4/94	34	17.7	PASS	No comment
12/2/94	67	34.9	PASS	No comment
1/6/95	139	72.4	PASS	No comment

The CVR data from these leak tests were analyzed (1) to verify that the test method was performing properly in this application and (2) to confirm that during this assessment period the leak testing process had remained stable; that is, that the performance of the method as applied to this particular tank was not deteriorating. This analysis included a comparison of the F-501 CVRs with the test results originally used to evaluate the performance of the test method, as well as other statistical tests. This analysis, described in Section 7.3.4.3, showed the data obtained from F-501 are consistent with the results of the performance evaluation. The analysis also showed that the leak testing process remained stable during the assessment period.

7.3.4.2 Pipelines

The results of the leak detection tests on the testable F-501 pipelines are summarized in Section 7.3.4.2.1. An assessment of the Tank F-501 pipelines which could not be tested for leaks with existing approved methods is summarized in Section 7.3.4.2.2.

7.3.4.2.1 Testable Pipelines

The testable portion of the F-501 Tank System consists of the gravity-fed inlet line from Building 3525 to Tank F-501 (see Figure 10). This line was tested for leaks in October 1994. Table 11 summarizes the results, describing the line in terms of its line segment, the test date, the test result, and any relevant comments. The line passed the leak test and is thus considered free of leaks at the rate of flow for which the test was conducted.

Table 11 Summary of Leak Test Results for the F-501 Gravity-Fed Line

Index No.	Line Segment	Test Date	Test Result	Comment
G30	74, 149	10/6/94	PASS	No comment

7.3.4.2.2 Untestable Pipelines

The untestable portion of the F-501 Tank System includes a portion of the inlet line leading from Tank F-201 to Tank F-501, and the discharge line leading from Tank F-501 to Tank W-12. No transfer data was available for the F-201 to F-501 inlet line. However, in the case of the F-501 to W-12 discharge line, the volume in both of these tanks is measured and recorded by Waste Operation Control Center (WOCC). Transfer logs show that during the period from November 1994 through December 1994, six transfers were made from F-501 to W-12. These transfers are summarized in the first four columns of Table 12. The difference between the volume sent (Column 3) and the volume received (Column 4) for each transfer is shown in Column 5.

Table 12 Summary of Transfers between F-501 and W-12 Between September 1994 and December 1994

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum Expected Error (Gal)	Is difference greater than expected error?
11/17/94	F-501 to W-12	114	120	6	3	Yes
11/18/94	F-501 to W-12	90	95	5	3	Yes
12/1/94	F-501 to W-12	124	130	6	3	Yes
12/1/94	F-501 to W-12	108	124	16	3	Yes
12/1/94	F-501 to W-12	68	71	3	3	No
12/27/94	F-501 to W-12	88	92	4	3	Yes

For the F-501 to W-12 transfers, given the pre-transfer and post-transfer liquid levels in the two tanks at the time each transfer occurred, the expected error was three gallons. Five recorded transfers showed input/output volume differences greater than the maximum expected error; however, all of the differences were positive indicating that more liquid was measured going into Tank W-12 than was measured leaving Tank F-501. These results suggest numerical errors in the volume balance, or unrecorded flush or prime water that was added to the system. No further investigation of these differences is warranted at this time.

7.3.4.3 Analysis of Leak Testing Data

The six leak tests performed on Tank F-501 all resulted in a PASS decision. Figure 11 shows a time series plot of the CVR data obtained from each test. All of the CVR values are well within the decision thresholds and are thus consistent with the PASS results. In addition, with the exception of the one outlier taken early in the testing program, the CVRs appear to vary in a stable manner over time and to be more or less randomly scattered about zero.

Figure 11 Time Series Plot of Leak Test CVRs from Tank F-501

In Figure 12, the CVR data obtained from Tank F-501 are compared to the scaled method evaluation data. In this figure, the column-like plot is a histogram of the CVR data shown in Figure 11. The smooth curve is a normal probability density function calculated from the mean and standard deviation of the evaluation data, scaled by the height-to-volume ratios of F-501 and the evaluation tanks. As explained in [DOE/OR/01-1167&D2], this allows a direct comparison between tanks. The normal curve indicates that, had the evaluation been performed in a tank the size of F-501, all of the F-501 CVR error values would lie approximately between -0.02 and +0.02 gal/h. A visual comparison of the normal curve with the superimposed histogram of the F-501 CVR data shows that the latter appears to be well contained within the envelope of the expected-results curve.

Figure 12 A Comparison of F-501 CVRs (Histogram) and Scaled Evaluation Data CVR Errors (Normal Curve)

The F-501 data was analyzed to determine whether the data shown above was consistent with data expected from a non-leaking tank, with the evaluated performance of a calibrated leak testing method used as the comparator. This analysis examined the distributions of the data. An F-test [Summers 1977] was performed on the variance of the CVR data to determine whether the spread of the data was consistent with expectations as determined from the evaluation data. Similarly, a Student's T-test [Mendenhall 1992] was also performed to determine whether the mean of the CVR data was consistent with expectations.

The six usable CVR results have a mean of -0.008 gal/h and a standard deviation of 0.009 gal/h. The statistical tests can be performed using these values, together with the scaled evaluation data mean of -0.021 gal/h and standard deviation of 0.024 gal/h. Table 13 summarizes the results of this analysis. In this table, column 1 describes which test is being used, column 2 shows the test statistic, and column 3 shows the test critical value (for a 1% level of significance). The inference drawn from the test is shown in column 4. If the test statistic is greater than the corresponding test critical value, it means that, with only a 1% chance of error, the two data sets are from different variance populations.⁴

⁴ To the extent that an F-statistic is much smaller than the F-critical value, an inverse F-test (F^{-1}) may be used to show that the test data are from a different population than the evaluation data. In this case, the test data would be interpreted as being significantly better (i.e., less noisy) than the evaluation data; this finding, however, has no value in this analysis and is not considered further.

Table 13 Summary of Statistical Comparisons Between Evaluation Data and F-501 CVR Data

Test	Test Statistic	Test Critical Value	Inference
F-test	1.86	4.07	Not different
T-test	-1.97	4.60	Not different

The F-test result in Table 13 shows that, at a 1% level of significance, the variance of the F-501 data is no different than the variance of the evaluation data. The T-test also shows that, at a 1% level of significance, the mean of the F-501 data is no different than the mean of the evaluation data. Based upon this analysis, it is concluded that the leak testing process as applied to F-501 is stable and that the leak test data obtained from F-501 are substantially consistent with the those expected from a non-leaking tank.

7.3.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines.

Review of the design drawings indicated that the tank was designed in accordance with acceptable practices defined by ASTM and ASME. The design drawings revealed a sound design of the F-501 Tank.

The corrosion assessment determined that with the present and past uses of the tank system, all forms of corrosion on the interior walls of the tank and associated piping may be considered possible.

Leak testing of Tank F-501 was completed by the DP method in six tests. The tank passed each of the six tests.

One testable pipeline exists for this tank system (G30). This line passed the EPA approved test method.

Transfer logs were used to qualitatively assess the pipelines which are untestable by currently approved methods. Transfer logs reveal that six transfers were made, during the period between November 1994 and December 1994. The difference between the measured volume sent from Tank F-501 and the measured volume received in Tank W-12 exceeded the maximum expected error in five of the six transfers. However, all of the excessive measured differences were positive, indicating more liquid measured going into Tank W-12 than was measured leaving Tank F-501. The volume of these transfers along with the latest qualitative assessment of the pipelines are reported to EPA and TDEC in the "Quarterly Highlights for LLLW Tank System Activities". Although, a limited

evaluation of the untestable pipelines can be made using transfer logs, this method of assessment is not deemed valid for certification purposes, because of limited accuracy.

All of these factors were considered in determining certification of the F-501 Tank System components. Table 14 summarizes the elements of the tank system which were certified and the conditional limits on their certifications.

Table 14 Summary of F-501 Tank System Testing and Certification

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank F-501		Yes	DP	PASS	Yes	72.4%
LS-61	202	No	N/T*	N/A	No	N/A
LS-74	9	Yes	EVB	PASS	Yes	32 gph
LS-149	12	Yes	EVB	PASS	Yes	32 gph
LS-189	8	No	N/T*	N/A	No	N/A
LS-194	7	No	N/T*	N/A	No	N/A
LS-154	18	No	N/T	N/A	No	N/A
* Transfer records available DP Differential Pressure EVB Enhanced volume balancing gph Gallons per hour LS Line segment N/A Not applicable N/T Not testable						

7.3.6 Certification

Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that Tank F-501 retains sufficient structural integrity to contain liquids at operating levels up to the maximum level which achieved a PASS during the testing program. Also, based upon the results of the pipeline tests, it is my professional opinion that Line Segments 74 and 149 retain sufficient integrity to contain liquids up to a flow rate of 32 gph. Table 14 provides a summary description of the certifications for the F-501 Tank System. If future testing is conducted at larger pipeline flows and greater tank levels, then certification levels may also increase.

It is recommended that leak detection and line testing be continued using EPA and TDEC approved methods, to support annual certification, until this system has been removed from operation or replaced.

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7.4 HFIR Tank System

The HFIR Tank System is located west of the HFIR (Building 7900) as shown in Figure 1A. The tank system is made up of the HFIR Tank and nine line segments connected to the tank. Because the lines and tank are all singly contained, the tank system has been classified as Category C, according to the FFA. This tank system is scheduled to be replaced by the Melton Valley LLLW Collection and Transfer line item construction project, which will be completed in FY96.

7.4.1 HFIR Tank Description

The HFIR Tank is a 13,000 gallon, buried, singly contained tank. Installed in 1961, the HFIR Tank is mounted horizontally and is encased in reinforced concrete. The tank is constructed of SS with an undetermined wall thickness and has dished heads at both ends. The working volume of the tank is recorded by WOCC as 9,148 gallons. The design drawing for the HFIR Tank System is provide as Figure 13.

The tank is equipped with two flanged nozzles and an 18" dia manhole. Both nozzles and the manhole are located on top of the tank aligned along the tank centerline. The manhole contains one 6" dia and two 2" dia nozzles which extend down into the tank. The tank also contains one 6" dia flanged nozzle on the bottom and near the end of the tank. This nozzle has been closed using a 150 pound, 304L SS blind flange.

The tank is located in a earthen pit that is trapezoidal in cross-section. Concrete completely surrounds and covers the tank except for the tip nozzles and manhole. A network of #5 rebar surrounding the tank provides reinforcement. Earth backfill was placed over the concrete. The tank is buried to a depth of 18'-6" to the top of the tank.

The HFIR Tank System is used to collect LLLW from the HFIR reactor in Building 7900, R&D laboratories, the off-gas stack from Building 7911, and filter pit wastes from Buildings 7913 and 7920. A schematic of the tank system with numbered line segments is provided in Figure 14.

7.4.2 HFIR Pipeline Descriptions

There are two testable pipeline elements associated with the HFIR tank system. The first consists of only one segment, Line Segment 60 (node 26 to node 28 in Figure 14). This segment is a 1,947' long, 3" dia, cast iron, pressurized portion of the discharge pipeline connecting the HFIR Tank to the Diversion Box for Tanks T-1 and T-2. The second testable element is a 400' long, gravity-fed pipeline leading from Building 7900 to the HFIR Tank (node 17 to node 21). This element is made up of two line segments. The first segment, identified as Line Segment 78, is a 190', 3" dia cast iron line segment that leads from Building 7900 to a sump containing a 6" dia x 3" dia pipeline reducer (node 17 to node 20 in Figure 14). The second segment, identified as Line Segment 79, is a 210' long, 6" dia SS segment connecting the reducer to the HFIR Tank (node 20 to 21).

Figure 13. Drawing of HFIR Tank Installation

Figure 14. HFIR Tank System

The HFIR Tank System has five pipeline elements that cannot be tested for leaks because they lack physical access. The first two untestable elements are two segments of suction lines connecting the HFIR Tank to the HFIR transfer pumps known as Pump A and Pump B. Each of these line segments are 38' in length, 2" dia, and constructed of SS. These two segments are identified as Line Segments 38 and 39 (node 23 to node 24 and node 23 to node 25, respectively). A third untestable element is made up of two segments, Line Segments 121 (node 16 to node 19) and 77 (node 19 to node 17). This pipeline element is a gravity-fed line leading from the Building 7913 filter pit to Building 7900. This element is a total of 152' long, has a 3" dia, and is made of cast iron. The fourth untestable pipeline, Line Segment 76, (node 14 to node 30) is a portion of the gravity-fed line from the Building 7920 filter pit to the line leading to the Building 7913 Filter Pit. This line segment is 20' long with a 2" dia and is made of cast iron. The fifth untestable pipeline, Line Segment 75 (node 15 to node 18) is a portion of the gravity-fed line from the Building 7911 Stack to the Building 7913 Filter Pit. This line segment is 22' long with a 2" dia, and is made of cast iron. Characteristics of line segments associated with the HFIR Tank are summarized in Table 15.

Table 15 Characteristics of Line Segments Evaluated as a Part of Tank System HFIR

Line Segment	38	39	60	75	76	77	78	79	121
Node Number	23 to 24	23 to 25	26 to 28	15 to 18	14 to 18	18 to 17	17 to 20	20 to 21	16 to 19
Index Number	*	*	P1				G16	G16	
Diameter (in)	2	2	3	3	2	3	3	6	3
Material	304L SS	304L SS	CI	CI	CI	CI	CI	304L SS	CI
Length (ft)	38	38	1,947	22	45	140	190	210	12
Volume (gal)	7	7	748	9	8	54	73	315	5
Transfer Method	CP Suct.	CP Suct.	CP	G	G	G	G	G	G
Install Date	1961	1961	1961	1961	1961	1961	1961	1961	1961
* Transfer records available CI Cast iron CP Centrifugal Pump G Gravity SJ Steam jet pump SS Stainless Steel Suct. Suction									

7.4.3 Corrosion Assessment of the HFIR Tank System

The HFIR tank receives solution from regeneration of ion exchange resins used to purify the HFIR and pool waters as well as small amounts of resin fines. Until 1991, new anion resin was purchased in the chloride form and was converted to the hydroxide form with 5% sodium hydroxide; the cation resin was purchased in the sodium form and was converted to the hydrogen form with 4% nitric acid. Excess sodium hydroxide was always used so that the pH of the liquid added to the tank was 13 or greater and contained sodium nitrate, sodium chloride, small amounts of resin fines and sodium hydroxide. The same procedure was used to regenerate depleted resins, except chloride ions were not present in the waste stream. Since 1991, resins were purchased in the hydrogen and hydroxide forms, and chlorides have not been added to the tank.

One interesting feature of this system is that an underground cast iron pipe line connects the HFIR Tank to the T-1/T-2 diversion box. Cast iron generally has much poorer corrosion resistance to aqueous environments than SS. In highly alkaline solutions, such as the waste solution, corrosion resistance by cast iron should be adequate, but if the pH becomes seven or less, rapid general corrosion would be expected.

Assuming that the tank conditions have always been as described above, attack on the SS tank should be very low even with chloride in solution. During short periods when the solution may have been slightly acid, enough nitrate ions were probably present to prevent any damaging or pitting.

External corrosion of the tank should be minimal. The concrete encasing the tank should not enhance corrosion; in fact, the presence of concrete may actually protect most of the SS surface from soil and ground water and increase the pH of any water that may come in contact with the SS through cracks or pores in the concrete. Underground SS piping in direct contact with the soil is unlikely to have experienced serious corrosion based on information cited in General Aspect of Corrosion at ORNL (Section 4).

7.4.4 Results of Leak Tests on the HFIR System

This section summarizes the results of the leak detection tests conducted on the HFIR Tank System. Each element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for tank methods; 0.1 gal/hr for pipeline methods) with a Pd no less than 95% and a PFA no greater than 5%. The methods used for each element are shown in Section 7.4.5.

7.4.4.1 Tank

Due to the uncontrolled inflows into the HFIR Tank, no tests have been conducted to date. Liquid level data have been collected regularly since February 1994 so that personnel could get an idea of what conditions to expect in this tank prior to actual leak testing. These data show that the HFIR tank has a continuous inflow on the order of 4 gal/h. This inflow is thought to come mainly from a hot-off-gas filter pit. The HFIR tank cannot be conclusively leak tested until this inflow is mitigated.

7.4.4.2 Pipelines

The results of the leak detection tests on the testable HFIR pipelines are summarized in Section 7.4.4.2.1. An assessment of the HFIR pipelines that cannot be tested for leaks with existing approved methods is summarized in Section 7.4.4.2.2

7.4.4.2.1 Testable Pipelines

The testable pipelines in the HFIR System consist of two elements: a pressurized portion of the discharge pipeline connecting the HFIR Tank to the Diversion Box, designated Index Number P1 (Line Segment 60), and a gravity pipeline leading from Building 7900 to the HFIR Tank, designated Index Number G16 (Line Segment 78 and 79). The pressurized line passed leak testing in February 1995. The variable inflow into the HFIR Tank caused an INCONCLUSIVE decision for the leak test conducted on the testable gravity-fed pipeline. Table 16 summarizes these results, showing line segment numbers, test date, test results, and any relevant comments.

Table 16 Summary of Leak Test Results for the HFIR Testable Lines

Index No.	Line Segment	Test Date	Test Result	Comment
P1	60	2/13/95	PASS	No comment
G16	78, 79	6/27/95	INCONCLUSIVE	Variable inflows during EVB test caused one inconclusive test

7.4.4.2.2 Untestable Pipelines

The HFIR Tank System has five untestable pipeline elements associated with the system. Line Segments 38 and 39 are the parallel suction lines connecting the HFIR Tank to the HFIR transfer pumps, Pump A and Pump B. These lines carry transfers from the HFIR Tank to Tanks T-1 or T-2; the volume in these tanks is measured and recorded by Waste Operations Control Center (WOCC). Transfer logs show that during the period from January 1994 through December 1994, 17 transfers were made from the HFIR tank to either T-1 or T-2. These transfers are summarized in the first four columns of Table 17. The difference between the volume sent (Column 3) and the volume received (Column 4) are shown in Column 5.

For the HFIR to T-1/T-2 transfers, given the pre-transfer and post-transfer liquid levels in the tanks during the transfer, the expected errors are shown in Column 6. Fifteen of the 17 recorded HFIR to T-1/T-2 transfers show input-output volume differences greater than the maximum expected error; possible reasons for two of these differences are explained in the transfer logs. Since all but one of these differences are negative, indicating a measured loss of volume, further investigation is warranted. The suspected cause of these significant transfer differences is inaccuracy in the HFIR Tank strapping table, which is used to convert liquid level in the tank to volume.

There is strong evidence that the cause of the transfer differences is something other than a lack of integrity in the suction line. Most of the line (between node 26 and node 28) passed a leak test, leaving only short sections at the HFIR Tank and T-1/T-2 ends in question. Also, if the HFIR suction line lacked integrity, it would most likely not have been possible to prime the pump(s); however, both pumps do prime.⁵ Lastly, an "error sensitivity" analysis suggests that the volume being pumped out of the HFIR Tank is inconsistent with the volume expected to be pumped out, based on a modeled strapping table. That is, the measured volume change with time does not agree with the change that would be determined from the strapping table. Thus, it is likely that the transfer differences are measurement-related, and not related to the integrity of the pipeline.

Table 17 Summary of Transfers Between HFIR and T-1 and T-2 During 1994

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum Expected Error (Gal)	Is Difference Greater than Expected Error?
1/12/94	HFIR to T-2	6636	6284	-352	120	Yes
2/15/94	HFIR to T-1	7086	6846	-240	127	Yes
2/26/94	HFIR to T-1	6360	6363	3	118	No
2/28/94	HFIR to T-2	5160	4970	-190	100	Yes
3/4/94	HFIR to T-2	7311	6937	-374	129	Yes
5/27/94	HFIR to T-2	5093	4813	-280	99	Yes
9/5/94	HFIR to T-2	4320	4180	-140	89	Yes
10/17/94	HFIR to T-2	4539	4892	353	95	Yes
10/27/94	HFIR to T-1	5618	5363	-255	106	Yes
10/27/94	HFIR to T-2	1915	1846	-69	64	Yes
10/27/94	HFIR to T-2	4285	4141	-144	89	Yes
10/28/94	HFIR to T-1	4800	4645	-155	96	Yes
10/28/94	HFIR to T-2	705	800	95	58	Yes
11/10/94	HFIR to T-1	4460	3660	-800	88	See Note 1
11/11/94	HFIR to T-2	1369	1400	31	61	No
11/16/94	HFIR to T-1	4920	1738	-182	97	Yes
12/14/94	HFIR to T-2	4389	3561	-828	87	See Note 1
Note 1) Line was refilled						

⁵ In addition, a lack of integrity in the upper (T-1/T-2) end of the line would have caused the line to drain. There is no time delay, however, between the start of the draw-down at HFIR and the responses at T-1/T-2, which indicates that this line is full when a transfer is initiated. (Several minutes delay would be expected if the line had to be refilled first.)

The third untestable element in the HFIR system is the gravity-fed line from the Building 7911 stack to the filter pit. This line cannot be tested because it cannot be accessed, and its integrity cannot be assessed using transfer records because there are none available.

The fourth untestable element is the gravity-fed line from the Building 7920 filter pit to Building 7913 to the filter pit. Again, this line cannot be tested because it is inaccessible, and its integrity cannot be assessed by means of transfer records because there are none available.

The fifth untestable pipeline in the HFIR System is a portion of the gravity-fed line from the Building 7913 filter pit to the HFIR Building 7900. Again, this line cannot be tested because there is no access, and its integrity cannot be assessed using transfer records because there are none available.

7.4.4.3 Analysis of Leak Test Data

An analysis of the HFIR Tank monthly leak test data was not conducted due to the lack of test data.

7.4.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines. The design drawings revealed a sound design of the HFIR tank.

During the corrosion assessment it was determined that with the present use of the tank system, all forms of corrosion on the interior walls of the tank and associated piping should be non-existent. Corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. Furthermore, an analysis of the general aspects of corrosion at ORNL revealed that corrosion of SS by ORNL soil is not believed to be severe.

Leak testing of the HFIR Tank was not completed due to the inflow present in the tank.

One of the testable line segments passed leak testing by one of the methods discussed previously. The other testable line segments did not pass the volume balancing leak test due to uncontrolled inflows into the HFIR Tank.

Transfer logs were used to qualitatively assess the pipelines which are untestable by currently approved methods. Transfer logs reveal that of 17 transfers made, 15 show input/output volume differences greater than the expected measurement errors. The suspected cause of these differences is inaccuracy in the HFIR Tank strapping table, which is used to convert liquid level in the tank to volume. The volume of these transfers along with the latest qualitative assessment of the pipelines are reported to EPA and TDEC in the "Quarterly Highlights for LLLW Tank System Activities". Although a limited evaluation of the untestable pipelines can be made using transfer logs, this method of assessment, due to its limited accuracy, is not deemed valid for certification purposes.

All of these factors were considered in determining certification of the HFIR Tank System components. Table 18 summarizes the elements of the tank system which were certified and the conditional limits on their certifications.

Table 18 Summary of HFIR Tank System Testing and Certification

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank HFIR		No	N/T	N/A	No	N/A
LS-38	38	No	N/T*	N/A	No	N/A
LS-39	38	No	N/T*	N/A	No	N/A
LS-60	1947	Yes	GPD	PASS	Yes	Full flow
S-75	22	No	N/T	N/A	No	N/A
LS-76	45	No	N/T	N/A	No	N/A
LS-77	140	No	N/T	N/A	No	N/A
LS-78	190	Yes	EVB	INC	No	N/A
LS-79	210	Yes	EVB	INC	No	N/A
LS-121	12	No	N/T	N/A	No	N/A
* Transfer records available EVB Enhanced volume balancing GPD Gas pressure decay INC Inconclusive LS Line segment N/T Not testable N/A Not applicable VDP Volumetric DP Methods						

7.4.6 Certification

The HFIR Tank cannot be certified at this time. Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that Line Segment 60 retains sufficient integrity to contain liquids up to the full flow potential of this line segment. Table 18 provides a summary description of the certifications for the HFIR Tank System.

It is recommended that line testing be continued using EPA and TDEC approved methods, to support annual certification, until this system has been removed from operation or replaced.

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7.5 T-1 Tank System

The T-1 Tank System is located near Building 7567 as shown in Figure 1A. The T-1 Tank System collects LLLW from the HFIR Tank prior to transferring it to the Evaporator Complex in Bethel Valley. The system is made up of Tank T-1 and two pipeline segments connected to the system. Because the lines and tank are all singly contained, the tank system has been classified as Category C, according to the FFA.

7.5.1 T-1 Tank Description

Tank T-1 is a 15,000 gallon, buried, singly contained tank. The tank is constructed of 304L SS and has a wall thickness of $\frac{1}{4}$ " with ASME standard $\frac{3}{8}$ " thick 304L SS flanged dished heads. The outside dia of the tank is 10'-0" with a total length of 27'-5".

Installed in 1963, T-1 is mounted horizontally on two reinforced concrete 3'-6" pillars, anchored to 12'-0" x 7'-0" x 2'-0" footings. Tank T-1 has a $3\frac{1}{4}$ " x $\frac{1}{4}$ " 304L SS strap over the top, bolted to a $1\frac{1}{4}$ " dia 304L SS anchor cast into the concrete supports.

Tank T-1 is contained in an earthen pit, along with Tank T-2. The pit has bottom dimensions of 34'-0" x 29'-0". The long axis of the tanks are parallel to the shorter bottom dimension of the pit. The tanks are separated by a reinforced concrete wall 37'-0" x 9'-0" x 1'-0" supported on a continuous 3'-0" x 1'-0" footing. On either side of the concrete dividing wall and supported by the wall footing is a dry well constructed of 12" dia vitrified clay pipe extending vertically to the surface. The pit is backfilled with 1" dia gravel to centerline of the tanks. A layer of polyethylene covers the gravel, with the remaining pit volume backfilled with earth to an elevation of 6'-6" above the top of the tanks. The design drawings for Tank T-1 are provided as Figure 15 and Figure 15A.

The tank is equipped with nine 2" dia Schedule 40 SS welded nozzles, two 1" dia Schedule 40 SS welded nozzles, one 4" dia Schedule 40 SS welded nozzle, and one 18" dia manhole. All measurements are on centers of the nozzles or the manhole. All materials, fabrication, welding and inspection are in accordance with ORNL specification XSP-56.

Tank T-1 has only one inlet line and one outlet line. Tank T-1 is capable of receiving material from one source, the HFIR Tank. The liquids generated in Building 7900 are transferred directly into the tank identified as HFIR. LLLW is transferred from the HFIR Tank to Tank T-1 prior to being transferred to the Evaporator Complex in Bethel Valley. A schematic of the tank system with numbered line segments is shown in Figure 16.

Figure 16. T-1 Tank System

7.5.2 T-1 Pipeline Descriptions

The T-1 system has two pipeline segments. Line Segment 81 (node 6 to node 7 in Figure 16) is a 28' long, 4" dia, 304L SS section of piping connecting the T1/T2 Diversion Box with Tank T-1. The Line Segment 57 is a singly contained suction pipeline running between Tank T-1 and the Building 7567 Pump House. This segment (node 8 to node 9), is 65' long, with a 2" dia, and is made of 304L SS. Both lines are used regularly, with transfers from the HFIR Tank through the diversion box piping to T-1 and subsequent flow through the suction piping to the Building 7567 transfer pumps. The main section of the transfer line from the HFIR Tank to the diversion box is tested and covered in the structural integrity assessment for the HFIR Tank. The main segment of the transfer line from Building 7567 Pump House to the Evaporation Complex is tested and covered in the structural integrity assessment for Tank WC-20. Table 19 contains a summary of the T-1 Tank System line characteristics.

Table 19 Characteristics of Line Segments Evaluated as a Part of Tank System T-1

Line Segment	81	57
Node Number	6 to 7	8 to 9
Index Number	*	*
Diameter (in)	4	2
Material	304L SS	304L SS
Length (ft)	28	65
Volume (gal)	18	11
Transfer Method	CP and SJ	CP Suct.
Install Date	1963	1963
* Transfer records available CP Centrifugal Pump SJ Steam jet pump SS Stainless Steel Suct. Suction		

7.5.3 Corrosion Assessment of the T-1 Tank System

Since 1976, Tank T-1 has collected only waste from the HFIR Tank, which may include small amounts of liquids from filter pits (rain water). Consequently, the environment in Tank T-1 is essentially the same as in the HFIR Tank: sodium nitrate, sodium hydroxide, traces of radionuclides and a few resin fines, with a pH of about 13. Prior to 1976 Tank T-1 also collected alkaline waste from the Transuranium Processing Facility, but in 1976 Tank WC-20 was placed in service and since then all transuranic wastes have been collected in that tank. All indications are that the liquid environment in Tank T-1 has always been alkaline, and if true, corrosion damage to the interior of the tank should not be very significant.

Tank T-1 and most of its associated piping are buried directly in soil. As with other tank system, SS would be expected to have reasonably good corrosion resistance to soil at ORNL. This system has been underground only since 1963, whereas other SS tanks have been buried in similar soil since 1951 without evidence of leakage.

7.5.4 Results of Leak Tests on the T-1 System

This section summarizes the results of the leak detection tests conducted on Tank System T-1 (the tank and its associated pipelines). Each element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for tank methods; 0.1 gal/hr for pipeline methods) with a Pd no less than 95% and a Pfa no greater than 5%.

7.5.4.1 Tank

Leak testing of Tank T-1 was performed from December 1993 through January 1995, with a total of 14 leak tests conducted. The results are summarized in Table 20, which shows the date of each test, average volume of LLLW in the tank during the test, the percent of Tank T-1's total volume⁶ containing LLLW during the test, the test results, and, where appropriate, comments pertinent to particular tests. The table shows that, although one test suffered from data quality problems and resulted in an inconclusive test decision, Tank T-1 passed the other 13 leak tests. The maximum capacity at which the tank passed the leak testing was 54.9% of the total tank capacity, or 8,258 gallons.

Table 20 Summary of Leak Tests Conducted on Tank T-1

Date	No of Gallons	% Capacity	Test Result	Comments
Dec 1993	2933	19.5	PASS	No comment
Jan 1994	5776	38.4	PASS	No comment
Feb 1994	7761	51.6	PASS	No comment
Mar 1994	8243	54.8	PASS	No comment
Apr 1994	8243	54.8	PASS	No comment
May 1994	8258	54.9	PASS	No comment
Jun 1994	8212	54.6	INCONCLUSIVE	Poor data quality
Jul 1994	7836	52.1	PASS	No comment

⁶The look-up table used by the tank liquid level monitoring systems uses a capacity of 15,041 gallons for T-1, while the documentation and drawings show a 15,000 gallon capacity. Since the leak tests are based upon data from the level monitoring system, the percent of capacity here is based on a 15,041 gallon capacity.

Date	No of Gallons	% Capacity	Test Result	Comments
Aug 1994	7882	52.4	PASS	No comment
Sep 1994	3520	23.4	PASS	No comment
Oct 1994	6392	42.5	PASS	No comment
Nov 1994	6588	43.8	PASS	No comment
Dec 1994	4347	28.9	PASS	No comment
Jan 1995	3595	23.9	PASS	No comment

The CVR data from these leak tests was analyzed (1) to verify that the test method was performing properly, and (2) to confirm that during this assessment period the leak testing process had remained stable; that is, that the performance of the method as applied to this particular tank was not deteriorating. This analysis included a comparison of the T-1 CVRs with the test results originally used to evaluate the performance of the test method, as well as other statistical tests. This analysis, described in Section 7.5.4.3, showed that the data obtained from T-1 are consistent with the results of the performance evaluation. The analysis also showed that the leak testing process remained stable during the assessment period.

7.5.4.2 Pipelines

Neither of the pipelines associated with the T-1 Tank System could be tested, Line Segment 81 because it is not accessible and Line Segment 57 because it contains no isolation valve at the tank. An assessment of the pipelines that could not be tested for leaks with existing approved methods is summarized in Section 7.5.4.2.2.

7.5.4.2.1 Testable Pipelines

Neither of the line segments associated with the T-1 Tank System is capable of being tested.

7.5.4.2.2 Untestable Pipelines

The untestable portion of the T-1 system (Line Segments 81 and 57) consists of the inlet line connecting the HFIR/WC-20 diversion box with Tank T-1, and the suction pipeline between Tank T-1 and the Building 7567 pump house. The untestable inlet line is a part of the transfer line from the HFIR Tank to Tank T-1; the volume in both of these tanks is measured and recorded by Waste Operation Control Center (WOCC). The untestable suction line is a part of the T-1 to W-22 transfer line; the volume in W-22 is also measured and recorded by WOCC. Transfer logs show that during the period from January through December 1994, six transfers were made from HFIR to T-1 and twelve transfers were made from T-1 to W-22. Table 21 summarizes the transfers from HFIR to T-1, and Table 22 summarizes those from T-1 to W-22. The data from the transfer logs are shown in the first four columns of each table. The difference between the volume sent (Column 3) and the

volume received (Column 4) is shown in Column 5. For both the HFIR-to-T-1 and T-1-to-W-22 transfers, given the pre-transfer and post-transfer levels of liquid in the two tanks at the time each transfer occurred, the expected errors are shown in Column 6.

The recorded HFIR-to-T-1 transfers all show input-output volume differences greater than the maximum error expected for each transfer. Since these differences are negative, indicating a measured loss of volume, further investigation is warranted. The suspected cause of the transfer differences is inaccuracy in the HFIR tank strapping table, which is used to convert liquid level in the tank to volume.

Table 21 Summary of Transfers Involving Untestable T-1 Pipelines During 1994 (HFIR to T-1)

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum Expected Error (Gal)	Is Difference Greater than Expected Error?
2/15/94	HFIR to T-1	6636	6284	-352	120	Yes
2/26/94	HFIR to T-1	7086	6846	-240	127	Yes
10/27/94	HFIR to T-1	5618	5363	-255	106	Yes
10/28/94	HFIR to T-1	4800	4645	-155	96	Yes
11/10/94	HFIR to T-1	4460	3660	-800	88	See Note 1
11/16/94	HFIR to T-1	4920	4738	-182	97	Yes
Note 1) Line was refilled						

Table 22 Summary of Transfers Involving Untestable T-1 Pipelines During 1994 (T-1 to W-22)

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum expected Error (Gal)	Is Difference Greater Than Expected Error?
1/11/94	T-1 to W-22	7378	6189	-119	184	No
2/22/94	T-1 to W-22	7953	7953	0	200	No
2/22/94	T-1 to W-22	1387	1387	0	143	No
3/3/94	T-1 to W-22	7370	7280	-90	192	No
10/9/94	T-1 to W-22	5149	6850	1701	180	Yes
10/9/94	T-1 to W-22	1000	1000	0	142	No

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum expected Error (Gal)	Is Difference Greater Than Expected Error?
10/12/94	T-1 to W-22	6558	9104	2546	203	See Note 1
10/27/94	T-1 to W-22	4484	5840	1356	170	Yes
10/29/94	T-1 to W-22	4510	4930	420	164	See Note 2
11/11/94	T-1 to W-22	4055	5080	1025	164	See Note 3
11/12/94	T-1 to W-22	257	1340	1083	142	See Note 1
12/14/95	T-1 to W-22	3391	3844	453	155	See Note 1
Note 1) Line was flushed Note 2) Another transfer was taking place at the same time Note 3) Prime water added						

Seven of the twelve recorded T-1-to-W-22 transfers (Table 22) show input/output volume differences greater than the maximum error expected. Except in two cases, possible reasons for these differences were noted in the transfer logs. All differences were positive, indicating that more liquid was measured going into Tank W-22 than was measured leaving Tank T-1; these results suggest numerical errors in the volume balance, or unrecorded flush or prime water that was added to the system. No further investigation of these differences is warranted at this time.

7.5.4.3 Analysis of Leak Test Data

Tanks T-1 has a capacity of 15,000 gallons. Because T-1 has a much larger height to volume (H/V) factor (at mid-tank level) than the evaluation tanks (164 gal/in vs. 20 gal/in), and because the level measurement precision is directly proportional to H/V, the leak test method used for the smaller tanks had to be modified in order to meet the performance criteria for tanks as large as T-1. So that the leak testing method would meet performance requirements, the length of the analysis period was extended from 24 to 48 hours. In addition, due to the poor quality of the level-measurement data, it was necessary to conduct multiple trials (four or five, on average) each month and then to average the CVRs. The problem responsible for the poor quality of the level data was corrected in the summer of 1994. Since January 1995, the same two-trial test strategy used with other tanks has been applied to T-1, although the 48 hour analysis period has been retained.

During the period between December 1993 and January 1995, a total of 14 leak tests were conducted on Tank T-1. Of these, there were one inconclusive result and 13 PASS results. Figure 17 shows a time series plot of the CVR data obtained from all the tests that resulted in a PASS. The figure shows that all of the CVR values are within the decision thresholds⁷ and are thus consistent with the PASS results. In addition, the CVRs appear to vary in a stable manner over time and to be more or less randomly scattered about a small positive mean value.

Figure 17 Time Series Plot of Leak Test CVRs from Tank T-1

In Figure 18, the CVR data obtained from Tank T-1 are compared to the scaled method evaluation data. The smooth curve is a normal probability density function calculated from the mean and standard deviation of the evaluation data, scaled by the appropriate H/V ratio and also scaled for the improvement provided by the trial-averaging approach discussed above. This normal curve indicates that, had the evaluation been performed in a tank the size of T-1, all of the method error values would lie approximately between -0.15 and +0.15 gal/h. A visual comparison of the normal curve with the superimposed histogram of the T-1 CVR data shows that the latter appears to be contained within the envelope of the expected-results curve. This is to be expected, since the Modified Differential Pressure (MDP) method used on T-1 was designed to have better performance, for a given H/V, than the DP method used on smaller tanks.

⁷ Prior to January 1995, a variable number of trials were required to achieve the requisite performance. Accordingly, the detection threshold was recalculated for each test.

Figure 18 A Comparison of T-1 CVRs (Histogram) and Scaled Evaluation CVR Errors (Normal Curve)

The T-1 data was analyzed to determine whether the data shown were consistent with data expected from a non-leaking tank, using the evaluated performance of a calibrated leak testing method used as the comparator. This analysis examined the distributions of the data. An F-test [Summers 1977] was performed on the variance of the CVR data to determine whether the spread of the data was consistent with expectations as determined from the evaluation data. Similarly, a Student's T-test [Mendenhall 1992] was also performed to determine whether the mean of the CVR data was consistent with expectations.

There were 13 usable CVR results, having a mean of 0.025 gal/h and a standard deviation of 0.037 gal/h. The statistical tests can be performed using these values, together with the scaled evaluation data mean of 0.003 gal/h and standard deviation of 0.005 gal/h. Table 23 summarizes the results of this analysis. Column 1 describes which test is being used, column 2 shows the test statistic, and column 3 shows the test critical value (for a 1% level of significance). The inference drawn from the test is shown in column 4. If the test statistic is greater than the corresponding test critical value, it means that, with only a 1% chance of error, the two data sets are from different variance populations.⁸

⁸ To the extent that an F-statistic is much smaller than the F-critical value, an inverse F-test (F^{-1}) may be used to show that the test data are from a different population than the evaluation data. In this case, the test data would be interpreted as being significantly better (i.e., less noisy) than the evaluation data; this finding, however, has no value in this analysis and is not considered further.

Table 23 Summary of Statistical Comparisons Between Evaluation Data and T-1 CVR Data

Test	Test Statistic	Test Critical Value	Inference
F-test	0.06	2.90	Not different
T-test	2.41	3.06	Not different

The F-test result in Table 23 shows that, at a 1% level of significance, the variance of the T-1 data is no different than the variance of the evaluation data. The T-test also shows that, at a 1% level of significance, the mean of the T-1 data is no different than the mean of the evaluation data. Based upon this analysis, it is concluded that the leak testing process as applied to T-1 is stable and that the leak test data obtained from T-1 are substantially consistent with the those expected from a non-leaking tank.

7.5.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines.

Review of the design drawings indicated that the tank was designed in accordance with acceptable practices defined by ASTM and ASME. One concern noted was an abundance of nozzles into the tank that were not connected to pipelines. However, because the unused nozzles are located on the top of the tank, there is no concern that leakage could occur at those location as long as the tank is operating at less than full capacity. The design drawings revealed a sound design of the T-1 Tank.

The corrosion assessment determined that, with the present use of the tank system, all forms of corrosion on the interior walls of the tank and associated piping should be non-existent. Corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. Furthermore, an analysis of the general aspects of corrosion at ORNL revealed that corrosion of SS by ORNL soil is not believed to be severe.

Leak testing of Tank T-1 was completed by the Modified DP method in 14 tests. The tank passed 13 of the tests and had inconclusive results in one test. The inconclusive result was due to data quality problems associated with the liquid measurement device.

The T-1 Tank System consists of two line segments, neither of which were testable by the current methods. Transfer logs were used to qualitatively assess the pipelines which are untestable by currently approved methods. These transfer logs reveal that 6 transfers were made between HFIR and T-1 and 12 transfers were made between T-1 and Tank W-22. Seven of the transfers between HFIR and T-1 exceeded the maximum expected difference between the recorded volume sent and

the recorded volume received. Two transfers between T-1 and W-22 also exceeded the expected difference. Eight other transfers, to or from Tank T-1, exceed the expected difference but were explainable. It is suspected that the cause of these recorded differences is due to inaccuracy in the strapping tables which are used to convert liquid levels in the tanks to volume. The volume of these transfers along with the latest qualitative assessment of the pipelines are reported to EPA and TDEC in the "Quarterly Highlight for LLLW Tank System Activities". Although a limited evaluation of the untestable pipelines can be made using transfer logs, this method of assessment, due to its limited accuracy, is not deemed valid for certification purposes.

All of these factors were considered in determining certification of the T-1 System components. Table 24 summarizes the elements of the tank systems which were certified and the conditional limits on their certifications.

Table 24 Summary of T-1 Tank System Testing and Certification

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank T-1		Yes	MDP	PASS	Yes	54.9%
LS-57	65	No	N/T*	N/A	No	N/A
LS-81	28	No	N/T*	N/A	No	N/A
* Transfer records available LS Line segment MDP Modified Differential Pressure N/A Not applicable N/T Not testable						

7.5.6 Certification

Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that Tank T-1 retains sufficient structural integrity to contain liquids at operating levels up to the maximum level which achieved a PASS during the testing program. Table 24 provides a summary description of the certifications for the T-1 Tank System. If future testing is conducted at greater tank levels, then certification levels may also increase.

It is recommended that leak detection be continued, to support annual certification, until this system has been removed from operation or replaced.

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7.6 T-2 Tank System

The T-2 Tank System is located near Building 7567 as shown in Figure 1A. Tank System T-2 collects Melton Valley LLLW prior to transferring it to the Evaporator Complex in Bethel Valley. The T-2 Tank System is made up of Tank T-2 and two pipeline segments connected to the system. Because the lines and tank are all singly contained, the tank system has been classified as Category C, according to the FFA.

7.6.1 T-2 Tank Description

Tank T-2 is a 15,000 gallon, buried, singly contained tank. Installed in 1963, T-2 is mounted horizontally on two reinforced concrete 3'-6" pillars, anchored to 12'-0" x 7'-0" x 2'-0" footings. Tank T-2 has a 3¼" x ¼" 304L SS strap over the top bolted to a 1¼" dia 304L SS anchor cast into the concrete supports. The Tank is constructed of 304L SS and has a wall thickness of ¼" with ASME standard ¾" thick 304L SS flanged dished heads. The outside dia of the tank is 10'-0" with a total length of 27'-5". The design drawings for T-2 are given as Figure 19 and Figure 19A.

The Tank is equipped with nine 2" dia Schedule 40 NS SS welded nozzles, two 1" dia Schedule 40 NS SS welded nozzles, one 4" dia Schedule 40 NS SS welded nozzle, and one 18" dia manhole. All measurements are on centers of the nozzle or the manhole. All materials, fabrication, welding and inspection are in accordance with ORNL specification XSP-56.

Tank T-2 is contained in an earthen pit, along with Tank T-1. The pit has bottom dimensions of 34'-0" x 29'-0". The long axis of the tanks are parallel to the shorter bottom dimension of the pit. The tanks are separated by a reinforced concrete wall 37'-0" x 9'-0" x 1'-0" supported on a continuous 3'-0" x 1'-0" footing. On either side of the concrete dividing wall and supported by the wall footing is a dry well constructed of 12" dia vitrified clay pipe extending vertically to the surface. The pit is backfilled with 1" dia gravel to centerline of the tanks. A layer of polyethylene covers the gravel, with the remaining pit volume backfilled with earth to an elevation of 6'-6" above the top of the tanks.

Tank T-2 has only one inlet line and one outlet line. Tank T-2 is capable of receiving material from one source, the HFIR Tank. The liquids generated in Building 7900 are transferred directly into the tank identified as HFIR. LLLW is transferred from the HFIR Tank to Tank T-2 prior to being transferred to the Evaporator Complex in Bethel Valley. A schematic of the tank system with numbered line segments is provided as Figure 20.

Figure 19. Tank T-2 Installation Drawing

Figure 19A. End View of Tank T-2 Installation

Figure 20. T-2 Tank System

7.6.2 T-2 Pipeline Descriptions

The T-2 system has two pipeline segments. One segment is a 28' long, 4" dia, 304L SS section of piping connecting the T1/T2 diversion box with Tank T-2. This line is identified as Line Segment 82 (node 10 to node 11 in Figure 20). The second segment is a singly contained suction pipeline between Tank T-2 and the Building 7567 Pump House. This line, index number 56 (node 12 to node 13), is 46' long, has a 2" dia, and is made of 304L SS. Both of these lines are used regularly, with transfers through the diversion box piping to T-2 and subsequent flow through the suction piping to the Building 7567 transfer pumps. The transfer line from the HFIR Tank to the diversion box is tested and covered in the structural integrity assessment for the HFIR Tank. The main segment of the transfer line from Building 7567 Pump House to the Evaporation Complex is tested and covered in the structural integrity assessment for Tank WC-20. Table 25 contains a summary of the T-2 Tank System line characteristics.

Table 25 Characteristics of Line Segments Evaluated as a Part of Tank System T-2

Line Segment	56	82
Node Numbers	12 to 13	10 to 11
Index Number	*	*
Diameter (in)	2	4
Material	304L SS	304L SS
Length (ft)	46	28
Volume (gal)	8	18
Transfer Method	CP Suct.	CP and SJ
Install Date	1963	1963
* Transfer records available CP Centrifugal Pump SJ Steam jet pump SS Stainless Steel Suct. Suction		

7.6.3 Corrosion Assessment of the T-2 Tank System

Since 1976, Tank T-2 has collected only waste from the HFIR Tank, which may include small amounts of liquids from filter pits (rain water). Consequently, the environment in Tank T-2 is essentially the same as in the HFIR Tank: sodium nitrate, sodium hydroxide, traces of radionuclides and a few resin fines, with a pH of about 13. Prior to 1976 Tank T-2 also collected alkaline waste from the Transuranium Processing Facility, but in 1976 Tank WC-20 was placed in service and since then all transuranic wastes have been collected in that tank. All indications are that the liquid environment in Tank T-2 has always been alkaline, and if true, corrosion damage to the interior of the tank should not be very significant.

Tank T-2 and most of its associated piping are buried directly in soil. As with other tank systems, SS would be expected to have reasonably good corrosion resistance to soil at ORNL. This system has been underground only since 1963, whereas other SS tanks have been buried in similar soil since 1951 without evidence of leakage.

7.6.4 Results of Leak Tests on the T-2 System

This section summarizes the results of the leak detection tests conducted on Tank System T-2 (the tank and its associated pipelines). Each element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for tank methods; 0.1 gal/hr for pipeline methods) with a Pd no less than 95% and a PFA no greater than 5%.

7.6.4.1 Tank

Leak testing of Tank T-2 was performed from December 1993 through January 1995, with a total of 14 leak tests conducted. The results are summarized in Table 26, which shows the date of each test, the average volume of LLLW in the tank during the test, the percent of Tank T-2's total volume⁹ containing LLLW during the test, the test result, and, where appropriate, comments pertinent to particular tests. The table shows that five tests suffered from data quality problems and resulted in inconclusive test decisions, one test resulted in an INFLOW test decision, and the other eight tests resulted in a PASS test decision. The first four inconclusive results, starting in April 1994, occurred because of a deterioration of data quality in the tank's liquid level measurement system. This problem was corrected in July 1994, and the tank passed subsequent leak tests, with one exception in October 1994. The inconclusive result that month was due to frequent transfers that interfered with the leak test. The maximum volume at which Tank T-2 passed a leak test was 47.1% of the total tank capacity, or 7,048 gallons.

Table 26 Summary of Leak Tests Conducted on Tank T-2

Date	# of Gallons	% Capacity	Test Result	Comments
Dec 1993	4272	28.4	INFLOW	No comment
Jan 1994	5430	36.1	PASS	No comment
Feb 1994	3625	24.1	PASS	No comment
Mar 1994	3715	24.7	PASS	No comment
Apr 1994	3625	24.1	INCONCLUSIVE	Poor data quality
May 1994	5144	34.2	INCONCLUSIVE	Poor data quality
Jun 1994	12123	80.6	INCONCLUSIVE	Poor data quality

⁹The look-up table used by the tank liquid level monitoring systems uses a capacity of 15,041 gallons for T1 and T2, while the documentation and drawings show a 15,000 gallon capacity. Since the leak tests are based upon data from the level monitoring system, the percent of capacity here is based on a 15,041 gallon capacity.

Date	# of Gallons	% Capacity	Test Result	Comments
Jul 1994	2068	13.8	INCONCLUSIVE	Poor data quality
Aug 1994	3610	24.0	PASS	No comment
Sep 1994	7084	47.1	PASS	No comment
Oct 1994	6784	45.1	INCONCLUSIVE	Poor data quality
Nov 1994	7024	46.7	PASS	No comment
Dec 1994	4121	27.4	PASS	No comment
Jan 1995	4242	28.2	PASS	No comment

The CVR data from these leak tests were analyzed to (1) verify that the test method was performing properly in this application and (2) confirm that the leak testing process had remained stable during this assessment period; that is, that the performance of the method as applied to this particular tank was not deteriorating. This analysis included a comparison of the T-2 CVRs with the test results originally used to evaluate the performance of the test method, as well as other statistical tests. This analysis, given in Section 7.6.4.3, showed that except for a small positive bias, the data obtained from T-2 are consistent with what would be expected based on the results of the performance evaluation. The small bias is probably due to an instrument calibration error or a weak inflow condition. This bias may have contributed to the one INFLOW result experienced in the initial leak test on T-2. The analysis showed no indication of an outflow. The analysis also showed that the leak testing process remained stable after the data quality problem with the tank's liquid level measurement system was corrected in July 1994.

7.6.4.2 Pipelines

Neither of the pipelines associated with the T-2 Tank System could be tested, Line Segment 82 because it is not accessible and Line Segment 56 because it contains no isolation valve at the tank. An assessment of the pipelines that could not be tested for leaks with existing approved methods is summarized in Section 7.6.4.2.2.

7.6.4.2.1 Testable Pipelines

Neither of the line segments associated with the T-2 Tank System is capable of being tested.

7.6.4.2.2 Untestable Pipelines

The untestable portion of the T-2 system consists of the inlet line connecting the HFIR/WC-20 diversion box with Tank T-2 (Line Segment 82), and the suction pipeline that between Tank T-2 and the Building 7567 pump house (Line Segment 56). The untestable inlet line is a part of the transfer line from the HFIR tank to Tank T-2; the volume in both of these tanks is measured and recorded by the Waste Operations Control Center (WOCC). The untestable suction line is a part of the T-2 to W-22 transfer line; the volume in W-22 is also measured and recorded by WOCC.

Transfer logs show that during the period from January through December 1994, 11 transfers were made from HFIR to T-2 and 16 transfers were made from T-2 to W-22. Table 27 summarizes the transfers from HFIR to T-2, and Table 28 summarizes those from T-2 to W-22. The data from the transfer logs are shown in the first four columns of each table. The difference between the volume sent (Column 3) and the volume received (Column 4) is shown in Column 5. For both the HFIR-to-T-2 and T-2-to-W-22 transfers, given the pre-transfer and post-transfer levels of liquid in the two tanks at the time each transfer occurred, the expected errors are shown in Column 6.

Nine of the eleven recorded HFIR to T-2 transfers (Table 27) show input-output volume differences greater than the maximum error expected for each transfer. In two of these transfers, possible reasons for the differences were noted in the transfer logs. Since most of these differences are negative, indicating a measured loss of volume, further investigation is warranted. The suspected cause of the transfer differences is inaccuracy in the HFIR tank strapping table, which is used to convert liquid level in the tank to volume.

Table 27 Summary of Transfers Involving Untestable T-2 Pipelines During 1994 (HFIR to T-2)

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum Expected Error (Gal)	Is Difference Greater Than Expected Error?
1/12/94	HFIR to T-2	6360	6363	3	118	No
2/28/94	HFIR to T-2	5160	4970	-190	100	Yes
3/4/94	HFIR to T-2	7311	6937	-374	129	Yes
5/27/94	HFIR to T-2	5093	4813	-280	99	Yes
9/5/94	HFIR to T-2	4320	4180	-140	89	Yes
10/17/94	HFIR to T-2	4539	4892	353	95	Yes
10/27/94	HFIR to T-2	1915	1846	-69	64	See Note 1
10/27/94	HFIR to T-2	4285	4141	-144	89	Yes
10/28/94	HFIR to T-2	705	800	95	58	Yes
11/11/94	HFIR to T-2	1369	1400	31	61	No
12/14/94	HFIR to T-2	4389	3561	-828	87	See Note 1
Note 1) Line was refilled						

**Table 28 Summary of Transfers Involving Untestable T-2 Pipelines During 1994
(T-2 to W-22)**

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum Expected Error (Gal)	Is Difference Greater Than Expected Error?
1/21/94	T-2 to W-22	8068	8110	42	202	No
3/4/94	T-2 to W-22	5830	5870	40	175	No
3/7/94	T-2 to W-22	6550	6900	350	185	See Note 1
4/2/94	T-2 to W-22	5359	5357	-2	170	No
4/19/94	T-2 to W-22	9190	9190	0	216	No
6/20/94	T-2 to W-22	9100	10210	1110	224	See Note 1
6/21/94	T-2 to W-22	4456	4456	0	162	No
7/16/94	T-2 to W-22	6103	7590	1487	189	See Note 1
10/27/94	T-2 to W-22	1302	1310	8	143	No
10/29/94	T-2 to W-22	4670	4270	-400	161	See Note 2
11/12/94	T-2 to W-22	2916	3670	754	153	Yes
11/18/94	T-2 to W-22	3300	4510	1210	158	See Note 1
11/19/94	T-2 to W-22	1325	2474	1149	146	See Note 1
12/14/94	T-2 to W-22	1310	1310	0	143	No
12/14/94	T-2 to W-22	3697	3870	173	156	Yes
12/14/94	T-2 to W-22	4876	4876	0	165	No
Note 1) Line was flushed						
Note 2) Another transfer was taking place at the same time						

Eight of the 16 recorded T-2 to W-22 transfers show input/output volume differences that are greater than the maximum error expected. Except in two cases, possible reasons for these differences were noted in the transfer logs. All but one of the differences were positive, indicating that more liquid was measured going into Tank W-22 than was measured leaving Tank T-2; these results suggest numerical errors in the volume balance, or unrecorded flush or prime water that was added to the system. No further investigation of these differences is warranted at this time.

7.6.4.3 Analysis of Leak Test Data

Tank T-2 has a capacity of 15,000 gallons. Because T-2 has a much larger factor H/V (at mid-tank level) than the evaluation tanks (164 gal/inch vs. 20 gal/inch), and because the level measurement precision is directly proportional to H/V, the leak test method used for the smaller tanks had to be modified in order to meet the performance criteria for tanks as large as T-2. The length of the analysis period was extended from 24 to 48 hours so the leak testing method would meet performance requirements. In addition, due to the poor quality of the level-measurement data, it was necessary to conduct multiple trials (four or five, on average) each month and then to average the CVRs. The problem responsible for the poor quality of the level data was corrected in the summer of 1994. Since January 1995, the same two-trial test strategy used with other tanks has been applied to T-2, although the 48 hours analysis period has been retained.

During the period between December 1993 and January 1995, a total of 14 leak tests were conducted on Tank T-2. Of these, there were five inconclusive results, one INFLOW result, and eight PASS results. Figure 21 shows a time series plot of the CVR data obtained from all the tests that resulted in either a PASS or an INFLOW. The figure shows that all but one of the CVR values are within the decision threshold bands¹⁰ and are thus consistent with the PASS results; one CVR exceeded the inflow threshold. In addition, the CVRs appear to vary in a stable manner over time and to be more or less randomly scattered about a positive mean value.

Figure 21 Time Series Plot of Leak Test CVRs from Tank T-2

In Figure 22, the CVR data obtained from Tank T-2 are compared to the scaled method evaluation data. The smooth curve is a normal probability density function calculated from the mean and standard deviation of the evaluation data, scaled by the appropriate H/V ratio, and further scaled to account for the trial-averaging approach described above. This normal curve indicates that, had

¹⁰ Prior to January 1995, a variable number of trials were required to achieve the requisite performance. Accordingly, the detection threshold was recalculated for each test.

the evaluation been performed in a tank the size of T-2, and using the (41/2) trial averaging method, all of the T-2 CVR error values would lie approximately between -0.15 and +0.15 gal/h. A visual comparison of the normal curve with the superimposed histogram of the T-2 CVR data shows that, although the spread of the data is within expectations, there is a positive bias.

An analysis was performed on the T-2 data to determine whether the data shown above were consistent with data expected from a nonleaking tank, using the evaluated performance of a calibrated leak testing method used as the comparator. This analysis examined the distributions of the data. An F-test [Summers 1977] was performed on the variance of the CVR data to determine whether the spread of the data was consistent with expectations as determined from the evaluation data. Similarly, a Student's T-test [Mendenhall 1992] was also performed to determine whether the mean of the CVR data was consistent with expectations.

As shown, there were nine usable CVR results (including the INFLOW result), having a mean of 0.050 gal/h and a standard deviation of 0.034 gal/h. The statistical tests can be performed using these values, together with the scaled evaluation mean of 0.006 gal/h and standard deviation of 0.004 gal/h. Table 29 summarizes the results of this analysis. In this table, column 1 describes which test is being used, column 2 shows the test statistic, and column 3 shows the test critical value (for a 1% level of significance). The inference drawn from the test is shown in column 4. If the test statistic is greater than the corresponding test critical value, it means that, with only a 1% chance of error, the two data sets are from different variance populations.¹¹

Figure 22 A Comparison of T-2 CVRs (Histogram) and Scaled Evaluation CVR Errors (Normal Curve)

¹¹ To the extent that an F-statistic is much smaller than the F-critical value, an inverse F-test (F^{-1}) may be used to show that the test data are from a different population than the evaluation data. In this case, the test data would be interpreted as being significantly better (i.e., less noisy) than the evaluation data; this finding, however, has no value in this analysis and is not considered further.

Table 29 Summary of Statistical Comparisons Between Evaluation and T-2 CVR Data

Test	Test Statistic	Test Critical Value	Inference
F-test	0.05	3.23	Not different
T-test	4.41	3.36	Not different

The F-test result shows that, at a 1% level of significance, the variance of the T-2 data is no different than the variance of the evaluation data. The T-test also shows that, at a 1% level of significance, the mean of the T-2 data is different than the mean of the evaluation data. The reason for this small positive bias is believed to be due to the INFLOW result at the start of the test program for T-2; when the CVR from the December 1993 test is removed from the analysis set, the T-test shows that the mean of the T-2 data and the mean of the scaled evaluation data are not different. Based upon this analysis, it is concluded that the leak testing process as applied to T-2 is stable and that the leak test data obtained from T-2 are substantially consistent with the those expected from a non-leaking tank.

7.6.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines.

Review of the design drawings indicated that the tank was designed in accordance with acceptable practices defined by ASTM and ASME. One concern noted was an abundance of nozzles into the tank which were not connected to pipelines. However, because the unused nozzles are located on the top of the tank, there is no concern that leakage could occur at those locations as long as the tank is operating at less than full capacity. The design drawings revealed a sound design of the T-2 tank.

During the corrosion assessment it was determined that with the present use of the tank system, all forms of corrosion on the interior walls of the tank and associated piping should be non-existent. Corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. Furthermore, an analysis of the general aspects of corrosion at ORNL revealed that corrosion of SS by ORNL soil is not believed to be severe.

Leak testing of Tank T-2 was completed by the Modified DP method in 14 tests. The tank passed eight of the tests and had inconclusive results in five tests. One test resulted in an INFLOW. The inconclusive result was caused by data quality problems associated with the liquid measurement device.

The T-2 Tank System consists of two line segments, neither of which were testable by the current methods. Transfer logs were used to qualitatively assess the pipelines which are untestable by currently approved methods. These transfer logs reveal that 11 transfers were made between HFIR and T-2, and 16 transfers were made between T-2 and Tank W-22. Seven of the transfers between HFIR and T-2 exceeded the maximum expected difference between the recorded volume sent and the recorded volume received. Two transfers between T-2 and W-22 also exceeded the expected difference. Eight other transfers, to or from Tank T-2, exceed the expected difference but were explainable. It is suspected that the cause of these recorded differences is due to inaccuracy in the strapping tables which are used to convert liquid levels in the tanks to volume. The volume of these transfers along with the latest qualitative assessment of the pipelines are reported to EPA and TDEC in the "Quarterly Highlight for LLLW Tank System Activities". Although a limited evaluation of the untestable pipelines can be made using transfer logs, this method of assessment, due to its limited accuracy, is not deemed valid for certification purposes.

All of these factors were considered in determining certification of the T-2 system components. Table 30 summarizes the elements of the tank systems which were certified and the conditional limits on their certifications.

Table 30 Summary of T-2 Tank System Testing and Certification

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank T-2		Yes	MDP	PASS	Yes	47.1%
LS-56	46	No	N/T*	N/A	No	N/A
LS-82	28	No	N/T*	N/A	No	N/A
* Transfer records available LS Line segment MDP Modified Differential Pressure N/A Not applicable N/T Not testable						

7.6.6 Certification

Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that Tank T-2 retains sufficient structural integrity to contain liquids at operating levels up to the maximum level which achieved a PASS during the testing program. Table 30 provides a summary description of the certifications for the T-2 Tank System. If future testing is conducted at larger tank volumes, then certification volumes may also increase.

It is recommended that leak testing using the EPA and TDEC approved methods be continued, to support annual certification, until this system has been removed from operation or replaced.

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7.7 W-16 Tank System

The W-16 Tank System is located near the South Tank Farm, as shown in Figure 1. The tank system previously collected LLLW waste from Building 3026 and discharged these liquids by steam jet to Valve Box 1 at the Central Waste Collection Header. The system is made up of Tank W-16 and nine line segments connected to the tank system. Because the lines and tank are all singly contained, the tank system has been classified as Category C, according to the FFA.

7.7.1 W-16 Tank Description

Tank W-16 is a 1,000 gallon, buried, singly contained tank on a concrete pad. Installed in 1951, Tank W-16 is mounted vertically on $\frac{3}{8}$ " thick SS angle legs welded to the side of the tank near the base and bolted to an 8" thick concrete pad. The tank is constructed of 347 SS and has a wall thickness of $\frac{1}{4}$ ". The outside dia of the tank is 66", with a length of 88". The working volume of the tank is 700 gallons. The drawing for Tank W-16 is provided as Figure 23.

The tank is equipped with ten nozzles and one float gauge on the top of the tank. All the nozzles are located around an unknown radius of the tank center, and the float gauge is located in the center of the tank. Four lifting lugs are positioned symmetrically around the edges near the top of the tank. The tank is located below ground. The excavation pit was backfilled with crushed stone to the top of the tank. A schematic of the tank system with numbered line segments provided as Figure 24.

7.7.2 W-16 Pipeline Descriptions

Nine separate lines make up the portion of the LLLW pipeline system belonging to owner Tank W-16. Characteristics of the nine lines are listed in Table 31, and the line segments are shown in Figure 24. All pipelines associated with the W-16 Tank System are constructed of 347 SS and were installed in 1951.

As shown in Figure 24, W-16 has one inlet, and one discharge pipeline. The remaining eight line segments are not directly connected to Tank W-16.

Line Segment 145 is the pipeline that transports waste into Tank W-16. Segment 145 is a gravity-fed, 3" dia SS line, 200' in length that connects Building 3026D to Tank W-16. The remaining eight pipelines are all components of the tank discharge pipeline system. Segment 163 is a 14' long section of 1" dia suction line leading from the tank to a steam jet. Line Segments 181, 181A, 181B, and 181C are each 4' long sections of 2" dia line that make up a manifold system for the discharge of Tanks W-16, W-17 and W-18 (nodes 4 to 11, 11 to 13, 12 to 13 and 14 to 13 respectfully). The line leaving the discharge manifold, Line Segment 24, is a 55' section of 2" dia line. Each of these lines are pressurized by steam jet, which is used to transfer the liquids.

Figure 23. As-built Drawing of Tank W-16 Installation

Figure 24. W-16 Tank System

Line Segment 24 connects to a pipeline leading from the discharge of Tank WC-19 and continues to Valve Box No. 1 (VB-1). Two segments of 2" dia line make up this pipeline. Segment 25 is 145' long, pressurized line that runs from the WC-19 discharge connection to the connection with Segment 24. Line Segment 26 is a 281' long pressurized line that runs from the Segment 24 connection to VB-1.

Although lines 24, 25, 26, and 181A, 181B and 181C are all designated as Tank W-16 lines, these lines are not isolated from Tank WC-3 and Tank WC-19 discharge piping, all of which are denoted P37. Therefore, these six lines were leak tested with the WC-3 Tank System. The line segments which are part of P37 but defined as part of the W-16 Tank System are shown in Table 31. Leak test results are included in Section 7.7.4.

Table 31 Characteristics of Line Segments Evaluated as a Part of Tank System W-16

Line Segment	24	25	26	145	163	181	181A	181B	181C
Node Numbers	13 to 1	VP 3026 to 1	1 to VB-1	3026 to 2	3 to 4	4 to 11	11 to 13	12 to 13	14 to 13
Index Number	P37	P37	P37	G17			P37	P37	P37
Diameter (in)	2	2	2	3	1	2	2	2	2
Material	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS		347 SS
Length (ft)	55	145	281	200	14	4	4	4	4
Volume (gal)	10	25	49	77	2	1	1	1	1
Transfer Method	SJ	SJ	SJ	G	SJ Suct.	SJ	SJ	SJ	SJ
Install Date	1951	1951	1951	1951	1951	1951	1951	1951	1951
G Gravity S Steam jet pump Suct. Suction SS Stainless Steel									

7.7.3 Corrosion Assessment of the W-16 Tank System

Tank W-16 formerly collected waste from Building 3026D, but the tank has not been used for that purpose since at least 1990. The tank, however, is used as a pass through tank in collecting waste from other tanks so that the solution is changed out at irregular intervals. In all cases, the pH of the tank solution is maintained at about 13, and corrosion damage since at least 1990 should have been very slight. Corrosion damage that may have occurred when the system was used for its intended purpose (radioisotope production and decontamination) cannot be assessed.

Some of the SS piping is buried and is subject to corrosion by soil. However, based on information cited in Section 4.0, corrosion of SS by ORNL soil is not believed to be severe.

7.7.4 Results of Leak Tests on the W-16 System

This section summarizes the results of the leak detection tests conducted on Tank System W-16 (the tank and its associated pipelines). Each element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for tank methods; 0.1 gal/hr for pipeline methods) with a Pd no less than 95% and a PFA no greater than 5%. The test method used for each element are shown in Section 7.7.5.

7.7.4.1 Tank

Leak testing of Tank W-16 began in September 1993. From that time through January 1995, a total of 24 leak tests were conducted on this tank. Table 32 summarizes the results, showing the date of each test, the volume of LLLW in the tank during the test, the percent of Tank W-16's total volume represented by that volume, the test result, and where appropriate, comments pertinent to particular tests. The table shows that, although two tests suffered from data quality problems and resulted in an inconclusive test decision, and eight tests were conducted when the liquid level was below the dip-leg and resulted in an empty test decision, Tank W-16 passed the other 14 leak tests.

Table 32 Summary of Leak Tests Conducted on Tank W-16

Date	# of Gallons	% Capacity	Test Result	Comments
9/3/93	197	17.1	INCONCLUSIVE	Data concentrator/WOCC problem
9/17/93	191	16.7	PASS	No comment
10/1/93	*	*	EMPTY	Liquid level below dip-leg
11/5/93	*	*	EMPTY	Liquid level below dip-leg
11/19/93	*	*	EMPTY	Liquid level below dip-leg
12/3/93	*	*	EMPTY	Liquid level below dip-leg
12/10/93	*	*	EMPTY	Liquid level below dip-leg
1/7/94	33	2.9	PASS	No comment
1/14/94	35	3.1	PASS	No comment
2/4/94	37	3.2	PASS	No comment
3/4/94	*	*	EMPTY	Liquid level below dip-leg
3/11/94	*	*	EMPTY	Liquid level below dip-leg
4/1/94	*	*	EMPTY	Liquid level below dip-leg
5/6/94	116	10.1	PASS	No comment
6/3/94	138	12.0	INCONCLUSIVE	High noise in data

Date	# of Gallons	% Capacity	Test Result	Comments
6/10/94	142	12.4	PASS	No comment
7/1/94	365	31.8	PASS	No comment
8/5/94	382	33.3	PASS	No comment
9/2/94	119	10.4	PASS	No comment
9/30/94	166	14.5	PASS	No comment
10/7/94	160	14.0	PASS	No comment
11/4/94	132	11.5	PASS	No comment
12/2/94	128	11.2	PASS	No comment
1/6/95	122	10.7	PASS	No comment
* Unmeasurable				

The CVR data from these leak tests was analyzed to (1) to verify that the test method was performing properly in this application and (2) to confirm that during this assessment period the leak testing process had itself remained stable; that is, that the performance of the method as applied to this particular tank was not deteriorating. This analysis included a comparison of the W-16 CVRs with the test results originally used to evaluate the performance of the test method, as well as other statistical tests. The results of this analysis, described below, showed that the mean of the data obtained from W-16 are consistent with the results of the performance evaluation. The variance, however, was somewhat greater than expected. It is believed that this result may be related to a seasonal or instrument effect, but is not likely related to tank integrity.

7.7.4.2 Pipelines

The results of the leak detection tests on the testable W-16 pipelines are summarized in Section 7.7.4.2.1. An assessment of the W-16 pipelines that cannot be tested for leaks with existing approved methods is summarized in Section 7.7.4.2.2.

7.7.4.2.1 Testable Pipelines

The first testable pipeline element consists of the gravity-fed line leading from Building 3026D to Tank W-16. This pipeline (G17) is made up of Line Segment 145 (See Figure 24). This pipeline was tested in June 1994, however, results were found to be inconclusive. The line has not been used since 1990 is not scheduled for retesting at this time.

The second testable element associated with the W-16 Tank System is a portion of a testable element associated with Tank System WC-3 (P37). These lines are part of the W-16 discharge system and cannot be isolated from pipelines connecting this discharge system to the WC-3 piping.

This element was tested along with the WC-3 pipeline, however, those segments of the testable line that are associated with W-16 are reported in this section. Table 33 summarizes these results, describing the line in terms of its index number, the test date, the test result, and any relevant comments.

Table 33 Summary of Leak Test Results for the W-16 Testable Line

Index No.	Line Segment	Test Date	Test Results	Comments
P37	24, 25, 26, 181A, 181B, 181C	6/95	PASS	No comment
G17	145	6/94	INCONCLUSIVE	Line not in use, no test rescheduled.

7.7.4.2.2 Untestable Pipelines

The untestable portion of the W-16 System (Line Segments 181 and 163) carries transfers from Tank W-16 through VB-1 to Tank W-22. WOCC transfer records for this system show that during the period from September 1993 through December 1994, no transfers were made from Tank W-16 to Tank W-22. Thus, in the case of the W-16 Tank System, no assessment can be made based on the transfer data.

7.7.4.3 Analysis of Leak Test Data

During the period between September 1993 and January 1995, a total of 24 leak tests were conducted on Tank W-16. Of these, there were two inconclusive results, eight empty results, and 14 PASS results. Figure 25 shows a time series plot of the CVR data obtained from each test that resulted in a PASS. The figure shows that all of the CVR values are within the decision thresholds and are thus consistent with the PASS results. However, although the variation in the data appears to be stable over time, it also appears that there may be a cyclic pattern in the data about a small positive mean value and that the CVRs may not be truly random.

Figure 25 Time Series Plot of Leak Test CVRs from Tank W-16

In Figure 26, the CVR data obtained from Tank W-16 are compared to the scaled method evaluation data. The smooth curve is a normal probability density function calculated from the mean and standard deviation of the evaluation data, scaled by the appropriate H/V ratio. This normal curve indicates that, had the evaluation been performed in a tank the size of W-16, all of the method error values would lie approximately between -0.04 and +0.04 gal/h. A visual comparison of the normal curve with the superimposed histogram of the W-16 CVR data shows that, except for the two outlier results, the latter appears to be roughly centered with, but marginally within, the envelope of the expected-results curve.

Figure 26 A Comparison of W-16 CVRs (Histogram) and Scaled Evaluation CVR Errors (Normal Curve)

The W-16 data was analyzed to determine whether the data shown above was consistent with data expected from a non-leaking tank, with the evaluated performance of a calibrated leak testing method used as the comparator. This analysis examined the distributions of the data. An F-test [Summers, 1977] was performed on the variance of the CVR data to determine whether the spread of the data was consistent with expectations as determined from the evaluation data. Similarly, a Student's T-test [Mendenhall, 1992] was also performed to determine whether the mean of the CVR data was consistent with expectations.

As shown above, there were 14 usable CVR results, having a mean of 0.017 gal/h and a standard deviation of 0.045 gal/h. The statistical tests can be performed using these values, together with the scaled evaluation data mean of 0.023 gal/h and standard deviation of 0.061 gal/h. Table 34 summarizes the results of this analysis. In this table, column 1 describes which test is being used, column 2 shows the test statistic, and column 3 shows the test critical value (for a 1% level of significance). The inference drawn from the test is shown in column 4. If the test statistic is greater than the corresponding test critical value, it means that, with only a 1% chance of error, the two data sets are from different variance populations.¹²

¹² To the extent that an F-statistic is much smaller than the F-critical value, an inverse F-test (F^{-1}) may be used to show that the test data are from a different population than the evaluation data. In this case, the test data would be interpreted as being significantly better (i.e., less noisy) than the evaluation data; this finding, however, has no value in this analysis and is not considered further.

The F-test result in Table 34 shows that, at a 1% level of significance, the variance of the W-16 data is larger than the variance of the evaluation data, indicating worse performance than expected. When the two outliers are excluded, the F-test indicates that the variance of the W-16 data is still larger (by roughly 60%), though not nearly as large as when the outliers are included. The T-test, however, shows that, at a 1% level of significance, the mean of the W-16 data is indistinguishable from the mean of the evaluation data.

The appearance of a non-random distribution of the W-16 CVR data can be verified with a run test. A run test performed on this data indicates that there is a cyclic, or systematic, variation in the data, which could account for the larger variance indicated by the F-test. A possible explanation for this variation may be seasonal factors such as precipitation (rainwater entering the tank system) or ambient temperature effects on the instrumentation. Another possible explanation is that, in a number of the leak tests, the level of liquid in the tank is very low; there may be some adverse effect on the liquid level measurement associated with the liquid level being close to the bottom of the tank. It is recommended that the leak test data be monitored during the next assessment period so that the reason for the greater than expected variance can be examined.

Table 34 Summary of Statistical Comparisons Between Evaluation and W-16 CVR Data.

Test	Test Statistic	Test Critical Value	Inference
F-test	>10	2.83	Different
T-test	1.39	3.01	Not different

7.7.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines. Review of the design drawings revealed an abundance of nozzles into the tank that were not connected to pipelines. However, because the unused nozzles are located on the top of the tank, there is no concern that leakage could occur at those locations as long as the tank is operating at less than full capacity. The design drawings revealed a sound design of the W-16 tank.

During the corrosion assessment, it was determined that with the present use of the tank system, all forms of corrosion on the interior walls of the tank and associated piping should be non-existent. Corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. Furthermore, an analysis of the general aspects of corrosion at ORNL revealed that corrosion of SS by ORNL soil is not believed to be severe.

Leak testing of Tank W-16 was completed by the DP method in 24 tests. The tank passed 14 of the tests and had inconclusive results in two tests. The inconclusive results were explained by excessive noise in the liquid level measurement device and a problem associated with the WOCC data collection system.

Six of the eight testable line segments have passed leak testing. Two of these line segments are part of a pipeline that is no longer in use and is not scheduled for retesting. Although a limited evaluation of the untestable pipelines can be made using transfer logs, no transfers were made from this tank during the reporting period.

All of these factors were considered in determining certification of the W-16 Tank System components. Table 35 summarizes the elements of the tank system which were certified and the conditional limits on their certifications.

Table 35 Summary of W-16 Tank System Testing and Certification

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank W-16		Yes	DP	PASS	Yes	33.3%
LS-24	55	Yes	GPD	PASS	Yes	Full flow
LS-25	145	Yes	GPD	PASS	Yes	Full flow
LS-26	281	Yes	GPD	PASS	Yes	Full flow
LS-145	200	Yes	EVB	INC	No	N/A
LS-163	14	No	N/T	N/A	No	N/A
LS-181	4	No	N/T	N/A	No	N/A
LS-181A	4	Yes	GPD	PASS	Yes	Full flow
LS-181B	4	Yes	GPD	PASS	Yes	Full flow
LS-181C	4	Yes	GPD	PASS	Yes	Full flow
DP Differential Pressure EVB Enhanced volume balancing GPD Gas pressure decay INC Inconclusive LS Line segment N/A Not applicable N/T Not testable						

7.7.6 Certification

Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that Tank W-16 retains sufficient structural integrity to contain liquids at operating levels up to the maximum level which achieved a PASS during the testing program. Also, based upon the results of the pipeline tests, it is my professional opinion that Lines Segments 24, 25, 26, 181A, 181B, and 181C retain sufficient structural integrity to contain liquids up to full flow conditions. Table 35 provides a summary description of the certifications for the W-16 Tank System. If future testing is conducted at greater tank levels, then certification levels may also increase.

It is recommended that leak detection and line testing be continued using EPA and TDEC approved methods, to support annual certification, until this system has been removed from operation or replaced.

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7.8 WC-2 Tank System

The WC-2 Tank System is located near the northeast corner of Building 3092, as shown in Figure 1. The WC-2 Tank System collects LLLW from Buildings 3038 and hot off-gas (HOG) duct condensate from a HOG drain trap in Isotope Circle. The tank system is made up of Tank WC-2 and nine line segments connected to the system. Because the lines and tank are all singly contained, the tank system has been classified as Category C, according to the FFA.

7.8.1 WC-2 Tank Description

Tank WC-2 is a 1,000 gallon, buried, singly contained tank. Installed in 1951, WC-2 is mounted vertically to an 8'-0" x 8'-0" x 0'-8" concrete pad. The tank is constructed of 347 SS and was designed with a 1/4" wall thickness. All materials welded to the tank are also 347 SS. The tank is constructed with 3/8" thick ASME flanged dished heads on top and 1/4" thick ASME flanged dished heads on the bottom. The outside dia of the tank is 5'-6", with a total height of 7'-4 1/4". The design drawing for WC-2 is provided in Figure 27.

The tank is equipped with nine 3" dia flanged nozzles, one 8" dia flanged nozzle, and one 16" dia manhole opening. The flanged nozzles are located around a 2'-0" radius of the tank center, and the manhole is located in the center of the tank. Each of the 3" dia flanges are fitted to be secured by four 5/8" dia bolts, and the manhole is fitted to be secured by sixteen 3/4" dia bolts. All flanges are slip on welding type. All of the necessary welds on the tank are specified in accordance with code from the ASTM for unfired pressure vessels. At the time of construction, the welds were specified to provide substantially the same composition as adjacent unwelded metal.

The pit containing the tank was constructed with a one and half foot deep earthen sump located on the northeast corner of the tank pad. An 8" dia vitrified clay pipe, installed 6" from the bottom of the sump, extended to the surface of the backfilled tank pit and is currently used as a tank pit sample point.

During the tank installation, the tank pit was backfilled with 1 1/2" dia stone to a minimum depth of one foot above the concrete pad. The remainder of the tank pit was backfilled with earthen materials.

Tank WC-2 was designed to receive material from four sources, which originated in Buildings 3038, and 3028, an isotope off-gas duct condensate drain in Building 3092, and in a pump pit used to contain any spills or leaks that may occur within the vault containing the pump that discharges the liquids from the tank. The tank no longer receives waste from Building 3028. A schematic of the tank system with numbered line segments is provided in Figure 28.

Figure 27. As-built Drawing of Tank WC-2 Installation

3092
SCRUBBER

14

281
127'

S1
N11
VALVE
BOX 2

282
685'

16

7

171
6'

8

Pump Pit Vault

PUMP WC2 - 101

Sump

6

10

187
13'

137
18'

Building 3028

3

93
200'

Building 3038

1

92
200'

158
9'

117
30'

12

ISOTOPE
OFF-GAS DUCT
CONDENSATE
DRAIN

2

4

9

11

5

13

WC-2
(1000 gallon)

LEGEND

Untestable

Testable

2 • Node Number

Figure 28. WC-2 Tank System

7.8.2 WC-2 Pipeline Descriptions

Nine separate lines make up the portion of the LLLW pipeline system belonging to Tank WC-2. Characteristics of these nine lines are listed in Table 36, and line segments are shown in Figure 28. All pipelines associated with the WC-2 Tank System are constructed of 347 SS and were installed in 1951.

As shown in Figure 28, WC-2 has five inlets, one of which has been removed from service, and one discharge pipeline. The remaining three line segments are not directly connected to Tank WC-2.

Line Segments 92 and 93 are inlets for waste coming into Tank WC-2. Line Segment 92 is a 200' long, 2" dia gravity-fed pipeline leading from Building 3038 to Tank WC-2 (node 1 to node 2 in Figure 28). Line Segment 93 is a 200' long, 2" dia gravity-fed pipeline leading from Building 3028 to Tank WC-2 (node 3 to node 4). This line has been taken out of service and no future use is planned. The remaining inlets into the tank are made up of Line Segments 117, 137, and 187. Line Segments 117 and 137 are 2" dia inlets and Line Segment 187 is a 1" dia inlet. Line Segment 117 is a 30' long gravity-fed element that drains a hot off gas (HOG) duct condensate trap (node 12 to node 13). Line Segment 137 is an 18' long recirculation line for the WC2-101 pump back into WC-2 (node 8 to node 9). Line Segment 187 is a 13' long gravity-fed line that drains the WC2-101 pump pit drain to WC-2 (node 10 to node 11). Line Segments 117 and 187 are not accessible, therefore leak testing was not possible on these two line segments. Line Segment 137 is untestable due to the lack of an isolation valve at the point where the line enters the tank.

Line Segment 281 is a 127' long, 2" dia line comprised of suction and jet discharge transfer piping that jets waste from the Building 3092 scrubber into the WC-2 transfer piping (node 14 to node 16). There is no valve at the scrubber end of this segment to serve as an isolation point, thereby rendering this line untestable by existing approved methods.

Line Segment 158 is part of the primary tank discharge line (node 5 to node 6). This segment is a 9' long, 2" dia section of suction piping that extends from WC-2 to the inlet of centrifugal pump WC2-101. Line Segment 158 lacks a second valve and cannot be isolated and therefore cannot be tested. Flow into line 171 begins at the discharge of pump WC2-101 and extends to a valve known as V-WC2-104 (node 6 to node 7). Line Segment 171 is 6' in length, has a dia of 2". The pump sits in a concrete vault with a SS gate valve located on either side of the pump. The pump vault, which is not a part of the tested line system, has a 4.5 ft³ collection sump extending two feet below the floor elevation of the vault.

The third testable element, Line Segment 282, is a pressurized 685' long, 2" dia SS portion of the discharge between Tank WC-2 and Valve Box No. 2 (node 7 to S1 Node 11).

Lines Segments 92, 93, and 282 were leak tested. Limited access and the inability to isolate the lines prevented testing the other lines associated with WC-2. Line Segment 92 was tested by the

enhanced volume balancing (EVB) testing technique described in Section 3.1.2. Materials flow into Line Segment 92 from Building 3038 and exit the line into WC-2. Line Segment 93 is not used, and therefore was not tested. Flow in Line Segment 282 runs from valve V-WC2-104 to Valve Box No. 2 (node 7 to node 11). Segment 282 was tested by the gas pressure decay method described in Section 3.2.2. Leak test results are included in Section 7.8.4.

Table 36 Characteristics of Line Segments Evaluated as a Part of Tank System WC-2

Line Segment	92	93	117	137	158	171	187	281	282
Node Numbers	1 to 2	3 to 4	12 to 13	8 to 9	5 to 6	8 to 7	10 to 11	14 to 16	16 to S1-N11
Index Number	G14	G3							P16
Diameter (in)	2	2	2	2	2	2	1	2	2
Material	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS
Length (ft)	200	200	30	18	9	6	13	127	685
Volume (gal)	35	35	5	3	2	1	1	22	119
Transfer Method	G	G	G	CP	CP Suct.	CP	G	SJ & Suct.	CP
Install Date	1951	1951	1951	1951	1951	1951	1951	1951	1951
CP Centrifugal Pump G Gravity SJ Steam jet pump Suct. Suction SS Stainless Steel									

7.8.3 Corrosion Assessment of the WC-2 Tank System

For the last few years, all waste solutions going into Tank WC-2 were those used to decontaminate the hot cells in Buildings 3028 and 3038 in preparation for decommissioning these buildings. Investigations indicated that surfactants have been used, and the volume added to the tank has only averaged 10 to 20 gallons per week. If acid must be used in the future, based on information obtained from ORNL, only nitric acid would be considered. Type 347 SS is compatible with both of these environments. Furthermore, the solution in the tank is maintained at a pH of approximately 13. With the present use, all forms of corrosion on the interior 347 SS walls of the tank and associated piping should be essentially nil; corrosion damage that may have occurred when the system was used with other environments cannot be assessed.

Some of the SS piping is buried and is subject to corrosion by soil. However, based on information cited in Section 4.0, corrosion of SS by ORNL soil is not believed to be severe.

7.8.4 Results of Leak Tests on the WC-2 System

This section summarizes the results of the leak detection tests conducted on Tank System WC-2 (the tank and its associated pipelines). Each element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for tank methods; 0.1 gal/hr for pipeline methods) with a Pd no less than 95% and a PFA no greater than 5%.

7.8.4.1 Tank

Leak testing of Tank WC-2 began in December 1993. From that time through January 1995, a total of 17 leak tests were conducted on this tank. The results which are summarized in Table 37, show the date of each test, the volume in the tank at the time of the test, the percent of the tank's capacity represented by the specified volume¹³, the test result, and, where appropriate, comments pertinent to particular tests. The table shows that, although one test suffered from data quality problems and resulted in an INCONCLUSIVE test decision, the other 16 leak tests had PASS results. The maximum volume at which Tank WC-2 passed a leak test was 45.2% of the total tank capacity, or 519 gallons.

Table 37 Summary of Leak Tests Conducted on Tank WC-2

Date	# of Gallons	% Capacity	Test Result	Comments
12/3/93	326	28.4	PASS	No comment
12/10/93	325	28.3	PASS	No comment
1/7/94	325	28.3	INCONCLUSIVE	Two noise spikes in level data
1/14/94	327	28.5	PASS	No comment
2/4/94	335	29.2	PASS	No comment
3/4/94	354	30.9	PASS	No comment
4/1/94	388	33.8	PASS	No comment
5/6/94	493	42.9	PASS	No comment
6/3/94	493	42.9	PASS	No comment
7/1/94	519	45.2	PASS	No comment
8/5/94	519	45.2	PASS	No comment
9/2/94	263	22.9	PASS	No comment
9/30/94	289	25.2	PASS	No comment

¹³ The look-up table used by the tank liquid level monitoring system uses a capacity of 1,148 gallons for WC-2, while the documentation and drawings show a 1,000 gal capacity. Since the leak tests are based upon data from the level monitoring system, the percent of capacity here is based on 1,148 gallons.

Date	# of Gallons	% Capacity	Test Result	Comments
10/7/94	289	25.2	PASS	No comment
11/4/94	289	25.2	PASS	No comment
12/2/94	291	25.4	PASS	No comment
1/6/95	297	25.9	PASS	No comment

The CVR data from these leak tests were analyzed (1) to verify that the test method was performing properly in this application and (2) to confirm that during this assessment period the leak testing process had remained stable; that is, that the performance of the method as applied to this particular tank was not deteriorating. This analysis included a comparison of the WC-2 CVRs with the test results originally used to evaluate the performance of the test method, as well as other statistical tests. This analysis is given in Section 7.8.4.3, showed that the data obtained from WC-2 are consistent with the results of the performance evaluation. The analysis also showed that the leak testing process remained stable during the assessment period.

7.8.4.2 Pipelines

The results of the leak detection tests on the testable WC-2 pipelines are summarized in Section 7.8.4.2.1. An assessment of the WC-2 pipelines that cannot be tested for leaks with existing approved methods is summarized in Section 7.8.4.2.2.

7.8.4.2.1 Testable Pipelines

The testable portion of the WC-2 System consists of two gravity-fed inlet lines, one from Building 3028 to Tank WC-2 (Line Segment 93) and the other from Building 3038 to Tank WC-2 (Line Segment 92), and a pressurized section of the discharge line between Tank WC-2 and Valve Box No. 2 (Line Segment 282) (see Figure 28). Two of the lines were tested in August 1994. Table 38 summarizes these results, describing each line in terms of its line segment number, the test date, the test result, and any relevant comments. Two of the lines passed the leak test. The third line (G3) is not used, and therefore not scheduled for testing.

Table 38 Summary of Leak Test Results for the WC-2 Testable Lines

Element No.	Line Segment	Test Date	Test Result	Comment
G3	93	N/T	N/A	Not used, will not be tested.
G14	92	8/31/94	PASS	No comment
P16	282	8/16/94	PASS	No comment

7.8.4.2.2 Untestable Pipelines

The untestable portion of the WC-2 System, made up of Line Segments 158 and 171, carries transfers from Tank WC-2 through Valve Box 2 to Tank W-22. WOCC transfer records for this system show that during the period from December 1993 through December 1994, no transfers were made from Tank WC-2 to Tank W-22. In addition, no transfer records are available for the remainder of the untestable line segments (117, 137, 187, and 281). Thus, in the case of the WC-2 Tank System, no assessment can be made based on the transfer data.

7.8.4.3 Analysis of Leak Test Data

As described in Section 7.8.4.1, a total of 16 conclusive leak tests were conducted on Tank WC-2 during the period between November 1993 and January 1995, which resulted in a PASS decision. Figure 29 shows a time series plot of the CVR data obtained from each test. All of the CVR values are well within the decision thresholds for this tank and are thus consistent with the PASS results. In addition, the CVRs appear to vary in a stable manner over time and to be more or less randomly scattered about a small positive mean value.

Figure 29 Time Series Plot of Leak Test CVRs from Tank WC-2

In Figure 30, the CVR data obtained from Tank WC-2 are compared to the scaled evaluation method data. In this figure, the column-like plot is a histogram of the CVR data shown in Figure 29. The smooth curve is a normal probability density function calculated from the mean and standard deviation of the evaluation data, scaled by the ratio of the height-to-volume ratios of WC-2 and the evaluation tanks. This allows a direct comparison between tanks. The normal curve indicates that, had the evaluation been performed in a tank the size of WC-2, all of the WC-2 CVR

error values would lie approximately between -0.04 and +0.04 gal/h. A visual comparison of the normal curve with the superimposed histogram of the WC-2 CVR data shows that the latter appears to be well contained within the envelope of the expected-results curve.

Figure 30 A Comparison of WC-2 CVRs (Histogram) and Scaled Evaluation Data CVR Errors (Normal Curve)

The WC-2 data was analyzed to determine whether the data shown above were consistent with data expected from a nonleaking tank, with the evaluated performance of a calibrated leak testing method used as the comparator. This analysis examined the distributions of the data. An F-test [Summers 1977] was performed on the variance of the CVR data to determine whether the spread of the data was consistent with expectations as determined from the evaluation data. Similarly, a Student's T-test [Mendenhall 1992] was also performed to determine whether the mean of the CVR data was consistent with expectations.

As shown above, there were 16 usable CVR results, having a mean of 0.004 gal/hr and a standard deviation of 0.006 gal/hr. The statistical tests can be performed using these values, together with the scaled evaluation data mean of 0.005 gal/hr and standard deviation of 0.008 gal/hr. Table 39 summarizes the results of this analysis. Column 1 describes which test is being used, column 2 shows the test statistic, and column 3 shows the test critical value (for a 1% level of significance). The inference drawn from the test is shown in column 4. If the test statistic is greater than the corresponding test critical value, it means that, with only a 1% chance of error, the two data sets are from different variance populations.¹⁴

¹⁴ To the extent that an F-statistic is *much smaller* than the F-critical value, an inverse F-test (F^{-1}) may be used to show that the test data *are* from a different population than the evaluation data. In this case, the test data would be interpreted as being significantly *better* (i.e., less noisy) than the evaluation data; this finding, however, has no value in this analysis and is not considered further.

The F-test result in Table 39 shows that, at a 1% level of significance, the variance of the WC-2 data is no different than the variance of the evaluation data. The T-test also shows that, at a 1% level of significance, the mean of the WC-2 data is no different than the mean of the evaluation data. Based upon this analysis, it is concluded that the leak testing process as applied to WC-2 is stable and that the leak test data obtained from WC-2 are substantially consistent with the those expected from a non-leaking tank.

Table 39 Summary of Statistical Comparisons Between Evaluation and WC-2 CVR Data

Test	Test Statistic	Test Critical Value	Inference
F-test	0.21	2.75	Not different
T-test	2.4	2.95	Not different

7.8.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines.

Review of the design drawings indicated that the tank was designed in accordance with acceptable practices defined by ASTM and ASME. One concern noted was an abundance of nozzles into the tank that were not connected to pipelines. However, because the unused nozzles are located on the top of the tank, there is no concern that leakage could occur at those locations as long as the tank is operating at less than full capacity. The design drawings revealed a sound design of the WC-2 tank.

During the corrosion assessment it was determined that with the present use of the tank system, all forms of corrosion on the interior walls of the tank and associated piping should be non-existent. Corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. Furthermore, an analysis of the general aspects of corrosion at ORNL revealed that corrosion of SS by ORNL soil is not believed to be severe.

Leak testing of Tank WC-2 was completed by the DP method in 17 tests. The tank received PASS results for 16 of the tests and had INCONCLUSIVE results in one test. The INCONCLUSIVE result was explained by excessive noise in the liquid level measurement device.

Two of three testable line segments passed leak testing by methods discussed previously. The other testable line segment is not used and will not be tested. Although a limited evaluation of the untestable pipelines can be made using transfer logs, this method of assessment, due to its limited accuracy, is not deemed valid for certification purposes.

All of these factors were considered in determining certification of the WC-2 Tank System components. Table 40 summarizes the elements of the tank system which were certified and the conditional limits on their certifications.

Table 40 Summary of WC-2 Tank System Testing and Certification

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank WC-2		Yes	DP	PASS	Yes	45.2%
LS-92	200	Yes	EVB	PASS	Yes	32 gph
LS-93	200	No	N/T	N/A	No	N/A
LS-117	30	No	N/T	N/A	No	N/A
LS-137	18	No	N/T	N/A	No	N/A
LS-158	9	No	N/T	N/A	No	N/A
LS-171	6	No	N/T	N/A	No	N/A
LS-187	13	No	N/T	N/A	No	N/A
LS-281	127	No	N/T	N/A	No	N/A
LS-282	685	Yes	GPD	PASS	Yes	Full flow
DP Differential Pressure EVB Enhanced volume balancing gph Gallons per hour LS Line segment N/T Not testable						

7.8.6 Certification

Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that Tank WC-2 retains sufficient structural integrity to contain liquids at operating levels up to the maximum level which achieved a PASS during the testing program. Also, based upon the results of the pipeline tests, it is my professional opinion that Line Segment 92 retains sufficient integrity to contain liquids up to a flow rate of 32 gph and Line Segment 282 retains sufficient integrity to contain liquids up to the full flow potential of this line segment. Table 40 provides a summary description of the certifications for the WC-2 Tank System.

If future testing is conducted at larger pipeline flows and greater tank levels, then certification levels may also increase.

It is recommended that leak detection and line testing be continued using EPA and TDEC approved methods, to support annual certification, until this system has been removed from operation or replaced.

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7.9 WC-3 Tank System

The WC-3 Tank System is located directly south of Building 3025, as shown in Figure 1. The tank system is made up of Tank WC-3 and eight line segments connected to the tank system. The WC-3 Tank System collects waste from the gravity-fed pipeline system in Building 3025. These wastes are transferred from WC-3 to Valve Pit 3026 (VP-3026) via steam jet. Because the lines and tank are all singly contained, the tank system has been given the classification of Category C, according to the FFA.

7.9.1 WC-3 Tank Description

Tank WC-3 is a 1,000 gallon, buried, singly contained tank. Installed in 1951, WC-3 is mounted vertically to an 7'-6" x 7'-6" x 1'-3" concrete pad. The tank is constructed of 347 SS and was designed with a 1/4" wall thickness. All materials welded to the tank are also 347 SS. The tank is constructed with a 3/8" thick ASME flanged dished head on top and a 1/4" thick ASME flanged dished head on the bottom. The outside dia of the tank is 5'-6", with a total height of 7'-4 1/4". The design drawing for WC-3 is provided as Figure 31.

The tank is equipped with nine 3" dia flanged nozzles, one 8" dia flanged nozzle, and one 16" dia manhole opening. The flanged nozzles are located around a 2'-0" radius of the tank center, and the manhole is located in the center of the tank. Each of the 3" dia flanges are fitted to be secured by four 5/8" dia bolts, and the manhole is fitted to be secured by sixteen 3/4" dia bolts. All flanges are slip on welding type. All of the necessary welds on the tank are specified in accordance with code from the ASTM for unfired pressure vessels. At the time of construction, the welds were specified to provide substantially the same composition as adjacent unwelded metal.

The pit containing the tank was constructed with an 8" dia vitrified pipe dry well in the southeast corner, extending to just above ground surface. A jet pit which houses an earthen sump is located to the direct south of the tank pit. The sump is located in the northwest corner of the jet pit.

Building 3025 is the only source of waste which enters Tank WC-3. A schematic of the tank system with numbered line segments is shown in Figure 32.

Figure 31. Drawing of Tank WC-3 Installation

Figure 32. WC-3 Tank System

7.9.2 WC-3 Pipeline Descriptions

Eight separate lines make up the portion of the LLLW pipeline system belonging to Tank WC-3. Details of these lines are listed in Table 41, and line segment numbers are shown in Figure 32. All pipelines associated with the WC-3 Tank System are constructed of 347 SS and were installed in 1951. Materials are transferred through pipelines of WC-3 by either a steam jet pump (SJ), or a suction steam jet pump (SJ Suct.). As shown in Figure 32, WC-3 has one inlet line and two outlet lines. The remaining five line segments are not directly connected to Tank WC-3.

Of the eight pipelines associated with Tank System WC-3, there are three testable pipeline elements made up of five separate line segments. The first is a gravity-fed line that drains from Building 3025 into Tank WC-3. This line, identified as Line Segment 95 is a 35' long gravity-fed line with a 3" dia (Building 3025 to node 5 in Figure 32). Line Segment 95 passed a leak test by the enhanced volume balancing method.

A second testable pipeline element, P37, is a 1,263' long pressurized portion of the discharge pipeline leading from Tank WC-3 to Valve Box 1 via Valve Pit 3026. Element P37 consists of four segments, identified as Line Segment 147, 29, 30, and 28. Line Segments 28, 29, 147, and 30 all intersect at a manifold. Line Segment 28 (nodes 9S-22 to VP-3026) is a 2" dia line carrying LLLW from lines 29, 147, and 30 to valve pit VP-3026. Line Segment 29 (nodes 9 to 6) extends 35' from the isolation valve to the reducer, and intersects with Line Segment 147. Line Segment 30 (nodes 9S-22 to 8S-22) extends 595' from a reducer connecting to the WC-19 pipeline system.

The third testable pipeline element associated with Tank System WC-3 is a pressurized, 2" dia, 190' long segment leading from VP-3026 to Valve Box 2. This element is made up of Line Segment 404, which is no longer used and is therefore not scheduled for testing. All of these previously described lines are made of 347 SS.

The two outlet lines from the tank have index numbers 182 and 186. These lines are 16 and 15' long, respectively, and neither of these 1" dia lines is testable. The system has two steam jets inductors that are used to transfer LLLW from WC-3 to the VP-3026. The suction lines from Tank WC-3 to the jets cannot be tested because they cannot be isolated. Line Segment 182 runs from node 1 to node 2 in Figure 32. Line Segment 186 connects Line Segment 29 and Tank WC-3 (node 7 to node 9).

Line Segments 95, 147, 29, 30 and 28 were successfully tested. Each of the line segments were tested by the EVB or GPD testing technique described in Section 3.2.1. The results of the leak testing are included in Section 7.9.4. The characteristics of each of the eight lines evaluated as part of Tank System WC-3 are given in Table 41.

Table 41 Characteristics of Line Segments Evaluated as a Part of Tank System WC-3

Line Segment	28	29	30	95	147	182	186	404
Node Numbers	S22-N9 to VP-3026	9 to 6	S22-N9 to S22-N8	4 to 5	3 to 6	1 to 2	7 to 8	S29-N1 to 12
Index Number	P37	P37	P37	G2	P37	*	*	P19
Diameter (in)	2	2	2	3	1	1	1	2
Material	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS
Length (ft)	90	35	595	35	50	16	15	190
Volume (gal)	16	6	104	13	2	1	1	33
Transfer Method	SJ	SJ	SJ	G	SJ	SJ & Suct.	SJ & Suct.	SJ
Install Date	1951	1951	1951	1951	1951	1951	1951	1951
<p>* Transfer records available G Gravity SJ Steam jet pump Suct. Suction SS Stainless Steel</p>								

7.9.3 Corrosion Assessment of WC-3 Tank System

Tank WC-3 presently serves only Building 3025. The solutions added to the tank are those associated with analytical and metallographic procedures and include etching and electropolishing solutions (highly acidic), acetone, alcohol, and decontaminating solutions, some of which include salts of citric acid. No chlorine-containing chemicals are used. None of the waste solutions is neutralized before addition to the tank, but the lines are flushed with water after each addition. The pH of the tank solution is maintained at about 13 by adding a strong alkaline solution to the tank every time the waste is pumped out. Under the present conditions, attack on the interior tank walls should not be severe. How much damage may have occurred over the years when tank alkalinity may not have been maintained cannot be assessed.

The tank and associated piping are buried directly in the soil without benefit of coating or cathodic protection. However, based on information cited in Section 4, corrosion of SS by ORNL soil is not believed to be severe.

7.9.4 Results of Leak Tests on the WC-3 System

This section summarizes the results of the leak detection tests conducted on Tank System WC-3 (the tank and its associated pipelines). Each element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for tank methods; 0.1 gal/hr for pipeline methods) with a Pd no less than 95% and a PFA no greater than 5%.

7.9.4.1 Tank

Leak testing of Tank WC-3 began in June 1993. From that time through January 1995, a total of 27 leak tests were conducted on this tank. The results which are summarized in Table 42, show the date of each test, the volume in the tank at the time of the test, the percent of the tank's capacity represented by the specified volume¹⁵, the test result, and, where appropriate, comments pertinent to particular tests. The table shows that tank WC-3 received PASS results for 15 of the leak tests; had INCONCLUSIVE results in two tests (caused by noise in the liquid level measurement device); and showed an EMPTY result in eight tests because the tank level was below the dip-leg used for measurement. Two tests resulted in a decision of INFLOW. The INFLOW results were caused by steam being diverted into the tank during a pipeline modification procedure in early September, 1994. The maximum volume for which the Tank WC-3 passed the leak testing was 35.9% of the total tank capacity, or 412 gallons.

Table 42 Summary of Leak Tests Conducted on Tank WC-3

Date	# of Gallons	% Capacity	Test Result	Comments
6/18/93	31	2.7	EMPTY	No comment
7/2/93	31	2.7	EMPTY	No comment
7/30/93	31	2.7	EMPTY	No comment
8/20/93	35	3.0	PASS	No comment
9/3/93	46	4.0	INCONCLUSIVE	Noise spikes in level data
9/17/93	46	4.0	PASS	No comment
10/1/93	41	3.6	PASS	No comment
11/5/93	89	7.8	PASS	No comment
11/19/93	118	10.3	INCONCLUSIVE	Noise spikes in level data
12/3/93	31	2.7	EMPTY	No comment
12/10/93	31	2.7	EMPTY	No comment
1/7/94	278	24.2	PASS	No comment
2/4/94	72	6.3	PASS	No comment
3/4/94	31	2.7	EMPTY*	No comment
4/1/94	31	2.7	EMPTY*	No comment
5/6/94	31	2.7	EMPTY*	No comment
6/3/94	330	28.8	PASS	No comment

¹⁵ The look-up table used by the tank liquid level monitoring system uses a capacity of 1148 gallons for WC-3, while the documentation and drawings show a 1,000 gal capacity. Since the leak tests are based upon data from the level monitoring system, the percent of capacity here is based on 1,148 gallons.

Date	# of Gallons	% Capacity	Test Result	Comments
7/1/94	320	27.9	PASS	No comment
8/5/94	412	35.9	PASS	No comment
9/2/94	319	27.8	INFLOW	Steam diverted into tank
9/9/94	607	52.9	INFLOW	Steam diverted into tank
9/16/94	188	16.4	PASS	No comment
9/30/94	220	19.2	PASS	No comment
10/7/94	220	19.2	PASS	No comment
11/4/94	218	19.0	PASS	No comment
12/2/94	223	19.4	PASS	No comment
1/6/95	248	21.6	PASS	No comment
<p>* The results of these three tests, which were processed by an earlier version of the Leak Test software, were originally PASS. Manual examination of the level data, however, showed that in each case the level of liquid in the tank was below the bottom end of the dip leg. The results, therefore, should have been EMPTY rather than PASS. The current version of the software checks the level of liquid relative to the dip leg automatically.</p>				

The CVR data from these leak tests were analyzed (1) to verify that the test method was performing properly in this application and (2) to confirm that during this assessment period the leak testing process had remained stable; that is, that the performance of the method as applied to this particular tank was not deteriorating. This analysis included a comparison of the WC-3 CVRs with the test results originally used to evaluate the performance of the test method, as well as other statistical tests. This analysis, given in Section 7.9.4.3, showed that the data obtained from WC-3 are consistent with the results of the performance evaluation. The analysis also showed that the leak testing process remained stable during the assessment period.

7.9.4.2 Pipelines

The results of the leak detection tests on the testable WC-3 pipelines are summarized in Section 7.9.4.2.1. An assessment of the WC-3 pipelines that cannot be tested for leaks with existing approved methods is summarized in Section 7.9.4.2.2.

7.9.4.2.1 Testable Pipelines

The testable portion of the WC-3 System consists of one gravity-fed inlet line from Building 3025 to Tank WC-3 (Line Segment 95), an unused pressurized line leading from Valve Pit 3026 to Valve Box 2, and four other line segments comprising Element P37 of the tank system. Index No. P37 is made up of Line Segments 28, 29, 30, and 147, all of which are pressurized lines. Index No. P37 was tested using the GPD method in June 1995 and passed the test. Line Segment 95 passed a test by the EVB method in May, 1994. Line Segment 404 from Valve Pit 3026 to Valve Box No. 2 is not used, and therefore not scheduled for testing. Table 43 summarizes these results, describing each line in terms of its segment number, the test date, the test result, and any relevant comments.

Table 43 Summary of Leak Test Results for the WC-3 Testable Lines

Index No.	Line Segment	Test Date	Test Result	Comment
P19	404	N/T	N/A	Not used, will not be tested
P37	28, 29, 30, 147	6/95	PASS	No comment
G2	95	5/94	PASS	No comment
N/T Not Tested				

7.9.4.2.2 Untestable Pipelines

The untestable portion of the WC-3 System consists of two suction lines (Line Segments 182 and 186) between Tank WC-3 and the jet pumps that are used to transfer LLLW from Tank WC-3 to Valve Box 1 and on to Tank W-22. Line 186 (node 7 to node 9) is not used. Transfer logs show that during the period from January through December 1994 one transfer was made from WC-3 to W-22. This transfer is summarized in the first four columns of Table 44. The difference between the volume sent (Column 3) and the volume received (Column 4) is shown in Column 5.

Table 44 Summary of Transfers between WC-3 and W-22 During 1994

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum Expected Error (Gal)	Is Difference Greater than Expected Error?
1/13/94	WC3 - W-22	151	151	0	141	No

For the WC-3 to W-22 transfer, given the pre-transfer and post-transfer liquid levels in the two tanks at the time each transfer occurred, the expected error was 141 gallon. The recorded transfer showed an input output volume difference less than the maximum expected error.

7.9.4.3 Analysis of Leak Test Data

During the period between June 1993 and January 1995, a total of 27 leak tests were conducted on Tank WC-3. Of these, there were two INCONCLUSIVE results, two INFLOW results, eight EMPTY results, and 15 PASS results. Figure 33 shows a time series plot of the CVR data obtained from each of the tests that resulted in a PASS. Note that the two INFLOW results (CVR = +1.83 gal/h measured on 9 February 1994 and CVR = +1.59 gal/h measured on September 9, 1994) are not shown, nor are they included in the analysis below. This is because the reason for the inflow is well known and has been documented: work on a pipeline near WC-3 was being conducted and the steam in this line was diverted into WC-3. When the INFLOW results are left out, for the reasons noted above, all of the CVR values are well within the decision thresholds and are thus consistent with the PASS results. In addition, with the exception of two outliers recorded early in the program, the CVRs appear to vary in a stable manner over time and to be more or less randomly scattered about a small positive mean value.

Figure 33 Time Series Plot of Leak Test CVRs from Tank WC-3

In Figure 34, the CVR data obtained from Tank WC-3 are compared to the scaled method evaluation data. The smooth curve is a normal probability density function calculated from the mean and standard deviation of the evaluation data, scaled by the appropriate H/V ratio. This normal curve indicates that, had the evaluation been performed in a tank the size of WC-3, all of the method error values would lie approximately between -0.04 and +0.04 gal/h. A visual comparison of the normal curve with the superimposed histogram of the WC-3 CVR data shows that, with the exception of two outlier points, the latter appears to be well contained within the envelope of the expected-results curve.

The WC-3 data was analyzed to determine whether the data shown above was consistent with data expected from a non-leaking tank, with the evaluated performance of a calibrated leak testing method used as the comparator. This analysis examined the distributions of the data. An F-test [Summers, 1977] was performed on the variance of the CVR data to determine whether the spread of the data was consistent with expectations as determined from the evaluation data. Similarly, a Student's T-test [Mendenhall, 1992] was also performed to determine whether the mean of the CVR data was consistent with expectations.

As shown above, there were 15 usable CVR results, having a mean of -0.003 gal/h and a standard deviation of 0.022 gal/h. The statistical tests can be performed using these values, together with the scaled evaluation data mean of -0.004 gal/h and standard deviation of 0.030 gal/h. Table 45 summarizes the results of this analysis. In this table, column 1 describes which test is being used, column 2 shows the test statistic, and column 3 shows the test critical value (for a 1% level of significance). The inference drawn from the test is shown in column 4. If the test statistic is greater than the corresponding test critical value, it means that, with only a 1% chance of error, the two datasets are from different variance populations.¹⁶

¹⁶ To the extent that an F-statistic is much smaller than the F-critical value, an inverse F-test (F^{-1}) may be used to show that the test data are from a different population than the evaluation data. In this case, the test data would be interpreted as being significantly better (i.e., less noisy) than the evaluation data; this finding, however, has no value in this analysis and is not considered further.

Figure 34 A Comparison of WC-3 CVRs (Histogram) and Scaled Evaluation CVR Errors (Normal Curve)

The F-test result in Table 45 shows that, at a 1% level of significance, the variance of the WC-3 data is no different the variance of the evaluation data. The T-test also shows that, at a 1% level of significance, the mean of the WC-3 data is no different than the mean of the evaluation data. Based upon this analysis, it is concluded that the leak testing process as applied to WC-3 is stable and that the leak test data obtained from WC-3 are substantially consistent with the those expected from a non-leaking tank.

Table 45 Summary of Statistical Comparisons Between Evaluation and WC-3 CVR Data

Test	Test Statistic	Test Critical Value	Inference
F-test	2.83	2.80	Not different
T-test	-.057	2.98	Not different

7.9.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines.

Review of the design drawings indicated that the tank was designed in accordance with acceptable practices defined by ASTM and ASME. One concern noted was an abundance of nozzles

into the tank that were not connected to pipelines. However, because the unused nozzles are located on the top of the tank, there is no concern that leakage could occur at those locations as long as the tank is operating at less than full capacity. The design drawings revealed a sound design of the tank.

During the corrosion assessment it was determined that with the present use of the tank system, all forms of corrosion on the interior walls of the tank and associated piping should be non-existent. Corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. Furthermore, an analysis of the general aspects of corrosion at ORNL revealed that corrosion of SS by ORNL soil is not believed to be severe.

Leak testing of Tank WC-3 was completed by the DP method in 27 tests. The tank had PASS results for 15 of the leak tests, had INCONCLUSIVE results in two tests, eight EMPTY results and two INFLOW results.

Five of the six testable line segments passed leak testing by methods discussed previously. The other testable line segment is not used and will not be tested.

Transfer logs were used to qualitatively assess the pipelines which are untestable by currently approved methods. These transfer logs reveal that one transfer was made, during the period from January through December, 1994. The difference between the measured volume sent from Tank WC-3 and the measured volume received in Tank W-22 was less than the maximum expected error. The successful transfer, coupled with the untestable line being a suction line, are a positive indication of the lines integrity. The volume of the transfer along with the latest qualitative assessment of the pipelines are reported to EPA and TDEC in the "Quarterly Highlights for LLLW Tank System Activities". Although a limited evaluation of the untestable pipelines can be made using transfer logs, this method of assessment, due to its limited accuracy, is not deemed valid for certification purposes.

All of these factors were considered in determining certification of the WC-3 Tank System components. Table 46 summarizes the elements of the tank system which were certified and the conditional limits on their certifications.

Table 46 Summary of Tank System Certification for Tank WC-3

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank WC-3		Yes	DP	PASS	Yes	35.9%
LS-95	35	Yes	EVB	PASS	Yes	32 gph
LS-28	90	Yes	GPD	PASS	Yes	Full flow
LS-29	35	Yes	GPD	PASS	Yes	Full flow
LS-30	595	Yes	GPD	PASS	Yes	Full flow
LS-147	50	Yes	GPD	PASS	Yes	Full flow
LS-182	16	No	N/T*	N/A	No	N/A
LS-186	15	No	N/T	N/A	No	N/A
LS-404	190	No	GPD	N/A	No	N/A
<p>* Transfer records available DP Differential Pressure EVB Enhanced volume balancing GPD Gas pressure decay gph Gallons per hour LS Line segment N/T Not testable N/A Not Applicable</p>						

7.9.6 Certification

Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that Tank WC-3 retains sufficient structural integrity to contain liquids at operating levels up to the maximum level which achieved a PASS during the testing program. Also, based upon the results of the pipeline tests, it is my professional opinion that Line Segment 95 retains sufficient integrity to contain liquids up to a flow rate of 32 gph, and Line Segments 28, 29, 30, and 147 retain sufficient structural integrity to contain liquids up to full flow. Table 46 provides a summary description of the certifications for the WC-3 Tank System. If future testing is conducted at larger pipeline flows and greater tank levels, then certification levels may also increase.

It is recommended that leak detection and line testing using the EPA and TDEC approved methods be continued, to support annual certification, until this system has been removed from operation or replaced.

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7.10 WC-7 Tank System

The WC-7 Tank System is located southwest of Building 3504 in Bethel Valley, as shown in Figure 1. This active tank system serves Buildings 3504, 2533, 2531, and 2534. The tank system is made up of Tank WC-7 and eight pipelines associated with the system. Because the lines are all singly contained, the system has been classified as a Category C tank system, according to the FFA.

7.10.1 WC-7 Tank Description

Tank WC-7 is a 1,100 gallon, buried, singly contained tank located southwest of Building 3504. Installed in 1951, WC-7 is mounted vertically by SS structural members welded to the side of the tank which are anchored to an 8" thick concrete pad. The tank is constructed of 347 SS and has an unknown wall thickness. The outside dia of the tank is 64" with a length of 89". The working volume of the tank is 750 gallons. The drawing for Tank WC-7 is provided as Figure 35.

The tank is equipped with 3" dia 347 SS inlet piping and 2" dia 347 SS discharge piping. Crushed stone was placed around the tank to the top of the tank. The tank is covered by earth backfill 6'-5" from the top of the tank to the surface. The tank is equipped with a precision level sensor and can be tested for leaks.

7.10.2 WC-7 Pipeline Descriptions

Eight separate lines make up the portion of the LLLW pipeline system belonging to Tank WC-7. Characteristics of the lines are listed in Table 47, with the numbered line segments shown in Figure 36. All pipelines associated with the WC-7 system are constructed of 347 SS. A schematic of the tank system with numbered line segments is shown in Figure 36.

The inlet to WC-7 is a gravity pipeline from Building 3504. The outlet line transfers waste from Tank WC-7 through Valve Box 1 by means of steam jet. The remaining six line segments associated with the system are not directly connected to Tank WC-7. LLLW from the sump in Evaporator Complex Building 2533 is transferred to the central LLLW system through the WC-7 discharge line.

There are two testable pipeline elements associated with Tank System WC-7. The first is the gravity-fed inlet line that drains from Building 3504 into Tank WC-7. This element, G8 (node 1 to node 2 in Figure 36), is 20' long, has a 3" dia. The second testable element connects Tank WC-7 and the Building 2533 sump to Valve Box 1. This element (P18; nodes 4, 7, and 10 to S1 node 6) is a total of 1,165' long, with a 2" dia. Element P18 consists of four segments, Line Segments 221, 223, 224, and 225 that transfer waste into Valve Box 1. These segments cannot be individually isolated, and therefore must be tested as one element of the WC-7 system.

Figure 35. WC-7 Tank Design Drawing

Figure 36. WC-7 Tank System

Line Segment 129 is the only segment directly connected to the tank that serves as a discharge pipeline. This line segment transfers waste by steam jet and steam jet suction. This line segment was installed in 1951 and is 20' long and has a 2" dia. Line Segment 129 cannot be tested because there is no valve at the tank and therefore the line cannot be isolated. Line Segment 220 is the other non-testable line segment that is a part of the WC-7 Tank System. Line Segment 220 is a 2" dia line that runs 40' between Building 2534 and Building 2533. The line segment is a 2" dia gravity-fed line that drains Building 2534 to the Building 2533 sump. The 40' line cannot be tested because there is no access to the line.

Table 47 Characteristics of Line Segments Evaluated as a Part of Tank System WC-7

Line Segment	220	96	129	221	222	223	224	225
Node Numbers	5 to 6	1 to 2	3 to 4	7 to 11	10 to 11	11 to 8	4 to 8	8 to 6
Index Number		G8	*	P18	P18	P18	P18	P18
Diameter (in)	2	3	2	2	2	2	2	2
Material	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS
Length (ft)	40	20	20	20	82	247	709	107
Volume (gal)	7	8	4	4	14	43	123	19
Transfer Method	G	G	SJ & Suct.	N/A	N/A	N/A	SJ	SJ
Install Date	U	1951	1951	U	U	U	U	U
* Transfer records available CP Centrifugal Pump G Gravity N/A Not Available SJ Steam jet pump SS Stainless Steel Suct. Suction U Unknown								

7.10.3 Corrosion Assessment of WC-7 Tank System

Tank WC-7 has not collected LLLW from Buildings 3504 since January 1, 1992. Nothing has been purposely added to the tank since that time; some rain water has leaked into the tank. As with most waste tanks, the pH of the solution is above 13, and while at that level, corrosion damage should be of no concern. Corrosion damage that may have occurred when the tank received active chemical wastes without maintaining the high pH cannot be assessed.

Based on information cited in Section 4, soil-side corrosion of the underground tank and associated piping is probably not severe, even though the tank and piping is not coated or cathodically protected.

7.10.4 Results of Leak Tests on the WC-7 System

This section summarizes the results of the leak detection tests conducted on Tank System WC-7 (the tank and its associated pipelines). Each element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for tank methods; 0.1 gal/hr for pipeline methods) with a probability of detection (P_D) no less than 95% and a probability of false alarm (P_{FA}) no greater than 5%.

7.10.4.1 Tank

Leak testing of Tank WC-7 began in June 1993. From that time through January 1995, a total of 27 leak tests were conducted on this tank. The results are summarized in Table 48, which shows the date of each test, the volume of LLLW in the tank at the time of the test, the percent of Tank WC-7's total capacity represented by that volume, the test result, and, where appropriate, comments pertinent to particular tests. The table shows that, although three tests suffered from data quality problems and resulted in an INCONCLUSIVE test decision, Tank WC-7 passed the other 24 leak tests.

The CVR data from these leak tests were analyzed (1) to verify that the test method was performing properly in this application and (2) to confirm that during this assessment period the leak testing process had remained stable; that is, that the performance of the method as applied to this particular tank was not deteriorating. This analysis included a comparison of the WC-7 CVRs with the test results originally used to evaluate the performance of the test method, as well as other statistical tests. This analysis, described below, showed that except for small positive bias, the data obtained from WC-7 are consistent with the results of the performance evaluation. This small positive bias is probably due to an instrument calibration error; however, a weak inflow condition is also possible. The analysis showed no indications of an outflow. The analysis showed that the leak testing process remained stable during the assessment period.

Table 48 Summary of Leak Tests Conducted on Tank WC-7

Date	# of Gallons	% Capacity	Test Result	Comments
6/18/93	436	40.9	PASS	No comment
7/24/93	464	43.6	PASS	No comment
7/30/93	455	42.7	PASS	No comment
8/20/93	496	46.7	INCONCLUSIVE	Level shift in volume data
8/21/93	487	45.7	PASS	No comment
9/3/93	506	47.5	INCONCLUSIVE	Noise spike in volume data
9/17/93	476	44.7	PASS	No comment
10/1/93	481	45.3	PASS	No comment

Date	# of Gallons	% Capacity	Test Result	Comments
11/5/93	490	46.0	PASS	No comment
11/19/93	500	47.0	PASS	No comment
12/3/93	509	47.8	PASS	No comment
12/10/93	515	48.4	PASS	No comment
1/7/94	532	50.0	PASS	No comment
2/4/94	186	17.4	PASS	No comment
3/4/94	236	22.1	PASS	No comment
4/1/94	274	25.8	INCONCLUSIVE	Noise spikes in volume data
4/8/94	290	27.2	PASS	No comment
5/6/94	447	42.0	PASS	No comment
6/3/94	467	43.9	PASS	No comment
7/1/94	468	44.0	PASS	No comment
8/5/94	501	47.1	PASS	No comment
9/2/94	510	48.0	PASS	No comment
9/30/94	534	50.2	PASS	No comment
10/7/94	535	50.2	PASS	No comment
11/4/94	535	50.3	PASS	No comment
12/2/94	536	50.3	PASS	No comment
1/6/95	544	51.2	PASS	No comment

7.10.4.2 Pipelines

The results of leak detection tests on the testable WC-7 pipelines, and an assessment of the WC-7 pipelines that cannot be tested for leaks with existing approved methods, are summarized below.

7.10.4.2.1 Testable Pipelines

The testable portion of the WC-7 system consists of two pipeline elements. The first is the gravity-fed line, G8, which drains from Building 3504 into Tank WC-7, which failed a test in April 1994 because personnel made visual confirmation of a leak at the inlet of the line. This line was permanently taken out of service and no further testing is scheduled. The second testable element associated with Tank System WC-7 is a pressurized portion of the discharge line, designated P18. This element serves to transfer waste from WC-7 and the Building 2533 sump to Valve Box 1. The line was tested using the GPD method in July 1995 and passed the test. Table 49 summarizes these results, describing each line in terms of its index number, the test date, the test result, and any relevant comments.

Table 49 Summary of Leak Test Results for the WC-7 Testable Lines

Index No.	Line Segment	Test Date	Test Result	Comment
P18	221, 223, 224, 225	7/21/95	PASS	No Comment
G8	96	4/6/94	FAIL	No longer in use

7.10.4.2.2 Untestable Pipelines

There are two untestable elements in the WC-7 system, Line Segments 129 and 220. The first is the suction piping and a portion of the discharge piping that is used to transfer LLLW from the tank to Tank W-22, through Valve Box No. 1. This line cannot be tested for leaks with existing approved methods because there is no valve at the tank that could be used to isolate the line. However, LLLW transfers through this line are recorded by Waste Operation Control Center (WOCC) as volume balances from Tank WC-7 to Tank W-22; these transfers are amenable to the analysis described above. The second untestable element is the gravity-fed line that drains Building 2534 to the Building 2533 sump. This line cannot be tested because there is no access to it; further, its integrity cannot be assessed by means of transfer records because there are none available.

Transfer logs show that during the period from January through December 1994 one transfer was made from WC-7 to W-22. This transfer is summarized in the first four columns of Table 50. The difference between the volume sent (Column 3) and the volume received (Column 4) for the transfer is shown in Column 5. For the WC-7-to-W-22 transfer, given the pre-transfer and post-transfer liquid levels in the two tanks at the time the transfer occurred, the maximum expected error was 141 gallons. The recorded transfer showed input-output volume differences less than the maximum expected error; therefore, it is concluded that there were no significant differences during this assessment period.

Table 50 Summary of Transfers between WC-7 and W-22 During 1994

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum Expected Error (Gal)	Is Difference Greater than Expected Error?
1/20/94	WC-7 - W-22	391	420	29	141	No

7.10.4.3 Analysis of Leak Test Data

During the period between June 1993 and January 1995, a total of 27 leak tests were conducted on Tank WC-7. Of these tests, there were three INCONCLUSIVE results and 24 PASS results. Figure 37 shows a time series plot of the CVR data obtained from each of the tests that resulted in a PASS. All of the CVR values are well within the decision thresholds and are thus consistent with the PASS results. In addition, the CVRs appear to vary in a stable manner over time and to be more or less randomly scattered about a small positive mean value.

Figure 37 Time Series Plot of Leak Test CVRs from Tank WC-7

In Figure 38, the CVR data obtained from Tank WC-7 are compared to the scaled evaluation data. The smooth curve is a normal probability density function calculated from the mean and standard deviation of the evaluation data, scaled by the appropriate HTV ratio. This normal curve indicates that, had the evaluation been performed in a tank the size of WC-7, all of the method error values would lie approximately between -0.04 and +0.04 gal/h. A visual comparison of the normal curve with the superimposed histogram of the WC-7 CVR data shows that the width of the latter appears to be comparable to the width of the expected-results curve, but that there is a positive bias in the WC-7 data.

Figure 38 A Comparison of WC-7 CVRs (Histogram) and Scaled Evaluation CVR Errors (Normal Curve)

An analysis was performed on the WC-7 data to determine whether the data shown above was consistent with data expected from a non-leaking tank, with the evaluated performance of a calibrated leak testing method used as the comparator. This analysis examined the distributions of the data. An F-test [Summers, 1977] was performed on the variance of the CVR data to determine whether the spread of the data was consistent with expectations as determined from the evaluation data. Similarly, a Student's T-test [Mendenhall, 1992] was also performed to determine whether the mean of the CVR data was consistent with expectations.

As shown above, there were 24 usable CVR results, having a mean of 0.028 gal/h and a standard deviation of 0.017 gal/h. The statistical tests can be performed using these values, together with the scaled evaluation mean of 0.040 gal/h and standard deviation of 0.025 gal/h. Table 51 summarizes the results of this analysis. In this table, column 1 describes which test is being used, column 2 shows the test statistic, and column 3 shows the test critical value (for a 1% level of significance). The inference drawn from the test is shown in column 4. If the test statistic is greater than the corresponding test critical value, it means that, with only a 1% chance of error, the two data sets are from different variance populations.¹⁷

The F-test result in Table 51 shows that, at a 1% level of significance, the variance of the WC-7 data is no different the variance of the evaluation data. The T-test, however, shows that, at a 1% level of significance, the mean of the WC-7 data is statistically different than the mean of the

¹⁷ To the extent that an F-statistic is *much smaller* than the F-critical value, an inverse F-test (F^{-1}) may be used to show that the test data *are* from a different population than the evaluation data. In this case, the test data would be interpreted as being significantly *better* (i.e., less noisy) than the evaluation data; this finding, however, has no value in this analysis and is not considered further.

evaluation data. Though this bias is a substantial fraction of the inflow detection threshold, it is still not large enough to significantly impact the efficiency of the leak testing process; that is, as long as the performance does not deteriorate (and the tank remains non-leaking) this tank will continue to consistently pass leak testing.

Table 51 Summary of Statistical Comparisons between Evaluation and WC-7 CVR Data

Test	Test Statistic	Test Critical Value	Inference
F-test	1.99	2.54	Not different
T-test	7.82	2.81	Different

7.10.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines.

Review of the design drawings indicated that the tank was designed in accordance with acceptable practices defined by ASTM and ASME. One concern noted was an abundance of nozzles into the tank which were not connected to pipelines. However, because the unused nozzles are located on the top of the tank, the concern of leakage from the ports is nonexistent at operation levels of less than full tank capacity. The design drawings revealed a sound design of the tank.

During the corrosion assessment it was determined that with the present use of the tank system, all forms of corrosion on the interior walls of the tank and associated piping should be nonexistent. Corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. Furthermore, an analysis of the general aspects of corrosion at ORNL revealed that corrosion of SS by ORNL soil is not believed to be severe.

Leak testing of Tank WC-7 was completed by the Volumetric DP method in 27 tests. The tank received PASS results for 24 of the tests and had INCONCLUSIVE results in three tests. The INCONCLUSIVE results were explained by excessive noise in the liquid level measurement device.

Pipeline Index No. P18 was tested and passed the GPD method in July 1995. This element consisted of Line Segments 221, 223, 224, and 225.

Transfer logs were used to qualitatively assess the pipelines which are untestable by currently approved methods. These transfer logs reveal that one transfer was made, during the period from January through December, 1994. The difference between the measured volume sent from Tank WC-7 and the measured volume received in Tank W-22 was less than the maximum expected error. The volume of the transfer along with the latest qualitative assessment of the pipelines are reported to EPA and TDEC in the "Quarterly Highlights for LLLW Tank System Activities". Although a limited evaluation of the untestable pipelines can be made using transfer logs, this method of assessment, due to its limited accuracy, is not deemed valid for certification purposes.

All of these factors were considered in determining certification of the WC-7 Tank System components. Table 52 summarizes the elements of the tank system which were certified and the conditional limits on their certifications.

Table 52 Summary of WC-7 Tank System Testing and Certification

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank WC-7		Yes	DP	PASS	Yes	51.2%
LS-96	20	Yes	EVB	FAIL	No	N/A
LS-129	20	No	N/T*	N/A	No	N/A
LS-220	40	No	N/T	N/A	No	N/A
LS-221	20	Yes	GPD	PASS	Yes	Full Flow
LS-222	82	No	N/T	N/A	No	N/A
LS-223	247	Yes	GPD	PASS	Yes	Full Flow
LS-224	709	Yes	GPD	PASS	Yes	Full Flow
LS-225	107	Yes	GPD	PASS	Yes	Full Flow
* Transfer records available DP Differential pressure EVB Enhanced volume balancing gph Gallons per hour LS Line segment N/T Not testable N/A Not Applicable						

7.10.6 Certification

Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that Tank WC-7 retains sufficient structural integrity to contain liquids at operating levels up to the maximum level which achieved a PASS during the testing program. Also, based upon the results of the pipeline tests, it is my professional opinion that Line Segments 221, 223, 224, and 225 retain sufficient structural integrity to contain liquids up to full flowing conditions. Table 52 provides a summary description of the certifications for the WC-7 Tank System. If future testing is conducted at larger pipeline flows and greater tank levels, then certification levels may also increase.

It is recommended that leak detection and line testing using the EVB and GPD methods be continued, to support annual certification, until this system has been removed from operation or replaced.

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7.11 WC-9 Tank System

The WC-9 Tank System located in the Bethel Valley area south of Building 3503, as shown in Figure 1. The tank system is an active system, and collects rainwater from the WC-9 pump pit. It was also used to drain LLLW from Building 3503. The tank system is singly contained tank and is classified as Category C.

7.11.1 WC-9 Tank Description

Tank WC-9 is a 2,150 gallon, buried, singly contained tank, and was installed in 1962. The tank is mounted vertically on four legs anchored to a concrete pad. The tank is constructed of 347 SS with an outside dia of 7'-0" and a length of 10'-9". The bottom of the tank is concaved on an 84" radius, the top of the tank has a flanged dished head profile on an 84" radius with a 1/8" minimum wall thickness. The top of the tank has four 2" dia flanged nozzles, three 2-1/2" dia flanged nozzles, one 4" dia flanged nozzle, and one 18" dia flanged manhole located at the top center of the tank. All of the flanged nozzles are located around a 3'-0" radius from the center of the tank. The manhole is fitted with a 16" I. D. extension constructed with 3/16" SS walls. The manhole is capped with a 30" dia flanged inlet. The height of the extension is unknown. Two lifting lugs are provided located on opposite sides of the top of the tank. The operating volume of the tank is 1,500 gallons. The design drawing for Tank WC-9 is given in Figure 39.

The tank is located in an earthen pit backfilled with crushed stone. The burial depth is 6'-6" to the top of the tank. The tank is ventilated to the atmosphere through an HEPA filter.

Tank WC-9 is capable of receiving material from three sources. The sources originate in Building 3503, an off-gas condensate drain trap in Building 3503, and from a pump pit sump pump. A schematic of the tank system with numbered line segments is provided in Figure 40.

7.11.2 WC-9 Pipeline Descriptions

Nine separate line segments make up the portion of the LLLW pipeline system belonging to the Tank System WC-9. Characteristics of the lines are listed in Table 53, and line segments numbers are shown in Figure 40.

The testable portion of the WC-9 pipeline system consists of two elements: the gravity-fed inlet line from Building 3503 to Tank WC-9, and a portion of the pressurized discharge line between Tank WC-9 and Valve Box 2. The testable gravity inlet line, Line Segment 97 (node 1 to node 2 in Figure 39), is 95' long, and has a dia of 3", and is made of 347 SS. The testable pressurized line, index number P2 (node 41 to node 10) includes a recently installed section of doubly contained pipeline which connects Tank WC-9 with the discharge line to Valve Box 2. Designated as Line Segment 301, this line is 1,131' long, and has sections with dias of 2" and 3" respectively. Line Segment 301 (node 41 to node 42) is made of SS. Element P2 is made up of two line segments identified as Line Segments 301 and 27.

Figure 39. WC-9 Tank Design Drawing

Figure 40. WC-9 Tank System

There are four untestable pipeline elements associated with the WC-9 system. The first untestable pipeline element is the gravity-fed inlet line connecting an off-gas condensate drain trap to Tank WC-9. This pipeline element (node 7 to node 9) is comprised of two segments, Line Segments 132 and 157. The pipeline element is 59' long, and is comprised of 1" and 2" dia sections, and is made of 347 SS.

The second untestable pipeline element is the discharge line from a pump pit sump pump that empties the sump into WC-9. This element is made up of one SS segment, Line Segment 164 (node 30 to node 33), which is 29' long, with a 1" dia. The two remaining untestable elements are no longer used. This is a result of an upgrade program that installed a submersible pump in WC-9, and connected the submersible pump discharge to the WC-9 transfer piping via a section of doubly contained pipeline. One of the untestable elements is the (now-unused) suction piping between Tank WC-9 and Pump P-102 and a short section of P-102 discharge piping. This line (node 3 to node 5) is comprised of two segments, Line Segments 140 and 159, and is 25' long, with a 2" dia. The other untestable element is the (now-unused) piping, Line Segment 212, (node 34 to node 32) which served to drain Pump P-102 back into Tank WC-9. This pipeline is 2' long, with a 1" dia.

Table 53 Characteristics of Line Segments Evaluated as a Part of Tank System WC-9

Line Segment	27	97	132	140	152	157	159	164	212	301
Node Numbers	23 to 10	1 to 2	8 to 9	3 to 4	5 to 6	7 to 8	4 to 5	30 to 32	32 to 34	41 to 42
Index Number	P2	G1								P2
Diameter (in)	3	3	2	2	2	1	2	1	1	
Material	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS	347 SS	
Length (ft)	1096	200	20	16	11	39	9	29	2	35
Volume (gal)	421	95	4	3	2	2	2	2	<1	
Transfer Method	CP	G	G	CP	CP	G	CP	CP	CP	CP
Install Date	1952	1952	1952	1952	1952	1952	1952	1952	1952	1994
CP Centrifugal Pump G Gravity SS Stainless Steel										

7.11.3 Corrosion Assessment of the WC-9 Tank System

Tank WC-9 collects condensate from the hot off-gas system in Building 3503 and from the pump pit sump (rain water). The waste solution has not been characterized, but the pH in the tank solution is presently maintained near 13 which should minimize corrosion. Corrosion damage that may have occurred during periods when the pH of the solution was not maintained at a high value cannot be assessed.

Based on information cited in Section 4, soil-side corrosion of the underground tank and associated piping is probably not severe, even though the tank and piping are neither coated nor cathodically protected.

7.11.4 Results of Leak Tests on the WC-9 System

This section summarizes the results of the leak detection tests conducted on Tank System WC-9 (the tank and its associated pipelines). Each element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for tank methods; 0.1 gal/hr for pipeline methods) with a probability of detection (Pd) no less than 95% and a probability of false alarm (PFA) no greater than 5%.

7.11.4.1 Tank

Leak testing of Tank WC-9 was performed from June 1993 through January 1995, with a total of 29 leak tests conducted on the tank. The results are summarized in Table 54, which shows the date of each test, the volume of LLLW in the tank during the test, the percent of Tank WC-9's total volume represented by that volume, the test result, and, where appropriate, comments pertinent to particular tests. The table shows that, although six tests suffered from data quality problems and resulted in INCONCLUSIVE test decisions, Tank WC-9 passed the other 23 leak tests.

Table 54 Summary of Leak Tests Conducted on Tank WC-9

Date	# of Gallons	% Capacity	Test Result	Comments
6/18/93	1076	44.8	PASS	No comment
7/2/93	1050	43.8	INCONCLUSIVE	Problem with Action Pak
7/24/93	1092	45.5	PASS	No comment
7/30/93	1085	45.2	PASS	No comment
8/20/93	1124	46.8	INCONCLUSIVE	Noise in data
8/21/93	1087	45.3	PASS	No comment
9/3/93	1156	48.2	INCONCLUSIVE	Data concentrator/WOCC problem
9/17/93	1090	45.4	PASS	No comment
10/1/93	1373	57.2	PASS	No comment
11/5/93	268	11.2	PASS	No comment
11/12/93	271	11.3	PASS	No comment
11/19/93	273	11.4	PASS	No comment
12/3/93	396	16.5	INCONCLUSIVE	Excavation near tank channeling rainwater into tank
12/10/93	926	39.7	INCONCLUSIVE	Excavation near tank channeling rainwater into tank

Date	# of Gallons	% Capacity	Test Result	Comments
12/17/93	1156	48.2	INCONCLUSIVE	Excavation near tank channeling rainwater into tank
1/7/94	922	38.4	PASS	No comment
2/4/94	499	20.8	PASS	No comment
3/4/94	451	18.8	PASS	No comment
4/1/94	715	29.8	PASS	No comment
5/6/94	1050	43.8	PASS	No comment
6/3/94	1141	47.6	PASS	No comment
7/1/94	814	33.9	PASS	No comment
8/5/94	905	37.7	PASS	No comment
9/2/94	1016	42.4	PASS	No comment
9/30/94	1061	44.2	PASS	No comment
10/7/94	1061	44.2	PASS	No comment
11/4/94	1245	51.9	PASS	No comment
12/2/94	744	31.0	PASS	No comment
1/6/95	766	31.9	PASS	No comment

The CVR data from these leak tests were analyzed (1) to verify that the test method was performing properly in this application and (2) to confirm that during this assessment period the leak testing process had remained stable; that is, that the performance of the method as applied to this particular tank was not deteriorating. This analysis included a comparison of the WC-9 CVRs with the test results originally used to evaluate the performance of the test method, as well as other statistical tests. The results of this analysis, described below, showed that the data obtained from WC-9 are consistent with the results of the performance evaluation. The analysis also showed that the leak testing process remained stable during the assessment period.

7.11.4.2 Pipelines

The results of the leak detection tests on the testable WC-9 pipelines are summarized in Section 7.11.4.2.1. An assessment of the WC-9 pipelines that cannot be tested for leaks with existing approved methods is summarized in Section 7.11.4.2.2.

7.11.4.2.1 Testable Pipelines

The testable portion of the WC-9 system consists of two elements: the gravity-fed inlet line from Building 3503 to Tank WC-9, and a portion of the pressurized discharge line between Tank WC-9 and Valve Box 2 (see Figure 40). The gravity line is made up of Line Segment 97 which

passed leak testing in May 1994. The discharge line between Tank WC-9 and Valve Box 2 is made up of Line Segments 27 and 301. These line segments were tested together using the GPD method in July 1995. Table 55 summarizes these results, describing each line in terms of its index number, the test date, the test result, and any relevant comments.

Table 55 Summary of Leak Test Results for the WC-9 Testable Lines

Index No.	Line Segment	Test Date	Test Result	Comment
G1	97	5/10/94	PASS	No comment
P2	27, 301	7/12/95	PASS	No comment

7.11.4.2 Untestable Pipelines

There are six untestable line segments associated with the WC-9 system, three of which are no longer in service. The first two untestable segments, Line Segments 157 and 132, make up the gravity inlet line connecting the Off-Gas Condensate Drain Trap to Tank WC-9; while this line is used, there is no instrumentation to measure transfers. Line Segment 164 is a pump pit sump pump segment which drains into Tank WC-9; this segment is also still in use, but transfer data is not available. Line Segments 140 and 159 are an unused portion of the discharge line between Tank WC-9 and Pump P-102; this line is no longer used. Line Segment 212 is another unused line which served to drain Pump P-102 back into Tank WC-9.

7.11.4.3 Analysis of Leak Test Data

During the period between June 1993 and January 1995 a total of 29 leak tests were conducted on Tank WC-9. Of these, there were six INCONCLUSIVE results and 23 PASS results. Figure 42 shows a time series plot of the CVR data obtained from each test that resulted in a PASS. Note that there are two positive outliers, one on 11/5/93 and one on 1/7/94. The reason for these outliers is that, during this period of time, excavation work was in progress in close proximity to the tank. This allowed rainwater to be channeled into the tank. The figure shows that, except for the two outliers, all of the CVR values are well within the decision thresholds and are thus consistent with the PASS results. In addition, with the exception of the two outliers, the CVRs appear to vary in a stable manner over time and to be more or less randomly scattered about a small positive mean value.

Figure 42 Time Series Plot of Leak Test CVRs from Tank WC-9

In Figure 43, the CVR data obtained from Tank WC-9 are compared to the scaled method evaluation data. The smooth curve is a normal probability density function calculated from the mean and standard deviation of the evaluation data, scaled by the appropriate H/V ratio. This normal curve indicates that, had the evaluation been performed in a tank the size of WC-9, all of the method error values would lie approximately between -0.06 and +0.06 gal/h. A visual comparison of the normal curve with the superimposed histogram of the WC-9 CVR data shows that, except for the two outliers, the latter appears to be well contained within the envelope of the expected-results curve.

Figure 43 A Comparison of WC-9 CVRs (Histogram) and Scaled Evaluation CVR Errors (Normal Curve)

The WC-9 data was analyzed to determine whether the data shown above was consistent with data expected from a non-leaking tank, with the evaluated performance of a calibrated leak testing method used as the comparator. This analysis examined the distributions of the data. An F-test [Summers, 1977] was performed on the variance of the CVR data to determine whether the spread of the data was consistent with expectations as determined from the evaluation data. Similarly, a Student's T-test [Mendenhall, 1992] was also performed to determine whether the mean of the CVR data was consistent with expectations.

As shown above, there were 23 usable CVR results, having a mean of 0.028 gal/h and a standard deviation of 0.032 gal/h. The statistical tests can be performed using these values, together with the scaled evaluation mean of 0.015 gal/h and standard deviation of 0.026 gal/h. Table 56 summarizes the results of this analysis. In this table, column 1 describes which test is being used, column 2 shows the test statistic, and column 3 shows the test critical value (for a 1% level of significance). The inference drawn from the test is shown in column 4. If the test statistic is greater than the corresponding test critical value, it means that, with only a 1% chance of error, the two data sets are from different variance populations.¹⁸

¹⁸ To the extent that an F-statistic is *much smaller* than the F-critical value, an inverse F-test (F^{-1}) may be used to show that the test data *are* from a different population than the evaluation data. In this case, the test data would be interpreted as being significantly *better* (i.e., less noisy) than the evaluation data; this finding, however, has no value in this analysis and is not considered further.

The F-test result in Table 56 shows that, at a 1% level of significance, the variance of the WC-9 data is no different the variance of the evaluation data. The T-test also shows that, at a 1% level of significance, the mean of the WC-9 data is no different than the mean of the evaluation data. Based upon this analysis, it is concluded that the leak testing process as applied to WC-9 is stable and that the leak test data obtained from WC-9 are substantially consistent with the those expected from a non-leaking tank.

Table 56 Summary of Statistical Comparisons Between Evaluation and WC-9 CVR Data

Test	Test Statistic	Test Critical Value	Inference
F-test	2.19	2.56	not different
T-test	2.75	2.82	not different

7.11.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines.

Review of the design drawings indicated that the tank was designed with an abundance of nozzles into the tank which were not connected to pipelines. However, because the unused nozzles are located on the top of the tank, the concern of leakage from the ports is nonexistent at operation levels of less than full tank capacity. The design drawings revealed a sound design of the WC-9 tank.

During the corrosion assessment it was determined that with the present use of the tank system, all forms of corrosion on the interior walls of the tank and associated piping should be nonexistent. Corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. Furthermore, an analysis of the general aspects of corrosion at ORNL revealed that corrosion of SS by ORNL soil is not believed to be severe.

Leak testing of Tank WC-9 was completed by the Volumetric DP method in 29 tests. The tank passed 23 of the tests and had INCONCLUSIVE results in six tests.

Three of the four testable line segments passed leak testing by methods discussed previously. The remaining testable segment, Line Segment 152, is no longer in use.

No transfer logs are available for the untestable line segments currently in use, so no assessment can be made for the untestable lines.

All of these factors were considered in determining certification of the WC-9 system components. Table 57 summarizes the elements of the tank systems which were certified and the conditional limits on their certifications.

Table 57 Summary of WC-9 Tank System Testing and Certification

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank WC-9		Yes	DP	PASS	Yes	57.2%
LS-27	1096	Yes	GPD	PASS	Yes	Full flow
LS-97	200	Yes	EVB	PASS	Yes	32 gph
LS-132	20	No	N/T	N/A	No	N/A
LS-140	16	No	N/T	N/A	No	N/A
LS-152	11	No	N/T	N/A	No	N/A
LS-157	39	No	N/T	N/A	No	N/A
LS-159	9	No	N/T	N/A	No	N/A
LS-164	29	No	N/T	N/A	No	N/A
LS-212	2	No	N/T	N/A	No	N/A
LS-301	35	Yes	GPD	PASS	Yes	Full flow
CVR Compensated volume rate DP Differential pressure EVB Enhanced volume balancing GPD Gas pressure decay gph Gallons per hour LS Line segment N/T Not testable N/A Not applicable						

7.11.6 Certification

Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that tank WC-9 retains sufficient structural integrity to contain liquids at operating levels up to the maximum level which achieved a PASS during the testing program. Also, based upon the results of the pipeline tests, it is my professional opinion that Line Segment 97 retains sufficient integrity to contain liquids up to a flow rate of 32 gph, and Line Segments 27 and 301 retain sufficient structural integrity to contain liquids at operating levels up to full flow. Table 57 provides a summary description of the certifications for the WC-9 tank system. If future testing is conducted at large pipeline flows and greater tank levels, then certification levels may also increase.

It is recommended that leak detection and line testing using the EPA and TDEC approved methods be continued, to support annual certification, until this system has been removed from operation or replaced.

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7.12 WC-10 Tank System

The WC-10 Tank System is located south of Building 3587, as shown in Figure 1. The WC-10 Tank System collects LLLW and rainwater from the Isotope Circle area. The tank system is made up of Tank WC-10 and seven line segments connected to the system. Because the lines and tank are all singly contained, the tank system has been classified as Category C, according to the FFA.

7.12.1 WC-10 Tank Description

Tank WC-10 is a 2,300 gallon, buried, singly contained tank, installed in 1951. Tank WC-10 is mounted horizontally on two reinforced concrete pillars. The tank is constructed of SS and has an unknown wall thickness. The outside dia of the tank is 76" with a length of 124". The working volume of the tank is 1,650 gallons. The design drawing for Tank WC-10 is given in Figure 44 and 44A.

The tank is equipped with three 2" dia nozzles, one 3" dia nozzle, two ½" dia sample nozzles, three unused nozzles, and one manhole. All of the nozzles, including the manhole, are located on top of the tank aligned with the tank centerline.

The tank is anchored to the support pillars which are anchored to a 34'-0" x 16'-9" reinforced concrete pad. The pad also supports six other tanks, one horizontally mounted, five vertically mounted. The tank pad and all of the tanks are placed in an earthen pit which has been backfilled with gravel to the top of the tanks. The gravel was then covered with earth. The top of tank WC-10 is 10'-2" below the surface elevation. The tank is equipped with a precision level sensor and can be tested for leaks.

7.12.2 WC-10 Pipeline Descriptions

Seven separate line segments make up the portion of the LLLW pipeline system belonging to Tank WC-10. Characteristics of the lines are listed in Table 58. A schematic of the tank system with numbered line segments is shown in Figure 45. All pipelines associated with the WC-10 Tank System are constructed of SS and were installed in 1951.

PLAN OF WC-10 TANK DESIGN

Figure 44A. WC-10 Tank Design Drawing

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*Note: The stack fans and duct drains were cut and capped at node 34

Figure 45. WC-10 Tank System

Table 58 Characteristics of Line Segments Evaluated as a Part of Tank System WC-10

Line Segment	33	83	84	85	86	125	131
Node Numbers	56 to S1-N3	S21-N36 to 35	39 to 40	37 to 38	34 to 35	46 to 42	41 to 42
Index Number	P6	G29	G32	G32		P6	*
Diameter (in)	3	6	3	6	6	2	2
Material	SS	SS	SS	SS	SS	SS	SS
Length (ft)	1358	250	800	155	135	25	20
Volume (gal)	522	375	307	233	203	6	4
Transfer Method	P	SJ&G	G	G	G	P	P
Install Date	1951	1951	1951	1951	1951	1951	1951
* Transfer records available G Gravity P Pressure SJ Steam jet pump SS Stainless Steel							

As shown in Figure 45, WC-10 has one gravity fed inlet line and one pressure discharge pipeline. The remaining five line segments are not directly connected to Tank WC-10. There are three testable SS pipeline elements associated with Tank System WC-10. The first testable element is made up of two line segments. The first line segment of Element G32 is the gravity-fed line that drains from Building 3047 into Tank WC-10. The 3" dia gravity-fed inlet line is identified as Line Segment 84. This line segment runs 800' from a reducing valve (which converts Line Segment 83 from 6" dia to 3" dia), into Tank WC-10 (node 39 to node 40). Line Segment 85 is a testable gravity-fed line that runs 155' from Building 3093 to a reducing valve located in the inlet line (node 37 to node 39). Line Segments 85 and 84 both are testable, and were grouped together as Element G32 for testing purposes.

The second testable line of the WC-10 Tank System is identified as Element G29. The element is made up of Line Segments 83 and 84, and runs from Building 3028 to Tank WC-10. Line Segment 83 is a 6" dia gravity-fed line that runs 250' from node 36 (S21A on Figure 45) at Building 3028 to node 38. Line Segment 84, also a part of the first testable element of WC-10, is described above.

The third testable element of the WC-10 Tank System is Element P6, and consists of Line Segments 33 and 125. This element is a pressurized portion of the discharge line leading from Tanks WC-10 and WC-11 to Valve Box 1. This element runs from nodes 46, 49, 52, 55, and 42, to node 3 (S1). This element has a total length of 1383', and has sections with dias of 2" and 3".

The pipeline identified as Line Segment 86 originates as a drain for stack fans and duct drains in Building 3039 connects to the 6" dia Line Segment 83 at node 35. The duct drains have been cut and capped. Line Segment 86 is 135' in length and has a 6" dia. Line Segment 86 is not used and therefore will not be leak tested. The second untestable line segment is a 20'-2" section of discharge line identified as Line Segment 131 (node 41 to 42). This segment cannot be tested because it cannot be isolated at the tank end of the line.

7.12.3 Corrosion Assessment of the WC-10 Tank System

Tank WC-10 collects waste from hot cells in Buildings 3028 through 3033, 3047, and 3118. For the past several years, most of the liquid materials added to the tank were decontaminating solutions including nitric acid, oxalic acid, potassium permanganate, and commercial cleansers such as Ajax and Mr. Clean. Steel wool has been used occasionally. Only dilute solutions have been used, and these have been further diluted with large volumes of rinse water. After additions to the tank, drain lines are always flushed with water. As with the solutions in most waste tanks, the pH is maintained at a high value by adding a strong caustic to the tank after each emptying.

Under the present mode of operation, the interior surfaces of the tank should experience only slight corrosion. It is probable, however, that for some periods during the greater than 40 year life of the tank, the pH was neither neutral or acid, and corrosion may have been appreciable.

In November 1993, an attempt was made to determine the cumulative damage to the interior tank walls during its life. A small video camera was inserted into the tank and a video cassette was made. Examination of the video indicated no evidence of gross corrosion damage. Most of the wetted surfaces were covered with a scale that in some areas appeared to contain iron (red) and in other areas seemed much lighter in color. It is possible that heavy scale may have obscured heavy attack beneath it. In some scaled areas, there appeared to be many pits, but these may be small areas where some of the scale had spalled. The resolution of the video was not sufficient to determine the thickness of the scale, the depth of the apparent pits, or the morphology of the surface.

Based on information cited in Section 4.0, corrosion damage to the exterior surfaces of the buried 347 SS tank and pipelines associated with it are probably not extensive.

7.12.4 Results of Leak Tests on the WC-10 System

This section summarizes the results of the leak detection tests conducted on Tank System WC-10 (the tank and its associated pipelines). Each tested element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for the monthly tank testing; 0.1 gal/hr for the annual pipeline testing) with a probability of detection (P_D) no less than 95% and a probability of false alarm (P_{FA}) no greater than 5%.

7.12.4.1 Tank

Leak testing of Tank WC-10 was performed from September 1993 through January 1995, with a total of 54 leak tests conducted on the tank. The results are summarized in Table 59, which shows the date of each test, the volume of LLLW in the tank during the test, the percent of Tank WC-10's total volume represented by that volume, the test result, and where appropriate, comments pertinent to particular tests. The table shows that Tank WC-10 passed two tests, had one INCONCLUSIVE test, and had 51 tests that indicated an INFLOW (see note at the end of Table 59). The main source of inflow into Tank WC-10 is thought to be from process water entering the system. Efforts to isolate the source of inflow and to mitigate it are continuing.

Table 59 Summary of Leak Tests Conducted on Tank WC-10

Date	# of Gallons	% Capacity	Test Result	Comments
9/3/93	1616	70.2	INFLOW*	No comment
9/17/93	353	15.4	PASS	No comment
10/1/93	744	32.4	INFLOW*	No comment
10/8/93	1132	49.2	INFLOW*	No comment
11/5/93	398	17.3	INFLOW*	No comment
11/12/93	1452	63.1	INFLOW*	No comment
11/19/93	723	31.4	INFLOW*	No comment
12/3/93	438	19.1	INFLOW*	No comment
12/10/93	720	31.3	INFLOW	No comment
12/17/93	382	16.6	INFLOW	No comment
1/7/94	680	29.6	INFLOW*	No comment
1/14/94	1445	62.8	INFLOW*	No comment
2/4/94	1092	47.5	INFLOW*	No comment
2/18/94	676	29.4	INFLOW*	No comment
2/25/94	1390	60.5	INFLOW*	No comment
3/4/94	382	16.6	INFLOW*	No comment
3/11/94	1217	52.9	INFLOW*	No comment
3/18/94	786	34.2	INFLOW*	No comment
4/1/94	764	33.2	INFLOW*	No comment
4/8/94	1628	70.8	INFLOW*	No comment
4/15/94	541	23.5	INFLOW*	No comment
4/22/94	1206	52.4	INFLOW*	No comment

Date	# of Gallons	% Capacity	Test Result	Comments
4/29/94	814	35.4	INFLOW*	No comment
5/6/94	577	25.1	INFLOW*	No comment
5/13/94	1231	53.5	INFLOW*	No comment
6/3/94	1009	43.9	INFLOW*	No comment
6/10/94	594	25.8	INFLOW	No comment
6/17/94	1025	44.6	INFLOW*	No comment
7/1/94	1227	53.3	INFLOW*	No comment
7/8/94	846	36.8	INFLOW*	No comment
7/15/94	758	33.0	INFLOW*	No comment
7/22/94	1157	53.0	INFLOW	Tank was jetted during test
7/29/94	1061	46.1	INFLOW*	No comment
8/5/94	674	29.3	INFLOW*	No comment
8/12/94	1233	53.6	INFLOW	No comment
8/19/94	1175	51.1	INFLOW	No comment
8/26/94	827	35.9	INFLOW	No comment
9/9/94	573	24.9	INFLOW	No comment
9/16/94	1692	73.6	INFLOW	No comment
9/23/94	909	39.5	INFLOW	No comment
9/30/94	357	15.5	INFLOW	No comment
10/7/94	309	13.5	INFLOW	No comment
10/14/94	698	30.3	INFLOW	No comment
10/21/94	1311	57.0	INFLOW	No comment
10/28/94	937	40.7	INFLOW	No comment
11/4/94	1081	47.0	PASS	No comment
11/11/94	525	22.8	INFLOW	No comment
11/18/94	910	39.6	INFLOW	No comment
11/25/94	1351	61.9	INFLOW	No comment
12/2/94	1036	45.0	INFLOW	No comment

Date	# of Gallons	% Capacity	Test Result	Comments
12/16/94	781	34.0	INFLOW	No comment
12/23/94	354	15.4	INFLOW	No comment
12/30/94	909	39.5	INFLOW	No comment
1/6/95	661	28.8	INFLOW	No comment
* These tests were processed by an earlier version of the LEAKTEST software that was less tolerant of noise during an inflow condition and thus gave a result of INCONCLUSIVE. When personnel looked at the level data, it was clear that there was an inflow, even with the high noise. If these data were processed with the current version of LEAKTEST, the result would be INFLOW.				

The CVR data from these leak tests were analyzed (1) to verify that the test method was performing properly in this application and (2) to confirm that during this assessment period the leak testing process had remained stable; that is, that the performance of the method as applied to this particular tank was not deteriorating. This analysis included a comparison of the WC-10 CVRs with the test results originally used to evaluate the performance of the test method, as well as other statistical tests. The results of this analysis, described below, showed that the data from WC-10 are not consistent with the results of the performance evaluation. This is because of the inflow into the tank. However, the analysis also showed that the WC-10 data were consistent with what one would expect given an inflow condition; the CVR values were scattered from zero to 16 gal/h. It is noted here that there was no indication of a leak in this tank from any of the test data. Further, on the occasion when the inflow to the tank was stopped, the tank passed the leak test.

7.12.4.2 Pipelines

The results of the leak detection tests on the testable WC-10 pipelines and an assessment of the WC-10 pipelines that cannot be tested for leaks with existing approved methods are summarized below.

7.12.4.2.1 Testable Pipelines

The testable portion of the WC-10 system consists of the gravity-fed inlet line from Building 3047 to Tank WC-10, the gravity-fed inlet line from Building 3028 to Tank WC-10, and a pressurized portion of the discharge line leading from Tank WC-10 to Valve Box 1 (see Figure 45). Table 60 summarizes the leak testing results, describing each line in terms of its index number, the test date, the test result, and any relevant comments. The pressurized line (P6) passed the leak test in June 1994 and again in July 1994, and is thus considered free of leaks. The gravity-fed inlet line from Building 3028 is not used and therefore will not be tested. Due to the inflow into the tank, the November 1994 leak test on the gravity-fed inlet line from Building 3047 (G32) generated an INCONCLUSIVE result. Although this pipeline did not pass the leak test, there was no indication of a leak in the line.

Table 60 Summary of Leak Test Results for the WC-10 Testable Lines

Index No.	Line Segment	Test Date	Test Result	Comment
G32	85, 84	11/15/94	INCONCLUSIVE	INCONCLUSIVE due to inflow into the tank
G29	83	N/A	N/A	Line not used and will not be tested.
P6	125, 33	6/27/94	PASS	No comment

7.12.4.2.2 Untestable Pipelines

The untestable portion of the WC-10 system (designated by index numbers 86 and 131) consists of the gravity-fed line between the Building 3039 stack, fans and duct drain and Tank WC-10, and a portion of the discharge line leading from Tank WC-10 to Valve Box 1. No WOCC transfer records are available for the gravity-fed line. However, the discharge line carries transfers from Tank WC-10 through Valve Box 1 to Tank W-22 and the volume in both of these tanks is measured and recorded by WOCC. Transfer logs show that during the period from January through December 1994, 30 transfers were made from WC-10 to W-22. These transfers are summarized in the first four columns of Table 61. The difference between the volume sent (Column 3) and the volume received (Column 4) is shown in Column 5.

Table 61 Summary of Transfers between WC-10 and W-22 During 1994

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum Expected Error (Gal)	Is Difference Greater than Expected Error?
1/6/94	WC-10 to W-22	1080	1080	0	141	No
1/16/94	WC-10 to W-22	1372	1333	-39	141	No
1/25/94	WC-10 to W-22	1460	1460	0	141	No
2/1/94	WC-10 to W-22	1167	1260	93	141	No
2/17/94	WC-10 to W-22	1211	1211	0	141	No
2/23/94	WC-10 to W-22	592	592	0	141	No
2/26/94	WC-10 to W-22	349	270	-79	141	No
2/28/94	WC-10 to W-22	1235	1240	5	141	No
3/4/94	WC-10 to W-22	1174	1180	6	141	No
3/14/94	WC-10 to W-22	1094	1094	0	141	No
3/30/94	WC-10 to W-22	1083	1112	29	141	No
4/6/94	WC-10 to W-22	1086	1110	24	141	No

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum Expected Error (Gal)	Is Difference Greater than Expected Error?
4/12/94	WC-10 to W-22	838	838	0	141	No
4/15/94	WC-10 to W-22	1191	1320	129	141	No
4/25/94	WC-10 to W-22	1038	1038	0	141	No
5/5/94	WC-10 to W-22	1119	1307	188	141	Yes
5/16/94	WC-10 to W-22	1147	1160	13	141	No
5/27/94	WC-10 to W-22	1077	1130	53	141	No
6/15/94	WC-10 to W-22	1040	830	-210	141	Yes
7/14/94	WC-10 to W-22	1055	1014	-41	141	No
7/24/94	WC-10 to W-22	1080	970	-110	141	No
8/4/94	WC-10 to W-22	1085	1080	-5	141	No
8/22/94	WC-10 to W-22	1086	1086	0	141	No
9/30/94	WC-10 to W-22	1110	1130	20	141	No
10/11/95	WC-10 to W-22	963	962	-1	141	No
10/23/95	WC-10 to W-22	987	1000	13	141	No
11/10/95	WC-10 to W-22	1107	1150	43	141	No
11/27/95	WC-10 to W-22	1060	1065	5	141	No
12/10/95	WC-10 to W-22	1076	1076	0	141	No
12/12/95	WC-10 to W-22	1046	1070	24	141	No

For the WC-10-to-W-22 transfers, given the pre-transfer and post-transfer liquid levels in the two tanks at the time each transfer occurred, the expected error was 141 gallons. All but two of the recorded transfers showed input-output volume differences less than the maximum expected error. The first transfer that showed a significant difference during the assessment period occurred on May 5, 1994. In this case the receiving tank logged a greater volume than the sending tank, suggesting a gain in volume during the transfer. In the second transfer, which occurred on June 15, 1994, the receiving tank logged less volume than was sent. Because this was only one transfer out of 30, of which 28 had transfer volume differences below the maximum expected error, and because the 11 transfers that followed this one showed differences less than the maximum expected error, it is unlikely that this one instance represents a leak. Thus, no further investigation is warranted at this time.

7.12.4.3 Analysis of Leak Test Data (December 1993 to January 1995)

During the period between December 1993 and January 1995, a total of 45 leak tests were conducted on Tank WC-10. Of these, there were 44 INFLOW results and one PASS result. Figure 46 shows a time series plot of the CVR data obtained from these tests. The figure shows that all but one of the CVR values are well above the inflow threshold and that the one value below this threshold was greater than zero, consistent with the PASS and INFLOW results. It is clear from this plot that there is a substantial inflow into WC-10 which makes the leak testing process unstable; that is, most of the time leak tests will result in an INFLOW decision.

Figure 46 Time Series Plot of Leak Test CVRs from Tank WC-10

In Figure 47, a histogram of the CVR data obtained from Tank WC-10 is shown. The normal probability density function calculated from the mean and standard deviation of the evaluation data, scaled by the appropriate H/V ratio, is not shown, but it would be totally contained within the bins representing -0.1 and +0.1 gal/h. From this plot it is clear that the histogram of the WC-10 CVR data is well outside the envelope of the expected-results curve, which is what would be expected if the tank had a substantial inflow.

An F-test and a Student's T-test performed on these data show that the variance and the mean populations of the WC-10 data are distinctly different from those of the evaluation data. The inflow into Tank WC-10 is thought to be due to process water entering the system. Monthly leak testing of this tank cannot proceed with any confidence of achieving PASS results until the source of the inflow has been identified and mitigated.

Figure 47 A Comparison of WC-10 CVRs (Histogram) and Scaled Evaluation CVR Errors (Normal Curve)

7.12.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines.

Review of the design drawings indicated that the tank was designed in accordance with acceptable practices defined by ASTM and ASME. One concern noted was an abundance of nozzles into the tank which were not connected to pipelines. However, because the unused nozzles are located on the top of the tank, the concern of leakage out of the tank through the ports is nonexistent at operation levels of less than full tank capacity. The design drawings revealed a sound design of the WC-10 Tank.

During the corrosion assessment it was determined that with the present use of the tank system, all forms of corrosion on the interior walls of the tank and associated piping should be nonexistent. However, corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. An attempt to determine cumulative damage to the interior tank wells during its entire life revealed substantial iron containing scale on some areas of the tank. Heavy attack corrosion may be obscured beneath the scaled areas. An analysis of the general aspects of corrosion at ORNL revealed that corrosion of SS by ORNL soil is not believed to be severe.

Leak testing of Tank WC-10 was completed by the Volumetric DP method in 54 tests. The tank had PASS results on 2 of the tests and had INCONCLUSIVE results in one test. The tank had 51

tests which resulted in an INFLOW or INCONCLUSIVE due to an inflow result because of the extenuating inflow condition, it is my professional opinion that Tank WC-10 has not demonstrated that the tank is tight. The INCONCLUSIVE result was explained by excessive noise in the liquid level measurement device.

Two of five testable line segments passed leak testing by EPA and TDEC approved methods and two pipelines segments yielded inconclusive results due to an inflow into the tank. One testable line segment is not used and will not be tested.

Transfer logs were used to qualitatively assess the pipelines which are untestable by currently approved methods. Transfer logs reveal that 30 transfers were made during the period from January 1994 through December 1995. The difference in the volume sent and the volume received exceeded the expected error, one indicated a loss of liquid and one indicated a gain of liquid. The volume of each of the transfer along with the latest qualitative assessment of the pipelines are reported to EPA and TDEC in the "Quarterly Highlights for LLLW Tank System Activities". Although a limited evaluation of the untestable pipelines can be made using transfer logs, this method of assessment is not deemed valid for certification purposes, because of limited accuracy.

All of these factors were considered in determining certification of the WC-10 system components. Table 62 summarizes the elements of the tank system which were certified and the conditional limits on their certifications.

Table 62 Summary of Tank System Certification for Tank WC-10

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank WC-10		Yes	DP	INCONCLUSIVE	No	N/A
LS-33	1358	Yes	GPD	PASS	Yes	Full flow
LS-83	250	No	N/T	N/A	No	N/A
LS-84	800	Yes	EVB	INCONCLUSIVE	No	N/A
LS-85	155	Yes	EVB	INCONCLUSIVE	No	N/A
LS-86	135	No	N/T	N/A	No	N/A
LS-125	25	Yes	GPD	PASS	Yes	Full flow
LS-131	20	No	N/T*	N/A	No	N/A
<ul style="list-style-type: none"> • Transfer records available CVR Compensated volume rate DP Differential pressure EVB Enhanced volume balancing GPD Gas pressure decay LS Line segment N/T Not testable N/A Not applicable 						

7.12.6 Certification

Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that Tank WC-10 cannot be certified at this time. However, based upon the results of the pipeline tests, it is my professional opinion that Line Segments 33 and 125 retain sufficient integrity to contain liquids up to the full flow potential of this line segment. Table 62 provides a summary description of the certifications for the WC-10 tank system.

It is recommended that leak detection and line testing using the EPA and TDEC approved methods be continued, until this system has been removed from operation or replaced.

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7.13 WC-19 Tank System

The WC-19 Tank System is located north of Building 3047 in Bethel Valley, as shown in Figure 1. The WC-19 Tank System serves the Oak Ridge Reactor, the Bulk Shielding Reactor, the Graphite Reactor, and the 3001 Canal. The system is made up of Tank WC-19 and six line segments connected to the tank system. Because the lines and tank are all singly contained, the tank system has been classified Category C, according to the FFA.

7.13.1 WC-19 Tank Description

Tank WC-19 is a 2,100 gallon, buried, singly contained tank. Installed in 1955, WC-19 is mounted horizontally on two concrete pads conformed to the shape of the tank and having dimensions of 1'-0" x 6'-0" x 0'-6". The tank is anchored to the pads using turnbuckle cranes connected to 3/4" dia bolts extending 1'-6 1/2" into both ends of the pads. The tank is constructed of 347 SS with a 5/16" wall thickness. The outside dia of the tank is 6'-0" with a length of 10'-6 7/8". The working volume of the tank is 1,500 gallons. The drawing for Tank WC-19 is provided as Figure 48.

The tank is equipped with eight 3" dia Schedule 40 SS nozzles and one 16" extension tube containing a float gauge. All nozzles including the tube are located on top of the tank aligned along the tank centerline. Two of the nozzles are located 3-3/4" from each end of the tank, and three of the nozzles are equally spaced on 8 1/2" centers from the first nozzle on each side. The 16" tube is located along the centerline of the tank and extends 11' above the tank to the ground surface.

The tank is located in an earthen pit that was filled with 3' of 2" dia stone fill before being backfilled with dirt. The concrete floor of the pit is sloped to a 1'-0" x 1'-0" x 1'-0" sump in the southeast corner. A schematic of the tank system with numbered line segments is provided in Figure 49.

7.13.2 WC-19 Pipeline Descriptions

Six separate lines make up the portion of the LLLW pipeline system belonging to Tank WC-19. Characteristics of the six lines are listed in Table 63, and line segments are shown in Figure 49. Five of the pipelines associated with the WC-19 Tank System are constructed of 347 SS and one is constructed of Poly Vinyl Chloride (PVC). All pipelines were installed in 1955.

As shown in Figure 49, WC-19 has four inlet pipelines, three of which have been removed from service, and one discharge pipeline. The remaining line segment is not directly connected to Tank WC-19.

Figure 49. WC-19 Tank System

Line Segment 90 is the only active inlet for waste to enter Tank WC-19. Line Segment 90 is a 555' long, 2" dia gravity-fed pipeline leading from Building 3001, through Tank 3001B, to Tank WC-19 (node 10 to node 4 in Figure 49).

Line Segments 87, 88, 89, and 91 have served Tank WC-19 as inlets in the past, but are no longer in use today and have no future use planned. Each of these lines is a 2" dia gravity-fed line constructed of 347 SS. Line Segment 87 is a 161' long pipeline leading from the Filter Pit Condensate Drain Trap of Building 3042 to Tank WC-19 (node 15 to node 16). Line Segments 89 and 91 are both 300' long, gravity-fed elements that lead from Building 3042 to WC-19. Line Segment 89 leads from node 11 to node 6 and Line Segment 91 leads from node 12 to node 14-in Figure 49. Line Segment 88 is a 205' long, gravity-fed PVC line that connects Building 3119 to Line Segment 91 (node 13 to node 5).

Line Segment 173 is not accessible, therefore leak testing was not possible. This 10' long line segment is the suction side of the steam jet used to transport waste from Tank WC-19 to Tank W-22. The discharge from the steam jet to VP-3026 and on to W-22 is a part of testable Element P37. Testing on P-37 is shown in the leak test results for the WC-3 system.

Table 63 Characteristics of Line Segments Evaluated as a Part of Tank System WC-19

Line Segment	87	88	89	90	91	173
Node Numbers	15 to 16	13 to 5	11 to 6	10 to 4	5 to 14	7 to VP-3026
Index Number	G9	G12	G7	**	G6	*
Diameter (in)	2	2	2	2	2	1.5
Material	347 SS	Sch. 40	347 SS	PVC	347 SS	347 SS
Length (ft)	161	205	300	555	300	10
Volume (gal)	28	36	52	97	52	2
Transfer Method	G	G	G	G	G	SJ Suct.
Install Date	1955	1955	1955	1955	1955	1955
<p>* Transfer records available ** No index number was assigned G Gravity PVC Poly Vinyl Chloride SJ Steam jet pump SS Stainless Steel Suct. Suction</p>						

7.13.3 Corrosion Assessment of the WC-19 Tank System

Tank WC-19 formerly collected wastes from the Oak Ridge Research Reactor, Bulk Shielding Reactor, Graphite Reactor, and the 3001 Canal. These wastes were mostly nitric acid, sodium hydroxide, and small amounts of resin fines from regeneration of resins in the demineralizes. None of these solutions should have been corrosive to 347 SS. The pH of the solution is about 13 and under these conditions corrosion of the 347 SS tank should be negligible.

Some of the SS piping is buried and is subject to corrosion by soil. However, based on information cited in Section 4.0, corrosion of SS by ORNL soil is not believed to be severe.

7.13.4 Results of Leak Tests on the WC-19 System

This section summarizes the results of the leak detection tests conducted on Tank System WC-19 (the tank and its associated pipelines). Each element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for tank methods; 0.1 gal/hr for pipeline methods) with a P_D no less than 95% and a P_{FA} no greater than 5%. The test methods used for each element are shown in Section 7.13.5.

7.13.4.1 Tank

Leak testing of Tank WC-19 was performed from December 1993 through January 1995, with a total of 36 leak tests conducted on the tank. The results are summarized in Table 64, which shows the date of each test, the volume in the tank during the test, the percent of the tank's capacity represented by the specified volume¹⁹, the test result, and, where appropriate, comments pertinent to particular tests. The table shows that, with one exception, the first 27 leak tests suffered from an inflow condition before a leaking steam jet line was repaired in August, 1994. After the repair, testing produced seven PASS results and two INFLOW results which were caused by steam being diverted to Tank WC-19 during a second repair to the steam discharge system. WC-19 had a total of eight PASS results in the leak tests. The maximum volume at which Tank WC-19 passed a leak test was 49.1% of the total tank capacity, or 993 gallons.

Table 64 Summary of Leak Tests Conducted on Tank WC-19

Date	# of Gallons	% Capacity	Test Result	Comment
12/3/93	848	41.9	INCONCLUSIVE*	No comment
12/10/93	1084	53.6	INFLOW	No comment
12/17/93	403	19.9	INFLOW	No comment
1/7/94	971	48.0	INFLOW	No comment
1/14/94	561	27.8	INFLOW	No comment

¹⁹ The look-up table used by the tank liquid level monitoring system uses a capacity of 2,022 gallons for WC-19, while the documentation and drawings show a 2,100 gal capacity. Since the leak tests are based upon data from the level monitoring system, the percent of capacity here is based on 2,022 gallons.

Date	# of Gallons	% Capacity	Test Result	Comment
2/4/94	954	47.2	INFLOW	No comment
2/18/94	18	1.0	INCONCLUSIVE*	No comment
2/25/94	575	28.4	INCONCLUSIVE*	No comment
3/4/94	993	49.1	PASS	No comment
4/1/94	677	33.5	INCONCLUSIVE*	No comment
4/8/94	519	25.6	INCONCLUSIVE*	No comment
4/15/94	570	28.2	INCONCLUSIVE*	No comment
4/22/94	844	41.7	INCONCLUSIVE*	No comment
5/6/94	1039	51.4	INCONCLUSIVE*	No comment
5/13/94	913	45.1	INCONCLUSIVE*	No comment
6/3/94	718	35.5	INCONCLUSIVE*	No comment
6/10/94	937	46.4	INFLOW	No comment
6/17/94	1151	56.9	INCONCLUSIVE*	No comment
6/24/94	646	31.9	INCONCLUSIVE*	No comment
7/1/94	430	21.3	INCONCLUSIVE*	No comment
7/8/94	520	25.7	INCONCLUSIVE*	No comment
7/15/94	648	32.1	INCONCLUSIVE*	No comment
7/22/94	730	36.1	INCONCLUSIVE*	No comment
7/29/94	832	41.2	INCONCLUSIVE*	No comment
8/5/94	930	46.0	INCONCLUSIVE*	No comment
8/12/94	319	15.8	INFLOW	No comment
8/19/94	448	22.1	INFLOW	No comment
8/26/94	515	25.5	PASS	Leaking steam jet repaired prior to test
9/2/94	539	26.7	PASS	No comment
9/30/94	599	29.6	PASS	No comment
10/7/94	598	29.6	PASS	No comment
11/4/94	757	37.4	PASS	No comment
12/2/94	672	33.2	INFLOW	Steam diverted to tank during repairs
12/16/94	870	43.1	INFLOW	Steam diverted to tank during repairs
12/23/94	201	10.0	PASS	No comment
1/6/95	283	14.0	PASS	No comment

* These tests were processed by an earlier version of the LEAKTEST software that was less tolerant of noise during an inflow condition and thus gave a result of INCONCLUSIVE. When personnel looked at the level data, it was clear that there was an inflow, even with the high noise. If these data were processed with the current version of LEAKTEST, the result would be INFLOW.

The CVR data from these leak tests were analyzed after the August 25, 1994 repair procedure was conducted (1) to verify that the test method was performing properly in this application and (2) to confirm that during this assessment period the leak testing process had

remained stable; that is, that the performance of the method as applied to this particular tank was not deteriorating. This analysis included a comparison of the WC-19 CVRs with the test results originally used to evaluate the performance of the test method, as well as other statistical tests. The results of this analysis, described below, showed that the data obtained from WC-19 are consistent with the results of the performance evaluation. The analysis also showed that the leak testing process remained stable after August 1994, when the steam jet was repaired.

7.13.4.2 Pipelines

The results of the leak detection tests on the testable WC-19 pipelines are summarized in Section 7.13.4.2.1. An assessment of the WC-19 pipelines that cannot be tested for leaks with existing approved methods is summarized in Section 7.13.4.2.2.

7.13.4.2.1 Testable Pipelines

The testable portion of the WC-19 System consists of four gravity-fed lines and one now unused line (Line Segment 88) that connects Building 3119 to pipeline 91. Line Segment 90 is the only line segment which continues to be an active inlet into the tank. Use of the other inlets has been discontinued, and no further uses are planned. These unused inlet segments are Line Segments 87, 89, and 91. None of the unused segments were tested.

Line Segment 90 was tested in November 1994 and January 1995 by the EVB method. Both tests were inconclusive due to high tank level measurement noise and the fact that the line passes through Tank 3001B, which could have an indeterminable and erroneous impact on the leak test result. Table 65 summarizes the results of leak tests of testable lines, describing each line in terms of its line segment number, the test date, the test result, and any relevant comments. Line Segment 90 had INCONCLUSIVE leak test results. The other five lines are not in use and will not be tested.

Table 65 Summary of Leak Test Results for the WC-19 Testable Lines

Index No.	Line Segment	Test Date	Test Result	Comment
G9	87	N/T	N/A	Not used, will not be tested
G12	88	N/T	N/A	Not used, will not be tested
G7	89	N/T	N/A	Not used, will not be tested
*	90	11/2/94	INC	High liquid level measurement noise
*	90	1/26/95	INC	High liquid level measurement noise
G6	91	N/T	N/A	Not used, will not be tested
* No index number was assigned INC Inconclusive LS Line Segment N/T Not Tested				

7.13.4.2.2 Untestable Pipelines

The untestable portion of the WC-19 System (designated as Line Segment 173) consists of the steam jet suction portion of the discharge line leading from Tank WC-19 to Tank W-22. The volume in both of these tanks is measured and recorded by WOCC. Transfer logs show that during the period from January through December 1994, 21 transfers were made from WC-19 to W-22. These transfers are summarized in the first four columns of Table 66. The difference between the volume sent (Column 3) and the volume received (Column 4) for each transfer is shown in Column 5.

Table 66 Summary of Transfers between WC-19 and W-22 During 1994

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum Expected Error (Gal)	Is Difference Greater than Expected Error?
1/13/94	WC-19 to W-22	937	937	0	141	No
1/26/94	WC-19 to W-22	955	920	-35	141	No
2/9/94	WC-19 to W-22	930	930	0	141	No
2/20/94	WC-19 to W-22	875	1040	165	141	Yes
3/16/94	WC-19 to W-22	981	1010	29	141	No
3/18/94	WC-19 to W-22	1060	1230	170	141	Yes
3/27/94	WC-19 to W-22	655	639	-16	141	No
3/28/94	WC-19 to W-22	1002	990	-12	141	No
4/9/94	WC-19 to W-22	797	800	3	141	No
4/14/94	WC-19 to W-22	981	981	0	141	No
5/11/94	WC-19 to W-22	1029	1030	1	141	No
5/20/94	WC-19 to W-22	940	1060	120	141	No
6/21/94	WC-19 to W-22	853	870	17	141	No
7/1/94	WC-19 to W-22	1261	1270	9	141	No
7/1/94	WC-19 to W-22	1303	1300	-3	141	No
7/1/94	WC-19 to W-22	910	860	-50	141	No
11/14/95	WC-19 to W-22	937	920	-17	141	No
11/25/95	WC-19 to W-22	1030	1160	130	141	No
12/4/95	WC-19 to W-22	904	1050	146	141	Yes
12/10/95	WC-19 to W-22	1005	1060	55	141	No
12/20/95	WC-19 to W-22	896	870	-26	141	No

For the WC-19-to-W-22 transfers, given the pre-transfer and post-transfer liquid levels in the two tanks at the time each transfer occurred, the expected error was 141 gallons. All but three of the recorded transfers showed input-output volume differences less than the maximum expected error. The three volume differences which exceeded the maximum expected error were all positive values; that is, in each case, more liquid was measured being received by Tank W-22 than had been measured being sent from Tank WC-19. There were no significant negative differences, which, unlike positive differences, would warrant further investigation.

7.13.4.3 Analysis of Leak Test Data

During the period between December 1993 and January 1995, a total of 36 leak tests were conducted on Tank WC-19. Of these, there were 28 INFLOW results and eight PASS results. The INFLOW results occurred during the first part of the leak testing program for this tank; the source of the inflow was identified and corrected in August 1994. Seven of nine leak tests conducted after this time resulted in PASS; the other two resulted in INFLOW, due to the fact that steam was being directed into the tanks during repairs. Figure 50 shows a time series plot of the CVR data obtained from the seven tests conducted after August 1994; the INFLOW results are not shown because their source was identified as operation-related. The figure shows that all of the CVR values are within the decision thresholds and are thus consistent with the PASS results.

Figure 50 Time Series Plot of Leak Test CVRs from Tank WC-19

In Figure 51, the CVR data obtained from Tank WC-19 are compared to the scaled evaluation data. The smooth curve is a normal probability density function calculated from the mean and standard deviation of the evaluation data, scaled by the appropriate H/V ratio. This normal curve indicates that, had the evaluation been performed in a tank the size of WC-19, all of the method error values would lie approximately between -0.1 and +0.1 gal/h. A visual comparison of

the normal curve with the superimposed histogram of the WC-19 CVR data shows that the latter appears to be contained within the envelope of the expected-results curve.

Figure 51 A Comparison of WC-19 CVRs (Histogram) and Scaled Evaluation CVR Errors (Normal Curve)

The WC-19 data was analyzed to determine whether the data shown above was consistent with data expected from a non-leaking tank, with the evaluated performance of a calibrated leak testing method used as the comparator. This analysis examined the distributions of the data. An F-test [Summers, 1977] was performed on the variance of the CVR data to determine whether the spread of the data was consistent with expectations as determined from the evaluation data. Similarly, a Student's T-test [Mendenhall, 1992] was also performed to determine whether the mean of the CVR data was consistent with expectations.

As shown above, there were 7 usable CVR results, having a mean of 0.011 gal/h and a standard deviation of 0.059 gal/h. The statistical tests can be performed using these values, together with the scaled evaluation mean of 0.006 gal/h and standard deviation of 0.031 gal/h. Table 67 summarizes the results of this analysis. In this table, column 1 describes which test is being used, column 2 shows the test statistic, and column 3 shows the test critical value (for a 1% level of significance). The inference drawn from the test is shown in column 4. If the test statistic is greater than the corresponding test critical value, it means that, with only a 1% chance of error, the two data sets are from different variance populations.²⁰

²⁰ To the extent that an F-statistic is much smaller than the F-critical value, an inverse F-test (F^{-1}) may be used to show that the test data are from a different population than the evaluation data. In this case, the test data would be interpreted as being significantly better (i.e., less noisy) than the evaluation data; this finding, however, has no value in this analysis and is not considered further.

The F-test result in Table 67 shows that, at a 1% level of significance, the variance of the WC-19 data is no different the variance of the evaluation data. The T-test also shows that, at a 1% level of significance, the mean of the WC-19 data is no different than the mean of the evaluation data. Based upon this analysis, it is concluded that the leak testing process as applied to WC-19 is stable and that the leak test data obtained from WC-19 are substantially consistent with the those expected from a non-leaking tank.

Table 67 Summary of Statistical Comparisons Between Evaluation and WC-19 CVR Data

Test	Test Statistic	Test Critical Value	Inference
F-test	3.12	3.53	Not different
T-test	0.51	3.71	Not different

7.13.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines. Review of the design drawings revealed a sound design of the WC-19 tank.

During the corrosion assessment it was determined that with the present use of the tank system, all forms of corrosion on the interior walls of the tank and associated piping should be non-existent. Corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. Furthermore, an analysis of the general aspects of corrosion at ORNL revealed that corrosion of SS by ORNL soil is not believed to be severe.

Leak testing of Tank WC-19 was completed by the DP method in 36 tests. The tank received PASS results for eight of the tests and had INFLOW results in 28 tests. The inflows resulted from a leaking steam jet line, which was repaired in August 1994. Seven of the eight passing results were obtained from tests conducted subsequent to this repair. Two tests subsequent to the repair of the leaking steam jet line resulted in an INFLOW. This was caused by steam that was diverted into the tank during a second repair to the steam discharge system.

The one testable line segment that is still in use did not pass a leak test. The other testable line segments are not used and will not be tested.

Transfer logs were used to qualitatively assess the pipeline which are untestable by currently approved methods. The transfer logs reveal that 21 transfers were made, during the period from January through December, 1994. The difference between the measured volume sent from Tank WC-19 and the measured volume received in Tank-22 was less than them maximum expected error in all but three of the transfers. The three volume differences were positively biased, meaning that

more liquid was measured going into Tank W-22 than was measured leaving Tank WC-19. The successful transfers, coupled with the untestable line being a suction line, are a positive indication of the lines integrity. The volume of these transfers along with the latest qualitative assessment of the pipelines are reported to EPA and TDEC in the "Quarterly Highlights for LLLW Tank System Activities". Although a limited evaluation of the untestable pipelines can be made using transfer logs, this method of assessment, due to its limited accuracy, is not deemed valid for certification purposes.

All of these factors were considered in determining certification of the WC-19 Tank System components. Table 68 summarizes the elements of the tank system which were certified and the conditional limits on their certifications.

Table 68 Summary of WC-19 Tank System Testing and Certification

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank WC-19		Yes	DP	PASS	Yes	49.1%
LS-87	161	No	N/T	N/A	No	No comment
LS-88	205	No	N/T	N/A	No	No comment
LS-89	300	No	N/T	N/A	No	No comment
LS-90	555	Yes	EVB	INC	No	No comment
LS-91	300	No	N/T	N/A	No	No comment
LS-173	10	No	N/T*	N/A	No	No comment
* Transfer records available DP Differential Pressure INC Inconclusive LS Line segment N/A Not applicable N/T Not testable						

7.13.6 Certification

Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that Tank WC-19 retains sufficient structural integrity to contain liquids at operating levels up to the maximum level which achieved a PASS during the testing program. Table 68 provides a summary description of the certifications for the WC-19 Tank System. If future testing is conducted at greater tank levels, then certification levels may also increase.

It is recommended that leak detection and line testing be continued using EPA and TDEC approved methods, to support annual certification, until this system has been removed from operation or replaced.

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7.14 WC-20 Tank System

The WC-20 Tank System is located north of Building 7516, on the north side of Melton Valley Drive, as shown in Figure 1A. The WC-20 Tank System collects LLLW from the Radiochemical Engineering Development Center. The tank system is made up of Tank WC-20 and five line segments connected to the system. Because the tank vault lacks a ventilation system, the tank system was reclassified from Category B to Category C in January 1995, with the first leak test of the tank due in September 1995. Leak testing of the tank was first performed in August 1995; the results are included here for completeness.

7.14.1 WC-20 Tank Description

Tank WC-20 is a 10,000 gallon tank located in a SS-lined concrete vault. Installed in 1976, Tank WC-20 is anchored in place, horizontally, by two 304L SS shells conforming to the circumference of the tank and are secured to the floor by 1½" anchored bolts. The tank is constructed of 304L SS with a ¾" wall thickness with ¾" 304L SS dished heads. The outside dia of the tank is 10'-0" with a length of 19'-5½". The working volume of the tank is 7,000 gallons. The drawing for Tank WC-20 is provided as Figure 52.

The tank is equipped with three 6" dia Schedule 40 SS nozzles, five 2" dia Schedule 40 SS nozzles, two 1" dia Schedule 40 SS nozzles, two 1" dia air spargers, one 2" dia thermocoupler and one 20" dia manhole. All of the nozzles including the manhole, air spargers and thermocoupler are located on top of the tank aligned along the tank centerline. The manhole is located in the center of the top of the tank.

The tank is located in a reinforced concrete vault lined with 16 gauge SS having outside dimensions of 25'-0" x 18'-0" with 2'-0" thick walls. The floor of the vault is sloped to a sump 2'-0" x 2'-0" x 2'-0" in the southeast corner of the vault. The top of the vault is constructed to receive three inwardly stepped reinforced concrete plugs 5' thick used for inspection and maintenance.

Tank WC-20 receives waste from Buildings 7920 and 7930. A schematic of the tank system with numbered line segments is provided as Figure 53.

7.14.2 WC-20 Pipeline Descriptions

Five separate lines make up the portion of the LLLW pipeline system belonging to Tank WC-20. Characteristics of the lines are listed in Table 69, and line segments are shown in Figure 53 of this report. All pipelines associated with the WC-20 Tank System are constructed of SS and installed in 1976. As shown in Figure 53, WC-20 has one inlet and one discharge pipeline. The remaining three line segments are not directly connected to Tank WC-20.

Figure 52. As-built Drawing of Tank WC-20 Installation

Line Segment 94 is the inlet for waste coming into Tank WC-20 (node 2 to node 3 on Figure 53). Line Segment 94 is a 205', 2" dia steam jet pressurized pipeline connecting to lines leading from Tanks B-2-T, B-3-T, C-6-T, and F-126. Line Segment 55 is a 280' long, 2" dia pipeline leading from Tank WC-20 to a manifold inside Pump House Building 7567 (node 4 to node 5).

This line serves as the suction line for the centrifugal pump used to transfer waste out of Tank WC-20 and is doubly contained. Line Segments 31 and 142 are 19' long and 16' long sections of pipeline respectively, that connects the manifold from line 55 to the centrifugal transfer pumps located in Building 7567 (node 13 to node 22 and node 9 to node 22 respectively). Line Segment 31 has a 4" dia while 142 is a 2" dia line. Line Segment 32 is a 3,521' long section of 2" dia line leading from the pumps in Building 7567 to the Valve Box at the South Parking Lot in Bethel Valley (node 22 to south parking lot valve box).

Table 69 Characteristics of Line Segments Evaluated as a Part of Tank System WC-20

Line Segment	31	32	55	94	142
Node Number	13 to 22	22 to South Parking Lot Valve Box	4 to 5	2 to 3	9 to 22
Index Number	*	P21	*	P32	*
Diameter (in)	4	2	2	2	2
Material	304 SS	304 SS	304 SS	304 SS	304 SS
Length (ft)	19	3,521	280	205	16
Volume (gal)	3	613	49	36	3
Transfer Method	CP and CP Suct.	CP	CP Suct.	SJ	CP and CP Suct.
Install Date	1976	1976	1976	1976	1976
* Transfer records available CP Centrifugal Pump SJ Steam jet pump Suct. Suction SS Stainless Steel					

7.14.3 Corrosion Assessment of the WC-20 Tank System

This tank collects waste from Buildings 7920 and 7930, the Radiochemical Development Engineering Center. The major components in the process solutions from this facility are lithium chloride, hydrochloric acid, nitric acid, sodium nitrate, some organic material and traces of hydrogen peroxide, and transuranium isotopes. Before entering the tank all solutions are neutralized with sodium hydroxide, and enough excess is added to make the solution pH at least 13. Without the addition of sodium hydroxide, the solutions would rapidly corrode SS; with alkali present, these solutions should be compatible with SS and any corrosion should be slight.

7.14.4 Results of Leak Tests on the WC-20 System

This section summarizes the results of the leak detection tests conducted on Tank System WC-20 (the tank and its associated pipelines). Each element in the system was tested with a method appropriate for that element. Each method used has been demonstrated to detect a specified leak rate (0.2 gal/hr for tank methods; 0.1 gal/hr for pipeline methods) with a Pd no less than 95% and a PFA no greater than 5%.

7.14.4.1 Tank

Leak testing of Tank WC-20 began in August 1995²¹, four leak tests have been conducted on this tank. The results are summarized in Table 70, which shows the date of each test, the percent of Tank WC-20's total volume containing LLLW when that test was conducted, the volume of that LLLW in gallons, the test result, and comments pertinent to particular tests. The table shows that all of the tests resulted in PASS test decisions. Level data for these tests was obtained using a quartz DP cell and an external data acquisition computer because of the mechanical configuration of the tank liquid level measurement system used to "compensate" the pressure-based level measures for changes in specific gravity. While this data system is not identical to that part of the data system that was evaluated as part of the "DP method", it is equivalent; accordingly, the results shown here should be considered equivalent to those presented elsewhere in this document.

Table 70 Summary of Leak Tests Conducted on Tank WC-20

Date	% Capacity	# of Gallons	Test Result	Comments
Aug 2, 1995	37.5	3876	PASS	Quartz DP cell
Aug 4, 1995	37.7	3887	PASS	Quartz DP cell
Aug 6, 1995	37.5	3875	PASS	Quartz DP cell
Aug 13, 1995	37.5	3873	PASS	Quartz DP cell

7.14.4.2 Pipelines

The results of the leak detection tests on the testable WC-20 pipelines are summarized in Section 7.14.4.2.1. An assessment of the WC-20 pipelines that cannot be tested for leaks with existing approved methods is summarized in Section 7.14.4.2.2.

²¹

While the initial leak test from WC-20 were not due until September 1995, the results obtained in August 1995 as part of the demonstration program are reported here.

7.14.4.2.1 Testable Pipelines

The testable portion of the WC-20 System consists of two pressurized line segments. The first (P21) is the discharge line from the centrifugal pumps in Building 7567 to the South Parking Lot Valve Box. The second (P32) is a portion of the pressurized transfer line from the Category B Tank B-2-T to Tank WC-20. Table 71 summarizes the results, describing the line in terms of its index number, the test date, the test result, and any relevant comments.

Table 71 Summary of Leak Test Results for the WC-20 Testable Lines

Index No.	Line Segment	Test Date	Test Result	Comment
P21	32	9/3/94	PASS	No comment
P32	94	3/21/95	PASS	No comment

7.14.4.2.2 Untestable Pipelines

There are three untestable line segments associated with the WC-20 system. Line Segment 55 is the suction line that joins the WC-20 tank vault with the transfer pumps manifold in the Building 7567 pump house (node 4 to node 5 in Figure 53). Line Segments 31 and 142 are the discharge side of pumps P2 and P1, respectively (these line segments are also used on transfers from T-1 and T-2 to W-22). These lines are a portion of the WC-20 to W-22 transfer line; the volume in the tank is measured and recorded by Waste Operation Control Center (WOCC). Transfer logs show that during the period from April 1994 through December 1994, six transfers were made from Tank WC-20 to W-22. These transfers are summarized in the first four columns of Table 72. The difference between the volume sent (Column 3) and the volume received (Column 4) for the transfers are shown in Column 5.

For the WC-20 to W-22 transfers, given the pre-transfer and post-transfer liquid levels in the tanks at the time each transfer occurred, the expected errors are shown in Column 6. Four of the recorded WC-20-to-W-22 transfers show input/output-volume differences greater than the maximum error expected for each transfer; possible reasons for three of these differences are explained in the transfer logs. The one unexplained difference was positive, indicating that more liquid was measured going into Tank W-22 than was measured leaving Tank WC-20. There were no unexplained significant negative differences, which, unlike positive differences, would warrant further investigation. In addition, because the untestable portion of this line is comprised of suction piping, it would be unlikely that the transfer pumps could be primed if the line lacked integrity. Therefore the successful transfers are a positive indication of this line's integrity.

Table 72 Summary of Transfers between WC-20 and W-22 During 1994

Transfer Date	Transfer Log	Volume Sent (Gal)	Volume Received (Gal)	Difference (Gal)	Maximum Expected Error (Gal)	Is Difference Greater than Expected Error?
4/2/94	WC-20 to W-22	2200	1583	-617	142	Note 1
4/19/94	WC-20 to W-22	2510	2510	0	145	No
7/16/94	WC-20 to W-22	1861	1910	49	143	No
10/9/94	WC-20 to W-22	1632	2180	548	143	Note 2
11/18/94	WC-20 to W-22	2214	2950	736	146	Note 2
12/14/94	WC-20 to W-22	2065	2265	200	144	Yes
Note 1) Switched to T-2 during transferring, showed in flush.						
Note 2) Prime and flush water.						

7.14.4.3 Analysis of Leak Test Data

A detailed statistical analysis of the leak test data has not been conducted due to the limited number of tests.

7.14.5 Findings and Conclusions

The findings of this report are based on (1) a review of available tank design drawings, (2) a qualitative assessment of corrosion on the tank and pipelines, and (3) leak testing results from the tank and testable pipelines.

Review of the design drawings revealed a sound design of the WC-20 Tank System. One concern noted was an abundance of nozzles into the tank that were not connected to pipelines. However, because the nozzles are located on the top of the tank, there is no concern that leakage could occur at those locations as long as the tank is operating at less than full capacity.

During the corrosion assessment it was determined that with the present use of the tank system, all forms of corrosion on the interior walls of the tank and associated piping should be non-existent. Corrosion damage that may have occurred when the tank was used in past environments cannot be assessed. This tank is located in a SS lined concrete vault and corrosion damage to the tank should be nil. All underground SS piping associated with this tank is cathodically protected, and if the cathodic protection system is properly installed and maintained, corrosion on the exterior pipe surfaces should also be essentially nil.

Leak testing of Tank WC-20 was performed in August 1995. Four tests were conducted and all four resulted in PASS decisions. The two testable line segments passed leak testing by EPA and TDEC approved methods, and three pipeline segments are untestable by current approved methods.

Transfer logs were used to qualitatively assess the pipeline which are untestable by currently approved methods. These transfer logs reveal that six transfers were made between January and December 1994. The difference between the measured volume sent from Tank WC-20 and the measured volume received in Tank W-22 was greater than expected three times out of six and less than expected one time. Three of the differences were explained and the unexplained difference was a positive discrepancy, indicating more liquid was measured entering Tank W-22 than was measured leaving Tank WC-20. The successful transfers, coupled with the untestable line being a suction line, are a positive indication of the lines integrity. The volume of these transfers along with the latest qualitative assessment of the pipelines are reported to EPA and TDEC in the "Quarterly Highlights for LLLW Tank System Activities". Although a limited evaluation of the untestable pipelines can be made using transfer logs, this method of assessment, due to limited accuracy, is not deemed valid for certification purposes.

All of these factors were considered in determining certification of the WC-20 System components. Table 73 summarizes the elements of the tank system which were certified and the conditional limits on their certifications.

Table 73 Summary of WC-20 Tank System Testing and Certification

System Component	Length (ft)	Tested (Yes/No)	Leak Test Method	Test Result	Certification	Certification Level
Tank WC-20		Yes	MDP	PASS	Yes	37.7%
LS-31	19	No	N/T*	N/A	No	N/A
LS-32	3,521	Yes	GPD	PASS	Yes	Full flow
LS-94	205	Yes	GPD	PASS	Yes	Full flow
LS-142	16	No	N/T*	N/A	No	N/A
LS-55	280	No	N/T*	N/A	No	N/A
* Transfer records available GPD Gas pressure decay method LS Line segment MDP Modified differential pressure N/A Not applicable N/T Not testable						

7.14.6 Certification

Based on the results of the design drawings review, the qualitative corrosion assessment and the results of the leak testing program, it is my professional opinion that Tank WC-20 retains sufficient integrity to contain liquids at operating levels up to those achieving a PASS during the testing program. Furthermore, Line Segments 32 and 94 of the WC-20 Tank System retain sufficient integrity to contain liquids up to full flow conditions. Table 73 provides a summary description of the certifications for the WC-20 Tank System. If future testing is conducted at greater tank levels, then certification levels may also increase.

It is recommended that leak detection and line testing using EPA and TDEC approved methods be continued, to support annual certification, until this system has been removed from operation or replaced.

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