Market Survey of Leak Detection Systems for the Red Hill Fuel Storage Facility,
Fleet Industrial Supply Center, Pearl Harbor

Prepared for:

Defense Energy Support Center

Prepared under:

AFCEE Contract FA8903-04-D-8684-0008

Prepared by:

Michael Baker Jr., Inc.
Virginia Beach, Virginia

July 3, 2008

Market Survey of Leak Detection Systems for the Red Hill Fuel Storage Facility,
Fleet Industrial Supply Center, Pearl Harbor

TABLE OF CONTENTS

APPENDICIES

Appendix A – Vista Leak Detection LRDP-24-RH; Third Party Certification

Appendix B – MTC Pilot Test Results for Tanks 9 & 15 (March 2008) and Baker Supporting Trip Report

Appendix C - Draft NWGLDE Listings: Varec Leak Manager

Executive Summary

Michael Baker Jr. Inc (Baker) was contracted to conduct a market survey to serve as the first step in evaluating a comprehensive and cost-effective solution for a leak-detection system at the Red Hill facility. Baker conducted a search of possible technologies, manufacturers, and installers of petroleum equipment that have experience with leak detection in very large storage tanks.

The following is a list of candidates that were short listed based on prior experience at Red Hill or technology capable of leak detection on very large storage tanks.

- Asteroid Scientific Comet Software
- Varec Leak Manager Software and Enraf 854 ATG
- Gauging System Inc MTG 3000 and AFHE Control System
- Gauging System Inc MTG 3012 with stand alone leak detection system
- hydroGEOPHYISICS HRR-LDM
- Mass Technology Corporation MTPMMS
- Vista Leak Detection, Inc LRDP-24-RH

The candidates were evaluated using a set of criteria common to leak detection evaluations such as, Third Party Evaluation, Leak Detection Sensitivity, Instrument reliability, Customer Support, and System Installation, and Compatibility with existing ATG/AFHE infrastructure. A decision matrix was used to score and rank the technologies to identify strengths and weakness of each methodology. The issue of relative costs were also evaluated and included.

The results of this evaluation can be seen in the summary of Table 7-1. The results of this Market Survey have identified seven potential candidates for use as leak detection at Red Hill. The seven can generally be grouped as follows:

- The two highest ranked candidate technologies are both routinely used by the DOD and private industry for Integrity Testing of bulk storage tanks. While both are third party certified only Vista's LRDP-24-RH has been third party certified on the Red Hill Tanks. While the third party listing of the National Working Group for Leak Detection Evaluators (NWGLDE) that govern the use of the Mass Technology Corporation MTPMMS is still valid (no upper limit on capacity listed) and the theories and analysis remains the same the equipment has been slightly modified to deal with the higher pressures than normally experienced during this type of testing. It is Baker's opinion that while the system still produces a valid test, third party certification of this modified method should be performed specifically for Red Hill.

- The MTC MTPMMS system is better suited for use at Red Hill mainly due to the construction challenges faced by utilizing the Vista LRDP-24-RH method (clean and empty the tank to install equipment).

- Either MTC or Vista systems can be installed permanently and test run nearly continuously by either the operators or contractors.

- The middle three ranked systems all resulted in nearly the same scores. They are all some form of ATG system with analytical software to detect leaks. One relies on adjusting the existing AFHE system (which may or may not be practical) to make use of the existing ATG and the other two are newer variations of existing systems used in the industry.

- The use of the hydroGEOPHYISICS system seems unwarranted at this time due to the lack of this system in similar uses in industry.

- The lowest ranked system, the Asteroid Scientific Comet system, is analytical software required to be tied to a form of ATG. The use of another form of software with the existing ATG does not appear as attractive as other options considered. Use of the off site post operation analysis to confirm a suspected leak is attractive, but not a primary leak detection method.

Based on the Market Survey and evaluation of the systems it is Baker's opinion that the Mass Technology Corporation's MTPMMS system would be the best option as a primary leak detection solution for Red Hill. In addition Baker recommends that MTC Perform Point in time testing as soon as practical with a formal third party evaluation to conclusively identify the minimum detectable leak rate for this system in these USTS.

If the government chooses to go forward with any of the solutions identified in this Market Survey (other than point in time MTC MTPMMS testing) the next prudent step would be to perform a feasibility study. The focus of the feasibility study would be to identify and research specific design solutions, develop preliminary engineering design documentation (including cost estimates) that can give the government a realistic look at the required funding necessary to implement a solution.

1 Introduction

The objective of this market survey is to identify and research both commercially available and innovative technologies that may be used to solve the challenge of leak detection of the very large underground storage tanks (USTs) operated by the Fleet Industrial Supply Center Pearl Harbor (FISC PH) at Red Hill.

Defense Energy Support Center (DESC) and the Navy have tasked Michael Baker Jr. (Baker) with conducting a "Market Survey" of available technologies for leak detection of the very large USTs operated by FISC PH at Red Hill. Due to the extreme size of these storage tanks, typical off-the-shelf UST or bulk storage tank leak-detection systems are not applicable without modifications. Baker has been tasked to survey commercially available and new technologies that could be applied to the challenge of leak detection on the Red Hill USTs. This survey is being conducted under Delivery Order 008 of Contract FA8903-04-D-8684.

The Red Hill tanks pose a potential threat to an underlying critical water resource supplying potable water to the Navy and others in the vicinity of the Oahu facility. To mitigate this threat a contingency plan entitled "Red Hill Bulk Fuel Storage Facility Contingency Plan" was developed by TEC, Inc. for the Navy in 2007 which included an investigation into the implementation of a leak detection system. In response to this requirement, this market survey has been developed as the first phase within a multi-phased project involving the identification, research, selection, and pilot-scale testing and reporting of one or more technologies with the ability to detect leaks in these USTs.

1.1 Red Hill Site Layout and History

REDACTED

REDACTED

REDACTED

The need for leak detection systems of these tanks is not new. As far back as the initial commissioning of these tanks, attempts have been made to identify and correct leaks to the tanks. However one thing has remained constant since these tanks were commissioned in 1943 and that is that the technology available to detect leaks in the tanks still lags behind the required level of measurement needed to protect the groundwater in the aquifer surrounding the tanks.

1.2 Current Regulatory Compliance Obligations – Leak Detection Systems

The two main regulatory drivers focused on leak detection for USTs located within the United States are the federal UST regulations and any specific State regulations. The federal UST regulations are codified in 40 CFR 280 and specifically, Subpart D "Release Detection" relates to the focus of this project. However, since these USTs are "field constructed" they are deferred from most parts of 40 CFR 280 including the requirements of leak detection systems required in Subpart D. This is an excerpt from 40 CFR 280 identifying this:

> **40 CFR 280.10 Applicability.**
>
> **(c) *Deferrals.* Subparts B, C, D, E, and G do not apply to any of the following types of UST systems:**
>
> **(5) UST systems with field-constructed tanks.**

The portions of 40 CFR 280 that these systems must comply with are Subpart A, F, H and I. None of these Subparts include any specifics relative to leak detection.

The State of Hawaii regulations relating to the requirements of UST systems are included in the *"Hawaii State Regulations Title 11, Department of Health, Chapter 281 - Underground Storage Tanks."* Like 40 CFR 280 the State of Hawaii specifically defers "Field Constructed" USTs from the requirements of leak detection. This is identified in the state regulations "Hawaii Administration Rules" section 11-281-01 "Applicability". These regulations and the associated deferral are nearly identical in verbiage to the requirements of 40 CFR 280. The only sections that are applicable to the field constructed USTs at Red Hill do not include requirements for leak detection.

2 Leak Detection and Underground Storage Facilities

It is important to begin an evaluation of leak detection capabilities for Red Hill with a brief discussion of the general characteristics of leak detection of USTs.

Generally, there are three basic principals to which leak detection systems operate for USTs and they are:

- Directly measuring changes in some physical properties (level, mass, volume, etc.) of the stored liquid inside the UST and comparing that to what is expected.
- Measuring for some physical property of the liquid (or other marker) outside of the UST system and comparing that to what is expected.
- Constructing the storage tank system within a containment structure and inspecting for the stored product collecting in the containment structure.

2.1 Direct In-Tank Measurements

Historically, fuel system operators have been performing the first type of leak detection listed above for as long as there have been storage tanks. Simply stated, an operator would measure the depth (level) of product in the tank and compare it to what was expected to be in the tank (considering issues, receipts, etc.). Obviously, several factors influence the quality of this leak detection measurement most notably being the accuracy of the level measurement.

The level to which accurate measurements could be made would generally be the major factor in determining the allowable discrepancy and the ultimate determination of a leak. If a gasoline station operator could accurately measure the product level in his USTs with his gauging stick to 1/8” on a daily basis then he could really only determine if he were losing product if the measured changes from anticipated levels were more than 1/8” per day. On a gasoline system UST with a relatively small product surface area this equates detectable leaks with relatively small leak rates. This of course is not true of large bulk tanks with equally large product surface areas

As time went on devices became available that could automatically and more accurately measure the liquid level. These are generally referred to as Automatic Tank Gauges (ATGs). ATGs were then coupled with data collection systems to obtain level measurements over a period of time and analytical software to help determine for the operator the potential existence of a leak. Over time the industry became aware of physical factors such as changes in product temperature affecting liquid level measurements and these were accounted for in the calculation/determination of a leak. As the industry got more sophisticated better measuring devices and computer systems were introduced to help to more accurately account for all of these factors and determine if leaks existed. However one major factor still drove the sensitivity to which a leak could be determined and that is the accuracy of the “raw” product level measurement.

For a majority of the UST industry this is currently not an issue. The surface area of all “shop fabricated” UST systems is relatively small even at their greatest point (nearly all shop built USTs are some form of horizontal cylinder and therefore the surface area changes with changing product level) a measurable change in product depth still only equates to a relatively small change in volume. Since most regulations governing “shop built” USTs have a mandatory leak determination rate of 0.2 gallons per hour (gal/hr) the product measuring devices available today are capable of detecting a change of level in the UST that equates to this volumetric change. This is not true however of the larger “field constructed” USTs.

Since field constructed USTs have surface much larger than the traditional shop fabricated USTs the same liquid level measuring devices used to detect leaks on the smaller USTs will only detect leaks of much larger volumes. Since most field constructed USTs are deferred from specific leak detection regulatory requirements, this has not traditionally been a problem for the industry, and as a result relatively little effort has been directed at solving leak detection issues for large field constructed storage tanks. This factor coupled with the fact that as an industry very few field constructed USTs exist outside the DOD has led to relatively few solutions for this problem.

Some of the innovative technologies developed in the recent past have focused both on increasing the level of accuracy of the liquid level measurement as well as several technologies focusing on detection of anomalies outside of the UST.

2.2 Outside Tank Detection Systems

At some point in the history of UST leak detection it became obvious that one way of detecting that a tank was leaking was to find product outside of the tank. Devices such as groundwater or soil vapor monitoring wells were installed around the tank systems with the hopes of determining an increase of petroleum in the environment adjacent to the tank. Advances in this technology included placing automated sensors in the monitoring wells that would alarm when petroleum was detected as well as the use of chemical markers placed in the fuel in the tank. These chemical markers would be more volatile than the petroleum vapors aiding in their detection. Outside tank leak detection technologies can be employed as continuous or point in time testing.

Like direct in-tank measurements, certain limitations exist for this type of technology as well. One challenge is the issue of existing contamination. If a UST leaks and product is released into the environment it will be detected by these outside tank sensors. Once the tank is repaired and placed back into service a certain amount of residual contamination can be expected even after remediation. That means the sensitivity of the leak detection system will be diminished as any new leak will have to overcome the background concentrations of the existing contamination before it can be registered as a new leak. This is also true of chemical marker (Tracer) testing.

Another factor to be considered in the effectiveness of an outside the tank leak detection system is the suitability of the site relative to geologic and hydrogeologic conditions. Obviously monitoring soil vapors in a site that is blasted from rock or is perpetually saturated with groundwater will create challenges for the system to detect a leak. A thorough evaluation of the site should always be undertaken prior to the implementation of such an approach.

2.3 Containment System Detection

One obvious drawback to all of the methods of leak detection discussed so far is that if a leak is detected it is, by some accounts, already too late and that is most especially true for leak detection systems with higher leak detection rates. Whether it is through direct in-tank measurements or outside tank detection techniques the fact exists that once a leak is detected there has already been some degree of impact on the environment. To help mitigate this problem the industry developed double-walled or contained UST systems. These systems basically are completely contained within some additional form of structure with a two-fold benefit. First, detection of a leak is somewhat simplified. Placing some type of sensor in the interstitial space (the space between the primary tank wall and the containment structure) can alert an operator to a leak by the very existence of something within the interstitial space. Secondly there is the added feature that this release has been captured before it has escaped into the environment.

This type of leak detection system is nearly always incorporated into the initial design/manufacture/construction of a UST system. While, upgrading an existing single walled system to that of a double walled system is possible it is most often too cost prohibitive to be implemented.

2.4 Inventory Control versus Precision Leak Detection

It should be stated that there is a definite distinction between inventory control and precision leak detection. In many cases level measurements obtained by ATG are only needed to give the operators an indication of product inventory on hand. The level of accuracy needed for routine inventory control is far less than that required for precision leak detection.

3 Initial Candidate Selection

Baker was contracted to conduct this market survey to serve as the first step in evaluating a comprehensive and cost-effective solution for a leak-detection system at the Red Hill facility. Baker conducted a search of possible technologies, manufacturers, and installers of petroleum equipment that has experience in leak detection in large storage tanks. Based upon Baker's experience with established firms conducting leak detection, a literature review of established and novel technologies was conducted. Trade publications and journals were also used for sources.

The typical selection of a leak detection solution for USTS, whether for a military or a commercial facility is quite straight forward. The owner/operator or his agent typically searches a list of pre-qualified systems capable of solving their particular problem and that are acceptable to the regulators. These pre-qualified lists are usually either managed by the State or the National Working Group for Leak Detection Evaluators (NWGLDE).

In the case of the Red Hill USTs there are two main issues that make the traditional approach to selecting leak detection more challenging. First, since these USTs are field constructed and not regulated by either state or federal UST regulations there are no pre-approved State listed systems applicable for this site. Secondly, there are basically NO other bulk POL UST systems elsewhere in the world (with the possible exception of the FISC Yokosuka -Hakosaki USTs) that are as large and deep as these tanks. As a result since this is a one of a kind site nobody has undergone NWGLDE listing specifically with these tanks in mind (other than Vista Leak Detection who were paid by the Navy to perform their test and get third party evaluated, but were never listed with the NWGLDE) .

3.1 Historic and Existing Leak Detection at Red Hill

As a first step in identifying potential leak detection system candidates Baker began by looking at the historic and existing systems utilized at Red Hill. This section provides a brief history of the leak-detection systems that have been used in the past. The following Table is a listing of the previously installed or tested systems at Red Hill. A more detailed discussion of the systems follows in the remainder of Section 3.1.

Table 3-1 Historic and Existing Leak Detection Systems at Red Hill					
Technology	**Type of Test**	**Historic or existing**	**Theoretical minimum detectable leak rate**	**Comments**	**Candidate Selected for additional consideration at Red Hill**
Tell Tale System	Continuous	Historic	Unknown	Long term degradation by corrosion made system unusable. Unrealistic to repair system or install new.	No
Asteroid Scientific Comet	Continuous (Point in Time for post operation analysis)	Historic	Unknown	Original system tied to float level gauge system that has been removed. System can be tied to existing GSI ATG system. System can also be used as post operation analytical tool	Yes
Vista Leak Detection LRDP-24-RH	Point in Time	Existing in Tank 9 only	0.59 gal/hr	Third Party Certified to 0.59 gal/hr. For installation tanks must be empty and cleaned.	Yes

Table 3-1 Historic and Existing Leak Detection Systems at Red Hill					
Technology	**Type of Test**	**Historic or existing**	**Theoretical minimum detectable leak rate**	**Comments**	**Candidate Selected for additional consideration at Red Hill**
GSI MTG 3000 ATG System and AFHE Software Interface	Continuous	Existing	¾" change in fluid level	Difficult to determine minimum detectable leak rate. Need to understand if baseline is reset after weekly level data dump and how water draw offs are handled, With adjustments this system may be suitable as a leak detection system. Rigorous third party evaluation would be recommended to assess minimum detectable leak rate.	Yes
Groundwater Monitoring	Point in Time	Existing	Unknown	Not truly a valid form of primary leak detection. Other requirements may necessitate its continued use.	Not as a primary form of leak detection
Under Tank Vapor Monitoring Probes	Point in Time	Existing	Unknown	Effectiveness limited and dependent on probe location and geologic setting.	Not as a primary form of leak detection

3.1.1 Tell Tale System

The USTs at Red Hill were initially equipped with the simplistic “Tell-Tale” systems, which were eliminated from 16 of the 20 tanks because of operational problems. The original Tell-Tale systems consisting of tubes connected to the outer tank walls for visual gauging of oil levels were ineffective because of corrosion and clogging. Repair or retrofitting these systems would be cost prohibitive.

3.1.2 Asteroid Scientific Corporation Comet System

Asteroid Scientific (Asteroid) is a professional systems engineering firm and has a history of inventory control experience at the Red Hill facility. This system is a software package only that is tied to some form of tank gauging provided by others. Their COMET® system can receive data from a combination of level gauging equipment, temperature, and pressure sensors installed within a UST. This data will be used as input to their proprietary software that analyzes the data for leaks.

In 1970 Asteroid installed an inventory control system with a centralized electronic data transfer system. Subsequent improvements were made to the data transfer mechanisms. This system was adversely affected by corrosion and ultimately degraded to the point of being inoperable. The fluid level measurements used in the initial Asteroid system were tied to a basic float system that was ultimately removed/abandoned. The Asteroid system had the ability to analyze tank data from fluid level measurement devices, (either the original float system or the current ATG) off line from transmitted data files and arrive at a leak detection rate. Although the procedure still exists as an option, it is not currently part of the installed software owned or operated by FISC PH.

It is claimed by the manufacturer that the COMET® system can provide a leak detection rate of 0.2 to 0.5 gal/hr using the interface with existing ATG sensors and as long as those sensors provide a minimum level of resolution in level of 1/64th of an inch, and temperature of 0.001°F. No third party certification could be discovered for the COMET® system during the research by Baker personnel.

3.1.3 Vista Leak Detection LRDP

The Low-Range Differential Pressure (LRDP) system is offered by Vista Leak Detection Inc (Vista). This is a mass-based leak detection and monitoring system for bulk USTs and aboveground storage tanks (ASTs). The LRDP can be permanently installed for on-line monitoring and periodic tightness testing, or it can be transported to a site for a one-time tightness test. The performance of interest for Red Hill utilizing the LRDP is specifically tied to a third party evaluation performed in 2001 for the LRDP-24-RH.

In 2001 an evaluation was performed by the Navy on a Vista System. The Vista system is a form of in tank leak detection that utilizes Low-Range Differential Pressure to very accurately measure differential pressures between the product in the tank and a reference tube installed in the tank. A differential pressure can then be tied to a change in product level. In 2001 a leak detection rate of 0.59 gallon per hour (gph) at a 95 percent probability of detection was verified by third-party tests on a prototype of the LRDP-24-RH system in tank 9 at Red Hill. The system was considered to be operationally and cost prohibitive by the Government at that time for installation in all 20 tanks.

3.1.4 Gauging Systems Inc MTG 3000 TGI ATG and AFHE System

In 2001, The Mass Tank Gauging System 3000 (MTG 3000) from Gauging Systems Inc. (GSI) capable of measuring temperature and pressure was installed on all the USTs at Red Hill. This ATG system was tied directly to the Automated Fuel Handling Equipment (AFHE) control system and acts as the fluid level measuring module for that overall control system. The MTG 3000 is both a hybrid and hydrostatic tank gauge. Each tank is fitted with a vertical array of 21 temperature sensors (one every 10 feet) and four pressure sensors (three at the bottom and one in the vapor space). The MTG 3000 system records temperature and pressure in ATG mode, and the software converts these to mass and level. This data is then used in the tank level module of the AFHE system. Reportedly the AFHE system does currently perform a gross leak detection analysis by alerting operators to a change of 0.75” compared to some baseline level measurement.

Although the data from the MTG 3000 was considered suitable for inventory control and gross leak detection within the AFHE system (if properly calibrated), FISC noted certain concerns and limitations with the system as currently configured including the lack of a precision (sub 1.0 gal/hr) leak-detection capability.

In the present configuration the MTG 3000/AFHE system will currently at best alarm at a 0.75" loss in one week; the period which the current AFHE system stores level data. That equates to a minimum detectable leak rate of approximately 23.5 gallons/hr if that loss is over a one week period. This is poor performance for a precision leak detection rate and some adjustment of the AFHE software would be needed to make use of the 1/64" sensitivity of the existing ATG claimed by its manufacturer, GSI. Ultimately if the AFHE system can be modified to detect a leak by a fluid level change of closer to the 1/64" over a time greater than the current one week period theoretically this system could be used for leak detection. It would be highly recommended that such a system be rigorously evaluated by a third party to get an accurate assessment of the true sensitivity of the minimum detectable leak rate.

Because of the variety of existing sensors, AFHE equipment, and ATGs that currently exist, FISC's initial hope was to utilize the existing ATG and AFHE equipment for leak detection. The goal would be to monitor liquid levels in the tank with the ATG/AFHE equipment and with post operation analyses performed by Asteroid (either on-site with government lease/purchase of the software or with off-site analysis through some other contracting method) verify any suspected leaks.

3.1.5 Groundwater Monitoring

Both potable groundwater supply wells and groundwater monitoring wells are located in the vicinity of the Red Hill storage tanks. While these are routinely sampled and analyzed for petroleum products which does constitute a form of "outside the tank" leak detection it should not be considered a primary solution for leak detection of these tanks.

3.1.6 Under Tank Vapor Monitoring Probes

Currently 17 of the active 18 Bulk USTs are equipped with simple form of leak detection consisting of under tank vapor monitoring probes. The final probe array is scheduled to be installed in summer 2008. This system relies on permanent installation of probes installed beneath the USTs that are used as vapor sampling locations. The theory of this system as that any leaked product will travel to the monitoring probes and an increase in concentration of petroleum product vapor in the soil vapor sample can be detected with an electronic monitoring device. This is currently being performed as point in time testing on a monthly frequency.

In theory this system is similar to soil vapor monitoring systems used at many gas station to comply with the requirements of leak detection under 40 CFR 280 or the use of Tell-Tale piping under Bulk ASTs. The main drawback however to this system as that the geologic setting for the probe array locations is unknown and highly suspect. To work adequately soil vapor monitoring probes must be installed in a location conducive to the transport of the leaked petroleum product directly to the monitoring probe array. While the actual geologic setting of the Red Hill system is unknown it seems unlikely to be a homogeneous, highly porous soil capable of allowing transport of product to the monitoring probes. Verification of the adequate operation of this system appears impossible and it should not be relied upon as a primary source of leak detection.

3.2 NWGLDE Listed Bulk UST Leak Detection Systems

As the second step in identifying potential candidates Baker utilized the National Working Group for Leak Detection Evaluators. The NWGLDE is an organization of State and Federal environmental regulators who are actively managing leak detection system third party certifications. After a potential leak detection system vendor has undergone rigorous third party evaluation it can petition for listing on the NWGLDE. This credential is extremely important when selecting a leak detection system as it validates the claims made by leak detection system manufacturers or vendors.

Baker searched the NWGLDE listings for theoretically appropriate leak detection solutions for bulk UST systems. Table 3-2 depicts the search results.

While many of the bulk UST systems listed with the NWGLDE are not bound by an upper tank capacity or product depth, it is unlikely that anyone considered the Red Hill tanks when listing them with the NWGLDE. This is not realistic, as several of the methods rely on factors that would be affected by the extreme depth of the product. Since the industry that the NWGLDE serves does not have bulk USTs the size (depth) of Red Hill it is understandable that they did not specifically consider this in their listing.

Its Baker's opinion that many of them will not work at Red Hill as listed. There are others that do show promise and that should be reevaluated for the Red Hill tanks specifically. The systems are listed as applicable with no upper threshold of product depth and are certified but may in fact need modifications to the equipment to work under the conditions at Red Hill. These are systems of greatest interest to this Market Survey and are evaluated in more detail in the remainder of this document.

Table 3-2 NWGLDE Listing for Bulk UST Leak Detection Systems					
Vendor	**Test Method & Test Type**	**Leak Rate/Threshold/Max Product Surface Area**	**Theoretical Applicability to Red Hill**	**Realistic Applicability to Red Hill**	**Selected for additional consideration**
ASTTest Services, Inc.	ASTTest Mass Balance Leak Detection System Continuous Test Method	[(product surface area in ft^2 ÷ 5,575 ft^2) x 0.88 gph]/ [(product surface area in ft^2 ÷ 5,575 ft^2) x 0.44 gph]/13,938 ft^2.	Applicable with theoretical anticipated leak rate of 1.35 gal/hr	No information available for vendor. May no longer be available. "Probe" installations generally require the tank to be cleaned and emptied.	No
Engineering Design Group, Inc.	EDG XLD 2000 Plus (Revision 1.02) Leak Detection System (MTS DDA Magnetostrictive Probe) Continuous Test Method	[(product surface area in ft^2 ÷ 12,074 ft^2) x 1.92 gph]/ [(product surface area in ft^2 ÷ 12,074 ft^2) x 0.96 gph]/12,076 ft^2.	Not applicable- Red Hill tanks too large	N/A	No
Engineering Design Group, Inc.	Ronan X-76 CTM Automatic Tank Gauging System (MTS Level Plus UST Probe) (Continuous Test Method)	[(product surface area in ft^2 ÷ 564 ft^2) x 0.2 gph]/ [(product surface area in ft^2 ÷ 564 ft^2) x 0.96 gph]/846 ft^2.	Not applicable- Red Hill tanks too large	N/A	No

Table 3-2 NWGLDE Listing for Bulk UST Leak Detection Systems					
Vendor	**Test Method & Test Type**	**Leak Rate/Threshold/Max Product Surface Area**	**Theoretical Applicability to Red Hill**	**Realistic Applicability to Red Hill**	**Selected for additional consideration**
Leak Detection Technologies, LLC (Listed separately not in Bulk UST section)	MDleak Enhanced Leak Detection Method (Point in Time Test method)	0.05 gph/ A tank system should not be declared tight when tracer chemical or hydrocarbon greater that the background level is detected outside of the tank. Not limited by capacity.	Not applicable- Impossible to array probes appropriately and non-homogenous backfill outside parameters of method applicability	N/A	No
MassTechnology Corp.	Precision Mass Measurement System (24 hr test) (Point in Time Test Method)	[(product surface area in ft² ÷ 1,257 ft²) x 0.1 gph]/[(product surface area in ft² ÷ 1,257 ft²) x 0.05 gph]/3,143 ft².	Not applicable- Red Hill tanks too large	N/A	No
Mass Technology Corp.	Precision Mass Measurement System (48 hr test) (Point in Time Test Method)	[(product surface area in ft² ÷ 6,082 ft²) x 0.294 gph]/[(product surface area in ft² ÷ 6,082 ft²) x 0.147 gph]/6,082 ft².	Not applicable- Red Hill tanks too large	N/A	No

Table 3-2 NWGLDE Listing for Bulk UST Leak Detection Systems					
Vendor	**Test Method & Test Type**	**Leak Rate/Threshold/Max Product Surface Area**	**Theoretical Applicability to Red Hill**	**Realistic Applicability to Red Hill**	**Selected for additional consideration**
Mass Technology Corp.	Precision Mass Measurement System (72 hr test) (Point in Time Test Method)	[(product surface area in ft^2 ÷ 14,200 ft^2) x 0.638 gph]/[(product surface area in ft^2 ÷ 14,200 ft^2) x 0.319 gph]/35,500 ft^2.	Applicable with theoretical anticipated leak rate of 0.2 gal/hr	Due to extreme depth of tank leak a different pressure transducer is needed than original system. Theoretical results with this equipment is 0.5-0.6 gal/hr	Yes
Praxair Services, Inc. (originally listed as Tracer Research, Corp.)	Tracer ALD 2000 Automated Tank Tightness Test (Continuous Test Method)	0.05 to 0.1 gph/ A tank system should not be declared tight when tracer chemical or hydrocarbon greater that the background level is detected outside of the tank./Not limited by capacity.	Not applicable- Impossible to array probes appropriately and non-homogenous backfill outside parameters of method applicability	N/A	No

Table 3-2 NWGLDE Listing for Bulk UST Leak Detection Systems					
Vendor	**Test Method & Test Type**	**Leak Rate/Threshold/Max Product Surface Area**	**Theoretical Applicability to Red Hill**	**Realistic Applicability to Red Hill**	**Selected for additional consideration**
Praxair Services, Inc. (originally listed as Tracer Research, Corp.) (Listed separately not in Bulk UST section)	Non-Volumetric Tank Tightness Test Method (Point in Time Test Method)	0.05 to 0.1 gph/ A tank system should not be declared tight when tracer chemical or hydrocarbon greater that the background level is detected outside of the tank./Not limited by capacity.	Not applicable- Impossible to array probes appropriately and non-homogenous backfill outside parameters of method applicability	N/A	No
Universal Sensors and Devices, Inc.	LTC-1000 (Mass Buoyancy Probe) (Continuous Test Method)	[(product surface area in ft^2 ÷ 14,244 ft^2) x 1.4 gph]/[(product surface area in ft^2 ÷ 14,244 ft^2) x 0.7 gph]/35,610 ft^2.	Applicable with theoretical anticipated leak rate of 0.42 gal/hr	No information available for vendor. May no longer be available "Probe" installations generally require the tank to be cleaned and emptied.	No

Table 3-2 NWGLDE Listing for Bulk UST Leak Detection Systems					
Vendor	**Test Method & Test Type**	**Leak Rate/Threshold/Max Product Surface Area**	**Theoretical Applicability to Red Hill**	**Realistic Applicability to Red Hill**	**Selected for additional consideration**
Universal Sensors and Devices, Inc.	LTC-2000 (Differential Pressure Probe) (Continuous Test Method)	[(product surface area in ft^2 ÷ 14,244 ft^2) x 3.0 gph]/[(product surface area in ft^2 ÷ 14,244 ft^2) x 1.5 gph]/35,610 ft^2.	Applicable with theoretical anticipated leak rate of 0.90 gal/hr	No information available for vendor. May no longer be available. "Probe" installations generally require the tank to be cleaned & emptied.	No

Table 3-2 NWGLDE Listing for Bulk UST Leak Detection Systems					
Vendor	**Test Method & Test Type**	**Leak Rate/Threshold/Max Product Surface Area**	**Theoretical Applicability to Red Hill**	**Realistic Applicability to Red Hill**	**Selected for additional consideration**
Varec, Inc. (originally listed as Coggins Systems, Inc., and later as Endress + Hauser Systems and Gauging)	Fuels Manager and Remote Terminal Unit (RTU/8130) (MTS Magnetostrictive Probe) (Continuous Test Method)	[(product surface area in ft² ÷ 616 ft²) x 0.2 gph]/[(product surface area in ft² ÷ 616 ft²) x 0.1 gph]/924 ft².	Not applicable- Red Hill tanks too large	N/A	No
Varec, Inc. (originally listed as Coggins Systems, Inc., and later as Endress + Hauser Systems and Gauging)	Leak Manager with Barton Series 3500 ATG (48 hour test) (72 hour test) (Continuous Test Method)	[(product surface area in ft² ÷ 6,082 ft²) x 2.0 gph]/[(product surface area in ft² ÷ 6,082 ft²) x 1.0 gph]/15,205 ft².	Applicable with theoretical anticipated leak rate of 1.40 gal/hr	This system is in use at many DOD facilities. Varec is currently studying this software with next generation ENRAF gauges for better sensitivity.	Yes, but with newer ENRAF B.V. Gauges for improved sensitivity.
Vista Research, Inc. and Naval Facilities Engineering Service Center	LRDP-24 (V1.0.2, V1.0.3) (Point in Time Test Method)	[(product surface area in ft² ÷ 6,082 ft²) x 2.0 or 3.0 gph]/[(product surface area in ft² ÷ 6,082 ft²) x (2.0 or 3.0 gph - 0.223 gph)]/15,205 ft².	Applicable with theoretical anticipated leak rate of 2.58 gal/hr	Actual Third party evaluation testing performed on Tank 9 with LRDP-24-RH achieved leak rate of 0.59 gal/hr	Yes, but with LRDP-24-RH with third party certified leak rate of 0.59 gal/hr

Table 3-2 NWGLDE Listing for Bulk UST Leak Detection Systems					
Vendor	**Test Method & Test Type**	**Leak Rate/Threshold/Max Product Surface Area**	**Theoretical Applicability to Red Hill**	**Realistic Applicability to Red Hill**	**Selected for additional consideration**
Vista Research, Inc. and Naval Facilities Engineering Service Center	LRDP-48 (V1.0.2, V1.0.3) (Point in Time Test Method)	[(product surface area in ft^2 ÷ 6,082 ft^2) x 2.0 or 3.0 gph]/[(product surface area in ft^2 ÷ 6,082 ft^2) x (2.0 or 3.0 gph - 0.188 gph)]/15,205 ft^2.	Applicable with theoretical anticipated leak rate of 2.62 gal/hr	Actual Third party evaluation testing performed on Tank 9 with LRDP-24-RH achieved leak rate of 0.59 gal/hr	Yes, but with LRDP-24-RH with third party certified leak rate of 0.59 gal/hr
Vista Research, Inc. and Naval Facilities Engineering Service Center	LRDP-24 (V1.1) (Point in Time Test Method)	[(product surface area in ft^2 ÷ 6,082 ft^2) x 0.856 gph]/[(product surface area in ft^2 ÷ 6,082 ft^2) x 0.632 gph]/15,205 ft^2.	Applicable with theoretical anticipated leak rate of 0.89 gal/hr	Actual Third party evaluation testing performed on Tank 9 with LRDP-24-RH achieved leak rate of 0.59 gal/hr	Yes, but with LRDP-24-RH with third party certified leak rate of 0.59 gal/hr
Vista Research, Inc. and Naval Facilities Engineering Service Center	LRDP-48 (V1.1) (Point in Time Test Method)	[(product surface area in ft^2 ÷ 6,082 ft^2) x 0.749 gph]/[(product surface area in ft^2 ÷ 6,082 ft^2) x 0.563 gph]/15,205 ft^2.	Applicable with theoretical anticipated leak rate of 0.80 gal/hr	Actual Third party evaluation testing performed on Tank 9 with LRDP-24-RH achieved leak rate of 0.59 gal/hr	Yes, but with LRDP-24-RH with third party certified leak rate of 0.59 gal/hr

A few clarifications are required for the results shown in Table 3-2. First, Vista's Third Party Certification for the LRDP-24-RH is included in Appendix A. This is not listed on the NWGLDE as it only applies to these tanks and in a discussion with Vista it was reported that it was not worth the cost or effort to list them on the NWGLDE.

Secondly, several of the systems are listed as applicable with no upper threshold of product depth. This is not realistic as several of the methods rely on factors that would be affected by the depth of the product. Since the industry that this group serves does not have bulk USTs the size (depth) of Red Hill it is understandable that they did not specify consider this in their listing. Table 3-2 lists systems that are certified, but may in fact need modifications to the equipment to work in under the conditions at Red Hill.

3.2.1 Mass Technology Corporation

The Mass Technology Corporation (MTC) *Mass Technology Precision Mass Measurement System* (MTPMMS) measures the differential pressure between one point at the bottom of the contained fluid and another point in the vapor space immediately above the fluid surface. The pressure at or near the bottom of the tank corresponds to the mass above the measuring point and independent of liquid level changes caused by the thermal expansion and contraction of the product under test.[1] It is a field-proven and third-party certified technology. It is claimed that a leakage rate of 0.8 gph in a tank of 100,000 barrel capacity can be detected by their technology.

Mass Technology Corporation's system is a third party certified system that would need some enhancements to work in the deeper tanks of Red Hill. Since the third party system generally operates on traditional cut/cover USTs the deeper Red Hill USTs would require the system to be upgraded to deal with the higher pressures associated with these deeper than usual tanks. While the theories and technology are identical to their standard third party certified test a newer pressure transducer would be required and it is not exactly clear whether this change to the MTC test equipment "invalidates" the third party certification or if it would just be considered an "enhancement" necessary for a test at this depth.

---

[1] H. Kendall Wilcox, *Evaluation of the Mass Technology Precision Mass Measurement System on Bulk Field-Constructed Tanks (2,000,000 Gallon Vertical Tank Evaluation)*
http://www.kwaleak.com/certifications/Mass%20Technology_Bulk%20Tank_1998_03_25.pdf
March 1998

3.2.2 Varec Leak Manager and ITT Barton 3500 Gauge

Varec's Leak Manger software and Barton 3500 ATG is used in some DOD installations to perform leak detection for Bulk storage tank systems. The Varec software utilizes the ATG data to determine if a tank is leaking. The use of Varec's Leak Manager Software coupled with the ITT Barton 3500 gauge is another such system that would probably need modification given the depth of these USTs. Therefore Baker would suggest that instead of researching this system it would make better sense to research the next generation of this technology which is the Leak Manager Software coupled with an Enraf B.V. ATG. This new system is undergoing third party evaluation on bulk cut/cover USTs at FISC Point Loma. See Section 3.3.3 for a discussion of this new technology.

3.2.3 Vista Leak Detection Systems

Vista has several leak detection systems listed on the NWGLDE. However, the one most applicable to Red Hill is the system that was tested and third party certified on Red Hill Tank 9 in 2001. This is discussed in Section 3.1.3

3.3 Innovative and State of the Art Leak Detection Systems

In addition to the historic leak detection systems and those identified in an initial candidate search of the NWGLDE, Baker researched other potential candidates. These are typically systems that are either new to the leak detection industry and do not yet see the benefit of being listed or are vendors that have similar systems already in use and listed, but are developing new systems that are not yet fully third party evaluated.

The following listed in Table 3-3 were identified as innovative or state of the art and warrant further technological evaluation.

Table 3-3 Innovative or State of the Art Leak Detection Systems				
Vendor	**System**	**Test Type & Theoretical minimum detectable leak rate**	**Comments**	**Candidate Selected for additional consideration at Red Hill**
hydroGEOPHYISICS	HRR-LDM	Continuous Test Unknown Leak Rate	Unable to obtain copy of third party evaluation to determine applicability to Red Hill Site	Yes
Gauging Systems Inc.	MTG 3012 Multi-function Tank Gauge	Continuous Test Unknown Leak Rate	Next Generation of existing tank gauge system already installed at Red Hill coupled with the components needed to make a stand alone leak detection system. MTG is a third party certified Gauge by another independent evaluation group.	Yes
Varec, Inc.	FuelsManager with Enraf 854 ATG (Servo Buoyancy Probe)	Continuous Test 2.17 gal/hr	Next generation of Leak Manager system used widely in DOD. Third Party certification Pending. Like all probe and gauge systems construction and sensitivity at Red Hill site maybe an issue.	Yes
Varec, Inc.	Fuels Manager with MTS M-Series ATG (MTS Magnetostrictive Probe)	Continuous Test 3.25 gal/hr	Next generation of Leak Manager system used widely in DOD. Third Party certification Pending. Not as promising as Enraf 854 ATG system.	No

3.3.1 hydroGeophysics HRR-LDM

High Resolution Resistivity-Leak Detection and Monitoring (HRR-LDM), a new methodology developed by hydroGEOPHYSICS, Inc. (HGI), was performance evaluated during a three-month EPA-guided test at a mock tank site in the Hanford 200E Area, Richland, WA. HGI has been working very closely with CH2M-Hill Group in successfully applying ex-situ approaches to leak detection based on geophysical resistivity methods at the Hanford Site in Southeast Washington. HGI is using their leak detection methods to perform real-time monitoring at several large single-shell storage tanks containing high-level radioactive wastes that have capacities of on the order of about 1 million gallons of waste each. They are familiar with the Red Hill facility having been involved in the preparation of proposals of how their methods could be applied to the Red Hill facility in response to a solicitation in the 2004.

3.3.2 GSI MTG 3012 Multi-function Tank Gauge

In its current configuration, the existing GSI MTG 3000 ATG system itself does not perform leak detection, but rather works with the AFHE system to perform a form of leak detection. Gauging Systems Inc has tested and developed several improvements to the algorithms, sensor housings, transducers, transmitter cards and the system programs (RH calc) since the existing installation. The *MTG 3012 Multi-function Tank Gauge* provides both quantitative and qualitative measurement of product. Increased resolution and stability would be required of the existing ATG sensor array readouts and data transfer system, as well as high resolution level measurement, appropriate analytical software and a user interface for a certifiable leak detection system. The MTG™ (tank gauge) is third party certified for leak detection (Mass sensitivity) by IOML (International Organization of Legal Metrology) R-125 for “Measuring systems for the mass of liquids in storage tanks”.[2]

3.3.3 Varec Leak Manager with Enraf 854 ATG (Servo Buoyancy Probe)

As identified in Section 3.2.2 Varec’s Leak Manger software is used in some DOD installations to perform leak detection for Bulk storage tank systems. The software is tied to ATG data

[2] *MTG™ 3012 "Multi-function Tank Gauge,* http://www.gaugingsystemsinc.com/article.cfm?id=100

determine if a tank is leaking or not. All Varec leak Manager systems are therefore tied to the sensitivity of the ATG in use at the site. In order to increase the sensitivity of the MDLR of the Leak Manager systems Varec has gone to newer generation ATGs than the ITT Barton 3500s described in Section 3.2.2. The remainder of this section discusses the system utilizing the Enraf Enraf 854 ATG (Servo Buoyancy Probe)

Enraf B.V. specializes in the development, manufacture, and support of the precision instrumentation and software for bulk storage management. Enraf B.V. provides products that utilize level and hydrostatic gauging. Temperature sensors and radar level gauges are also used to complement the inventory measurement.

In a telephone conversation between Baker Personnel (J.C. Davis, 2008) with Tom Graves, Enraf B.V., he indicated that Enraf B.V., and Varec® are conducting a leak detection test at Point Loma DFSP to obtain data for third party certification. At the time of the conversation, the test was completed and the results were submitted to the NWGLDE, but official listing on by the work group was not available at the time of this report date.

On 06 June 2008 Baker was provided with a copy of the draft NWGLDE listing of this system. This listing is provided in Appendix C and indicates that the third party certified minimum detectable leak rate (MDLR) for this system will be tied to the product surface area. According to this proposed NWGLDE listing the MDLR for the Red Hill USTs would be approximately 2.17 gal/hr. However, the major issue with this proposed listing is that it identifies a maximum tank size as 2,100,000 gallons and therefore the applicability of this system at Red Hill is highly questionable. Additional testing and third party certification of this system specifically for Red Hill would be required to make a decision as to the actual MDLR on these tanks.

3.3.4 Varec Leak Manager with MTS M-Series ATG (Magnetostrictive Probe)

In addition to the Leak Manger and Enraf 854 ATG leak detection system Varec has also recently submitted another Leak Manger and ATG system to the NWGLDE for listing. This system utilizes the MTS M-Series ATG. The draft NWGLDE listing is presented in Appendix C. This system appears to be both less sensitive and more problematic to install than the Enraf 854 gauge described in Section 3.3.3. It appears from the draft listing that a sensor pipe must be installed in the tank and it must be maintained annually. Additionally temperature sensors must be installed on 18 inch centers from the bottom of the tank. It would appear that of the two new Varec Leak Manager systems the MTS ATG system is a less desirable candidate than the Enraf system. No further evaluation should be considered.

3.4 Initial Candidate Selection Summary

In the previous sections Baker has considered the historic, NWGLDE listed, and innovative/state of the art leak detection solutions with potential at Red Hill. Table 3-4 is a summary of those technologies that warrant further evaluation due to their perceived applicability to this unique challenge.

Table 3-4 Initial Candidate Selection Summary				
Vendor	**System**	**Test Type**	**Theoretical minimum detectable leak rate**	**Comments**
Asteroid Scientific	Comet	Continuous (Point in Time for post operation analysis)	Unknown	Original system tied to float level gauge system that has been removed. System can be tied to existing GSI ATG system. System can also be used as post operation analytical tool
Vista Leak Detection	LRDP-24-RH	Point in Time	0.59 gal/hr	Third Party Certified to 0.59 gal/hr. For installation tanks must be empty and cleaned. Coordination with existing tank structures needed.

Table 3-4 Initial Candidate Selection Summary				
Vendor	**System**	**Test Type**	**Theoretical minimum detectable leak rate**	**Comments**
Gauging Systems Inc ATG System and AFHE Software Interface	MTG 3000 and AFHE Existing system	Continuous	Unknown Tied to MTG accuracy	Difficult to determine minimum detectable leak rate. Need to understand if baseline is reset after weekly level data dump and how water draw offs are handled, With adjustments this system may be Suitable as a leak detection system. Rigorous third party evaluation would be recommended to assess minimum detectable leak rate.
Mass Technology Corp.	Precision Mass Measurement System	Point in Time	anticipated leak rate of 0.5 gal/hr	Due to extreme depth of tank leak a different pressure transducer is needed than original system. Theoretical results with this equipment is 0.5-0.6 gal/hr Simple to perform with no in tank construction needed for testing

Table 3-4 Initial Candidate Selection Summary				
Vendor	**System**	**Test Type**	**Theoretical minimum detectable leak rate**	**Comments**
Varec, Inc.	FuelsManager with Enraf 854 ATG (Servo Buoyancy Probe)	Continuous Test	2.17 gal/hr	Next generation of Leak Manager system used widely in DOD. Third Party certification Pending and is not applicable to tanks the size of the Red Hill USTs Like all probe and gauge systems construction and sensitivity at Red Hill site may be an issue. Coordination with existing tank structures needed.
hydroGEOPHYISICS	HRRLDM	Continuous Test	Unknown Leak Rate	Unable to obtain copy of third party evaluation to determine applicability to Red Hill Site

Table 3-4 Initial Candidate Selection Summary				
Vendor	**System**	**Test Type**	**Theoretical minimum detectable leak rate**	**Comments**
Gauging Systems Inc.	MTG 3012 Multi-function Tank Gauge	Continuous Test	Unknown Leak Rate	Next Generation of existing tank gauge system already installed at Red Hill coupled with the components needed to make a stand alone leak detection system. Coordination with existing tank structures needed. MTG is a third party certified Gauge by another independent evaluation group.

4 Evaluation Criteria

A decision matrix will be used to aid in the selection of the most appropriate technology for further consideration. A decision matrix is a chart that allows a team or individual to systematically identify, analyze, and rate the strength of relationships between sets of information. The matrix is especially useful for looking at large numbers of decision factors and assessing each factor's relative importance. The evaluation criteria described in the following paragraphs will be used in the decision matrix chart.

Each criterion will be assigned a weight to demonstrate the relative importance of each function. Leak rate sensitivity and third party certification have been assigned the highest weight of 5 since they have a combined effect on a system evaluation. Instrument reliability was given a weight of 3 to demonstrate the importance consistency of the leak detection system. The remaining criterion was determined to be important to include in the matrix but have the lowest value of 2 assigned. The following criteria will be used in the decision matrix:

- Third party certification- Ensure that the leak detection systems under review meet EPA and/or other regulatory performance standards

- Leak rate sensitivity- Quantify the minimum detection leak rate

- Compatibility with existing MTG-3000 and/or existing AFHE® system- Optimize and refine the existing ATG inventory and control system to better meet the goals of a leak detection system that is protective of the environment and human health.

- Instrument reliability- Define and quantify instrument accuracy and service life

- Customer support & reliability- Identify the effort required to train facility operators and perform scheduled leak detection tests.

- System installation- Define the level of difficulty to install the leak detection system in the unique UST environment.

A rank-order for all options will be given according to how well each meets the criterion, with 1 being the option that is least desirable according to that criterion. Multiply each option's rating by the weight. Add the points for each option. The option with the highest score will not necessarily be the one to choose, but the relative scores can generate meaningful discussion.

5 Evaluation

This section evaluates each methodology by each criterion and provides a discussion of the system parameters.

5.1 Asteroid Scientific Comet Software with existing ATG

	3rd party certification	Leak Rate sensitivity	Compatibility with MTG/AFHE	Instrument Reliability	Customer Support	System Installation
Weight	5	5	2	3	2	2
Score	0	3	1	1	0	2

The COMET system has not been certified by an independent third party evaluator and receives the lowest score in this column. Asteroid claims that the COMET system is capable of detecting leaks at the 0.2 to 0.5 gallons per hour leak rate on a monthly basis. This rate will obviously depend on the ATG and other hardware that the software utilizes for liquid level measurements. The quoted leak rate values are based on theoretical inputs that may not be possible to achieve in practical implementation and without the third party certification this leak rate is unproven. Also the probability of detection, usually 95% for certified leak detection systems was not published and cannot be verified.

A request for information was sent via email from Baker to Asteroid for a technological description, but no response was provided and repeated phone messages were not returned. The request for information contained questions regarding the COMET leak detection system and inquired about measurement inputs. The reliability of the COMET system is unknown and cannot be determined without feedback from Asteroid.

The compatibility with the MTG to provide the necessary level data to compute leak detection is valid, but integration to the AFHE system appears problematic. This gained them a score of 1 in this category. The Customer Support criterion was given a low score based on their lack of response to the questionnaire and the critical tone of their website to the Red Hill leak detection effort.

If this software upgrade were to be utilized with the existing ATG system it would be a straightforward installation process gaining them a maximum score in this category.

5.2 Vista Leak Detection, Inc LRDP-24-RH

	3rd party certification	Leak Rate sensitivity	Compatibility with MTG/AFHE	Instrument Reliability	Customer Support	System Installation
Weight	5	5	2	3	2	2
Score	5	5	1	3	1	0

Vista Leak Detection developed the Low Range Differential Pressure (LRDP-24-RH) for the Red Hill facility and performed a pilot test in June and August of 2001. A third party evaluation was performed during the test and a Minimum Detectable Leak Rate of 0.59 gallons per hour was determined. Although the Vista technology is not compatible with the MTG gauging system, reliability is satisfactory based upon Baker's observations with Vista's technology. The most significant drawback to this alternative is the installation difficulty. The key component of the LRDP is the vertical "reference" tube, which spans the full usable height of the tank. This installation requires that the tank be emptied and taken out of service and coordination with existing tank structures is required.

While there is no apparent way to integrate a Vista Leak Detection system with the ATG/AFHE it would be possible to utilize the existing data transfer (fiber optic) system to get data the Pearl Harbor FISC control center. This gives them a score of 1 for this category.

Vista has performed integrity testing and leak detection services for the DOD for several years with adequate success. However, company realignments and staffing has caused reduced customer service focus in the last few years earning them a reduced score in this category.

5.3 Gauging System Inc. MTG 3000 and AFHE System (existing)

	3rd party certification	Leak Rate sensitivity	Compatibility with MTG/AFHE	Instrument Reliability	Customer Support	System Installation
Weight	5	5	2	3	2	2
Score	1	2	2	3	2	2

The Tank Gauging System at Red Hill is a hybrid MTG 3000, and has been certified by the International Organization of Legal Metrology (OIML) for "Measuring system for the mass of liquids in storage tanks". It was installed under a proof of concept contract and later expanded to the remainder of the Red Hill tanks. This system is coupled with the AFHE control system installed under Space and Naval Warfare Command (SPAWAR) oversight.

A minimal score for the third party certification was given since even though the MTG itself is certified (albeit the certification does not follow U.S. EPA regulatory performance standards) the entire existing Leak Detection system is really run by the AFHE system and this combination has not been third party certified. Additionally the "hybrid" caveat to the nomenclature of the MTG suggests that this system, like most ATG systems, was not evaluated on a tank of the size of the Red Hill USTs leading to the questioning of the validity of the third party certification.

The existing leak rate sensitivity for the GSI MTG 3000 coupled with the AFHE system is reportedly based on a product level change of 0.75". It is unclear at the facility how this level change is effected by the routine weekly purging of the level data files or such operational parameters as water draw-off. If the level change is directly tied to the starting level data for the week then the minimum detectable leak rate would be nearly 24 gal/hr over the week (0.75" level change in one week). This is relatively poor performance.

The compatibility with the existing MTG equipment is excellent although in a conversation with GSI representatives, the existing industrial PC and software (RH calc) are old and in need of upgrading. Instrument reliability was given high marks since it has not moving parts and has only one electrical connection and point of maintenance. Customer Service was also given a high rating based on availability and product documentation for GSI and the involvement of SPAWARS for the AFHE interface.

This system is currently installed and the upgrades could be performed on both the ATG and the AFHE software that could improve the overall capabilities of this system.

5.4 Mass Technology Corporation MTPMMS

	3rd party certification	Leak Rate sensitivity	Compatibility with MTG/AFHE	Instrument Reliability	Customer Support	System Installation
Weight	5	5	2	3	2	2
Score	4	5	1	3	2	2

Mass Technology Corporation MTPMMS has received third party certification for bulk UST leak detection from Ken Wilcox Associates in accordance with U.S. EPA protocols and is listed on the NWGLDE. Modification to the test equipment is necessary to deal with the greater pressures associated with testing these deeper than usual USTs and therefore it is somewhat questionable as to whether the third party certification is completely valid. Since the theories and technologies used are still the same as the initially certified system it is Bakers opinion that the third party remains valid even given this change of component and therefore a score of 4 was assigned. To achieve a score of 5 and certainly before the Government were to implement this technology as a primary form of leak detection it would be recommended that the upgraded system be third party evaluated specifically for the Red Hill site.

As part of this Market Survey Baker and MTC performed a Pilot Test of this modified system on two if the Red Hill USTs in February 2008. The results of this test were that no leaks above the minimum detectable leak rate of 0.5 gal/hr were noted on Tank 9 for a 10 day test or tank 15 for a

5 day test. The test reports and supporting Baker Trip Report for the MTC testing of tanks 9 and 15 are included in Appendix B.

The Mass Technology and MTG/AFHE equipment are not compatible. However, if a permanent MTC system were to be installed at Red Hill the existing data transfer system (fiber optics) could be utilized gaining them minimum score in this category. The reliability of Mass Technology is good due to the non-intrusive, non-hazardous safe operation. The test is not dependant on temperature and requires a short stabilization time. Customer support has been very responsive to DESC on their Centrally Managed Integrity Testing Program. System installation is given a top rating due to the single point of entry and easy retrieval. No tank cleaning is required for test equipment installation.

5.5 Varec Leak Manager Software and Enraf 854 ATG

	3rd party certification	Leak Rate sensitivity	Compatibility with MTG/AFHE	Instrument Reliability	Customer Support	System Installation
Weight	5	5	2	3	2	2
Score	3	3	1	2	2	0

Enraf B.V is the supplier of the high precision instrumentation and software for bulk storage operations, but does not provide leak detection software. The Enraf instrumentation can be used as the data input necessary for third party certified software to obtain leak detection. The Varec Leak Manager is PC-based software used to process probe data. This combination was recently evaluated on standard cut/cover USTs to become a third party certified leak detection system. This third party certification is valid only to tanks of 2.1 million gallons and therefore is not applicable to the unique USTs at the Red Hill site. It is possible that further testing could be perform to get this system certified on these unique tanks to get a validated, third party certified leak rate. This outstanding question results in a reduced score in the first two categories being evaluated.

While there is no apparent way to integrate the ENRAF/Varec system with the MTG/AFHE it would be possible to utilize the existing data transfer (fiber optic) system to get data the Pearl Harbor FISC control center. This gives them a score of 1 for this category. Both Enraf and Varec are known and utilized by the Department of Defense in gauging and leak detection capacities and therefore this system receives favorable scores in customer support.

Although historically systems produced by these companies are reliable the actual Instrument Reliability for such a new technology is not known and therefore receives a reduced score. Installation of most any ATG system in these USTs is problematic and may even require the emptying and cleaning of the tanks and therefore a minimal score is given for this type of application.

5.6 hydroGEOPHYSICS HRR-LDM

	3rd party certification	Leak Rate sensitivity	Compatibility with MTG/AFHE	Instrument Reliability	Customer Support	System Installation
Weight	5	5	2	3	2	2
Score	0	2	1	3	2	1

This technology was performance tested at the Hanford Site, WA but has not received an independent third party certification and cannot provide precise leak rate sensitivity. Due to the fact that the technology is ex-situ, compatibility with the existing MTG is non-existent. Their reliability and support was given a high score since they have been performance tested at the Hanford Site. hydroGEOPHYSICS is familiar with the Red Hill facility and has submitted proposals for installation of a High Resolution Resistivity-Leak Detection and Monitoring (HRR-LDM) at Red Hill in 2004.

While there is no apparent way to integrate a hydroGeophysics system with the MTG/AFHE it would be possible to utilize the existing data transfer (fiber optic) system to get data the Pearl Harbor FISC control center. This gives them a score of 1 for this category.

Ex-situ installation of any system in the Red Hill area would most likely be very problematic, but since it does not involve emptying the USTs it receives a moderate score in the System Installation category. The installation of the system electrodes will also depend on electrical interference with normal facility operations.

5.7 Gauging System Inc. MTG 3012 with Stand alone Leak Detection

	3rd party certification	Leak Rate sensitivity	Compatibility with MTG/AFHE	Instrument Reliability	Customer Support	System Installation
Weight	5	5	2	3	2	2
Score	3	3	1	2	2	0

The GSI MTG 3012 is a next generation ATG system with stand alone leak detection system capability. Gauging Systems Inc has tested and developed several improvements to the algorithms, sensor housings, transducers, transmitter cards and the system programs (RH calc) since the existing MTG 3000 installation.

Since increased resolution and stability would be required of the existing MTG-TGI sensor array readouts and data transfer system, as well as high resolution level measurement, appropriate analytical software and a user interface for a certifiable leak detection system this essentially is a new installation of an ATG system similar to what is currently installed (albeit with stand alone leak detection capability). As stated previously the installation of any improved ATG probes is difficult leading to a minimal score in the installation category.

The MTG™ 3012 (tank gauge) is third party certified for leak detection (Mass sensitivity) by IOML (International Organization of Legal Metrology) R-125 for “Measuring systems for the mass of liquids in storage tanks”.[3] The leak rate sensitivity has been tested to 0.9 gph over a 24 hour period and 0.49 gph over a 72 hour period, but without following the U.S. EPA regulatory

[3] *MTG™ 3012 "Multi-function Tank Gauge,* http://www.gaugingsystemsinc.com/article.cfm?id=100

performance standards nor in tanks the depth of the Red Hill USTs. This gains them a moderate score in the categories of leak rate sensitivity and third party certification.

Instrument reliability was given high marks since it has not moving parts and has only one electrical connection and point of maintenance. Customer Service was also given a high rating based on availability and product documentation.

5.8 Evaluation of Comparative Costs

This Market Survey has focused on the technical merits of the individual systems to gauge the relative potential for successful implementation of a leak detection system. It is however important to also discuss the relative costs of these systems. This will aid in selecting which systems to consider for further evaluation.

It should be noted that possibly the most significant factor in the cost to install leak detection systems on these USTs comes in the emptying and cleaning costs. Some of the solutions presented are some form of ATG that would require construction inside the tanks. Obviously in order to do this the tanks need to be emptied, cleaned and made safe for worker entry. In addition any of the gauging systems would have to consider the coordination of existing structures within the tank such as ladders/elevators, stilling wells, etc. Any system requiring this type of installation will be judged as being a relatively high cost for implementation.

Generally the cost for implementing these leak detection systems falls into the following categories:

Low:

- MTC MTPMMS: This system has a relatively low construction cost to implement. Since the probe system is flexible it can be lowered to the bottom of the USTs from the gauging port on top of the tank. This means that there is no requirement to empty or clean the tank to install equipment. There also does not appear to be significant issues of coordination with the existing structures within the tanks. This ease of installation was verified during the Pilot Testing of this system when testing of two USTs was completed with virtually no installation effort short of opening the gauge port and lowering the flexible probe system to the bottom of the tanks. Retrieval of the probes proved equally unremarkable.

- Asteroid's Comet Software with existing ATG. This is basically just utilizing the existing ATG data with a new and potentially off-site leak detection software package with no significant construction. It would only entail software and is therefore relative low in cost to implement.

- Gauging System Inc. MTG 3000 and AFHE (existing system with modifications to AFHE software). This is basically upgrading or modifying the AFHE software to evaluate the level data provided by the existing ATG. No in tank construction would be required and therefore the relative cost would be low.

Medium:

- hydroGEOPHYISICS HRR-LDM. This solution would entail installation of ex-situ probes around the tanks at Red Hill. This could be significantly challenging given the location, but probably not as expensive as any of the solutions requiring the cleaning of the tanks.

High:

- Vista Leak Detection, Inc LRDP-24-RH. This solution requires the tanks to be emptied and cleaned for construction of in tank probes and sensors. This results in a relatively high cost for installation. Vista has provided a "order of magnitude cost" of $150,000 per tank for the installation of this system beyond the cost to clean and empty the tanks.

- Varec Leak Manager and Enraf 854 ATG. This solution also most likely requires the tank to be emptied and cleaned to perform construction inside the tank. This results in a relatively high cost for installation.

- Gauging System Inc. MTG 3012. This solution also most likely requires the tank to be emptied and cleaned to perform construction inside the tank. This results in a relatively high cost for installation.

5.8.1 Detailed Cost Estimating

The focus of this Market Survey was to research leak detection systems that have potential to operate successfully in the unique situation of the Bulk USTs at Red Hill. To fully implement such a complex project will require more in depth study and design. It is therefore impossible at this time to develop detailed cost estimates since no preliminary engineering designs exist for any of these leak detection system solutions.

It is recommended that as a next step to implementing a leak detection solution a detailed feasibility study is performed on the solutions identified in this Market Survey that show a potential for success. The focus of the feasibility study would be to identify and research specific design solutions, develop preliminary engineering design documentation (including cost estimates) that can give the government a realistic look at the required funding necessary to implement a solution.

6 Decision Matrix

Table 6-1 Decision Matrix

	3rd party certification	Leak Rate sensitivity	Compatibility with MTG/AFHE	Instrument Reliability	Customer Support	System Installation	**Total**
Weight	5	5	2	3	2	2	19 max.
Asteroid Scientific Comet Software with existing ATG (relative cost – Low)	0	3	1	1	0	2	7
Vista Leak Detection, Inc LRDP-24-RH (relative cost – High)	5	5	1	3	1	0	15
Gauging System Inc. MTG 3000 and AFHE (existing system with modifications to AFHE) (relative cost – Low)	1	2	2	3	2	2	12
Mass Technology Corporation MTPMMS (relative cost – Low)	4	5	1	3	2	2	17
Varec Leak Manager & Enraf 854 ATG (relative cost – High)	3	3	1	2	2	0	11
hydroGEOPHYISICS HRRLDM (relative cost – Medium)	0	2	1	3	2	1	9
Gauging System Inc. MTG 3012 (relative cost – High)	3	3	1	2	2	0	12

7 Conclusions

Baker has researched and evaluated potential leak detection system technologies for use at the Red Hill Fuel Storage Complex at FISC Pearl Harbor, HI. Available information was used to assemble a decision matrix as shown in Table 6-1. To help summarize the results of that evaluation the systems are ranked and disused in Table 7-1.

Table 7-1 Potential Technologies Rankings				
Ranking (Best to worst)	Vendor	System	Decision Matrix Score	Comments
1	Mass Technology Corporation	MTPMMS	17	Pilot testing performed at Red Hill achieved a point in time test to a reported minimum detectable leak rate of 0.5 gal/hr. Formal Third Party evaluation should be done to document Pilot Testing results of minimum detectable leak rate if technology is selected. Testing can be done as either point in time or permanently installed. Simple installation that does not require tank to be emptied. Relative cost is Low
2	Vista Leak Detection, Inc	LRDP-24-RH	15	Third Party certified to 0.59 gal/hr. Testing can be done as either point in time or permanently installed. Significant construction challenges to install reference tube (for either permanent or point in time testing). Tank must be emptied and cleaned for worker entry. Coordination with existing structures within the tanks (stilling wells, ladders, elevator systems) must be considered and adds to the cost. Relative cost is High

Table 7-1 Potential Technologies Rankings				
Ranking (Best to worst)	Vendor	System	Decision Matrix Score	Comments
3	Gauging System Inc.	MTG 3000 and AFHE (existing system with modifications to AFHE)	12	Existing ATG and AFHE Control System Currently performs inventory control and gross leak detection. Potential exists to modify AFHE system to obtain better leak detection results. Additional research and coordination with SPAWAR required to assess feasibility of approach and identify theoretical minimum detectable leak rate Formal Third Party evaluation should be done to document results of minimum detectable leak rate if technology is selected for Red Hill. Relative cost is low

Table 7-1 Potential Technologies Rankings				
Ranking (Best to worst)	Vendor	System	Decision Matrix Score	Comments
4	Gauging System Inc.	MTG 3012 (stand alone)	12	A new ATG system with stand alone leak detection capabilities Next generation of ATG currently used at Red Hill Significant construction challenges if new sensors are needed Tank must be emptied and cleaned for worker entry. Coordination with existing structures within the tanks (stilling wells, ladders, elevator systems) must be considered and adds to the cost. Relative cost is High

Table 7-1 Potential Technologies Rankings				
Ranking (Best to worst)	Vendor	System	Decision Matrix Score	Comments
5	Varec, Inc.	Leak Manager & Enraf 854 ATG	11	Draft Third party evaluation listing for NWGLDE available. System not certified for tanks larger than 2.1 million gallons. Theoretical results expected from Third Party Evaluation may differ from actual results in the field due to size of USTs at Red Hill. Formal Third Party evaluation should be done to document results of minimum detectable leak rate if technology is selected for Red Hill. Significant construction challenges to install equipment inside the tanks. Tank must be emptied and cleaned for worker entry. Coordination with existing structures within the tanks (stilling wells, ladders, elevator systems) must be considered and adds to the cost. Relative cost is High

Table 7-1 Potential Technologies Rankings				
Ranking (Best to worst)	Vendor	System	Decision Matrix Score	Comments
6	hydroGEOPHYISICS	HRRLDM	9	Not currently used for POL system leak detection Unknown theoretical detection limit Not currently third party evaluated for POL leak detection in any circumstance let alone Red Hill. Ex-Situ installation may be difficult at Red Hill. Formal Third Party evaluation should be done to document results of minimum detectable leak rate if technology is selected for Red Hill. Relative cost is Medium
7	Asteroid Scientific	Comet Software with existing ATG	7	Software analytical tool used with ATG. ATG data can be sent off-site for analysis Limited applicability Relative cost is low

As can be seen in the summary of Table 7-1 the results of this Market Survey have identified seven potential candidates for use as leak detection at Red Hill. The seven can generally be grouped as follows:

- The two highest ranked candidate technologies are both routinely used by the DOD and private industry for Integrity Testing of bulk storage tanks. While both are third party certified only Vista's LRDP-24-RH has been third party certified on the Red Hill Tanks. While the third party listing of the NWGLDE that govern the use of MTC's MTPMMS is still valid (no upper limit on capacity listed) and the theories and analysis remains the same the equipment has been slightly modified to deal with the higher pressures than normally experienced during this type of testing. It is Baker's opinion that while the system still produces a valid test, third party certification of this modified method should be performed specifically for Red Hill.

- The MTC MTPMMS system is better suited for use at Red Hill mainly due to the construction challenges faced by utilizing the Vista LRDP-24-RH method (clean and empty the tank to install equipment).

- Either MTC or Vista systems can be installed permanently and test run nearly continuously by either the operators or contractors.

- The middle three ranked systems all resulted in nearly the same scores. They are all some form of traditional ATG system with analytical software to detect leaks. One relies on adjusting the existing AFHE system (which may or may not be practical) to make use of the existing ATG and the other two are newer variations of existing systems used in the industry.

- The use of the hydroGEOPHYISICS system seems unwarranted at this time due to the lack of this system in similar uses in industry.

- The lowest ranked system, the Asteroid Scientific Comet system, is analytical software required to be tied to a form of ATG. The use of another form of software with the existing ATG does not appear as attractive as other options considered. Use of the off site post operation analysis to confirm a suspected leak is attractive, but not a primary leak detection method.

It should be noted that the uniqueness of the USTs at Red Hill leads to a significant challenge in selecting appropriate leak detection. The fact that there really are no other USTs comparable to these leads to a total lack of focus by industry to solve such a leak detection system problem. This phenomenon and its relevance to the situation at Red Hill can be summarized as follows:

- No similarly large USTs exist elsewhere in the world so industry has not focused its attention to the problem of leak detection for such tanks. There just are not enough of them to warrant the cost of developing a certified solution.

- Even the leak detection systems that have been developed for large USTs or cut/cover tanks and have undergone formal third party evaluations to prove that their technology works often have their certification limited by an maximum tank size, usually the size of the tank that the evaluation was performed on. The test is most often done on the largest tank that is available to the tester and evaluator and these are typically drastically smaller in size than the Red Hill USTs.

- Conversely several of the methods that are third party certified with no upper limits to the method could in fact be significantly challenged by such large USTs. It was probably just never a consideration that such tanks existed and needed to be tested and therefore no upper level cap was deemed necessary

- While several of the systems evaluated for this Market Survey have their third party certification limited by a maximum tank size it is possible that they in fact could work on the Red Hill USTs. Only site specific evaluation would determine this conclusively.

8 Recommendations

Based on the Market Survey and evaluation of the systems it is Baker's opinion that the Mass Technology Corporation's MTPMMS system would be the best option as a primary leak detection solution for Red Hill. In addition Baker recommends that MTC Perform Point in time testing as soon as practical with a formal third party evaluation to conclusively identify the minimum detectable leak rate for this system in these USTS.

If the government chooses to go forward with any of the solutions identified in this Market Survey (other than point in time MTC MTPMMS testing) the next prudent step would be to perform a feasibility study. The focus of the feasibility study would be to identify and research specific design solutions, develop preliminary engineering design documentation (including cost estimates) that can give the government a realistic look at the required funding necessary to implement a solution.

9 Figures

Figure 9-1

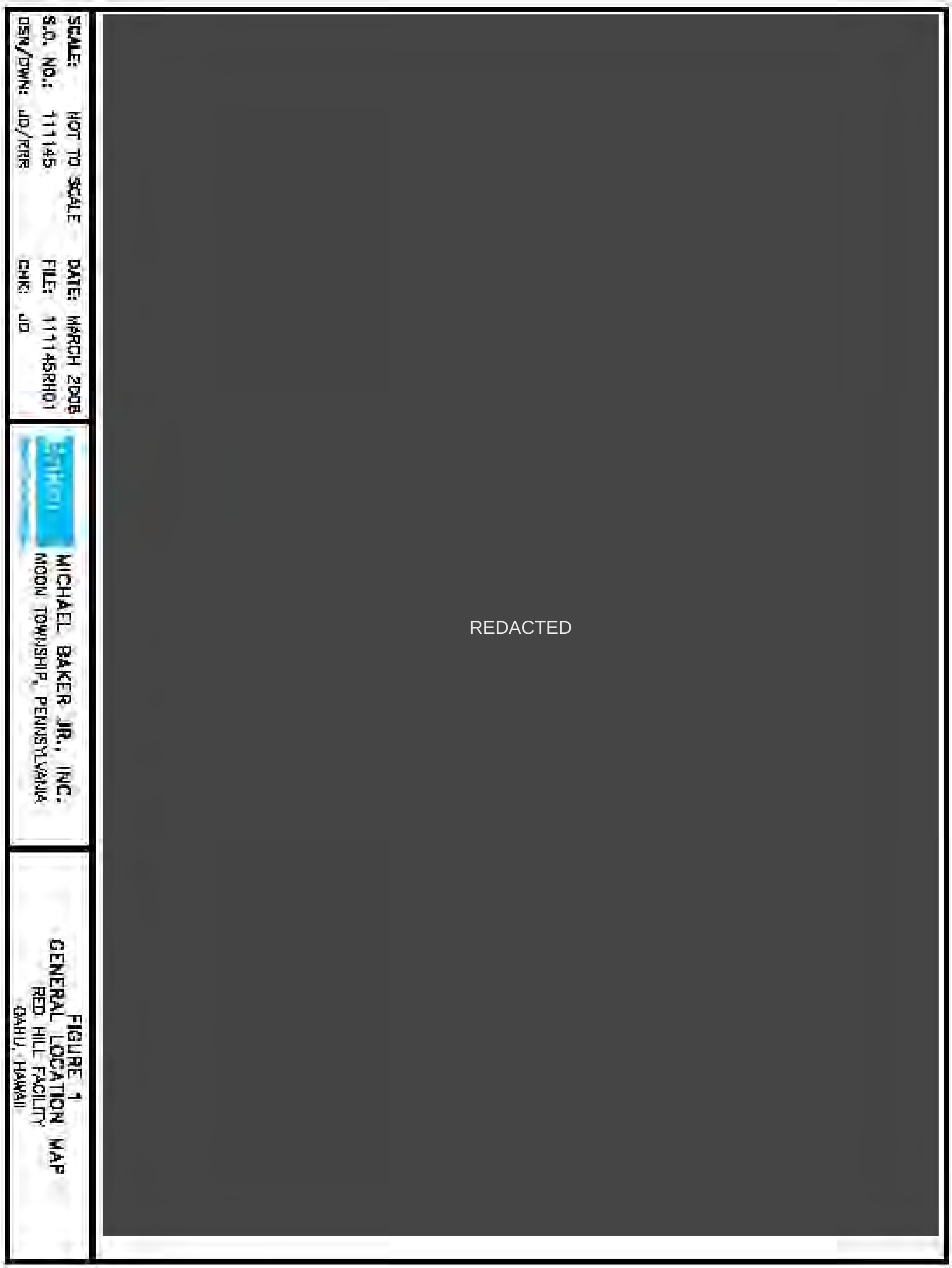
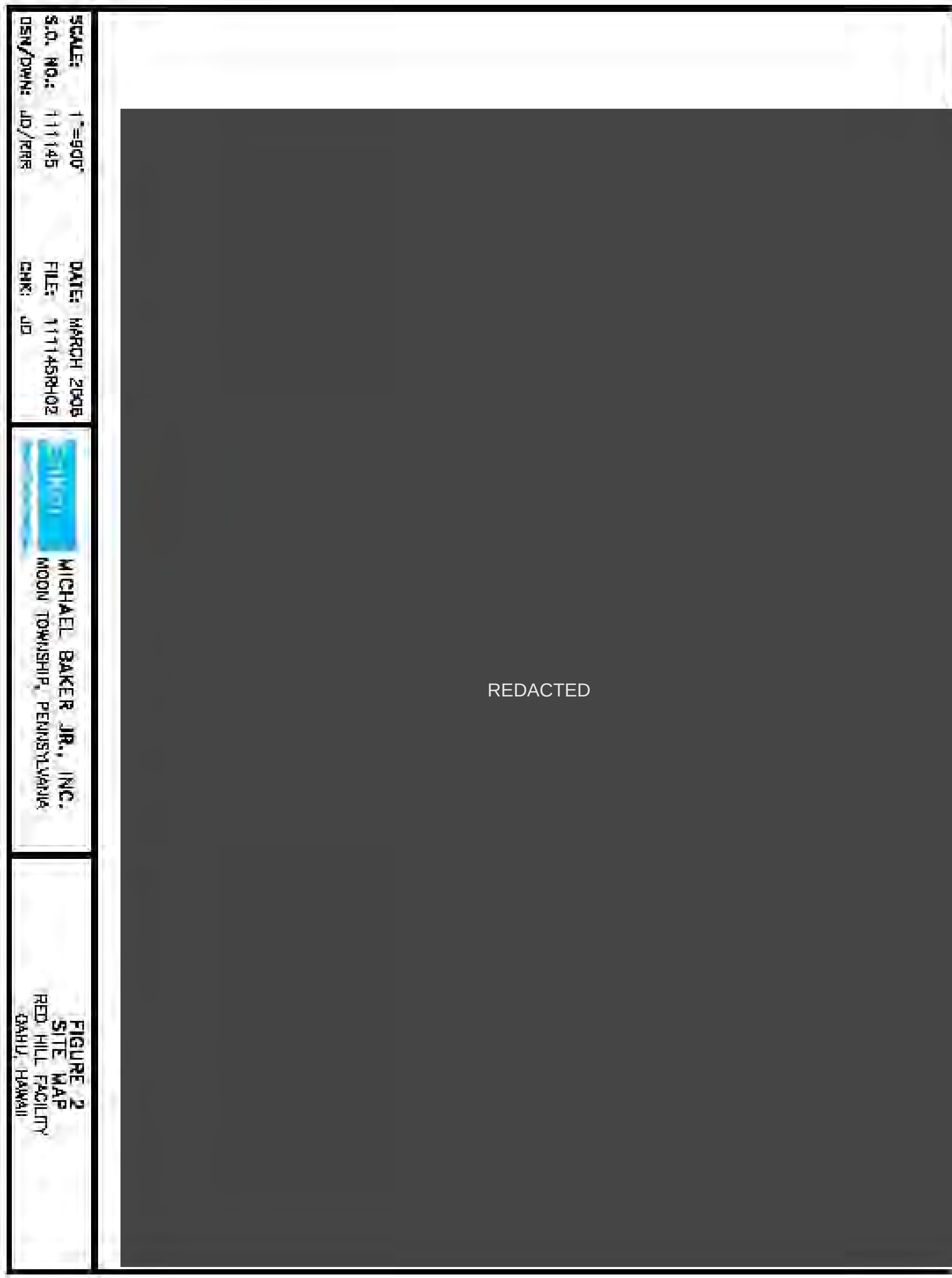

SCALE: NOT TO SCALE
DATE: MARCH 2006
S.O. NO.: 111145
FILE: 111145RH01
DSN/DWN: JD/RRR
CHK: JD
MICHAEL BAKER JR., INC.
MOON TOWNSHIP, PENNSYLVANIA
FIGURE 1
GENERAL LOCATION MAP
RED HILL FACILITY
OAHU, HAWAII
REDACTED

Figure 9-2


SCALE: 1"=900'
S.O. NO.: 111145
DSN/DWN: JD/RRR
DATE: MARCH 2006
FILE: 111145RH02
CHK: JD
MICHAEL BAKER JR., INC.
MOON TOWNSHIP, PENNSYLVANIA
FIGURE 2
SITE MAP
RED HILL FACILITY
OAHU, HAWAII
REDACTED

Appendix A

Vista Leak Detection
LRDP-24-RH
Third Party Evaluation

Addendum to the Evaluation of the LRDP-24 and the LRDP-24-n on Bulk Field-Constructed Tanks

Final Report

PREPARED FOR:

Naval Facilities Engineering Service Center and Vista Research, Inc.

August 28, 2001

KWA

Ken Wilcox Associates, Inc.
1125 Valley Ridge Drive, Grain Valley, MO 64029, USA
Voice (816) 443-2494, Fax (816) 443-2495
E-mail info@kwaleak.com, Web http://www.kwaleak.com

Addendum to the Evaluation of the LRDP-24 and the LRDP-24-n on Bulk Field-Constructed Tanks

Final Report

PREPARED FOR:

Naval Facilities Engineering Service Center
1100 23rd Avenue
Port Hueneme, CA 93043-4370

Vista Research, Inc.
755 North Mary Avenue
Sunnyvale, CA 94085

August 28, 2001

Preface

This report describes a third independent evaluation of the LRDP-24 and the LRDP-24-n as leak detection systems for bulk field-constructed tanks. This evaluation was conducted to determine the performance of these two LRDP methods for use in the 12,500,000-gal underground storage tanks (USTs) located at the Red Hill Underground Fuel Storage Facility. This report is an addendum to previous evaluation reports for the LRDP-24 and the LRDP-24-n and should be used in conjunction with them. .[1, 2, 3, 4] This report is considered an addendum, because it applies only to these bulk Red Hill tanks. Modifications to the standard evaluation protocol [5] were made to accommodate the requirements of testing a tank with such a large volume and with curved walls. These tanks, which typically store product at intervals of approximately 9 months without a fuel transfer, require testing during this period. As a consequence, only one fuel transfer (or delivery) was included in the evaluation.

REDACTED

[redacted] simulations, data collection, data analysis, and reporting were conducted by Ken Wilcox Associates, Inc.

This report was prepared by Mr. Jeffrey K. Wilcox and Dr. H. Kendall Wilcox. Technical Questions regarding this evaluation should be directed to Ms. Leslie A. Karr, NFESC at (805) 982? 1618 and Dr. Joseph W. Maresca, Jr., Vista Research, Inc., at (408) 830-3306.

KEN WILCOX ASSOCIATES, INC.

Jeffery K. Wilcox

Approved:

H. Kendall Wilcox, President
August 28, 2001

---

[1] Evaluation Update of the LRDP-24 on Bulk Field-Constructed Tanks, Final Report, Prepared for Naval Facilities Engineering Service Center and Vista Research, Inc., December 4, 2000.
[2] Evaluation Update of the LRDP-24-n on Bulk Field-Constructed Tanks, Final Report, Prepared for Naval Facilities Engineering Service Center and Vista Research, Inc., December 4, 2000.
[3] Evaluation of the LRDP-24 on Bulk Field-Constructed Tanks, Final Report, Prepared for Naval Facilities Engineering Service Center and Vista Research, Inc., January 29,1998.
[4] Evaluation of the LRDP-24-5 on Bulk Field-Constructed Tanks, Final Report, Prepared for Naval Facilities Engineering Service Center and Vista Research, Inc., January 29, 1998.
[5] Alternative Test Procedures for Evaluating Leak Detection Methods: Mass-based and Volumetric Leak Detection Systems for Bulk Field-constructed Tanks", Ken Wilcox Associates, Inc., November 2000.

Table of Contents

1.0 Introduction

This report describes an independent evaluation of the LRDP-24 and LRDP-24-n for use in the [redacted] bulk underground storage tanks (USTs) located at the Red Hill Underground Fuel Storage Facility, Honolulu, Hawaii. These LRDP systems were developed by the Naval Facilities Engineering Service Center (NFESC) and Vista Research, Inc., to conduct leak-detection tests on bulk field-constructed tanks and are currently included on the 8th Edition list of methods of the National Work Group on Leak Detection Evaluations that have been evaluated acceptably. The evaluation was conducted because the top and bottom sections of these Red Hill tanks have curved walls. Twelve tests were conducted in June and July 2001 with nominal leak rates ranging from 1 to 4 gal/h. A modified version of the bulk tank protocol[1] was used for the evaluation. The calculations and results contained in this report use the procedures described in the bulk tank protocol. Users of the LRDP equipment should, however, use this report in conjunction with earlier evaluation reports.[2,3,4 5]

---

[1] Alternative Test Procedures for Evaluating Leak Detection Methods: Mass-based and Volumetric Leak Detection Systems for Bulk Field-constructed Tanks", November 2000.

[2] Evaluation Update of the LRDP-24 on Bulk Field-Constructed Tanks, Final Report, Prepared for Naval Facilities Engineering Service Center and Vista Research, Inc., December 4, 2000.

[3] Evaluation Update of the LRDP-24-n on Bulk Field-Constructed Tanks, Final Report, Prepared for Naval Facilities Engineering Service Center and Vista Research, Inc., December 4, 2000.

[4] Evaluation of the LRDP-24 on Bulk Field-Constructed Tanks, Final Report, Prepared for Naval Facilities Engineering Service Center and Vista Research, Inc., January 29, 1998.

[5] Evaluation of the LRDP-24-5 on Bulk Field-Constructed Tanks, Final Report, Prepared for Naval Facilities Engineering Service Center and Vista Research, Inc., January 29, 1998.

2.0 Description of the Test Tank

[redacted]

REDACTED

Openings in the tank were available for the LRDP system equipment and for the KWA leak simulation equipment. The test tank was made available to KWA staff 24 hours a day for the duration of the evaluation. KWA staff was present for the duration of the evaluation and defined the testing schedule of the evaluation.

3.0 Description of the LRDP-24 and the LRDP-24-n Systems

A description of the LRDP-24 that was provided by NFESC and Vista Research follows:

The Low Range Differential Pressure (LRDP) system is a mass-based system for testing bulk tanks for leaks. The system fully compensates for both thermally induced fuel level changes and for evaporation and condensation. The system is specifically configured to significantly improve the precision of the pressure measurements and to reduce the thermal drift of the pressure transducer. Thus, an off-the-shelf, industrial grade differential pressure sensor can be used in the system.

[redacted] REDACTED geometry of the upper and lower domes of the tank. The fuel in the tank is allowed to enter or leave the reference tube through a valve located at the bottom of the tube. When the tank is to be tested for the possibility of a leak, the valve is closed, isolating the fuel in the tube from the fuel in the tank. With the exception of a level change due to a leak, the level of the fuel in the reference tube mimics the level of the fuel in the tank. The differential pressure sensor, which is placed in a sealed container at the bottom of the tube (and tank), is used to detect very small level (pressure) changes between the fuel in the tube and the fuel in the tank. Thus, when the valve is closed, the differential pressure sensor directly senses and quantifies the fuel level changes due to a leak, if a leak is present.

An industrial grade differential pressure sensor can be used in the system, because the measurement configuration only requires measurements to be made over a height range of ±0.5 inches and not over the entire height of the tank. As used in the evaluation, this configuration increased the precision of the differential pressure sensor by a factor of 300 over a system that did not use a reference tube. Thermally induced drift of the pressure sensor is avoided, because it is housed at the bottom of the tank and is not subject to ambient air conditions. The performance of the LRDP system can be easily verified any time the valve is in the open position, because the differential level (pressure) changes are known to be zero.

The test duration of the LRDP system will depend on the tank size and the desired performance. The LRDP-24 uses a test duration of 24 hours. The LRDP-24-n averages up to n (for n<12) separate 24-h tests with the LRDP-24 before applying the threshold. The system was operated as a stand-alone system with the leak rates reported automatically at the conclusion of the testing.

4.0 Leak Simulation Equipment

The leak simulation procedures used in the evaluation were those described in the bulk tank protocol, which are identical to those described in the standard EPA protocols for ATG and volumetric systems.

Leak simulations were conducted at the bottom of the tank by removing fuel from the tank through one of the sample valves. The pressure at the bottom of the tank was approximately 75 psi. One end of the hose was connected to the sample valve and the other to a flow meter equipped with a needle valve to control the flow rate. The flow rate was measured volumetrically at the beginning of the test and again at the end. The flow rate could be visually monitored with the flow meter at any time. Because of the extremely stable ambient conditions in the tunnel, the flow rate was very stable and exhibited almost no drift over the test period.

5.0 Description of the Evaluation Procedures

Tables 1 and 2 summarize the test conditions and the leak rate data that were present during the evaluation. NFESC and Vista Research installed the LRDP system in the test tank in its normal configuration. Testing was carried out using the manufacturer's normal test routine. Leak simulations were induced at the bottom of the tank through one of the sample ports. The leak rate reported by the LRDP-24 was compared to the actual induced leak rate. A statistical analysis of the data was used to determine the performance characteristics of the test method.

A total of 12 tests were conducted with the LRDP-24. Product deliveries were not made during the evaluation [redacted] test tank. Testing was done at [redacted] Test times were 24 hours for each of the 12 tests. Leak simulations were controlled and monitored by KWA throughout the duration of the testing.

Table 1. Testing Conditions

Test No.	Date at Completion Of Last Fill (m/d/y)	Time at Completion Of Last Fill (hhmm)	Wait Time (hours)	Product Level (%)	Product Temperature Differential (Deg F)	Date Test Began (m/d/y)	Time Test Began (m/d/y)	Date Test Ended (m/d/y)	Time Test Ended (m/d/y)	Test Time (hours)
1	N/A	N/A	N/A	97%	N/A	06/27/01	1040	06/28/01	1040	24.0
2	N/A	N/A	N/A	97%	N/A	06/28/01	1040	06/29/01	1040	24.0
3	N/A	N/A	N/A	97%	N/A	06/29/01	1252	06/30/01	1252	24.0
4	N/A	N/A	N/A	97%	N/A	06/30/01	1505	07/01/01	1505	24.0
5	N/A	N/A	N/A	97%	N/A	07/01/01	1640	07/02/01	1252	20.2
6	N/A	N/A	N/A	97%	N/A	07/03/01	0930	07/04/01	0930	24.0
7	N/A	N/A	N/A	97%	N/A	07/04/01	1015	07/05/01	1015	24.0
8	N/A	N/A	N/A	97%	N/A	07/05/01	1050	07/06/01	1050	24.0
9	N/A	N/A	N/A	97%	N/A	07/06/01	1125	07/07/01	1125	24.0
10	N/A	N/A	N/A	97%	N/A	07/07/01	1200	07/08/01	1200	24.0
11	N/A	N/A	N/A	97%	N/A	07/08/01	1220	07/09/01	1220	24.0
12	N/A	N/A	N/A	97%	N/A	07/09/01	1220	07/10/01	1220	24.0

Table 2. Leak Rate Data

Test No.	Wait Time (hours)	Product Level (%)	Product Temperature Differential (deg F)	Nominal Leak Rate (gal/h)	Induced Leak Rate (gal/h)	Measured Leak Rate (gal/h)	Meas.-Ind. Leak Rate (gal/h)	Product Temperature Start of Test (deg F)	Product Temperature End of Test (deg F)	Temperature Change (deg F)
1	N/A	95%	N/A	3.0	2.690	2.535	-0.155	83.9	83.9	0.00
2	N/A	95%	N/A	3.0	2.710	2.639	-0.071	83.9	83.9	0.00
3	N/A	95%	N/A	0.0	0.000	0.058	0.058	83.9	83.9	0.00
4	N/A	95%	N/A	1.0	1.170	0.800	-0.370	83.9	83.9	0.00
5	N/A	95%	N/A	2.0	2.145	2.007	-0.138	83.9	83.9	0.00
6	N/A	95%	N/A	0.0	0.000	0.144	0.144	83.9	83.9	0.00
7	N/A	95%	N/A	3.0	3.080	3.205	0.125	83.9	83.9	0.00
8	N/A	95%	N/A	4.0	4.040	3.763	-0.277	83.8	83.8	0.00
9	N/A	95%	N/A	1.0	1.691	1.549	-0.142	83.8	83.8	0.00
10	N/A	95%	N/A	3.0	3.300	3.349	0.049	83.8	83.8	0.00
11	N/A	95%	N/A	2.0	2.430	2.210	-0.220	83.8	83.8	0.00
12	N/A	95%	N/A	0.0	0.000	0.017	0.017	83.8	83.8	0.00

6.0 Calculations

This section describes the procedures for calculating the results contained in Section 7.0. The procedures were taken from the bulk tank protocol.

6.1 Calculation of Probability of False Alarm (P_{FA}), Probability of Detection (P_D), and Minimum Detectable Leak (MDL)

All of the statistical calculations described in the standard EPA test protocol for volumetric systems apply to evaluations conducted on large bulk tanks. The threshold and MDL to obtain a probability of detection (P_D) of 95% and probability of false alarm (P_{FA}) of 5% are to be reported for the evaluation. Procedures for determining the P_D, P_{FA}, and MDL are contained in the standard EPA test protocol for volumetric systems[1] and are summarized below.

From the differences between the leak rates reported by the system, L_i, and the induced leak rates, IL_i,

$$D_i = L_i - IL_i. \qquad (6\text{-}1)$$

The bias is estimated by the mean of the differences:

$$B = \Sigma D_i/N, \qquad (6\text{-}2)$$

where N is the number of tests (usually 12) in the evaluation and the summation is over all differences. The variance of the differences is found using the formula

$$V = \Sigma (D_i - B)^2/(N -1). \qquad (6\text{-}3)$$

The standard deviation, S, is the square root of the variance. A test of whether the bias is zero is based on the statistic

$$t = (N)^{1/2} B/S, \qquad (6\text{-}4)$$

which is compared to the two-sided value from a t-distribution with N-1 degrees of freedom. For N=12, the appropriate value from the t-table is 2.201. If the absolute value of t is less than the value from the t-table, then B is negligible. This means that zero is substituted for B in the following equations.

[1] Standard Test Procedures for Evaluating Leak Detection methods: Volumetric Tank Tightness Testing Methods", pages 28-33 describe procedures for calculating the P_D, P_{FA}, and MDL.

Probability of False Alarm

The probability of a false alarm, P_{FA}, is the probability that the measured leak rate will exceed the threshold for declaring a leak when the testing is done on a tight tank. If C denotes the threshold, then the probability of a false alarm is estimated from

$$P_{FA} = P\,[t > (C - B)/S]. \qquad (6\text{-}5)$$

This probability is calculated by computing the term (C – B)/S using the specified threshold C and the bias, B, and standard deviation, S, computed from the test results. The result is used with a t-distribution with 11 degrees of freedom. A table of the t-distribution is used to find the probability that a t-statistic with 11 degrees of freedom exceeds the computed value.

Probability of Detection

The probability of detecting a leak depends on the specific leak rate. For a leak rate of size R, the probability of detection, P_D, is given by

$$P_D = P\,[t > (C - R - B)/S]. \qquad (6\text{-}6)$$

In the formula, the threshold, C, is specified as before, the leak rate for which the P_D is calculated is R, and B and S are calculated from the test data as before. The term (C - R - B)/S is computed. A t-distribution with 11 degrees of freedom is used to look up the probability that a t-statistic exceeds the calculated value.

Setting the Threshold

The threshold, C, may be set to give a specified probability of false alarm. For example, if a P_{FA} of 5% is desired, use the t-table to determine that the probability is 5% that a t-statistic with 11 degrees of freedom will exceed 1.796. To choose C, set

$$(C - B)/S = 1.796 \qquad (6\text{-}7)$$

and solve for C to get

$$C = (1.796)(S) + B \qquad (6\text{-}8)$$

which reduces to

$$C = (1.796)(S) \qquad (6\text{-}9)$$

if B is zero.

Here B and S have been calculated from the test data.

Finding the Minimum Detectable Leak Rate.
For a specified threshold C, the smallest leak rate that can be detected with a specified probability, e.g. 95%, can be determined as the minimum detectable leak rate, MDL. This is accomplished by using a t-table to find the probability that a t-statistic with 11 degrees of freedom will exceed –1.796. Set

$$(C - R - B)/S = -1.796 \qquad (6\text{-}10)$$

The value of R that solves the above equation is the MDL for the threshold C.

$$MDL = C - B + 1.796\,(S) \qquad (6\text{-}11)$$

The value of R that satisfies the previous equation using the threshold for a 5% P_{FA} is the MDL for a 5% P_{FA} and a 95% P_D. This is the smallest leak rate that is detectable with 95% probability using the threshold C. Note if the bias is not statistically significantly different from zero it is taken to be zero.

Operation of the LRDP-24.
If $R \geq MDL$, the LRDP-24 is operated to achieve a $P_D = 95\%$ and a $P_{FA} \leq 5\%$. The threshold, C, of the LRDP-24 is given by

$$C = R - 1.796\,(S) + B \qquad (6\text{-}12)$$

which reduces to

$$C = R - 1.796\,(S) \qquad (6\text{-}13)$$

if B is zero. The P_{FA} for C and S is given by Eq. (6-5). As an example, if R = 1.0 gal/h and S = 0.163 gal/h, then C = 0.707 gal/h for B = 0, and the P_{FA} = 0.059%, which is reported as $P_{FA} < 1\%$.

6.2 Averaging of Test Results

The performance of a leak detection system can be improved significantly by combining the results of two or more independent tests. Averaging more than one test result to achieve better performance is a recognized statistical technique. The bulk tank protocol addresses some of these statistical processes. The two most common applications of averaging is to use it (1) to detect smaller leak rates, R_n, with the same P_D and P_{FA}, or (2) to minimize the P_{FA} without changing the P_D or the specific leak rate, R, to be detected. An example is given in Section 7.2

The performance of the LRDP-24-n system, where n is the number of independent tests averaged together, is obtained using the *standard deviation of the mean* test result, S_m, of the LRDP-24 system. The standard deviation of the mean test result can be determined from the standard deviation of the single-test results, S, computed as part of the evaluation. Once the standard deviation of the mean test result is known, the performance of the mean (average) test result (in terms of P_D and P_{FA}) can be computed using the same methods as for the single test results. This is accomplished by substituting S_m for S in the above equations.

For independent tests, S_m of the LRDP-24 is obtained from S and the number of tests, n, averaged together. The standard deviation of the mean, S_m, is given by

$$S_m = S / (n)^{0.5} \qquad (6\text{-}14)$$

For the first application of averaging mentioned above, the specified leak rate R_n can be computed from R using

$$R_n = R / n^{0.5}, \qquad (6\text{-}15)$$

where R is the specified leak rate when n = 1. The threshold, C_n, used to detect this R_n is computed using

$$C_n = R_n - 1.796\,(S_m). \qquad (6\text{-}16)$$

6.3 Water Detection Mode (if applicable)

The calculations for a bulk tank water detector are identical to those described in the standard ATGS protocol. The LRDP is a mass-based system, however, and the water detection mode calculations do not apply to it.

6.4 Tank Size Limitations

For the bulk tank protocol, tank size limitations are based on surface area for mass based systems. Table 3 illustrates applying the evaluation to tanks of differing sizes.

Table 3. Tank Size Limitations

	Product Surface Area	Product Volume	Leak Rate Scaling
Scaling Limits	Maximum 2.5 X Area (No minimum) *See Note Below	50,000 gallon Minimum, No Maximum	Yes, but not below 0.2 gal/h
* Extrapolation beyond this surface area requires 6 additional tests in larger tanks using the same test procedures and parameters. The surface area limitation will then be equal to the surface area of the tank used in the confirmatory tests.			

Since no other bulk USTs have curved walls, scaling is not reported as part of this evaluation.

6.5 Rate and Threshold

The test data are used to calculate the basic statistics described in the bulk tank protocol. Once the data are available and the statistics have been calculated the following results are to be reported.

1. The standard deviation
2. The threshold for declaring a leak
3. The minimum detectable leak rate
4. The target leak rate
5. The P_{FA} and P_D for the target leak rate

The test developer is allowed to select any target leak rate and threshold as long as the results are within the specifications of the regulatory agency. In general, the results must show that the system is capable of detecting the target leak rate with a probability of detection of 95% or greater and a probability of false alarm of 5% or less. The threshold can be adjusted within these limits to either reduce the false alarm rate or improve the probability of detecting a small leak. The P_D and P_{FA} are assumed to remain constant for the purpose of scaling the results to other tank sizes.

The vendor may choose to report the test results using more than one target leak rate and threshold. Some regulatory agencies may choose to reject one or more of the calculations based on the applicable regulatory standards.

6.6 Leak Rate and Threshold Scaling

The bulk tank protocol describes procedures for scaling the leak rate and threshold to tank sizes different than the tank used in the evaluation. The standard deviation of the evaluation tank is multiplied by the ratio of the surface areas of the size of tank to which the evaluation results are to be applied. This can be expressed mathematically by the equation

$$S_2 = S_1 \times A_2/A_1 \qquad (6\text{-}17)$$

where S_1 is the population standard deviation obtained from the evaluation test data using a reference tank, S_2 is the population standard deviation to be used to predict performance on a tank of a different size, A_1 is the surface area of the evaluation reference tank, and A_2 is the surface area of the new tank.

The scaling is limited by the following restrictions.

1. The tank must be field constructed;
2. It must be a vertical wall tank;
3. The method must be based on mass measurement rather than volumetric principles;
4. The scaling is based on the product surface area rather than tank volume;

The maximum size tank that may be tested is determined by consideration of the performance of the method as measured by the standard deviation. The standard deviation is scaled up or down using equation 6-17. A new minimum leak rate for a P_D of 95% must then be calculated if the tank has a different product surface area than the evaluation tank. For example, to apply a method that has been evaluated on a tank with a surface area of 2,000 sq. ft. and a measured standard deviation of 0.5 gal/h to a tank with a surface area of 3,000 sq. ft, a new minimum detectable leak based on a standard deviation of 0.75 gal/h would be used.

The maximum tank size to which the method may be applied is limited to not more than 2.5 times the surface area of the tank used for the evaluation. A maximum value of 5% for the P_{FA} is permitted. Using 5% for P_{FA}, when the corresponding P_D reaches the limit set by the regulations, no further scaling is permitted. Scaling to smaller tanks is allowed, but scaling to target rates smaller than 0.2 gal/hr is not permitted.

When scaling the results, the appropriate standard deviation for the test tank should be used, if the results are based on a single test. If the results are based on the average of n tests, then the base standard deviation used for scaling is S_m.

Since the evaluation tank is not solely constructed with vertical walls, scaling does not apply for this evaluation.

6.7 Maximum Temperature Differences and Stabilization Times

The bulk tank protocol contains procedures for calculating the maximum difference in temperature that can be present between the product in the tank and that added to fill the tank before a valid leak test can be conducted. These procedures require that product deliveries with temperature differentials be done during the evaluation. Since there were no product deliveries done for this evaluation, these calculations cannot be done.

The bulk tank protocol also contains procedures for calculating the minimum stabilization time required to conduct a valid leak test following a product delivery. Since there were no product deliveries done for this evaluation, these calculations also cannot be done. In any case, product deliveries at the FISCPH tanks are relatively rare, and it is likely that stabilization times will be substantially long before the LRDP-24 or the LRDP-24-n conducts testing following deliveries.

6.8 Test Time

The test time is measured from the start of data collection to the end of the data collection. Test times for all tests are included in the average.

7.0 Results

7.1 Probability of False Alarm (P_{FA}), Probability of Detection (P_D), and Minimum Detectable Leak (MDL)

Basic Statistics
The basic statistics are calculated from the differences between the vendor's reported leak rate and the actual leak rate induced by KWA. Basic statistics include the variance, mean squared error, standard deviation, and bias.

Bias
Bias is the average of the differences between the reported and the actual leak rate. The vendor's analysis algorithm included removing a constant calibration value of 0.6 gal/h from the measured volume rate; this calibration constant may change from one tank to another. The bias of the evaluation test results, after calibration, was -0.082 gal/h, which is not significant.

Variance
The variance was calculated to be 0.0266 gal^2/h^2.

Standard Deviation
The variance was calculated to be 0.163 gal/h.

Mean Squared Error
The variance was calculated to be 0.0310 gal^2/h^2.

Probability of Detection (P_D) and Probability of False Alarm (P_{FA})
Table 4 below contains the P_D and P_{FA} for several threshold/leak rate combinations that were selected by the vendor.

Table 4. Summary of the P_D and P_{FA} Results

No.	Threshold (gal/h)	Leak Rate (gal/h)	P_D	P_{FA}
1	0.293	0.586	95%	5%
2	0.707	1.0	95%	<1%
3	0.877	1.17	95%	<1%
4	1.707	2.0	95%	<<1%
5	2.707	3.0	95%	<<1%

Minimum Detectable Leak Rate
The minimum detectable leak rate is 0.586 gal/h when the threshold is set at 0.293 gal/h. If the leak rate is less than 0.586 gal/h, or if a threshold other than 0.293 gal/h is used, the P_D and P_{FA} will not meet the 95/5 criteria.

7.2 Averaging of Test Results

Table 5 summarizes the leak rate, R_n, that can be detected for some of the leak rates R computed for n = 1 in Table 4.

Table 5. Illustration of the Leak Rate, Rn, that can be Detected by Averaging n Test Results Together.

Number of Averages, n	R_n = Specified Leak Rate of the Averaged Test Result			
	(gal/h)	(gal/h)	(gal/h)	(gal/h)
1	0.586	1.000	2.000	3.000
2	0.414	0.707	1.414	2.121
4	0.293	0.500	1.000	1.500
6	0.239	0.408	0.816	1.225
9	0.195	0.333	0.667	1.000
12	0.169*	0.289	0.577	0.866
P_D	95%	95%	95%	95%
P_{FA}	5.0%	<1%	<<1%	<<1%
C_n	$(0.586/n^{0.5})$ - $1.796*S_m$	$(1.0/n^{0.5})$ - $1.796*S_m$	$(2.0/n^{0.5})$ - $1.796*S_m$	$(3.0/n^{0.5})$ - $1.796*S_m$

* Any R_n less than 0.2 gal/h can only be used at 0.2 gal/h.

As an example, the leak rate, R_n, that can be detected by the LRDP-24-n with a P_D = 95% and a P_{FA} = 5.0% is 0.2 gal/h when n = 9 test results are averaged together. A threshold of $C_{n=9}$ = 0.098 gal/h is used.

7.3 Water Detection Mode

The LRDP system is a mass-based system, which will detect increases and decreases in mass in the tank. Water leaks into or out of the tank are detected as changes in mass and the tank operator is alerted if a problem exists. The calculations for a bulk tank water detector are identical to those described in the standard ATGS protocol. The water detection mode calculations do not apply to the LRDP system.

7.4 Tank Size Limitations

The maximum size tank that the results of this evaluation can be applied to is 2.5 times the product surface area of the evaluation tank. As stated in Section 6.6, since the evaluation tank is not solely constructed with vertical walls, scaling does not apply for this evaluation.

7.5 Rate and Threshold

NFESC and Vista Research have selected several target leak rates and thresholds to report results for in this report, which are listed in Table 6 below. The basic statistics were obtained from the test data using the calculations described in the bulk tank test protocol. The bulk tank protocol states that the following results are to be reported after the data are available and the statistics have been calculated.

Table 6. Summary of the Rates and Thresholds

No.	Standard Deviation (gal/h)	Threshold (gal/h)	Target Leak Rate (gal/h)	P_D (%)	P_{FA} (%)	Minimum Detectable Leak Rate (gal/h)
1.	0.163	0.293	0.586	95%	5%	0.586
2.	0.163	0.707	1.0	95%	<1%	N/A
3.	0.163	0.877	1.17	95%	<1%	N/A
4.	0.163	1.707	2.0	95%	<<1%	N/A
5.	0.163	2.707	3.0	95%	<<1%	N/A

7.6 Leak Rate and Threshold Scaling

The evaluation was performed for the [redacted] bulk USTs at the Red Hill Facility. No scaling is reported.

7.7 Maximum Temperature Differences and Stabilization Times

Since product deliveries were not done for this evaluation, calculations cannot be done to determine the maximum allowable temperature differences following deliveries and the required stabilization time. NFESC and Vista Research specify that a 24-hour stabilization time following a delivery should be used before conducting a valid leak detection test. Product deliveries at the FISCPH tanks are relatively rare, and it is likely that the stabilization time will be longer than 24 hours in most cases.

7.8 Test Time

The average test time was 23.7 hours. One of the 12 tests was terminated 3.7 h short, but was approved for use in the evaluation by the vendor. All of the other tests conducted for the evaluation had test times of 24 hours as specified by the vendor.

8.0 Summary of LRDP-24 and LRDP-24-n Performance Parameters and Limitations

8.1 Volume and Surface Area Limitations

This evaluation was performed specifically for the [redacted] bulk USTs found at the Red Hill Underground Fuel Storage Facility. As a consequence, no scaling is reported.

8.2 Temperature Differential and Minimum Stabilization Time Limitations

Product deliveries were not made during the evaluation and temperature differential limitations and minimum stabilization time limitations cannot therefore be specified. The vendor specifies a minimum stabilization time of 24 hours after a product delivery.

8.3 Test Duration

The average test time was 23.7 hours. The vendor specifies a test time of 24 hours.

Appendix A

EPA Results Forms

Method Name and Version: LRDP-24 Version a-rh
Date of Certification: August 28, 2001

Results of U.S. EPA Alternative Test Procedures
Bulk Field-Constructed Tank
Mass-Based Leak Detection Method

This form describes the performance of the leak detection method described below. The evaluation was conducted by the equipment manufacturer or a consultant to the manufacturer according to a modification of the U.S. EPA's "Standard Test Procedure for Evaluating Leak Detection Methods: Volumetric Tightness Testing Methods." The full evaluation report also includes a form describing the method and a form summarizing the test data.

Tank owners using this leak detection system should keep this form on file to provide compliance with the federal regulations. Tank owners should check with State and local agencies to make sure this form satisfies their requirements.

Leak Detection Method Description

Name LRDP-24

Version number a-rh

Vendor(s)

NFESC 1100 23rd Avenue (street address) Port Hueneme, CA 93043-4370 (city) (state) (zip) (805) 982-1618 (phone)	Vista Research, Inc. 755 North Mary Avenue (street address) Sunnyvale, CA 94085 (city) (state) (zip) (408) 830-3300 (phone)

Evaluation Results

This method ( ) does (X) does not use multiple tests. If multiple tests are used, the results are based on _____ independent tests. The results apply only when ____ tests are performed and the estimated leak rates averaged.

This Leak Detection Method which declares tank to be leaking when the measured leak rate exceeds the threshold of TLR - 0.293 gallons per hour, has a probability of false alarm [P_{FA}] of $\leq$ 5 % for tests conducted on tanks with a surface area [A] of 7,854 sq. ft or less. The TLR is the target leak rate in gal/h. The TLR can have any value greater than or equal to 0.586 gal/h.

The corresponding probability of detection [P_D] of a TLR $\geq$ 0.586 gallon per hour leak is 95 %, where the TLR can have any value greater than or equal to 0.586 gal/h.

Evaluation Results (continued)

The standard deviation of the test data results was 0.163 gal/hr. The performance of the method is computed using 0.163 gal/h.

The smallest leak that can be detected with a probability of detection of 95% and a probability of false alarm of 5% [MDL] is 0.586 gal/hr in a tank with a surface area of 7,854 sq. feet.

The minimum water level (threshold) in the tank that the method can detect is N/A inches.

The minimum change in water level that can be detected by the method is N/A inches (provided that the water level is above the threshold).

Test Conditions During Evaluation

The evaluation testing was conducted in a nominal [redacted] tank with a surface area of [redacted] The tank was constructed of (X) steel ( ) fiberglass (X) concrete ( ) other (describe)

The tank geometry included vertical walls and was [redacted] (X) feet in diameter or ______ ( ) feet long and ______ ( ) feet wide and [redacted]

The tests were conducted with the tank product level 97 % full.

The product used in the evaluation was JP-5.

The temperature differences between product added to fill the tank and product already in the tank ranged from N/A deg F to N/A deg F, with a standard deviation of N/A deg F.

The system was operated as an automatic device. (X) Yes ( )No

Limitations on the Results

The performance estimates above are only valid when:

- The method has not been substantially changed.
- The vendor's instructions for installing and operating the Leak Detection Method are followed.
- The tank contains a product identified on the method description form.
- The tank is a field-constructed tank with vertical walls of constant cross section.
- The waiting time after adding any substantial amount of product to the tank is 24 hours 0 minutes.
- The total data collection time for the test is at least 24 hours 0 minutes.
- The maximum product surface area is [redacted]

Limitations on the Results (continued)

- The evaluation applies only to the [redacted] bulk USTs at the Red Hill Underground Fuel Storage Facility.
- The threshold for declaring a leak is adjusted for different tank sizes by multiplying the ratio of the product surface area used in the evaluation, which was [redacted] and the product surface area in the tank being tested. The detectable leak rate is scaled up or down by multiplying in the same way.
- The detectable leak rate ( ) may (X) may not be scaled below 0.2 gal/h.
- Other limitations specified by the vendor of determined during testing:

Procedural Information

State the procedures used to compensate for the presence of a water table above the bottom of the tank.

If a water leak is present, into or out of the tank, the leak will be detected as an inflow.

State the procedures used to determine when the tank is stable.

Tank stability is not an issue for mass measurement systems.

State the procedures used to account for fuels of different volatility.

No procedural changes are necessary. The reference tube compensates for evaporation and condensation.

Other Information

Summary of Test Procedure Modifications

Temperature Variations were achieved by: (describe briefly)

The volume of the test tank (nominally [redacted] was too large to physically create temperature variations. Deliveries were not simulated, because fuel transfers to fill the tanks are accomplished infrequently, and fuel is typically stored for approximately 9 months before being transferred out of the tank. The tank was filled approximately five days before the start of the evaluation. No temperature measurements were made.

Other Modifications: (describe briefly)

Method Name and Version: LRDP-24 Version a-rh

Date of Certification: August 28, 2001

Summary of Performance Estimates (Threshold is based on setting the PD = 95% such that the PFA is less than or equal to 5% and is as small as possible.)

	Test Tank/Tank 1	Test Tank/Tank 1	Test Tank/Tank 1
Diameter	[redacted]	[redacted]	[redacted]
Surface Area	[redacted]	[redacted]	[redacted]
Standard Deviation*	0.163 gal/h	0.163 gal/h	0.163 gal/h
Target Leak Rate, TLR	1.000 gal/h	2.000 gal/h	3.000 gal/h
Vendor's Threshold	0.707 gal/h	1.707 gal/h	2.707 gal/h
PFA	< 1%	<< 1%	<< 1%
PD(for target leak rate)	95%	95%	95%
MDL	0.586 gal/h	0.586 gal/h	0.586 gal/h
* Standard deviation based on (X) a single test or ( ) average of ______ tests.			

Note: Additional copies of this table for other leak rate may be included as desired.

Summary of Performance Estimates and Scaling (Threshold is based on setting the PD = 95% and the PFA = 5%.)

	Test Tank/Tank 1		
Diameter	[redacted]		
Surface Area	[redacted]		
Standard Deviation*	0.163 gal/h		
Target Leak Rate, TLR	0.586 gal/h		
Vendor's Threshold	0.293 gal/h		
PFA	5%		
PD(for target leak rate)	95%		
* Standard deviation based on (X) a single test or ( ) average of ______ tests.			

> **Safety disclaimer: This test procedure only addresses the issue of the Leak Detection Method's ability to detect leaks. It does not test the equipment for safety hazards.**

Certification of Results

I certify that the Leak Detection Method was installed and operated according to the vendor's instructions and that the results presented on this form are those obtained during the evaluation.

H. Kendall Wilcox, Ph.D., President
(printed name)

Ken Wilcox Associates, Inc.
(organization performing evaluation)

H. Kendall Wilcox
(signature)

Grain Valley, Missouri, 64029
(city, state, zip)

August 28, 2001
(date)

(816) 443-2494
(phone number)

Method Name and Version: LRDP-24-n Version a-rh
Date of Certification: August 28, 2001

Results of U.S. EPA Alternative Test Procedures
Bulk Field-Constructed Tank
Mass-Based Leak Detection Method

This form describes the performance of the leak detection method described below. The evaluation was conducted by the equipment manufacturer or a consultant to the manufacturer according to a modification of the U.S. EPA's "Standard Test Procedure for Evaluating Leak Detection Methods: Volumetric Tightness Testing Methods." The full evaluation report also includes a form describing the method and a form summarizing the test data.

Tank owners using this leak detection system should keep this form on file to provide compliance with the federal regulations. Tank owners should check with State and local agencies to make sure this form satisfies their requirements.

Leak Detection Method Description

Name LRDP-24-n

Version number a-rh

Vendor(s)

NFESC 1100 23rd Avenue (street address) Port Hueneme, CA 93043-4370 (city) (state) (zip) (805) 982-1618 (phone)	Vista Research, Inc. 755 North Mary Avenue (street address) Sunnyvale, CA 94085 (city) (state) (zip) (408) 830-3300 (phone)

Evaluation Results

This method (X) does ( ) does not use multiple tests. If multiple tests are used, the results are based on n independent tests. The results apply only when $1 < n \leq 12$ tests are performed and the estimated leak rates averaged.

This Leak Detection Method which declares tank to be leaking when the measured leak rate exceeds the threshold of TLR-$(0.293/n^{0.5})$ gallons per hour, has a probability of false alarm [P_{FA}] of ≤ 5 % for tests conducted on tanks with a surface area [A] of 7,854 sq. ft or less. The TLR is the target leak rate in gal/h. The TLR can have any value greater than or equal to $(0.586/n^{0.5})$ gal/h such that the TLR $\geq$ 0.20 gal/hr.

The corresponding probability of detection [P_D] of a TLR $\geq (0.586/n^{0.5})$ gallon per hour leak is 95 %, where the TLR can have any value greater than or equal to $(0.586/n^{0.5})$ gal/h such that the TLR $\geq$ 0.20 gal/hr.

Evaluation Results (continued)

The standard deviation of the test data results was 0.163 gal/hr. The performance of the method is computed using $(0.163/n^{0.5})$.

The smallest leak that can be detected with a probability of detection of 95% and a probability of false alarm of 5% [MDL] is $(0.586/n^{0.5})$ gal/hr in a tank with a surface area of 7,854 sq. feet.

The minimum water level (threshold) in the tank that the method can detect is

N/A inches.

The minimum change in water level that can be detected by the method is

N/A inches (provided that the water level is above the threshold).

Test Conditions During Evaluation

The evaluation testing was conducted in a nominal [redacted] tank with a surface area of [redacted] The tank was constructed of (X) steel ( ) fiberglass

(X) concrete ( ) other (describe)

The tank geometry included vertical walls and was [redacted] (X) feet in diameter or ______ ( ) feet long and ______ ( ) feet wide and [redacted] deep.

The tests were conducted with the tank product level 97 % full.

The product used in the evaluation was JP-5 .

The temperature differences between product added to fill the tank and product

already in the tank ranged from N/A deg F to N/A deg F, with a standard deviation of

N/A deg F.

The system was operated as an automatic device. (X) Yes ( )No

Limitations on the Results

The performance estimates above are only valid when:

- The method has not been substantially changed.
- The vendor's instructions for installing and operating the Leak Detection Method are followed.
- The tank contains a product identified on the method description form.
- The tank is a field-constructed tank with vertical walls of constant cross section.
- The waiting time after adding any substantial amount of product to the tank is 24 hours 0 minutes.
- The total data collection time for the test is at least 24 hours 0 minutes.
- The maximum product surface area is [redacted]

Limitations on the Results (continued)

- The evaluation applies only to the [redacted] bulk USTs at the Red Hill Underground Fuel Storage Facility.
- The threshold for declaring a leak is adjusted for different tank sizes by multiplying the ratio of the product surface area used in the evaluation, which was [redacted] square feet, and the product surface area in the tank being tested. The detectable leak rate is scaled up or down by multiplying in the same way.
- The detectable leak rate ( ) may (X) may not be scaled below 0.2 gal/h.
- Other limitations specified by the vendor of determined during testing:

Procedural Information

State the procedures used to compensate for the presence of a water table above the bottom of the tank.

If a water leak is present, into or out of the tank, the leak will be detected as an inflow.

State the procedures used to determine when the tank is stable.

Tank stability is not an issue for mass measurement systems.

State the procedures used to account for fuels of different volatility.

No procedural changes are necessary. The reference tube compensates for evaporation and condensation.

Other Information

Summary of Test Procedure Modifications

Temperature Variations were achieved by: (describe briefly)

The volume of the test tank (nominally [redacted] was too large to physically create temperature variations. Deliveries were not simulated, because fuel transfers to fill the tanks are accomplished infrequently, and fuel is typically stored for approximately 9 months before being transferred out of the tank. The tank was filled approximately five days before the start of the evaluation. No temperature measurements were made.

Other Modifications: (describe briefly)

Summary of Performance Estimates (Threshold is based on setting the PD = 95% such that the PFA is less than or equal to 5% and is as small as possible.)

	Test Tank/Tank 1	Test Tank/Tank 1	Test Tank/Tank 1
Diameter	[redacted]		
Surface Area			
Standard Deviation*	$0.163/n^{0.5}$ = 0.163 gal/h	$0.163/n^{0.5}$ = 0.115 gal/h	$0.163/n^{0.5}$ = 0.081 gal/h
Target Leak Rate, TLR	$1.000/n^{0.5}$ = 1.000 gal/h	$1.000/n^{0.5}$ = 0.707 gal/h	$1.000/n^{0.5}$ = 0.500 gal/h
Vendor's Threshold	$0.707/n^{0.5}$ = 0.707 gal/h	$0.707/n^{0.5}$ = 0.500 gal/h	$0.707/n^{0.5}$ = 0.353 gal/h
PFA	< 1%	< 1%	< 1%
PD(for target leak rate)	95%	95%	95%
MDL	$0.586/n^{0.5}$ = 0.586 gal/h	$0.586/n^{0.5}$ = 0.414 gal/h	$0.586/n^{0.5}$ = 0.293 gal/h
Number of Tests = n	1	2	4
* Standard deviation based on ( ) a single test or (X) average of n tests.			

Summary of Performance Estimates (Threshold is based on setting the PD = 95% such that the PFA is less than or equal to 5% and is as small as possible.)

	Test Tank/Tank 1	Test Tank/Tank 1	Test Tank/Tank 1
Diameter	[redacted]		
Surface Area			
Standard Deviation*	$0.163/n^{0.5}$ = 0.067 gal/h	$0.163/n^{0.5}$ = 0.054 gal/h	$0.163/n^{0.5}$ = 0.047 gal/h
Target Leak Rate, TLR	$1.000/n^{0.5}$ = 0.409 gal/h	$1.000/n^{0.5}$ = 0.334 gal/h	$1.000/n^{0.5}$ = 0.289 gal/h
Vendor's Threshold	$0.707/n^{0.5}$ = 0.289 gal/h	$0.707/n^{0.5}$ = 0.236 gal/h	$0.707/n^{0.5}$ = 0.204 gal/h
PFA	< 1%	< 1%	< 1%
PD(for target leak rate)	95%	95%	95%
MDL	$0.586/n^{0.5}$ = 0.239 gal/h	$0.586/n^{0.5}$ = 0.20 gal/h	$0.586/n^{0.5}$ < 0.2 gal/h
Number of Tests = n	6	9	12
* Standard deviation based on ( ) a single test or (X) average of n tests.			

Summary of Performance Estimates (Threshold is based on setting the PD = 95% such that the PFA is less than or equal to 5% and is as small as possible.)

	Test Tank/Tank 1	Test Tank/Tank 1	Test Tank/Tank 1
Diameter	[redacted]		
Surface Area			
Standard Deviation*	$0.163/n^{0.5}$ = 0.163 gal/h	$0.163/n^{0.5}$ = 0.115 gal/h	$0.163/n^{0.5}$ = 0.081 gal/h
Target Leak Rate, TLR	$2.000/n^{0.5}$ = 2.000 gal/h	$2.000/n^{0.5}$ = 1.414 gal/h	$2.000/n^{0.5}$ = 1.000 gal/h
Vendor's Threshold	$1.707/n^{0.5}$ = 1.707 gal/h	$1.707/n^{0.5}$ = 1.207 gal/h	$1.707/n^{0.5}$ = 0.854 gal/h
PFA	<< 1%	<< 1%	<< 1%
PD(for target leak rate)	95%	95%	95%
MDL	$0.586/n^{0.5}$ = 0.586 gal/h	$0.586/n^{0.5}$ = 0.414 gal/h	$0.586/n^{0.5}$ = 0.293 gal/h
Number of Tests = n	1	2	4
* Standard deviation based on ( ) a single test or (X) average of n tests.			

Method Name and Version: LRDP-24-n Version a-rh
Date of Certification: August 28, 2001

Summary of Performance Estimates (Threshold is based on setting the PD = 95% such that the PFA is less than or equal to 5% and is as small as possible.)

	Test Tank/Tank 1	Test Tank/Tank 1	Test Tank/Tank 1
Diameter	[redacted]	[redacted]	[redacted]
Surface Area	[redacted]	[redacted]	[redacted]
Standard Deviation*	0.163/n[redacted] = 0.067 gal/h	0.163/n[redacted] = 0.054 gal/h	$0.163/n^{0.5}$ = 0.047 gal/h
Target Leak Rate, TLR	$2.000/n^{0.5}$ = 0.816 gal/h	$2.000/n^{0.5}$ = 0.667 gal/h	$2.000/n^{0.5}$ = 0.577 gal/h
Vendor's Threshold	$1.707/n^{0.5}$ = 0.697 gal/h	$1.707/n^{0.5}$ = 0.569 gal/h	$1.707/n^{0.5}$ = 0.493 gal/h
PFA	<< 1%	<< 1%	<< 1%
PD(for target leak rate)	95%	95%	95%
MDL	$0.586/n^{0.5}$ = 0.239 gal/h	$0.586/n^{0.5}$ = 0.20 gal/h	$0.586/n^{0.5}$ < 0.2 gal/h
Number of Tests = n	6	9	12
* Standard deviation based on ( ) a single test or (X) average of n tests.			

Summary of Performance Estimates (Threshold is based on setting the PD = 95% such that the PFA is less than or equal to 5% and is as small as possible.)

	Test Tank/Tank 1	Test Tank/Tank 1	Test Tank/Tank 1
Diameter	[redacted]	[redacted]	[redacted]
Surface Area	[redacted]	[redacted]	[redacted]
Standard Deviation*	0.163/n[redacted] = 0.163 gal/h	0.163/n[redacted] = 0.115 gal/h	0.163/n[redacted] = 0.081 gal/h
Target Leak Rate, TLR	$3.000/n^{0.5}$ = 3.000 gal/h	$3.000/n^{0.5}$ = 2.121 gal/h	$3.000/n^{0.5}$ = 1.500 gal/h
Vendor's Threshold	$2.707/n^{0.5}$ = 2.707 gal/h	$2.707/n^{0.5}$ = 1.914 gal/h	$2.707/n^{0.5}$ = 1.354 gal/h
PFA	<< 1%	<< 1%	<< 1%
PD(for target leak rate)	95%	95%	95%
MDL	$0.586/n^{0.5}$ = 0.586 gal/h	$0.586/n^{0.5}$ = 0.414 gal/h	$0.586/n^{0.5}$ = 0.293 gal/h
Number of Tests = n	1	2	4
* Standard deviation based on ( ) a single test or (X) average of n tests.			

Summary of Performance Estimates (Threshold is based on setting the PD = 95% such that the PFA is less than or equal to 5% and is as small as possible.)

	Test Tank/Tank 1	Test Tank/Tank 1	Test Tank/Tank 1
Diameter	[redacted]	[redacted]	[redacted]
Surface Area	[redacted]	[redacted]	[redacted]
Standard Deviation*	0.163/n[redacted] = 0.067 gal/h	$0.163/n^{0.5}$ = 0.054 gal/h	$0.163/n^{0.5}$ = 0.047 gal/h
Target Leak Rate, TLR	$3.000/n^{0.5}$ = 1.225 gal/h	$3.000/n^{0.5}$ = 1.000 gal/h	$3.000/n^{0.5}$ = 0.866 gal/h
Vendor's Threshold	$2.707/n^{0.5}$ = 1.105 gal/h	$2.707/n^{0.5}$ = 0.902 gal/h	$2.707/n^{0.5}$ = 0.781 gal/h
PFA	<< 1%	<< 1%	<< 1%
PD(for target leak rate)	95%	95%	95%
MDL	$0.586/n^{0.5}$ = 0.239 gal/h	$0.586/n^{0.5}$ = 0.20 gal/h	$0.586/n^{0.5}$ < 0.2 gal/h
Number of Tests = n	6	9	12
* Standard deviation based on ( ) a single test or (X) average of n tests.			

Note: Additional copies of this table for other n and leak rates may be included as desired.

Method Name and Version: LRDP-24-n Version a-rh
Date of Certification: August 28, 2001

Summary of Performance Estimates and Scaling (Threshold is based on setting the PD = 95% and the PFA = 5%.)

	Test Tank/Tank 1	Test Tank/Tank 1	Test Tank/Tank 1
Diameter	[redacted]		
Surface Area			
Standard Deviation*	$0.163/n^{0.5}$ = 0.163 gal/h	$0.163/n^{0.5}$ = 0.115 gal/h	$0.163/n^{0.5}$ = 0.081 gal/h
Target Leak Rate, TLR	$0.586/n^{0.5}$ = 0.586 gal/h	$0.586/n^{0.5}$ = 0.414 gal/h	$0.586/n^{0.5}$ = 0.293 gal/h
Vendor's Threshold	$0.293/n^{0.5}$ = 0.293 gal/h	$0.293/n^{0.5}$ = 0.207 gal/h	$0.293/n^{0.5}$ = 0.147 gal/h
PFA	5%	5%	5%
PD(for target leak rate)	95%	95%	95%
MDL	$0.586/n^{0.5}$ = 0.586 gal/h	$0.586/n^{0.5}$ = 0.414 gal/h	$0.586/n^{0.5}$ = 0.293 gal/h
Number of Tests = n	1	2	4
* Standard deviation based on ( ) a single test or (X) average of n tests.			

Summary of Performance Estimates (Threshold is based on setting the PD = 95% such that the PFA is less than or equal to 5% and is as small as possible.)

	Test Tank/Tank 1	Test Tank/Tank 1	Test Tank/Tank 1
Diameter	[redacted]		
Surface Area			
Standard Deviation*	$0.163/n^{0.5}$ = 0.067 gal/h	$0.163/n^{0.5}$ = 0.054 gal/h	$0.163/n^{0.5}$ = 0.047 gal/h
Target Leak Rate, TLR	$0.586/n^{0.5}$ = 0.239 gal/h	$0.586/n^{0.5}$ = 0.20 gal/h	$0.586/n^{0.5}$ < 0.2 gal/h
Vendor's Threshold	$0.293/n^{0.5}$ = 0.120 gal/h	$0.293/n^{0.5}$ = 0.098 gal/h	$0.293/n^{0.5}$ = 0.085 gal/h
PFA	5%	5%	5%
PD(for target leak rate)	95%	95%	95%
MDL	$0.586/n^{0.5}$ = 0.239 gal/h	$0.586/n^{0.5}$ = 0.20 gal/h	$0.586/n^{0.5}$ < 0.2 gal/h
Number of Tests = n	6	9	12
* Standard deviation based on ( ) a single test or (X) average of n tests.			

Note: Additional copies of this table for other n may be included as desired.

> **Safety disclaimer: This test procedure only addresses the issue of the Leak Detection Method's ability to detect leaks. It does not test the equipment for safety hazards.**

Certification of Results

I certify that the Leak Detection Method was installed and operated according to the vendor's instructions and that the results presented on this form are those obtained during the evaluation.

H. Kendall Wilcox, Ph.D., President
(printed name)

Ken Wilcox Associates, Inc.
(organization performing evaluation)

H. Kendall Wilcox
(signature)

Grain Valley, Missouri, 64029
(city, state, zip)

August 28, 2001
(date)

(816) 443-2494
(phone number)

Description
Bulk Field-Constructed Tank
Leak Detection Method

This section describes briefly the important aspects of the bulk tank leak detection method. It is not intended to provide a thorough description of the principles behind the system or how the equipment works.

Method Name and Version

LRDP-24 Version a-rh and the LRDP-24-n Version a-rh

Product

> Product type

For what products can this Method be used? (check all applicable)

(X) gasoline

(X) diesel

(X) aviation fuel

(X) fuel oil #4

(X) solvents

(X) other (list) Any liquid.

> Water level

Does the Method measure inflow of water as well as loss of product (gallon per hour)?

(X) yes

( ) no

Does the Method detect the presence of water in the bottom of the tank?

( ) yes

(X) no

Principle of Operation

What technique is used to detect leaks in the tank system?

( ) directly measure the volume of product change

(X) changes in head pressure

( ) changes in buoyancy of a probe

( ) mechanical level measure (e.g., ruler, dipstick)

( ) changes in capacitance

( ) ultrasonic

( ) change in level of float (specify principle, e.g., capacitance, magnetostrictive, load cell, etc.) ____________________

( ) acoustical signal characteristics of a leak

( ) identification of a tracer chemical outside the tank system

( ) other (describe briefly) ____________________

Temperature Measurement

How many temperature sensors are used to measure the product temperature?

(X) Product temperature not measured

( ) One sensor

( ) Two sensors

( ) Three sensors

( ) Four sensors

( ) Five sensors

( ) Other (describe briefly) ____________________

What type of temperature sensor is used?

(X) Product temperature not measured

( ) resistance temperature detector (RTD)

( ) bimetallic strip

( ) quartz crystal

( ) thermistor

( ) other (describe briefly) ____________________

If product temperature is not measured during a test, why not?

(X) the factor measured for change in level/volume is independent of temperature (e.g., mass)

(X) the factor measured for change in level/volume self-compensates for changes in temperature

(X) other (explain briefly) Reference tube in combination with differential pressure will compensate for temperature differences.

Data Acquisition

How are the test data acquired and recorded?

( ) manually

( ) by strip chart

(X) by computer

Procedure information

> Waiting times

What is the required waiting period between adding a large volume of product (i.e., a delivery) and the beginning of a test (e.g., filling from 50% to 90-95% capacity)?
__24__ Hours __0__ Minutes

Additional Comments: ____________________

> Test duration

What is the required time for collecting data?

__24__ Hours __0__ Minutes

Additional Comments: ____________________

What is the sampling frequency for the level and temperature measurements?

( ) more than once per second

( ) at least once per minute

(X) every 1-15 minutes

( ) every 16-30 minutes

( ) every 31-60 minutes

( ) less than once per hour

( ) variable (explain) ____________________

> Use of multiple tests

Does the procedure use the average leak rate from more than one test in reaching a conclusion?

(X) Yes (How many tests? (where n = 1 for the LRDP-24 and where 1< n =12 for the LRDP-24-n)

(X) No (for the LRDP-24

Does the procedure base its conclusion on the agreement of k out of n tests?

( ) Yes (A leak is indicated if ______ (specify k) out of _____ (specify n) tests indicate a leak.)

(X) No

> Identifying and correcting for interfering factors

How does the Method determine the presence and level of the ground water above the bottom of the tank?

(X) level of ground water above bottom of the tank not determined

( ) observation well near tank

( ) information from USGS, etc.

( ) information from personnel on-site

( ) presence of water in the tank

( ) other (describe briefly) ______________________________

Does the method measure inflow of water as well as loss of product?

(X) yes

( ) no

Additional Comments: ______________________________

____

____

How does the Method correct for the interference due to the presence of ground water above the bottom of the tank?

(X) no action

( ) system tests for water incursion

( ) different product levels tested and leak rates compared

( ) other (describe briefly) ______________________________

> Interpreting test results

How are level changes converted to volume changes (i.e., how is height-to-volume conversion factor determined)?

(X) actual level changes observed when known volume is added or removed (e.g., liquid metal bar)

(X) theoretical ratio calculated from tank geometry

(X) interpolation from tank manufacturer's chart

( ) other (describe briefly)

( ) not applicable; volume measured directly

How is the coefficient of thermal expansion (Ce) of the product determined?

( ) actual sample taken for each test and Ce determined from specific gravity

( ) value supplied by vendor of product

( ) average value for type of product

(X) other (describe briefly) Not required. Method is self-compensating for product temperature changes.

How is the leak rate (gallon per hour) calculated?

( ) average of subsets of all data collected

( ) difference between first and last data collected

(X) from data from last 24 hours of test period

(X) from data determined to be valid by statistical analysis

( ) other (describe) ________________

What threshold value for product volume change (gallon per hour) is used to declare that a tank is leaking?

( ) 0.05 gal/hr	( ) 0.1 gal/hr	( ) 0.2 gal/hr
( ) 0.5 gal/hr	( ) 1.0 gal/hr	( ) 2.0 gal/hr

(X) Other $0.293/n^{0.5}$ gal/h for MDL = $0.586/n^{0.5}$ gal/h with a P(D) = 95% and a P(FA) = 5% in a tank to be tested with a surface area A [redacted] For a target leak rate [TLR] greater than or equal to ($0.586/n^{0.5}$) in gal/h, the threshold is equal to TLR – ($0.293/n^{0.5}$) in gal/h. When n = 1, these results are for the LRDP-24.

Additional Comments: ________________

Under what conditions are test results considered inconclusive?

( ) ground water level above the bottom of the tank

( ) soil not sufficiently porous

( ) too much variability in the data (standard deviation beyond a given value)

( ) unexplained product volume increase

(X) other (describe briefly) None

Exceptions

Are there any conditions under which a test should not be conducted?

( ) ground water level above the bottom of the tank

( ) large difference between ground temperature and delivered product temperature

( ) extremely high or low ambient temperature

( ) invalid for some products (specify) ______

(X) other (describe briefly) None

What are acceptable deviations from the standard testing protocol?

(X) lengthen the duration of test

( ) other (describe briefly) ______

( ) none

What elements of the test procedure are determined by personnel on-site?

(X) product level when test is conducted

(X) when to conduct test

(X) waiting period between filling tank and beginning test

(X) length of test (LRDP-24 requires a minimum test time of 24 hours.)

( ) determination of "outlier" data that may be discarded

( ) other (describe briefly) ______

( ) none

Appendix B

MTC Pilot Test Results
and
Supporting Baker Trip Report

Precision Leak Measurement Report

Customer Information:	FISC Red Hill Pearl Harbor, HI
Project Manager:	Mr. Christopher Caputi
Mass Technology Site Supervisor	Jimmy Wolford

Scope of Work: Furnish all required management, labor, services, materials and equipment to perform precision tightness testing of Tank # 9 an underground fuel storage tank located at FISC Red Hill, Pearl Harbor, HI.

Report compiled by: Larry D. Speaks Date: 03-20-2008
Larry D. Speaks

I declare under penalty of perjury that I am a licensed tank tester in the State of California and that the information contained in this report is true and correct to the best of my knowledge.

Test performed by: ____________ Date: 03-20-2008
Jimmy Wolford

License number: 90-1286

Mass Technology Corporation
P. O. Box 1578
Kilgore, Texas 75662
Phone (903) 986-3564
Fax (903) 984-3569

Table of Contents

Executive Summary

Testing of the REDACTED gal underground storage tank located at FISC Red Hill, Pearl Harbor, Hawaii commenced February 27, 2008 and was completed March 11, 2008. The tank was filled with JP-5 and a precision leak test was conducted. The result of that test indicates the tank is tight. Testing was performed using Mass Technology Corporation protocols set out in the third party evaluations. All tank valves were adequately secured such that any fluid loss was isolated to leakage. Therefore, the containment integrity of the tank was not compromised and the test is considered conclusive.

Tank 9: After 240 hours of testing the tank is certified tight.

Tank Data Tank 9

Diameter: REDACTED **Height:** REDACTED
Tank Type: Vertical Underground
Contents: JP-5
Properties: 0.82 Specific Gravity
Product Level: 210 ft.

Test Data

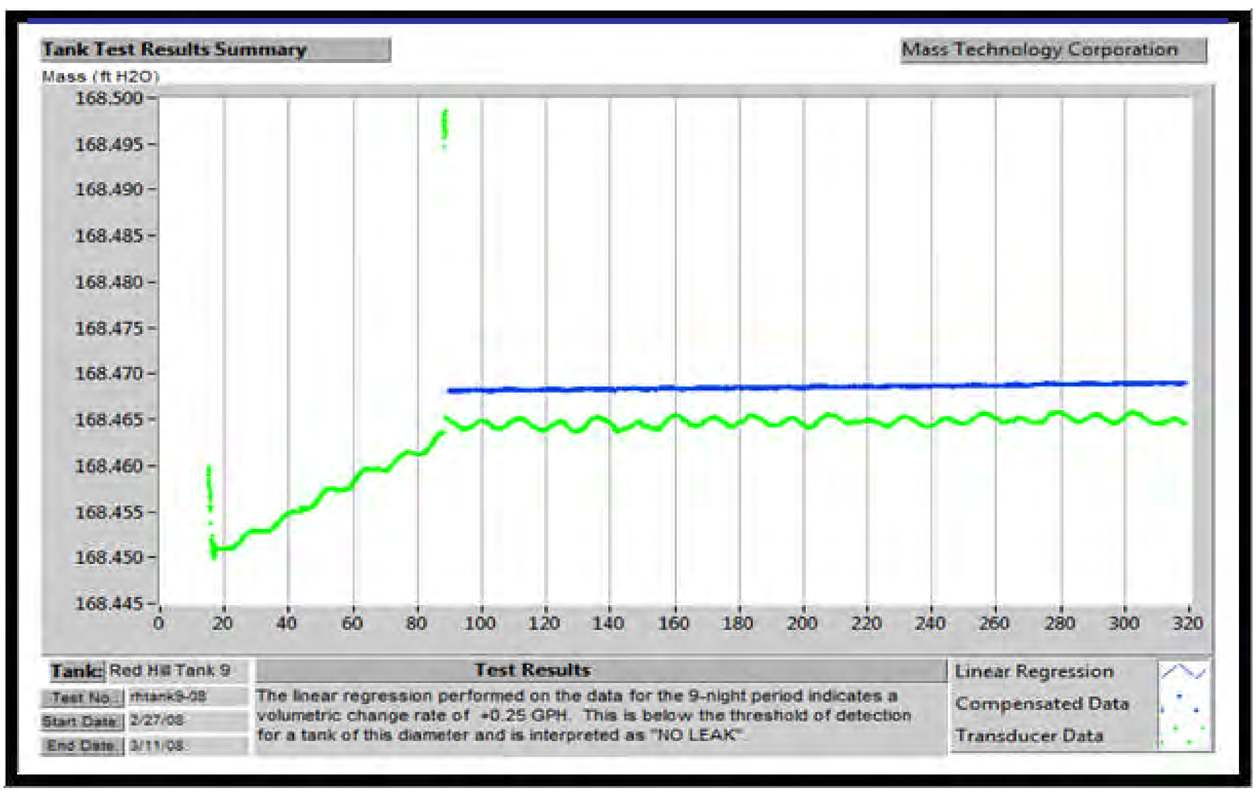
Start Date: 02-27-2008
Completion Date: 03-11-2008
Unit Operator: Jimmy Wolford

Test Results

Certified Tight

Summary of Results

The fluid mass data was recorded over a 240-hour test period. A linear regression of the recorded fluid mass data resulted in no leak detected above the minimum detection level of 0.5 gallons per hour. All tank valves were adequately secured such that any fluid loss was isolated to leakage. Therefore, the containment integrity of the tank has not been compromised and the tank is considered not to be leaking.



Precision Leak Measurement Report

Customer Information:	FISC Red Hill Pearl Harbor, HI
Project Manager:	Mr. Christopher Caputi
Mass Technology Site Supervisor	Jimmy Wolford

Scope of Work: Furnish all required management, labor, services, materials and equipment to perform precision tightness testing of Tank # 15 an underground fuel storage tank located at FISC Red Hill, Pearl Harbor, HI.

Report compiled by: Larry D. Speaks — Date: 03-20-2008

Larry D. Speaks

I declare under penalty of perjury that I am a licensed tank tester in the State of California and that the information contained in this report is true and correct to the best of my knowledge.

Test performed by: ______________ Date: 03-20-2008

Jimmy Wolford

License number: 90-1286

Mass Technology Corporation
P. O. Box 1578
Kilgore, Texas 75662
Phone (903) 986-3564
Fax (903) 984-3569

Table of Contents

Executive Summary

Testing of the 12,600,000 gal underground storage tank located at FISC Red Hill, Pearl Harbor, Hawaii commenced March 6, 2008 and was completed March 11, 2008. The tank was filled with DFM and a precision leak test was conducted. The result of that test indicates the tank is tight. Testing was performed using Mass Technology Corporation protocols set out in the third party evaluations. All tank valves were adequately secured such that any fluid loss was isolated to leakage. Therefore, the containment integrity of the tank was not compromised and the test is considered conclusive.

Tank 15: After 120 hours of testing the tank is certified tight.

Tank Data Tank 15

Diameter: REDACTED **Height:** REDACTED
Tank Type: Vertical Underground
Contents: DFM
Properties: 0.84 Specific Gravity
Product Level: 211 ft.

Test Data

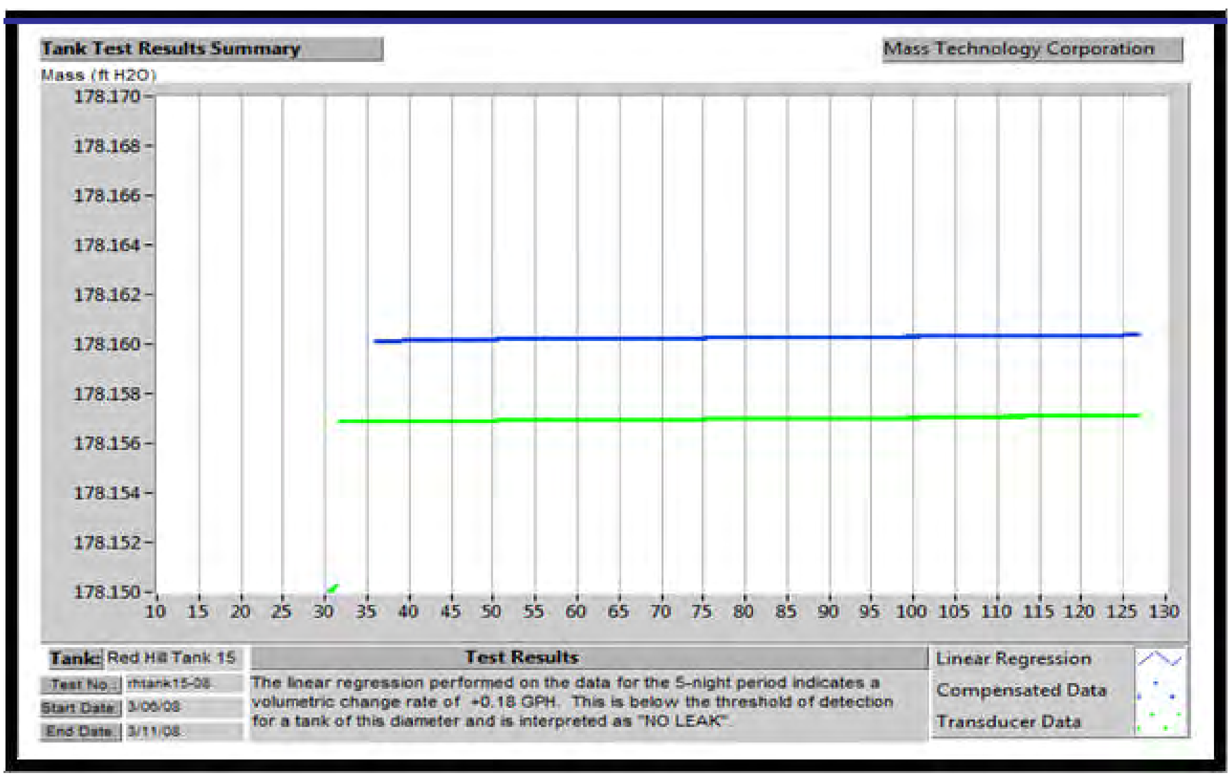
Start Date: 03-06-2008
Completion Date: 03-11-2008
Unit Operator: Jimmy Wolford

Test Results

Certified Tight

Summary of Results

The fluid mass data was recorded over a 120-hour test period. A linear regression of the recorded fluid mass data resulted in no leak detected above the minimum detection level of 0.5 gallons per hour. All tank valves were adequately secured such that any fluid loss was isolated to leakage. Therefore, the containment integrity of the tank has not been compromised and the tank is considered not to be leaking.



Trip Report
FISC Pearl Harbor
MTC Pilot Testing
In Support of
Leak Detection Market Survey

Introduction:

Baker and Mass Technology Corporation (MTC) mobilized to FISC Pearl Harbor, Hawaii on Monday February 25th 2008 to begin a Pilot test of the MTC leak detection system on one of the USTs at the Red Hill Bulk Storage Complex. The intent of this test was to evaluate the suitability of MTC testing on the large USTs at Red Hill. This information would be included in the Leak Detection Market Survey being developed by Baker for DESC and NAVSUP (NOLSC) at Ft Belvoir.

Background:

Baker is developing and documenting potential technologies available to provide leak detection on the REDACTED USTs located at the Red Hill Storage Complex at FISC Pearl Harbor, HI. This "Market Survey" of leak detection technologies will be used by the government to help select an appropriate system to provide a leak detection solution for these tanks. One of the potentially useful technologies short-listed by Baker was the MTC leak detection system. This system utilizes a precision mass measurement probe installed from a tank top opening to the bottom of the UST. Through data collection and software analysis leaks can be detected under 1.0 gallons per hour. The government directed Baker to perform a pilot test on one of the USTs at Red Hill to determine what physical or logistics challenges would be encountered during such testing which may detract from the potential use of such a system.

Site Visit and Pilot Test:

Monday February 25th 2008

Baker and MTC mobilized to FISC Pearl Harbor, Hawaii on Monday February 25th 2008.

Tuesday February 26th 2008

The first order of business was a Kickoff meeting hosted by the FISC office. This meeting took place on Tuesday 26 February 2008 from 8am until approximately 10:30 am. A list of the attendees of this meeting follows:

Name	Organization	Telephone	email
Victor Peters	FISC Pearl Harbor	808 479-0127	Victor.Peters@ Navy.mil
Lee Edwards	DESC Mid Pac	808 473-4311	Lee.Edwards@ DLA.mil
Lt Col Joy Griffith	DESC Mid Pac	808 473-4291	Joy.Griffith@ DLA.mil
Jimmy Wolford	MTC	903 987-5888	JWolford@ mtctesting.com
Chris Caputi	Baker	757 631-5490	ccaputi@ mbakercorp.com
George Cook	FISC Pearl Harbor	808 473-7833	George.Cook@ Navy.mil
John Roundy	DES DP	808 473-4286	John.Roundy @DLA.mil
Terry Strack	FISC Pearl Harbor	808 473-7892	Terry.Strack@ Navy.mil
Raelynn Della Sala	NAVFAC COMNAVREG HI	808 471-1171 Ext. 337	Raelynn.DellaSala @ Navy.mil
Alan Sugihara	NAVFAC HI	808 471-5094	Alan.Sugihara@ Navy.mil
Incheol Pang	NAVFAC NFESC	808 473-7898	Incheol.Pang@ Navy.mil
Steven Butler	FISC Pearl Harbor	808 473-7856	Steven.C.Butler@ Navy.mil
Al Hoyle	FISC Pearl Harbor	808 473-7805	Alfred.Hoyle@ Navy.mil
Calvin Lee	FISC Pearl Harbor	808 473-7816	Calvin.Lee@ Navy.mil

A copy of the agenda items discussed at this meeting is provided as Attachment A.

Generally, the kickoff meeting followed this agenda and focused on the particulars of this MTC test event and how best to proceed. Beyond these logistics items the following two major points were discussed:

> It was decided at this meeting that to provide an equal comparison to the Vista LRDP Leak Detection system that had been evaluated as a form of leak detection for these USTs in 2001, the MTC test should be performed on the same UST. Tank 9, a JP-5 tank filled to an approximate height of 209’, would be the tank selected for this MTC test.
>
> It was also determined that FISC PH wished to receive a copy of the tank testing report as a stand alone report in addition to the copy that would ultimately be incorporated into the Market Survey Report due on 31 March 2008.

After this kickoff meeting concluded, Baker, MTC, and Ms. Terry Strack of FISC PH proceeded to the Red Hill complex to look at the site and begin preparations for the tank test. It was identified during this inspection that the manual gauging port located on top of UST 9 was of (nominal) 3” inside diameter. MTC had been told that the gauging hatches on these tanks were greater than 6” in diameter and had brought test equipment based on that dimension. The rest of the day was spent finding a local machine shop able to turn down the diameter of the test equipment to fit into the gauging port of Tank 9.

Wednesday February 27th 2008

Baker and MTC arrived on site at the FISC PH office at 8 am to get the necessary passes to access Red Hill. At about 9 am Baker and MTC arrived on site at Red Hill Tank 9 and began setting up the MTC test equipment. At noon Baker and MTC went to the machine shop in Honolulu and obtained the newly modified test equipment and returned to Red Hill. The final touches were put on the test gear and the test was initiated at approximately 3pm. Baker, MTC and Ms. Strack then inspected the piping associated with Tank 9 in lower tunnel to determine that if there was a problem detected during testing how the variables such as valve bleed by could be addressed. It was decided due to the labor required not to drain the lines or manipulate valves unless a problem was detected . The tank fluid level was noted to be 209’ 9 and 15/16th inches as the test was set up (see Photo 1).

Photo 1 Tank 9 ATG on Feb 27th 2008 at 10:43 am
(note level is 209’ 9 and 15/16th”)

Thursday February 28th 2008

Baker and MTC checked on the status of the test at approximately 10 am. It was noted that a small increase in the mass was being detected within the test. Baker and MTC decided to monitor the test for another 24 hours before deciding if the increasing trend would normalize and level out or if in fact there was a true increase being detected.

The FISC PH POC was out with a personal issue.

Friday February 29th 2008

Baker and MTC checked on the status of the tank and did determine that the test was in fact monitoring an increase in product in the tank. It was also noted that the existing MTG Tank gauge was also fluctuating between 209' 09 and 15/16th inches and 209' 10 and 00/16th inches (see photos 2 and 3). This fluctuation was not noted during the test set up on the 27th. Baker and MTC wondered if the tank level gauge may also be reading an increase in product level and was at the threshold of detection by the gauge (1/16th of an inch). Baker/MTC met with Ms Strack at the FISC office and asked if historic tank level data was available for that tank to see if the MTG tank gauge was detecting an increase over time. It was discovered that the FISC office only holds the tank level data from Sunday to Saturday after which time it is purged from the computer system. Data was available from Sunday February 24th thru Friday February 29th. The hardcopy of the data provided to Baker showed the fluid level to be fairly constant within a range of about plus/minus 0.04" (slightly less than 1/16th of an inch). This did not seem to show an obvious rise of product level as expected by the results of the MTC test so far.

Photo 2 Tank 9 ATG on Feb 29th 2008 at 8:53 am
(note level is 209'10")

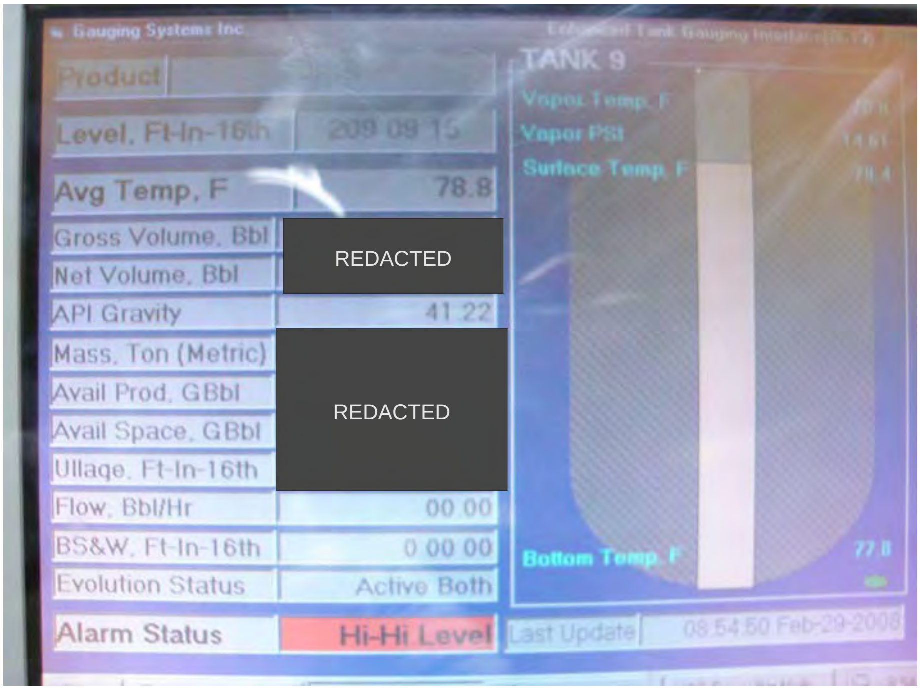


Photo 3 Tank 9 ATG on Feb 29th 2008 at 8:54 am
(note level is 209' 9 and 15/16th")

Baker/MTC and the FISC office determined that the next action taken would be to drain the pipes connected to the tank to relieve any potential of hydrostatic pressure head from nearby tanks from causing valve bleed by and causing the tank level to rise. This piping drain was performed Friday afternoon by FISC personnel, but given the levels and pressures in this piping there did not appear to be any chances of valve bleed by. MTC continued to log data and would determine over the weekend if the system continued to show a rising level or if it would stabilize.

During the late morning Baker met with Mr. Vic Peters of FISC to discuss some of the technical issues of the existing gauge system, AFHE, and the Asteroid system. This data will be incorporated into the Market Survey report.

During the afternoon Baker met with Ms. Terry Strack to discuss her needs for piping pressure testing. She is hoping to use the DESC centralized program to perform the USCG required annual pressure piping testing as well as pressure testing of the Hickam AFB transfer line. Baker will put together a scope of work to be bid to appropriate test vendors to perform this work. Baker will submit a draft of this SOW to Ms Strack to ensure all of her requests are included.

Baker demobilized from the Hawaii at 6pm on Friday. MTC remained to monitor the test.

Saturday March 1st 2008

MTC continued to monitor the tank test

Sunday March 2nd, 2008

MTC continued to monitor the tank test

Monday March 3rd, 2008

MTC contacted Baker and indicated that the pressure transducers had seemed to normalize and the system was testing normally (no liquid level gain issue). Baker authorized MTC to perform another 4 day test on another tank to see if the level gain experience in the beginning of this test would be indicative of testing all of these USTs.

Friday March 7th 2008

MTC contacted Baker and informed them that a second test had been begun on Tank 15 on Thursday. The same initial level gain was also being recorded during that time. It seems to be an issue that during the initial portion of the test the pressure transducers take a few days to normalize during which time a slight gain will be recorded. MTC will document this phenomenon while continuing to test Tank 15 over the weekend. MTC plans on terminating both tests on Monday and demobilizing on Tuesday.

ATTACHEMENT A
Kickoff Meeting Agenda

FISC Pearl Harbor
Red Hill UST Integrity Testing
To Support the
2008 Red Hill UST Leak Detection Market Survey
Kick-off Meeting Agenda

1. Introductions

Chris Caputi, P.E. – Michael Baker Jr. inc. – Project Manager
Jimmy Wolford- Mass Technology Corporation
John Davis, P.E. – Michael Baker Jr. inc. – Project Engineer

2. Purpose

To research leak detection solutions available for the USTs at Red Hill and specifically to perform the MTC Pilot Test.

3. Background

Tanks regulated by 40 CFR 112 not 280 – coordination with SPCC
DOH driven requirements for Leak Detection
No off the shelf solutions for leak detection
Previous Market Surveys performed
Vista LRDP system evaluated and 3rd party certified
No permanent actions taken towards tank leak detection

4. 2008 Leak Detection Market Survey

Research available technologies to perform leak detection on the Red Hill USTs
Develop short list of reasonable potential candidates
Pilot test MTC
Discuss Data averaging and "Mountain Home AFB" approach for MTC and Vista LRDP
Provide evaluation matrix
Provide recommendations

5. Pilot testing of MTC

Purpose of this visit (26 Feb 2008) is to determine the suitability/challenges of MTC testing.

6. Submittal of Results

Results of the MTC testing will be 1) Formal point in time test report for DESC/FISC/Navy records and 2) an appendix in the "Market Survey" – Due 31 March 2008.

7. Specifics/Schedule of MTC Pilot Test

Logistics and Set up (acquire nitrogen, mob equipment to test site, insert probe and hook up equipment)
Test Start
7-day test
Routine monitoring by MTC during test
Test demobilization
Test QA/QC
Reporting
Escorts and site access

8. Emergency Contact Information

Chris Caputi (757) 617-8004 (cell) or ccaputi@mbakercorp.com – (Blackberry)
Jimmy Wolford (903) 986-3564 (office – 24 hr)

9. Other DESC Related Items

Additional Market Survey data collection
USCG pipeline Pressure testing vs. Precision Integrity testing - Annual
Hickam AFB transfer line precision integrity testing vs. pressure testing. (Annual vs. biennial)
UFC 3-460 testing
Hickam AFB Hydrant system testing - biennial

10. Questions/Comments

Appendix C

Draft NWGLDE Listings
Varec Leak Manager

Revision Date: June XX, 2008

BULK UNDERGROUND STORAGE TANK LEAK DETECTION METHOD (50,000 gallons or greater)

VENDOR	EQUIPMENT NAME	LEAK RATE / THRESHOLD / MAX PRODUCT SURFACE AREA
ASTTest Services, Inc.	ASTTest Mass Balance Leak Detection System	[(product surface area in ft² ÷ 5,575 ft²) x 0.88 gph]/[(product surface area in ft² ÷ 5,575 ft²) x 0.44 gph]/13,938 ft²
Engineering Design Group, Inc.	EDG XLD 2000 Plus (Revision 1.02) Leak Detection System (MTS DDA Magnetostrictive Probe)	[(product surface area in ft² ÷ 12,074 ft²) x 1.92 gph]/[(product surface area in ft² ÷ 12,074 ft²) x 0.96 gph]/12,076 ft²
Engineering Design Group, Inc.	Ronan X-76 CTM Automatic Tank Gauging System (MTS Level Plus UST Probe)	[(product surface area in ft² ÷ 564 ft²) x 0.2 gph]/[(product surface area in ft² ÷ 564 ft²) x 0.1 gph]/846 ft²
Mass Technology Corp.	Precision Mass Measurement System (24 hour test)	[(product surface area in ft² ÷ 1,257 ft²) x 0.1 gph]/[(product surface area in ft² ÷ 1,257 ft²) x 0.05 gph]/3,143 ft²
Mass Technology Corp.	Precision Mass Measurement System (48 hour test)	[(product surface area in ft² ÷ 6,082 ft²) x 0.294 gph]/[(product surface area in ft² ÷ 6,082 ft²) x 0.147 gph]/6,082 ft²
Mass Technology Corp.	Precision Mass Measurement System (72 hour test)	[(product surface area in ft² ÷ 14,200 ft²) x 0.638 gph]/[(product surface area in ft² ÷ 14,200 ft²) x 0.319 gph]/35,500 ft²
Praxair Services, Inc. (originally listed as Tracer Research, Corp.)	Tracer ALD 2000 Automated Tank Tightness Test	0.1 gph/A tank system should not be declared tight when tracer chemical or hydrocarbon greater than the background level is detected outside of the tank./Not limited by capacity.
Universal Sensors and Devices, Inc.	LTC-1000 (Mass Buoyancy Probe)	[(product surface area in ft² ÷ 14,244 ft²) x 1.4 gph]/[(product surface area in ft² ÷ 14,244 ft²) x 0.7 gph]/35,610 ft²
Universal Sensors and Devices, Inc.	LTC-2000 (Differential Pressure Probe)	[(product surface area in ft² ÷ 14,244 ft²) x 3.0 gph]/[(product surface area in ft² ÷ 14,244 ft²) x 1.5 gph]/35,610 ft²
Varec, Inc. (originally listed as Coggins Systems, Inc. and later as Endress+Hauser Systems and Gauging)	Fuels Manager and Remote Terminal Unit RTU/8130 (MTS Magnetostrictive Probe)	[(product surface area in ft² ÷ 616 ft²) x 0.2 gph]/[(product surface area in ft² ÷ 616 ft²) x 0.1 gph]/924 ft²
Varec, Inc. (originally listed as Coggins Systems, Inc. and later as Endress+Hauser Systems and Gauging)	Fuels Manager with Barton Series 3500 ATG (48 hour test) (72 hour test)	[(product surface area in ft² ÷ 6,082 ft²) x 2.0 gph]/[(product surface area in ft² ÷ 6,082 ft²) x 1.0 gph]/15,205 ft²
Varec, Inc.	FuelsManager with Enraf 854 ATG (Servo Buoyancy Probe)	[(product surface area in ft² ÷ 11,786 ft²) x 3.00 gph]/[(product surface area in ft² ÷ 11,786 ft²) x 1.50 gph]/ 11,786 ft²
Varec, Inc.	FuelsManager with MTS M-Series ATG (MTS Magnetostrictive Probe)	[(product surface area in ft² ÷ 11,786 ft²) x 4.50 gph]/[(product surface area in ft² ÷ 11,786 ft²) x 2.25 gph]/ 11,786 ft²
Vista Research, Inc. and Naval Facilities Engineering Service Center	LRDP-24 (V1.0.2, V1.0.3)	[(product surface area in ft² ÷ 6,082 ft²) x 2.0 or 3.0 gph]/[(product surface area in ft² ÷ 6,082 ft²) x (2.0 or 3.0 gph - 0.223 gph)]/15,205 ft²
Vista Research, Inc. and Naval Facilities Engineering Service Center	LRDP-48 (V1.0.2, V1.0.3)	[(product surface area in ft² ÷ 6,082 ft²) x 2.0 or 3.0 gph]/[(product surface area in ft² ÷ 6,082 ft²) x (2.0 or 3.0 gph - 0.188 gph)]/15,205 ft²
Vista Research, Inc. and Naval Facilities Engineering Service Center	LRDP-24 (V1.1)	[(product surface area in ft² ÷ 6,082 ft²) x 0.856 gph]/[(product surface area in ft² ÷ 6,082 ft²) x 0.632 gph]/15,205 ft²

Issue Date: June XX, 2008

Varec, Inc.

Fuels Manager with Enraf 854 ATG
(Servo Buoyancy Probe)

BULK UNDERGROUND STORAGE TANK LEAK DETECTION (50,000 gallons or greater)

Certification	Leak rate is proportional to product surface area (PSA). For tanks with PSA of 11,786 ft^2, leak rate is 3.00 gph with PD = 95.3% and PFA = 4.7% For other tank sizes, leak rate equals [(PSA in ft^2 ÷ 11,786 ft^2) x 3.00 gph]. Example: For a tank with PSA = 10,000 ft^2; leak rate = [(10,000 ft^2 ÷ 11,786 ft^2) x 3.00 gph] = 2.54 gph. **Leak rate may not be scaled below 0.2 gph.**
Leak Threshold	Leak threshold is proportional to product surface area (PSA). For tanks with PSA of 11,786 ft^2, leak threshold is 1.50 gph. For other tank sizes, leak threshold equals [(PSA in ft^2 ÷ 11,786 ft^2) x 1.50 gph]. Example: For a tank with PSA = 10,000 ft^2; leak threshold = [(10,000 ft^2 ÷ 11,786 ft^2) x 1.50 gph] = 1.27 gph. A tank system should not be declared tight if the test result indicates a loss or gain that equals or exceeds the calculated leak threshold.
Applicability	Gasoline, diesel, aviation fuel. Other liquids may be tested after consultation with the manufacturer.
Tank Capacity	Use limited to single field-constructed vertical tanks 50,000 gallons to 2,100,000 gallons. Maximum product surface area (PSA) is 11,786 ft^2. Tank must be at least 44% full.
Waiting Time	None. Testing may be initiated immediately following a delivery provided a minimum of 72 hours of quality data are collected and analyzed.
Test Period	Minimum of 72 hours. There must be no dispensing or delivery during test.
Temperature	Measurement not required by this system. System is self-compensating for product temperature changes. Buoyancy of float changes with product density in response to temperature changes.
Water Sensor	None. Water ingress leaks are measured as an increase in product level inside the tank.
Calibration	Servo product level measurements must be verified annually and, if necessary, calibrated in accordance with manufacturer's instructions.
Comments	Not evaluated using manifolded tank systems. Tests only portion of tank containing product. As product level is lowered, leak rate in a leaking tank decreases (due to lower head pressure). Consistent testing at low levels could allow a leak to remain undetected.

Evaluated in a nominal 2,100,000 gallon vertical underground tank with diameter of 122.5 ft., height of 23.4 ft., and PSA of 11,786 ft^2.
System is a volumetric measurement test method.

Varec, Inc.
5834 Peachtree Corners East
Norcross, GA 30092
Tel: (770) 447-9202

Evaluator: Ken Wilcox Associates
Tel: (816) 443-2494
Date of Evaluation: 04/07/08

Issue Date: June XX, 2008

Varec, Inc.

Fuels Manager with MTS M-Series ATG
(MTS Magnetostrictive Probe)

BULK UNDERGROUND STORAGE TANK LEAK DETECTION (50,000 gallons or greater)

Certification	Leak rate is proportional to product surface area (PSA). For tanks with PSA of 11,786 ft^2, leak rate is 4.50 gph with PD = 96.3% and PFA = 3.7% For other tank sizes, leak rate equals [(PSA in ft^2 ÷ 11,786 ft^2) x 4.50 gph]. Example: For a tank with PSA = 10,000 ft^2; leak rate = [(10,000 ft^2 ÷ 11,786 ft^2) x 4.50 gph] = 3.80 gph. **Leak rate may not be scaled below 0.2 gph.**
Leak Threshold	Leak threshold is proportional to product surface area (PSA). For tanks with PSA of 11,786 ft^2, leak threshold is 2.25 gph. For other tank sizes, leak threshold equals [(PSA in ft^2 ÷ 11,786 ft^2) x 2.25 gph]. Example: For a tank with PSA = 10,000 ft^2; leak threshold = [(10,000 ft^2 ÷ 11,786 ft^2) x 2.25 gph] = 1.91 gph. A tank system should not be declared tight if the test result indicates a loss or gain that equals or exceeds the calculated leak threshold.
Applicability	Gasoline, diesel, aviation fuel. Other liquids may be tested after consultation with the manufacturer.
Tank Capacity	Use limited to single, field-constructed, vertical-walled tanks having a capacity of 50,000 to 2,100,000 gallons. Maximum product surface area (PSA) is 11,786 ft^2. Tank must be at least 44% full.
Waiting Time	None. Testing may be initiated immediately following a delivery provided a minimum of 72 hours of quality data are collected and analyzed.
Test Period	Minimum of 72 hours. There must be no dispensing or delivery during test.
Temperature	Average for product is determined by resistance temperature detectors (RTDs) located at 18 inch increments from the bottom of the tank.
Water Sensor	Must be used to detect water ingress. Minimum detectable water level in the tank is based on the length of the probe as follows: <25 feet = 3.0 inches <40 feet = 3.8 inches <60 feet = 4.7 inches The water sensor "inactive zone" can be countered by installing the probe over the tank sump. Minimum detectable change in water level is 0.015 inch. Water ingress sensing is continuous and independent of leak detection testing.
Calibration	No scheduled maintenance or recalibration is required. The sensor pipe should be checked annually for build up of process material. Floats should move freely along the sensor pipe. If they do not, routine cleaning should be performed.
Comments	Not evaluated using manifolded tank systems. Tests only portion of tank containing product. As product level is lowered, leak rate in a leaking tank decreases (due to lower head pressure).

Consistent testing at low levels could allow a leak to remain undetected.
Evaluated in a nominal 2,100,000 gallon vertical underground tank with diameter of 122.5 ft., height of 23.4 ft., and PSA of 11,786 ft^2.
System is a volumetric measurement test method.

Varec, Inc.
5834 Peachtree Corners East
Norcross, GA 30092
Tel: (770) 447-9202

Evaluator: Ken Wilcox Associates
Tel: (816) 443-2494
Date of Evaluation: 04/07/08