Technical Review of Leak Detection Technologies
Volume II
Aboveground Bulk Fuel Storage Tanks

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ACRONYM DEFINITIONS

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
AST	Aboveground Storage Tank
API	American Petroleum Institute
BAT	Best Available Technology
BFCAST	Bulk Field Constructed Aboveground Storage Tank
CSLD	Continuous Statistical Leak Detection
DDA	Direct Digital Access
EPA	Environmental Protection Agency
FDEP	Florida Department of Environmental Protection
GPD	Gallons Per Day
GPH	Gallons Per Hour
IPP	Industry Preparedness and Pipeline Program
LAM	Local Area Monitor
LDS	Leak Detection System
LFL	Lower Flammability Limit
P_d	Probability of Detection
P_{fa}	Probability of False Alarm
P_{md}	Probability of Missed Detection
ppm	parts per million
RTD	Resistive Temperature Devices
SCADA	Supervisory Control and Data Acquisition
SIM	Sensor Interface Module
SIR	Statistical Inventory Reconciliation
TPH	Total Petroleum Hydrocarbons
UST	Underground Storage Tank

PREAMBLE

The Alaska Department of Environmental Conservation (ADEC or department) has required leak detection for new aboveground bulk fuel storage tanks (AST) since 1997. Since most existing tanks (10,000 gallons or greater) do not have leak detection and there are only a few new facilities in the state with a leak detection system (LDS), ADEC has established the best available technology (BAT) process to ensure AST leak detection is uniformly applied throughout Alaska's oil industry. Aboveground storage tanks are required to comply with Alaska Administrative Code [18 AAC 75.065 (h)(4), 18 AAC 75.065 (i)(1)(D) and 18 AAC 75.425(e)(4)(A)(ii)] which states that new tanks; "must be equipped with a leak detection system…a sensitive gauging system or other leak detection system approved by the department." Existing tank installations must be equipped with "a leak detection system that an observer from outside the tank can use to detect leaks in the bottom of the tank, such as secondary catchment under the tank bottom with a leak detection sump, a sensitive gauging system, or another leak detection system approved by the department; cathodic protection in accordance with API Standard 651, First Edition, 1991; a thick film liner in accordance with API Standard 652, First Edition, 1991; or another leak detection or spill prevention system approved by the department."

Recognizing the importance of leak detection in the prevention of oil spills, and the need for a more thorough understanding of the use and effectiveness of leak detection technologies used by Alaska's oil industry, the ADEC developed BAT regulations for inclusion in their spill prevention assessment program. ADEC issued a contract to identify, analyze, and report on technologies and systems for detecting bulk fuel storage tank leaks, incorporating the BAT process requirements. Identifying strengths and weaknesses in leak detection technologies will help the Industry Preparedness and Pipeline Program of ADEC make further improvements in preventing oil spills via strategic and proper implementation of the BAT regulations.

The focus of this manual is to identify the various types of leak detection systems (LDS) for aboveground bulk fuel tanks, define a set of criteria for evaluating the performance of these systems and provide a general evaluation of each leak detection technology. AST leak detection technology can be classified into four broad categories: volumetric/mass methods, acoustic sensing, soil vapor/liquid monitoring, and inventory control. An extensive Internet search and subsequent responses received from questionnaires revealed 15 vendors with representative technologies for review. Detailed evaluations for each vendor's technology are presented under the tab "Leak Detection System Evaluations".

It should be noted that the leak detection technology assessments presented in this document are compiled for the purpose of providing technical justification for replacing outmoded technologies and to serve as reference materials for ADEC staff, industry representatives, and the interested public. These technologies do not replace a sound maintenance program and aggressive controller/operator training. This manual should be regarded as a dynamic tool for BAT evaluations and should be updated periodically.

1 INTRODUCTION

1.1 OBJECTIVES

The overall purpose of this project is to identify strengths and weaknesses in aboveground storage tank (AST) leak detection operations to gain information for strategic implementation of the State of Alaska best available technology (BAT) regulations. This document, which is to be used by Alaska Department of Environmental Conservation (ADEC or the Department) staff, as well as industry and the public, provides information about potential leak detection technologies to use in Alaska.

1.2 PROJECT BACKGROUND

In response to questions regarding the BAT regulations, ADEC issued a contract to identify, analyze and report on aboveground storage tank (AST) leak detection technologies to meet the requirements of 18 AAC 75.065 (h)(4), 18 AAC 75.065 (i)(1)(D), and 18 AAC 75.425(e)(4)(A)(ii).

Due to recent changes in the regulations, BAT reviews are a required element of Oil Discharge Prevention and Contingency Plan documentation. The Plan must identify and include a written analysis of all available leak detection technologies using the applicable criteria in 18 AAC 75.445(k)(3); and include written justification that the proposed technology is the best available for the applicant's operation. The technical and performance information may be used by ADEC, industry representatives, and the public, as a reference to determine an individual technology's suitability with respect to the general requirements of 18 AAC 75.065 (h)(4) and 18 AAC 75.065 (i)(1)(D), and specific requirements of 18 AAC 75.445(k)(3). In addition, the information in this report may assist AST operators in preparing, and ADEC in evaluating, the written analysis contained in BAT reviews for AST leak detection systems (LDSs).

1.3 REGULATORY FRAMEWORK

Regulations defining best available technologies applicable to Alaskan oil facilities and vessels became effective on April 4, 1997. All oil discharge prevention and contingency plans or plan renewals submitted to ADEC after this date must undergo a BAT review before they are approved. Elements of operations requiring the BAT review are specified in 18 AAC 75.425(e)(4). The review must demonstrate BAT using the applicable criteria in 18 AAC 75.445(k)(3), unless Federal law preempts a particular requirement. The required plan elements which are subject to a BAT review and are relevant to this project are Leak Detection Systems for Newly Constructed Oil Storage Tanks [18 AAC 75.065(h)(4)]; and Prevention and Control Systems for Existing Tanks [18 AAC 75.065(i)(1)(D)].

For these plan elements, applicants must identify all possible alternative technologies for each category per 18 AAC 75.425(e)(4)(A). Each alternative must then be evaluated in relation to the technology either in place or proposed based on the criteria provided in 18 AAC 445(k)(3) and listed below:

- Availability;
- Transferability;
- Effectiveness;
- Cost;
- Age and Condition;
- Compatibility;
- Feasibility; and
- Environmental Impacts.

Once this evaluation has been completed, the applicant must then provide written justification for each applicable technology determined to be the best available for the applicant's operation.

2 RESEARCH/DATA COLLECTION

The approach to researching available AST leak detection technologies included internet and literature searches for viable leak detection vendors and technologies, attending related workshops, and contacting and soliciting information from vendors and industry users. The reference materials obtained during the research phase of this project were cataloged and are available at the ADEC's Anchorage office, Division of Spill Prevention and Response.

2.1 INTERNET SEARCH

An Internet search for AST leak detection vendors and oil companies potentially using LDSs was performed. The search identified approximately 50 potential vendors of LDSs. Another 30 were identified in various EPA references. Several of these vendors were eliminated because they were no longer "in the business" or they dealt solely with underground storage tank leak detection.

2.2 LITERATURE SEARCH

A great deal of leak detection literature was obtained from a variety of sources, including the American Petroleum Institute (API), the U.S. Environmental Protection Agency (EPA), the Oil and Gas Journal database, and Gulf Publishing. A full reference list is presented in Section 5. Leak detection literature from vendors was also helpful in understanding and describing vendor specific systems.

2.3 WORKSHOPS

Contractor personnel attended a three-day conference on Advancements in Aboveground Storage Tank Management, February 23 through 25, 1999. The conference was held in Anchorage, AK and was hosted by Tank Industry Consultants Inc. The three-day conference included seminars and presentations on ATS related subjects:

- API 653 (Tank inspection, repair, alteration and reconstruction);
- Risk Based Assessment of Storage Tanks, Seismic Design;
- Foundations, Secondary Containments and Leak Detection Systems; and
- Corrosion, Coatings and Cathodic Protection.

2.4 VENDORS

Viable leak detection vendors for AST systems were contacted via email, fax, or phone and were sent a detailed questionnaire. Vendors were asked to complete the questionnaire and return it with product literature and a client reference list. Approximately 15 responses were received. The final list of vendors with applicable AST leak detection products and who responded to the questionnaire is presented below.

- Andover Controls Corp.
- ASTest Services Inc.
- EBW/CATLOW, Inc.
- FCI Environmental, Inc.
- National Environmental Services Company (NESCO)
- PermAlert
- Petro Vend, Inc.
- Physical Acoustics

- Raychem Corp.
- SensorComm
- Tracer Research Corp.
- USTest, Inc.
- Veeder-Root

2.5 INDUSTRY

Companies in Alaska and the lower 48 were contacted, interviewed, and sent questionnaires to assess the effectiveness of LDSs presently being used in the field. The National AST Newsletter also published the industry questionnaire. Additionally, credible references identified by vendors were contacted to determine the veracity of vendor claims. Industry representatives that were contacted and responded are presented below.

- All-American Pipeline Co.
- Alyeska Pipeline Service Company
- Arco Alaska, Inc.
- British Petroleum-Amoco Alaska
- Elmendorf Air Force Base
- Exxon Corporation
- Hill Air Force Base
- Ken Wilcox & Associates
- Kinder Morgan Energy Partners
- Koch Pipeline Company
- Malmstrom Air Force Base
- Mapco Petroleum
- Paramount Petroleum
- Pt. Loma Naval Air Station
- Texaco Company

3 LEAK DETECTION SYSTEMS FOR ASTs

Other than requiring a leak detection system, the ADEC has no specific standards regarding performance of LDSs for ASTs. U. S. Environmental Protection Agency (EPA) requirements governing underground storage tank (UST) LDSs require a sensitivity of 0.2 gallons per hour (GPH) with a probability of detection of at least 95% and a probability of false alarm of no more than 5%. For large ASTs, this level of performance using the same leak rates may be difficult to achieve owing to high tank volume and low leak rates.

Terminology with respect to leak identification is common across AST leak detection technologies. In the most basic sense, each LDS detects *noise* and *signals*. *Noise* is anything that may interfere with accurate leak detection such as temperature fluctuations, condensation, structural deformations or other non-leak related interference (API, 1996). The *signal* is any distinguishable event caused by a leak. Each type of system has its own form of signals and noise, depending on the method it uses to monitor tank integrity. The most difficult task associated with these systems is accurately identifying a leak signal while filtering out background noise. LDSs, regardless of which technology they are based on, rely on measuring, quantifying and interpreting the signal-to-noise ratio accurately. Reliable detection can only be accomplished when signals can be distinguished from the noise.

Leak detection systems used in the oil industry range from simple visual inspection of floor sumps under the ASTs, to automated electronic data gathering instruments connected to sophisticated consoles or computer systems. Most continuous monitoring systems have automatic leak alarm capabilities, while other methods of leak detection are conducted as part of a regularly scheduled maintenance program and rely on daily visual inspections for evidence of initial leak detection.

Systems with automatic leak notification capabilities have similar configurations. Electronic level gauges or transducers, along with temperature probes, can be thought of as the data acquisition centers. Data from these instruments are routed to a microprocessor, which carries out the appropriate data processing of the signals, including sending a visual or audible alarm to a control panel when it has been determined that a leak has occurred.

Other LDSs rely on a wide variety of parameters from sampling and testing the interstitial soil pore space for hydrocarbon vapors to acoustic emissions monitoring. Technologies performed non-invasively (i.e., not in direct contact with the fuel product) have a reliable track record for leak detection. Non-invasive leak detection technologies include liquid sensing cables, which are placed either in the interstitial space of a double walled tank or buried in the soil beneath the tank, soil vapor monitoring, or acoustic emissions testing. These systems can be programmed to monitor a tank continuously or they can be part of the regularly scheduled tank testing and maintenance program.

3.1 INTERSTITIAL MONITORING

Monitoring the interstitial space of double-walled and double-bottomed tanks is a widely recognized and effective AST leak detection method. There are several methods to electronically monitor a tank's interstitial space. The most common method uses hydrocarbon-sensitive sensor cables or probes connected to a monitoring console. This console is equipped with an audible and visual alarm that goes off in the presence of hydrocarbons thus indicating a leak in the tank (API, 1996).

Vacuum monitoring of the interstitial space in an AST is another leak detection method. With this technology, a vacuum is pulled on the interstitial space in an AST. If the vacuum remains unchanged, the tank is maintaining its integrity. The vacuum on the space will begin to change when a hole or crack occurs in either the fuel storage portion of the tank or the external wall.

Yet another method of interstitial space monitoring is to partially fill the interstitial space in the tank with a monitoring fluid. If the level of the fluid changes, a leak may be present.

3.2 RELEASE PREVENTION BARRIERS (DOUBLE BOTTOM TANKS)

A type of release prevention barrier (RPB), the double bottom tank, has been proven to be an effective means for preventing and detecting leaks from aboveground fuel storage tanks (Myers, 1999; API, 1997). The basic leak detection mechanism of an RPB is that it blocks the downward flow of leaking product and channels it to the tank's perimeter where it can be observed. Interstitial monitoring is also used with double bottom tanks. RPBs act to minimize the occurrence of leaks due to tank-bottom corrosion by introducing a barrier against corrosion-causing environmental elements (moisture and salt). Tank bottom corrosion can occur from the topside or the under side. Topside corrosion is the result of water condensed from the petroleum product or introduced to the tank during rain events or pumping. Under-side corrosion is the result of moisture, oxygen, and salts from the surrounding environment acting on the tank surface.

When installing a new tank bottom, a minimum thickness 80-mil polyethylene (HDPE) liner is placed on the old bottom. A spacer, typically sand or concrete, is used to separate the old bottom from the new. One major oil company prefers a concrete spacer because it functions as a corrosion inhibitor (i.e., becomes alkaline when wetted) and provides a solid surface for accurate control of the tank bottom slope (Myers, 1999). Once the concrete is poured and sloped to a predetermined angle, the new bottom is welded on top of the spacer. Finally, the shell slot is sealed using appropriate welding techniques. It is recommended that tank bottoms be covered with a corrosion-inhibiting coating. API Standard 650 Appendix I addresses the requirements for constructing double-bottomed tank systems.

According to Myers (1999), double bottom tanks have the advantages presented below:

- They are passive means of leak detection;
- They essentially have a zero threshold leakage rate;
- They essentially have a 100% probability of detection; and
- They may extend the life expectancy of the tank by 10 to 25 years.

The disadvantages of double bottom tanks as presented in API 340 (1997) are listed below:

- Single bottom ASTs are very costly to retrofit;
- The shell of the tank must be cut;
- The tanks are out of service for a long period of time;
- The lower bottom cannot be inspected or repaired; and
- It is difficult to replace anodes in the future.

3.3 LIQUID SENSING PROBES AND CABLES

Liquid sensing probes and cables are commonly used in AST leak detection. When monitoring single-wall tanks the probes and cables are buried beneath or immediately down-gradient of the AST. In double-wall tank applications the probes or cable sensors may be installed in the tanks' interstitial space to detect leaking liquid before it leaves the tank. This method of leak detection is efficient, cost effective and is used extensively in the retail petroleum industry to monitor USTs.

3.4 VOLUMETRIC AND MASS MEASUREMENT METHODS

Volumetric and mass measurements systems use suitably precise sensors to quantify the amount of liquid in the tank (API, 1996). Volumetric methods of leak detection generally use a product level measurement device and a temperature probe in the tank. The volume of product in the tank is calculated, taking temperature into account. If the calculated volume of product decreases inexplicably, a leak may be present.

Mass measurement methods generally measure the pressure that the liquid exerts on the tank. In this way, the temperature of the liquid does not play into the calculations of product in the tank. Similar to volumetric methods, an unexplained loss of mass may indicate the presence of a leak.

3.5 STATISTICAL INVENTORY CONTROL METHODS

Statistical inventory control methods are among the least complex of the leak detection methods presently available. A detailed record is kept of additions or withdrawals to a tank over a specified period of time. Level or mass of the liquid is monitored concurrently. At the end of the monitoring period, the two measurements are compared. A discrepancy in the numbers may indicate a leak in the tank. This method of inventory control/leak detection has several sources for error including inaccurate measurement or recording of deliveries, sales volumes, product levels and product level-to-volume conversions (Rogers, 1998).

A modification of this method has emerged into a more sophisticated and sensitive method of analysis. This method not only has greater sensitivity but also involves shorter data collection duration than traditional methods. Statistical Inventory Reconciliation (SIR) involves statistical analysis that accomplishes two main objectives: (1) to separate out and quantify effects that are not "leak-related" and (2) to react appropriately to those effects that are not compatible with leakage. For each data set analyzed, SIR can determine not only whether or not a leak is present but also the smallest leak that could be detected, given the quality of data provided (Rogers, 1998).

Qualitative SIR methods are designed to classify a tank system as Pass, Fail or Inconclusive. A Pass means that, according to the data analyzed, the system is tight. A Fail means that the system <u>may</u> be leaking; however, it could also mean that dispensers are miscalibrated, deliveries are inaccurately metered or product has been stolen. An Inconclusive results means that a determination of pass or fail could not be reached based on the data analysis. Quantitative SIR methods also classify results as Pass, Fail or Inconclusive, but they also provide an estimated leak rate, usually in gallons per hour (Rogers, 1998).

Because the volume of leakage over any reasonable test period is so much smaller than the average tank volume, API has determined that it is not technically feasible to rely solely on inventory control and monitoring strategies such as SIR for leak detection in

ASTs (Myers, 1996). Inventory control measures should only be used for their original intended purpose, stock loss control.

3.6 AUTOMATIC TANK GAUGING

Automatic tank gauging continuously monitors the hydrostatic level of product in the tank using a series of electronically monitored floats, probes, and sensors to determine the temperature and level of product in the tank. These sensors are connected to a controller, which may be connected to a Personal Computer (PC). The sensors continuously monitor temperature and fluid levels in the tank and compensate for daily fluctuations in the tank that may influence the liquid volume but are not related to detection of a leak.

3.7 PASSIVE-ACOUSTIC SENSING

Acoustic sensing technology is based on the principle that liquid escaping though a hole or fissure in an AST produces a sound that is detectable. It has been shown that a leak in the floor of an AST actually produces two different types of sound simultaneously. One type, the “continuous” sound, is similar to the hissing noise that might be expected when liquid escapes from a container under pressure. The second type is an intermittent popping sound that extends beyond the audible frequency range. Known as “impulsive” sound, it is created by the interaction between the flow field of the leak and the air bubbles trapped in the backfill material below the AST floor (API, 1996).

Passive-acoustic sensing technology is available in two basic formats, continuous monitoring and regularly scheduled testing. The sensors or transducers used in acoustic testing convert the energy from a sound wave into an electrical signal. The two types of transducers suitable for acoustic testing are an accelerometer and hydrophone. Accelerometers are mounted on the exterior wall of the tank and have the advantage of being non-intrusive. Non-intrusive methods are easier and less expensive to implement, are easily accessible in case of malfunction, and eliminate the need for contact with the product. Hydrophone transducers are submerged in the liquid.

Typically, arrays of acoustic sensors are either suspended from the tank roof or at evenly spaced intervals around the external circumference of the tank. The sensors monitor the tank acoustic levels/locations. A background level of noise is documented by continuous tank monitoring. This background noise is used to create an “acoustic map” of the tank. A persistent anomalous or out of character acoustic signal in a consistent location within a tank may indicate a leak.

3.8 VAPOR MONITORING

Leak detection using vapor-monitoring techniques is a fairly straightforward concept. Liquids leaking from an AST into the soil or backfill under the tank volatilize filling the backfill or soil pore space. Perforated or screened pipes are arranged under or in monitoring wells surrounding the AST to gather the vapors and to act as a conduit through which soil vapors are extracted. The soil vapor is collected and analyzed for either hydrocarbons or the presence of a chemical tracer or both. Tracers or chemical markers are often added to the product in the tank being monitored to differentiate leaking product from naturally occurring background vapors or vapors from previous spills. Tracers or markers detected during analysis of the vapors may indicate a leak in the tank.

3.9 FIBER OPTIC SENSING PROBES

Fiber optic sensing probe can be installed during construction or easily retrofitted to existing ASTs. The probes are driven into the soil beneath an AST. The fiber optic probe has a covering that changes its refractive index in the presence of very small amounts of hydrocarbons. This change in refractive index is registered optically by the probe, and converted to a parts-per-million reading of the hydrocarbons. The sensing probe is capable of detecting both liquid and vapor phase hydrocarbons. This system has been used in several leak detection applications for a little more than five years.

3.10 PERFORMANCE ISSUES

The concept of performance as a way to measure the effectiveness and reliability of an AST LDS evolved from research on USTs. Although performance measures for AST leak detection are yet to be implemented, many of the same general concepts are expected to be applicable. LDS performance is defined in terms of the *probability of detection,* or P_d, which is the likelihood that a test will detect a real leak, and the *probability of a false alarm*, or P_{fa}, which is the likelihood that a test will declare the presence of a leak when none exists. A related issue is the *probability of missed detection*, or P_{md}, which is the likelihood that a test will not find a leak that does exist (API, 1996). All of the leak detection methods reviewed have inherent strengths and weaknesses, not all systems reviewed will be suitable for all locations or conditions.

Ensuring the selection of the most effective AST LDS for the individual situation and location is essential. The LDS selection process should include factors such as the age, type and configuration of the tank, product to be stored, type and disposition of the backfill under the AST, and the hydrogeology of the area. Backfill that is too compacted (a non-engineered backfill) or is saturated with either product or water will limit the number of viable LDSs for that AST. Another issue includes deciding whether monitoring and leak detection will be internal, external, continuous, or part of a scheduled maintenance program.

When selecting an LDS, system redundancy is recommended. Combining two different leak detection methods assists in determining the validity of an alarm prior to emptying, cleaning and inspecting the tank bottom. For example, coupling acoustic emission testing with soil vapor monitoring adds a layer of checks and balances to the process. Both systems are non-invasive and both have the capability of not only determining whether or not there is a leak, but also giving an approximate leak location. Another example is combining soil vapor sampling with a volumetric technology. The soil vapor testing will offer an approximate location of the leak while the volumetric technology verifies fluid loss.

3.10.1 Pre-existing and Previous Leaks

Installation of leak detection systems on existing tanks will probably occur numerous times in Alaska. Determining the disposition of a tank prior to installation and selection of an LDS is an important consideration. If the tank is aged and has a history of previous leaks, this information will influence the type of LDS applicable for that particular tank and situation. Proper identification of previous leaks, their locations and the approximate quantity of product that escaped will help minimize possible sources of noise after selection and installation of an LDS.

3.10.2 False Alarms

Elimination or minimization of false alarms is the primary goal in leak detection technology. Frequent false positives erode credibility of the LDS and can lead to an unnecessary and expensive, time and labor-intensive effort to drain, clean, and inspect the tank. Regardless of whether there is an actual leak or simply a false alarm the tank must be inspected. Thus, if a lower alarm threshold is selected for the purpose of increasing the probability of detection, an accompanying rise in false alarms is probable and system redundancy (i.e. using more than one LD method on a tank) may prove to be cost effective.

3.10.3 Redundant Systems

In some situations, more than one LDS might be appropriate for attaining BAT. Redundant systems offer faster detection speeds and lower leak volume thresholds than single systems. For example, a combination of mass balance (which can detect large volume leaks) and acoustic analysis (which can detect small leaks very rapidly) would offer a combination of sensitivity, speed, and a leak location ability that might be considered BAT for a particular application.

4 LEAK DETECTION TECHNOLOGY EVALUATION

As noted in Section 1.3, the ADEC BAT evaluation is focused on the performance and suitability criteria listed in 18 AAC 75.445(k)(3). These criteria were combined with related performance and limitation considerations to construct a leak detection technology evaluation strategy.

4.1.1 Applicability/Availability

The applicability criterion simply serves to ensure that any technology selected for use on a bulk fuel aboveground storage tank system was designed for that intended use. Once the technology is determined to be applicable to an AST, this criterion must include regional considerations that may limit the effectiveness of an AST LDS. Regional considerations are discussed below. The availability criterion refers to the commercial availability of an LDS and its components.

4.1.2 Effectiveness

Effectiveness deals primarily with the performance related aspects of LDSs and is evaluated in terms of sensitivity, accuracy, reliability, and robustness. Unfortunately, focus on attaining ideal performance in one area, say sensitivity, may result in degradation of the other criteria.

Most leak detection technologies attempt to attain a satisfactory tradeoff between sensitivity, accuracy, reliability, and robustness by understanding the specific operating conditions of an AST and the operator's expectations. The LDS ultimately selected by an AST operator will depend upon the performance requirements specific to that company.

4.1.2.1 Sensitivity

Sensitivity is defined as the composite measure of the size of leak that a system is capable of detecting, and the time required for the system to issue an alarm in the event that a leak of that size should occur (API, 1995b). The relationship between leak size and the response time is dependent upon the nature of the LDS. Some LDSs manifest a strong correlation between leak size and response time, while with others, response time is largely independent of leak size. Note that there are no known systems that tend to detect small leaks more quickly than large leaks.

In terms of response time, the regulations do not stipulate a time frame in which the system be capable of detecting leaks. Where available, field performance data are presented in the evaluation, but it is the AST operating company's responsibility to establish an appropriate response time for their AST.

4.1.2.2 Accuracy

Accuracy is a measure of LDS performance related to estimation parameters such as leak rate, total volume lost, and leak location (API, 1995b). A system, which estimates these parameters within an acceptable degree of tolerance, as defined by the AST operator, is considered to be accurate. Often times an LDS will use existing AST instrumentation such as volumetric gauges and floats in their processes. The accuracy of these LDSs is largely dependent upon the accuracy of the instrumentation.

For this project, leak location accuracy is discussed in terms of the capability of a technology to locate the leak within a certain percentage of a given tank bottom segment or within so many feet of an indicating sensor. The accuracy of a leak detection technology in estimating measurement parameters such as leak rate and total volume lost is evaluated in terms of the accuracy, repeatability, and precision of the recommended or provided AST instruments themselves. Instrument accuracy represents the measurement performance of an instrument relative to that of an ideal device. Repeatability is a measure of the instrument's ability to consistently return the same reading for a given set of conditions. Precision is a measure of the smallest change that can be seen in the output of the instrument.

4.1.2.3 Reliability

Reliability is a measure of the ability of an LDS to render accurate decisions about the possible existence of a leak in an AST. Accurate leak detection directly related to the probability of detecting a leak, given a leak does in fact exist, and the probability of incorrectly declaring a leak, given that no leak has occurred. A system that incorrectly declares leaks is considered to be less reliable; however, if the system has the capability to use additional information to disqualify, limit, or inhibit an alarm, a high rate of leak declarations may be considered less significant.

Reliability pertains only to the leak detection hardware and software, not the SCADA system, instrumentation, communication equipment, or any other factor beyond the control of the vendor. Reliability can be managed through operator response and established procedures; however, unless the LDS automatically adjusts to decision thresholds, these procedures cannot be used to discriminate between LDSs. For this project, the reliability of a leak detection technology is evaluated in terms of the frequency of reported false alarms on operating AST LDSs.

4.1.2.4 Robustness

Robustness is a measure of an LDSs ability to continue to function and provide useful information, even under changing conditions. A system is considered robust if it continues to perform its principle functions under less than ideal conditions. For this project, robustness is evaluated in terms of the capability of the LDS to distinguish between normal operating conditions and real leak events, and the ability to automatically make temporary system adjustments or disable certain leak detection functions as needed.

4.1.3 Transferability/Feasibility

An assessment of a technology's transferability is its ability to be effectively implemented under a variety of conditions and to monitor a variety of liquid mediums. The feasibility aspect is incumbent upon the technology and manufacturers ability to provide the required service in a reasonable amount of time and at a reasonable cost. While some LDS may be part of a regularly scheduled tank maintenance program these same systems may also offer a continuous monitoring methodology.

4.1.4 Compatibility/System Requirements

Whether or not an LDS is compatible with an AST depends upon the existing tank configuration, the requirements of the LDS and operator specifications. Some systems like those with electronic monitoring devices possess the ability to interface with a terminal or communication lines previously established at the site.

4.1.4.1 Instrumentation

Instrumentation requirements for the installation and operation of the LDS at the site include all hardware and peripherals that may be required or are optional that may enhance the performance of the LDS.

4.1.4.2 Operating System/Communications

Operating systems are discussed in relation to the AST and how the systems electronics interface. Communication requirements for each system vary from none to systems that have the ability to be accessed remotely or are incorporated into the on site computer network.

4.1.4.3 Testing Frequency

System design regarding testing frequency varies. For systems categorized as continuously monitoring testing frequency may be cycled. Other systems are automatic testers and will take advantage of system "down times" or quiet times when the system is not in service. Systems that are not in the first two categories and are not continuous or considered automatic are LDSs that are incorporated into the regularly scheduled maintenance program.

4.1.4.4 Operator Training

This criteria evaluates the time and cost of operator training. Many systems and manufacturers will come to the site and provide hands-on training, while others require training at their headquarters. There are several systems that boast that their system is so simple and easy to operate that no or minimal training is required.

4.1.5 Environmental Impacts

The BAT requirements define environmental impacts as "whether other environmental impacts of each alternative technology, such as air, land, water, energy and other requirements, may offset any anticipated environmental benefits." Internally installed LDSs typically do not represent a significant change to the environment outside the AST. However, externally installed systems may require excavation or other disturbances to the environment surrounding the AST.

4.1.6 Regional Considerations

Regional considerations play a substantial role in the selection of an LDS in Alaska's environment. The primary consideration for an AST LDS is their viability and capability of adjusting to large temperature fluctuations, from the possibility of –60°F ambient temperature on the North Slope, to 100+°F ambient temperature in the interior of Alaska. Other considerations pertain to location and year round accessibility,

4.1.7 Field Performance

The evaluation of actual LDS field performance is essential to substantiate vendor claims of system sensitivity, accuracy, reliability, and robustness. Industry references provided by the vendors and ADEC were contacted to verify and comment on the performance of their LDS.

4.1.8 Cost

Any evaluation of LDS performance involves an assessment of cost; however, the real and potential costs incurred for each incorrect alarm, missed alarm, late alarm, and/or any other deviation from ideal performance are beyond the capabilities and scope of this document. In short, the true cost associated with a new LDS system must include an institutional/management cost. Prior to installation this cost is more difficult to quantify than the purchase cost of the LDS unit itself, and increases with an operator's increased commitment to attain a higher level of LDS sensitivity. Therefore, the costs presented are those associated with the LDS's hardware, software, and installation.

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6 GLOSSARY

Acoustic: Pertaining to sound; specifically to the propagation of sound waves caused by pressure fluctuations.

Acoustic Signal: A transient elastic wave generated by a rapid release of energy due to some structural alteration in a solid material; for example, the wave produced in a fluid filled tank as liquid escapes through a small hole in the bottom.

Algorithm: A set of mathematical steps devised for the solution of a specific problem.

Backfill: The material under and around the bottom of a tank, usually sand or gravel, that forms a porous boundary between the tank and the surrounding soil. The backfill provides a relatively even surface for the bottom of an AST.

Best Available Technology: The best-proven technology that satisfies the applicable requirements of 18 AAC 75.425(e)(4) and criterion of 18 AAC 75.445(k).

Bulk Field Constructed Aboveground Storage Tank: Also known as BFCAST are tanks constructed on location, usually tanks of very high volume and large diameters.

False Alarm: Any event that triggers an alarm indicating a leak when none exists.

Floating Roof: A type of AST roof that rests on the surface of the liquid in the tank, moving up and down as product is added or removed.

Hydrostatic Head: The amount of pressure, measured in pounds per square inch (psi), exerted by a liquid.

Leaker: A leaking aboveground storage tank.

Noise: Anything that interferes with accurate leak detection.

Signal: Any distinguishable event caused by a leak.

Structural Deformation: The physical changes that a tank undergoes when it is filled with product, or when product is withdrawn. The tank shell, for example, bulges outward when product is added, and the floor deflects downward, causing a drop in product level that is not indicative of fluid loss but that can be mistaken as such.

Technology: As defined in 18 AAC 75.425(f) means equipment, supplies, other resources and related practices associated with using that technology.

Thermal Expansion or Contraction (of shell or product): A temperature induced change in the volume of product in the tank or in the dimensions of the tank shell itself. One can influence the other and both are influenced by ambient air temperature.

Threshold: A predetermined value that is the basis for declaring a leak. Data points that fall within the threshold setting are considered noise, whereas those that exceed the threshold are considered indicative of a leak.

Tracer: An organic chemical used as the target substance in a soil-vapor monitoring test. A tracer can be a substance that occurs naturally in the product or one that has been added to it, as long as it is not present in the environment outside the tank. (Also known as a “chemical marker” or “test adjustment”).

Transducers: A device that converts the energy from a sound wave into electrical signal.

Ullage: The amount of space remaining between top of the product in the tank and the top of the tank.

7 VENDOR INDEX

Listed by vendor name in alphabetical order, with leak detection method and system name. Specific product details available on cd-rom from:

mailto:Holly_Hill@envircon.state.ak.us

1. Andover Controls Corporation - Volumetric Technology - Infinity RS-485 Tank Probe
2. ASTTest Services Inc. - Volumetric Technology - ASTTest Mass Balance Leak Detection
3. EBW/CATLOW - Volumetric Technology - AUTO/STIK
4. FCI Environmental Inc. - Fiber Optic Chemical Sensor (Liquid and Vapor Monitoring) - PetroSense®
5. NESCO Technology Division (Formerly Arizona Instruments) - Soil Vapor Monitoring - Soil Sentry Twelve-XE®
6. PermAlert - External Liquid Sensing Cable - PAL-AT®
7. Petro Vent, Inc. - Volumetric Technology - SiteSentinel Model II and Model III
8. Physical Acoustics Corporation - Acoustics Emissions Testing - TANKPAC®
9. Raychem Corp. - Liquid Sensing Cables - TraceTek Leak Detection Systems
10. SensorComm - External Liquid Sensing Cable - SensorComm
11. Tracer Research Corporation - Soil Vapor Detection - TracerTight®
12. USTest - Electronic Probe Gauge with Statistical Inventory Reconciliation (SIR) - USTest2001 AST Level Measurement System
13. Veeder-Root Co., Sub. Of Danaher - Volumetric with Inventory Control - Guardian™ AST Monitoring System