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Buried Pressurized Piping Systems Leak Detection Guide

Regulatory and Scientific Affairs

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FOREWORD

This document is intended to provide the reader with a general background in leak detection technologies for the buried pressurized piping in airport hydrant fueling systems and petroleum product terminal systems. This document was developed by Argus Consulting and Ken Wilcox Associates under the guidance of the joint Air Transport Association of America (ATA) and the American Petroleum Institute (API) Leak Detection Committee. The document incorporates information on leak detection technologies including research, laboratory testing, field testing, analysis, and experience. While an attempt has been made to determine the most logical technologies for application in airport hydrant fueling and petroleum product terminal systems, the reader should recognize that there may be other forms of leak detection technologies and concepts not discussed in this publication. The reader is also advised that piping systems, facilities, and site-specific differences can affect technology performance. Therefore, each technology being considered for actual use should be carefully evaluated. Inclusion in this publication of a particular leak detection technology should not be construed as an endorsement of that technology by either API or ATA.

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Buried Pressurized Piping Systems Leak Detection Guide

I. EXECUTIVE SUMMARY

This Study Documentation Report (the Study) analyzes the performance of different types of leak detection technologies that were applied to buried pressurized piping systems used in airport hydrant fueling and petroleum product terminals. The Study was conducted by Argus Consulting and Ken Wilcox Associates on behalf of the Air Transport Association of America (ATA) and the American Petroleum Institute (API). This report is intended to provide an overview of the Study methodology and results.

The purpose of the Study, as defined by the joint API and ATA Leak Detection Committee, was to “identify and evaluate reliable leak detection technologies that are currently commercially available and cost-effective for buried piping associated with airport hydrant fueling systems and petroleum product terminals.”

The Study was conducted in three phases. In Phase I, the Study consultants collected published data and vendor information regarding the leak detection technologies reported to be applicable to the buried, pressurized piping in airport hydrant fueling systems and petroleum product terminals. During that phase, criteria were identified for evaluating the leak detection technologies in the specified applications. Through application of those criteria, six types of leak detection technologies were determined to have the potential to satisfy the Study purpose. One vendor of each of these technologies was selected and agreed to participate in Phase II of the Study, which consisted of actual testing under conditions intended to represent or approximate conditions at an airport hydrant fueling system or petroleum product terminal.

Testing of the various technologies addressed in Phase II of the Study was conducted at either the Kansas City International Airport (MCI) or a special test facility designed and maintained by Ken Wilcox Associates. The factors considered in evaluating the potential of these technologies included, but were not limited to: applicability to buried piping at airport hydrant fueling systems and petroleum product terminals; compatibility with the operating requirements for such systems and facilities; performance of the technology; installation procedures; operational requirements; reliability, and cost.

Because the Study is not intended to serve as an evaluation or endorsement of particular leak detection technology vendors, rather than identifying the technologies tested by vendor name, the technologies are identified by descriptive categories. While technology categories are used throughout the report, the reader is advised that each of the technologies actually tested have proprietary features that may be unique. The features are described to the extent necessary for accurate reporting purposes consistent with the vendors’ proprietary protections.

The six categories of leak detection technologies tested are identified as follows:

- Pressure decay—dual pressure
- Volumetric—dual pressure
- Pressure decay with temperature compensation
- Acoustic emission
- Chemical marker
- Hydrocarbon vapor monitoring

The first three technologies can be classified as pressure-based technologies involving the measurement of fluid within the pipe. The acoustic technology analyzes acoustic signals caused by a leak, which are transmitted through the piping and piping contents. The last two technologies employ external monitoring methods, monitoring the backfill outside of the buried piping for evidence of a leak.

The following is a summary of the information gleaned about the six categories of leak detection technologies:

- Pressure decay—dual pressure. This leak detection technology requires a means to isolate sections of the piping to conduct the test. This is normally accomplished with double block and bleed valves and a pressure transmitter installed in each test section. Application of this technology also requires a means to pressurize and depressurize the piping section being tested. Each leak detection test takes approximately 45 minutes when the piping system is isolated and under static pressure conditions.

The technology appears to be capable of detecting a leak of about 0.01 percent of the line volume per hour with 99 percent probability while operating at a one percent false alarm rate.

It appears to be viable on both new and existing piping systems.

Previous applications of the technology have used a minimum test pressure of 100 psi, which would limit its applicability for petroleum product terminals. Conversations with the vendor indicate that the technology can be used on lower pressure lines, but there is little experience with that application. The technology requires that any trapped air in the lines be eliminated, and surge suppressors be isolated from the lines, during the test. Elevation differences in the line can affect the results. There is no effect if the leak is at the same elevation as the pressure measurement. The reported result will be biased high if the leak is above the test point, and biased low if the leak is below the test point. The effect would be about 10 percent for a 50-ft elevation change.

Reported rates are standardized to 10 bar (150 psi). Since most of the testing is conducted at night, the effects of exposed pipeline are minimized.

- Volumetric—dual pressure. This technology is designed for permanent installation but can also be employed as a mobile unit where the vendor can conduct a leak detection test on demand. When permanently installed, it is often set up to block in and test the entire line. Unless there is special provision for switching the leak detection unit to different sections of the line by valves, separate fixed units are required for each section. Alternatively, a mobile unit can be utilized to test individual segments of the piping system on a scheduled basis.

This leak detection technology tests the line in a static condition and controls the pressure to two different levels during the test by adding or removing a volume of liquid product from the line. The test can take two to three hours, depending on the size of the line being tested.

This technology appears capable of detecting a leak of about 0.006 percent of the capacity of the line with a 99 percent probability of detection and with a false alarm rate of about one percent. This technology appears to be viable on both new and existing airport hydrant fueling systems and petroleum product terminals.

The technology is affected by elevation differences, with the measured leak rate biased low if the leak is located below the top of the line. The performance estimates are based on

testing a line with a 50-ft elevation difference and with the measured rates biased low by about 40 percent. If the same tests were run on a flat line, the system should be able to detect a leak of 0.0037 percent of the line volume based on the 175,000 gallon line tests.

- Pressure decay with temperature compensation. This technology monitors the pressure decay in a static line and sends a pressure pulse through the line at the beginning and end of the test to measure any temperature changes. It requires approximately a 30-minute test period. Testing of this technology during the Study was abbreviated because the vendor determined that further enhancements were needed.

This technology showed promise, but it appears to require further research and development before being implemented in an operational setting. Its application will depend on improvements by the vendor, but apparently this technology could be designed for either permanent installation or point-in-time testing at both airport hydrant fueling systems and petroleum product terminals.

- Acoustic emission. This technology operates through the placement of microphones (or accelerometers) with radio transmitters on the pipe at intervals of 300 to 500 feet. The acoustic signal generated by liquid flowing out of a defect in the pipe is recorded and analyzed by a computer software program.

This technology is adversely affected by ambient noise. Thus, given the noise associated with operations at airports, this technology appears to require further development and testing to be viable in actual application at an airport or petroleum product terminal.

Testing at MCI estimated that it could find a leak of about 89 gallons per hour with one percent PFA and 99 percent PD. With development, this technology could be expected to be capable of detecting a leak rate on the order of 20 gallons per hour. Unlike the pressure-based methods, this technology can also provide an estimate of the location of a leak.

- Chemical marker. The goal in this Study was to assess performance of the technology in cases with high water tables. The technology is well established and appears capable of detecting very small leaks. It also appears capable of locating leaks to within 10 feet or less. However, this technology requires the installation of sampling

ports approximately every 20 feet, which can be expensive (ports must be closer if the medium is water). Samples must be collected from each of these ports and analyzed periodically.

It also requires the addition of a chemical marker compound to the fuel, which generally requires approval by relevant officials. Testing conducted during the Study demonstrated that this technology can detect leaks as small as 0.05 gal/h even when the pipes are below the water table. However, under these conditions, the time to detection was increased.

This technology appears to be applicable to both airport hydrant fueling systems and petroleum product terminals. However, continuous monitoring could be highly labor intensive. There could also be issues regarding product purity, as it would require continuous injection of the marker compound.

- Hydrocarbon vapor monitoring. This technology monitors hydrocarbon liquid or vapors in the soil and/or dissolved hydrocarbons below the water table. It is designed for permanent installation and continuous monitoring. To properly interpret the data resulting from the monitoring, a representative of the vendor's staff generally must be involved. Testing during the Study found leaks of 0.05 gal/h at 5-feet from the sensor within 15 days. This method requires the installation of probes at 20-foot intervals or less, which can be expensive. The interpretation of results in the presence of existing hydrocarbons is open to question. This technology appears to be viable as applied to either airport hydrant

fueling systems or petroleum product terminals. However, the cost of installing probes and paying for a vendor's interpretation of the data must be taken into account.

The following summary tables show how the various leak detection technologies performed during testing and under the particular conditions of the Study. It must be noted that results will vary with application. In selecting a leak detection system, facility owners and operators should consider the configuration and operation of their specific piping systems.

Different technologies have inherently different measures of performance. To make the results as comparable as possible, systems that use pressure as part of the technology are presented as gallons per hour (g/hr) in percent of volume enclosed. A rate in gallons per hour for the size of the system is also presented.

The acoustic system, chemical marker, and hydrocarbon monitoring systems are presented in gallons per hour with the external technologies coupled with the distance from the leak and the time.

Since results were generally different for the airport hydrant systems compared to the API system, two performance tables are reported. The acoustic, chemical marker, and hydrocarbon monitoring methods did not differ for the size of line, so they only appear in the hydrant system table.

Table I-1 Performance Summary
Airport Hydrant Systems (Results at MCI with 50-foot Elevation Difference)

Technology	Threshold	PFA*	PD*	MDL (99%)	Test Time	Notes
Pressure Decay/Dual Pressure	0.0048% of 175,000 g vol.	1%	99%	0.0095% of 175,000 g vol. (16.6 g/hr)	45 min.	Permanent installation or mobile unit
Volumetric/Dual Pressure	0.0028% of 175,000 g vol.	1%	99%	0.006% of 175,000 g vol. (9.7 g/hr) ³	2.5 hr.	Permanent installation or mobile unit. Mobile unit can be used for one-time test.
Pressure Decay w/ Temp-Compensation ²	ND	ND	ND	ND	30 min.	Needs development; could locate leak
Acoustic emission	NA	1% ¹	99%	89 g/hr	2 min.	Needs development; could locate leak
Chemical Marker	NA	ND	99+%	0.05 g/hr (18 g at 10 ft in 15 days)	2-3 weeks	Ports every 20 ft; locates leak to about 10 ft (Results for high water)
Hydrocarbon Vapor Monitoring	NA	ND	ND	0.05 g/hr (18 g at 5 ft in 15 days)	2-3 weeks	Probes every 10 ft; locates leak to 5 ft. (Results for high water)

NA—Not applicable
ND—Not determined

Threshold – Leak Rate
PFA – Probability False Alarm

PD – Probability of Detection
MDL – Minimum Detectable Leak

* For quantitative technologies, a threshold for indicating a leak was calculated based on a fixed probability of false alarm (PFA) of 1%. In addition, the minimum leak size that could be detected (MDL) with a probability of 99% was reported. The estimates were based on a normal statistical model. The percentages used (PFA=1% and PD=99%) were selected for purposes of consistent presentation. It was beyond the scope of this study to determine if other percentages were more appropriate. For the qualitative technologies, the threshold was a characteristic of the specific technology and was proprietary. Based on the computed probability of detection curve using a logistic model, a leak rate that was expected to be detected with 99% probability and a corresponding 1% PFA was reported.

¹The threshold used by the vendor produced a PFA of 35% and a PD of 63%.

²The test data after product was circulated gave false alarms and missed detections. The data were not sufficient to provide valid estimates of PD and PFA or MDL.

³ Performance may be better for lines with no elevation differences.

Table I-2 Performance Summary:
Petroleum Product Terminal System (Based on Tests at MCI, No Elevation Difference)

Technology	Threshold	PFA*	PD*	MDL (99%)*	Test Time	Notes
Pressure Decay Dual Pressure	0.009% of 12,000 g vol.	1%	99%	0.018% of 12,000 g vol. (2.2 g/hr)	45 min.	Permanent installation or mobile unit.
Dual-Pressure Volumetric	0.008% of 12,000 g vol.	1%	99%	0.015% of 12,000 g vol. (1.9 g/hr)	2.5 hr.	Permanent installation or mobile unit. Mobile unit may be used for one-time test.
Pressure Decay w/ Temp-Compensation	ND	ND	ND	ND	30 min.	Needs development; could locate leak

NA—Not applicable
ND—Not determined

Threshold – Leak Rate
PFA – Probability False Alarm

PD – Probability of Detection
MDL – Minimum Detectable Leak

- For quantitative technologies, a threshold for indicating a leak was calculated based on a fixed probability of false alarm (PFA) of 1%. In addition, the minimum leak size that could be detected (MDL) with a probability of 99% was reported using a normal model. The percentages used (PFA=1% and PD=99%) were selected for purposes of consistent presentation. It was beyond the scope of this study to determine if other percentages were more appropriate. For the qualitative technologies, the threshold was a characteristic of the specific technology and was proprietary. Based on the computed probability of detection curve using a logistic function, a leak rate that was expected to be detected with 99% probability and a corresponding 1% PFA was reported.

II. INTRODUCTION

A. Background

Because of the complex physical configuration and unique operational characteristics of buried pressurized piping systems found in petroleum product terminals and airport hydrant fueling systems, proven leak detection technologies have not previously been available. However, within the last few years, several technology vendors and companies have worked to develop and improve leak detection technologies for these unique piping systems. The purpose of this Study was to assess the success of their efforts to date.

In 1997, the American Petroleum Institute (API) and the Air Transport Association of America (ATA) formed a joint Leak Detection Committee to review the new generation of leak detection technologies for potential application to petroleum product terminal piping as well as the hydrant fueling systems at airports. The Leak Detection Committee defined its goals as follows: “Identify and evaluate reliable leak detection technologies that are currently commercially available and cost-effective for buried piping associated with airport hydrant fueling systems and petroleum product terminals.”

B. Program Structure

The Leak Detection Committee adopted a three-phased approach to the leak detection Study. In the first phase, the Study consultants collected published data and vendor information regarding the leak detection technologies reported to be applicable to the buried, pressurized piping in airport hydrant fueling systems and petroleum product terminals. In addition, during Phase I, the Committee discussed and identified criteria for evaluating the leak detection technologies in the specified applications. The following twelve evaluation criteria were identified:

- Availability of technology
- Capability of detecting small leaks
- Operational reliability
- Accuracy (defined as the ability of the technology to closely match the actual leak rate)
- Sensitivity
- High probability of detection; low probability of false alarm
- Applicable to new or existing piping systems
- Minimal impact on existing infrastructure

- Minimal maintenance requirements
- Properly operated by site staff
- Procured, installed, and operated at reasonable cost
- Certifiable to comply with the applicable regulations at the installed site

After identifying the evaluation criteria, the Committee applied the criteria to the leak detection technologies that had been identified in the early part of Phase I. Through this process, six existing leak detection technologies were determined to be potentially applicable to airport hydrant fueling systems and petroleum product terminals. The Committee then developed testing protocols for testing these technologies in the field. The following is an outline of the Phase I activities that were undertaken:

- Phase IA – Gather Data
 - Solicitation of Vendors and Data
 - Evaluation of Vendors and Technologies
 - Discussions with Vendors
 - Development of Screening Matrix
 - Organization of Data from Vendors
 - Analysis of Data
 - Selection of Vendors and Technologies
- Phase IB – Prepare Testing Facilities
 - Determine Facility Requirements
 - Evaluate Potential Facilities
 - Secure Test Facility
 - Develop Facility/System Concept
 - Design Facility/System Modifications
 - Construct Facility/System Modifications
 - Conduct Base Line Tests of Systems

Phase II of the Study consisted of actual testing of the technologies under specified conditions. The following is an outline of specific tasks that were undertaken during Phase II of the Study:

- Phase II – Implement Testing
 - Organize and Schedule Testing
 - Prepare Written Procedures
 - Prepare Written Protocols
 - Prepare Vendors for Testing
 - Set up Technologies for Testing
 - Conduct and Monitor Tests
 - Gather and Analyze Testing Data

This document, the Study Documentation Report, is a result of Phase III of the study and

contains information on the study approach, the conditions under which testing was conducted, and the results of the testing under the specified conditions. The following is an outline of the tasks undertaken in Phase III:

■ Phase III – Document Findings

- Prepare Outline of Final Report
- Develop Draft Report
- Review Results and Draft within Committee
- Solicit Comments from Study Participants
- Prepare Study Documentation Report

The Study Documentation Report is intended to provide the designers, contractors, operators, owners, and regulators of the buried, pressurized piping in airport hydrant fueling systems and petroleum product terminals with an evaluation guide that may be applied in assessing the leak detection technologies that are currently available. In addition, the testing protocols contained in Volume II of the Study provide a basis for evaluating and comparing the performance of additional leak detection technologies that may be developed or refined in the future for application in the piping systems addressed in the Study.

C. Applications

As noted above, the Study addressed the applicability of currently available leak detection technologies for pressurized piping systems at petroleum product terminals and airport hydrant fueling systems. In general terms, such piping systems contain petroleum hydrocarbon fuels with a specific gravity range between 0.65 and 0.85, and operate within a pressure range of 50 to 200 PSIG at flow rates between 100 and 20,000 gpm. Piping volume ranges from ten thousand to one million gallons.

The petroleum product terminals and airport hydrant fueling systems that were the subject of the Study typically have a combination of aboveground and underground piping systems consisting of pumps, filters, meters, pipes, and fittings. The focus of the Study was to address the application of leak detection technologies to the underground piping within these facilities. In most cases, the underground piping is composed of transfer or distribution lines ranging in size from 6 to 30-inch piping. While slight variations may exist in system materials and methods of construction, the majority of the piping is composed of carbon steel with welded (or bolted flanged) joints meeting ASTM - A53, ASTM - A106 or API-5L specifications. In many cases, the piping is

externally coated, cathodically protected, and installed in a selected backfill trench material.

D. Testing Facilities

A significant element of this Study was the testing of technologies on operational buried piping systems under field conditions. The existing airport hydrant fueling system at Kansas City Mid-Continent International Airport (MCI) in Kansas City, Missouri was utilized. The facility at MCI was selected in large part because the piping systems are representative of the buried pressurized piping systems found at both petroleum product terminals and airport hydrant fueling systems. In addition, MCI was chosen because the fueling system has redundant lines that allowed certain lines to be isolated for the Study testing while others were maintained for airport operations.

To create a test facility at MCI, piping manifolds and headers with double block and bleed valves for positive shutoffs were installed at necessary locations. In this manner, the two pipelines dedicated for testing were isolated from the three lines that continued to serve normal airport fueling operations. These modifications to the airport hydrant fueling system at MCI resulted in a test facility that included the following components:

- A 210,000 gallon (5,000 barrel) aboveground jet fuel storage tank;
- 2400 gpm pumping and filtration equipment;
- 14-inch and 16-inch transfer lines, each approximately 10,000 feet in length;
- 2500 feet of 12-inch hydrant system piping, with twenty hydrant pits, around a passenger terminal building; and
- 3000 feet of 8-inch tank return and system recirculation piping.

Following the modifications to the facility, the installation contractor conducted a hydrostatic line test on March 13, 1999. As is generally the case, no temperature compensation was included with this hydrostatic test. The results of the test indicated a loss of 8.6 psi over a 13-hour period. This converts to a volume loss of approximately one gallon per hour. This effect is considered normal with cold weather temperature changes.

An additional test site was constructed at an off-site facility. A series of lined trenches and containment tanks was installed to test specific external monitoring technologies.

E. Who Should Read This Report

This Study will be useful to owners, managers, operators, designers, vendors, contractors, users, and regulators of aviation and petroleum product terminals. Information within this report includes:

- Identification of the challenges associated with the testing and application of leak detection technologies with respect to complex petroleum piping systems.
- A description of each of the different leak detection technologies that were tested and analyzed as a part of this program.
- A description of the operation and performance of specific leak detection technologies as field tested in a particular operational scenario.
- Information on the operating parameters of high pressure, high volume, buried piping systems with variable flow rates and, hence, the conditions under which leak detection technologies for these systems must operate.
- Discussion of the leak detection rates and performance that might be realistic and attainable within these systems.
- Guidance for interpreting stated performance criteria during the selection of a leak detection technology for a particular installation.
- Discussion of the benefits of conducting moderate large scale tests.

F. Notes Of Caution

Individuals using this report should consider the following cautionary points in applying the information herein. First, there are limitations to each of the leak detection technologies discussed in this report; none of the technologies discussed in this report will detect a small leak rate 100 percent of the time. Further, occasional anomalies in reliability, repeatability, sensitivity, accuracy, and alarms should be expected from most, if not all, of the technologies. This is a consequence of applying leading edge technologies to complex piping systems.

Although the Leak Detection Committee believes the testing that was undertaken during the Study was representative of the buried, pressurized piping likely to be found in petroleum product terminals and airport hydrant fueling systems, it should be recognized that each individual system will vary. Thus, the characteristics of a given system should be considered when a particular leak detection technology is reviewed for actual application.

Similarly, all testing results in this report were obtained using Jet A fuel. Other fuels may have

higher or lower coefficients of thermal expansion. This could affect temperature dependent technologies adversely. In addition, use of fuels with different vapor pressures may significantly affect the performance of hydrocarbon vapor monitoring technologies.

Because the Study was not intended to serve as an evaluation or endorsement of particular leak detection technology vendors, the technologies that were tested are identified in the Study by descriptive categories. While the technologies are described in a general manner, the reader is advised that each of the technologies actually tested have proprietary features that may be unique. The features are described to the extent necessary for accurate reporting purposes consistent with the vendors' proprietary protections.

Finally, the technologies tested within this Study were those believed to provide the highest probability of successful application for the buried, pressurized piping under consideration. Leak detection technologies for such applications continue to develop and emerge. As they do so, additional data will be developed. The Committee strongly supports the development of performance data that allows comparisons to be made between leak detection technologies under the conditions present in actual application.

This report should be used as a guideline for understanding the capabilities and limitations of current leak detection technologies as applied to the buried, pressurized piping at petroleum product terminals and airport hydrant fueling systems. This report does not recommend one vendor or technology over another, nor is it intended to do so. Rather, this report is intended to be an unbiased documentation of field application and operational testing at MCI.

III. FACILITY/SYSTEM CHARACTERISTICS

A. Airport Hydrant Fueling Systems

The construction and use of airport hydrant systems (AHS) date back to the early 1960's with the introduction of jet engine powered aircraft.

Today, most large airports in the world utilize an AHS to serve commercial air carrier operations. Using an AHS to fuel the aircraft generally is the most cost-effective and efficient delivery method. The alternative means of fueling aircraft is through the use of multiple refueling vehicles, which transport fuel from airport storage facilities to aircraft. An AHS uses a piping distribution system that pumps fuel to aircraft from a storage facility. Pressure reducing and filtering carts connect the aircraft to the AHS during fueling operations. Nearly all of the AHS piping is buried underground.

A typical AHS is comprised of thousands of feet of buried piping ranging in size from 4-inches to 30-inches. An AHS maintains constant pressure and is a flow-on-demand system. Normal operating pressures are in the 150-200 psig range with pumping systems from 2000 gallons per minute for small operations and up to 20,000 gallons per minute at large volume airports. Some AHS have hydraulic surge absorbers to mitigate pressure surges within the system that are created by the closure of hydrant valves.

As interest in validating the integrity of AHSs has increased during the past few years, factors that impose testing limitations have been identified. Several operational characteristics were identified that affect the capability of various leak detection technologies. These were the daily usage pattern, nighttime operations, pressure fluctuations as flows are started and stopped, temperature effects, and the relationship between pressure changes and the volume of product in the line.

The following is a list of specific issues that must be considered.

- Most testing must be performed in a static (locked-in pressure) state.
- Due to airport operations, the AHS normally is in an extended static state only during late night and early morning hours (e.g., between the hours of 11:00 p.m. and 5:00 a.m.).
- The AHS may be divided into several sections to serve multiple gates. For testing, each section should be capable of positive shut off with isolation valves.
- Because the volumetric capacity of an AHS can be significant, positive isolation must be provided to facilitate leak detection technologies.
- Surge absorbers and entrapped gases will affect the rate of pressure change for a given leak rate in an isolated system. Accordingly, surge absorbers must be isolated and entrapped gases identified and addressed during the testing process for best performance.
- An AHS is highly susceptible to pressure variations caused by temperature changes of the fuel when shutdown and isolated. Temperature changes can occur due to differences between the fuel and ground temperature and from solar and ambient temperature change effects on the aboveground storage tanks, piping, and equipment.
- Gases may be trapped in high points of the pipeline and could affect various leak detection systems. Trapped gas would have the effect of reducing the bulk modulus in a way similar to a surge suppressor. Any trapped gas should be bled out of the system before testing to the extent possible.

Figure 3-1 is an illustration of a representative airport hydrant fueling system.

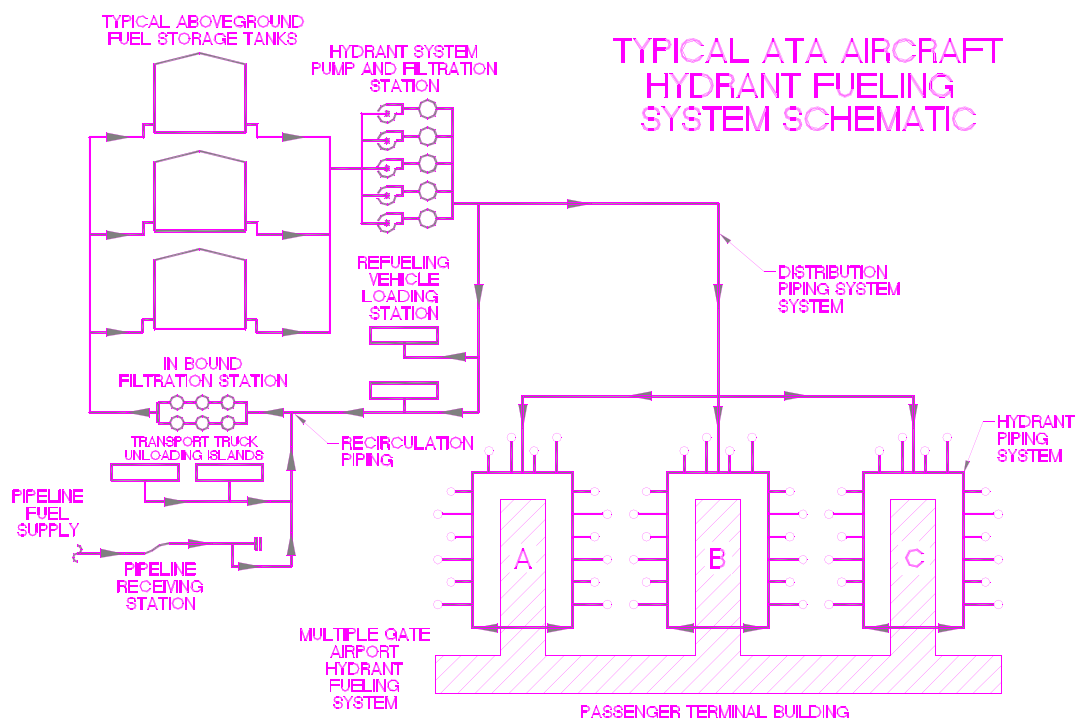


Figure 3-1. Representative Airport Hydrant Fueling System

B. MCI Operating Characteristics

The conclusions supported by the data from the limited monitoring of the operation of the MCI hydrant fueling system are as follows:

1. The pressure within the MCI AHS was seldom stable. Although pressure was relatively stable for short periods during the night, these periods were the exception rather than the rule and were not predictable. Pressure changes almost certainly were the result of temperature changes that could be expected to occur at virtually any AHS. Based on this, leak detection technologies must be able to account for pressure changes not associated with leaks (e.g., due to temperature changes) to have successful application in an AHS.
2. The uninterrupted time without fueling at night at MCI ranged from less than two hours to five or six hours at most. Given the significant effect that fueling can have on leak detection and the operational constraints of testing during the day, it is reasonable to conclude that leak detection technologies that cannot operate within the window of a few night hours will not be suitable for airport use. Larger airports or airports with higher traffic volumes might have even shorter windows for testing.
3. Diurnal pressure changes in out-of-service lines can vary substantially due to ambient temperature and sun conditions. These changes can be large and must be considered.
4. Noise from airport operations was generated at MCI at virtually all times. Although nighttime can be quieter, some noise occurs even then. This can be an obstacle to the effectiveness of acoustical leak detection technologies.
5. At MCI, the time periods during the day when the AHS was not fueling were short, usually between 5 and 15 minutes.
6. Fueling operations occurred at multiple gates simultaneously between the hours of 5 a.m. and 11 p.m. or later. There were few times when the flow was uniform for more than 5 minutes.

C. Petroleum Product Terminal Systems

The typical petroleum product terminal system has less buried pressurized piping than an airport hydrant system. While the materials and methods of

construction are very similar, petroleum product terminals are usually smaller systems.

The majority of piping found in petroleum storage facilities is used for transferring products between tanks for storage and for distribution from tanks to truck loading racks. Such piping operates within a flow rate range of 100 to 1000 gallons per minute, at pressures between 50 to 100 psi. The piping ranges in size from 3 to 12 inches.

While petroleum product terminals and airport hydrant systems have many shared characteristics, there are significant differences as well. The two most significant differences affecting leak detection are times available for testing and use of surge absorbers. Petroleum product terminals generally have a greater window of opportunity to test the piping systems due to transfer schedules. Secondly, these piping systems operate at a lower pressure, eliminating the need for surge absorbers.

Figure 3-2 is an illustration of a petroleum product terminal system.

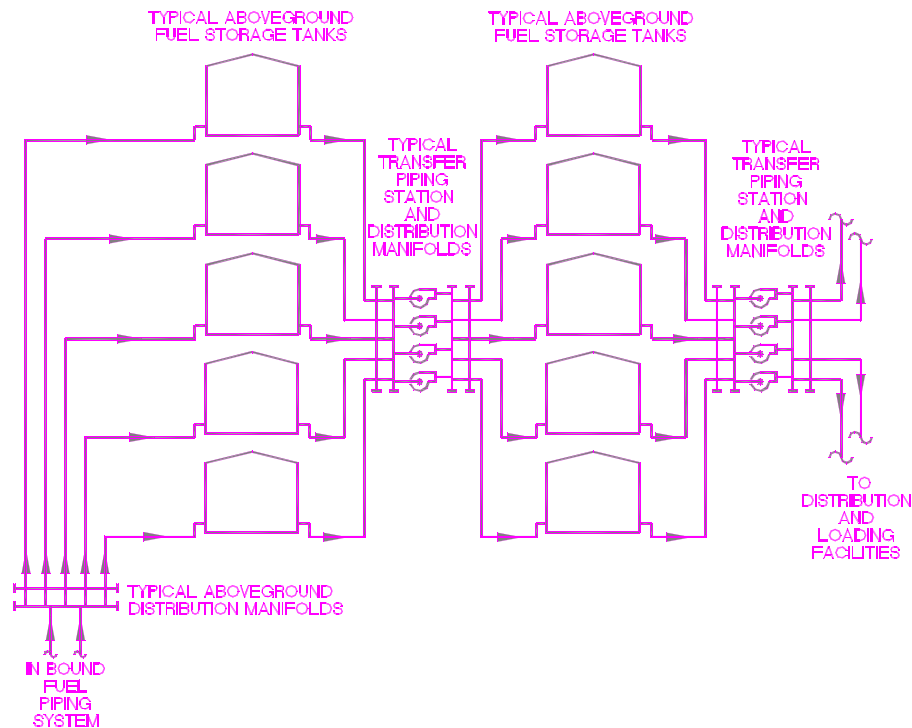


Figure 3-2. Representative Petroleum Product Terminal System