SECTION 6

TANK TESTING FIELD PROCEDURES

The field testing phase of the national survey required collecting descriptive information from each test site, conducting tightness tests on the tank systems and associated piping, and collecting ancillary environmental data. MRI managed the field testing and data acquisition, developed and maintained the test schedule, and served as the primary contact with the establishment owner/operator (o/o). The three-person field teams were comprised of an MRI field data technician and a two-person tank test crew provided by a commercial tank testing firm under subcontract to MRI. The tank test crews were provided by O.H. Materials, Inc., Double Check Company, Inc., and Protanic, Inc. This section describes the procedures used to accomplish the field data collection. A more detailed description of the field testing procedures may be found in MRI's Test and Analysis Plan.[1]

I. PRE-TEST PREPARATIONS

Preparations for field data collection at each establishment were initiated soon after the site identification and survey questionnaire results were received from Westat. The questionnaire responses and site diagrams were reviewed and a preliminary test date was assigned for each site. Tests were scheduled to maximize efficient use of the field teams and to complete the

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[1]"Test and Analysis Plan for the Tank Testing Program of the National Survey of Underground Storage Tanks," H.K. Wilcox, J.W. Maresca, Jr., J.D. Flora, C.L. Haile, June 10, 1985.

survey as expeditiously as possible. Key scheduling considerations were the geographic locations of the sites, the number of tank systems at each establishment, and any special problems related to tank testing anticipated from the survey questionnaire results. Because up to three tank systems could typically be tested each work day at a single establishment, one day was allocated for sites with three or fewer tank systems. Similarly, two days were allocated for sites with four or more tanks. However, as testing three systems in a single day generally required significant overtime, consecutive three-system days were avoided where possible. Days were also incorporated into the schedule for makeup tests.

As soon as possible following assignment of a preliminary test date, the o/o was contacted by phone to arrange the test appointment. The testing and data collection program were fully explained and a mutually agreeable test date was established. The o/o was also instructed how to file compensation claims to EPA for costs incurred due to closure for testing.

The key requirements of the tightness testing were that the system be removed from service during the test and that the tanks be completely filled. Several gallons of additional product were also required to top off the tank during testing. If the o/o was unable to arrange product delivery to accommodate the test requirements, assistance was provided in the form of contacts to the appropriate fuel supplier.

The field crew assigned to a specific site contacted the establishment o/o by phone or visit approximately two days prior to the scheduled test date. This contact served to confirm the test date, confirm that the establishment would be ready for testing, and answer any additional questions from the o/o.

II. SITE DESCRIPTION INFORMATION

A site inspection was conducted at each establishment during the test visit prior to or during setup of the tank system test equipment. The purpose of the inspection was to provide an accurate-detailed record of the layout of the establishment, tank system configurations, and environmental features that may be related to system failure or leakage. This information was recorded in the form of overall site sketches, detail sketches for each tank, and a table of critical features. The site sketches recorded the layout of tank systems and dispensers as well as locations of buildings, roads and pavements, power lines, and waterways. Color instant print photographs were taken to supplement descriptions contained in the sketches. The following details were recorded on a critical features data form for each tank system:

- Survey ID No.
- Tank number
- Product type
- Number of dispensers
- Tank size
- Size of fill pipe
- Size of gauge pipe
- Size of stick pipe
- Drop tube - permanent or removable
- Delivery system - pressure, suction
- Depth of tank from grade
- Surface over tank
- Presence of overhead power lines
- Presence of nearby waterways

III. TANK SYSTEM TIGHTNESS TESTING

After the evaluation of a number of tank tightness test methods (see Appendix C), it is clear that none of the standard test methods evaluated in the program can consistently and reliably achieve detection of the 0.05 gallon per hour leak rate specified by the NFTA 329 "Recommended Practices for Underground Leakage of Flammable and Combustible Liquids, 1983." This conclusion is based entirely on the data collected during the method selection phase of the program, since supporting data which was requested from the test companies to document their performance claims was not received. EPA modified, for use in the survey, one of the tank test methods to improve the accuracy of the test results.

While some methods can provide reliable results under some specific conditions, there are many situations which commonly occur in the test environment (such as the presence of a water table) which can invalidate the test results. Unless the test crew takes specific steps to identify these conditions, the reported results may be either misleading or incorrect. Most test methodologies currently in use fail to take definitive steps to identify one or more of these problem areas. The test results obtained must therefore be suspect to the degree that these factors are not recognized. The effects can be substantial and cannot be generally evaluated from the test data after the test crew has left the test site.

One of the major objectives of the program prior to the national survey was to identify and characterize a test method suitable for use on the program. A modification of the Petro-Tite method was developed and characterized for this purpose. This method was selected as the method with the most consistent approach to identifying potential problems and taking action to correct for them. It was judged to provide the most consistenyly reliable data for the national survey. It has stated procedures to identify and correct for tank end deflection, temperature effects, water table, and vapor pockets. EPA modified the method in three ways in order to improve accuracy: (1) the test time and sample frequency were increased; (2) the temperature correction algorithm was improved; and (3) statistical hypothesis testing procedures were applied to the data to determime leak status.

A. System Test

1. Method Description

The Petro-Tite tank test measures product loss from the tank system by monitoring the change in product level in an elevated standpipe. Apparent volume changes are corrected for expansion and contraction caused by product temperature changes during the test to produce a net volume change. The net volume change over time is equivalent to the leak rate. The key features of the Petro-Tite method are that the test is conducted with the tank overfilled into an elevated standpipe and that the product is circulated during the test. The reference level in the standpipe is set to maintain a hydraulic pressure, or fuel head pressure, of 4 psig on the bottom of the tank in excess of any back pressure caused by groundwater at a level above the tank bottom. The purpose of conducting the test at an elevated pressure is to increase the probability of detecting small leaks, to mitigate masking of leaks by groundwater back pressure, and to stabilize end cap deformation. The product is circulated during the test to produce and maintain temperature homogeneity.

The Petro-Tite tank test equipment is shown in Figure 6.1. A probe, inserted into the fill tube, consists of the circulation pump inlet and discharge tube and a thermistor assembly. The probe is sealed in the fill tube with an air bladder seal. The

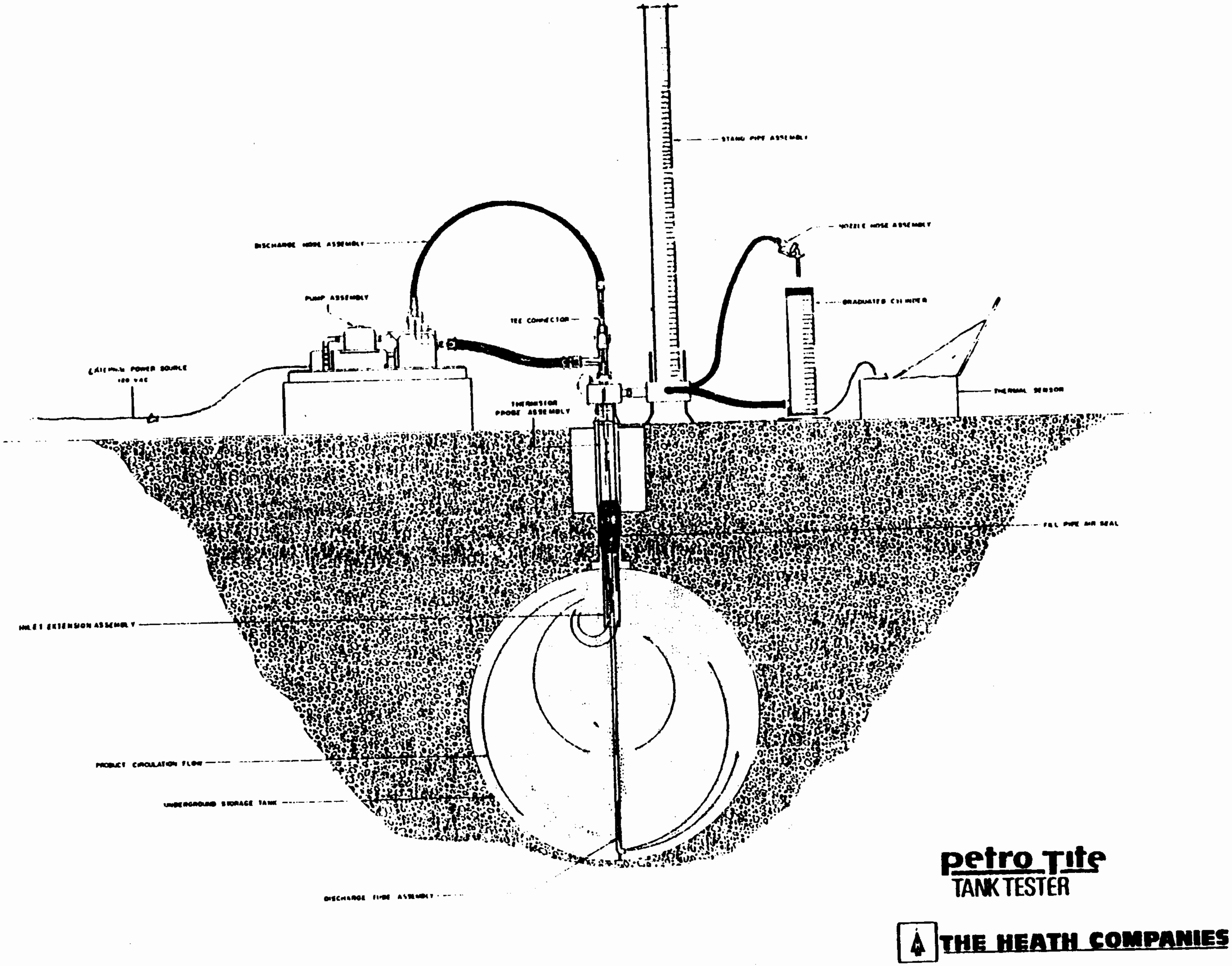

Figure 6-1. Test equipment

circulation pump withdraws product from the fill pipe and discharges it through a jet nozzle located near the bottom of the tank. The nozzle is directed at a 45-degree angle down the longitudinal axis of the tank to produce a swirling circulation. The thermistor is located at the pump inlet and is connected to an electronic thermal sensor module to provide temperature readout. The standpipe is connected to the probe and also to a graduated cylinder. During the test, the product level in the standpipe is readjusted to the reference level using the graduated cylinder. The volume of product added to or removed from the standpipe to reach the reference level is measured from the cylinder by difference, i.e., volumes in the cylinder are read before and after raising the standpipe level to the reference mark.

2. Method Operation

At the beginning of the test, the probe and thermistor units were installed into the fill pipe and the circulation was initiated. A small bore hole was drilled near the tank, preferably in the tank backfill, to determine if and at what level the water table was above the bottom of the tank. The density and temperature of the fuel product was determined with a hydrometer and a thermometer. The product temperature and density were used to determine the thermal expansion coefficient for the fuel from physical properties tables prepared by the American Petroleum Institute. The product density and depth to the water table were used to determine the standpipe reference levels.

The standpipe and graduated cylinder were installed and product was added to the standpipe to a "high" level reference level to place a pressure of 5 psig on the tank bottom. Product was periodically added to maintain this level until the rate of change indicated that end cap deformation had stabilized. Then, the level was lowered to the "low" level to place 4 psig on the tank bottom. This was the reference level for the leak rate test.

The product level in the standpipe was readjusted to the reference level at 5-minute intervals. The volume of product in the cylinder before and after releveling were recorded on the test data sheet. Fuel temperature readings were made and recorded on the test data sheet at 5-minute intervals. These data were also entered into a LOTUS 123 (tm) spreadsheet file on a portable microcomputer. The test was conducted for 2 h with readings at 5-minute intervals. The tank system leak rate was calculated using the volume change, temperature data, tank volume, and thermal expansion coefficient of the product. At the conclusion of the system test, a line test was conducted. After completion of the line test, the equipment was removed from the tank.

Where possible, the entire tank system was tested as a single unit. This included vent lines, distribution lines, and, in the case of multiple tanks manifolded into a single system, all tanks and syphon lines. However, in cases where vapor pockets were found or the piping layout was not well known, tanks were isolated and tested separately. Isolation of tanks from associated piping generally required excavation to expose the top of the tank.

Vapor pockets were also indicated in several single tank systems. Vapor pockets were suspected when the standpipe level fluctuated in an apparent haphazard manner. This was typically caused by vapor trapped in manway or piping on the top of the tank. In cases where vapor pockets were indicated, the top of the tank was exposed by excavation and air bleed valves were installed on manway and bung covers. The vapor was bled from the filled tank and normal tank tightness test was conducted. Identification of vapor pocket problems and the need for excavation could not be identified until the tank test was attempted. Hence, testing tanks with vapor pocket indications generally required at least two test days.

3. Performance Characteristics

The performance characteristics of the Petro-Tite test method were empirically determined during the survey by examining the variance within specific tests, and between retests on 34 pairs of data. The total variance was found to be 0.00264 gal^2/h^2 which represents a standard error of $\pm$ 0.0514 gallons per hour. This procedure is covered in Appendix D of this report.

B. Line Tests

Tightness testing was conducted on the distribution lines where possible. The system requirements for conducting a line test are a suitable connection at the delivery end of the line to install the test unit and a check valve in good working order. The check valve, typically installed at the inlet of the distribution line in the tank (foot valve) or in the line just above the tank (angle check valve), prevents product in the line from draining back into the tank. Hence, the location of the check valve determines the portion of line subjected to the test.

1. Method Description

The Petro-Tite line test system pressurizes the system with product and measures the volume of product required to maintain the reference pressure. Lines for pressure and suction distribution systems are tested in a similar manner, although the test pressure differs. A diagram of the line test system is shown in Figure 6.2. The test unit is connected to the delivery end of the distribution line and the line is pressurized using a foot operated pump to 15-30 psig for suction lines or 30-80 psig for pressure lines. This pressure closes the check valve to prevent fuel loss back to the tank. The pressure is monitored using the gauge and the pressure restored periodically. The volume of product required to restore the reference pressure is recorded.

2. Method Operation

The line test was conducted at the conclusion of the tank system test, before the tank test equipment was removed. Air was bled from the line and the test unit was connected to the distribution line. Product was pumped into the line to achieve the required pressure. The product level in the tank test standpipe was monitored simultaneously to determine if the foot valve was functioning properly. If product loss from the line was observed as a volume increase in the tank test standpipe, the check valve was considered leaking and the line test was inconclusive. If possible, the check valve was replaced and the test repeated.

The line set pressure was monitored and restored using the test pump at 15-minute intervals. The product level in the graduated reservoir was recorded before and after each pressure restoration. The total product volume added during the 1-h test

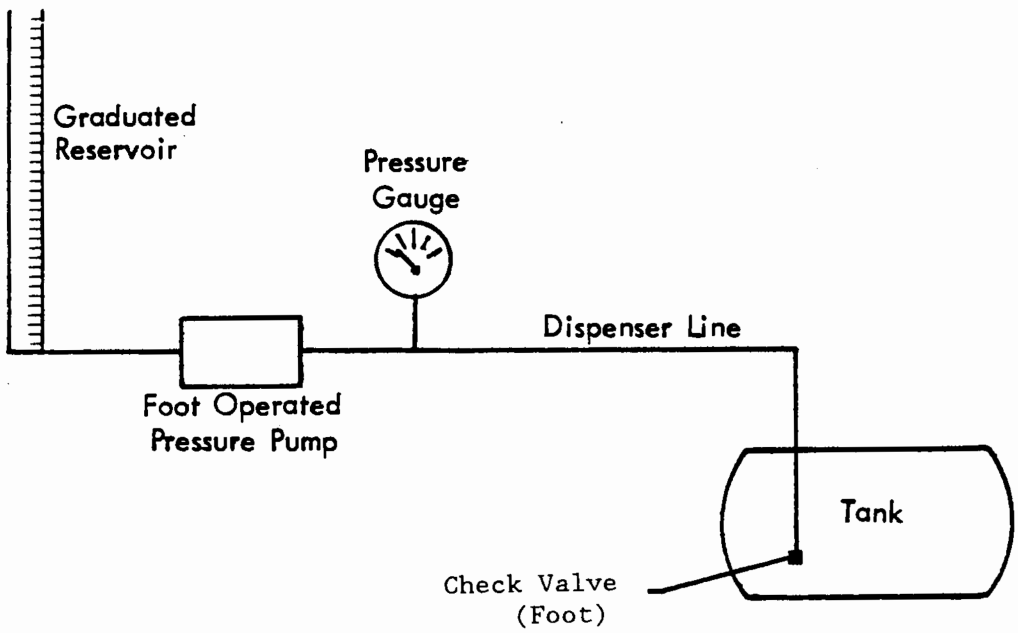

Figure 6-2. Line test equipment

(a total of four 15-minute interval readings) was reported as the line leak rate. If the volume required to restore pressure is less than 0.025 gallons per hour for suction lines or 0.010 gallons per hour for pressure lines, the line is considered to be tight. Volumes greater than these indicate that the line is leaking or an invalid test.

3. Performance Characteristics

The performance characteristics of the line leak detector have not been verified by independent measurements. However, expert users of the device have stated its tolerance to be at least ± 0.0005 gallons per hour when used on a typical delivery line.

The average standard error of line tests conducted on the national survey was of the order of 0.001 gallons per hour. This is more than an order of magnitude more sensitive than the threshold leak rate.

Four situations can occur which can cause volume changes. These are: leaks (or a bad check valve); changes in the liquid temperature in the line; line expansion or stretching due to the high pressure; and compression or shrinkage of air vapor present in the line. All of these produce characteristics which can be recognized by experienced personnel.

The two problems which caused the large number of line leaks to be declared invalid were bad check valves and air pockets. Ninety-one tests were declared to be invalid for these reasons. In order to complete the testing on the 77 systems with bad check valves, it would have been necessary to excavate the top of the tank in most cases. This was beyond the scope of survey.

At the conclusion of the line test, the pressure on the line was released and the product allowed to flow back into the graduated reservoir. The bleed back volume was also measured. A bleed back volume of greater than 0.050 gal indicated air in the line and the test was considered inconclusive. The test was repeated after air was bled from the line. If the repeat test also had excessive bleed back, the test was considered inconclusive.

IV. ENVIRONMENTAL DATA COLLECTION

General environmental data were also collected during the tank system and line testing. These data included the following:

- Ambient air temperature
- Surface temperature above the tank
- Subsurface soil temperature
- Barometric pressure
- General climatic conditions
- Water table level.

These data were collected to provide a record of any external temperature and pressure conditions that may have an effect on the operation and results of the system and line tightness tests.

All environmental data except the water table level were recorded hourly during the test visit. The water table was typically determined by drilling a bore hole through the tank backfill material to the depth of the tank bottom. If water was not encountered at that depth, it was recorded as being lower. Anecdotal information concerning seasonal or other periodic fluctuations were recorded as available. The ambient air temperature was measured using a mercury-in-glass thermometer. Surface temperature was also measured with a mercury thermometer placed on the surface at grade level over the tank. A thermistor inserted into the bore hole previously drilled to determine water level was used to monitor subsurface soil temperature. Barometric pressure was measured with an aneroid barometer. General climatic conditions, based on the observations of the field technician, were recorded in common climatic terms such as: light and variable winds, foggy, light rain, or sunny.

V. Tightness Testing Field Experience

A. Test Completion

A summary of the tests completed is presented here. There were 485 manifolded tank systems from which 560 tanks were selected for tightness testing. However, about 10 percent were not tested because they were found to be out of scope or untestable for technical reasons, or testing was refused by the facility owner/operator. Out-of-scope tank systems consisted of a closed fuel service station, small tank systems on farms (i.e., less than 1,100 gallons), and one system at an establishment that had been misclassified. Technical problems included several unused tank systems containing a residual sludge and tank systems installed that did not permit access to install an air bleed valve when vapor pockets were indicated. Some of the latter cases included tank systems without bungs on the top and tank systems installed under a building. A tank system installed under a hospital helicopter emergency landing pad was considered untestable due to the lack of an alternate landing location. The final refusal rate was 3 percent.

B. Technical Problems

A summary of the technical problems encountered in tank system and distribution line testing is presented in Table 6-1. Fuel delivery problems and vapor pockets were the most disruptive to the test schedule. Coordination of fuel delivery scheduling with the test schedule was a significant part of the test preparation effort. In spite of extensive preparation, failure of the supplier to deliver product as scheduled caused delays in 19 tests. Vapor pockets were indicated in 21 tests. These required exposing the top of the tank by excavation and installation of air bleed valves.

Many of the other problems involved features requiring resolution to permit installation of the test equipment or mitigation of vapor pockets. Permanent drop tubes, vapor recovery systems, and pumps were removed and remote fill pipes were excavated and disconnected to facilitate installation of the test equipment. Manifolds were disconnected to mitigate vapor pockets and to allow separate testing of individual tank systems in some manifolded tank systems. Failure of foot valves was a frequent problem encountered during distribution line testing. Also, excessive bleed-back volumes, indicating air in the distribution line, caused 14 line tests to be considered unreliable.

Table 6-1. Technical problems summary

Problem	Number[1]
Fuel delivery	19
Vapor pockets	21
Permanent drop tubes	17
Vapor recovery systems	6
Pump	2
Remote fill pipe	2
Manifolds	14
Other	23
Foot valve failure	77
Excessive bleed-back volume	14

[1]More than one problem could be encountered in a given test. Hence the total number of problems is greater than the number of tests with any problem.