Pacific Environmental Services, INC.
1930 14th Street Santa Monica, California 90404

I. BACKGROUND

This guideline is related to the control of volatile organic compounds (VOC) from gasoline tank trucks and vapor collection systems at bulk terminals, bulk plants, and service stations. Guideline documents have already been published on bulk plants, bulk terminals, and service stations. The intent of this guideline is to define leak tight conditions and related test procedures for vapor collection systems and tank trucks while loading and unloading at these facilities. VOC emitted from leaks in collection equipment are primarily C_4 and C_5 paraffins and olefins which are photochemically reactive (precursors to oxidants).

Methodology described in this guideline represents the presumptive norm or reasonably available control technology (RACT) that can be applied to an existing facility. RACT is defined as the lowest emission limit that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility. It may require technology that has been applied to similar, but not necessarily identical, source categories. It is not intended that extensive research and development be conducted before a given control technology can be applied to the source. This does not, however, preclude requiring a short-term evaluation program to permit the application of a given technology to a particular source. This latter effort is an appropriate technology-forcing aspect of RACT.

A. NEED TO REGULATE

Control techniques guidelines are being prepared for source categories that emit significant quantities of air pollutants in areas of the country where National Ambient Air Quality Standards (NAAQS) are not being attained. Leaks from tank trucks and vapor collection systems are a significant source of VOC and tend to be in areas where the oxidant NAAQS are likely to be violated.

B. CONTROL APPROACH

The approach described in this document is improved maintenance and would be enforced through the surveillance and periodic testing of suspect leak points. It should be noted that while some leak sources (such as vapor piping joints) may stay in leak tight condition for extended periods of time, others (such as pressure and vacuum vents, and hatch seals) may leak shortly after maintenance. It is expected that compliance with the suggested control measure will in some cases require replacement of truck pressure and vacuum vents and dome covers. In addition, a greater degree of surveillance and maintenance will be needed at bulk terminals equipped with top loading vapor collection (vapor head) systems.

II. DRAFT REGULATION

A. AFFECTED FACILITIES

The affected facilities are gasoline tank trucks and the vapor collection system at bulk terminals, bulk plants, and service stations that are equipped with vapor balance and/or vapor processing systems.

B. RECOMMENDED REGULATION

B.1 Gasoline Tank Trucks

Gasoline tank trucks should not sustain a pressure change of more than 750 pascals (3 inches of H_2O) in 5 minutes when pressurized to 4500 pascals (18 inches of water) or evacuated to 1500 pascals (6 inches of water).

During loading or unloading operations there are to be no visible liquid leaks.

B.2 Vapor Collection Systems

B.2.1 - During loading or unloading operations at service stations, bulk plants and bulk terminals, there shall be no reading greater than 50 percent of the lower explosive limit (LEL, measured as propane) within 2 centimeters around the perimeter of a potential leak source as detected by a combustible gas detector. In addition, there should be no visible liquid leaks. The vapor collection system includes all piping, hoses, connections, vents and other possible leak sources between the truck and the vapor processing unit or the storage tanks; and

B.2.2 - The vapor collection and vapor processing equipment must be designed and operated to prevent gauge pressure in the tank truck from exceeding 4500 pascals (18 inches of water) and prevent vacuum from exceeding 1500 pascals (6 inches of water).

C. MONITORING REQUIREMENTS

C.1 Gasoline Tank Trucks

Gasoline trucks must be certified leak tight as described in Section B.1 annually.

In addition, trucks can be monitored by regulatory agencies as needed during loading and unloading using the combustible gas detection procedure described in B.2.1. Trucks with leaks greater than 50 percent of the LEL are to be repaired within 15 days or be required to take and pass the pressure and vacuum test described in Section B.1.

C.2 Vapor Collection Systems

Vapor collection systems can be monitored by regulatory agencies as needed using the combustible gas detection procedure described in B.2.1, provided that the requirements in Section B.2.2 are met.

D. RECORD KEEPING AND REPORTING REQUIREMENTS

D.1 Gasoline Tank Trucks

Each truck should have a sticker displayed on each tank indicating the identification number of the tank and the date each tank last passed th- pressure and vacuum test described in Section B.1.

D.2 Vapor Collection System

Bulk terminal, bulk plant, and service station owners should keep records for two years indicating the last time the vapor collection facility passed the requirements described in B.2 and identifying points at which VOC leakage exceeded the provisions of Section B.2.1.

E. OTHER CONSIDERATIONS

Presently, there is limited information available on the amount of monitoring necessary to ensure that leaks are kept to the limits described above. Therefore, regulations should allow for modifications in the monitoring schedule where experience proves it to be either inadequate or excessive. If, after over one year of monitoring, i.e., at least two complete annual checks, the operator of an affected facility feels that the modifications of the requirements are in order, he may request in writing to the air pollution control officer that a revision be made. The submittal should include data that have been developed to justify any modifications in the monitoring schedule. On the other hand, if the air pollution control officer finds an excessive number of leaks during an inspection, or if the operator finds an excessive number of leaks during scheduled monitoring, consideration should be given to increasing the frequency of inspections.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE: 13 NOV 1978

SUBJECT: Control of VOC from Gasoline Tank Trucks and Vapor Collection Systems

FROM: Stephen A. Shedd
Petroleum Section, CPB (MD-13)

TO: See Below

The draft report entitled, "Leak Testing of Gasoline Tank Trucks," mailed to you on October 19, 1978, contained only the odd numbered pages of the report. Enclosed is a complete copy of the report. I hope this error has not delayed your review of the control document and background reports. Should you have any problems completing your comments by November 30, 1978, please contact me at FTS 629-5371.

Enclosure

Addressees:
Director, Air & Hazardous Materials Division - Regions I and IV
Pat McManus - Region III
Beverly Foster - Region V
John Crocker - Region VI
Robert J. Chanslor - Region VII
Gary Parish - Region VIII
Gary Lavagninio - Region IX
Richard Greenberg - MSED
Doug Carter - DSSE (EN341)
Robert Marshall - DSSE (EN341)

EPA FORM 1320-6 (REV. 3-76)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE: 19 OCT 1978

SUBJECT: Control of VOC from Gasoline Tank Trucks and Vapor Collection Systems

FROM: Robert T. Walsh, Chief
Chemical and Petroleum Branch (MD-13)

TO: See Below

The enclosed document was prepared to aid States in preparation of their implementation plans to control precursors of photochemical oxidants. Specifically, the document contains recommendations to control volatile organic compound leaks from gasoline tank trucks and vapor collection systems at bulk terminals, bulk plants, and service stations. Also enclosed are two draft EPA contractor reports that provide background information and data used in developing the recommendations.

Before finalizing the recommendations, we are asking for your review. Please submit comments to me by November 30, 1978. Questions of a technical nature should be directed to Stephen Shedd at (FTS) 629-5371.

3 Enclosures

Addressees:
Director, Air & Hazardous Materials Division - Region I
Vincent J. Pitruzzello - Region II
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GASOLINE TANK TRUCKS AND BULK PLANTS: EVALUATION OF VAPOR LEAKS AND DEVELOPMENT OF MONITORING PROCEDURE

Contract No. 68-02-2606
Work Assignment No. 11

EPA Project Officer -- Nancy D. McLaughlin

Project Manager -- Robert Norton

September 1978

Prepared for

ENVIRONMENTAL PROTECTION AGENCY
Emission Measurement Branch
Emission Standards and Engineering Division
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Pacific Environmental Services, INC.

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1.0 INTRODUCTION

In the prevention of hydrocarbon emissions during the transfer of gasoline, hydrocarbon vapor recovery systems have been installed. These systems have been developed to contain hydrocarbon emissions and to transfer the vapors through piping systems either to the delivery tank during gasoline deliveries or to the storage tanks during the loading of the delivery vehicle. The effectiveness of these vapor recovery systems is dependent upon the absence of leaks in the vapor containing equipment and assorted piping.

As a special task under EPA Contract No. 68-02-2606, Pacific Environmental Services, Inc. (PES) conducted a study to define the leakage areas, the equipment necessary to contain the vapors, and the costs necessary to maintain the vapor containing equipment in a leak tight condition. The study also aimed at developing a monitoring procedure which would be a quick, low cost technique. This procedure would be used as an enforcement tool to determine if the vapor transfer system was operating without leaks as defined by some pass/fail criteria.

To determine the availability and the cost of maintaining the necessary vapor containing equipment, numerous equipment manufacturers and equipment operators were contacted. Identification of leakage areas were performed by observing delivery tank loadings. Maintenance costs were obtained by observing actual tank maintenance procedures conducted by several tank truck operators.

To determine an appropriate field monitoring procedure, a field test program of candidate methods was developed by PES. The field test program, conducted by another contractor, was supervised by both PES and EPA personnel. Tests were conducted in the Los Angeles, California area because truck fleet operators in California are required to maintain their trucks in a leak tight condition as defined by the California Air Resources Board (CARB) certification criteria. Maintenance and equipment specifications were also obtained mostly from California sources because of the leak tight requirements. Tests were conducted at both bottom and top loading terminals with a total of over 150 tank loadings monitored.

2.0 HYDROCARBON VAPOR LEAKAGE

2.1 SOURCES OF HYDROCARBON LEAKAGE

2.1.1 TANK TRUCK

Sources of hydrocarbon leakage from truck delivery tanks include dome covers, pressure-vacuum vents, and vapor collection piping and vents. Smaller instances of leakage occur at tank welds, liquid and vapor transfer hoses, overfill sensors, and vapor couplers.

2.1.1.1 Dome Covers

Dome covers consist of a series of openings, clamps and seals each of which is a potential hydrocarbon vapor leakage point. The first potential source is the seal where the dome assembly itself attaches to the truck tank. A gasket material is placed between the dome base ring and the tank welding ring and the dome cover clamped to the tanks. Hydrocarbon leakage can occur at this seal if dirt or foreign material becomes lodged in the interface, if the gasket material becomes cracked or worn, or if the dome base ring becomes warped or damaged.

Another source of hydrocarbon leakage from the dome cover is at the seal between the dome lid which covers the hatch opening. This seal can be easily damaged if foreign material lodges in the interface, especially if open or closed regularly as in top loading. The dome lid is also spring loaded and acts as a secondary pressure relief vent normally set to open if the tank pressure reaches 3 psi. The hatch cover can become warped or damaged and leakage can occur.

Fugitive hydrocarbon emissions can also occur at the pressure-vacuum (P-V) vents which are normally installed in the dome lid. These vents are installed as a vapor control measure to reduce the emission of hydrocarbons from the vapor space of the compartments.

during transit. Emissions or leaks may occur if the P-V vent is not installed or is not maintained properly. The valve seat may become dirty or damaged which would not allow the valve to seal properly. The valve actuating devise, such as a spring loaded valve, may become damaged also allowing improper sealing and causing hydrocarbon leakage.

2.1.1.2 Vapor Collection Piping and Internal Vents

For those truck delivery tanks that have vapor recovery installed, hydrocarbons can leak from the vapor collection and piping systems. Normally, each compartment has a vent valve which is opened when that compartment is being loaded or unloaded. This vent allows vapors to be removed from or returned to the compartment through piping into the vapor recovery system. The compartment vent valve is covered either with a rubber boot assembly or metal bolted or welded cover to contain the vapors in the vapor transfer system. The vapor return line can be either rubber hoses or metal pipe placed on top of the tank or incorporated into the overturn rail or any combination of these. The vapor PRD terminology
return line, which is manifolded to each compartment, will have "Roll Ridge"
joints or connectors in the piping for each compartment.

Hydrocarbon vapors can leak from the vent valve cover due to tears in the rubber boot, leaks in gaskets from bolted covers or faulty welds from welded covers. Leaks can occur in the vapor line connectors from poor seals or clamping mechanisms with the rubber hoses or faulty welds or seals with metal piping.

2.1.1.3 Liquid and Vapor Transfer Hoses

Leaks can occur from liquid and vapor transfer hoses and from their respective couplers. Hoses can become torn, worn, cracked, etc. to produce hydrocarbon vapor leaks. Fugitive hydrocarbons can occur from vapor coupler connections if these are not coupled or closed properly. Coupler gasket material can also be worn or damaged causing a poor seal. If dry break or vapor tight couplers are used, the valve seat may become worn or foreign matter may become lodged in the seal causing hydrocarbon vapors to leak to the atmosphere.

2.1.1.4 Miscellaneous Emission Sources

Other sources of leakage from truck delivery tanks are possible but occur considerably less frequent than those already discussed. Leakage can occur from flaws in the tank shells, improperly welded seams, or improperly installed overfill protection sensors.

2.1.2 BULK PLANTS AND TERMINALS

Various leakage of hydrocarbon vapors from bulk plants and terminals can occur from vapor couplers and hoses corresponding to the vapor recovery system, top loading connectors (if applicable), vapor piping to storage tanks, and pressure relief vents on fixed roof storage tanks (if applicable).

and others on tanks ie sampling hatch

2.1.2.1 Vapor Piping to Storage Tanks

Vapor recovery piping can be installed at bulk plants for both incoming loads to the storage tank and for vapor control at the loading racks. Vapor recovery piping installed at terminals will run from the storage tanks to the loading rack. This piping is usually above ground and is normally flanged or threaded metal pipe. Hydrocarbon vapor leaks can occur at piping joints or connections dur to improper installation, faulty flange gaskets, or accidental damage.

2.1.2.2 Vapor Couplers and Hoses

As discussed in the delivery tank section, losses can occur from damaged or worn transfer hoses or imporperly connected or damaged vapor transfer couplers. Bottom loading coupler losses can occur from worn or contaminated vapor tight valve seats or from worn gaskets.

2.1.2.3 Top Loading Vapor Connectors

Vapor leakage from top loading collection and loading arms can occur from movable joints or swivels. The arms can be either pneumatically operated or manually swiveled as in smaller bulk plant type top loading operations. Even with vapor recovery loading arms, recent test data has shown that hydrocarbons can escape during over 95 percent of the loading operations.[1] Liquid spillage and leaking joints, such as swivels and flange gaskets, account for a number of hydrocarbon vapor sources. Hydrocarbons can also escape from the loading arm-hatch opening interface. Test data show that this can be the most significant source of leakage from the top loading operations.[2]

2.1.2.4 Storage Tank Pressure Relief Vents

At either bulk plants or terminals where fixed roof tanks are employed, pressure-vacuum vents are used to control breathing and working losses from the storage tanks. these valves are similar in concept to those discussed in Section 2.1.1.1. The valves can be either spring loaded or weighted to open at the desired internal pressure. Dirt or other debris can become lodged in the valve seat causing it to seat poorly and become a hydrocarbon leak source. The spring or weights system may get out of allignment and not allow the valve to return to its seat properly, thereby causing leaks.

2.1.3 SERVICE STATIONS

Fugitive hydrocarbon emissions can occur during service station gasoline deliveries at the delivery and vapor transfer couplers, at the underground tank vent, and at the underground vapor piping.

2.1.3.1 Vapor Piping

The vapor piping at service stations is almost exclusively underground and therefore should not be a significant source of hydrocarbons. However, if improper installation does occur vapors can escape from the piping and reach the atmosphere.[3]

2.1.3.2 Underground Tank Vent

Hydrocarbon vapors can be emitted from the underground tank vent during unloading of the gasoline. This could be caused by restrictions in the vapor return line, by not connecting the vapor line during the delivery, or by temperature differences between the gasoline being unloaded and that which is present in the underground tank.

2.1.3.3 Vapor and Liquid Transfer Couplers

Leakage can occur due to damaged or improperly attached vapor couplers as discussed in previous sections. Damaged couplers may not allow the sealing mechanisms to operate properly and, if not coupled tightly, hydrocarbon vapors can be emitted.

2.2 POTENTIAL AND CONTROLLED EMISSIONS

Quantifying a leakage source is difficult since the size of the leak and the corresponding leakage rate can vary significantly. The leakage rate is proportionate to the equilavent orifice size of the leak opening and the tank pressure.[4] All of the leakage sources prescribed in Section 2.1 have the potential to be large leaks, however, some of the leak sources are normally more predominate than others.

Leakage of hydrocarbons from hatch covers, hatch base rings, and pressure vacuum vents are the sources where hydrocarbon vapors most often occur. These uncontrolled leakage rates have the potential to exceed 10 percent of the vapor transferred.[5] Under controlled conditions these sources should not leak in excess of 1 percent of the volume of vapor transferred. This is based on the CARB tank truck pressure loss criteria which, when calculated, does not allow the delivery tank to leak greater than 1 percent of the volume of vapors transferred (99 percent containment).

The other sources discussed, such as the vapor piping, couplers, and storage tank vents also have the potential for large leaks depending upon the size of the leakage area. Vapor losses from properly installed and maintained piping and couplers should be eliminated. Vapor losses from P-V vents, when the tank pressure is below the venting level, can also be eliminated with properly installed and maintained equipment.

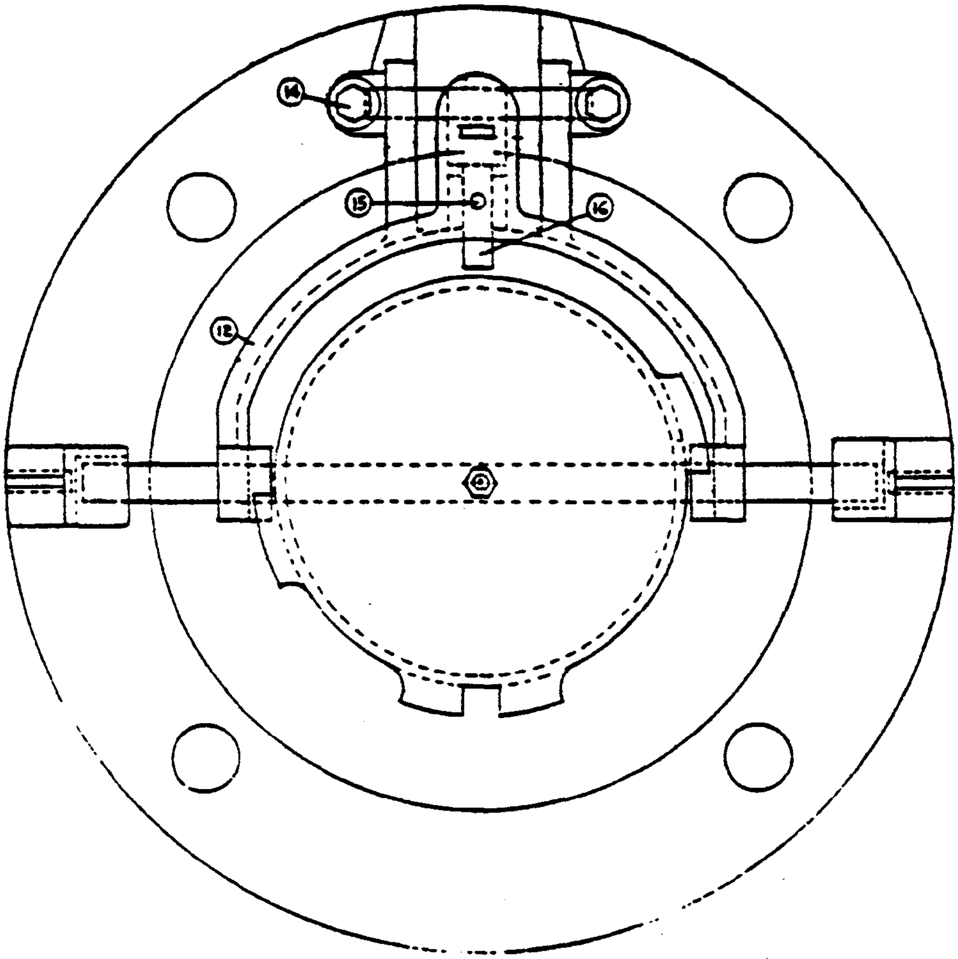
2.3 AVAILABLE EQUIPMENT TO CONTROL EMISSIONS

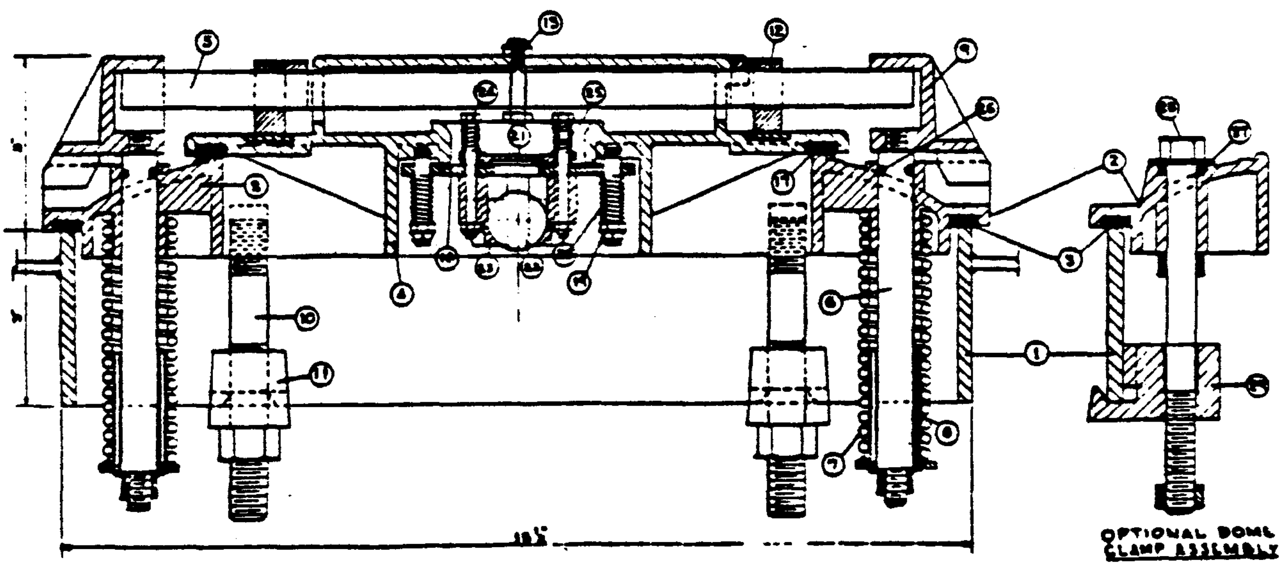
2.3.1 TANK TRUCK DOME COVERS

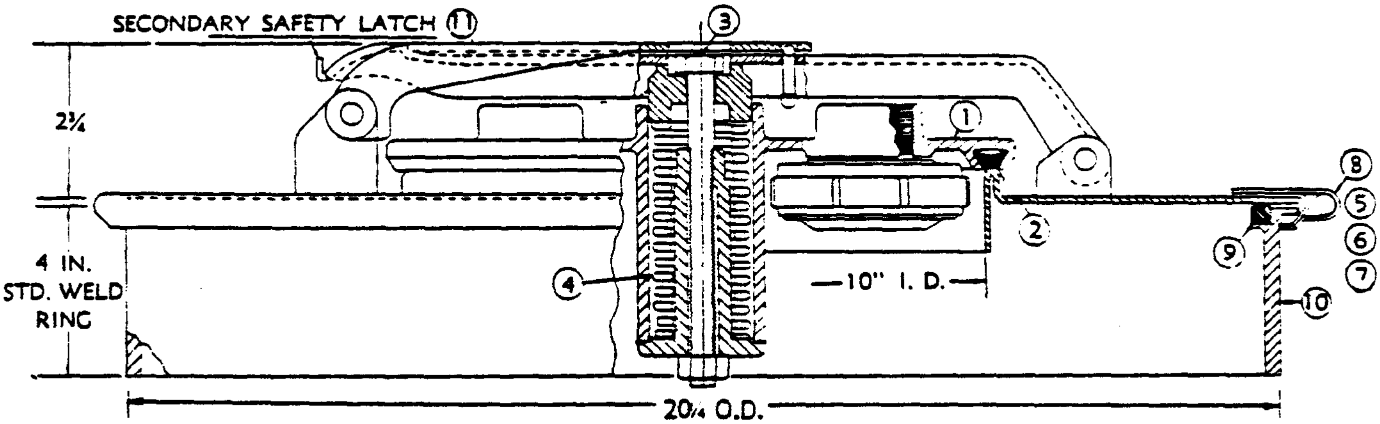
In California where leakage must be contained within the limits specified in the certification criteria, only two firms manufacture hatch covers which can meet these requirements. These domes are supplied by C-B Equipment, Inc., Lynwood, California and Tiona-Betts, Inc. Warren, Pennsylvania. From interviewing tank truck operators, conflicting opinions were obtained on a preference of either of the hatch covers. The Tiona dome base ring is made from a flat plate while the C-B dome base ring is cast and has support ridges (see Figures 2-1 and 2-2). This added support makes the C-B dome less apt to succomb to bends or warpage. However, the

Figure 2-1. C-B Dome Assembly
(Courtesy C-B Equipment, Lynwood, California)

SYM.	PART No.	REQ.	DESCRIPTION
1	1002	1	WELDING RING
2	7466	1	DOME BASE RING
3	1017	1	GASKET
4	7457	1	DOME CAP
5	7458	1	DOME LOCKING BAR
6	7459	2	SHAFT ASSEMBLY
7	7460	2	EXCESS PRESS SPRING
8	7461	2	SLEEVE
9	7462	2	LOCKING BAR CATCH
10	7463	4	DOME STUD
11	7464	4	DOME CLAMP LUG
12	7465	1	LOCK HANDLE
13	7466	1	RETAING BOLT
14	7467	2	HINGE BOLT
15	7468	1	SAFETY LATCH BOLT & SPRING
16	7469	1	SAFETY LATCH
17	7470	1	DOME CAP GASKET
18	7471	1	VACUUM VALVE DISC
19	7472	2	VACUUM VALVE STUD-NUT-PIN
20	7473	2	VACUUM VALVE SPRING
21	7474	1	PRESSURE VALVE DISC
22	7475	1	PRESSURE VALVE BALL
23	7476	1	PRESSURE VALVE BALL RET.
24	7477	2	PRESSURE VALVE BOLT ASSY
25	7478	2	PRESSURE VALVE SPRING
26	204	2	O-RING
27	206	4	O-RING
28	7481	4	DOME CLAMP ASSEMBLY
29	7482	4	DOME CLAMP LUG







No.	Description	Material	Part No.
1	Fill Cover	Aluminum	8046-AL
2	Fill Gasket	Buna-N	3119-BN
		Viton	3119-VT
3	Bolt - Spring	Steel Cd. Pt.	3139-CP
4	Spring	Van. Steel	3129-CP
5	Bolt - Clamp	Steel Cd. Pt.	3029-CP
		Stls 304	3029-SL
6	Nut - Clamp	Brass	3030-BR
		Stls 304	3030-SL
7	Washer - Clamp	Steel	3031-MS
		Stls 304	3031-SL
8	Clamping Ring	Steel	3036-MS
		Steel Cd. Pt.	3036-CP
		Stls 304	3036-SL

No.	Description	Symbol	Material	Part No.
9	Manhole Gasket Channel Type	C	Cork-Buna-N	3175-CB
		B	Buna-N	3175-BN
		A	Asbestos	3175-AS
		E	Teflon-Asb.	3175-AT
10	Manhole Collar (Channel Type)	F	Steel	3176-MS
		H	¼ Aluminum	3176-AE
		J	Stls 304	3176-SL
		K	Stls 316	3176-SS
11	Closure Assem. (Includes Cover Plate, Strong Back, Latch, Hinge Lugs & Pins)	S	Steel	6083-MS
		B	Steel Cd. Pt.	6083-CP
		G	Stls 304*	6083-SP
		C	Stls 304	6083-SL
		D	Stls 316	6083-SS

*Latch and Strongback Steel Cadmium Plated.

Figure 2-2. Tiona Dome Cover
(Courtesy of Tiona-Betts, Warren, Pennsylvania)

rigidity of the C-B dome does not allow the type of maintenance that can be performed on the Tiona dome (see Section 2.4). The flat plate of the Tiona dome can be worked and manipulated to retain vapor tightness, where as the entire C-B dome, if damaged, must be replaced. This can be significant when considering the cost of the dome covers (Tiona approximately $80; C-B dome approximately $120). The dome lids themselves are somewhat similar (although the C-B cover has reinforced ribs) and both use a spring loaded closure mechanism for containing vapors.

The pressure vacuum vents are built into the dome lids in both cases. The Tiona dome incorporates a separate piston-type valve for the pressure and vacuum release vents. These valves are both spring loaded pistons which will open when the actuation pressure is reached. The C-B dome uses a valve which can seat in either the pressure relief directon or the vacuum release direction. The C-B vent does not use pistons but uses spring loaded discs. One spring loaded disc constitutes the pressure vent and another spring loaded disc constitutes the vacuum vent. These discs will then move as the pressure reaches the critical point. This vent system is easier to repair and clean than the Tiona system and is less susceptible to leakage caused by debris because there are no pistons. The piston system has more tendency to leak due to tight or sticky piston movement caused by dirt or other foreign material becoming lodged in the piston sleeves. A ball is inserted in both the C-B and Tiona vents to act as a shutoff valve in case the tank is rolled over. This contains the liquid and will not allow it to escape from its container. One operator has devised a conversion kit made so that the C-B vent can be installed on the Tiona dome.

Emissions from poorly installed or maintained dome covers or pressure-vacuum vents can be sizable. However, if proper domes are installed and maintained correctly, emissions can be reduced significantly. The CARB certification requirements, which require leak-tight trucks, illustrates that emissions from domes and pressure-vacuum vents can be controlled and trucks maintained to reduce hydrocarbon leakage.

2.3.2 TANK TRUCK VAPOR COLLECTION PIPING AND INTERNAL VENTS

Leakage can occur around the internal vent covers and vapor piping joints. Leaks can be detected by using a bubble indicating solution or sonic detector. The internal vent allows vapors to enter the vapor return system when loading or unloading liquid into the compartment and are pneumatically coupled with the compartment loading. The vent opens into a covered area which in turn is piped into the vapor return piping system. These vent covers are made of either metal or rubber and are either welded, bolted, or clamped into position over the vent valve (see Figure 2-3). The vapor collection or return piping can also be made of metal or rubber and can take severall configurations. Separate piping may be used for the vapor return or use may be made of the overturn rail. If separate piping is used, the piping could be of rubber or metal pipe, manifolding the exhausts from each compartment into the main exhaust line. If metal piping is used, joints could be welded or flanged with gasket material. If the vapor line is rubber, band clamps are used most often at the joints to maintain tightness. If the overturn rail is used as the vapor return line, piping is run from the vent valve to the overturn rail and can again be welded pipe or rubber hose. Joints could also be welded, flanged, or clamped. Welded pipe and vent valve covers provide a better vapor tight transfer system than the rubber boot or rubber hose transfer

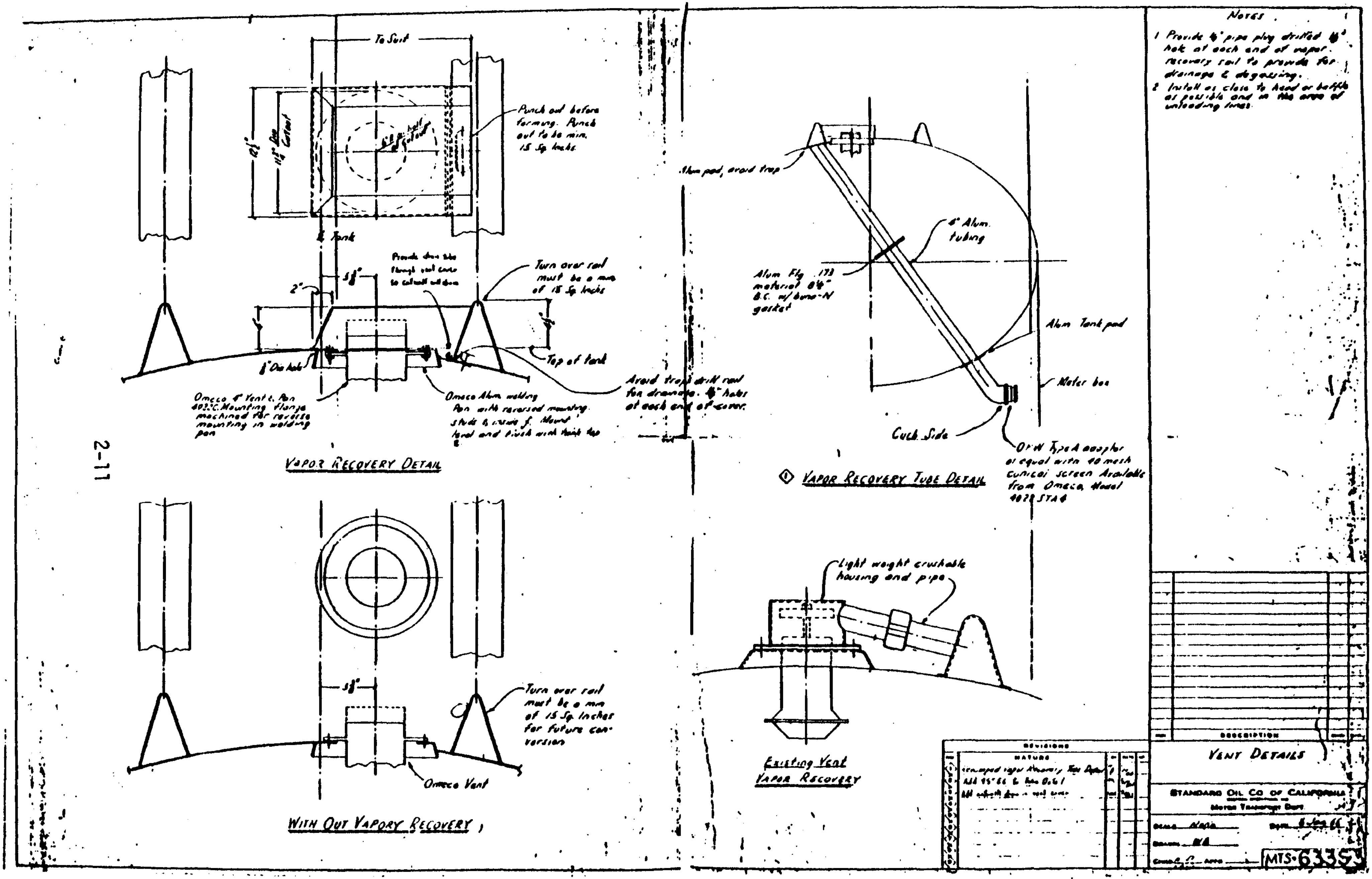


Figure 2-3. Typical Vent Cover Configuration

systems. Leaks are less frequent when using welded piping and covers and replacement equipment losses are greatly reduced. However, installation costs for the welded system would be higher than that of the rubber system.

With properly installed welded vent covers and piping, emissions should be eliminated from these areas with the exception of damage caused by accidents. Proper installation, and a proper maintenance program should reduce leakage from flanged and rubber clamped vapor hoses significantly. These last two methods do require a conscientious maintenance plan to maintain the system in proper working order.

2.3.3 VAPOR TRANSFER PIPING

Vapor transfer piping includes flexible vapor hoses for the tank truck loading rack and all vapor transfer piping at terminals, bulk plants, and service stations. Flexible vapor transfer hoses are made from gasoline resistant rubber and normally are attached to coupling fittings using band clamps. Vapor transfer piping at terminals and bulk plants are normally rigid metal pipe and can be found above or below ground in either welded, threaded, or flanged pipe. Service station piping is almost exclusively underground. Leakage can occur from poorly installed piping, leaking gaskets, loosely applied clamps at the couplers, etc. However, welded or threaded vapor piping, if correctly installed should eliminate hydrocarbon vapor losses. Flanged pipe must be maintained and monitored more frequently because of the gaskets involved at the joints but can all but eliminate hydrocarbon leakage if maintained properly.

2.3.4 VAPOR TRANSFER COUPLERS

Vapor transfer couplers for bulk plant, terminal, and service station vapor transfers can take on numerous configurations. The couplers become leak tight through a compression mechanism incorporating a gasket material chemically resistant to the liquid being transfered. These couplers could include; dry-break couplers or vapor tight spring-loaded couplers for vapor lines at bulk plants, terminals, and service stations; kam lock type couplers for tank truck vapor connections; coaxial fittings at service station drops. The couplers used are dependent upon the vapor transfer configuration selected. These couplers are readily available from several manufacturers and are similar to liquid transfer couplers which have been used for years. The leakage problems from couplers occur when the gasket becomes work or damaged or the coupler connectors or body becomes damaged, not allowing an adequate seal.

If the vapor transfer couplers are in good working order and coupled properly, emissions from the coupler joints should be minimized. Small leaks may be encountered through the vapor hoses or vapor to coupler joints, but these will be very small if the system is maintained properly.

2.3.5 STORAGE TANK PRESSURE-VACUUM RELIEF VENTS

For fixed roof storage tanks, pressure-vacuum vents are installed to relieve positive or negative pressures which exceed their set point. These P-V vents are similar in approach to those discussed in the tank compartment dome cover. The valves can have either separate vent locations or may be designed to have a single vapor outlet. The valves are held closed by either a series of weights or force supplied by a spring. The weights or spring force are designed to be offset by the internal tank pressusre and will be full open at the desired pressure setting. Pressure settings on storage tanks are normally 6 ounce pressure and one-half ounce vacuum.

Hydrocarbon vapor emissions cannot be eliminated from these vents since their purpose is to release pressure. However, if the valve is maintained properly, emissions from the valve when the tank is below the actuation pressure should be minimized.

2.4 OPERATING AND MAINTENANCE PROCEDURES

The equipment manufacturers contacted did not give much information on recommended maintenance beyond the fact that damaged parts should be replaced. However, several of the operators interviewed had devised their own operating or maintenance procedures and these are discussed in this section, along with recommended maintenance procedures for maintenance not currently conducted. A visual inspection of the vapor containing equipment is an integral part of the maintenance program. A suggested checklist for a periodic visual inspection of equipment is shown in Appendix A. Actual maintenance performed on truck tanks during the field test phase are outlined in Appendix B.

2.4.1 DOME COVERS

Dome cover maintenance procedures range from visual observation to severe manual adjustments. Maintenance practices vary greatly between operators from nearly nonexistent to monthly inspections. For pruposes of this report, California maintenance procedures will be discussed because of the tank tightness requirements and the corresponding maintenance necessary to obtain the required tightness. Common causes for leakage around the domes, as discussed in Section 2.1, can be caused by damaged or warped dome cover-base rings or dome lids, dirty gaskets, or faulty pressure-vacuum vents. Before pressurizing the tank, the dome lids should be visually inspected. The gasket between the dome lid and base ring should be inspected for damage such as tears or cracks. Dirt, or other foreign material, should also be removed from the gasket sealing surface. If the gasket shows signs of excessive wear or damage, it should be replaced. The dome lid itself may be damaged or warped and should be checked for the quality of the seal between the lid and base ring. Several methods can be used, two of which are discussed here. The gasket or seal or the dome lid could be coated with a type of grease or other easily visible material and the dome lid closed, sealed, and then reopened. The inability of the dome lid to close or seal around the entire circumferrence can then be clearly visible by showing gaps in the indicating material on the mating surface.

The other method suggested by a tank truck operator would be to use a piece of thin paper placed between the dome lid and the base ring with the dome lid closed securely. If the paper can then be moved, the seal is not tight enough and a leak will most likely occur.

The P-V vents should be visually inspected to determine if foreign material is lodged in the valve seats not allowing the valve to seal properly. The vent should also be tested to determine if the spring loaded valve closures are working smoothly without sticking or rubbing. The bolts and/or clamps used to attach the base ring to the tank should also be tested for tightness. If any of these visual techniques should indicate the necessity of repair, the maintenance should be performed before proceeding.

The tank should then be pressurized to determine the ability of the tank to maintain pressure. A bubble solution or sonic detector could be used to indicate the presence of leakage points. When these leaks have been found, the maintenance necessary to reduce these leaks to acceptable limits should be performed.

The maintenance required to minimize leakage points identified around the dome cover would include bending or reshaping the dome base ring if possible or replacement of the entire dome cover. If a leak occurs between the dome lid and base ring, bending or reshaping of the dome base can be done by pounding with hammers or applying leverage to the hatch opening in an attempt to create a good seal at the dome lid. The dome lid itself can be adusted by tightening the hold down mechanism. However, since the dome lid is a secondary pressure relief vent (normally at 3 psi) there is a limit on this adjustment. If the leak cannot be repaired satisfactorily, the dome cover must be replaced. For leakage around the tank/base ring interface, the bolts or attachment clamps should be tightened. If the leak persists the dome cover should be removed and the gasket inspected and replaced if necessary. The dome cover may have to be reshaped or replaced entirely if damaged to the extent that a good seal cannot be maintained.

Leakage at the P-V vents will require removing the vent from the dome lid and dissambling and cleaning the components. The valve seats should be cleaned and all foreign material removed to ensure a good seal. If the components are damaged they should be replaced. The springs holding the vents closed may need replacing or stretching to return them to their designed holding force. The piston housing, if applicable, should also be cleaned to ensure the piston can move freely without rubbing or sticking. The valve should be then reassembled and installed. If leakage occurs which is still not acceptable, the vent valve should be replaced.

Visual inspection of all dome covers should be performed on a regularly scheduled basis and equipment which needs repair or replacement should be fixed accordingly. This should be performed when the truck is in the shop for normal maintenance or at least every two months. This should not require pressurization of the tank but only replacement of visably damaged or faulty equipment. Some operators perform visual inspections as often as once every two to three weeks.[6]

... Inspection should also be done at a bulk terminal during ~~[illegible]~~ actual loading conditions... G.S.

2.4.2 VAPOR COLLECTION PIPING AND INTERNAL VENTS

Vent valve covers and vapor piping joints should be visually checked with the dome covers. During the visual inspections, bolts in flanged covers should be checked for tightness and rubber boots and hoses should be inspected for tears or cracks. Bolts should be tightened and rubber equipment replaced as required.

These leakage points may be less obvious and pressurization of the delivery tank may be necessary to locate the leak. Bubble solution, sonic detectors, or explosimeters can be used to pinpoint the hydrocarbon vapor emission sources. Leaks at the vent valve covers can occur at welded joints, bolted covers, or from rubber covers. The leaks found in welds should be marked and the weld repaired. If a leak occurs at bolted covers, the bolts should be checked for tightness. If the leak persists, the vent cover gasket should be inspected and replaced if excessively cracked or damaged. Rubber covers should be checked for tears or cracks and replaced as needed.

Vapor piping joints should be checked in a similar fashion. Welded joints should be inspected for weld integrity and and repaired as needed. Flanged joints should have the bolts tightened and the gasket material replaced as needed. All bolted or clamped vapor piping joints should be checked for tightness. Rubber vapor hoses should be checked for leaks and replaced if worn or cracked. Gasket materials for flanged piping should be replaced if leaks persist after tightening.

2.4.3 VAPOR TRANSFER PIPING

Leakage from vapor transfer piping can occur at piping joints due to worn or deteriorated gasket material, improper installation, or loosened flange clamping mechanisms. The piping, where above ground, should be visibly inspected for damage or obvious leakage areas. An explosimeter, sonic detector, or bubble indicating solution can be used to find smaller leaks. For welded pipe the leakage point should be marked and the point repaired or plugged. For flanged pipe, all flange bolts should be checked for tightness and adjusted. If leaks persist at these flanged joints, the gasket material should be replaced. For threaded pipe, if leaks are found at joints the fittings should be disconnected and reassembled using some type of thread sealing compound to ensure a tight fit. If the piping cannot be practically dismantled, the leakage area should be marked and the leak minimized.

Flexible vapor hoses should be checked visually for obvious cracks and tears, and the hose to coupler clamp should be checked for tightness. A bubble indicating solution can be applied to the hose to indicate the location of leaks. However, before replacing this equipment, the hose should be tested with the entire tank truck system since small leaks in the hose can occur and the system may still pass the test (see Section 3.2). If during inspection the hose has excessive wear or damage, it should be replaced.

2.4.4 VAPOR TRANSFER COUPLERS

Vapor transfer couplers should be inspected periodically to ensure their vapor tightness is maintained. The gasket material should be visually inspected and replaced if work, cracked, or damaged excessively. Vapor tight couplers such as dry breaks or spring loaded connectors should have the valve seat inspected and cleaned to maintain a good tight vapor seal. Coupler clamping mechanisms should be inspected and adjusted as necessary. The coupler interface can be checked for leaks using an explosimeter or bubble indication solution. If leaks persist after maintenance has been performed the coupler unit should be replaced.

2.4.5 STORAGE TANK PRESSURE-VACUUM RELIEF VENTS

As in other pressure-vacuum reflief vents, the most common leakage point would be around valve seats. Dirt or other foreign debris can become lodged on the valve seat face causing the valve to close incompletely and vapors to escape. Valves can also have a problem of reseating improperly once they have opened. The closing disc can get out of allignment resulting in the valve face resting at an angle and not firmly on the valve seat. To assure good valve closure, the valve seats must be periodically checked to remove dirt and debris. The valves should also be inspected to ensure they have reseated properly and that the valve guides are clean and free of obstructions. Because of the potentially large emission source from an open P-V valve, these vents should be checked at least once per week. This should not prove to be too much of a burnden since most fixed roof tanks are gaged for liquid level from the top whenever liquid deliveries are made.

2.4.6 MISCELLANEOUS EMISSION SOURCES

This catagory includes leaks in tank shells, poorly welded seams, damage caused by an accident, or poorly installed overfill protection on tank trucks. These leaks are usually small and therefore hard to detect. However once they are repaired, usually when the tank is first pressure tested, the occurrence of these leak sources decrease significantly. These sources are commonly found using a bubble indication solution while the tank is pressurized. The sources are marked and repaired as necessary, normally when performing a tank pressurization test. Probability of a leak occuring at other sources is so much higher that these sources are usually the last checked.

2.5 COSTS AND MAN-HOURS NECESSARY TO MAINTAIN VAPOR CONTAINING EQUIPMENT

2.5.1 TANK TRUCKS

The costs presented here are for maintaining a tank in a leak tight condition. These costs include performing the required maintenance to reduce leakage to an acceptable level, supplying the necessary replacement materials, and performing the required CARB test to verify the tank leakage integrity.

The costs have been divided into two categories. The first category deals with the cost of maintenance and equiment to initially bring an existing tank truck into the limits of the specified vapor tightness. These costs are generally higher because there may be many leak sources, which after being maintained initially, do not require maintenance at every succeeding certifcation test. The second category deals with the cost of maintaining a truck within specified vapor tightness limits which has previously been certified. The costs are also given for two degrees of vapor tightness. The first, or more stringent case, deals with San Diego County which allowed a pressure drop of 1 inch in 5 minutes. The second case was that required in the remainder of the State of California, which allowed, at the time these costs were generated, a pressure drop of 3 inches in 5 minutes. The costs are shown in Table 2-1.

The costs for the more stringent case are three to four times greater because as the allowable leak rate becomes smaller the significance of smaller leaks increases. Additional man-hours must be spent to identify and repair the smaller leaks.

Currently these maintenance procedures and certification tests are performed on an annual basis. Several operators indicated that visual observations and minor maintenance is performed on the tanks between annual certifications. This maintenance is usually

Table 2-1. COSTS FOR MAINTAINING TRUCKS IN LEAK TIGHT CONDITIONS[a,b]

	Labor Hours	Labor $[c]	Materials $	Total Cost $
San Diego[d]				
Initial[e]	34	748	30	778
Retest[f]	11	242	20	262
California[g]				
Initial	8	176	20	196
Retest	3.5	77	20	97

[a]Costs obtained from John Snyder, Chevron, USA From A Presentation to California Air Resources Board, December 2, 1976, and from Larry Cowie, Shell Oil, from file data on actual maintenance performed.

[b]Leak tight conditions specified as passing certification tests.

[c]Labor rate = $22/hr.

[d]San Diego tests allow leak rate of 1 in H_2O/5 minutes.

[e]Initial = First certification

[f]Retest = Any certification following the first.

[g]California tests allow leak rate 3 in H_2O/5 minutes (1976).

coordinated with the normal truck power unit maintenance schedule which is performed approximately every 4 to 6 weeks. This periodic maintenance normally costs approximately $50 to $100 per occurrence depending upon the amount of replacement parts required. The average cost is about $70 per occurrence.[7]

Estimates were received on the total tank maintenance required on the tank truck product handling equipment. This included maintenance for the vapor recovery hoses, couplers and adapters, internal valves, overfill protection and vapor recovery equipment. These costs ranged from $65 to $272 per month with an average monthly maintenance cost of $158/month. These costs are actual monthly average costs based upon over 100 months of actual maintenance performed. The costs to maintain the truck in a vapor tight condition would be about 45 percent (70/158) of the total maintenance costs required monthjly on the product delivery equipment (this does not include maintenance costs for the power unit). The total annual maintenance required on the tank equipment would be $1,896 per year.

Incorporating these figures into Table 2-2, the total costs including certification testing and maintenance are shown. Costs are also shown indicating total costs if certification tests were required more ofter during the year. This is included because some operators felt the certification may be more meaningful if performed more often. However, with this they would like to see a relaxation of the vapor tightness requirements. The California certification program includes a gradual tightening of the leak rate limits until, in 1979, the requirements are the same as san Diego (1 inch of water in 5 minutes). Also shown in the table are the annual costs expressed as a percentage of original purchase price (assumed $30,000 for tank product delivery equipment). As the maintenance requirements increase so does the percentage of

Table 2-2. TOTAL ANNUAL MAINTENANCE COSTS FOR PRODUCT DELIVERY EQUIPMENT[a,b]

	Monthly Costs $	Total Annual Costs $	Percent of Original Purchase Price per Year[c] %
1. Product Delivery Maintenance	88	1,056	3.5
2. Product Delivery and Vapor Tightness Maintenance	158	1,896	6.3
3. Product Delivery and Vapor Tightness Maintenance and Annual Recertification maintenance and testing			
San Diego	-	2,158	7.2
California	-	1,993	6.6
4. Product Delivery and Vapor Tightness Maintenance and Semi-Annual Recertification Maintenance and Testing			
San Diego	-	2,420	8.1
California	-	2,090	7.0
5. Product Delivery and Vapor Tightness Maintenance and Quarterly Recertification Maintenance and Testing			
San Diego	-	2,944	9.8
California		2,284	7.6

[a]Product delivery equipment includes delivery tank, couplers, internal valves, vapor recovery requipment, overfill protection, and dome covers.

[b]All costs are averages given on a per truck basis.

[c]Original purchase price of product delivery equipment estimated at $30,000.

the purchase price, until at the maximum rate the percentage reached approximately 10 percent of the original purchase price per year. Even at this upper level, this is not an unreasonable rate.

2.5.2 OTHER EMISSION SOURCES

Maintenance costs for other fugitive hydrocarbon emission sources would involve mostly labor requirements for visual inspections and cleaning of equipment. This would include visual inspections of vapor return lines, storage tank pressure-vacuum vents, couplers, and adapters. These activities would be performed at bulk plants and terminals and by the tank truck operators. However, this type of maintenance program was not performed by the operators interviewed so no data on actual hours spent were obtained. The costs discussed here can therefore only be estimated. A visual inspection of the equipment including leak indication should take no more than 2 hours. Like in the tank truck maintenance, the inital equipment inspection will turn up many more leaks than subsequent inspections assuming the leaks are repaired after the first inspection. The time required to perform the maintenance following the initial inspection cannot be estimated because of the numerous possibilities of leak sources. If a labor rate similar to that use for the truck maintenance is used, the inspection should not cost more than $44 per occurrence. The most likely place for leaks, once piping losses have been repaired, would be at pressure vacuum vents or at vapor tight dry break couplers. This maintenance would mostly require cleaning of valve seats or replacement of gasket material. If it is assumed this takes an additional 2 hours and that average replacement parts were on a similar scale to that of tank trucks ($20), the total cost of this maintenance would be $108 per occurrence. If this maintenance were required on a monthly basis, this cost would not be unreasonble.

References for Section 2.0

1. Leak Testing of Gasoline Tank Trucks, Scott Environmental Technology, EPA Contract No. 68-02-2813, Work Assignment No. 19, August 1978 (Draft).

2. Ibid.

3. Powell, D.J. and D.E. Hasselman, Reliability Observations and Emission Measurements at Gasoline Transfer Vapor Recovery Systems. TRW, Inc., EPA Contract No. 68-02-0235, Novemer 1974.

4. Letter from R.A. Nichols Engineering to H.B. Uhlig, Chevron U.S.A., June 10, 1977.

5. Ibid.

6. Presentation by John Snyder, Chevron U.S.A. to California Air Resources Board, December 2, 1976.

7. Ibid.

3.0 DEVELOPMENT OF MONITORING PROCEDURE

3.1 TEST METHODS

Several test methods were explored as to there acceptability or usability as a monitoring procedure within the confines of this task. A test method was sought that would give pass-fail compliance information for hydrocarbon leakage at various sources. The test method desired was to be low cost, quick, and would not require taking the truck out of service for any great length of time. The methods researched for their usefulness are described in the following sections.

3.1.1 VAPOR TO LIQUID VOLUME DETERMINATION (V/L)

This method determines a ratio of the volume of vapor exhausted versus the volume of liquid loaded (V/L ratio). The liquid volume is determined by monitoring the gallons of liquid loaded and converting this to cubic feet. The volume of vapors displaced are monitored by installing a low pressure drop positive displacement meter in the vapor return line. Pressure, vapor temperature and liquid temperatue can also be monitored during transfers. The V/L ratio is a simple volume ratio without corrections. However the additional physical data obtained can be used to explain some phenomenon which take place. This method has been used before in conjunction with EPA mass emission determinations at both bulk plants and terminals. The EPA method called for obtaining a leak tight truck and determining the V/L ratio. This V/L ratio was then compared to all the other trucks checked during the test period. The leak tight trucks were used to determine a baseline for comparison of the other trucks tested.

3.1.2 EXPLOSIMETER

The explosimeter method calls for the use of an explosimeter or combustible gas analyzer to monitor the potential leakage sources described in Section 2.1 for evidence of hydrocarbon emissions. The probe of the portable instrument is positioned around the potential leak source and the meter reading recorded in percent of the lower explosive limit (LEL). Explosimeters have long been used to pinpoint leakage points when handling gasoline or hydrocarbon vapors. The method calls for monitoring of truck hatches, P-V vents, couplers, hoses, etc. during loadings and unloadings of gasoline from the truck tanks and recording the relative leakage observed.

3.1.3 SONIC DETECTOR

The sonic detector is used in a similar fashion as the explosimeter. Instead of measuring hydrocarbons, the sonic detectors monitor the noise made by the gas escaping through the leak area. The soinic detector can be used to measure leakage caused by any gas and can be used if the system is either under pressure (leakage out) or vacuum (leakage in). The sonic detector would monitor at all the same emission sources as the explosimeter or combustible gas analyzer.

3.1.4 SAN DIEGO "BAG" TEST

In this test method, a bag is placed over the dome cover to capture and quantify the otherwise fugitive vapors. The bag is attached to a modified bicycle tire which has been filled with sand. The weight of the sand in the tire forces the assembly against the truck tank and creates the vapor seal. The bag is sized based upon calculations of the amount of vapors that would be lost given the allowable pressure decline rate (1 inch H_2O in 5 minutes). The bags are oversized so that on filling, San Diego County inspectors are certain that a violation has taken place. The bag is placed over the compartment which is being loaded and the number of times the bag fills or the approximate volume of vapors collected in the bag are estimted.

3.1.5 PRESSURE-VACUUM TEST (CARB)

The California Air Resources Board (CARB) has passed regulations which define the degree of tightness that is required on gasoline delivery tanks. To ensure that this tightness is maintained, all trucks must pass a pressure tightness test each year. A test procedure was derived by the CARB which would be used to test the trucks as to their tightness. The truck, if its last load was gasoline, is purged of volatile hydrocarbon gases by blowing air into the compartments with the dome lids open. This purging has normally been done for about 10 minutes per compartment. This will remove the volatile vapors and allow for a better pressure determination within the test tank. Some truck owners will either purge the compartment with diesel or make the last load before testing diesel. This will eliminate the volatile vapors in the truck compartments and eliminate the necessity of purging. The trucks are then brought into a covered shop area where the effects of temperature variation, and therefore pressure variation, caused by the sun and wind would be minimized. The truck hatches are closed and the delivery and vapor transfer hoses are attached and capped on the ends. The internal valves are opened and the compartments are all manifolded together. The compartments can be tested separately, but this is considerably more time consuming.

The truck is then pressurized most commonly with shop supplied compressed air. A manometer is attached to the truck and the truck pressure brought to 18 inches of water. The pressure loss versus time is then monitored and checked against the allowable leakage rate. The current allowable leakage rate is 2 inches of water in 5 minutes (from 18 to 16 inches of water). The truck is then placed under vacuum, most commonly using the vacuum supplied by the exhaust manifold of an automobile engine. The tank is evacuated to 6 inches of water and the pressure monitored again for 5 minutes. The allowable in-breathing is currently from 6 inches of water vacuum to 4 inches of water vacuum. Many of these other test methods discussed are based upon estmating the amount of leakage that is allowed or specified by the CARB certification test procedures.

3.1.6 BUBBLE INDICATION METHOD

This test method employs the use of a soap solution or other solution whch will indicate gas leakage by the forming of bubbles around the leakage area. The solution is applied to hoses, couler interfaces, hatch covers and pressure vacuum vents and the appearance of bubbles indicates a leakage source.

3.1.7 QUICK LEAK DECAY

The quick leak decay method is similar in concept to the CARB method except that liquid is used to supply the pressure or vacuum needed to determine the amount of pressure or vacuum loss. Liquid, such as gasoline or diesel, would be desirable to use since the truck would not have to be removed from service. During loading, the vapor return line would be capped off, and liquid pumped into the vehicle until the desired pressure is reached. The truck would be allowed to stabilize and then the pressure decay would be noted. During unloading at a bulk plant or service station the vapor return line would be capped off toward the end of the unloading (tank close to empty) and gasoline allowed to flow out until the desired vacuum is reached. This time the increase in pressure (or decrease in vacuum) is monitored with respect to time. The leak rate during the vacuum test is performed with a tank as close as possible to empty to best correlate with the CARB test methods.

3.1.8 VOLUME LEAKAGE

The volume leakage method maintains a constant pressure in the test compartment by continually introducing air into the compartment. It is assumed that the amount of air introduced into the compartment to maintain the desired pressure is equal to the leak rate at that pressure. The tank is pressurized to the desired pressure in a similar manner as described in the CARB test method and a rotameter is used to measure the amount of air necessary to maintain the pressure. When the introduction rate has been stabilized, the rate of air introduced into the tank is assumed to be equal to the leak rate of gases out of the tank.

3.2 EVALUATION OF TEST PROCEDURES

The test procedures were included in a field test program performed under a separate contract. These included the explosimeter method, sonic detector method, CARB method, V/L method, bubble indication method, and the volume leakage test. The quick leak decay method was analyzed under laboratory conditions and the San Diego "bag" test method was observed in the field, as performed by San Diego County personnel.

Both a top and bottom loaded terminal were selected for inclusion in the test program. The top loading terminal, operated by Shell Oil Company, was located in Los Angeles, California. The bottom loaded terminal, operated by Chevron, U.S.A., was located in Montebello, California. Selection of the truck fleet to be tested was important to obtain a representative cross-section of trucks. Initial data indicated that the age of the tank and its corresponding vapor containing equipment may be significant. Tanks were selected for the test program therefore in an attempt to maximize the number of tanks that could be tested and to obtain a reasonable cross-section of tanks of varying ages and tanks with varying types of vapor containing equipment. Data on the trucks selected for the test program are shown in Table 3-1. Included in the table is information on capacity of the tank shell, type of dome cover used, type of vapor piping emloyed, number of compartments, type of suspension, and the year the tank was put into service (tank age). The type of suspension was included in the data because the spring type suspension is sized upon a fully loaded tank. This results in a very stiff ride when empty and subjects the vapor containing equipment to additional vibrations. Air suspension on the other-hand can vary as the load changes and should yield a smoother ride. All tanks tested used the overturn rail for the manifold line on the vapor piping system. However, several types of vent valve covers and piping to the overturn rail were observed.

The test programs at both the top and bottom loaded terminals were nearly identical. The trucks to be tested were scheduled into the shop at varying times during the week for various tests to be performed. Meanwhile, monitoring of leaks was performed on all loadings of trucks included in the test plan. This included monitoring for leaks before and after shop tests and maintenance were performed giving information on tanks that leaked and tanks that were vapor tight. Loadings were monitored using the explosimeter method, sonic detector method and the V/L method.

Before the trucks were tested in the shop, removal of the volatile gasoline vapors were necessary. At the bottom loaded terminal the trucks were scheduled to haul a load of diesel before being tested. At the top loading terminal diesel was not available, so compartments were purged with air.

Table 3-1. TEST FLEET PHYSICAL DATA

Top Loading

Tank I.D. Number	Age[a]	No. of Compart-ments	Shell Capacity, Gallons	Liquid Capacity, Gallons	Hatch Type	Suspen-sion	Vapor Recovery Type	
							Vent Cover	Vapor Line
63806	8/74	2	4408	4000	No Data	Air	No Data	No Data
53306	12/74	3	5159	4800	No Data	Spring	No Data	No Data
63767	7/73	2	4408	4000	Tiona	Air	Welded	Welded
53256	9/68	3	5380	No Data	Tiona	Spring	Welded	Welded
63766	7/73	2	4408	4000	Tiona	Air	Welded	Welded
53345	9/77	3	5315	4900	Tiona	Spring	Rubber Boot	Rubber Hose
63765	7/73	2	4408	4000	C-B	Air	Bolted Cover	Clamped & Welded Pipe
53304	11/73	3	5159	4800	2-C-B/ 1-Tiona	Spring	Bolted Cover	Clamped & Welded Pipe
63804	4/74	2	4408	4000	Tiona	Air	Bolted Cover	Welded Pipe
53307	12/74	3	5159	4800	Tiona	Spring	Bolted Cover	Welded Pipe
63803	4/74	2	4408	4000	Tiona	Air	Bolted Cover	Welded Pipe
53297	7/74	3	5159	4800	Tiona	Spring	Bolted Cover	Welded Pipe
63805	4/74	2	4408	4000	Tiona	Air	Bolted Cover	Welded Pipe
53305	12/74	3	5159	4800	Tiona	Spring	Bolted Cover	Welded Pipe

Table 3-1. TEST FLEET PHYSICAL DATA (CONCLUDED)

Bottom Loading

Tank I.D. Number	Age[a]	No. of Compart-ments	Shell Capacity Gallons	Liquid Capacity Gallons	Hatch Type	Suspen-sion	Vapor Recovery Type	
							Vent Cover	Vapor Line
67-775	6/67	5	8650	8150	Tiona	Air	Welded	Welded
67-182	4/71	5	8650	8250	Tiona	Air	Welded	Welded
67-392	4/73	5	8650	8050	C-B	Air	Bolted	Rubber Hose
67-475	10/74	4	8650	8200	Tiona	Air	Welded	Welded
68-795	4/78	2	5097	4600	C-B	Spring	Welded	Welded
68-795*	4/78	2	5319	4350	C-B	Spring	Welded	Welded
68-597	9/75	2	5087	4300	Tiona	Air	Welded	Welded
68-597*	9/75	2	5327	4550	Tiona	Air	Welded	Welded
68-275	11/62	2	4447	3670	C-B	Spring	Bolted	Rubber Hose
68-275*	11/62	2	5053	4400	C-B	Spring	Bolted	Rubber Hose
68-377	8/69	3	5184	4000	Tiona	Spring	Welded	Welded
68-977	8/69	3	5180	4750	Tiona	Spring	Welded	Welded

* Trailer

[a] Tank age indicates year put into service

In the shop, equipment was arranged and a volume leakage test was conducted on the test tank before any maintenance was performed. A volume leakage rate was determined for varying pressures starting with 9 inches of water and increases to 18 inches of water in 3 inch increments. This was performed to establish a leak rate before any higher pressure might "blow" a leak and also to determine if the leak rate increased rapidly with pressure. A CARB pressure and vacuum test followed the volume leakage tests.

This established the condition of the truck with respect to leak tightness prior to maintenance. Maintenance was then performed on the truck tanks to make them leak tight as defined by the CARRB leak rate criteria. A CARB pressure vacuum test and volume leak rate test were then performed again.

3.2.1 V/L RATIO METHOD

Vapor to liquid volume ratios were determined for 120 loadings over the 2 week test period. The results were separated on a daily basis since the ambient conditions can severely effect the V/L ratio can be expected on a leak tight truck. Table 3-2 and Table 3-3 indicate the results of the V/L tests for both top and bottom loading and presents the V/L ratio for trucks that passed the CARB certification tests and those that failed.

The EPA terminal tests using the V/L method prescribe determining the V/L from a leak tight truck for a particular day or set of conditions and then comparing this value to the other trucks tested. The data presented in Tables 3-2 and 3-3 indicate a wide variability in the V/L ratio for both the tanks that pass and the tanks that fail the CARB reference test. A frequency distribution of the V/L ratios for both the tanks that passed and the tanks that failed is shown in Figure 3-1. As indicated by this figure, the V/L ratio takes the same frequency of occurrence regardless if the tank passed or failed the certification tests.

Table 3-2. V/L RESULTS FOR TOP LOADING

Test No.	Date	V/L Ratio		Temperature of		Back Pressure (inches H_2O)
		Pass[a]	Fail[b]	Air °F	Vapor °F	
1	6/19		1.12	80	90	9.25
2	6/19		1.16	80	92	7.5
3	6/19		1.39	80	92	9.8
4	6/19		0.99	80	92	15.0
5	6/19		1.18	80	92	10.7
6	6/19		1.34	80	93	10.8
7	6/19		1.14	80	90	7.8
8	6/20	1.05		66	80	8.0
9	6/20		1.06	70	80	5.6
10	6/20		1.11	70	83	9.8
11	6/20	1.04		76	88	9.7
12	6/20		1.56	80	90	15.6
13	6/20		1.08	80	92	11.1
14	6/20	1.05		78	90	6.0
15	6/20		1.20	78	90	12.3
16	6/21	1.02		68	76	10.3
17	6/21		1.43	68	80	9.1
18	6/21	0.99		68	80	8.9
19	6/21	No data		68		
20	6/21	No data		70		
21	6/21	1.08		74	90	11.0
22	6/22		1.18	74	90	13.0
23	6/21		1.08	80	90	12.2
24	6/21	1.07		80	92	5.1
25	6/21		0.70	80	94	11.5
26	6/21	1.39		80	90	12.6
27	6/22		1.05	70	75	5.9

Table 3-2. V/L RESULTS FOR TOP LOADING (CONCLUDED)

Test No.	Date	V/L Ratio Pass[a]	V/L Ratio Fail[b]	Temperature of Air °F	Temperature of Vapor °F	Back Pressure (inches H_2O)
28	6/22	0.95		70	80	9.3
29	6/22	No data		70		
30	6/22	1.07		70	82	10.8
31	6/22	1.01		72	80	10.6
32	6/22		1.49	78	83	9.0
33	6/22	1.05		80	89	12.8
34	6/22	No data		80		
35	6/22	1.15		80	88	8.9
36	6/22	No data		81		
37	6/22	1.42		82	94	12.7
38	6/22		1.47	82	92	10.9
39	6/22	No data		82		
40	6/22	No data		72		
41	6/22	1.06		72	90	10.5
42	6/22		1.06	77	86	8.6
43	6/22	0.80		77	86	10.5
44	6/22	1.22		77	86	8.5
45	6/22	0.80		78	86	6.7
46	6/23		1.06	80	88	10.8
47	6/23	No data		80		
48	6/23	0.71		84	92	6.6
49	6/23		1.92	88	96	6.3
50	6/23	1.09		88	96	8.2
51	6/23		1.01	84	87	9.2
52	6/23	1.04		84	85	8.9
53	6/23		1.12	78	88	5.2

Notes for Table 3-2

[a] Pass indicates a tank that will meet the CARB leak tight criteria.

[b] Fail indicates a tank that leaks greater than the allowable rate defined by the CARB leak tight criteria.

[c] All trucks tested were truck and trailer units but a V/L ratio could not be obtained for each tank. Tanks were loaded simultaneously and all loading arms manifolded together before the vapor meter.

Table 3-3. V/L RESULTS FOR BOTTOM LOADING

Test No.	Date	V/L Ratio		Temperature of		Back Pressure (inches H_2O)
		Pass[a]	Fail[b]	Air °F	Vapor °F	
1	6/12		1.23		98	11.5
2	6/12		0.86		98	4.4
3	6/12		0.97		101	5.5
4	6/12		0.55/ 0.88[c]		100/ 110	4.1/ 4.8
5	6/12		0.85/ 0.75		108	1.7/ 2.4
6	6/12		0.84/ 0.95		108	9.5/ 7.1
7	6/12	1.02			110	7.3
8	6/12		0.96/ 0.63		106/ 103	7.5/ 4.9
9	6/13		1.01		78	2.7
10	6/13		0.94		79	3.0
11	6/13		1.06		98	5.1
12	6/13	1.02			100	5.5
13	6/13		0.89		90	6.9
14	6/13		0.99		96	15.8
15	6/13	1.26/ 1.02			110/ 102	6.1/ 6.3
16	6/13		0.79	95	108	3.4
17	6/13	0.96		95	106	8.9
18	6/13		0.98	95	110	10.1
19	6/13	1.11/ 0.78		93	102/ 103	10.2/ 4.1
20	6/13		0.61	91	100	4.3
21	6/13		0.37/ 1.06	91	100/ 103	3.8/ 2.6
22	6/13	0.88		90	100	9.1
23	6/13	0.84/ 0.80		90	100	3.8/ 6.0

Table 3-3. V/L RESULTS FOR BOTTOM LOADING (CONTINUED)

Test No.	Date	V/L Ratio		Temperature of		Back Pressure (inches H_2O)
		Pass[a]	Fail[b]	Air °F	Vapor °F	
24	6/14	0.71/ 0.82		68	78	17.5/ 16.2
25	6/14	0.84		71	83	3.0
26	6/14	1.15		73	80	6.6
27	6/14		0.69	76	84	3.0
28	6/14		0.87/ 1.00	78	89/ 92	2.7/ 2.3
29	6/14	0.83		79	85	4.9
30	6/14		0.93/ 0.67	85	90	7.7/ 8.1
31	6/14	0.97		86	90	10.7
32	6/14	0.67		87	100	10.0
33	6/14		0.80/ 0.91	88	92/ 102	4.0/ 3.0
34	6/14	0.88/ 1.12		87	98/ 104	9.4/ 7.1
35	6/14	0.99		88	96	4.0
36	6/14	0.91		88	100	8.9
37	6/14	0.92/ 0.72		87	100/ 90	4.3/ 5.6
38	6/15	1.07		67	75	6.4
39	6/15	0.80		67	70	7.4
40	6/15	0.97		69	76	6.2
41	6/15		0.80/ 0.75	71	82/ 80	8.0/ 7.5
42	6/15	0.78		73	86	11.0
43	6/15	0.99		74	83	7.1
44	6/15		1.08	77	90	4.1
45	6/15	0.83/ 0.97		79	90/ 92	6.5 4.3
46	6/15		0.92	83	98	5.4

Table 3-3. V/L RESULTS FOR BOTTOM LOADING (CONCLUDED)

Test No.	Date	V/L Ratio Pass[a]	V/L Ratio Fail[b]	Temperature of Air °F	Temperature of Vapor °F	Back Pressure (inches H_2O)
47	6/15	0.96		83	98	5.4
48	6/15	0.83/ 0.70		86	103/ 90	4.1/ 8.3
49	6/15	0.84/ 0.88		84	90/ 104	3.5/ 4.0
50	6/15	0.96/ 0.93		86	90/ 107	3.4/ 3.4
51	6/15	0.89		86	90	4.7
52	6/15	1.03		87	92	4.7
53	6/15		0.81	86	103	4.1
54	6/15	0.90/ 1.04		87	102/ 87	6.2/ 7.3
55	6/16	1.00		67	80	10.5
56	6/16	1.06		70		6.9
57	6/16	0.91/ 0.74		72	72/ 84	6.9/ 4.6
58	6/16	0.99		78	76	12.0
59	6/16		0.88	79	78	3.9
60	6/16	1.02		80	88	3.7
61	6/16	1.52		84	90	4.7
62	6/16	1.07		85	97	6.2
63	6/16	1.04/ 1.17		85	100/ 93	5.5/ 6.9
64	6/16		1.12/ 1.14	87	79/ 81	7.5/ 9.4
65	6/16	1.03/ 0.98		85	101/ 103	8.0/ 6.8
66	6/16	0.95		85	95	3.5
67	6/16		0.58/ 0.88	84	100/ 92	3.0/ 2.3

Notes for Table 3-3

[a] Pass indicates a tank that will meet the CARB leak tight criteria.

[b] Fail indicates a tank that leaks greater than the allowable rate defined by the CARB leak tight criteria.

[c] Indicates the truck tested was a truck and trailer unit. Data is presented for each tank (truck/trailer).

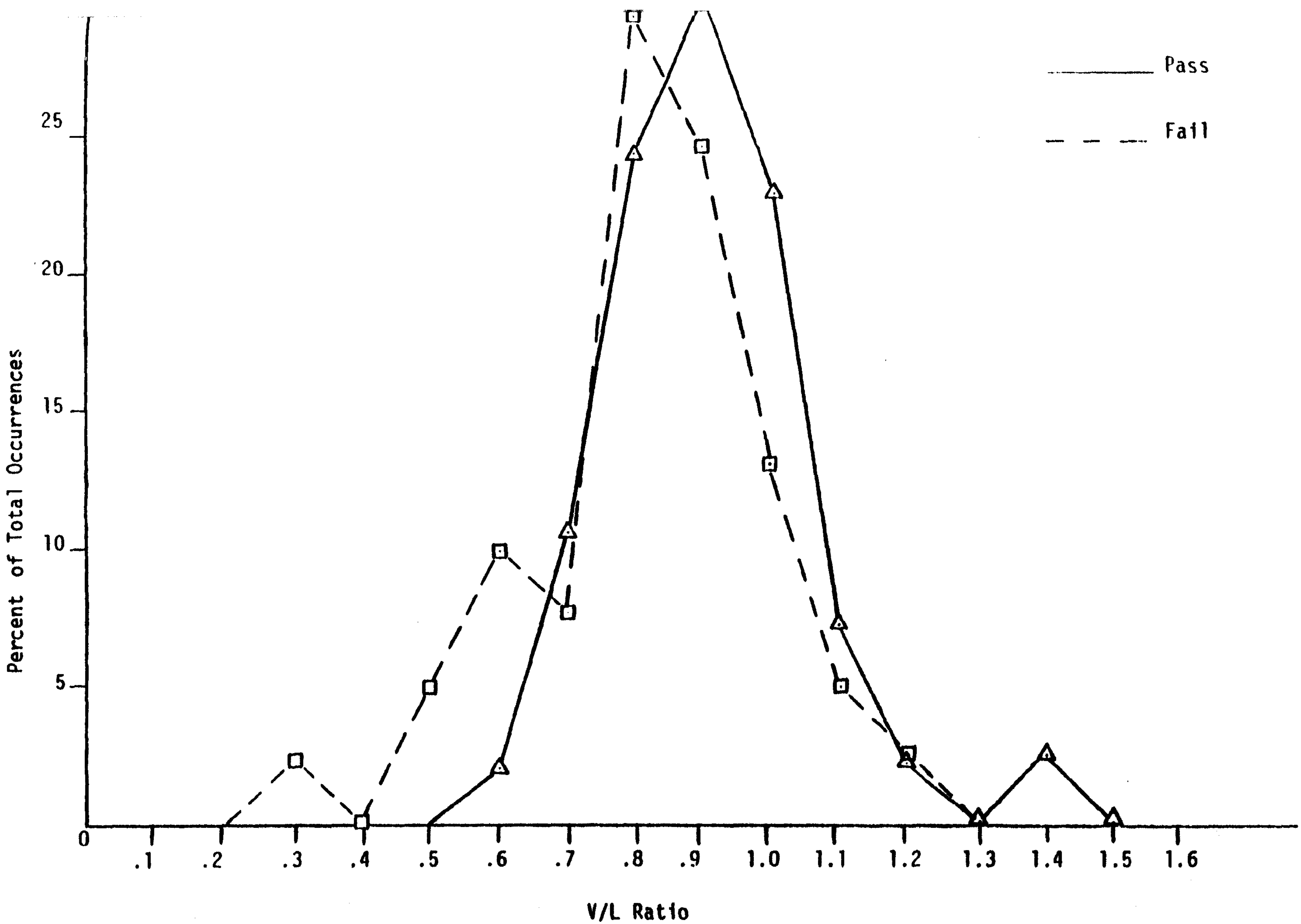


Figure 3-1. Frequency Distribution of V/L Ratio for Tanks That Pass Certification Tests and Tanks That Fail Certification Tests

A relationship was attempted to determine if there was any correlation between V/L ratio and the back pressure observed in the tank during loading. Correlation factors were calculated for the V/L ratio versus back presssure. The correlation factors are shown in Table 3-4, and as indicated there is no correlation between V/L ratios and back pressure.

In summary, the V/L ratio showed no relationship between vapor tight tanks or tanks that leaked. The V/L ratio also showed no relationship when compared to the back pressure experienced during the loading operation.

3.2.2 EXPLOSIMETER METHOD

The explosimeter method was extensively tested in the field test program. The CARB pressure test was used as the reference to determine the acceptability of the explosimeter method. During each tank loading, the explosimeter was used to monitor for leaks at the hatch cover, P-V vent, vapor piping, couplers, etc. Loadings were monitored before and after the CARB certification test and maintenance to determine whether the tank was under a leak tight condition as defined by the CARB criteria. The readings taken by the explosimeter, which was calibrated against propane, were then compared to the CARB results to determine the types of readings obtained on a leak tight tank and on a tank which is known to leak. This was performed at both top and bottom loaded facilities.

The results were much more consistant and meaningful at the bottom loaded terminal than at the top loaded terminal. At the top loading terminal, since the hatch cover is not closed, the data does not reflect the relative vapor tightness of the tank which is traceable back to the CARB pressure test. Instead, the loading

Table 3-4. CORRELATION FACTORS (r) FOR V/L RATIOS AND TANK LOADING BACKPRESSURE

Loading	Pass/Fail	r
Top	Pass	0.49
Top	Fail	-0.02
Bottom	Pass	0.04
Bottom	Fail	-0.02
Combined	Pass	0.03
Combined	Fail	-0.07

arm/hatch interface, loading arm connections and swivels become the major sources of hydrocarbon leakage.

Tables 3-5 and 3-6 show the results of the explosimeter tests performed at the loading terminals. When discussing the usefulness of this test method as a means of performing tank vapor tightness the discussion will be limited to the bottom loaded data. Leaks occurred at almost every top loading occurrence regardless if the tank had passed or failed the CARB certification test. The data from the bottom loading terminal indicates that the tanks that fail the CARB certification test show considerably more leaks than the tanks that pass the certification tests. This becomes more significant as the explosimeter readings become larger. For example, at the 0.5 lower explosive limit (LEL) level, over 90 percent of the hatches indicating this relative size of leak were those that exceeded the allowable leakage criteria. At the 1.0 LEL level, over 95 percent of the hatches indicating this relative size of leak failed the certification tests.

The explosimeter method at the 0.5 LEL level or the 1.0 LEL level is an acceptable method to determine the compliance of the tank vehicle based on the on the CARB certification. The data was more meanigful at bottom loading operations but this does not mean that the method is not applicable to top loading systems. The presence of a leak was still detected, it was just difficult to determine if the violation was caused by the tank truck or the loading apparatus. It should also be noted that the adequacy of the method, and the apparent LEL levels where the method is useable, are based on the CARB leak criteria. If other criteria are used to define a leak tight truck, the method will have to be re-evaluated to determine the applicable LEL levels to be used as pass/fail criteria.

Table 3-5. PERCENT OF COMPARTMENTS WITH LEAKS AT SPECIFIC LOCATIONS

	Top Hatch[a]	Base Ring	P-V Vent	Loading Arm Vapor Connectors	Vapor Collector Cover
Top Loading					
Pass[b]	99.3	85.9	N.A.[f]	43.0	40.8
Fail[c]	94.9	82.2	N.A.	33.1	34.7
Total[d,e]	97.3	84.2	N.A.	38.5	38.1
Bottom Loading					
Pass[b]	5.2	8.6	7.8	N.A.	N.L.[g]
Fail[c]	42.3	42.3	48.7	N.A.	N.L.
Total[d,e]	22.7	22.2	24.2	N.A.	N.L.

[a] Top Hatch top loading indicates the loading arm/hatch interface

[b] Pass indicates a tank that is leak tight as defined by the CARB criteria

[c] Fail indicates a tank that has failed the CARB test and therefore leaks in excess of the allowable criteria

[d] Total = Percent of all compartments where leak occurred at specific location

[e] For bottom loading a total of 195 hatches were tested, 116 in the pass mode and 79 in the fail mode. For top loading, 260 hatches were tested, with 142 in the pass mode and 118 in the fail mode

[f] N.A. = Not applicable since compartment loaded with hatch open

[g] N.L. = No leaks detected

Table 3-6. OCCURRENCE OF HYDROCARBON LEAKAGE AT VARIOUS EXPLOSIMETER LEVELS[a]

	Percent of Hatches Where Leak Occurs			Avg. No. of Occurrences Per Hatch			Percent of All Leaks[b]		
	>0 LEL	≥0.5 LEL	≥1.0 LEL	≥ 0 LEL	≥0.5 LEL	≥1.0 LEL	>0 LEL	≥0.5 LEL	≥1.0 LEL
Top Loading									
Pass[c]	100	89.4	85.9	1.70	1.05	0.96	53.2	51.0	53.1
Fail[d]	96.6	88.1	84.7	1.80	1.21	1.02	46.8	49.0	46.9
Bottom Loading									
Pass	19.6	5.2	2.6	0.36	0.07	0.03	25.1	8.5	4.5
Fail	63.5	53.2	39.2	1.58	1.09	0.80	74.9	91.5	95.5

[a] For bottom laoding a total of 195 hatches were tested, 116 in the pass mode and 79 in the fail mode. For top loading, 260 hatches were tested, with 142 in the pass mode and 118 in the fail mode

[b] Indicates the percent of total leaks at that level found at a hatch that either passed or failed the CARB test

[c] Pass indicates a tank that is leak tight as defined by the CARB criteria

[d] Fail indicates a tank that has failed the CARB test and therefore leaks in excess of the allowable criteria

3.2.3 SONIC DETECTOR

The sonic detector was used much in the same manner as the explosimeter. The hatch covers, P-V vents, vapor collectors and vapor piping were checked for leakage during the loading operation. This unit was used almost exclusively when the previous load was diesel because no volatile gasoline vapors were in the gases being emitted.

The sonic detector test method did not prove to be very useful in the field. The instrument itself worked well in detecting the presence of gas leakage, however, the instrument could not give repeatable results on the relative size of the leakage. The instrument sensitivity and indicator scale would vary with the volume setting of the instrument. On a given constant leak, two people could get two readings based on the volume setting of the instrument and hearing ability of the operator.

However, this instrument and method could become usable if either a calibration method is devised based upon a standard sound level or if the instrument were modified to incorporate several set ranges which in turn could be calibrated.

3.2.4 SAN DIEGO "BAG" METHOD

Compliance tests of tank trucks were observed as performed by San Diego Air Pollution Control District (SDAPCD) personnel at a bottom loading terminal in San Diego. As described in Section 3.1, the tire-bag appratus was placed over all hatch covers of the tank being loaded. This included putting bags over compartments that were not being loaded but were interconnected through the vapor piping. No leak should occur at the compartment that was not being loaded because the internal valve should be closed, however, if a leak is detected this would indicate a faulty internal valve.

As the truck is loaded, the bag is closely watched to observe any leakage. The bags are sized so that the volume escaping is about twice the allowable leak rate based upon a leak decay of 18 inches of water to 17 inches of water in 5 minutes. A violation can then be easily noted by estimating the volume of leakage collected in the bag (or several bags). The bags are placed only over the hatch covers, which include the P-V vents, because this is the mose predominant leak source and other leakage areas could be determined during the annual State Certification Test (see CARB pressure test).

The test method has several advantages. The equipment is inexpensive to buy and easy to use. A visual, easily detected violation can be determined. Any leakage around the bag or innertube - truck hatch interface are errors always in favor of the truck. According to SDAPCD personnel, they have a 100 percent success rate on trucks they note as violators. In other words, every truck they have cited for violation has in fact, after a shop test, been found to leak in excess of the allowed rate. The truck must then be maintained to a level to pass the annual requirements again.

This test does have its drawbacks. This method can obviously be used only on bottom loaded trucks. The bag appratus itself may not be able to fit all tank hatch configurations. Other equipment, such as overfill protectors, tank compartment vapor vent housing, etc., may get in the way and not allow a good seal between the tank and the bag. However, the bag equipment is somewhat flexible and very inexpensive and bags could be made to fit several configurations. The other drawback is that there are many errors that may be involved and that these are all in the favor of the truck. This means some trucks get by that may actually fail the criteria. However, the test is now set up so that they do catch the larger violators and have a 100 percent success record for their field procedure.

3.2.5 PRESSURE-VACUUM TEST (CARB)

The CARB pressure-vacuum tests were performed on each tank at least once during the test period. The tanks were tested both prior to maintenance and after maintenance procedures were performed. This defined the leak rate and the subsequent compliance status of the tank with regard to the CARB annual certification compliance criteria. This criteria is currently set as allowing a leak in the tank such that when the tank is pressurized to 18 inches of water, the pressure will not decline more than 2 inches of water in 5 minutes. The vacuum criteria allows a decrease from 6 inches of water vacuum to 4 inches of water vacuum in 5 minutes. By July 1979, the criteria for both pressure and vacuum variations will be set at 1 inch of water in 5 minutes. The Air Resources Board was contacted to determine the reason for the particular pressure and vacuum limits used in the certification test procedure. The pressure and vacuum vent valves are spring loaded and designed to slowly open and be full open at 1 psi (27 inches of water) pressure and 6 ounce (10 inches of water) vacuum as specified by DOT regulations. The limits selected by CARB are the maximum pressure or vacuum that can be applied to the tank before the vent starts to open.[2]

Back pressures observed during loading operations at both the top and bottom loading terminals ranged from as low as 1.7 inches of water to as high as 17.5 inches of water which approaches the value used by CARB in their certification testing. The average back pressure over 144 tank loadings was 7.3 inches of water. Figure 3-2 shows the frequency distribution of the back pressures experienced. These indicate, with the types of vapor recovery systems employed, that the loadings observed at both the top and bottom loading terminals are consistently lower than the 18 inch criteria used in the CARB certification test.

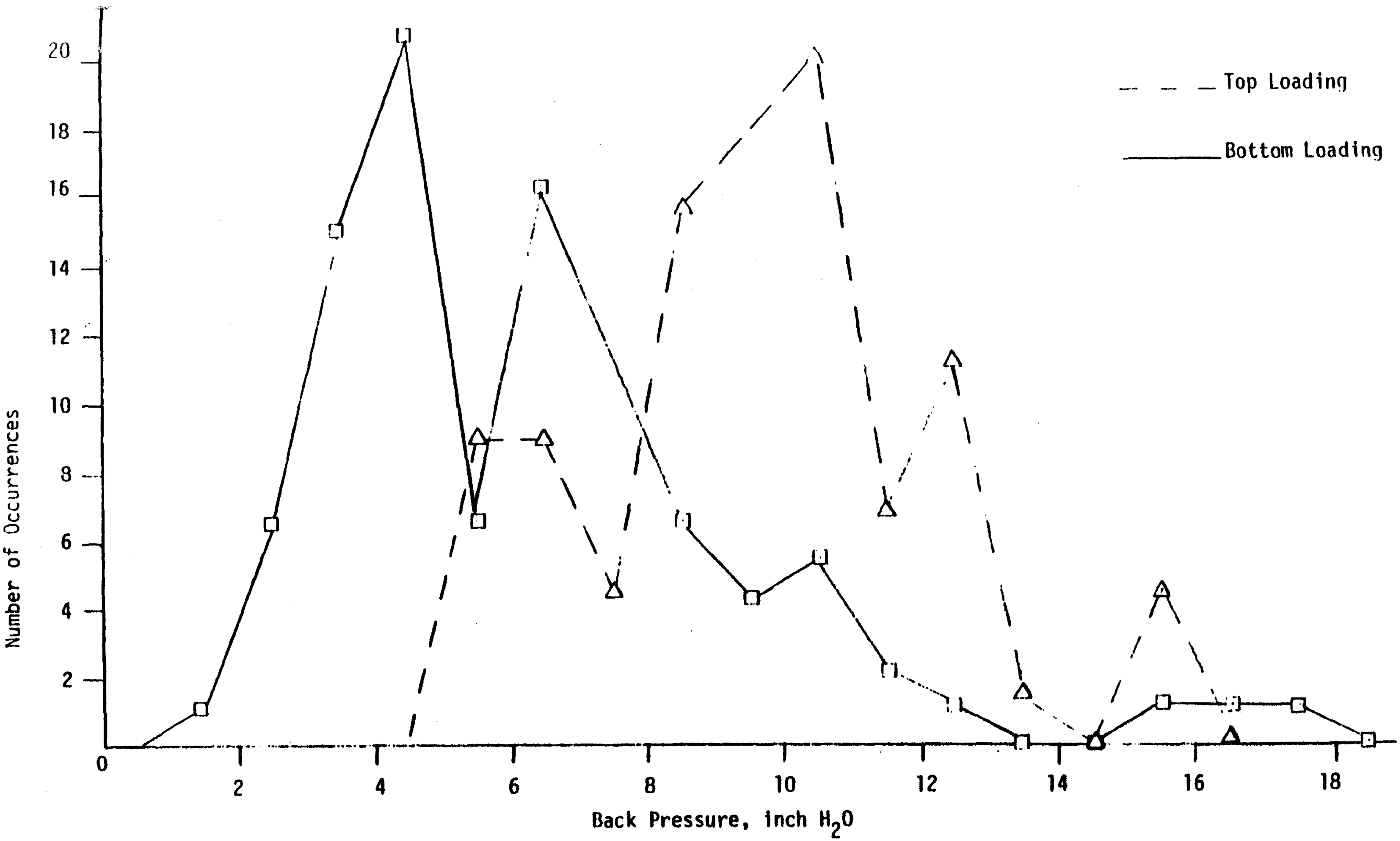


Figure 3-2. Frequency of Occurrences of Back Pressure During Loading Operations

Historical data was obtained from the terminal operators on each of the test tanks which included the dates of the previous certification. This data was used to determine how long the trucks are able to remain in certifiable condition under normal use. The shop test data was used to indicate the condition of the tanks which was compared to the historical data (see Table 3-7). As indicated, only four tanks remained in certifiable condition. The time frame ranged from one year to one month. Of the tanks that passed, the time since the last certification date ranged from four months to four days.

The CARB test performed in the shops were also monitored for pressure drop past the 5 minute time requirement. Tests were run for as long as 20 minutes to determine if the pressure would continue to drop with time or would level off at a lower pressure. This was performed predominantly on the tanks before maintenance was performed to determine the extent of the leak. Figures 3-3 and 3-4 illustrate examples of the pressure decay rate. In about every case, the pressure continued to decline at an approximate linear rate. This indicates the pressure decay rate is more dependent on the size of the leak than on the pressure in the test tank.

A phenomenom was also noted in the shop tests at the top loading facility. The tank was pressurized to 18 inches of water and the pressure increased with time. This occurred at the top loading terminal where the compartments were degassed by blowing air through them and not at the bottom loading terminal where the gasoline vapors were removed by hauling a load of diesel prior to the test. This phenomenom was duplicated in the laboratory using a smal leak tight tank which had held gasoline. The tank was loaded and unloaded with gasoline several times. A pump was then used to push air through the tank to simulate the degassing. When the degassing was completed for 20 minutes the tank was immediately pressurized and sealed off. The pressure again increaseed with

Table 3-7. TANK TIGHTNESS HISTORY

Tank Identification Number	Last Certification Date[a]	Field Test Date	Pass/ Fail	Type of Loading
63806	2/24/78	6/23/78	F	Top
53306	2/24/78	6/23/78	F	Top
63767	2/09/78	6/20/78	F	Top
53256	2/09/78	6/20/78	P	Top
63766	2/08/78	6/20/78	F	Top
53345	2/08/78	6/20/78	F	Top
63765	2/07/78	6/19/78	F	Top
63765	6/19/78	6/23/78	P	Top
53304	2/07/78	6/23/78	P	Top
63804	2/16/78	6/21/78	F	Top
53307	2/16/78	6/22/78	F	Top
63803	2/10/78	6/21/78	F	Top
53297	2/10/78	6/21/78	F	Top
63805	2/28/78	6/22/78	F	Top
53305	2/28/78	6/22/78	F	Top
67-182	5/18/78	6/14/78	F	Bottom
67-392	5/23/78	6/13/78	F	Bottom
67-475	5/24/78	6/15/78	P	Bottom
68-795	5/03/78	6/14/78	F	Bottom
68-597	6/13/77	6/13/78	F	Bottom
68-275	6/28/77	6/15/78	F	Bottom
68-977	5/03/78	6/16/78	F	Bottom
67-775	No data	6/12/78	F	Bottom

[a] Passed CARB Certification Test

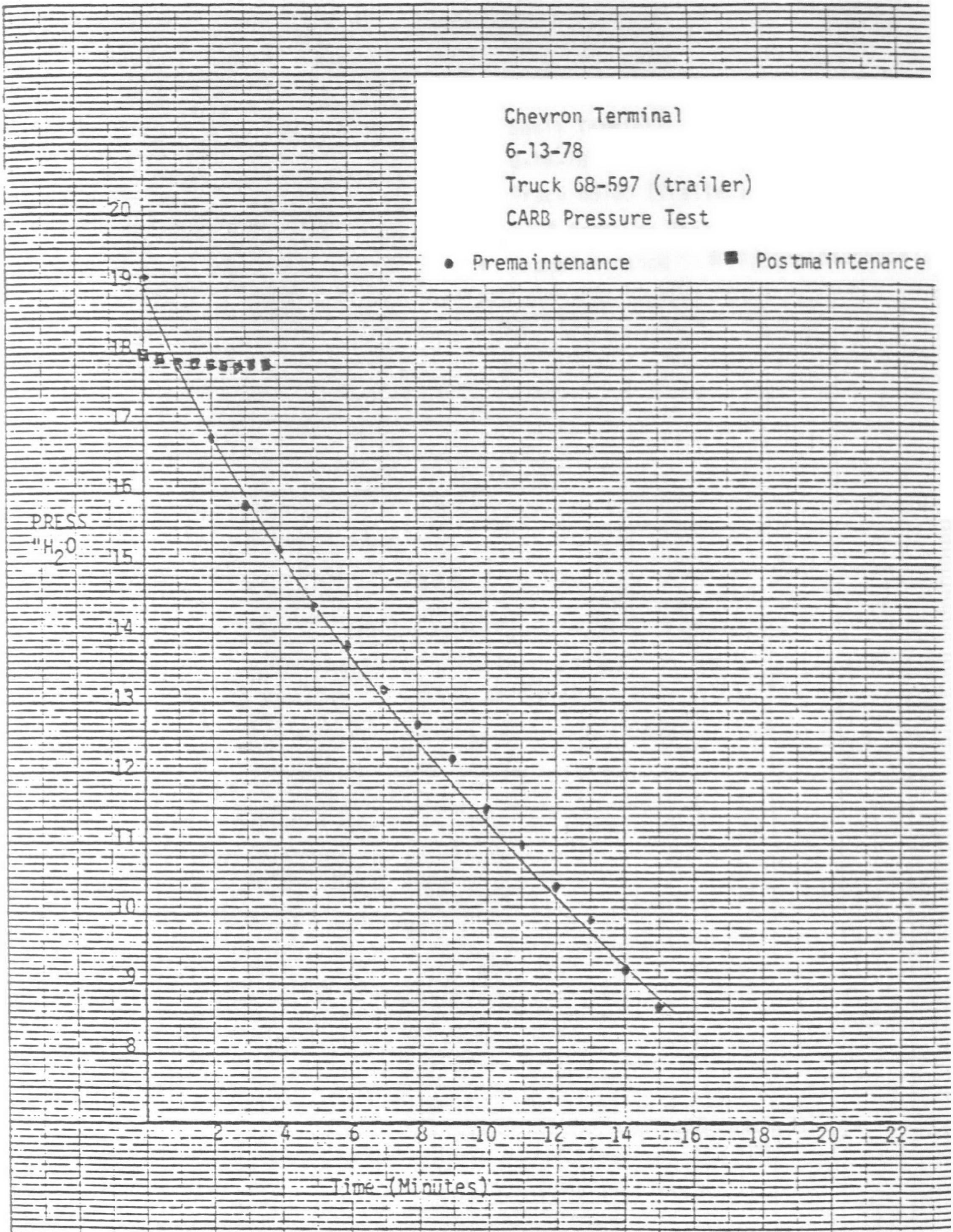


Figure 3-3. Typical CARB Pressure Test Results at Bottom Loaded Terminal (Ref. 1)

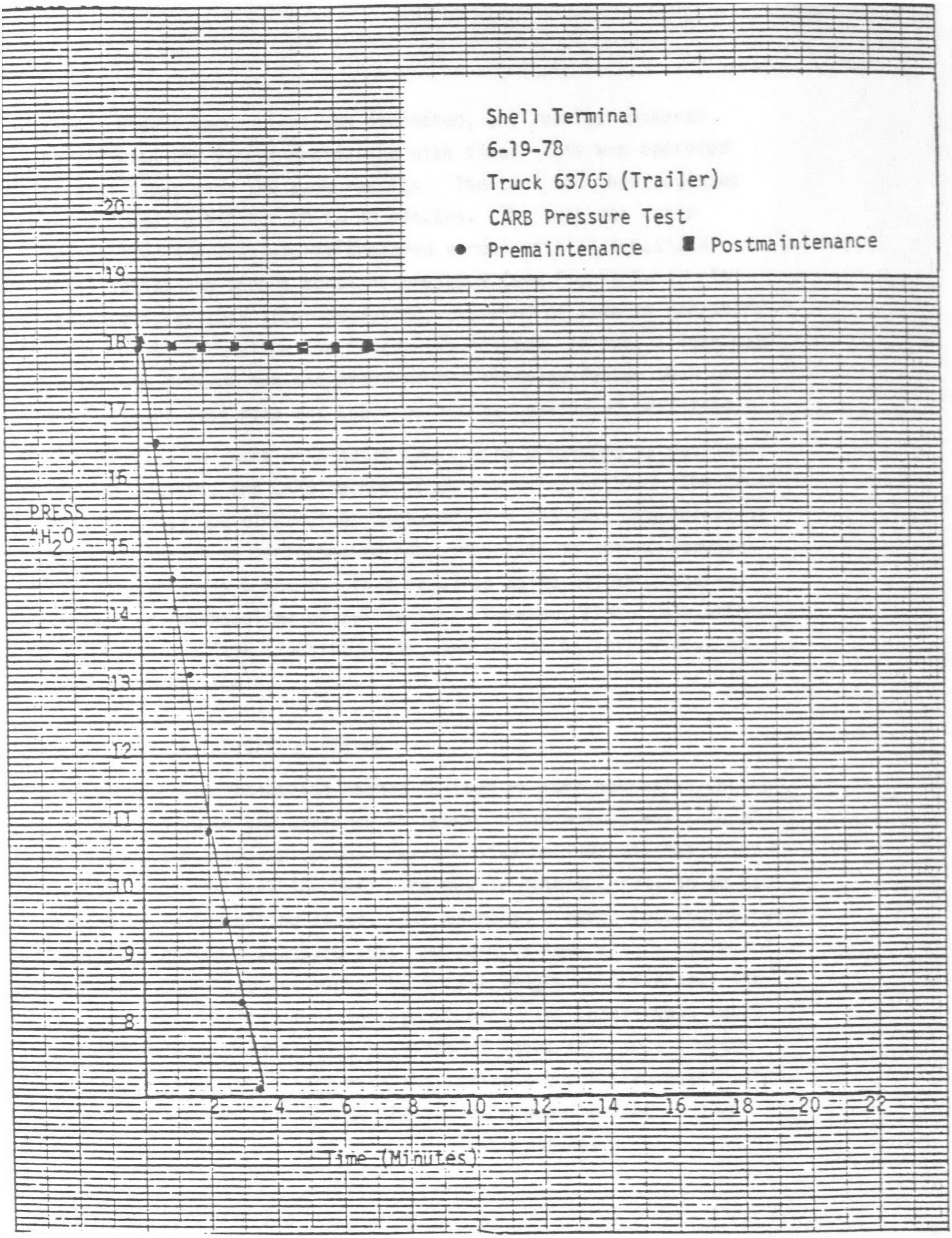


Figure 3-4. Typical CARB Pressure Test Results at Top Loaded Terminal (Ref. 1)

time. When a vacuum test was attempted, the results appeared normal with the vacuum decreasing with time. This was operated several times with the same results. The tank was then degassed and allowed to sit for 20 to 30 minutes. The tank was again pressurized and the results appeared normal with an immediate equilization and then a constant pressure (see Figure 3-5). This data indicates that after degassing, a period of time is necessary before testing to allow the tank to stabilize. If not, a leak may in fact be present but the pressure may increase faster than or equal to the leak rate and the tank may be considered certified.

For the purposes of a quick monitoring procedure as outlined by this project, the CARB method is not very reasonable. The truck must be taken out of service, degassed, and tested. Regardless if the maintenance is performed or not, the truck is out of service for approximately 3 hours. This requires using either a back-up vehicle or rescheduling of deliveries. However, since this method defines what a leak tight truck is, the method is very useful as an enforcement tool.

3.2.6 BUBBLE INDICATION METHOD

The bubble indication method is used by many mechanics during tests to indicate the presence of leaks. This method was incorporated into the shop test procedures and used to indicate the locations of the leak sources. The bubble method proved to be too sensitive in indicating leaks. For example, a vapor hose connected to a tank during a pressure test indicated a leak with a series of extremely small bubbles along the entire length of the hose. The pressure test indicated no leakage at all. The bubble test would also be able to relate relative sizes of leaks only to a limited extent and this would vary with the indicating solution used. This method is however, similar to the sonic detector method in that both can be used as an indicator or locator of leaks.

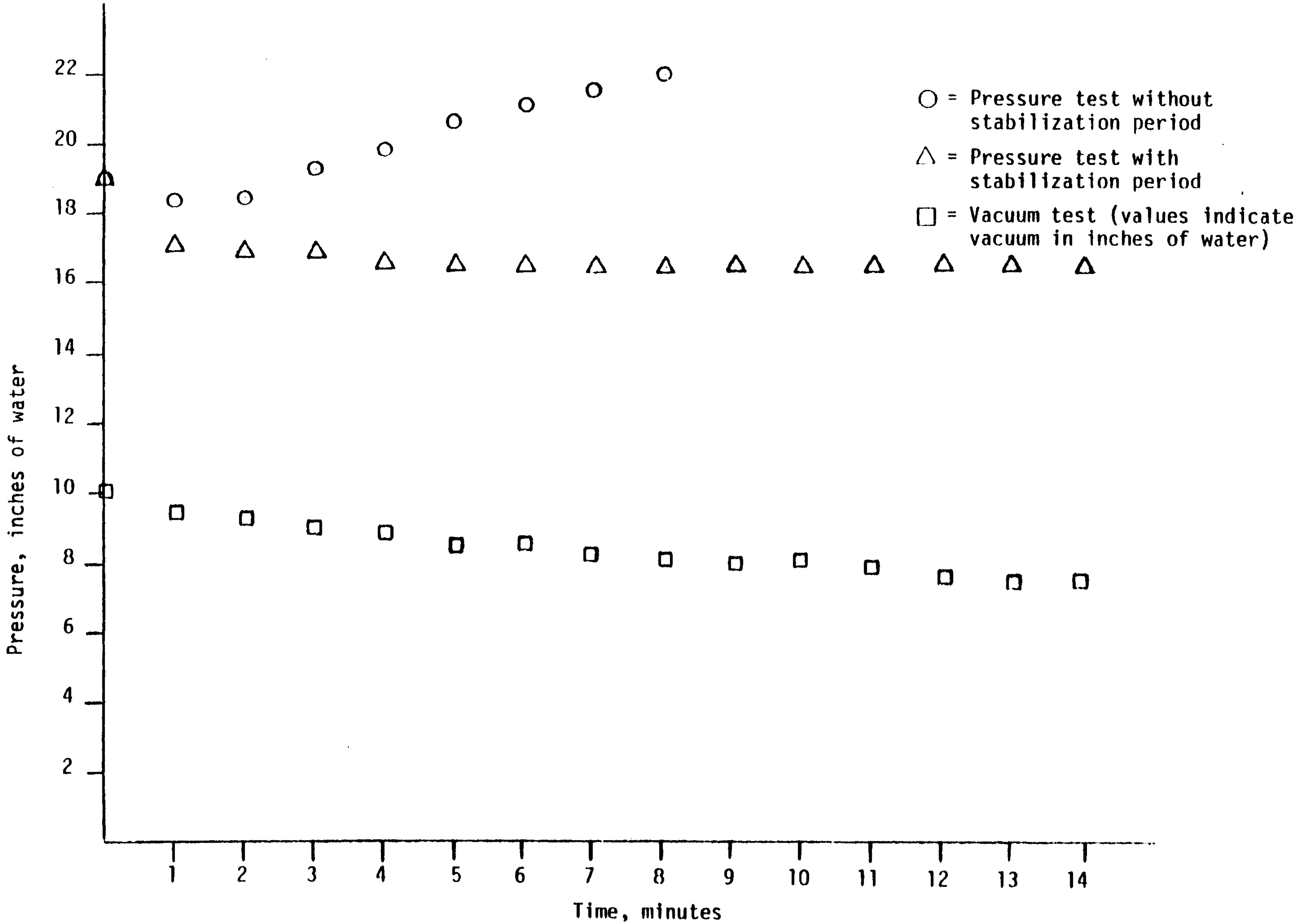


Figure 3-5. Laboratory Test Results for CARB Pressure Test

3.2.7 QUICK LEAK DECAY METHOD

The quick leak decay method was not included in the field test program because it was felt that additional information based upon laboratory tests was needed along with information regarding the safety limitations. Safety was a factor that had to be dealt with because the method called for the pressurization of the delivery tank with liquid gasoline. Several fire marshalls were contacted and all gave similar responses. Since the tank pressure sought (18 inches of water) is below the pressure at which the tank is designed to maintain around the liquid gasoline (27 inches of water), there should be no safety problems. This was provided that the normal safety precautions regarding static discharge and proximity to sources of flame are upheld.

The laboratory tests were conducted by first constructing a leak tight delivery tank simulation model. The tank had to be leak tight to ensure that pressure changes taking place inside the tank could be attributed to liquid-vapor equilibrium changes and not to leaks in the tank. A pressure transducer was attached to the tank and all other ports sealed. The tank was pressurized and the pressure recorded on a strip chart recorder. A leak was found at a tank weld and repaired. Thermocouples were installed and attached to a multipoint recorder to monitor ambient temperature, tank vapor temperature, liquid temperature in the tank, and liquid loading tempertature. The appratus was assembled as shown in Figure 3-6. Gravity was used as a driving force for loading or unloading the liquid gasoline.

After initially loading the tank with gasoline, it took some time to reach a stabilized condition (the pressure no longer increased with time). Once the system had stabilized, liquid was forced into the sealed tank until the desired pressure was reached. Temperature and pressure were recorded and the time required to

1. Multipoint temperature recorder
2. Ambient temp
3. Vapor temp
4. Tank liquid temp
5. Entering liquid temp
6. Liquid gasoline supply
7. Pressure relief vent
8. Pressure transducer
9. Signal conditioner
10. Strip chart recorder
11. Test tank
12. Needle valve

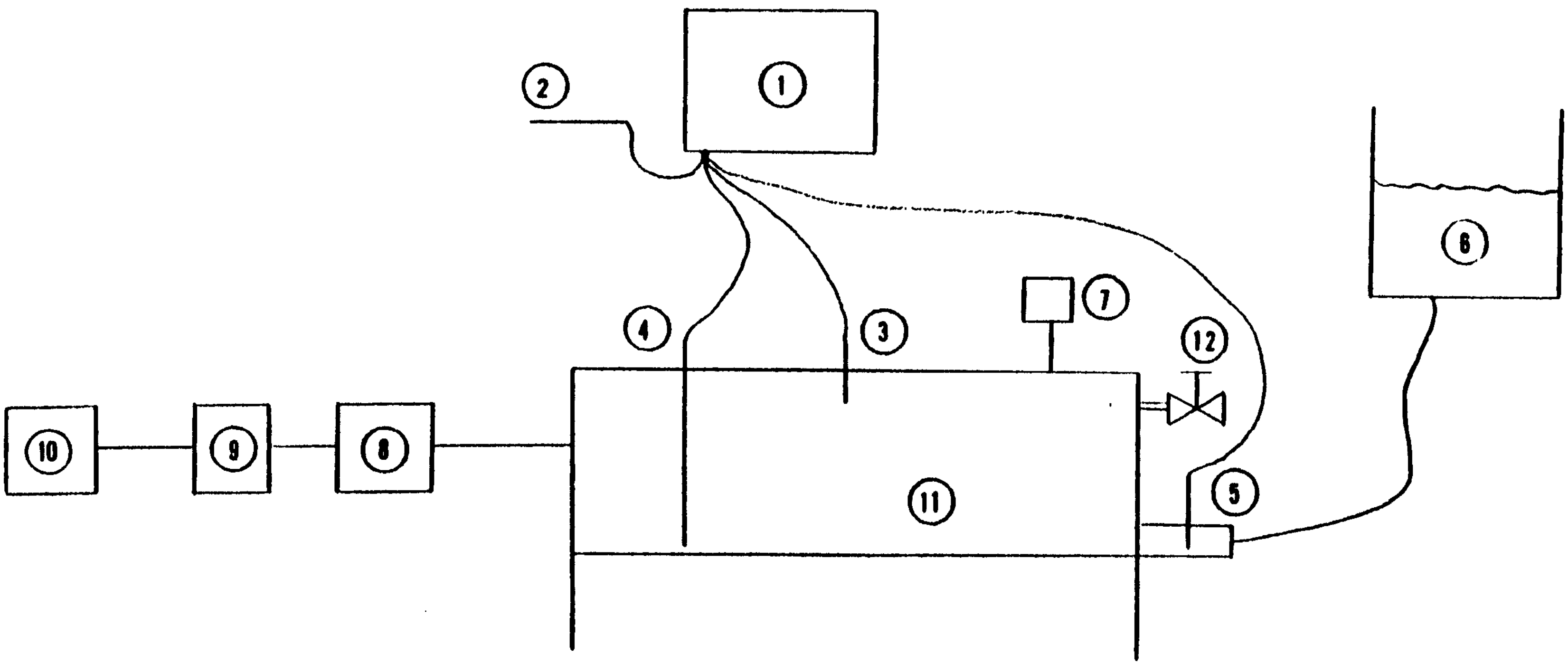


Figure 3-6. Quick Leak Decay Test Apparatus

reach a stable pressure noted. The pressure was released and the tank again sealed with the liquid still inside. The liquid was then allowed to drain out until the desited vacuum in the tank was achieved. Again temperature, pressure, and time were recorded until a stable pressure was reached. Typical pressure versus time curves are shown in Figure 3-7. The time for stabilization of the pressure tests was normally about 10 minutes.

It is difficult to estimate what time period would be necessary to stabilize pressure in a full scale tank vehicle. It is safe to say however, that this time period should be significantly longer. This time requirement will probably eliminate the usefulness of this method as a quick detection technique. Diesel fuel has been used successflly as a pressurizing liquid after the tank has been rinsed or flushed with diesel.[2] Diesel fuel is not available at all loading facilities so the method was assessed for acceptability using gasoline. It should be noted that even though this method may not be useable as a quick monitoring technique, it does illusrate the need of removing as much gasoline vapors as possible from the test tank and allowing the test tank to stabilize before testing to obtain reliable results.

3.2.8 VOLUME LEAKAGE

The volume leakage test was compared in the shop to the CARB data results. The pressure was increased and held at 9 inches of water, then held at 12 inches of water, then 15 inches of water and finally, at 18 inches of water. This approach was used before the CARB test so that the lower pressure data could be obtained before reaching the higher pressures and eliminating the possibility of "blowing" a leak at the 18 inch pressure. The results of the volume leakage data as they compare to the CARB data is shown in Figures 3-8 and 3-9 for bottom and top loading instances. The top loading data is not as complete as the bottom loading data because

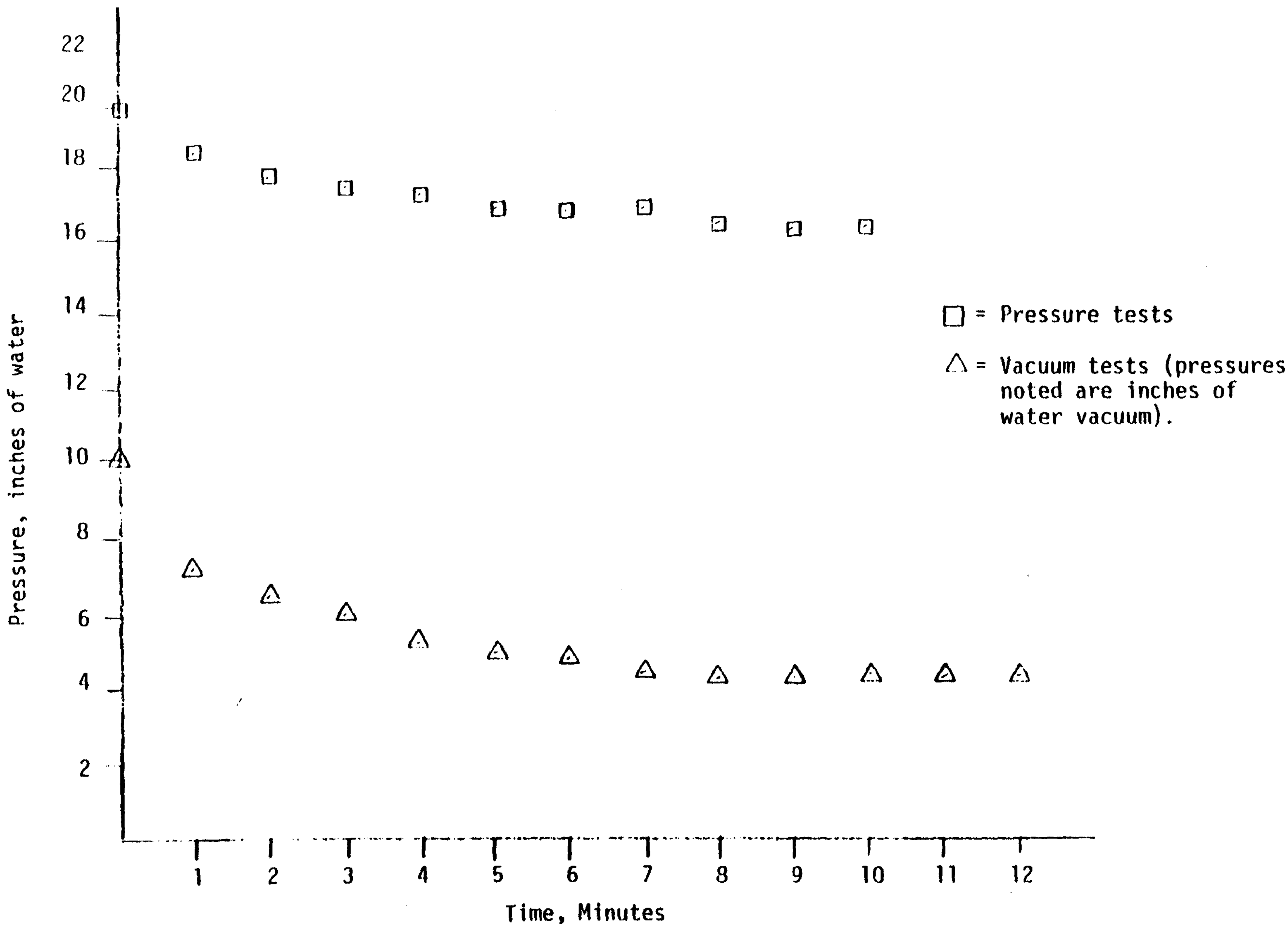


Figure 3-7. Typical Pressure Versus Time Curves for Laboratory Tests of Quick Leak Decay Method

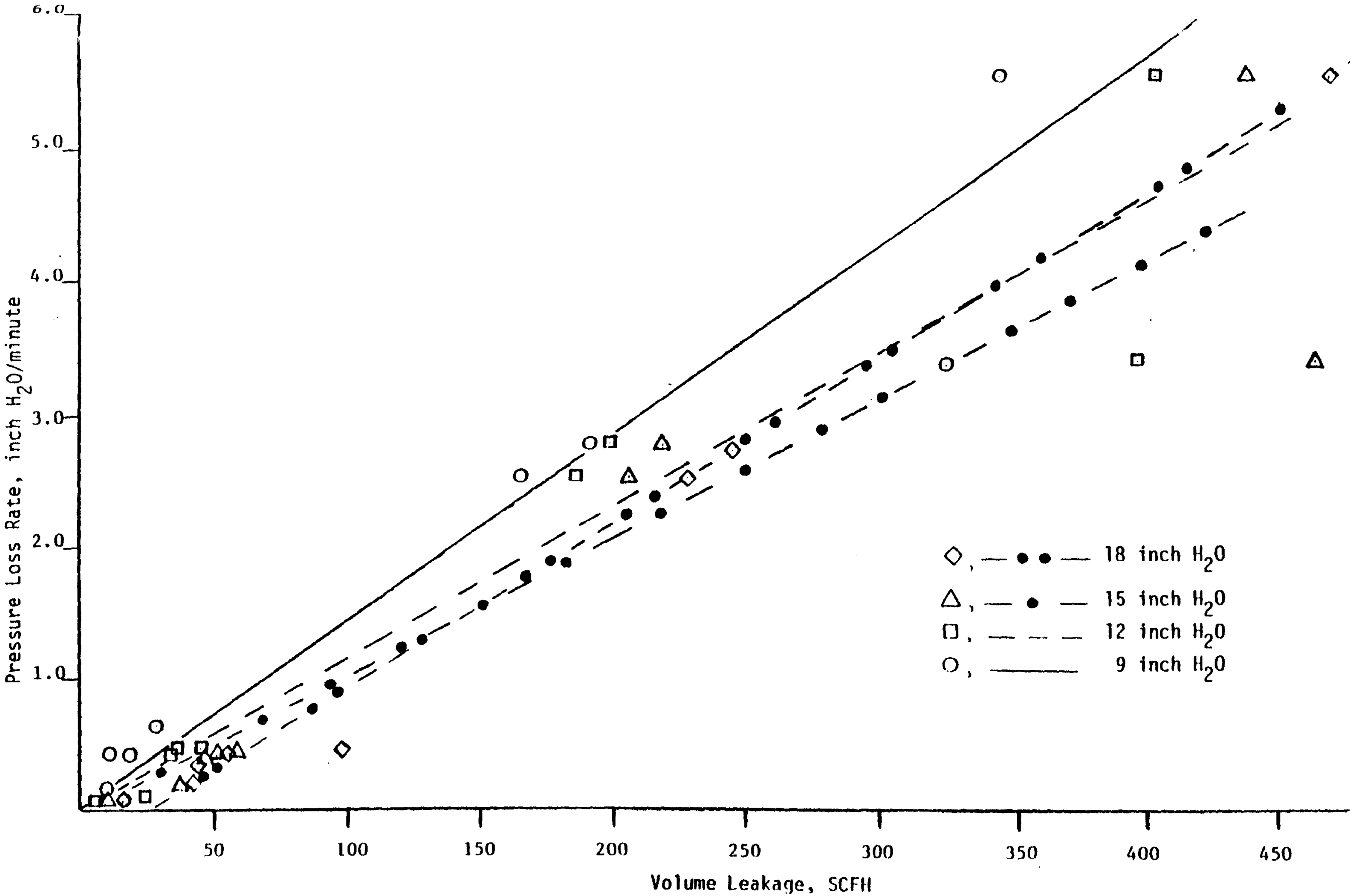


Figure 3-8. Volume Leakage vs Pressure Decay for Bottom Loaded Tanks at Various Pressures

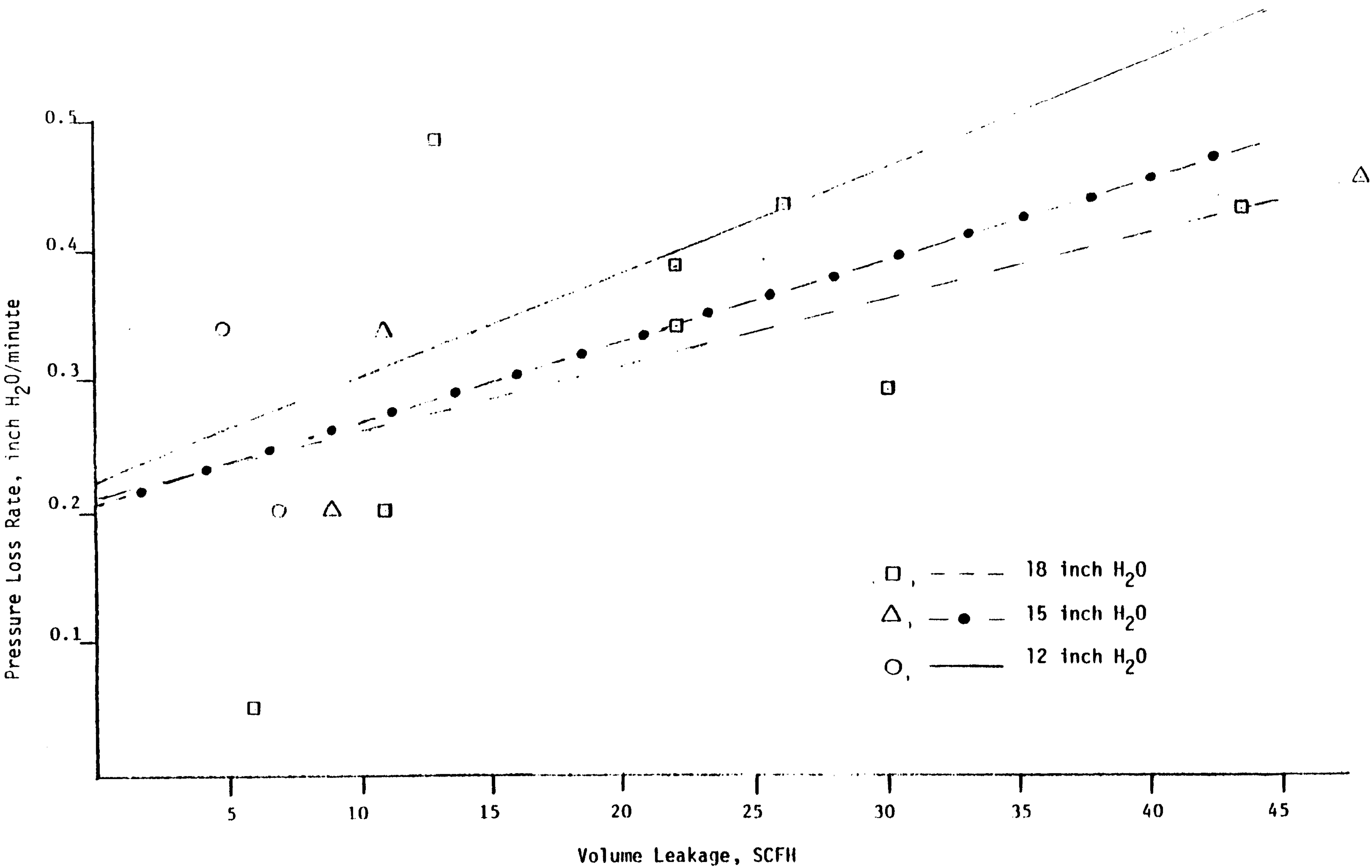


Figure 3-9. Volume Leakage vs Pressure Decay Rate for Top Loading Tanks at Various Pressures

of time constraints when performing the field tests. Linear regression analyses were performed on the data and the best fit curves are illustrarted. The correlation coefficients were calculated and the bottom loaded data are significant at the 0.1 percent probability level. The top loading data was significant only at the 10 percent level. Correlation coefficients for the volume leakage versus CARB test are listed in Table 3-8.

The volume leakage test compared very favorably to the CARB method. However, for this project the volume leakage method is not shorter or quicker than the CARB test but in fact longer and requires more equipment. The truck must still be taken out of service and degassed. In addition to all the necessary CARB equipment, rotameters and corresponding valves and tubing for measuring volume rate are required. This method is however, like the CARB method in that it can be used to define an aceptable leak rate.

3.3 PASS/FAIL CRITERIA

The pass/fail criteria selected will obviously be determined by the monitoring technique chosen. Based on the test method evaluation, the methods to be included in this discussion are the explosimeter method, San Diego "Bag" method, the volume leakage method, and the CARB pressure loss rate mehtod.

The explosimeter tests reveal that an LEL limit of 0.5 LEL or 1.0 LEL can be used as a pass/fail value using this method. The limit selected will depend upon the reliability of the method that can be accepted. Using the criteria of allowing no leaks greater than 1.0 LEL, if a reading of 1.0 LEL was found the chances would be very high (96/100) that the tank would be one that would fail the CARB criteria and not one that would pass. This criteria would yield a high success rate (meaning the tank identified as a violator is in fact leaking in excess of the criteria) for selecting leaking tanks, but may not indicate some tanks that would

Table 3-8. CORRELATION COEFFICIENTS FOR VOLUME LEAKAGE RESULTS WITH RESPECT TO CARB TEST RESULTS

Constant Pressure Held	Correlation Coefficient
Bottom Loading	
9 inches H_2O	0.96
12 inches H_2O	0.95
15 inches H_2O	0.94
18 inches H_2O	1.00
Top Loading	
12 inches H_2O	0.90
15 inches H_2O	0.90
18 inches H_2O	0.65

fail (e.g., leaks of 0.8 LEL). Using the criteria of no leaks greater than 0.5 LEL, the chances of identifying a leak tight truck as one that leaks increases from 4.5/100 to 8.5/100. This lower allowable level will yield a lower success rate but will exclude fewer of the tanks actually in violation.

San Diego APCD personnel have seleted pass/fail criteria based upon the allowable pressure loss defined by the CARB certification tests. The volume of vapor that would be lost due to a pressure decrease from 18 inches of water to 17 inches of water is calculated and a loss rate (over the five minute test) can be established. The pass/fail criteria can then be established determining the margin of error that can be allowed in identifying all the violators. In San Diego, because of the possible errors involved in the method, personnel have selected a volume of vapor lost during loading operations of twice that allowed by the CARB criteria. SDAPCD has experienced a 100 percent success rate using this enforcement technique. There is, however, no information on how many violators are not detected by this method. The pass/fail criteria for this screening method is therefore dependent upon the definition of a leak tight truck.

The pass/fail criteria selected for the volume leakage test will depend upon the allowable leakage that will define a leak tight truck. The leak tightness of the tank can be defined as a percentage of the total vapors transfered and an acceptable leakage rate can be selected. For example, if a tank vapor volume of 5,000 gal (670 ft^3) and a loading rate of 500 gallons per minute (67 CFM) is assumed, a pass/fail limit can be determined dependent upon the vapor containment necessary. If a containment of 99 percent is required, the allowable leakage can be calculated as follows:

(vapor volume flow rate)(1-containment required)
= Allowable volume leakage rate

For this example, the allowable volume leakage would be:

$$(67\ ft^3/min)(60\ min/hr)(1-0.99) = 40.2\ ft^3/hr$$

By referring to Figure 3-5, this rate can be compared with the CARB leak rate criteria, and for those trucks tested the corresponding pressure leak rate would range from 1.25 inches of water to 3.25 inches of water in 5 minutes. Table 3-9 shows several corresponding volume leakage rates for various containment requirements. The table can also be used to determine the pressure loss requirements for a CARB type test given the vapor containment required during the loading process.

Table 3.9. VOLUME LEAKAGE RATE REQUIRED FOR VARIOUS VAPOR CONTAINMENT REQUIREMENTS[a]

Required Vapor Containment, Percent	Volume Leakage Rate, SCFH	Corresponding CARB Pressure Loss Rate, in H_2O/5 Minutes[b]			
		9 in H_2O	12 in H_2O	15 in H_2O	18 in H_2O
90	402.0	28.3	23.0	20.3	23.0
95	201.0	14.3	11.5	10.3	10.8
98.1	75.0	5.5	4.3	3.8	3.0
99	40.2	3.3	2.5	2.3	1.3

[a] Based upon a tank volume of 5,000 gallons and a loading rate of 500 GPM

[b] See Figure 3.5, data based upon tanks tested during field test phase.

References for Section 3.0

1. Leak Testing of Gasoline Tank Trucks, Scott Environmental Technology, EPA Contract No. 68-02-2813, Work Assignment No. 19, August 1978 (Draft)

2. Personal communication with Dean Simeroth, California Resources Board, Sacramento, California

3. Ibid

4.0 CONCLUSIONS

4.1 VAPOR CONTAINING EQUIPMENT AND MAINTENANCE

Vapor containing equipment is available to either eliminate or minimize hydrocarbon vapor leakage from delivery tanks and from bulk plant and terminal vapor piping. Test data indicates that the type of equipment selected or age of equipment was not as much a factor as the maintenance required to keep the equipment in good working order. How long the equipment will remain controlling vapors in a leak tight manner is unknown, but with a proper maintenance program some tanks have shown leak tightness maintained for over 6 months.

The CARB certification program specifies testing the trucks annualy. However, the program may be more meaningful if the trucks were tested more often, e.g., either semi-annually or quarterly. Some truck fleet operators stated that they would be willing to test the tanks more often than the current annual test but they felt also that the degree of leak tightness required by the CARB program should be reduced.

4.2 COSTS OF MAINTAINING VAPOR TIGHT CONDITIONS

The costs, as outlined in Section 2.5, of maintaining the equipment in a leak tight condition are not unreasonable. Even if certification tests were required more often, the costs still remain reasonable. Requiring certification more often than quarterly would not be realistic because of the time required to certify a truck fleet and the scheduling and delivery adjustments that would be required.

4.3 MONITORING PROCEDURES

Of the eight monitoring procedures studied, only four appear to show promise as an acceptable procedure. These include the explosimeter method, San Diego Bag method, the CARB pressure loss rate method and the volume leakage method. The other methods studied include the quick leak decay method, sonic detector method, bubble indication method and the V/L ratio method. The quick leak decay was evaluated using gasoline as the pressurizing liquid because diesel is not available at all facilities. The quick leak decay method would take too long to reach stabilizing pressures to act as a quick monitoring method. The sonic detector indicated the presence of leaks but because of the way the instrument was used no relative sizing of the leaks could be obtained on a repeatable basis. The bubble indication method also worked very well at identifying leakage areas but also could not be used to determine the relative size of the hydrocarbon leaks. The data for the V/L method indicates that there was no correlation between V/L test results and the leak tight condition of the truck thereby eliminating it, as used, as a possible compliance method.

Of the tests selected yielding acceptable results, either of the two shop tests, the CARB test or the volume leakage test, should be used as the compliance test. The volume leakage test is based upon actual vapor volumes emitted to the atmosphere but this determination requires slightly more time and equipment than the CARB test. Either of the short monitoring methods, the explosimeter test or San Diego Bag test should be used as an interim enforcement of screening procedure. These short methods could be used to monitor loadings and determine violators, and in turn would require the leaks to be minimized as specified by the shop test selected.

4.4 PASS/FAIL CRITERIA

Pass/fail criteria for leaks emanating from the tank trucks will depend upon the degree of leak tightness defined in the shop test. Pass/fail criteria have been developed based upon the existing CARB leak tight definition of allowing a pressure decrease of 2 inches of water in 5 minutes (from 18 inches of water to 16 inches of water). San Diego has developed pass/fail criteria using the bag method. A criteria could be developed using 0.5 LEL or 1.0 LEL using the explosimeter method, depending upon the success rate required by the method. If another definition of leak tight were developed using volume leakage rate criteria or pressure loss rate criteria, pass/fail criteria for the screening methods would have to be modified.

For other leakage areas not involving the delivery tank, pass/fail criteria can be established. From vapor piping to the storage tanks, no hydrocarbon leakage should occur as indicated with either a sonic detector or a bubble indication solution. No hydrocarbons as indicated by an explosimeter should leak from a fixed roof storage tank pressure-vacuum vent if the storage tank pressure is below the vent open setting. No leakage should occur from vapor couplers as indicated by an explosimeter or bubble indication solution.

APPENDIX A

SUGGESTED MONTHLY VISUAL MAINTENANCE INSPECTION CHECKLIST

APPENDIX A

SUGGESTED MONTHLY VISUAL MAINTENANCE INSPECTION CHECKLIST

TANK TRUCK OPERATOR -- (To be performed on each truck)

1. Inspect hatch cover for integrity of gasket and seal surfaces. Clean dome lid gasket as required.
2. Inspect P-V valve seals for debris or foreign material on seat Check valve operation to ensure valve will move smoothly and will reseat properly.
3. Inspect condition of hatch base ring for severe damage or warpage.
4. Inspect condition of compartment vapor vent covers especially if covers are the flanged bolted type or the rubber boot type. Inspect flange bolts for tightness and/or inspect rubber boots for cracks or tears.
5. Inspect vapor recovery piping. If rubber hoses are used, check the hoses for tears or cracks and check the tightness of any connector clamps.
6. Inspect couplers for damage or wear which will not allow the coupler to close properly. Check the coupler gaskets also for excessive wear or damage.
7. Inspect vapor and liquid transfer hoses for cracks, tears or excessive wear or damage. Check hose to coupler clamps for tightness.

For all items above, repair or replace worn or damaged parts as required.

BULK PLANT AND TERMINAL OPERATORS

1. Inspect all gasoling delivery tanks as described above.
2. Inspect loading rack vapor and liquid couplers for signs of wear, damage or liquid leakage. Check flexible vapor hoses (if applicable) for cracks, tears, or damage. Check all hose clamps for tightness.

3. Inspect above ground vapor piping using a bubble indicating solution. Check all piping connections and joints with the solution and look for signs of damage to the rigid piping.

4. For fixed roof storage tanks, inspect the condition of the pressure-vacuum vents. Be sure that the valves are seated or can be seated properly and that the valves can move freely in the valve guides. Check to make sure all valve seats are clean and free of debris.

5. For top loading arms, use an explosimeter or bubble indication solutions to identify leaks at the loading arm swivels and joints. Check any tapered rubber loading arm hatch sealing mechnaisms for signs of damage or excessive wear.

Repair or replace damaged components as required.

SERVICE STATION OPERATORS

1. Inspect vapor couplers used for vapor transfer to underground storage tanks. Check valve seats to make sure they are clean and free of debris and foreign material.

2. Inspect vapor hoses (if applicable) as stated above.

APPENDIX B

ACTUAL MAINTENANCE PERFORMED ON DELIVERY TANKS DURING FIELD TEST PHASE

APPENDIX B

ACTUAL MAINTENANCE PERFORMED ON DELIVERY TANKS

DURING FIELD TEST PHASE

Truck/63806
Degassed, start 1030 - end 1145
Dome No. 1 - bad leak at lid seal
Dome No. 2 - smaller leak at lid seal
Dome No. 2 - high level shutoff also loose
(1 man -- 9 minutes)
Nos. 1 and 2 -- straightened the hatch bases and adjusted the lid spring tension. Tightened the high level shutoff (for bottom loading)

Trailer/53306
Degassed, start 1200 - end 1415
No. 3 has bad leak at dome lid
(1 man -- 4 minutes)
Straightened base, adjusted spring tension and tightened base ring.

Truck/63765, Trailer/53304
Truck degassed, start 0615 - end 0720
Trailer degassed, start 0730 - end 0930
Truck - No maintenance
Trailer - No maintenance

Truck/63804
No. 2 dome lid leak - adjust tension
No. 3 dome lid leak - adjust tension and straightened hatch
(1 man -- 5 minutes)

Trailer/53307

No. 3 tightened base ring, replaced base ring and gasket

No. 1 dome lid leak - adjust tension

(1 man -- 10 min)

Trailer/53305

30 minutes - leak compartment

Start 0630 - end 0850

Truck/63805

Degass, start 0810 - end 1030

Trailer

No. 3 dome lid leaking, cannot get over 1 inch H_2O

(1 man -- 17 minutes)

Nos. 1 and 2 also leaking, adjust spring tension of lid

No. 3 straightened out hatch and adjust spring tension, replace gasket in vapor recovery outlet

Truck

Nos. 1 and 2 dome lid leaking, straightened dome lids and adjusted spring tension

(1 man -- 8 minutes)

Truck/63804

Degassed 10 minutes for each compartment

No. 1 vent missing, replace

(1 man -- 5 minutes)

Only truck tank tested because of time limitations, truck only degassed for 10 minute/compartment, complete stabilization not achieved because of time limitation, vacuum test -- 6.12 to 6.28 inches H_2O in 5 minutes -- invalid since not stabilized

Trailer/53297 - Trailer 63803
Degas, start 0630 - end 0805 (on trailer)
Degas, start 0815 - end 1050 (on truck)
Maintenance/trailer -- all three covers leaked, adjust tension and spring clamps, No. 3 has bent dome lid, also tightened high level shutoff, start 0824 - end 0846
Maintenance/truck -- leak at hose clamp on vapor return hose, replace clamp (1 man -- 5 minutes), dome covers adjusted after EPA Volume Leakage test

Truck/63767
No. 1 cover leaking, upon adjusting spring tension a bolt broke, must replace dome lid
(1 man -- 19 minutes)

Trailer/53345
No. 1 cover leaks, tighten base ring and adjust spring tension on cover, (5 minutes -- 1 man)
Blew the rubber boot off of No. 1 collector at 23 inches H_2O
(3 minutes 1 man)
No testing done pre-maintenance

Maintenance for CARB Certification 9:10 to 10:30

Truck/68-275, Trailer
Previous load diesel - old CB equipment
Bad leak compartment No. 3 vent, detectable by smell, ear, feel, leak dur to small 1/8 inch diameter rock in seal. Repaired by cleaning vent/seal 9:10 to 9:30
Repressurize to find more leaks 9:30-9:40
18 inch and 15 inch in 5 minutes (1 inch too much drop), 6 medium/small leaks found, pressure and vacuum valves in each compartment, repaired--started 9:40 to 10:00; pressure valves seal, compartment No. 1, small 1/8 inch rock in seal, pressure valves seal, compartment No. 3; replace both, all other 4 valves cleaned

Repressurize to find more leaks, 10:00 to 10:10
18 inch to 15.1 inch in 5 minutes
Three small leaks found, compartment No. 1, pressure valve; compartment No. 2, screw threads on vacuum valve; compartment No. 3, vacuum valve still leaks
Repaired, start 10:10 to 10:20, replaced domes in compartments Nos. 1 and 3 with brand new domes, leaked approximately 3 inches in 3 minutes 10:20-10:30
Decision: Will fail CARB certification until new domes are purchased and installed.

Truck/67-182
Maintenance 1250 - 1305
Replaced vent dome cover Nos. 1, 3, and 5 leak very badly and Nos. 2 and 4 not as bad
1250 - maintenance started (2 minutes)
1350 - end maintenance
One of the vapor hoses has minute seeping leaks of the full length of the base, neq hose with a new material cover, many leaks but total volume not significant

APPENDIX C

SUGGESTED ENFORCEMENT INSPECTION CHECKLIST

APPENDIX C

SUGGESTED ENFORCEMENT INSPECTION CHECKLIST

GASOLINE DELIVERY TANKS -- (Based on explosimeter method and 1.0 LEL leak criteria)

While the delivery tank is being loaded, check the following with an explosimeter:

- Dome lid/base ring interface
- Base ring/tank interface
- P-V vent
- Compartment vapor vent cover
- Vapor piping
- Vapor couplers
- Vapor transfer hoses

Any reading greater than 1.0 LEL constitutes a violation.

BULK PLANT AND TERMINALS

Check the following with an explosimeter:

- Vapor piping
- Vapor tight couplers

Any explosimeter reading constitutes a violation.

P-V vents on fixed rood storage tanks should be inspected to determine if they are seated properly. Vent valves should be tested to determine if they open and close smoothly.

SERVICE STATIONS

During gasoline transfers, vapor couplers should be checked with an explosimeter. Any indication of a leak shall constitute a violation.

In all instances, the inspector should note the condition of the vapor containing equipment and give suggestions on required maintenance necessary to bring the violation into compliance.