DESIGN CRITERIA

FOR

STAGE I VAPOR CONTROL SYSTEMS

GASOLINE SERVICE STATIONS

U. S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
EMISSION STANDARDS AND ENGINEERING DIVISION
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Background

Transportation Control Plans (TPC's) promulgated by EPA in 1973 and 1974 include requirements for the control of gasoline vapors at service stations in some 17 Air Quality Control Regions (AQCR's) throughout the nation. In all cases, control of gasoline vapors during storage tank filling (Stage I sources) is required. In many areas, control of vehicle fueling (Stage II sources) is also required. For storage tank filling, EPA regulations prohibit the release of more than 10 percent by weight of displaced organic vapors.

While Stage I vapor control systems are relatively new, there has been substantial testing which shows that compliance with prescribed limits can be accomplished at commerical service stations. Tests by oil companies,[1,2,3] EPA,[4] and a local control agency[5] indicate that efficiencies greater than 90 percent are effected with simple balance systems if certain common design elements are employed and if the equipment is properly maintained and operated. Based primarily on this testing, criteria have been developed for Stage I control systems. The purpose of this document is to provide direction to operators who are required to install vapor recovery systems.

These criteria list the key features of systems which have been found to meet Stage I requirements. Systems incorporating different criteria may be installed if test data are supplied to show that they meet the emission limitation and other provisions of the Stage I regulations.

All current systems used to control emissions from storgage tank filling return displaced vapors to the tank truck. Vapor balance (displacement) systems release any excess vapors to the atmosphere; vacuum assist systems process excess vapors in secondary recovery units.

As shown in the vapor balance systems of Figures 1 and 2 and the secondary system in Figure 3, flexible hoses carry liquid gasoline from the tank truck down a drop tube to the underground tank. Entering liquid forces the air-hydrocarbon mixture in the tank out through a flexible hose to the tank truck. Alternately, the vapors may exit from the underground tank through a vent pipe (about 2 inches in diameter) extending at least 12 feet above ground level (OSHA and National Fire Protection Code 30 requirement). At the truck, the vapor hose is connected to a piping manifold which may serve as a rollover rail to prevent damage to the tank in case the truck is overturned. The roll-over rail piping is interconnected with the truck compartments by vents which are opened selectively during truck unloading, allowing returning vapors from the underground tank to enter respective product compartments on the truck.

Two-Point Systems

The most effective method of conducting displaced vapors from the underground tank to the truck is by means of a separate connection to the underground tank for the 3-inch vapor return hose, as shown in Figure 1. The vast majority of the tests showing compliance with prescribed limits are from systems utilizing this feature.

Concentric or Coaxial Systems

However, in some cases a separate entry is not available or the operator desires to avoid the excavation necessary to reach an unused entry. For these cases, coaxial devices have been developed to remove the vapors through the same opening through which the fuel is delivered.

In one system, shown in Figure 4, a drop tube of smaller diameter is inserted in the existing fuel riser. The vapors exit through the annular space. A coaxial adaptor fits on the riser and provides connections for the fuel delivery hose and the vapor return hose. In another system, shown in Figure 5, the fuel and vapor passages are separated in a "Y" fitting which is permanently attached to the underground tank. The fittings for the hose connections are located in a conventional manhole. A 6-inch coaxial fitting is shown in Figure 7. Most of these devices provides less cross-sectional area in the vapor return passage than do separate connectors and tend to reduce vapor recovery efficiency to some extent. Vent pipe restrictions will improve efficiencies.

Manifolded Vent Lines

Several schemes have been used to manifold vents from two or more tanks to a common vapor hose connection. Manifolding may be above or below grade. A number of configurations are acceptable for use with suitable vent restrictions as shown in Figure 8. The 3-way connector of Figure 9 provides the most effective arrangement since connection of the vapor hose to the common connector blocks flow to the atmosphere and routes all displaced vapor to the tank truck. In any manifold piping system, care must be exercised to prevent contamination of "no-lead" gasoline product.

Objectives of Design Criteria

Design criteria presently included in this document pertain primarily to commercial stations where filling conditions are most severe. Here there are usually two or three storage tanks, each of which range up to 10,000 gallons in capacity. They are normally filled from a tank truck of about 4,000-gallon capacity if a single tanker or 8,000-gallon capacity if a trailer is added. Each truck and trailer is compartmented such that different grades of gasoline can be transported without comingling.

Normal practice at commercial stations is to fill storage tanks at a rate of 200 to 500 gallons per minute. Thus, a typical 4,000-gallon drop may be accomplished in 10 to 20 minutes. The drop rate is critical since it governs the rate of vapor transfer. Where slower fill rates are used, it may be possible to use smaller transfer hoses and connections. Also, leakage at storage tanks and tank trucks tends to be of lesser magnitude at slower filling rates.

Criteria were developed to accomplish the following:

(a) assure submerged fill, i.e., discharge liquid below the gasoline surface in the storage tank,

(b) assure that the vapor return line and connections are of sufficient size and sufficiently free of restrictions to allow transfer of vapor to the truck tank and achieve the desired recovery,

(c) assure that there are no significant leaks in the system or the tank truck which reduce vacuum in the truck or otherwise inhibit vapor transfer,

(d) assure that the vapor return line will be connected during tank filling.

In addition, cognizance has been taken of safety requirements of the Occupational Safety and Health Administration (OSHA) and the recommendations of the National Fire Protection Association.

Design Criteria

1. Drop Tube Specifications. Submerged fill is specifically required by certain TCP regulations while others are silent on the method of filling. All test data submitted to EPA were obtained from systems utilizing submerged fill. If submerged fill is not used, test data must be submitted to show the required recovery will be obtained. The submerged fill requirement is interpreted to mean a drop tube extending to within 6 inches of the tank bottom. Under normal industry practices, a tube meeting this specification will always be submerged since the tanks are not pumped dry.

Deviation from the criteria will be allowed if the owner/operator shows that a shorter tube will guarantee submerged fill. In such instance, the owner/operator is required to present records which show that the level in the tank never falls below the drop tube. Exceptions also will be allowed for tanks which cannot be converted to submerged fill, e.g., tanks with offset fill lines or poor accessibility.

2. Gauge Well. If a gauge well separate from the fill tube is used, it must be provided with a drop tube which extends to within 6 inches of the tank bottom. This will prevent vapor emissions in case the gauge well cap is not replaced during a drop.

3. Vapor Hose Return. Existing data indicate that a 3-inch ID hose is needed to transfer vapors from the storage tank to the truck when a 4-inch drop tube is used. Smaller diameter hoses may be satisfactory where fill rates are appreciably less than 400 gallons per minute. If a hose smaller than 3 inches is to be used, the owner/operator is required to show that the hose will achieve the required vapor recovery.

4. Vapor Line Connections. Where separate vapor lines are used with 4-inch product tubes, nominal 3-inch or larger connections should be utilized at the storage tank and truck-trailer. When smaller product tubes are used, a smaller vapor line connection may be used, provided the ratio of the cross-sectional area of the connection to the cross-sectional area of the product tube is 1:2 or greater. If the ratio is smaller, test data must be provided to show the required recovery efficiency will be met.

Vapor lines from two or more tanks may be manifolded to a common vapor hose connector using configurations typified by Figures 8 and 9.

For concentric or other tube-in-tube fittings, operating characteristics are unique to the particular design. To date, adequate test data have been supplied for 4-inch and 6-inch tube-in-tube adapters. These are listed in Attachment A. Other fittings will be added to Attachment A when supporting data are supplied. If fittings not listed are to be used, test data must be provided.

5. Type of Liquid Fill Connection. Vapor tight caps are required for the liquid fill connection for all systems. A positive closure utilizing a gasket or other similar sealing surface is necessary to prevent vapors from being emitted at ground level. Cam-lock closures meet this requirement. Dry-break closures also are acceptable, but are not required.

6. Tank Truck Inspection. Vapor tight tank trucks are specifically required by TCP regulations. This is interpreted to mean that the truck compartments won't vent gases or draw in air unless the settings of the pressure-vacuum relief valves are exceeded. An inspection procedure should be submitted to include frequent visual inspection and leak testing at least twice per year. Leak testing should demonstrate that the tank truck when pressurized to 5 inches W.C. will not leak to a pressure of 2 inches W.C. in less than

3 minutes. Frequent visual inspection is necessary to insure proper operation of manifolding and relief valves.

7. Closures or Interlocks on Underground Tank Vapor Hose Connectors. Closures or interlocks are required to assure transfer of displaced vapors to the truck and to prevent ground level gasoline vapor emissions due to failure to connect the vapor return line to the underground tanks. These devices must be designed: (a) to keep the storage tank sealed unless the vapor hose is connected to it; or (b) to prevent delivery of fuel until the vapor hose is connected, i.e., an interlock. Tank openings designed for combined fill and vapor recover shall also be protected against vapor release unless connection of the liquid delivery line to the fill pipe simultaneously connects the vapor recovery line, e.g., an interlock. All connections must be vapor tight.

8. Vapor Hose Connection to the Tank Truck. A means must be provided to assure that the vapor hose is connected to the truck before fuel is delivered. Acceptable means of providing this assurance include: (a) permanent connection of the vapor hose to the truck; (b) an interlock which prevents fuel delivery unless the vapor hose is connected, such as a bracket to which the product and vapor hose are permanently attached so that neither hose can be connected separately; and (c) a closure in the vapor hose which remains closed unless the hose is attached to the vapor fitting on the truck.

9. Vent Line Restrictions. Vent line restrictions improve recovery efficiency and provide assurance that the vapor return line will be connected during transfer. If the liquid fill line were attached to the underground tank and the vapor return line disconnected, closures would seal the vapor return path to the truck forcing all vapors out the vent line. Restriction of the vent line through the use of an orifice or pressure-relief valve greatly reduces fill rate in such instances warning the operator that the vapor line is not connected.

Suitable restrictive orifices or pressure-relief valves are required wherever the systems would otherwise be incapable of achieving 90 percent control or would otherwise not assure that the vapor return line is connected. For available hardware this means that these restrictive devices are necessary for all except systems with interlock connections at both the truck and storage tank.

Either of the following restrictive devices are acceptable:

(a) Orifice of 1/2 to 3/4 inch ID.

(b) Pressure-vacuum relief valve set to open at 8 oz. per square inch or greater pressure and 4 oz. per square inch or greater vacuum. The vacuum relief feature of a P-V valve is not required for Stage I recovery purposes but may be required by safety authorities.

The NFPA Interim Amendments (April 1975) to Code 30 require that when vent restriction devices are used the tank and associated piping be protected to limit back pressure development to less than the maximum working pressure of the tank and equipment by the provision of pressure vacuum vents, rupture discs or other tank venting devices installed in the tank vent lines, and that these devices shall be protected to minimize the possibility of blockage from weather, dirt, or insect nests. Local fire marshals should be consulted regarding the use of these devices in your area.

References

1. Performance of Service Station Vapor Control Concepts, Scott Research Laboratories for the American Petroleum Institute, Interim Report, June 26, 1974.

2. Service Station Vapor Recovery, Atlantic-Richfield Company, April 8, 1974.

3. Presten, J. E. et al, The "Displacement" System: An Effective Method of Controlling Hydrocarbons, November 1973.

4. TRW Contract Test, June 1974, San Diego, California.

5. Bay Area Air Pollution Control District, 1974.

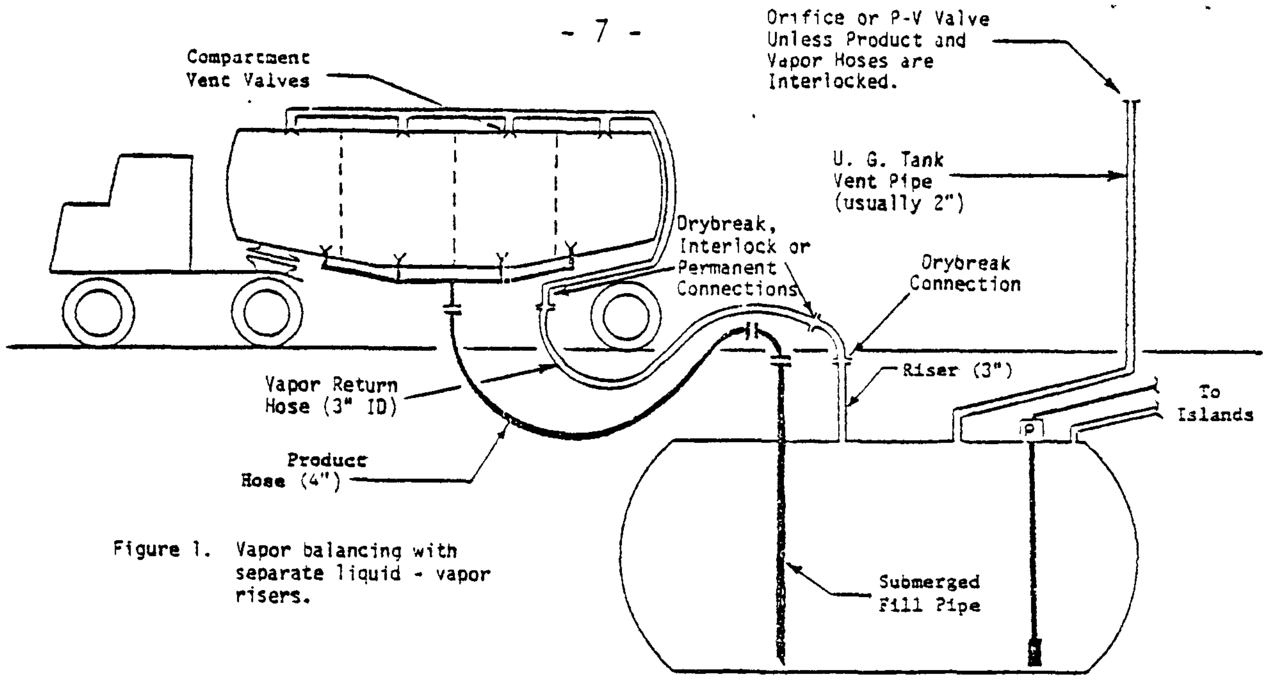

Figure 1. Vapor balancing with separate liquid - vapor risers.

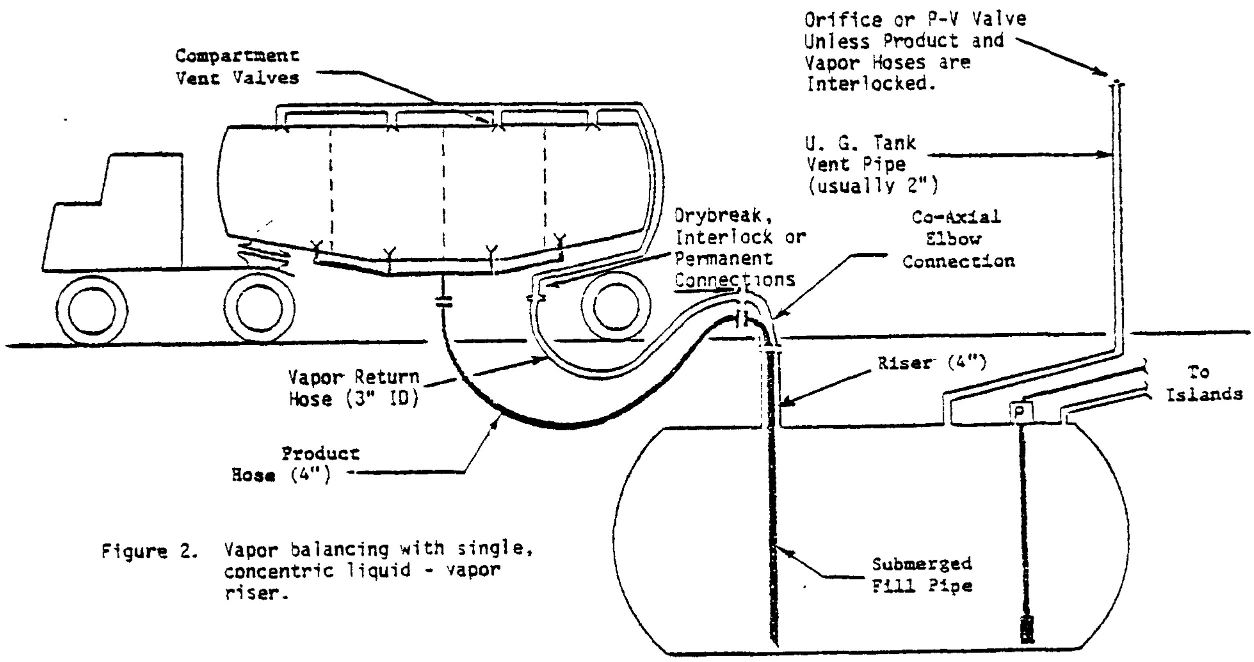

Figure 2. Vapor balancing with single, concentric liquid - vapor riser.

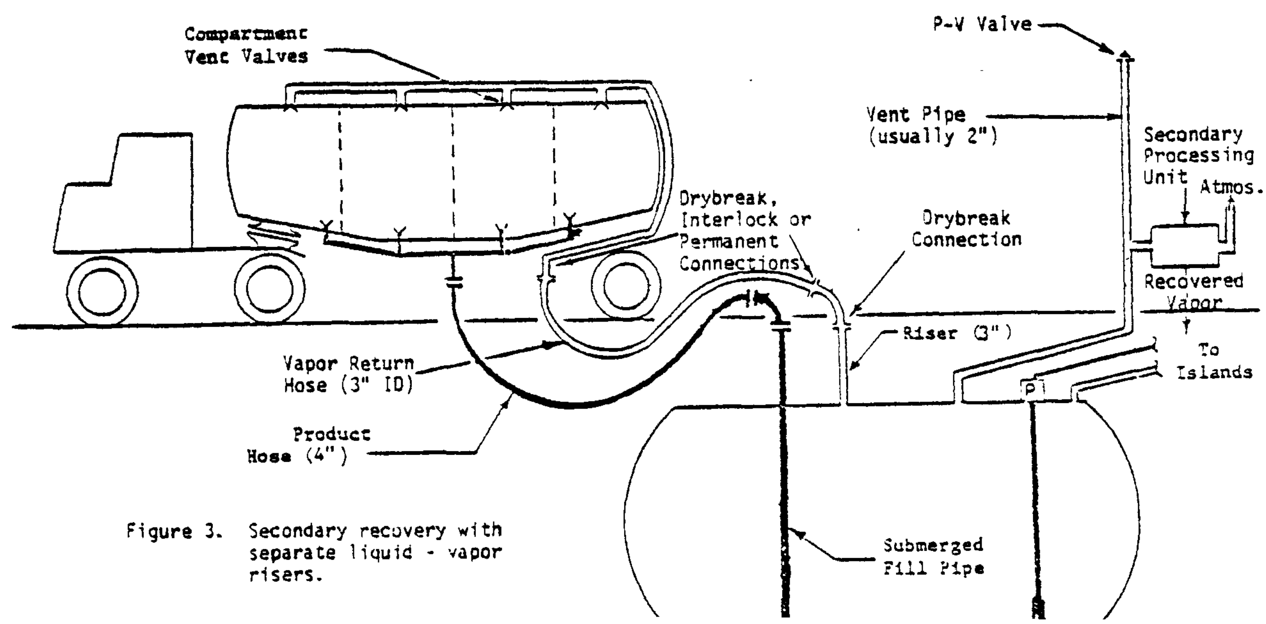

Figure 3. Secondary recovery with separate liquid - vapor risers.

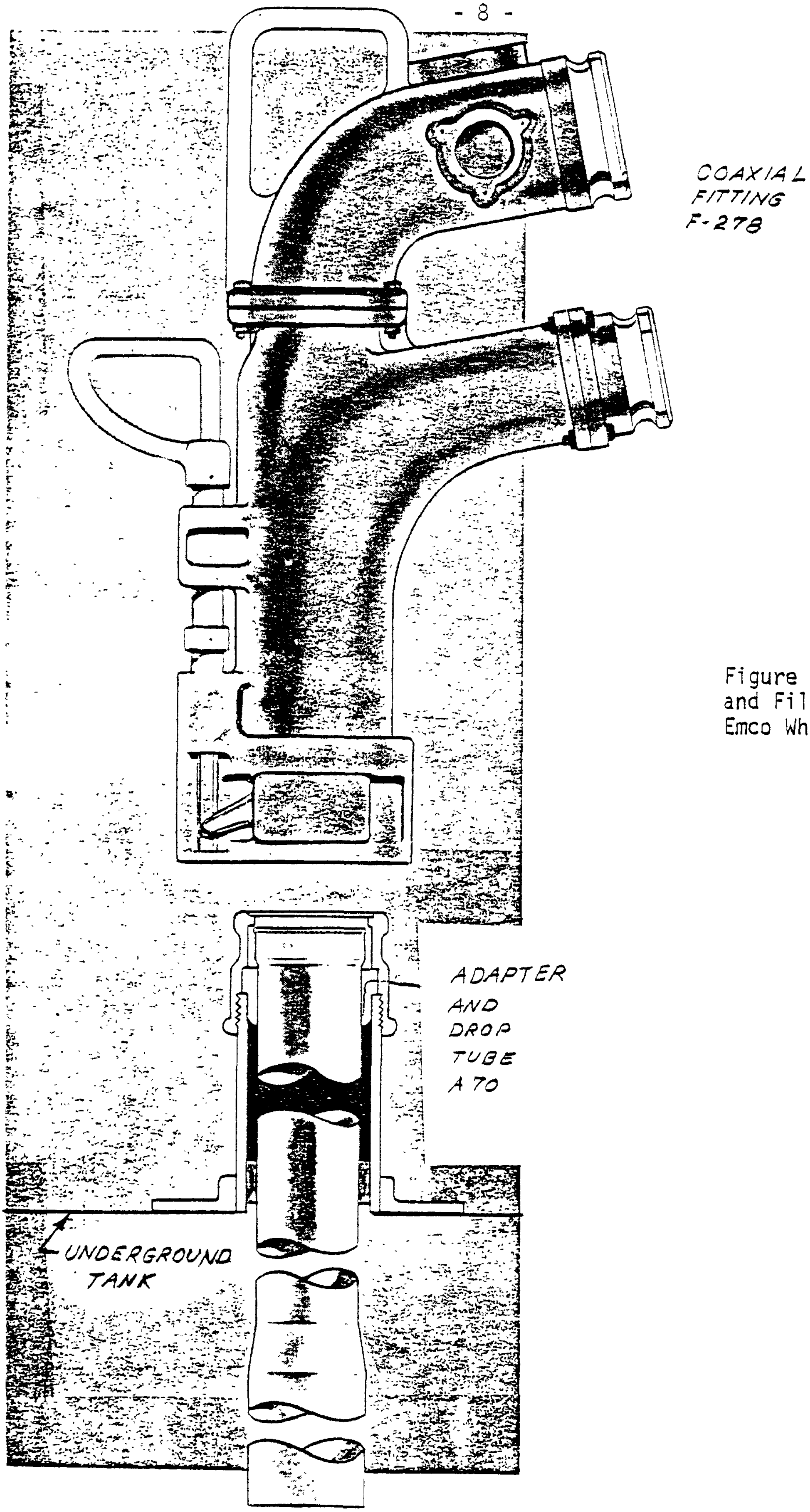

Figure 4. Coaxial Fitting and Fill Tube Adapter. Emco Wheaton Inc.

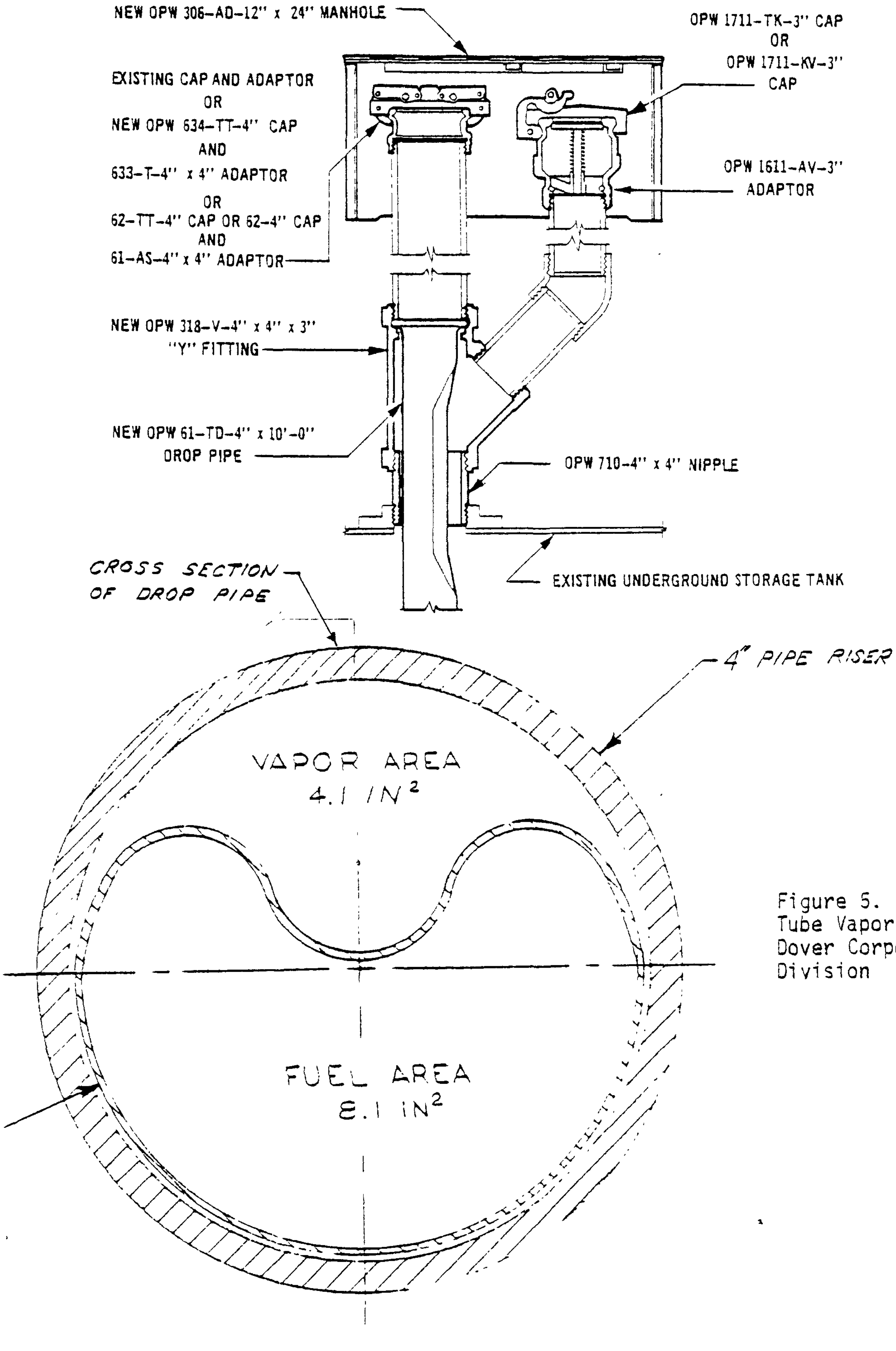

Figure 5. "Y" Tube-
Tube Vapor Return F
Dover Corporation/OI
Division

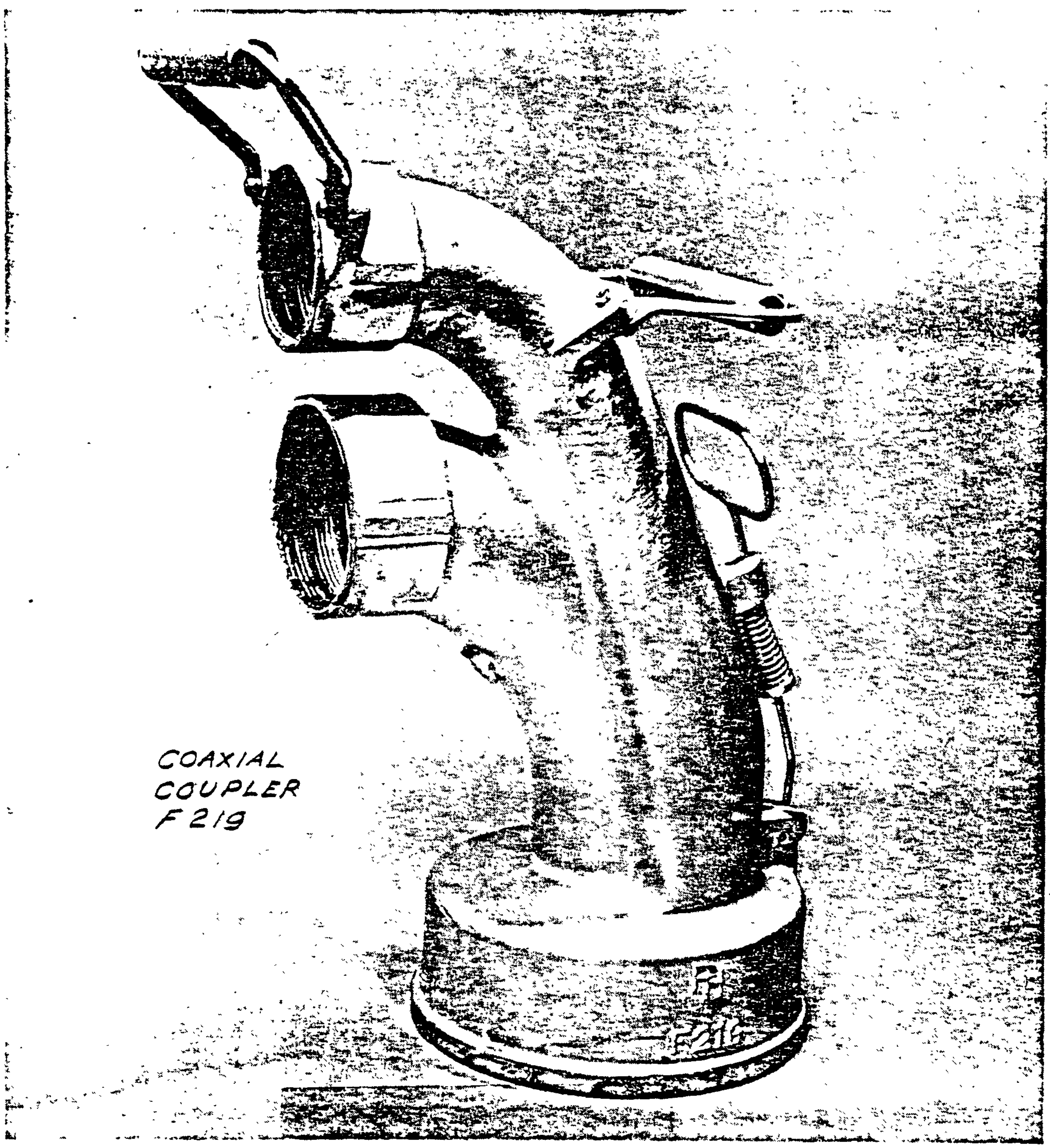

Figure 6. Coaxial Fitting for 6" Riser Pipes.
Parker Hannifin, Inc.

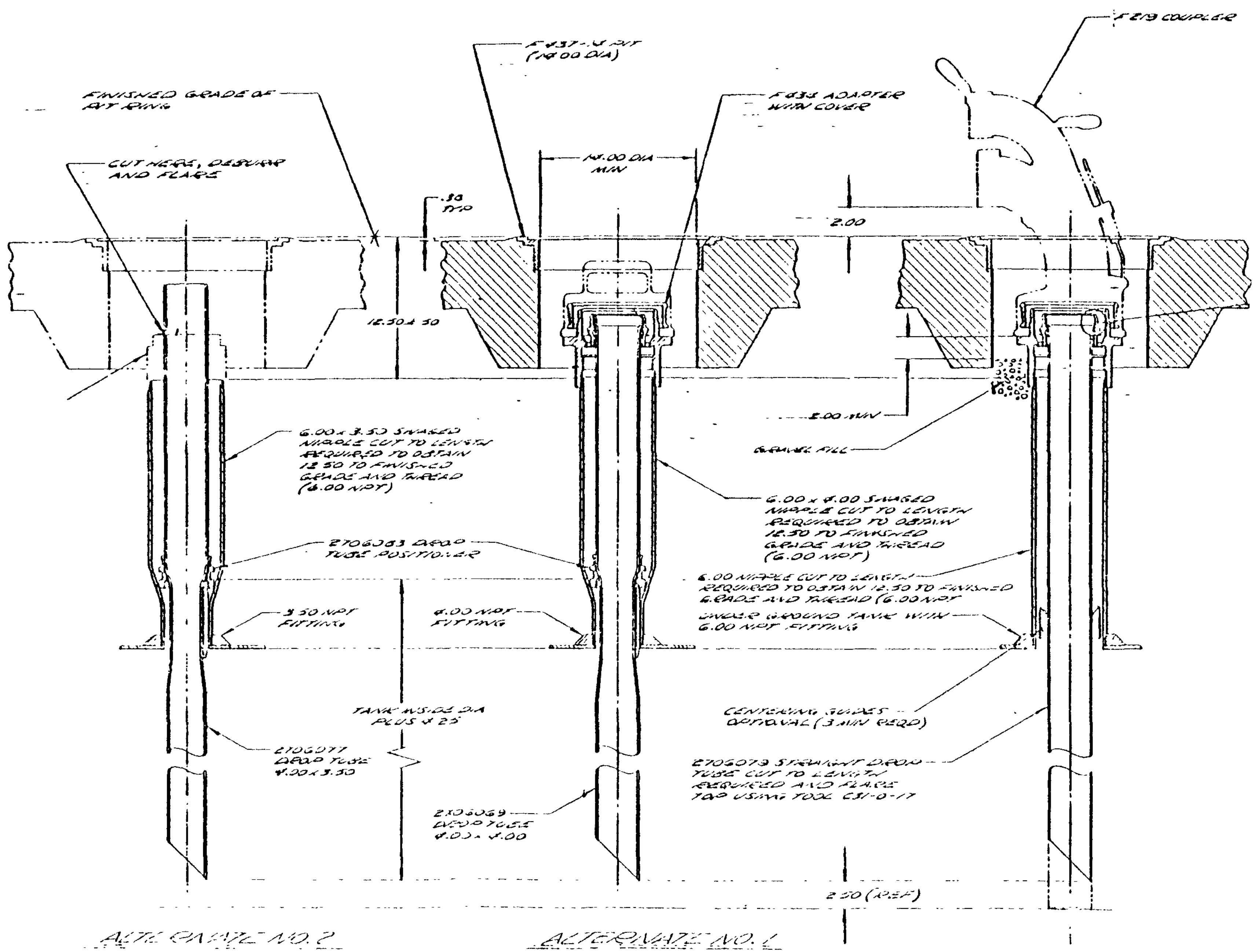

Figure 7. Risers and Drop Tubes Used With F 219 Coupler. Parker Hannifin, Inc.

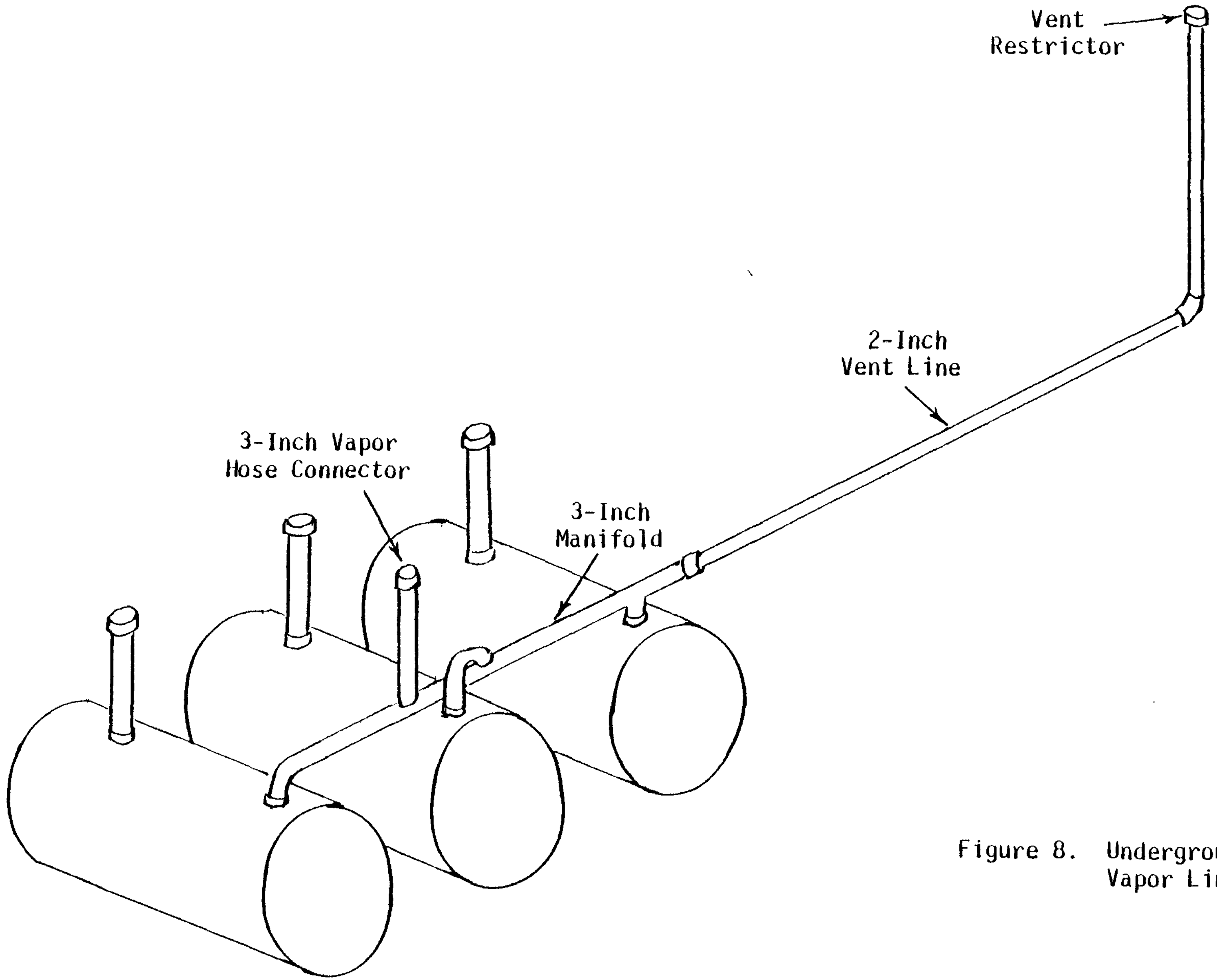

Figure 8. Underground Manifolding of Vapor Lines

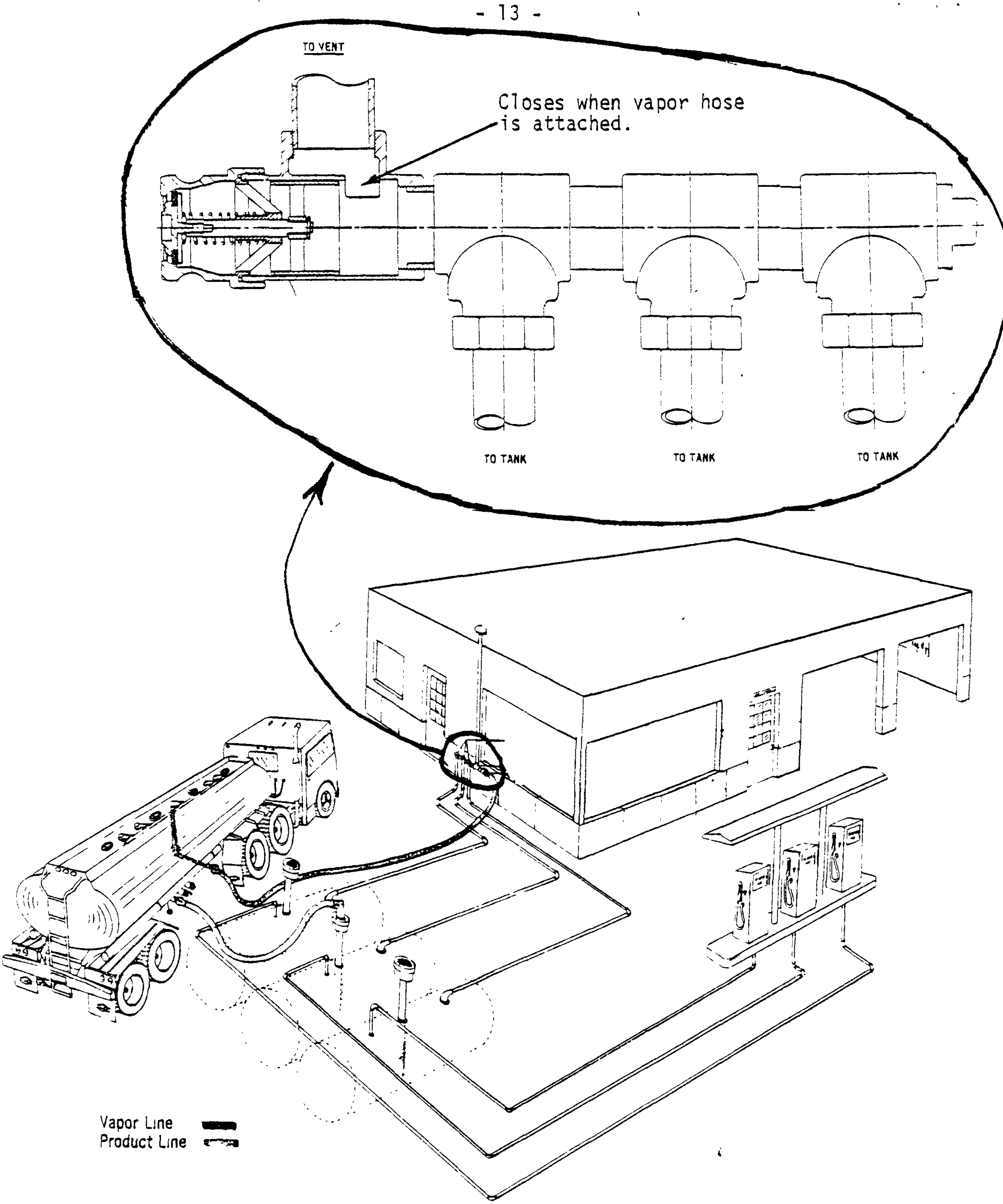

Figure 9. Aboveground Manifolding of Vapor Lines.

Attachment A*
(Revised November 1975)

Concentric and tube-in-tube couplers for which test data show acceptable performance:

1. Emco Wheaton 4-inch Coaxial Fitting F-278, adapter and Drop Tube Assembly A70-001.

2. Emco Wheaton 4-inch Coaxial Fitting F-278. Adapter with a 4-inch to 3-inch bushing and Drop Tube Assembly A70-003.

3. Dover Corporation/OPW Division 4-inch Tube-In-Tube Y-Fitting No. 318 with 61-TD-4 Inch Drop Pipe.

4. Parker Hannifin 6-inch Coaxial Fitting F-219 with a 6-inch Straight Riser or a 6-inch by 4-inch Riser.

5. Universal Valve 4-inch Fill/Vapor Return Fitting No. 715.

*This attachment has no relation to "two point" systems, i.e., systems with a separate connection for the vapor return hose to the underground tank. Such systems are to be evaluated by the Criteria.