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LPG DRIVER ATTENDED TRANSPORT LOADING

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INTRODUCTION

The safest and most accurate method of transferring LPG from bulk storage to a transport is through a reliable metering system. The basic concept in designing an LPG Metering System is to provide dependable components, which can safely be operated by drivers or plant personnel. The system must provide a means to limit the filling of the transport and provide a hard-copy of the total volume and the amount of odorant injected for each loading transaction.

Basic equipment and design considerations should include the following:

DESIGN CODES

The thorough review and understanding of Design Codes and Safety Standards are the first steps in planning a successful installation. Design Codes may vary slightly from state to state. Most states adopt National Codes and guidelines such as the Department of Transportation (DOT) covering transportation regulations, the American National Standards Institute (ANSI) covering pipeline and refinery locations, the American Petroleum Institute (API) covering custody transfer metering and proving and the National Fire Protection Agency (NFPA) covering safety design considerations.

DESIGN CONDITIONS

The following parameters should be considered in the design of an efficient and reliable metering system;

1. Flow Rate - Design flow rate is based on the size and type of filling connections furnished on the LPG transports to be loaded. Loading rates will also be affected by the LPG transports internal liquid and vapor connections and whether they are equipped with internal spray bars. Once design flow rate is established, the metering and piping system can be sized.

2. Working Pressure - Design working pressure is based on the vapor pressure of the product at the highest operating temperature and the total pressure drop between the storage facility and the transport loading manifold. Once design working pressure is determined, the LPG transfer pump rate and the piping ANSI rating can be established.

3. Operating Temperature - Product temperature, as well as ambient temperature, must be considered in order to prevent the possibility of measuring vapors instead of liquids.

4. Metering Location - After a location is selected, the line size and distance between the storage facility and the metering facility should be considered. Whether the product supply lines are to be buried, exposed or insulated should be evaluated.

5. Odorant Rates - Since LPG is colorless, odorless and heavier than air in the vapor state, it is necessary to add an artificial odor to warn users of its presence. The most common odorant in use today is ethyl mercaptan. Most states require a minimum of 1.0 pound of odorant be injected into 10,000 gallons of LPG. Due to a condition called "odorant fade", which occurs in new tanks and piping systems, and to allow a margin of safety, most installations agree on an odorant rate of 1.5 pounds of odorant per 10,000 gallons of LPG loaded.

COMPONENTS

Major components to consider in designing an LPG Metering System are illustrated in Figure 1 and would include the following;

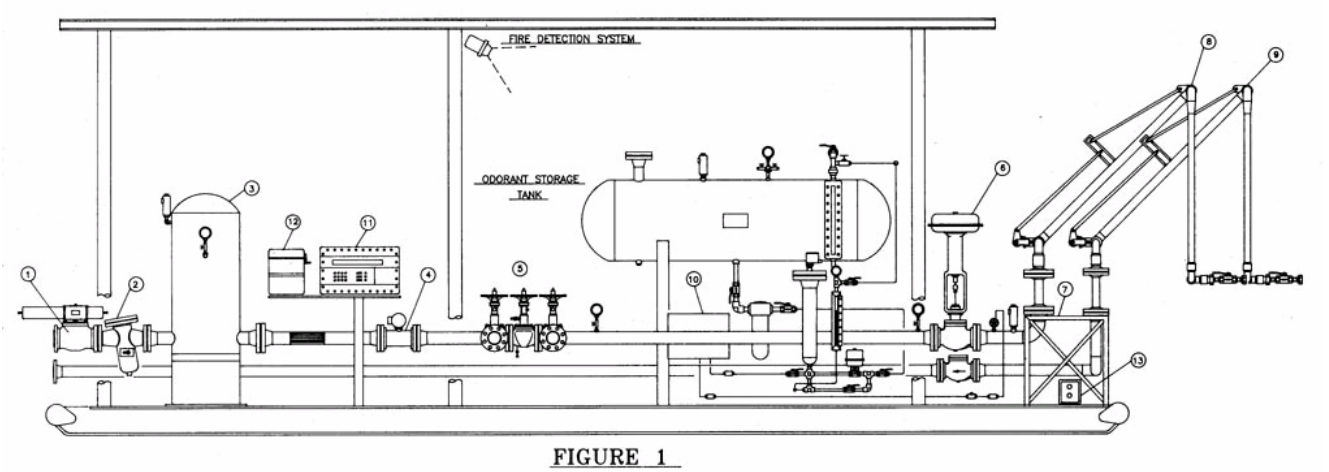

FIGURE 1

1. Emergency Shut-Down Valves (ESD) - An ESD valve is a self- contained, normally closed valve which can be actuated on loss of a control signal to automatically shut-down product flow any time there is an emergency condition. These valves are installed at the storage facility, at the inlet to the metering system, at the outlet of the metering system or at all locations. When used at the inlet to the metering system, the ESD valve can also be used for product isolation and for strainer cleaning purposes.

2. Strainer - A strainer is a device which houses a removable perforated basket designed to collect solid materials present in the flowing stream. A strainer is not designed to filter the product, but to collect large contaminants which may cause damage to the meter.

3. LPG Condensing Tank - Condensing tanks are used to ensure a liquid head on the meter at all times and to provide for product condensation by condensing vapors as they are formed during product flow. Condensed liquids are also used to fill voids created by product contraction during idle periods. Depending upon the distance from the storage facility to the metering and loading system, it may be necessary to consider the use of an LPG condensing tank.

4. Meter - The meter is the most critical component of an LPG Transport Loading System and care should be given in selecting only the most accurate meter. The two most common types of meters in use today are the turbine meter and the positive displacement meter.

   * The turbine meter is an inference type meter that derives flow based on properties of the flowing stream, such as angular velocity, which is proportional to flow. Since the turbine meter depends upon properties of the flowing stream, it is necessary to condition flow into the meter using doweled upstream and downstream piping sections in accordance with API Guidelines. Turbine meters use an electronic pick-up coil and preamplifier to transmit meter pulses to an electronic counting totalizer. The turbine meter can be an accurate LPG metering device provided flow parameters are controlled and suitable electronics are used. The advantage of the turbine meter over the positive displacement meter is that it does not use an external packing gland and is less expensive to install and repair. In most cases a turbine meter will be one pipe size smaller than an equivalent positive displacement meter. The disadvantage of the turbine meter is a lower accuracy based on fluctuating flows during start/stop loading. It also develops a higher pressure drop compared to the positive displacement meter.

   * The positive displacement meter determines flow through the use of an internal rotating device by dividing the flowing stream into discrete volumetric segments using a small amount of energy from the flowing stream. Metered volume is transmitted using a mechanical gear train through a packing gland. Any number of meter accessories may be attached to the meter to provide electrical pulse outputs and

mechanical totalization. The advantage of the positive displacement meter over a turbine meter is that it is more accurate, does not require flow conditioning pipe spools and is a low pressure drop device.

5. Prover Manifold - Regardless of the meter selected for custody transfer, provisions must be made to allow meter calibration. A simple solution is to provide a three-valve prover manifold using two piping tees with two valves side-mounted between an inline valve. The inline valve must be a quality block and bleed type with provisions to determine seal leakage during a meter calibration, since every drop of liquid going through the sales meter must go thorough the prover system. The prover manifold allows the sales meter to be placed in series with a proving device of a traceable and known volume. A ratio between sales volume and prover volume ("meter factor") is used to determine true volume. The prover manifold should be furnished with a temperature indicator (and/or transmitter) and a pressure gauge (and/or transmitter) which are used to communicate to the electronic preset controls and to the proving system during a meter proving. The most common provers used for LPG meter calibration are the Bi-Directional prover, the small volume prover and, in some cases, the master meter.

6. Control Valve - Installation of a control valve that is capable of providing differential back pressure and flow control is the key to accurate metering. Differential back pressure control is accomplished by continually monitoring temperature and pressure during a transport loading and adjusting valve position to insure that product is always metered above vapor pressure, regardless of the product flowing temperature. The most desirable valve is easily and accurately controlled by either a mechanical or electronic preset system. It should also be capable of providing controlled opening (to prevent line surges), controlled closing (to prevent hydraulic shock) and of being used as an emergency shut-down valve. It is important to consider a dynamically stable "fail closed", pneumatically operated diaphragm valve rather than a self contained valve dependent upon LPG energy and differential pressure across the valve to provide control. Most self contained valves depend upon solenoids and pilots to provide valve control and they are difficult to control with fluctuating flows generally encountered in loading LPG transports. Maintenance problems are greatly reduced by using the diaphragm type valve, with the only disadvantage being that instrument air or nitrogen is required during operation.

7. Discharge Spool and Bulkhead - A discharge spool equipped with all necessary pressure gauges, thermal relief valves, an odorant injection point and a mechanical excess flow valve (if required by regulations) must be provided. A bulkhead is a fabricated steel or concrete structure that is used to rigidly mount and install the load arms to prevent damage to the piping system in case a transport accidentally drives away with an arm connected. It is important to install the arm in a vertical position because it is easier to control an LPG fire in the vertical position should a transport separate a loading arm from a bulkhead and a fire develop. Some states require that a mechanical excess flow valve be installed upstream of the bulkhead to limit the amount of LPG that escapes if a loading arm is accidentally separated from the bulkhead. Some states also require that the outlet piping to the bulkhead be furnished with a length of flexible hose to help absorb the shock should a loading arm be pulled away from the bulkhead.

8. Rigid Loading Arms vs. Hoses - A rigid loading arm is constructed of piping sections connected to several swivel joints to allow manipulation. The weight of a typical arm is offset using a counterbalance or spring-balance assembly. An advantage of the rigid loading arm is that it is an extension of the piping system and a manual shutoff valve can be installed on the outlet end. Many installations prefer to use hoses in lieu of rigid loading arms due to their flexibility and ease of attachment to an LPG transport. The disadvantages of the hose are the low rated working pressure (usually 350 PSIG maximum) and the potential damage to the hose due to high thermal expansion of LPG if a hose is left pressurized. Even with the use of thermal relief valves, most installations prefer to bleed the hoses to a flare header after each loading sequence to prevent possible over-pressurization due to thermal expansion. Should hoses be considered, use only hoses which are Underwriters Laboratories (UL) approved and stamped for LPG service.

9. Vapor Return Arms or Hoses - Should a vapor return arm or hose be required to relieve transport pressure buildup during loading, it should be installed using a bulkhead. A check valve should be furnished

immediately upstream of the bulkhead to prevent backflow of product to the atmosphere in the event an arm or hose is pulled away by the transport.

10. Odorant Injection System - A fail-safe automatic odorant injection system should be selected that injects odorant proportional to flow and provides a printed record of the odorant injected for each loading transaction. The system must be designed to alarm and shut down loading any time an odorant malfunction develops. Some states require that a sight glass assembly be provided to give operators a visual indication of the total amount of odorant injected for each loading transaction. Refer to Figure 2 for a typical odorant system design using a pressurized nitrogen storage tank, a calibrated sight glass assembly and an odorant injector.

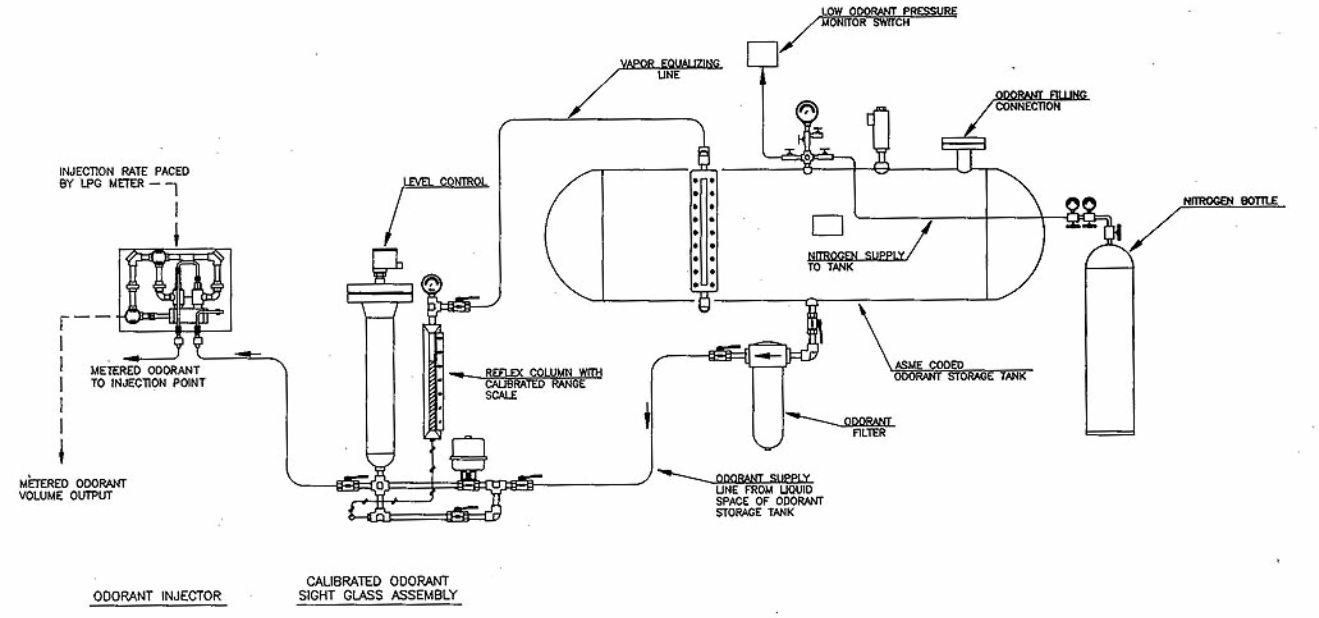

FIGURE 2

11. Electronic Presets - Provisions should be made to allow operators to preset the volume of product to be loaded. This is best accomplished using electronic or mechanical preset counters. Electronic presets should be capable of presetting either temperature corrected (net) volumes (using a temperature transmitter input), non-temperature corrected (gross or water volume) and pressure compensation (using a pressure transmitter input). An electronic preset should provide visible indications of all phases of operation, including alarms and safety shutdowns. In addition, they should provide full valve control by manipulation of simple solenoid controls installed on the control valves. These valve controls should include differential back pressure (using a pressure transmitter input), flow rate, slow speed start and zero no-slam shutoff. Most electronic presets have multiple transmitter outputs as well as RS-232 and RS-485 communication outputs which lend themselves to both simple and sophisticated automation systems.

12. Printer - A printer capable of providing a record of each transaction should be provided. The printer should be capable of printing the amount of LPG metered as well as the amount of odorant injected for each loading transaction.

13. Electrostatic Grounding - Electrostatic grounding is used to discharge or dissipate a static buildup which may develop on an LPG transport prior to loading. The electrostatic grounding system should provide a visual indication, as well as an electrical permissive signal, when an LPG transport has been satisfactorily grounded. If a grounding connection is interrupted during a loading sequence, the system should be designed to shut down loading until the ground is re- established.

14. Safety Features - Safety features should include automatic "ESD" valves which are designed to shut down all loading when activated locally or from a remote location. Additional safety devices should include fire sensors and combustible gas detectors.

15. Weather Protection - A drivers' building with insulation and heating should be considered in colder climates. As a minimum, a canopy should be considered to help minimize the effect of the sun on piping thermal expansion in warmer climates.

16. Remote Data or Accounting System - The application may dictate the installation of a Remote Data or Accounting System utilizing a microprocessor or personal computer (PC) designed to interface with the loading system. Features should include customer identification and product release though a card reader or keypad entry, time and date of loading, product volumes, amount of odorant injected, limitation of the amount of product to be loaded by each transport and customer lockouts due to credit. The system should be capable of printing a manifest as well as communicating information on each loading transaction to a host computer system.

Summary - Through good design and planning, a safe and reliable system can be provided for LPG Driver Attended Transport Loading.