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Truck Unloading Metering Systems

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Introduction

The purpose of this paper is to discuss a method of metering the liquid hydrocarbon fuels or chemical products delivered by typical tank trucks. Also included will be receiving methods, essential considerations required, the receiving equipment required, such as pumps, meters, air eliminator tanks, strainers, control valves, and alarm devices. A section will also be devoted to the performance of these systems in terms of accuracy and efficiency.

Recent marketing studies have revealed an estimated 20,000 facilities in the U.S.A., such as manufacturing or process plants, electric utilities, hospitals, institutions, etc., buy more than $37,813,381,000 (see Reference 1) worth of fuel oil each year, much of which is unmetered. Also, although this paper is about truck unloading, there are about 850,000 rail car loads of petroleum products (not including petrochemicals) that are unloaded without accurate accountability. The considerations for unloading rail cars are very similar to truck unloading.

Truck Types and Manifolds Typically Used

The tank trucks typically used would be represented by the diagram shown in Figure 1. The typical tank truck has four compartments, each containing 2,000 gallons, thus totaling 8,000 gallons for the entire load.

A typical piping or outlet manifold arrangement could be for individual discharge outlets or manifolded together as shown by Figure 2. The piping connections shown are also used for bottom loading the tank truck.

Receiving Positions and Types

It is customary to receive liquid hydrocarbon fuels by means of either gravity flow to lower than grade storage tanks, or by pumping product into above grade storage tanks. The gravity flow systems are rather simple, and the most common example is the typical system used at gasoline stations where the truck connects its bottom outlets with a flexible hose to the tank inlets at the ground level.

A typical system for pressure applications is shown in Figure 3. The main elements of this system are the air

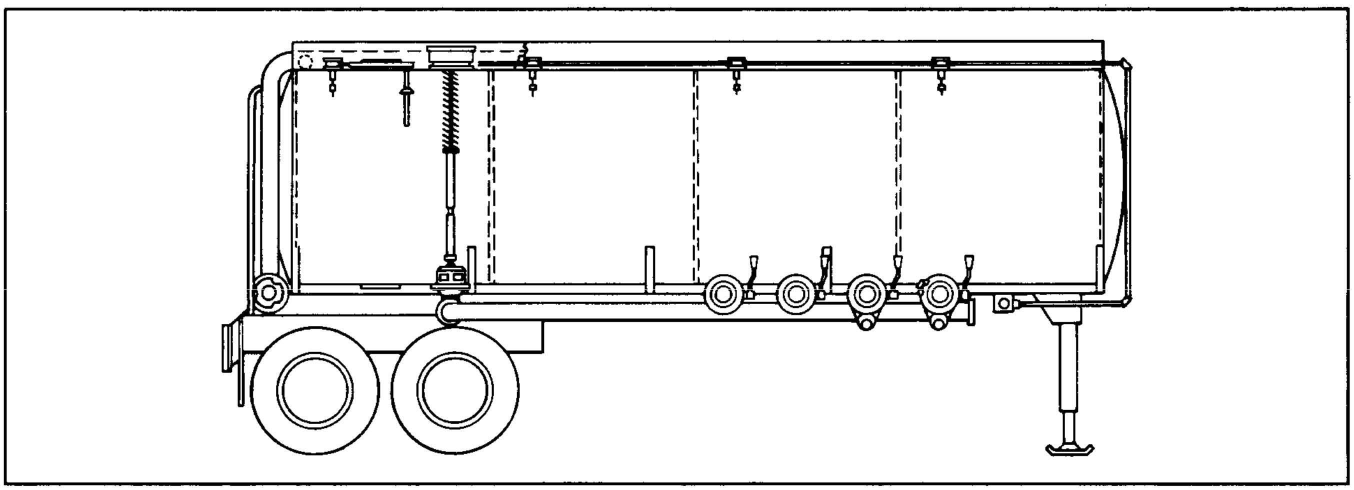

Figure 1 — Typical Tank Truck

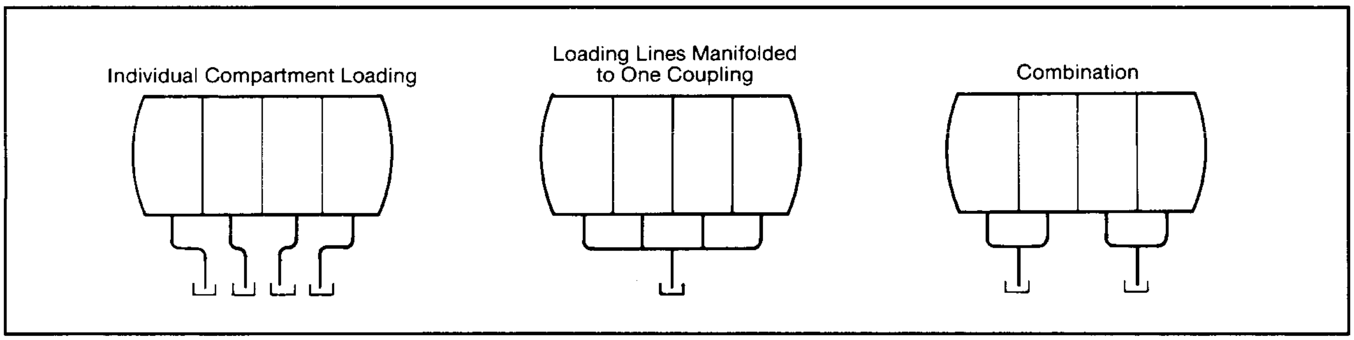

Figure 2 — Truck Manifolds

eliminator tank with its air sensing float switch system, the air vent system around the meter, the positive displacement meter, and the flow control valve which will be discussed later. The pump for this system can be either on the delivering truck or permanently ground mounted as part of this system. Other features of this system can include water detectors, which shut down the system if water is detected, or remote overfill protection devices, which can also shut down the flow control valve if the maximum tank fluid level is achieved.

Essential design considerations are:

- Safety
- Accuracy
- Accountability
- Reliability
- Security

Safety

Safety is maintained by careful selection of the proper materials, flange ratings, flow ratings, electrical approvals, pressure and temperature limits, and correct flow capabilities.

Accuracy

Accuracy is spelled "MONEY" and is documented by NBS (National Bureau of Standards) metering rules and guidelines. Basically, a meter should be used with a demonstrated capability of ±0.1% accuracy or better. This is verified by proving and calibration operations, which should be performed at least two times a year.

Accountability

Accountability is maintained by the utilization of a receiving ticket which provides a numerical record of the amount of product received. In order to avoid expansion and contraction errors, it is possible to obtain a volume record that shows the amount of fuel corrected to a 60° F temperature. Thus, the record of fuel on hand can always refer to one standard temperature. The incoming fuel ticket can also be obtained with the temperature corrected amount as well. The product dispensed from the storage tanks can also be metered and controlled if desired. This provides a complete "in vs. out" record.

Reliability

Reliability is obtained by procuring the metering system equipment from a reputable source who has a proven record of supplying reliable equipment to the petroleum industry. A nationwide sales, spare parts, and service organization helps considerably when requests are made for additional equipment, or should replacement parts be required, or if the assistance of a field service person is needed.

Security

Security steps must be taken to minimize the possibilities of product pilferage. Such pilferage can be the result of tampering with the metering equipment by unauthorized personnel.

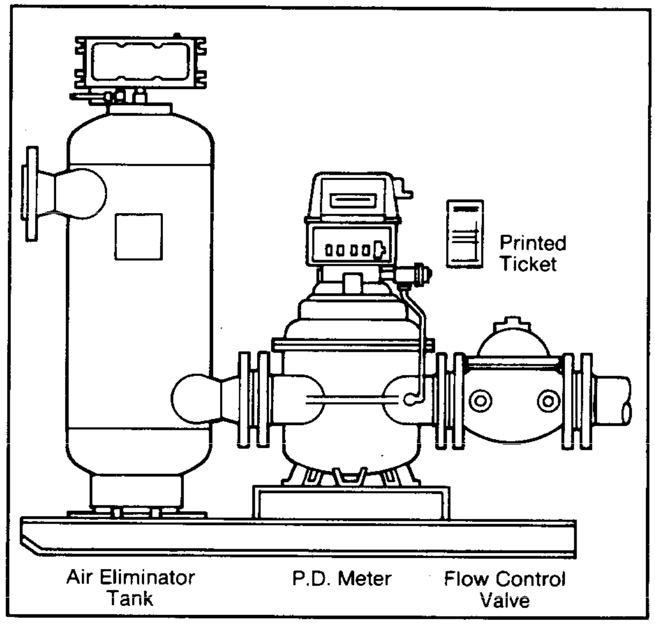

Figure 3

Equipment

Equipment normally required to perform the truck unloading metering includes the following:

- Pumps
- Air Eliminator Tanks
- Meters and Accessories
- Flow Control Valves
- Water Detectors
- Backflow Prevention
- Overfill Alarms

Pumps

Pumps are required if the storage tanks are at a higher elevation than the tank trucks, or if the flow rate achieved during gravity flow is not acceptable. Several types of pumps are used, including centrifugal and positive displacement types. A typical system to handle an 8,000-gallon truck to unload approximately 20 minutes would require a flow rate capability of 400 gpm against the flow resistance (head loss) created by the receiving equipment, the lines to the tanks, and the height of product in the tank itself.

Air Eliminator Tanks

The elimination of gas and vapors from liquid product metering systems is essential to metering accuracy. The presence of entrained and/or slug air has long been recognized as a potential threat to optimum accuracy, and there are various methods utilized to eliminate the entrapped air before it can pass through the metering element.

The most efficient means of eliminating air before it can pass through the system meter is the utilization of a settling tank. The principle by which a settling tank expels entrapped air is a simple one — the product to be metered is allowed to accumulate in a large tank or basin creating a zero velocity situation, during which time the air, being lighter than the liquid, rises to the top of the accumulated liquid and escapes to atmosphere. The level of efficiency of this method is a direct function of the product viscosity and the duration of the "settling" period.

Because a significant amount of time is required to separate all of the entrained air from a volume of liquid, the settling tank method may not always be a practical one. In addition, the capital investment required and space limitations of an installation might also prohibit the settling tank approach. A common alternative is the installation of an in-line air eliminator tank upstream of the system meter. The method of operation of an air eliminator is similar to that of a settling tank. Since the air eliminator tank body diameter is significantly larger than the adjoining system piping, the velocity of the product passing through the tank is reduced, allowing air trapped within the liquid time to rise and accumulate at the top of the vessel. However, since the flow condition through the air eliminator is not a zero velocity condition, it is likely that the bulk of "slug air," and only a portion of the entrained air, will be separated from the liquid due to a lack of sufficient "rise time." To enhance the removal of the entrained air, a series of "scrubber plates" can be incorporated into the air eliminator tank. As the product passes through the tank, the entrained or smaller "bubbles" of air collect along the scrubber plates, which are inclined in parallel, and then rise to the top of the vessel.

Both horizontal and vertical body styles are used in the design of air eliminators. In the "horizontal" mode, the tank body is typically installed in parallel with the system piping, with the inlet and outlet flanges on the same center line as the piping. This arrangement allows for the use of the aforementioned scrubber plates, as well as a perforated baffle plate, which is typically installed internally near the inlet side of the tank. The baffle plate further enhances the separation of air from the liquid by equally distributing the flow through the vessel. In addition, the horizontal design lends itself to a multiple air release head arrangement which is advantageous in high flow capacity systems.

In "vertical" tank designs, the body is upright, perpendicular to the system piping, the inlet flange located near the top of the tank and the outlet flange close to the bottom. When the inlet and outlet nozzles are installed tangentially to the tank body, air removal is enhanced by centrifugal forces caused by the "swirl" of the product along the tank wall as it passes through the vessel.

Both horizontal and vertical air eliminators are with an air release port or "head." The air release head provides an escape path for the accumulated air, venting the air

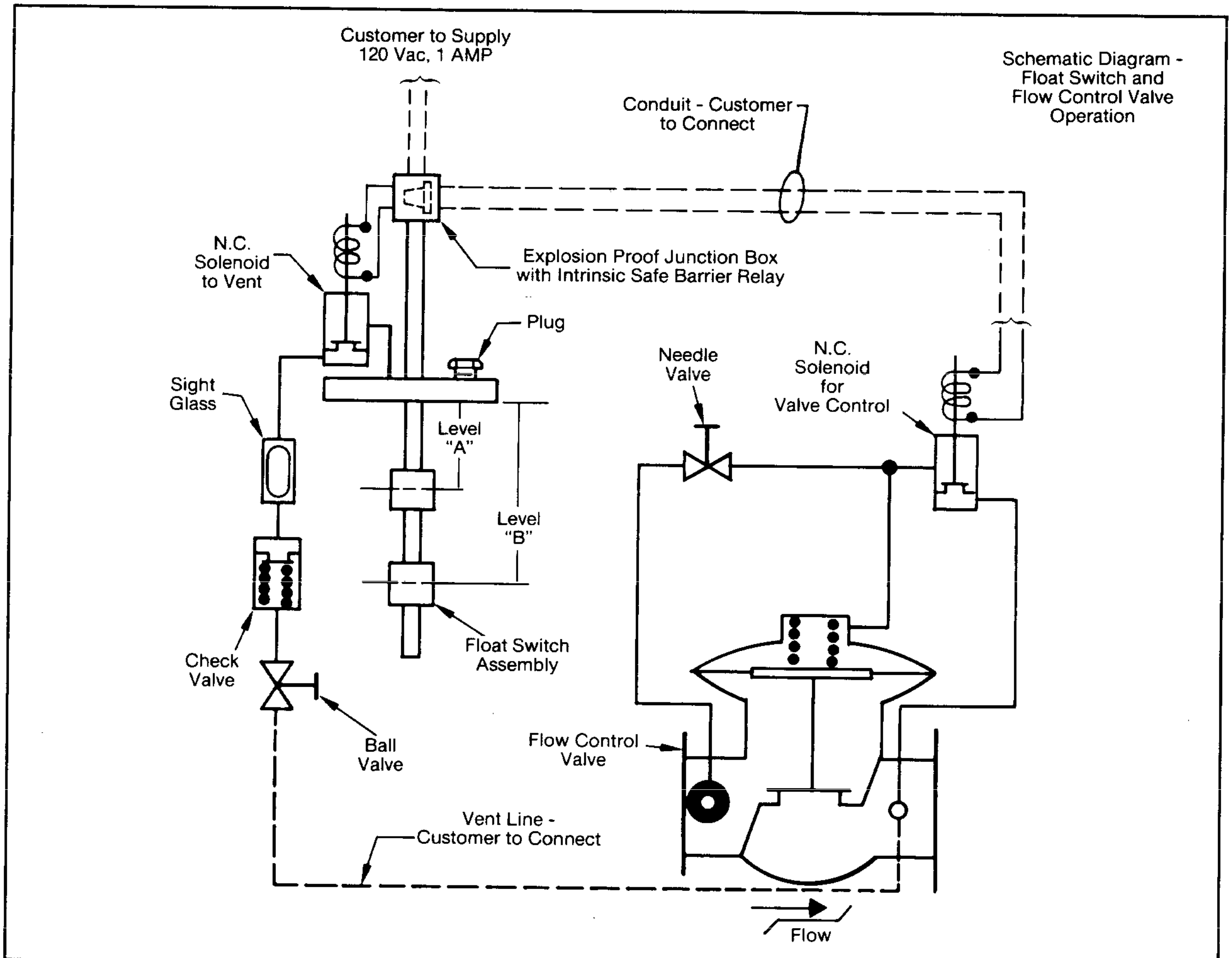

Figure 4

to atmosphere or to a point upstream or downstream as dictated by the system design. The most basic air release head is the poppet/float arrangement where a float, connected by a rod to the head poppet assembly, is suspended from the top of the tank. When the tank is sumped or full of liquid, the float is buoyed near the top of the tank blocking the air vent path. As air accumulates, the float begins to drop, opening the poppet, allowing the air to vent from the tank.

Another float style of a mechanical air release head commonly used is the "rocker" or "roll band" design. This arrangement features a float connected to a steel band which wraps around or lays over a block through which the vent port is drilled. As the float drops, the band peels off the vent port allowing the accumulated air to be released.

A more sophisticated approach to air elimination is one in which an air sensing device interfaces with a block valve installed downstream of the system meter. By this method, when a significant amount of air is detected, the block valve closes quickly, stopping flow until the air is expelled from the air eliminator tank. This simulates the zero velocity condition realized when a settling tank is in use. The valve reopens when all of the sensed air is eliminated.

One method of sensing air utilizes a device for monitoring the capacitance of the fluid. When the capacitance of the fluid changes due to the increased presence of air, an electrically controlled system valve is closed, preventing the resumption of product flow until the air is released.

Another method of combining an air sensing device with a block valve is one which utilizes a dual float switch assembly suspended from the air release head which is electrically connected to a valve installed downstream of the meter. (See Figure 4).

When the fluid level stays at or near Level "A," the float control valve is allowed to remain open, permitting flow, until the trapped air causes the liquid level to drop below Level "B." When the lower float drops, a switch is tripped and solenoid electrical power is interrupted by the intrinsically safe relay, thereby closing the flow control valve and stopping product flow. This same switching action also causes the vent solenoid valve to open to release the trapped air out of the vent port. As the trapped air is vented and replaced by rising liquid, the float control valve remains closed until the liquid rises to the high float or Level "A." This raises the upper float and trips a second switch. This logic de-energizes the vent solenoid to close it and cease the venting action while simultaneously energizing the solenoid on the flow control valve, permitting it to open slowly to resume flow.

As was mentioned previously, a major factor affecting the separation of liquid and air is the product viscosity. The removal of entrained air from a viscous product has always been considered virtually impossible unless the settling tank approach were used. The dual float switch/block valve method of air elimination is adaptable to high viscosity product applications and provides a substantial improvement over poppet or roll band systems. The Smith Model DE-2, for example, is typically used

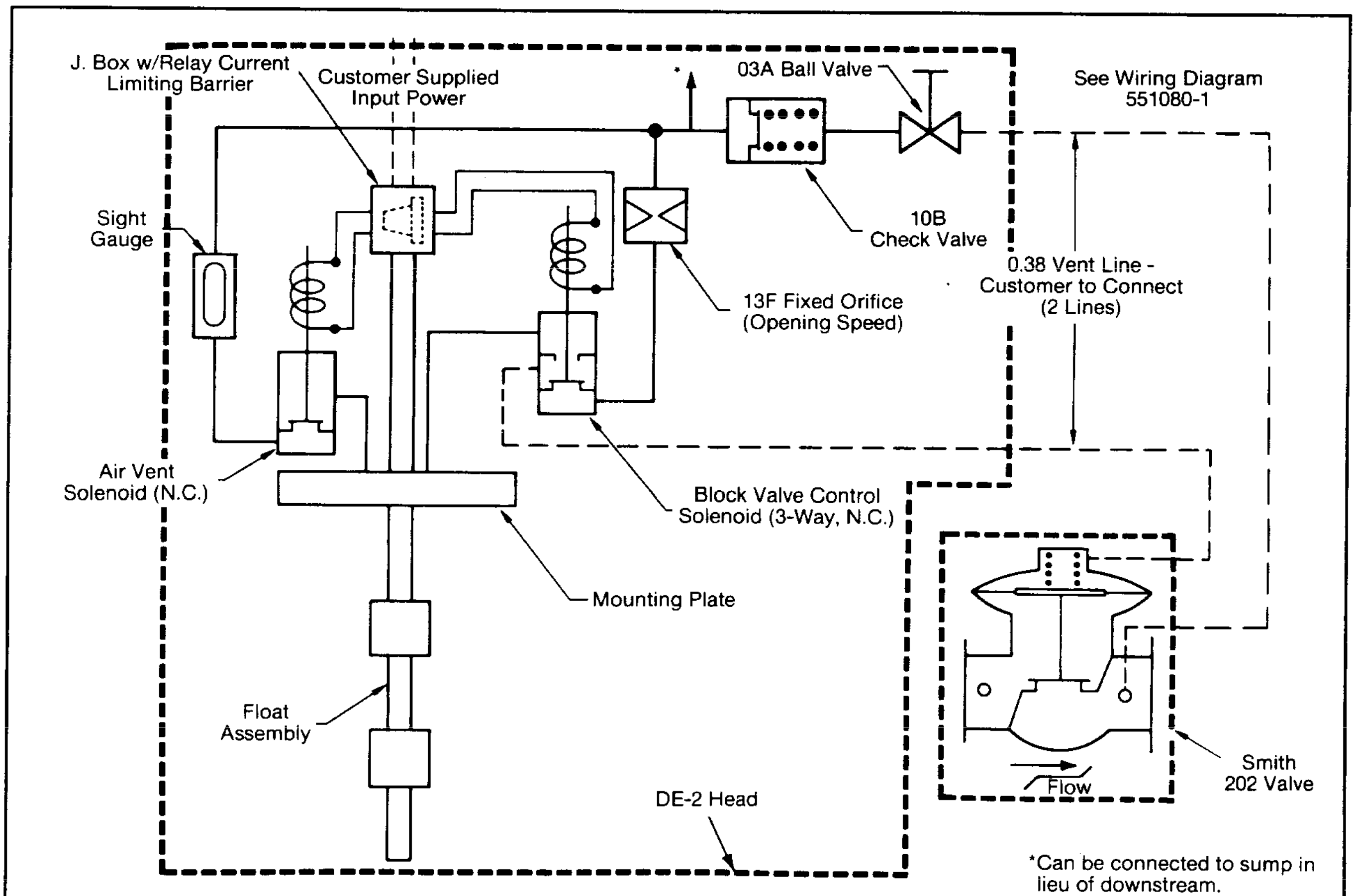

Figure 5 — Smith Model DE-2 with 202 Bare Valve

with a block valve that is void of the pilot loop arrangement which is vulnerable to the performance problems caused by viscous fluids (see Figure 5). The DE-2 incorporates all of the features described in the dual float switch system described above. However, when the fluid level falls low enough to permit the lower float to drop, a three-way solenoid is also actuated, allowing the pressure of the accumulated air to pressurize the cover chamber of the block valve, causing the valve to close, thereby stopping product flow. Once the accumulated air has been vented through the two-way solenoid, the fluid level again rises, with the valve remaining closed until the upper float rises. This action de-energizes both solenoids, blocking the air vent path through the two-way solenoid and simultaneously permitting the pressure in the valve cover chamber to be vented downstream of the meter, thus allowing the block valve to reopen.

Meters and Accessories

Positive Displacement (P.D.) Meters are most appropriate for offloading applications because of the systems' inherent operating conditions. P.D. Meters are ruggedly constructed and are adaptable to changes in operating parameters, such as product viscosity and flow rate. In addition, they are best suited to perform accurately during the stop/start sequences caused by the closing and opening of a system block valve linked to an air sensing device.

Available meter accessories include various types of calibrators, temperature compensators, counters, ticket printers, and pulse transmitters, all of which can be arranged in numerous combinations suited to satisfy unique system requirements.

Flow Control Valves

They provide control functions, such as flow rate limiting, on/off permissive, over temperature emergency shutdown, and pressure regulation. It may also shut down the flow if the proper signaling is provided.

Backflow Prevention

Backflow prevention from above ground tanks is essential because of the possibility of having the tank head flow backward out of the receiving system. A simple check valve between the outlet of the receiving system and the tank satisfies this requirement.

Flow Indicators, Water Detectors, Alarm Devices

These devices can be utilized to cover special situations when circumstances warrant them. Flow rate indicators can be provided to give operators a manual indication that the system is flowing smoothly. Water detectors can be installed to shut down the receiving position if the percentage of water content is greater than the permissible amount. Overfill protection devices and alarms are available to protect the receiving customer from the dangers and hazards of overfilling the receiving tank.

Performance

Performance for petroleum product metering systems, including air removal efficiency, is defined per National Bureau of Standards Handbook 44 - Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices. This handbook covers a multitude of measuring and weighing devices from taximeters to berry boxes, including liquid-measuring devices and vehicle tank meter combinations, such as a home heating oil fuel delivery truck.

The standard states in Section 3.30, Table 2, that the overregistration or underregistration error is limited to 25 cubic inches for 50 gallons, plus one-quarter cubic inch for each gallon over 50 gallons. This calculates out to be .00216 or roughly 0.2%, and this is (+) or (-) for 50 gallons. If the delivered volume becomes 10,000 gallons, then the accuracy limit is now 2,512.5 cubic inches or .00109 or roughly 0.1%. A typical meter accuracy curve is shown in Figure 6.

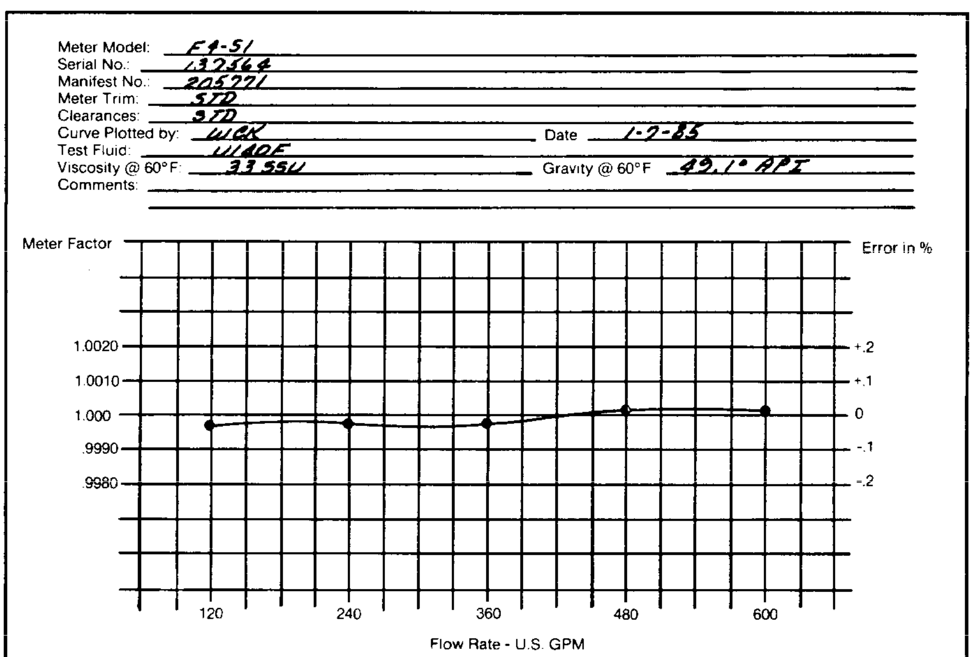

Figure 6 — P.D. Meter Accuracy Curve

Curve No.: G-18713

Conclusion

Several factors contribute to a successful truck unloading metering system. However, the ultimate goal is a system that can be economically justified. Because of the monetary value of the product being transferred from the custody of one party to another, it is imperative that measurement problems be anticipated and that steps are taken to minimize or eliminate the effects of these problems. Critical factors, such as the presence of air, for example, have to be addressed if optimum system accuracy is to be maintained.

This paper was presented by the author at the 60th International School of Hydrocarbon Measurement in Norman, Oklahoma, April, 1985.

References

Basic Petroleum Data Book, Vol. IV, No. 3, September 1984, American Petroleum Institute, Washington, D.C.

National Petroleum News - 1984 Fact Book.

National Bureau of Standards Handbook 44 - 1982, U.S. Department of Commerce, Washington, D.C.

Streeter, Victor L., "Handbook of Fluid Dynamics," McGraw-Hill, New York, 1961.

Streeter, Victor L., "Fluid Mechanics," McGraw-Hill, New York, 1958.

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