Vehicle-Tank Meters

Inspector's Manual

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It is sincerely hoped that this course helps weights and measures officials throughout the country meet their personal and professional objectives.

The staff of Industrial Training Corporation.

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CHAPTER 1

INTRODUCTION TO THE MODULE

CHAPTER OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Explain the purpose and content of the National Training Program.

2. Identify the purpose and objectives of this module.

3. Describe the prerequisite knowledge and skills necessary to comprehend the content of the module.

THE NATIONAL TRAINING PROGRAM

As a weights and measures official, you are responsible for enforcing the system of weights and measures in the United States. You are probably aware that enforcement is a function of State and local jurisdictions rather than the Federal Government. However, the National Institute of Standards and Technology (NIST) has a mandate to provide technical assistance and advice to promote measurement uniformity and traceability of standards. Historically, training has been part of NIST's approach to providing this technical assistance and advice. In addition, NIST provides significant support to the National Conference on Weights and Measures (NCWM) in partial implementation of its statutory responsibility for cooperation with the States in securing uniformity in weights and measures laws and methods of inspection among the State and local jurisdictions.

In recent years, technological advances, especially in the area of electronic devices, have increased the need for training weights and measures officials. In response to this need, the National Conference on Weights and Measures, at its 67th Annual Meeting in 1982, adopted a plan to establish a national training program to:

- promote inspection and regulatory uniformity, and

- provide weights and measures officials with the knowledge and skills they need to deal with and benefit from changing technologies.

The program is divided into modules to meet the specific training needs of individuals or groups. The modules are designed primarily to provide structured and uniform training for new employees in the weights and measures field. However, the experienced official will benefit from refresher training and upgrading of skills. A series of "functional modules" provides detailed instruction on specific functions of weights and measures officials such as inspecting and testing different types of equipment. Successful completion of these modules is a first step in obtaining certification as a qualified inspector of a specific weighing and measuring device. Another series of the modules, called "elective modules," covers

background, theory, and policy on weights and measures related subjects. In some cases, the training provided by elective modules may prepare an official to study the functional modules. In other cases, the elective modules are intended as follow-ups to the functional modules. The following modules cover topics that are related to specific aspects of this module, and may be especially useful either in preparation for your study of vehicle-tank meters or as supplements:

- "Introduction to NIST Handbook 44"
- "Introduction to Electronic Weighing and Measuring Systems"

MODULE OBJECTIVES

It is safe to say that the average American consumer gives relatively little thought to the subject of vehicle-tank meters. If he or she takes any notice of them at all, it is usually while stuck in traffic behind a tanker truck that is laboring up an incline on a one-lane road. At that, the exasperated motorist probably has at best a very limited understanding of the complicated looking contraption mounted on the back or the side of the truck, with its profusion of pipes, valves, levers, and indicators. This lack of knowledge -- and interest -- on the part of the consumer is at the same time easy to understand and somewhat paradoxical.

It is easy to understand because the average American (who does not live on a farm and works at home or in an office) has little direct contact with vehicle-tank meters or the jobs they perform. The only common retail application of these devices is in the delivery of home heating fuel. And when we see the delivery person dragging that long hose up to the side of the house on a blustery winter day, how many of us go out to stand by the truck and observe what's going on? The delivery person may drop off a ticket at the end of the delivery that shows us how much fuel we have purchased, but we are rarely present when the ticket is printed and really have no idea how it is produced. Even though we pay quite a bit of money for the fuel that keeps us warm in the winter, we are not overly anxious about whether or not we are actually getting what we pay for.

This truly is a paradox, especially in a consumer-oriented society like ours. And it is the more surprising when we stop to consider that those complicated looking contraptions are involved quite directly in bringing us so many of the products we buy or use. Nearly all liquid products -- from gasoline to laundry detergent to milk -- are transported during at least some part of their travel from their place of production to their place of final sale in tank trucks. And farms and factories depend upon tank truck deliveries of such liquid products as fertilizers, pesticides, lubricants, industrial chemicals, and others too numerous to mention, to produce the consumer goods that provide our abundant material way of life. Almost every time a tanker truck makes a delivery of product to a buyer, that complicated looking contraption is used as the basis for determining the price of the transaction. The sum of these transactions amounts to billions of dollars every year, dollars that ultimately come from consumers and taxpayers. Should we be anxious about whether or not we are actually receiving what we pay for?

The fact is that we are not, and that we have every reason to feel secure, but few of us realize that we owe our peace of mind, in this regard at least, to two things: the precision instrument that we think of -- if we think of it at all -- as that complicated looking contraption on the back of the truck, and the efforts of the weights and measures officials who periodically inspect and test these devices to assure that they are operating at the high levels of accuracy and reliability for which they are designed.

As a weights and measures official, you serve both the purchasing public and the members of the commercial community who sell to them, by assuring equity in the marketplace, discouraging unfair competition, and promoting consumer confidence.

So your job is more important than many people may realize. It is challenging work, requiring knowledge, skill, and judgment. You must master the complexities of the exacting technical specifications, tolerances, and procedures that have been established by your jurisdiction. You must be able to use precision test equipment expertly. And, you must perform your tasks judiciously, in such a way as to assure the protection of the public and at the same time minimize the burden of inspections and tests to the user of weighing and measuring devices.

So it is not enough simply to master procedures, as important as they may be. You must also understand something of how the business and marketplace work. And it is not enough to learn specifications and tolerances. As you will see in the following chapters, you must also be able to recognize and distinguish between various types and classes of devices before you can decide which particular specifications and tolerances apply in a given situation. And you must also, to do your job well, understand the entire vehicle-tank metering system, of which the measuring device is only a part.

Finally, you must keep up-to-date with a constantly changing and evolving technology. As you are probably aware, the "high-tech" electronic revolution, which in recent years has extended to every sector of our economy and has entered our schools and homes as well, has not passed over the meter industry. So you must be prepared to deal with frequent changes in already complex and highly sophisticated systems.

You should understand, however, that the purpose and objectives of this module are limited. It is not intended to train you as a mechanical or electronic technician, repairperson, or troubleshooter. Its primary purpose is to help you perform the no less important job of a weights and measures official.

Upon completion of the module, you should have the knowledge and skills to:

- Identify and describe the types and classes of positive displacement vehicle-tank meters that are commonly encountered in the field. (milk meters and mass flow meters are not covered in this module)

- Identify and describe the operation of the principal components of these devices, especially those involved in measuring, indicating, recording, and delivering product.

- Identify the appropriate equipment used for testing vehicle-tank meters in the field and describe procedures for setup, reading, and maintenance of this equipment.

- Describe safety procedures prescribed and recommended for inspectors conducting tests on vehicle-tank meters in the field.

- Describe procedures for inspecting vehicle-tank meters to determine compliance with specifications and requirements set forth in NIST Handbook 44.

- Describe procedures for testing vehicle-tank meters in the field to determine compliance with tolerances and other performance requirements set forth in Handbook 44.

- Describe post-test tasks that must be performed upon completion of inspection and test procedures, including documentation and recordkeeping.

- Understand the field training component of your training and procedures for certification.

PREREQUISITES

No previous knowledge of vehicle-tank metering systems is required. You should, however, be familiar with the introductory and general sections of the latest edition of NIST Handbook 44, "Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices," before taking this module.

SUMMARY

This training module is part of a National Training Program for weights and measures officials. It is intended to help you prepare to perform the important task of examining vehicle-tank metering systems in the field.

CHAPTER 2

THE VEHICLE-TANK METERING SYSTEM

CHAPTER OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Describe the vehicle-tank metering system, its uses, and its relation to other liquid-volume measurement and delivery systems.

2. Explain the difference between gravity- and power-operated vehicle-tank metering systems.

3. Describe the major functional components of the vehicle-tank metering system.

INTRODUCTION

Vehicle-Tank Meters and Their Relation to Other Liquid-Measuring Devices

As is obvious from their generic, or common name, vehicle-tank meters are measuring devices that are employed in commercial deliveries of products from tank trucks. It may not be at all obvious, however, why NIST Handbook 44 distinguishes vehicle-tank meters as a class from several other types of devices that are quite similar in design and function. It would seem logical that their classification has something to do with the fact that they are mounted on tank trucks, but in fact this is not the primary reason.

To understand how and why vehicle-tank meters are distinguished, you must first be aware of their relation to these other classes of metering devices, each of which is treated as a distinct class in Handbook 44:

- retail motor-fuel dispensers ("gas pumps")
- loading-rack meters (used to measure deliveries from stationary storage facilities, pipelines, etc.)
- LPG meters (used for metering liquefied petroleum gases, such as propane and butane)
- cryogenic product meters (used for liquid oxygen, nitrogen, and argon)
- milk meters
- water meters

All the devices listed above share three important features:

- They are used exclusively for measuring liquid products (or, in the case of LPG and cryogenic meters, products that are sold in a liquid state).

- They all mostly employ the positive displacement method of measuring liquid volume (described in detail in the next chapter of this module). (Only positive displacement meters are covered in this module.)

- They are designed to measure and deliver product simultaneously, as opposed to measuring devices like graduates or capacity containers in which the liquid is measured first and then delivered. (Another example of the latter type of device is the old fashioned gas pump, which was operated by first pumping gasoline into a graduated cylinder until the desired amount was indicated, then draining the cylinder into the motorist's fuel tank.)

These are basic similarities among these different classes of liquid-measuring devices, but there are many more particular likenesses in design and function. For example, gas pumps, loading-rack meters, and vehicle-tank meters are used for dispensing gasoline and other motor fuels, and both LPG and cryogenic product meters are commonly mounted on tank trucks (although they are not classified as "vehicle-tank meters" in Handbook 44 codes). Many of these meters are manufactured by the same companies, and some are so similar in design and appearance (especially certain models of vehicle-tank and loading-rack meters) that they are virtually indistinguishable as they come from the factory. Given their many similarities, why are these classes of metering devices differentiated for weights and measures purposes? Is the classification simply arbitrary?

Of course, the answer is that the classification is not arbitrary. Although many of the requirements set forth in Handbook 44 for these separate classes are identical, there are significant differences. These differences reflect, for the most part, the different ways in which these very similar devices are used in the commercial marketplace. These usage factors generally affect the design of the device in ways that, in turn, affect the way it is examined in the field.

It is beyond the scope of this introduction to make a comprehensive comparison of these factors. Many of them will be apparent to you when you have had a chance to see the devices in operation in the field.

But it is important at this point in your training that you be aware, in general, of the reasons for the separate classification of these devices. So, let us consider a comparative example that relates directly to vehicle-tank meters.

Most gas pumps are designed for deliveries to highway vehicles, and especially automobiles. The gas tanks on some compact cars hold no more than 10 gallons of fuel when full, and the standard fill pipe opening is less than 2 inches in diameter. Given these small dimensions, gasoline (or diesel fuel, gasohol, etc.) can not safely be delivered to automobile fuel tanks at a rate of more than about 20 gallons per minute (gpm). In fact, most gas pumps that are used primarily for passenger cars have maximum discharge rates of between 12 and 15 gpm. In addition, to avoid overfill and to permit the operator to effectively control the delivery to within 0.01 gal, the dispenser must be capable of delivering fuel -- and measuring it accurately -- at much lower flow rates.

The fuel products dispensed at most filling stations are stored in underground storage tanks. These tanks vary in capacity with the needs of the operation, but may hold several thousand gallons of a particular product. Very large storage tanks hold as much as 12,000 gallons. These storage tanks are supplied periodically by tank trucks, which may deliver as much as several thousand gallons of product to a large

tank (for obvious reasons, deliveries are made before the storage tank is nearly empty). Consider a delivery of 5,000 gallons of gasoline. If a meter like the one installed in the station's dispenser was used, the delivery would take more than 5½ hours! Obviously, the vehicle-tank meter installed on the tank truck will be designed to operate at a considerably higher delivery rate in order to reduce the overhead costs associated with a single delivery. Meters installed on petroleum tankers typically operate at maximum flow rates ranging from 40 to 180 gpm.

The tank truck, in turn, picks up its load from a distribution facility which uses a loading-rack meter to measure the amount of product dispensed to the truck. Because the truck tank may have a capacity of as much as 9,000 gallons or more, the same economic factors will dictate that the loading-rack meter operate at a proportionately higher flow rate than the vehicle-tank meter installed on the truck. Some loading-rack meters are capable of discharge rates as high as 1,000, or even 1,500 gpm, 100 times the flow rate of the gas pump that is used to make the final delivery of the product to the consumer.

All three meters involved in the delivery of this product are capable of comparable accuracy, and are required to deliver the indicated volume of product to a tolerance of 1 cubic inch per gallon, or less. But to test the accuracy of these three metering devices requires different equipment and, to some extent, different procedures. We have pointed out that these meters are designed to operate at widely different delivery rates because this is perhaps the most significant factor in determining how they will be tested. For reasons that will be explained in greater detail in a later chapter, a performance test for any liquid-measuring device operating at a delivery rate equal to or greater than 20 gpm requires a test draft the volume of which is at least as great as the quantity that the device can deliver in one minute at its maximum flow rate. For any liquid-measuring device operating at a delivery rate of less than 20 gpm, a test draft of at least 19 liters or 5 gallons is required. So for the typical meters described above, the inspector might have to draw quantities of 5, 180, and 1,500 gallons, respectively, necessitating the use of three different sized provers.

The point of this extended example is that the differentiation of liquid-measuring devices into a number of classes is based upon differences in typical operating characteristics, such as maximum flow rate, that may affect the way the device is tested in the field. Thus vehicle-tank meters form a distinct class not because they are mounted on tank trucks, but because their operating characteristics typically fall within a range that is distinguishable from other types of meters.

The Vehicle-Tank Metering System

As a weights and measures inspector, you are primarily concerned with the ability of a vehicle-tank meter to measure and indicate the quantity of product delivered accurately. However, because these devices are designed to measure and deliver product simultaneously, their ability to do this depends upon the proper functioning of the entire dispensing system, of which the measuring and indicating elements are only a single component. So it is important that you understand this system.

All vehicle-tank metering systems consist of four essential components (illustrated in Figure 2-1): the tank, the air eliminator, the measuring and indicating elements, and the pipelines and control elements that regulate the passage of the product from the tank, through the meter, and to the point of delivery. Let us now look briefly at the function of each of these components. A detailed discussion of their operation will be presented in the next chapter.

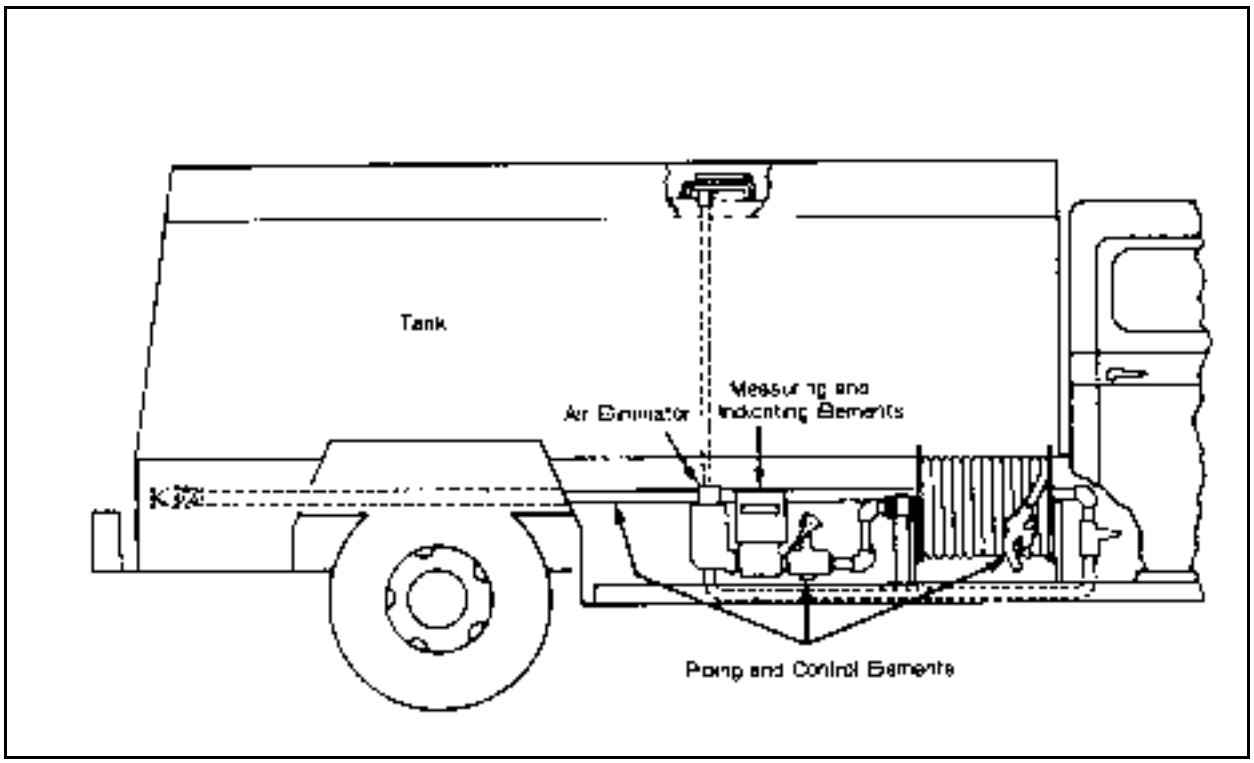

Figure 2-1. The Vehicle-Tank Metering System

Truck-mounted tanks range in capacity from several hundred to several thousand gallons. The tank trucks that are used to deliver home heating oil typically hold about 2 500 gallons of product; petroleum "super-tankers" may hold more than 9 000 gallons (a maximum capacity is often established by State law). The tanks are equipped with baffles, partial partitions that prevent excessive shifting of the fuel when the truck is in motion and accelerating or decelerating. The tank may also be divided into separate compartments. This permits the truck to be loaded with different products (for example, different grades of gasoline). The tank, or separate tank compartment, is usually filled from the top. The fill opening is securely covered at other times to prevent spillage, contamination of the product, and air pollution due to excessive venting of vapor. The tanks are also equipped with relief valves, usually installed in the fill opening cover(s), which allow air to be drawn into the tank to relieve the partial vacuum created as the liquid level drops during delivery, and to permit air and vapor to be vented when thermal expansion of the product causes pressure inside the tank to exceed a safe amount.

During delivery, product drains through an outlet in the bottom of the tank, and is carried through piping toward the meter. If the tank is divided into compartments, the product usually passes first into a manifold (see Figure 2-2), which has one inlet connected to each tank compartment, and a single outlet connecting it to the intake line heading toward the meter. The manifold inlets are equipped with valves, so that the product is drained from only one compartment at a time.

Small amounts of air and product vapor are often mixed with the liquid contents of the tank. These entrapped gases must be removed from the liquid before it is metered, so that they are not measured along with the product that the customer is paying for. This is accomplished by the air eliminator, which separates the entrapped or entrained gases from the liquid flow and vents them, either back into the storage

tank or, in the case of one type of system, to the receiving tank via a bypass around the meter to the discharge line.

The liquid product, now free of air and vapor, passes through the meter, and the mechanical action of the meter caused by its passage produces a continuous indication of the quantity that has been delivered. The indicating device is usually called the register. These are the measuring and indicating elements.

The metered product then passes through the discharge line to a nozzle, which is connected to the fill opening of the receiving tank. The flow of product is controlled by valves that are located on the discharge side of the meter, either at the meter outlet or at the discharge nozzle. These, along with the manifold and intake lines, are piping and control elements.

These four functional components -- tank, air eliminator, measuring and indicating elements, and piping and control elements -- are employed in all vehicle-tank metering systems. Before we consider them in more detail, however, you should be aware of the two basic types of systems that are in use.

Gravity-Discharge and Power-Operated Systems

Some tank trucks are used exclusively for making deliveries to underground storage tanks (for example, tankers that supply motor fuel to gas stations). This type of system is diagrammed in Figure 2-2. Since the product is delivered to a tank that is entirely below the level of the truck tank, it is most efficient to allow the pressure that results from the level of the product in the tank (the "head") to propel it through the system. This type of system is known as a gravity-discharge system. The delivery rate of a gravity-discharge system will depend upon the quantity of product in the truck tank, since it is the head pressure that propels the liquid. A typical gravity-discharge petroleum tank truck is capable of delivering at rates between about 90 gpm at "low head" (that is, as the quantity of product in the tank approaches zero) to approximately twice the rate -- about 180 gpm -- at "full head" (when the truck tank is full). A typical average delivery rate is more than 125 gpm.

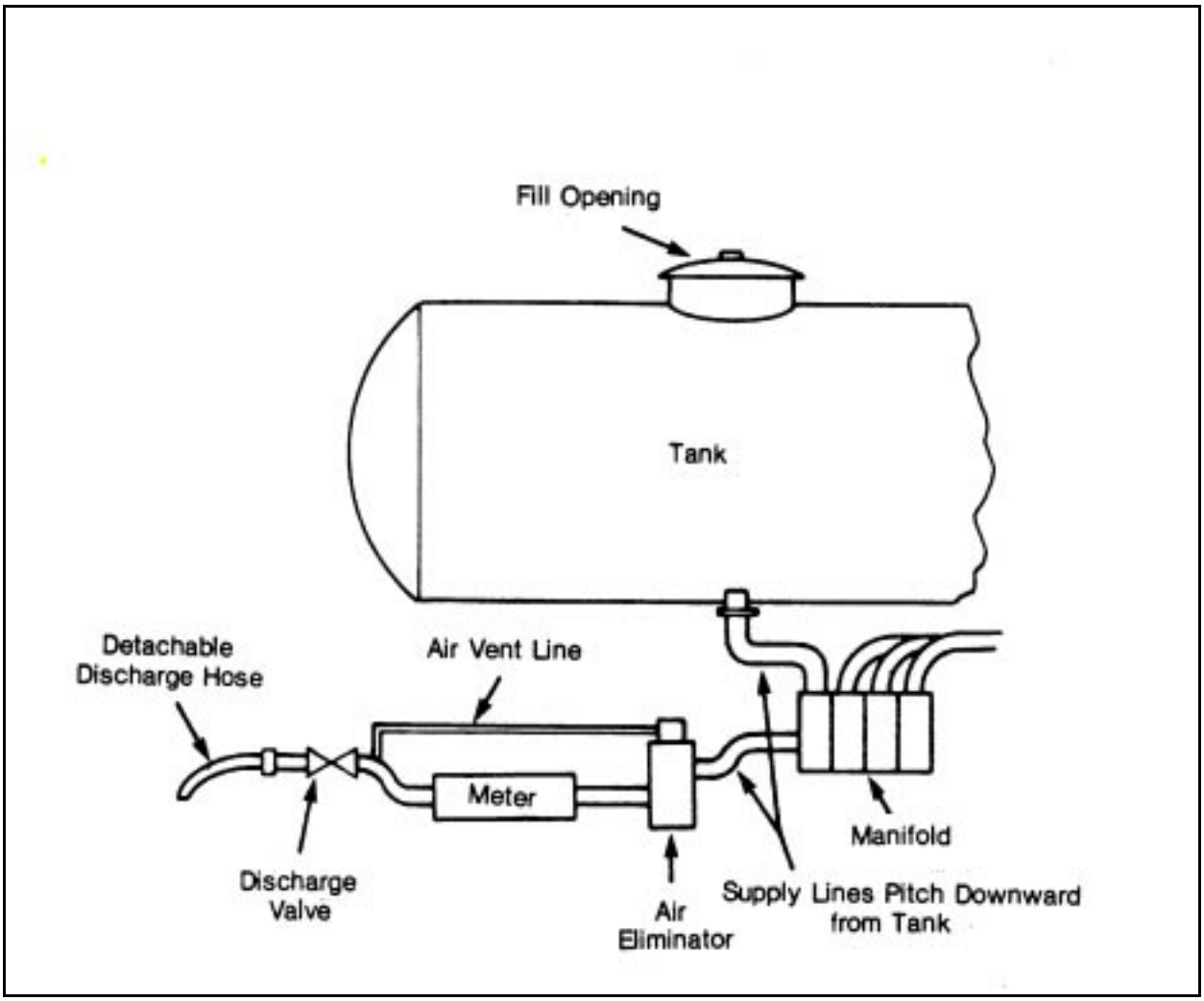

Figure 2-2. Diagram of a Gravity-Discharge System

When the product must be delivered to a storage tank that is above ground, a pump (usually driven by the vehicle engine) is used to provide the pressure required to deliver the product. This type of system, called a power-operated system, is diagrammed in Figure 2-3. The most common example of a power-operated vehicle-tank metering system is the truck used for deliveries of home heating oil. Maximum discharge rates for power-operated systems are generally slightly lower than those for gravity-discharge systems, ranging from 30 to 100 gpm (although some power-operated systems are capable of delivery rates of 300 gpm or more).

Aside from the presence or absence of a pump, gravity- and power-operated systems are, in most respects, identical in design and function. In fact, most meters can be used for either type of system, and some trucks can make either gravity- or power-operated deliveries as needed, simply by using a bypass around the pump for gravity-discharge deliveries. There are several minor differences, which we will discuss in greater detail in later chapters. However, there is one major difference that you should understand from the start.

At the end of a delivery, the discharge line from the meter outlet to the nozzle will be filled with liquid that has passed through the meter, and thus has been charged to the purchaser. Some means must be provided to assure that this quantity of product is actually received. In a gravity-discharge system this is accomplished by draining the discharge line completely into the receiving tank. The line is attached near the meter outlet by means of a detachable connector (see Figure 2-2) so that it can be removed and raised to a vertical position to allow complete drainage of the hose. To accomplish this, the length of the discharge line must be kept to a minimum; ideally it will be no longer than needed to drop straight from the meter to the receiving tank fill opening.

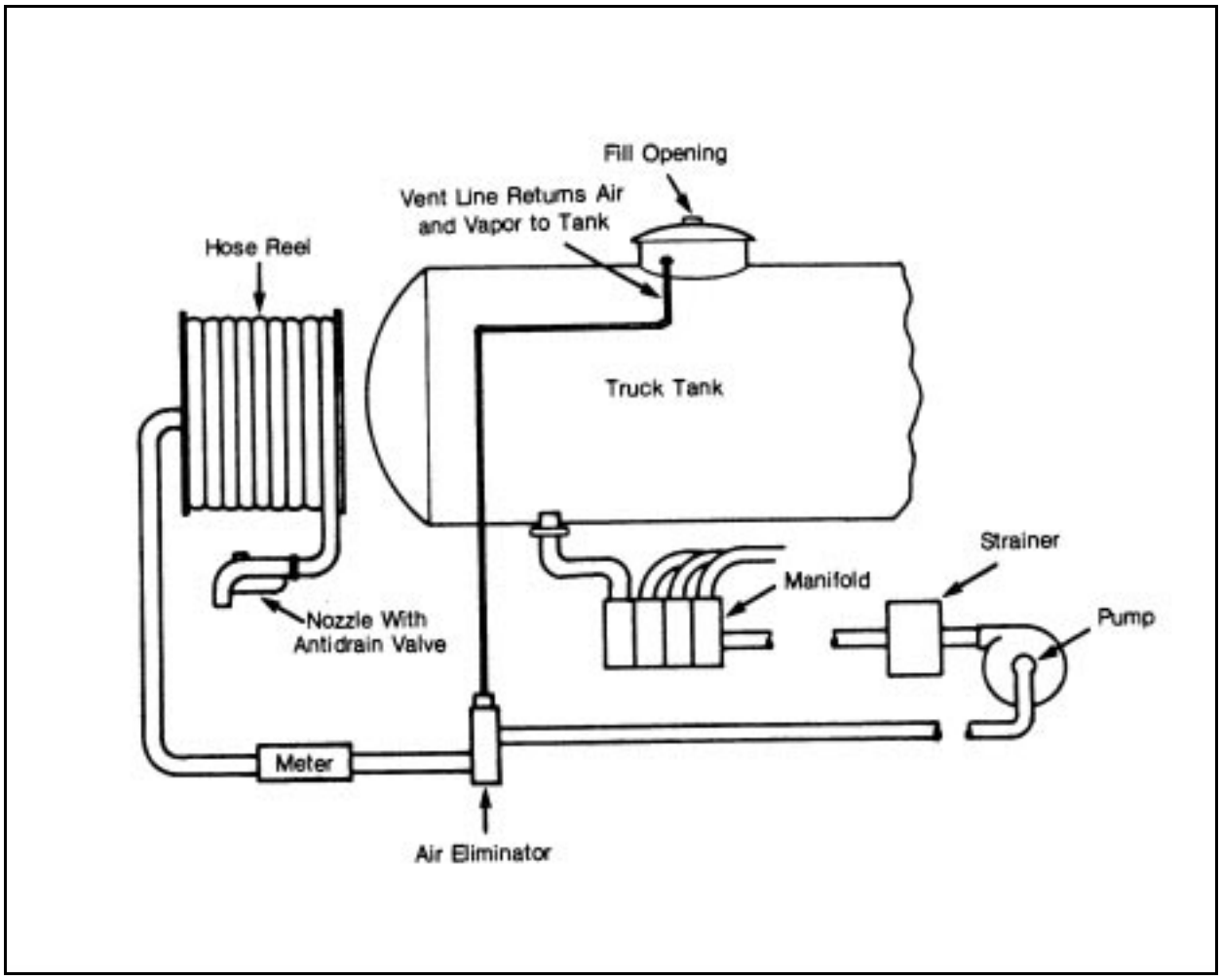

Figure 2-3. Power-Operated System

In a power-operated system the length of the discharge hose and the relative height of the delivery point make draining the hose impracticable. So the entire discharge line, from the meter to the inlet of the discharge nozzle, is kept full of product at all times. An antidrain valve installed in the nozzle prevents product from being discharged when pump pressure is no longer being supplied. Since the discharge hose

contains the same quantity of product at the beginning and end of each delivery, the entire amount of product indicated will actually have been delivered to the receiving tank.

A gravity-discharge system is referred to as a "dry-hose" system, because the discharge hose is emptied of liquid at the end of each delivery; a power-operated system is a "wet-hose" system because the hose is kept full of liquid product at all times.

SUMMARY

Vehicle-tank meters as designated in NIST Handbook 44 are used to measure products that are liquids at atmospheric temperatures and pressures as they are dispensed from tank trucks. As a class, vehicle-tank meters are distinguished from other liquid-measuring devices that are similar in design and function by their typical operating characteristics (maximum flow rates, etc.), not by the fact that they are mounted on tank trucks. The vehicle-tank metering system is comprised of four functional components: the tank, an air elimination device, the measuring and indicating elements (meter and register), and the piping and control mechanisms that connect these components and regulate their operation. There are two basic types of systems: (1) gravity-discharge systems, which are "dry-hose" systems; and (2) power-operated systems, which operate with a "wet-hose." Some systems are capable of operation in either mode.

CHAPTER 3

THE OPERATION OF VEHICLE-TANK METERING SYSTEMS

CHAPTER OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Identify and describe the operation of specific major elements of the vehicle-tank metering system.

2. Describe differences in design and operating characteristics of these elements in different types of systems.

3. Describe in general terms the operation of a positive-displacement metering device.

4. Understand the difference between analog and digital indicating and recording elements of vehicle-tank metering systems.

INTRODUCTION

In this chapter we will take a closer look at each of the major operating elements of a vehicle-tank metering system. A variety of designs are in common use, and new features are being incorporated almost continually with advancements in technology and with changes in the marketplace. In the interest of providing a thorough and comprehensible introduction, we will not cover specific features of every model available from each of the manufacturers of these components. You will acquire this specific knowledge most effectively through experience in the field. This introduction will instead focus on design features and operating characteristics that are generally significant for the range of devices you are most likely to encounter. In some cases, illustrations of particular designs are used. These are intended to help you understand typical features.

The Vehicle Tank and Intake Lines

We have already discussed the general features of the vehicle tank. In a system that is properly installed, maintained, and operated, the design and capacity of the tank will generally not affect the capability of the metering components to measure and indicate accurately.

The manifold that controls the flow of product from multiple tank compartments was also described in the last chapter. One obvious function of this component is to select which compartment will deliver product to the meter. This is accomplished by closing all compartment valves at the manifold except the one that contains the desired product. The manifold also performs another important function -- to prevent air from being drawn into the system from empty compartments. When a compartment is empty, its manifold valve must be closed before delivery is resumed from another compartment. If this is not done, air can be drawn from the empty compartment through the open manifold valve and churned into the product being delivered from the other tank. The resulting quantity of air introduced into the system may then exceed the

capability of the air eliminator to remove it. If this happens, air can be drawn into the meter and cause overregistration (the indicated quantity is greater than the quantity of product actually delivered).

Piping from the tank outlet (or from the manifold outlet if the tank is compartmented) carries product ahead toward the meter, and so can be referred to as the meter intake or supply line. It should, like the tank, be made of material that is appropriate for the product(s) it carries. It should also be installed in such a way as to be shielded from the sun and wind in order to minimize the effects of extreme outdoor temperature conditions on the product, and should have no vertical bends that could trap air or vapor. In addition, the piping should be of the correct size (inside diameter) for the meter. This is especially important in a gravity-discharge system. If gravity is drawing product through the meter and into the discharge line faster than it can be supplied by the intake line, a negative (suction) pressure condition could develop at the meter inlet. Some products that can be maintained in a liquid state under atmospheric pressure will tend to vaporize readily under relatively small negative pressure. A good example is gasoline, a typical grade of which has a vapor pressure (absolute) of about 7 pounds per square inch (psi) at 80 °F. At ambient pressures less than its vapor pressure (atmospheric pressure is about 15 psi) gasoline will readily change to its vapor state. If the pressure at the meter inlet is less than the vapor pressure of the product (a "negative pressure" condition), vapor will accumulate at that point. If the accumulation is more than the air eliminator can handle, the vapor may be drawn into the meter, resulting in overregistration.

If the system is power operated, the pump will be located on the intake line, as shown in Figure 3-1. The pump is usually driven directly by the truck engine, through a linkage that is controlled by the operator. When the pump is engaged, it draws product from the tank and propels it toward the meter. The pump should be installed at a level slightly lower than the tank outlet (although the line should not pitch sharply at the pump) and should be matched to the size of the intake line. Again, the purpose of these measures is to minimize the effects of negative pressure conditions on product in the intake line. The pump must obviously also be capable of developing sufficient pressure in the line ahead of it to propel the product to its delivery point.

The Air Eliminator

Before we look at the operation of a typical air eliminator, let us consider why such a device is needed in the first place. Obviously, the customer does not want to be paying for air or vapor, but how do these gases get into the liquid flow?

The most common way for air to enter the system is through the tank. This is especially true if a vortex forms at the drain opening. (A vortex is what you often see when you drain a sink or bathtub: the water swirls around a column of air that is moving rapidly downward and into the drain.) It is possible to minimize this effect, which will draw large quantities of air, by installing baffle plates above the drain openings. This breaks the column of air as it forms, and so eliminates the vortex.

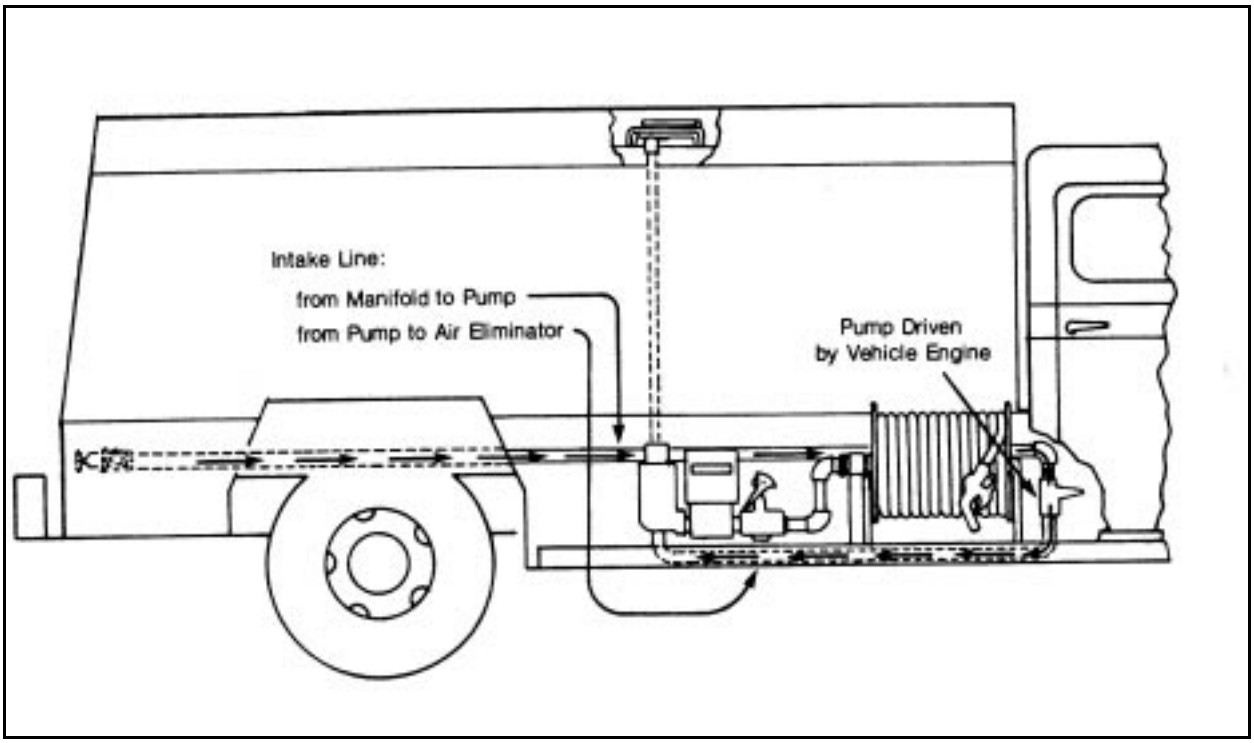

Figure 3-1. Power-Operated System

Under normal operating conditions, large quantities of air are also introduced into a system when a tank compartment is emptied. This will occur regardless of how quickly the operator detects the condition and responds by shutting off the discharge flow, disengaging the pump, or closing the manifold valve for the empty tank and opening the valve for another compartment that contains product. The intake line will fill with air almost instantly, even in a system that is in excellent operating condition. Product vapor will, of course, also be drawn into the intake line from the tank, along with the air.

The only other source of significant quantities of vapor in a system that is installed, maintained, and operated properly is the result of temperature changes in the product, usually during periods when the system is at rest. For example, on a hot summer day, the entire system, including the product, will warm gradually as the day progresses. In addition, the product is heated slightly by friction produced as it flows through the system. When the truck is parked for the night, the product filling the lines will be warm. As the ambient temperature drops overnight, the product loses heat, and as it does, it contracts and occupies less volume. The result, as the product continues to cool, is a partial vacuum in the lines. This condition encourages some vaporization. By the next morning, when the truck goes out to make its first delivery, a significant amount of vapor may have accumulated in the lines.

Air and/or vapor may also be introduced into the system as the result of improper installation or maintenance. We have already mentioned one such condition, mismatching of meter and/or pump capacities with the size of the system's piping. Air may also be drawn into the intake line through leaks in piping connections or faulty valve seals.

These are the major sources of air and vapor in the system. Since some accumulation of these gases is normal and practically unavoidable even in a properly installed, maintained, and operated system, the

air eliminator is not simply a "back-up" or emergency component, but must function correctly under all operating conditions.

The air eliminator is installed at the end of the intake line, with its outlet connected directly to the meter inlet. Figure 3-2 illustrates a typical configuration.

In addition to eliminating air from the liquid flow before it enters the meter, most air eliminators are equipped with a strainer, which traps any solid particles in the product. This strainer is removable, and should be cleaned as part of the regular maintenance of the system. A clogged strainer can disrupt flow, and an excessive accumulation of foreign matter in the strainer can lead to its rupture and the subsequent passage of these solid particles into the meter. This can cause serious damage to the mechanism and may also affect the accuracy of the meter.

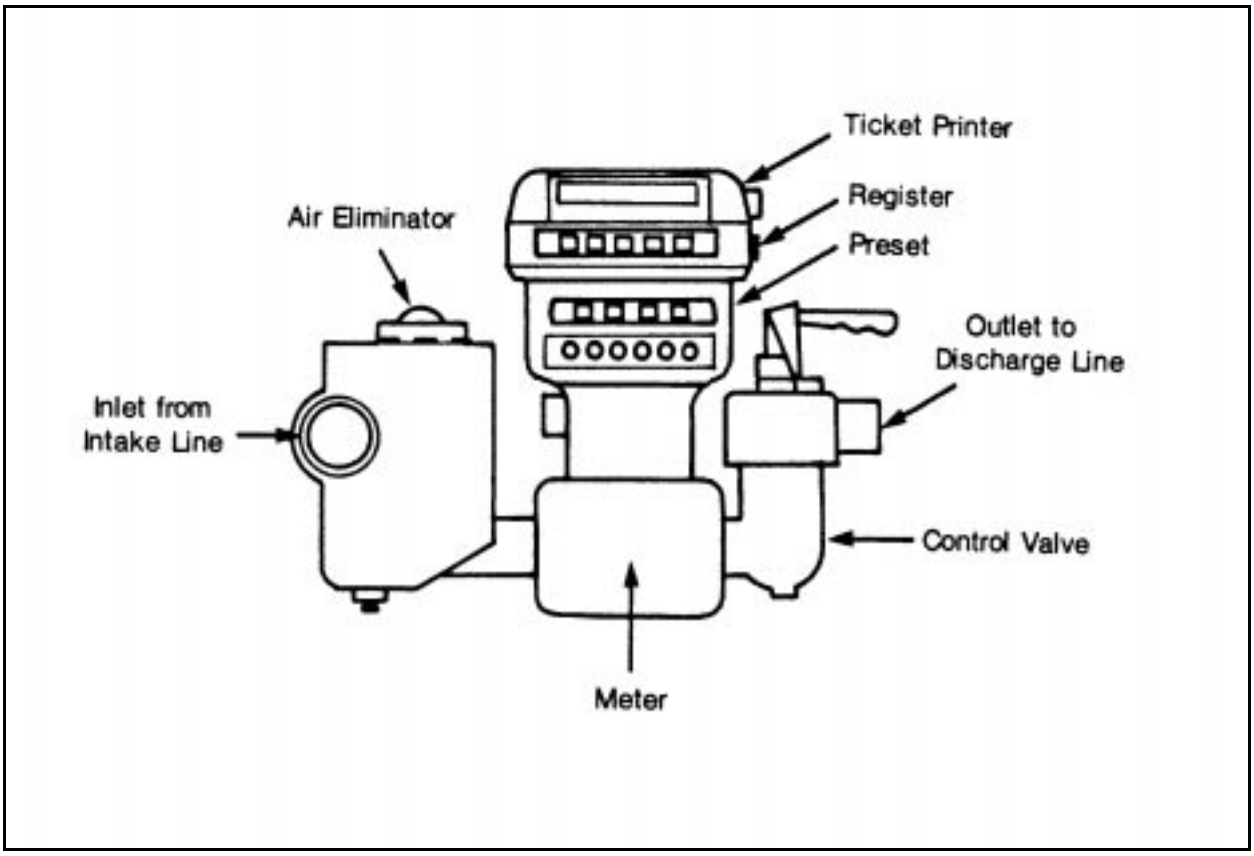

Figure 3-2. Air Eliminator and Meter Assembly

A number of different designs of air eliminators are available, but their basic principle of operation is the same. This can be seen in the cutaway of a typical air eliminator shown in Figure 3-3. Liquid product flows through the strainer (A) and fills the bottom portion of the chamber. Air and vapor that have been carried through the line rise into the upper portion, and pass from the top of the chamber into a vent line (B). To prevent product from rising through the chamber and into the vent line, a valve is installed at the opening to the vent line (C). This design keeps some quantity of air/vapor in the top of the chamber at all times, and thus prevents the liquid level from rising above a certain point. This level is regulated by a float (D), which actuates the valve at the top of the chamber, generally by means of a direct linkage, as

in the example shown (E). As the quantity of air/vapor trapped above the liquid increases, the liquid level lowers. This in turn lowers the float.

When the float drops to a specified level, it pulls open the valve, permitting the gases to flow into the vent line. As this happens, the liquid level rises once again, pushing air and vapor into the vent line and raising the float with it. When the float rises to a specified level again, it pushes the valve to the vent line closed, trapping the desired quantity of air/vapor behind it.

The vent valve depicted in this example is actually a two-stage valve. The first-stage valve (F) is smaller, and is actuated by the float, as described above. When this valve is opened, air/vapor escapes into the vent line, reducing pressure below the plunger (G) that is attached to the larger second-stage valve (H). Higher pressure above the plunger then forces the second-stage valve down off its seat, permitting a larger quantity of air/vapor to be expelled. When the float rises again, it closes the first-stage valve. Pressure then equalizes above and below the second-stage valve, which is then forced back onto its seat by a spring. Such a design provides a smooth opening of the valve and thus prevents an abrupt expulsion, reducing shock and wear on the mechanism.

When there is not sufficient product supply to the bottom of the chamber, as occurs when the tank or compartment is empty, the float continues to drop after the vent valve has been fully opened. When the float reaches a lower specified level, another linkage closes a valve at the outlet to the meter (I), preventing any air or vapor from being drawn through. (The example shown utilizes a butterfly valve. Other designs incorporate an air-actuated valve, which operates on the same unequal-pressure principle described above.)

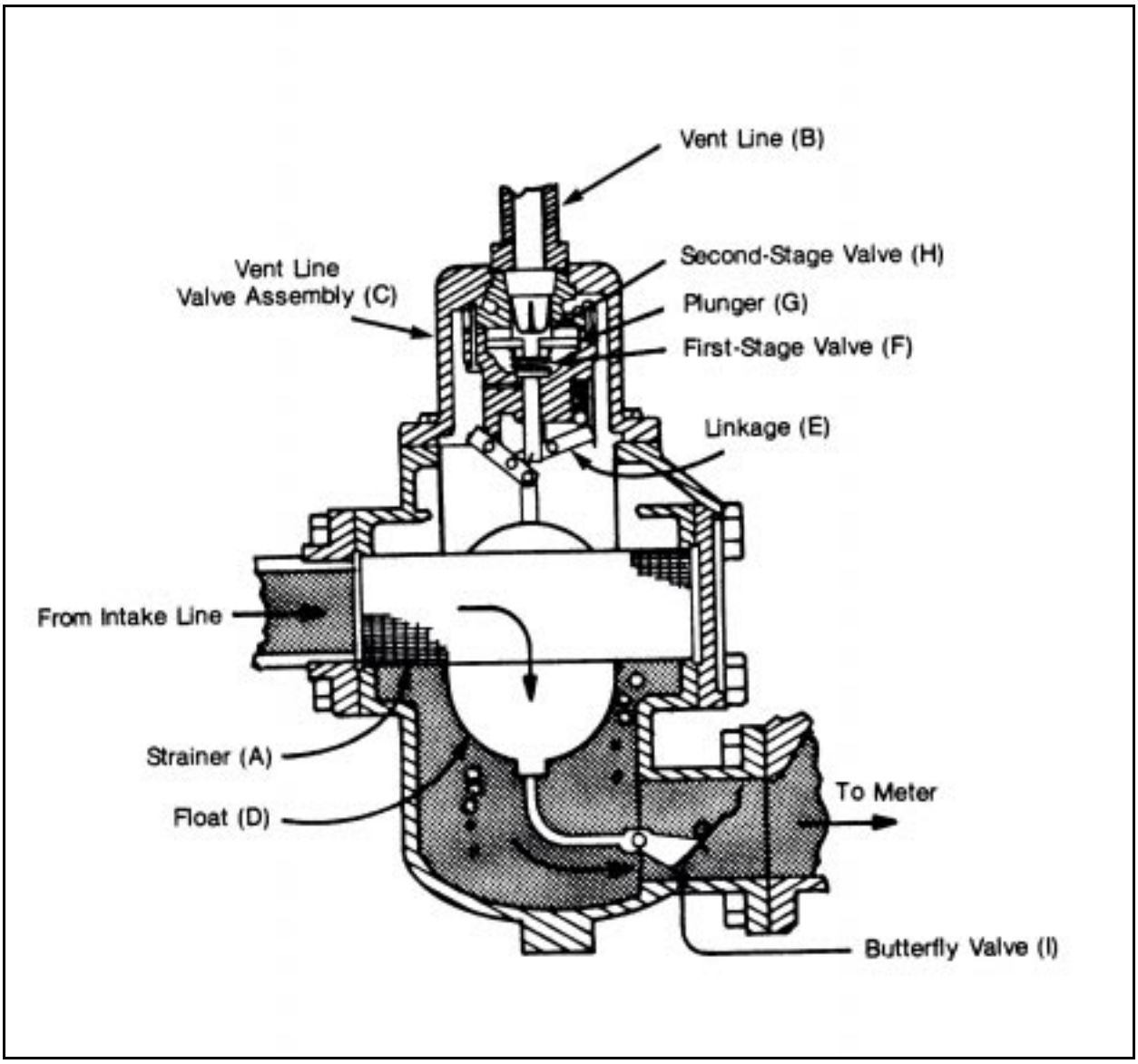

Figure 3-3. Cutaway of a Typical Air Eliminator

In a power-operated system, the vent line carries the expelled gases back to the tank, where they are vented (as shown in Figure 3-4).

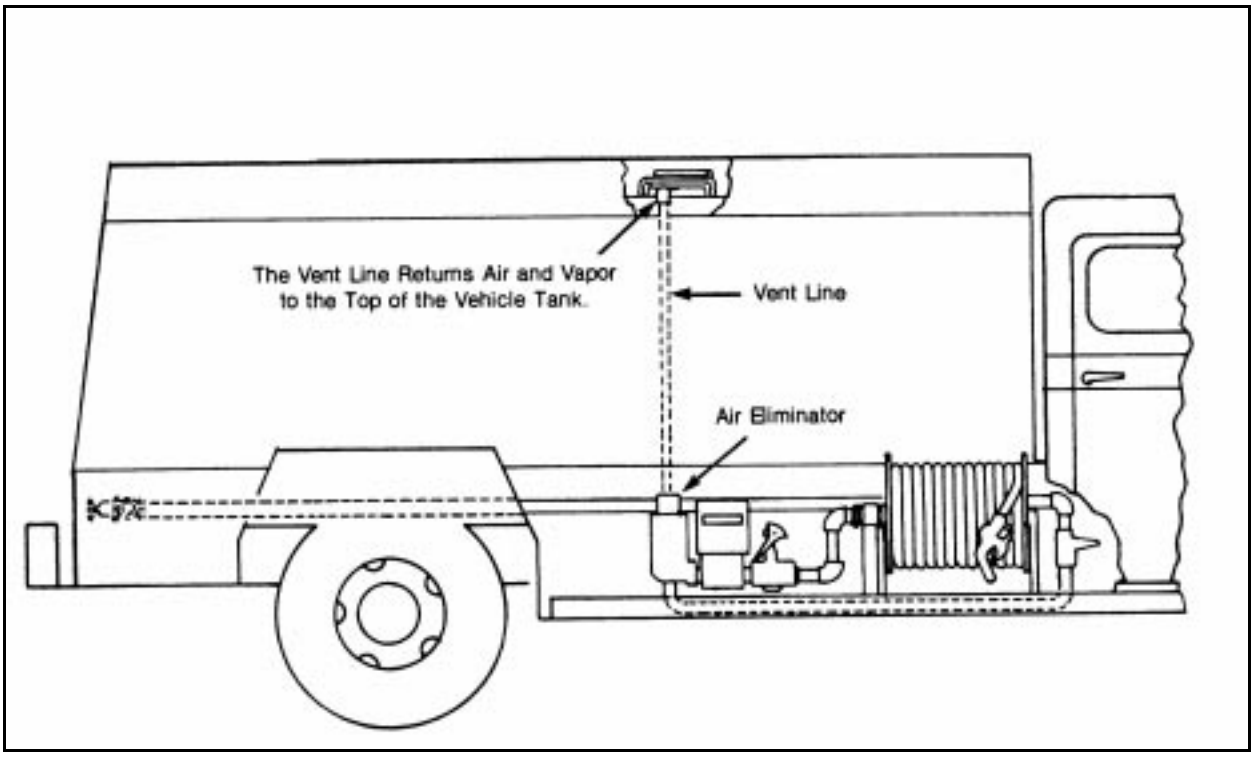

Figure 3-4. Installation of Vent Line, Power-Operated System

In a gravity-discharge system, the vented gases are generally dispersed in another way, as shown in Figure 3-5. Air and vapor are carried around the meter and vented into the discharge line. This nature of this design serves as a siphon-breaker, which is necessary (and required by Handbook 44) because the suction pressure of product in the discharge line will continue to draw upon the meter, even though there may be no product supply. The air/vapor vented into the discharge line relieves suction pressure at the meter outlet, and allows the product in the discharge line to fall into the receiving tank. This prevents the meter from being drained of liquid.

The air eliminator should be capable of preventing gases from entering the meter under normal operating circumstances, including a "split-compartment" delivery (when product is exhausted from one tank compartment and delivery is resumed from another). Its failure to perform may result from any one of several factors:

- Mechanical failure of the float mechanism, resulting from rupture of the float itself or damage to or distortion of its linkages.

- Malfunction of the air vent valve. If it will not close, liquid can rise into the vent tube, blocking the vapor passage. If the valve will not open, pressure inside the chamber will eventually force air/vapor into the meter.

- If the vent tube is obstructed, either by a crimp or by the induction of solid material, unrelieved pressure will similarly force gases into the meter.

The split-compartment delivery generally provides the most severe test of the air eliminator, since it must respond quickly to a large and rapid influx of air. An air eliminator which is worn or in need of

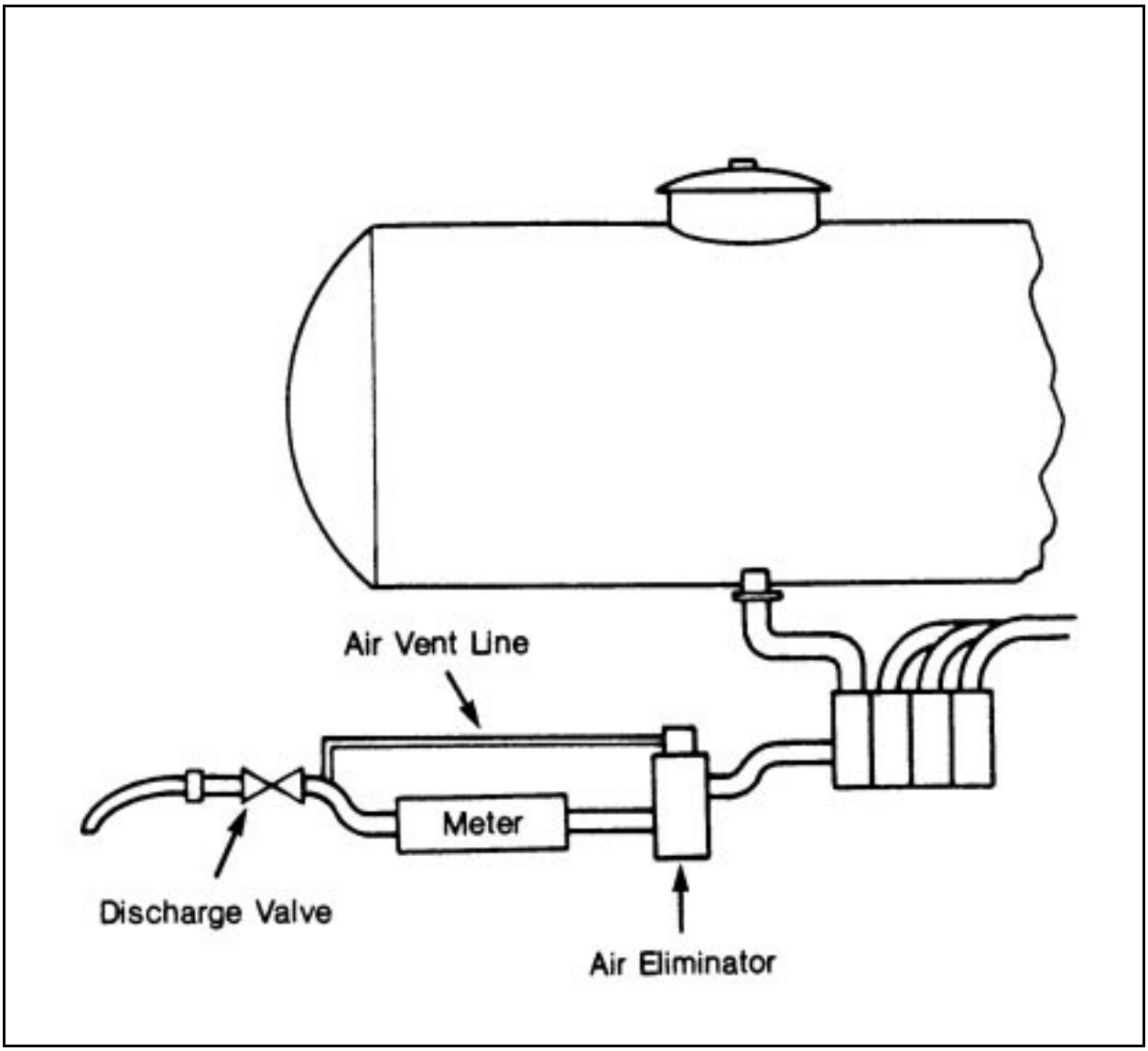

Figure 3-5. Installation of Vent Line, Gravity Discharge System

reconditioning may function adequately under most conditions, but be incapable of responding effectively to this extreme situation.

The Meter

The meter is the heart of the vehicle-tank system, capable of measuring liquid flow at rates that (depending upon the rated capacity of the meter) may exceed 300 gpm with a degree of inaccuracy of less than 0.1% (e.g., an indicated delivery of 500 gallons of product can be no more than 500.5 gal and no less than 499.5 gal, a maximum error of no more than 2 quarts)! This amazing capability is in large part due to the positive-displacement method of metering that is employed by all modern vehicle-tank systems.

The design of these devices is, from an engineering point of view, highly sophisticated. But their principle of operation is quite simple. The cutaway diagram of a typical design in Figure 3-6 illustrates this principle. Liquid product flowing through an enclosed space -- the meter chamber -- is momentarily separated into segments of a known volume. The segments are then rejoined and flow from the meter into the discharge line.

In the example shown, the liquid is segmented by retractable blades (A), which are mounted on a revolving rotor (B). Fluid pressure on the blades causes the rotor to revolve at a rate that corresponds to the flow. In Stage 3, you can see that a quantity of product has been segmented by blades C and D. In Stage 4, the next quantity (E) has been segmented. Since the exact volume of each segment -- enclosed between the blades, the rotor wall, and the inside walls of the chamber -- is known, and since the number of segments produced in a single revolution of the rotor is known, the exact volume of liquid that passes through the chamber in a single revolution of the rotor is also known. In a typical meter, one gallon of product passes through the meter in a single revolution. The rotor is mounted on a shaft (F), which revolves with it. This revolving meter shaft drives the register (see Figure 3-6).

The example shown is a rotary-type design, a type commonly used in vehicle-tank meters. This particular example was chosen because it illustrates the principle clearly in a two-dimensional drawing. Each of the manufacturers of vehicle-tank meters has one or more of its own proprietary designs, each of which has some unique features. You can learn about these specific designs, and the claims that are made for them, by reviewing the manufacturers' literature and industry publications.

One obvious advantage of this type of design is that it requires relatively few moving parts. This minimizes friction and wear. Another common design feature reduces these factors even further. Though it is not apparent in the diagram, the elements that segment the flow -- in the case of the example, the retractable blades -- never actually touch the walls of the metering chamber. A small clearance -- typically 0.005 inch or less -- separates these surfaces when they are at the point of closest proximity.

Because of its relative simplicity of operation and few moving parts, meter malfunctions are caused by a limited number of factors. As has been mentioned, dirt or foreign matter that is drawn into the meter can cause problems if it interferes with the free movement of the rotor or segmenting elements. Solid particles can also have an abrasive effect on the machined and polished surfaces of the meter wall. This can increase friction and widen the very small clearances, allowing product to slip between opposing surfaces. (For this reason, it is especially important that the tank and supply lines of a new system be thoroughly flushed before the meter itself is installed. This will wash away filings and other loose waste metal left behind during the finishing process at the factory.)

The only other factor that is likely to affect the accurate performance of the meter is normal wear. Even a slight amount of play, especially in the moving elements that segment the flow will increase friction and slippage of product through meter clearances, causing erratic measurement. No matter how well designed, maintained, and operated, any meter will eventually require reconditioning.

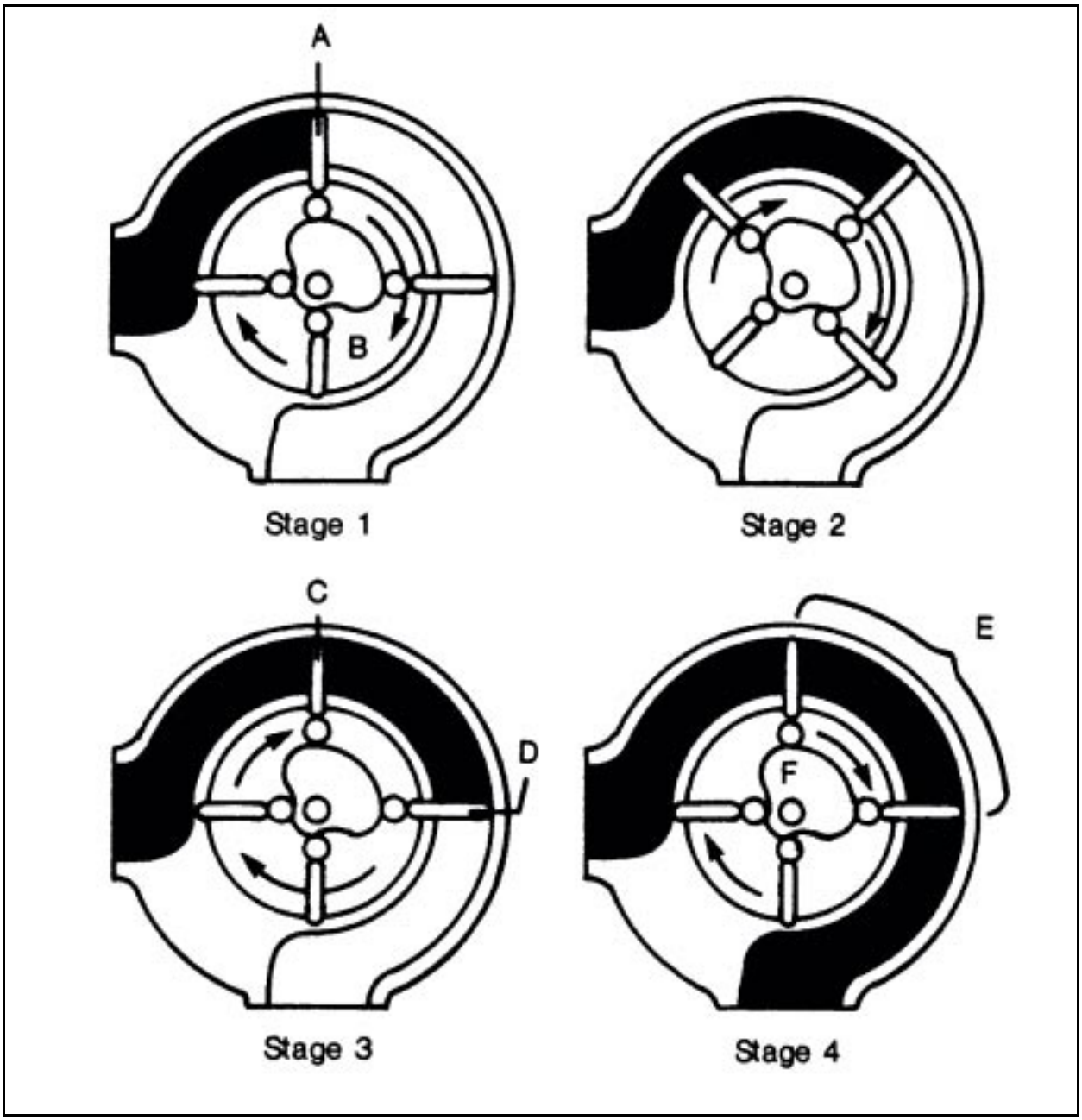

Figure 3-6. Diagram of Typical Positive-Displacement Meter

The meter itself can not be adjusted in increments (as, for example, a gas pump meter can). The system is calibrated by adjusting the indicating element, the register. This will be discussed in the next section.

The Register

If the meter is the heart of the vehicle-tank system, the register is the brains. Its primary function is to "count" the number of revolutions made by the meter during a delivery and, on the basis of this count, to

display the quantity of product that has passed through the meter. The register produces its indication directly from the revolving shaft of the meter, either mechanically or electronically.

The mechanical register used on vehicle-tank systems incorporates a wheel-type indicator, the type used on many mechanical gas pumps. The revolving meter shaft transfers its motion through a gear train directly to a revolving wheel. As you can see in Figure 3-7, graduations and number values are printed on the edge of this wheel. These markings divide the circumference of the wheel into a number of equal segments, usually ten, and show the value that each particular segment represents.

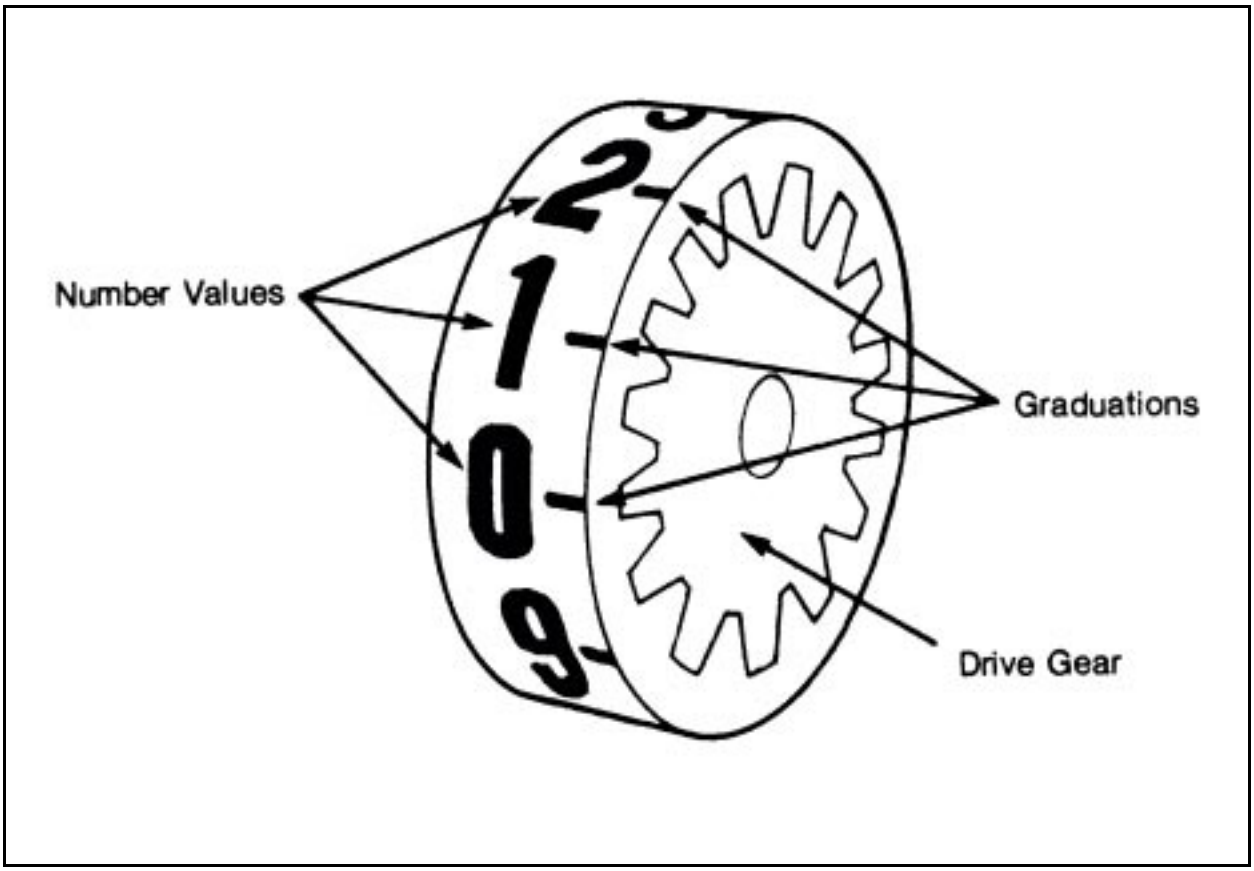

Figure 3-7. Indicating Wheel

In most vehicle-tank systems this wheel is geared to revolve at the same speed as the meter shaft: each complete revolution represents the passage of one gallon of product through the meter. A portion of the wheel's edge is visible through a window in a cover plate, as can be seen in Figure 3-8. Attached to the side of the window is a fixed indicator (a pointer). In this example, the passage of one segment of the wheel (from the center of one graduation to the center of the next) past the pointer represents one-tenth of a gallon of product delivered.

During the latter part of each revolution, the movement of the wheel causes another wheel, located to its left and usually identical to it, to turn through one tenth of its own circumference. In the example shown in Figure 3-8, each segmented interval thus represents one gallon delivered on this wheel, and a complete revolution represents 10 gallons. This process is repeated for three more identical wheels, each turned through one tenth of its circumference by the complete revolution of the wheel to its right. Each wheel

thus represents values 10 times greater than those represented by the wheel on its right: each interval for the leftmost wheel indicates one thousand gallons of product delivered.

An electronic register also produces its indication directly from the motion of the meter shaft. But in an electronic register, this mechanical motion is transformed into digital signals. This is accomplished by a component that is commonly called the pulser. The pulser generates a known number of discrete electrical pulses for each complete revolution of the meter shaft. Pulsers installed on vehicle-tank systems generate 10 to 1,000 pulses per revolution, depending upon the design.

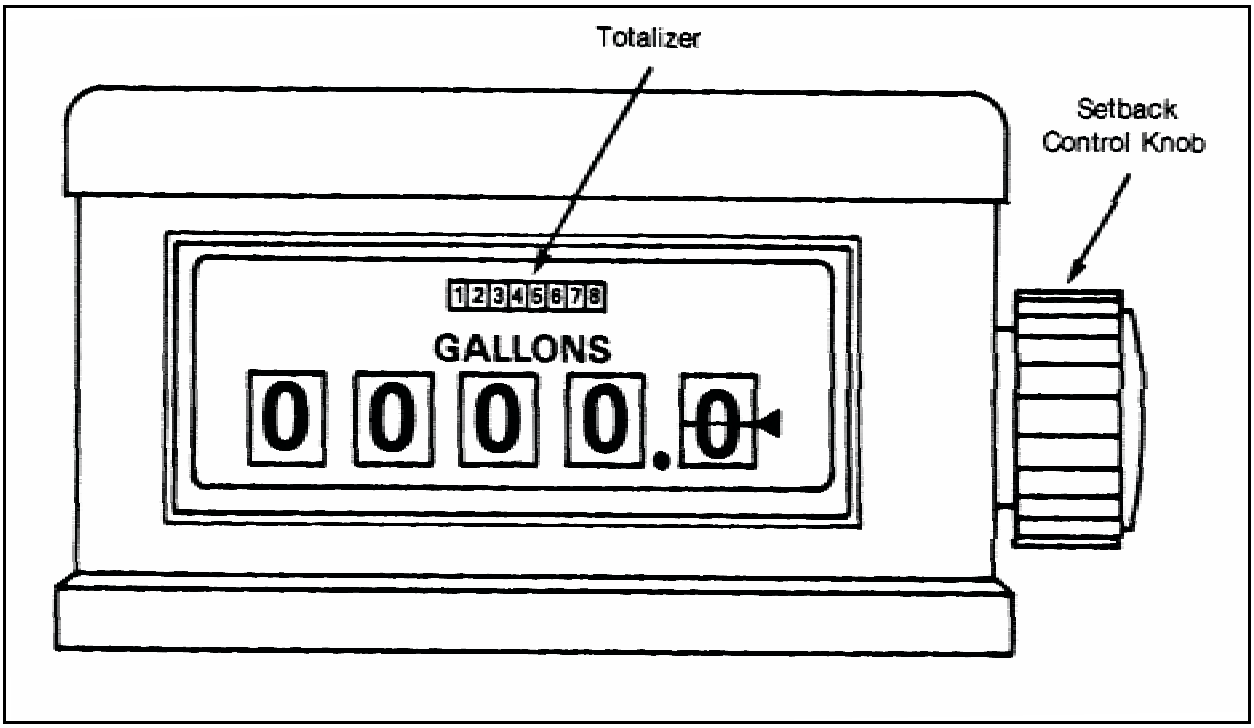

Figure 3-8. Mechanical Register

There are various types of digital signal pulsers, but most commonly the pulser is a switch that opens and closes with the rotation of the shaft driven by the meter. Some pulsers use shaft encoders including a disc containing narrow opaque regions spaced from each other by relatively wide transparent regions. As the meter shaft rotates, light from a light source is directed through the regions toward a light detector. The output from the light detector is then a train of pulses.

The square wave output from either a switch or a shaft encoder is illustrated in Figure 3-9. It is a train of pulses which relate directly to the rotation of the meter.

The duration of individual pulses and the intervals between them will vary with the rate of rotation of the meter shaft, but their voltages will be of the same magnitude and, for the duration of each pulse, constant. These discrete pulses are transmitted to a component of the register's circuitry called the central processing unit (CPU). The CPU "recognizes" these pulses as signals, "counts" them, and computes the number of gallons on the basis of the known number of pulses per meter revolution. The CPU then sends its own signals, which activate the digital display: each signal from the CPU instructs the display to add one

increment (usually 0.1 gal) to the value of its current display. An electronic register is illustrated in Figure 3-12.

As you will see when we turn our attention to field examination procedures in Chapter 5, specific requirements for mechanical and electronic registers differ in a number of respects. These differences reflect an important distinction, which your understanding of the design and operation of these devices should help make clear. This is the distinction between analog and digital devices.

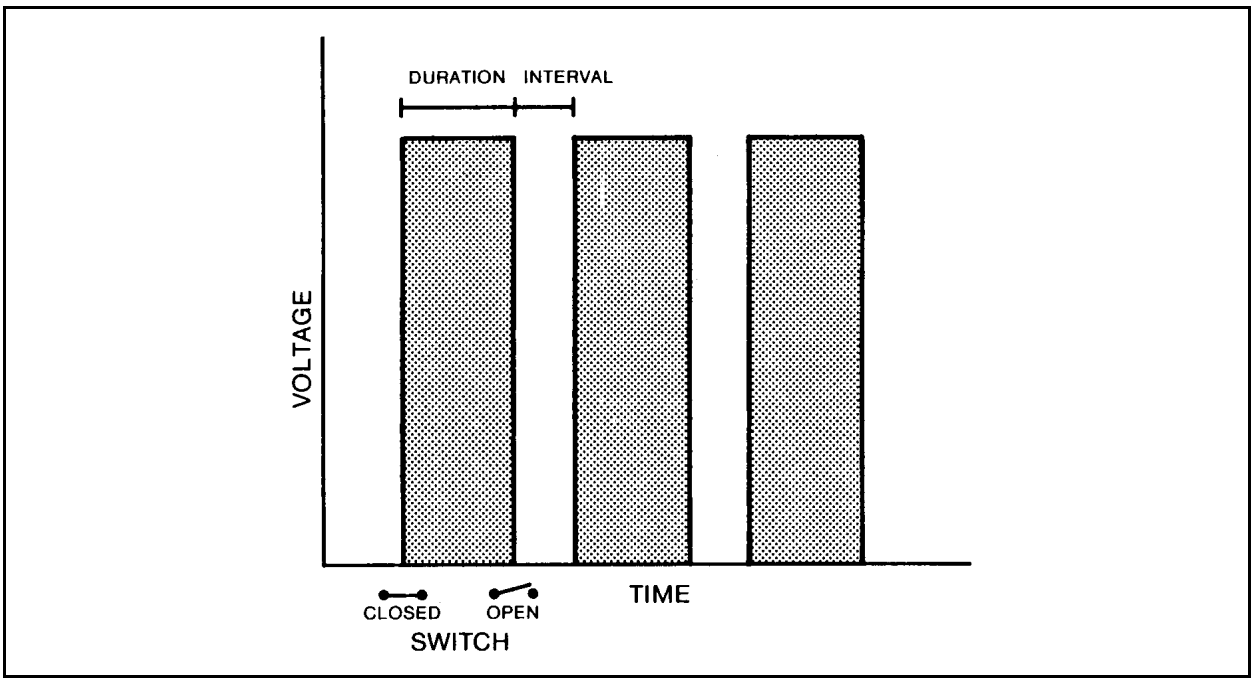

Figure 3-9. Generating Discrete Pulses

Mechanical registers are analog-type devices. A formal definition of this type is provided in Handbook 44.

> analog type. A system of indication or recording in which values are presented as a series of graduations in combination with an indicator, or in which the most sensitive element of an indicating system moves continuously during the operation of the device.

A mechanical register like the one described above meets both parts of this definition. You have seen how values are presented as a series of graduations on the indicating wheel, with an indicator (the pointer) used in combination with the graduations on the righthand wheel (in our example, the tenths-of-a-gallon wheel) to effect a reading. This righthand wheel is the most sensitive element of the indicating system, because it indicates the smallest quantities that the system is capable of representing. And this most sensitive element moves continuously during the operation of the device, driven directly by the meter shaft and gear train. As it moves, and the indicator passes from one graduation to the next, it also passes through an infinite number of intermediate values (though our ability to read these values is limited from a practical point of view.) Now let us look at the formal definition of a digital device type:

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digital type. A system of indication or recording of the selector type or one that advances intermittently in which all values are presented digitally, or in numbers. In a digital indicating or recording element, or in digital representation, there are no graduations.

Of course, there are no graduations on a digital register display, only the numbers themselves. And in contrast to the analog register, whose indicator passes through an infinite number of intermediate values between graduations, the digital register indicates no intermediate values. It "jumps" from one value to the next.

Consider the indicators depicted in Figure 3-10. They look quite similar, and in fact indicate exactly the same quantity, 100.0 gallons. The drawing on the left represents an analog indicator, that on the right a digital indicator.

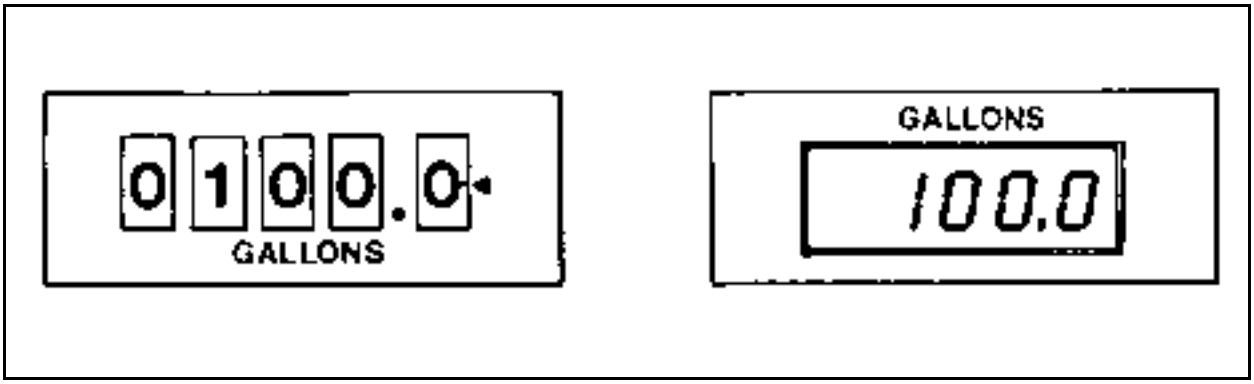


Figure 3-10. Analog vs. Digital Indications (I)

Now imagine that we deliver exactly the same very small quantity of product from both systems. The indicators then might appear as in Figure 3-11.

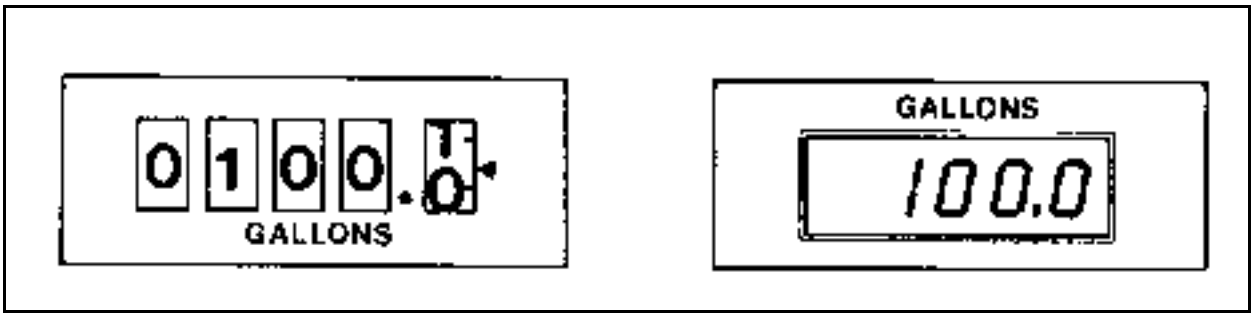


Figure 3-11. Analog vs. Digital Indications (II)

It is clear from the reading of the mechanical indicator on the left, that some additional product has been delivered. We can see at a glance that slightly less than 0.05 gallon has been added to the earlier reading of 100.0 gal, and by subdividing the interval visually we can arrive at an approximate reading of 100.04 gal. The digital indication on the right, however, still reads 100.0 gal, despite the additional delivery of product, and will continue to do so until about 0.01 gal more has been delivered (since, like most digital indicators, it is designed to round up to the next higher value half-way between two consecutive values, and will thus read 100.1 gal for all deliveries between 100.05 and 100.149 gal).

What difference does this make? To the buyer and seller of the product it will make virtually no difference at all. In our example, if the price of the product is $1.00/gal and if the operator of the analog device follows the practice of rounding up to the next higher volume quantity, the buyer from the digital system will have received a penny's worth of "free" product for a delivery costing $100.00 -- an insignificant amount. But to a weights and measures inspector conducting an official test, 0.04 gallon could be very significant. As you will learn in Chapter 6, the tolerance specified in Handbook 44 for a 100-gallon test draft delivered from some vehicle-tank metering systems that are new or that have been recalibrated or reconditioned within the past 30 days is only 0.162 gal (37.5 cu in). In such a test situation, a meter could easily be erroneously rejected (or erroneously approved) on the basis of a difference of 0.04 gal!

In fact, most electronic registers are capable of being programmed to indicate hundredths of a gallon for test purposes, and some models are equipped with light-emitting diodes that light up at the midpoint of the smallest indicated increment. As a result, this will rarely present a practical problem for you in the field. However, it points out the reason for the general distinction between analog and digital registers. As you will see, this distinction is also significant in other ways.

Weights and measures regulations require that all vehicle-tank meters used in commercial transactions must be equipped with a means of resetting the register to zero prior to the start of a delivery. The reason for this requirement will be described in detail in Chapter 5. On a mechanical register, the reset control is usually a lever or knob on the side of the register, like the one shown in Figure 3-8. Operating the control all the way to its stop will turn the indicating wheels (usually forward) until all of them are in a definite zero position. The reset control on an electronic register is usually a pushbutton that, when depressed, clears the display, as in the example shown in Figure 3-12.

If the device is cleared by advancing its elements to zero, it is also required that some effective means be provided to prevent the device from displaying any readable indication during the course of the resetting process (see also Chapter 5). Most mechanical registers are equipped with shutters that cover the indicating wheels while they are being advanced to zero. On electronic meters the display is blanked out completely while the circuits are being cleared and reset.

In addition to the resettable "primary" indicating element, most registers also have cumulative indicators, more commonly referred to as totalizers (see again Figures 3-8 and 3-12). These displays are used by the owner or operator to monitor sales and inventory and to provide a means of detecting pilfering of product by employees. The totalizers can usually be reset by the owner or operator, but are protected by security seals or codes from unauthorized resetting. Since they are usually not used as the basis for commercial transactions, totalizers are generally not subject to weights and measures requirements regarding accuracy, readability, etc.

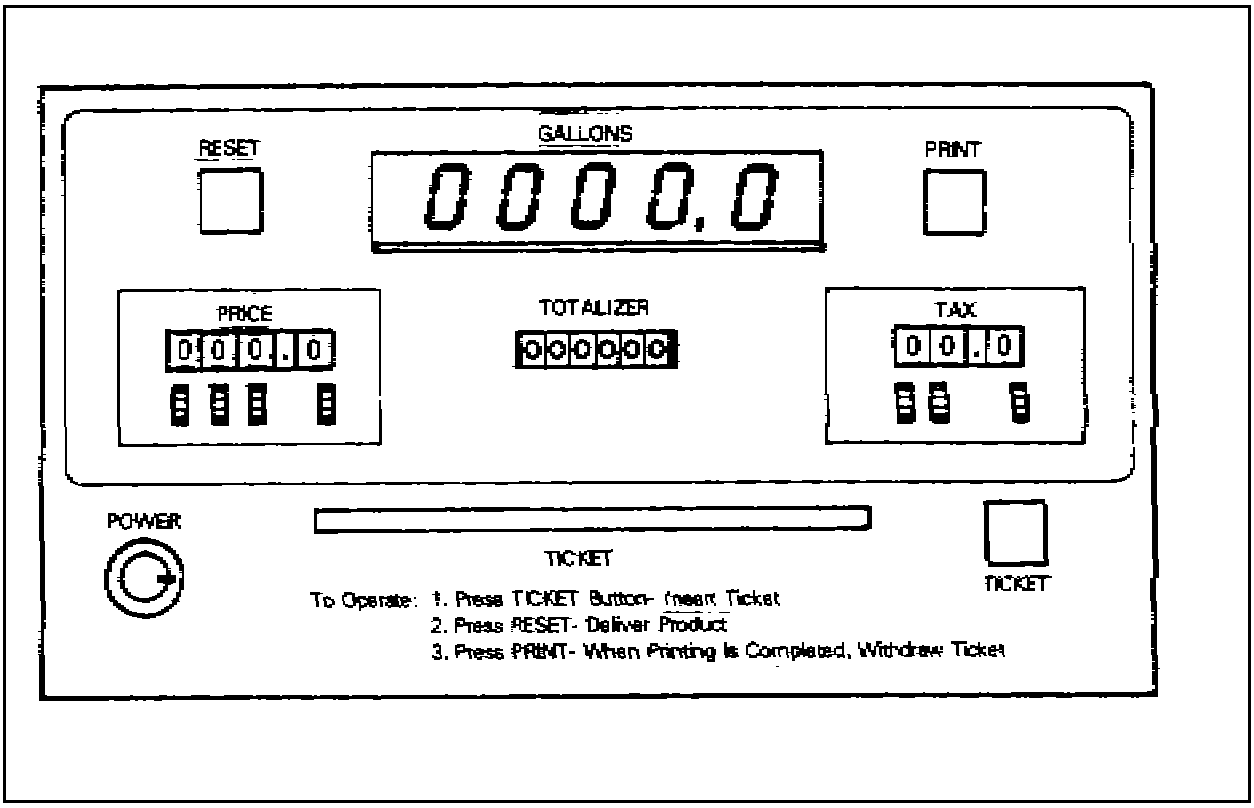


Figure 3-12. Electronic Register

However, the inspector will use them to determine the total amount of product dispensed during tests. The operator can then be informed of the extent of the discrepancy in his or her inventory to be attributed to testing (since product is returned to the truck tank at the conclusion of tests, but will have been registered on the totalizer as delivered).

The Calibrator

When a vehicle-tank meter is calibrated, it is the register rather than the meter that is directly affected by the change. Unless it is reconditioned, the meter will continue to process the same amount of product per complete revolution at a given discharge rate; the register is adjusted to bring the indication of the delivery as close as possible to a zero-error condition.

Mechanical registers are adjusted by means of a mechanism that alters the rate of revolution of the indicating wheel relative to the revolution of the meter shaft. In some designs, this is accomplished by actually changing the drive gears: the larger the driving gear in relation to the driven gear, the more revolutions the driven gear will make per revolution of the driving gear (its relative rate of revolution will increase), and vice versa. Such an adjustor is, appropriately, called a "gear changer." The adjustment mechanism itself is usually calibrated, so that an adjustment of a single step will effect a predictable change in the indication per gallon metered. For example, a typical adjustor might be capable of stepped corrections in increments of 0.5 cubic inch per gallon metered.

As you might expect, calibration of electronic registers is performed electronically. The operator or repairperson determines a "calibration factor" based upon the error observed during a performance test. This factor is read into the system circuitry, and subsequently corrects all indications by a consistent amount. Recalibration is based upon the current meter factor.

A meter can only be calibrated effectively when its errors are reasonably consistent over its full range of operating conditions. A meter that is excessively worn will register erratically, and its inaccuracy will eventually vary widely at different flow rates. The calibrator can thus be considered a fine tuning instrument for a meter that is not badly worn or damaged. At some point, however, the calibrator will no longer be capable of correcting the meter to within acceptable limits of inaccuracy (tolerances), and the meter itself will then have to be reconditioned or replaced. The topic of meter wear and recalibration will be discussed further in Chapter 6.

The Printer

Handbook 44 requires that, except for systems used solely for the sale of aviation fuel into aircraft and for aircraft-related purposes, vehicle-tank metering systems be equipped with a ticket printer, and the device owner must use the ticket printer for all sales where product is dispensed through the meter. (A contrasting example is one in which an entire truckload of product is gravity dropped at a service station rather than running the product through the meter on the back of the truck. In this case, the customer is provided with a printed invoice from the loading-rack meter system used to fill the vehicle-tank truck. Because product is not delivered through the meter for the sale, the ticket printer on the vehicle-tank meter is not required to be used for the delivery.) In addition to using the ticket printer for all sales, the seller must leave a copy of the ticket with the customer at the time that the delivery is made unless the customer makes other arrangements with the seller.

Ticket printers reduce the operator's effort and are consistently accurate, whereas hand-printed invoices take time to prepare and are sometimes inaccurate due to errors in reading of the register indications, errors in transcription, or in computations made by the operator.

A ticket printer is driven directly by the register, either mechanically or electronically. The recorded representations produced by a ticket printer are required to be digital. That is, the quantity delivered (as well as the total price and unit price if the system is of the computing type) must appear on the ticket as numbers. It would not be acceptable, for example, for the printer to show a representation of indicating wheels or a dial with graduations and an indicator, even if this is the means by which register indicates amounts and values. This requirement applies regardless of whether the register produces analog or digital indications. Computing-type registers (described in detail in Chapter 5) may also provide complete invoice information for a compatible printer, including the unit price of the product, quantity delivered, and total sale price. A number of specific requirements apply to the design, installation, and use of ticket printers. These requirements will be explained in detail in Chapter 5.

Temperature Compensators

Devices designed and used to correct register indications for the effects of temperature on product volume are not widely used for vehicle-tank meters because they are generally not considered to be cost-effective for most commercial applications. However, several States permit their installation, and they are available through a number of manufacturers. Temperature compensators are not covered by any specific

requirements in the Vehicle Tank Meter Code of Handbook 44, and no general guidelines can be presented here for dealing with them in the field. Your instructor will explain your jurisdiction's policies and procedures regarding field examinations of vehicle-tank meters that are equipped with temperature compensators.

A temperature compensator is basically an automatic calibrator, and the design of its correcting elements is similar. A sensor located in the product line relays the temperature to these correction elements.

The Discharge Line

After product passes through the meter it enters the discharge line. The elements of the discharge line include a main control valve, a discharge hose, and, on power-operated systems, a discharge nozzle. Power-operated systems are also equipped with automatic directional flow valves. A preset control device is optional.

The Control Valve

The control valve is the main flow control on both gravity-discharge and power-operated systems, although in the latter the discharge nozzle can also be used to regulate flow during delivery. The control valve is located at the outlet of the meter. The design and operation of the valve are straightforward, as you can see in Figure 3-13.

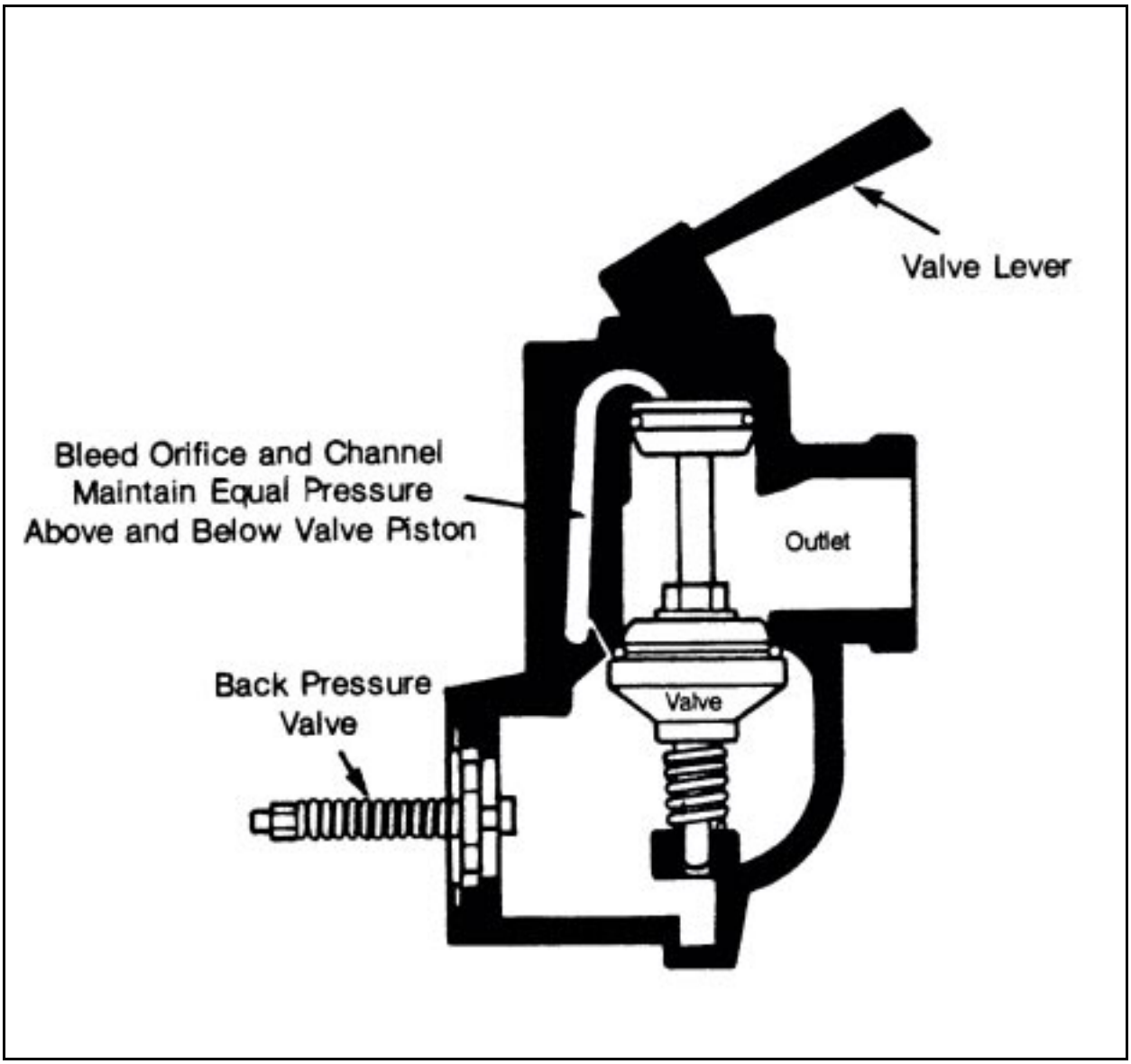


Figure 3-13. Cutaway Diagram of Control Valve

Most control valves, like the one depicted, have a design that maintains balanced pressure on both sides of the valve throughout its operation. This prevents the valve from opening or closing abruptly, and thus minimizes hydraulic shock in the meter and discharge line. This particular design employs a bleed tube and orifice. Others incorporate a two-stage valve, similar to the air eliminator vent valve shown earlier.

You will notice that this control valve is equipped with a back-pressure valve at its inlet. A back-pressure valve requires a calibrated amount of pressure on the inlet side to keep it open. So pressure in the meter, in the air eliminator, and back through the supply line is maintained at or above the desired back pressure. This helps the air eliminator function more efficiently by preventing the product level from fluctuating with changes in discharge flow.

Notice also that this control valve functions as a check valve, allowing product to flow only in the direction of the outlet and discharge line. This prevents the system, and especially the meter, from draining backward toward the supply. Most manufacturers recommend that a back-pressure valve be used with power-operated systems. A back-pressure valve is not necessary in gravity-discharge systems, and might inhibit delivery at low head.

The Preset Control

Many vehicle-tank systems that make primarily partial-load deliveries, like home heating oil trucks, are equipped with a preset control device, sometimes referred to as the quantrol (short for "quantity control"). The operator can set this device to deliver a predetermined quantity of product and then shut off delivery automatically. It is then unnecessary for the operator to monitor the delivery at the meter/register. He or she may instead stand at the discharge nozzle, which may be some distance away. The preset is linked, either mechanically or electronically, to the meter shaft and to the control valve. It is usually mounted on the meter "stack," that is, either on top of the meter or on top of the register. In some systems the preset is incorporated in the register.

The operator punches in the desired quantity on the preset display, using a separate pushbutton to set each digit (see Figure 3-14). This establishes a trip point. When the delivery begins, the preset functions just like a register, but counts backwards, indicating continuously on its quantity wheels the amount left to be delivered. When the delivered quantity reaches the preset trip point and the preset indicates zero, the device actuates the control valve, shutting off flow.

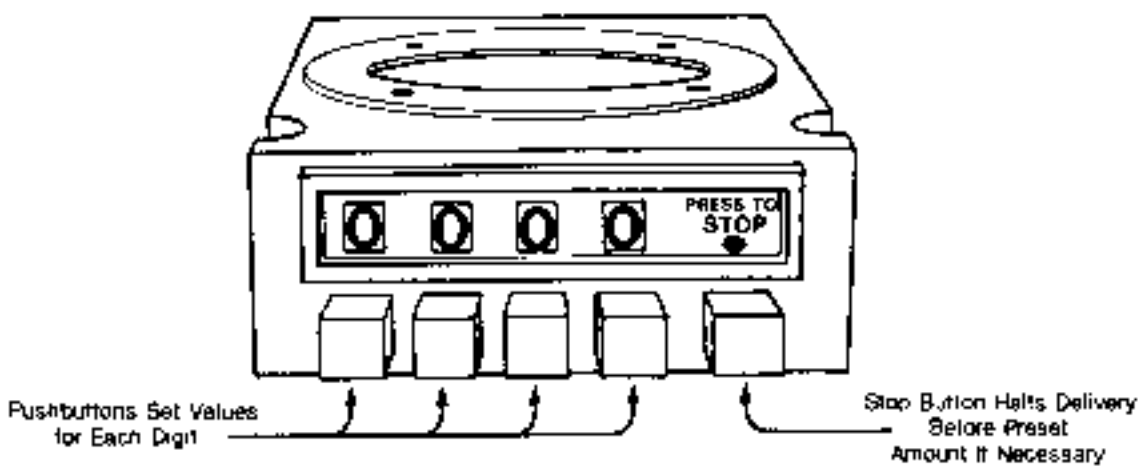


Figure 3-14. Preset Control

The Discharge Hose

As mentioned earlier, the discharge hose on a gravity system should be no longer than necessary to drop directly to the underground storage fill opening. The short hose facilitates complete drainage at the conclusion of the delivery. For the same reason, gravity-discharge hoses are reinforced so that they are semi-rigid. Since the system is of the dry-hose type, the discharge end of the hose is not equipped with a valve. The delivery is regulated entirely at the control valve.

The discharge hose on a power-operated system, on the other hand, may have to be much longer to reach its delivery point (as is often the case for home heating oil deliveries), and its length will not be limited by the necessity of draining it completely, since it is a wet-hose system. However, the hose should still be no longer than necessary. A shorter hose will reduce pressure drop and the effects of ambient temperatures on the system by reducing surface area. The use of a hose reel protects any unused length of discharge hose from exposure to the effects of wind and sun.

The discharge nozzle on a power-operated system has two essential functions:

- to regulate discharge at the delivery point
- to prevent drainage of the discharge hose

The first of these is performed by a manually operated valve, with a lever-type operator. This allows the driver to regulate the delivery at the fill station, which may be at some distance from the truck. At the conclusion of the delivery, the driver closes the discharge nozzle valve, then returns to the truck, closes the control valve at the meter, and disengages the pump from the truck engine to complete the system shutdown.

The discharge nozzle on a power-operated system must also be equipped with an antidrain valve. The antidrain valve is installed in the nozzle inlet, and is similar in design to the back-pressure valve we looked at earlier. It is calibrated to open only under pump pressure. When the driver closes the control valve at the meter, pump pressure is no longer supplied to product in the discharge hose, and the antidrain valve will no longer open, even if the discharge nozzle valve is opened. Thus the antidrain valve, when functioning correctly, effectively prevents the discharge hose from being drained, thereby assuring accurate registration of the quantity delivered.

In some power-operated systems, the discharge nozzle is also equipped with an automatic shutoff valve, which functions in the same way as its counterpart on a gas pump, shutting off the flow when the tip of the nozzle comes in contact with liquid rising in the receiving tank fill pipe. This valve permits deliveries to be made to the capacity of the receiving tank, "topping it off," without danger of overfill or excessive back pressure on the nozzle valves.

SUMMARY

A number of separate elements work together to assure the safe, efficient, and accurate operation of a vehicle-tank metering system. Because of their functional interdependence, the failure or malfunction of one element can inhibit the effectiveness of others and impair the correct operation of the entire system. Specific requirements relating to the selection, installation, maintenance, and use of these elements are described in detail in Chapters 5 and 6.

CHAPTER 4

PRELIMINARIES TO THE FIELD EXAMINATION

CHAPTER OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Identify test equipment used in field examinations of vehicle-tank meters.

2. Describe the selection and setup of a large-capacity prover.

3. Describe the steps in performing a test measurement using a large-capacity prover.

4. Understand the use of official report forms used by your jurisdiction for examinations of vehicle-tank meters.

5. Describe safety procedures for testing vehicle-tank meters in the field.

INTRODUCTION

Before you conduct a field examination of any weighing or measuring device, a number of tasks must be performed to assure that the examination will be performed efficiently, accurately, and safely.

- You must know where and what you are going to be examining.

- You must notify the operator and make arrangements for access to the device(s) and needed assistance that will not cause an unreasonable disruption of the business.

- You must select the proper test equipment.

- You must determine what examination procedures are appropriate and any special circumstances that might require special procedures.

- You must be prepared when you arrive at the test site to conduct the examination as expeditiously as possible without compromising the accuracy or equity of the examination.

The first of these items -- where and what to examine -- may be determined primarily by your supervisors, who are generally responsible for planning the overall program of weights and measures enforcement for your jurisdiction. The schedules they develop will be based upon a number of factors, including the economic impact of particular devices in the marketplace, complaints from the public, the compliance history of particular types of devices or particular operators, and so on. The time of year may also be a factor in some cases. For example, most jurisdictions schedule examinations of vehicle-tank meters that are used by retail home heating oil services for the summer months, so as not to disrupt service during the

heating season. Additionally, advance scheduling is generally required for vehicle-tank meters since those devices are moved from location to location during normal use and may not be available at the company's main facility. Your instructor will explain how assignments are made in your jurisdiction, and you will learn and practice these and other administrative procedures in the course of your field training.

Similarly, notifying operators and scheduling examination times are administrative procedures that vary widely from jurisdiction to jurisdiction. However, it is likely that as an inspector you will have at least some role in preliminary dealings with device operators, since it is essential that you develop a cooperative relationship with them from the outset; this is usually initiated through personal contact. The importance of establishing this cooperative relationship can not be emphasized enough, since cooperation will make your work more effective and will reduce any burden on the device owner to a minimum. Again, you will learn and practice these procedures thoroughly in the course of your field training.

This chapter will focus on several other aspects of the other pre-examination tasks listed above, specifically your test equipment, report forms, and safety procedures.

TEST EQUIPMENT

The essential items of equipment required for field examinations of vehicle-tank meters include:

- Safety gear, including a fire extinguisher, prover grounding cable, first aid kit, and any special gear, such as goggles, gloves, etc. required for a specific job.
- An accurate watch, with a second hand or a digital display that indicates seconds, or a stopwatch.
- A 5-gallon metal bucket with a bail or handle and sufficiently sturdy to permit pouring its contents without spilling.
- A copy of NIST Handbook 44 and other codes applicable in your jurisdiction.
- Copies of the NIST Examination Procedure Outlines (EPO's) for gravity-discharge and power-operated vehicle-tank meters, as well as checklists, worksheets, etc. used by your jurisdiction.
- Official examination report forms.
- Security seals, inspection stickers, tags, and other marking devices used by your jurisdiction.
- A field standard prover of the type, construction, and capacity required for the test liquid and the metering system being examined and which is certified as correct.

Safety equipment and report forms will be described in detail later in this chapter. The use of Handbook 44, EPO's, seals and marking devices, bucket, and watch will be discussed in later chapters, when we turn to examination procedures. Our discussion here will, therefore, begin with the last -- and largest, if not most important -- item on the list, the prover.

Field Standard Provers

All liquid-measuring devices are tested in the field under conditions that approximate as nearly as possible the normal operating conditions of the device. In the case of vehicle-tank meters, this generally means that test liquid is delivered from the truck tank, through the meter and discharge line, into a container of known capacity. The difference between the quantity actually delivered and the quantity indicated on the register is the test error, and this provides the basis for determining the system's compliance or non-compliance with performance requirements. The "container of known capacity" employed in the test is the prover.

The prover (formally referred to as a "field standard prover" because it is employed as a test standard in the field) is itself a precision measuring device, which must be tested and certified as accurate and correct periodically, like the devices it is used to test. In fact, the performance requirements for provers, as for all field standards, are considerably more stringent than those that apply to the commercial devices that are tested. As a general rule, the standard must perform within tolerances that are no greater than one-third of the tolerances that apply to the device under test.

To assure this degree of accuracy, provers must be certified by a State metrologist or by a licensed testing laboratory. Standard provers maintained by weights and measures jurisdictions are used for almost all examinations, although the official use of a prover owned and maintained by a device operator may be permitted under special circumstances, provided that the prover is certified by the appropriate State authority. Such a situation might arise if the jurisdiction desired to examine a particular device but could not provide an appropriate prover. Specific requirements for provers are established in NIST Handbook 105-3, "Specifications and Tolerances for Graduated Neck Type Volumetric Field Standards."

Provers are constructed of metal (usually low carbon or stainless steel), with their interior surfaces treated by galvanizing, plating, coating with an epoxy resin, or some other means to resist corrosion from the test liquid(s) they are used to measure. They are available in a variety of sizes, ranging from 20 gal to 1 500 gal capacity (provers used for testing vehicle-tank meters generally fall within the range of 50 gal to 200 gal capacity). The size required for a particular test depends upon the rated capacity of the meter being tested: the prover must have a capacity equal to or greater than the quantity of product that is delivered by the system in one minute, operating at its maximum discharge rate. Additionally, the test draft shall not be less than 50 gal (180 L). The reason for this requirement will be discussed presently.

Figure 4-1 illustrates the essential features of a typical prover.

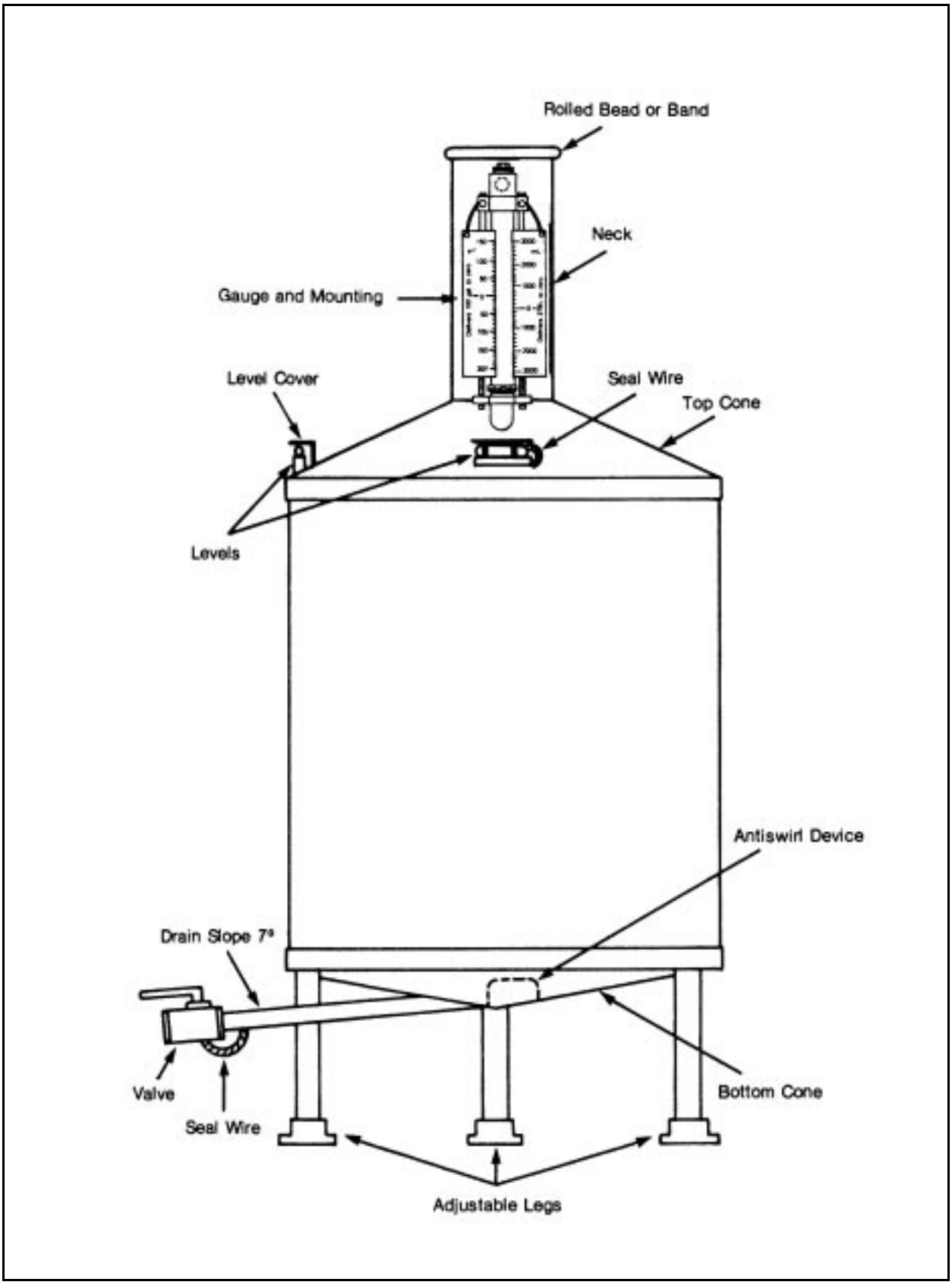


Figure 4-1. Typical Field Standard Prover

Test liquid is delivered through an opening at the top of the elongated neck of the prover (though some larger capacities of provers may be filled from the bottom) and falls to the bottom of the container, filling the drain pipe, where its flow is checked by a valve. The level inside the container rises as the delivery continues. When it reaches the neck, the liquid also rises in a glass gauge tube, which penetrates the container through an opening in the top cone. When delivery is halted, the level of the liquid in this tube is used to indicate the quantity contained on a scale plate that is securely attached to the prover.

Before we look more closely at this gauge, we should notice two other features of the prover depicted in Figure 4-1. The first is that it is equipped with adjustable legs and levels. Leveling the device from front to back and side to side is essential to an accurate indication, since the liquid level in the gauge tube will be directly affected. For example, if the prover were tilted forward slightly (toward you as you view it), the level inside the tube would rise slightly. The level indication should also be verified after the prover is filled with product since the weight of the product might affect the level condition of the prover when full as compared with the prover empty. Second, all elements of the prover whose deliberate or accidental alteration could affect the accuracy of the measurement are protected by security seals. For example, the length of the drain pipe affects the capacity of the prover, since each inch of pipe holds several cubic inches of liquid. Sealing the end of the pipe to the drain valve makes it impossible to alter or replace the pipe without removing or mutilating the seal. Similarly, the mounting brackets for the levels must be parallel to the top and bottom of the prover, and to the graduations on the gauge. Because they are adjustable, these too are sealed. The seals are applied at the time the prover is certified and should not be removed except for recalibration or recertification. Checking all security seals before the start of an official test will assure both you and the operator regarding the correct condition of the prover.

Figure 4-2 is an enlarged view of the prover gauge. The gauge may be equipped with two scales, one employing U.S. inch-pound units (cubic inches), the other metric units (milliliters). Each scale plate is independently adjustable, so each is independently sealed. Graduation lines and numbers are engraved on the plates, along with the nominal capacity of the prover, in the units of the appropriate system (here 100 gallons and 378 liters). The notation on the gauge plate ("Delivers 100 gal. to zero" "Delivers 378 L to zero") indicates that when the level of the liquid is exactly adjacent to the graduation marked 0 (zero), the prover will deliver its nominal capacity (details on reading the prover gauge are covered later in this chapter). Deviations from the nominal capacity are read on the diverging scales above and below the zero line, in divisions of 10 cu in or 200 mL (the value of these divisions varies with the capacity of the prover).

The scale plate of this prover indicates that it delivers 100 gallons (378 L) to zero. This is not the same as saying that it contains its nominal capacity. In fact, a prover that is calibrated "to deliver" will contain somewhat more than its nominal capacity when filled to the zero line. The reason for this method of calibration is that liquid tends to cling to the sides of a container. Even after thorough draining, a film of liquid will adhere to the sides of a container, and this clingage can be significant in a precision measuring device (clingage in a 100-gallon steel prover could amount to several cubic inches of liquid). If the standard can be wiped completely dry before it is used again, clingage is not a problem. But field examinations require successive test drafts, and it would be impractical to dry the inside of the prover thoroughly after each one. Calibration "to deliver" compensates for the clingage. However, because the prover is calibrated to contain more liquid than its nominal capacity, whenever it is dry (before the first official test draft) it must be filled with test liquid and then drained correctly, so that clingage will be present when the first test measurement is made. To assure the correct amount of clingage, a specified drain time must be carefully observed. We will discuss this procedure shortly.

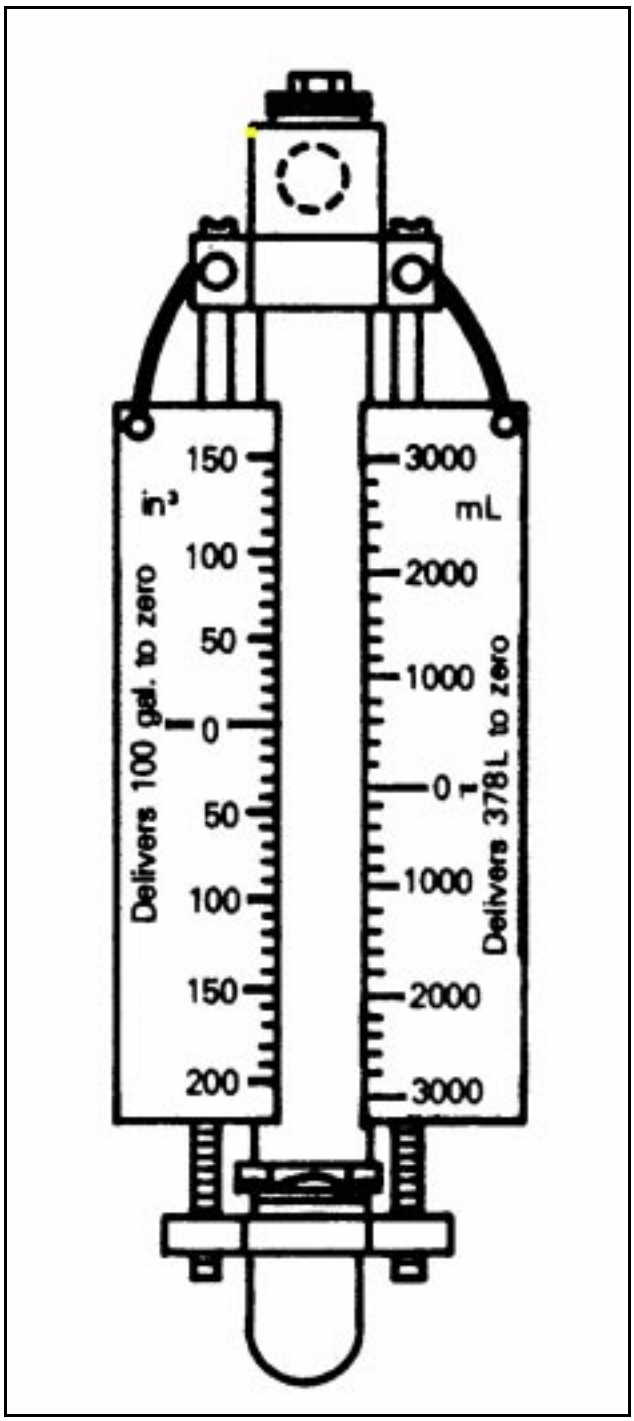


Figure 4-2. Prover Gauge

Large-capacity provers like those used for testing vehicle-tank meters are often mounted on trailers or flat-bed trucks. This makes it possible to transport them to the site of a field examination. However, provers used to test gravity-discharge systems must be positioned at a level below the tank truck, either in a pit or below a platform onto which the vehicle can be driven. Gravity-discharge test pits are generally permanent installations. So the operator must transport his or her trucks to the jurisdiction's test site for examination. Figure 4-3 illustrates testing from a pit.

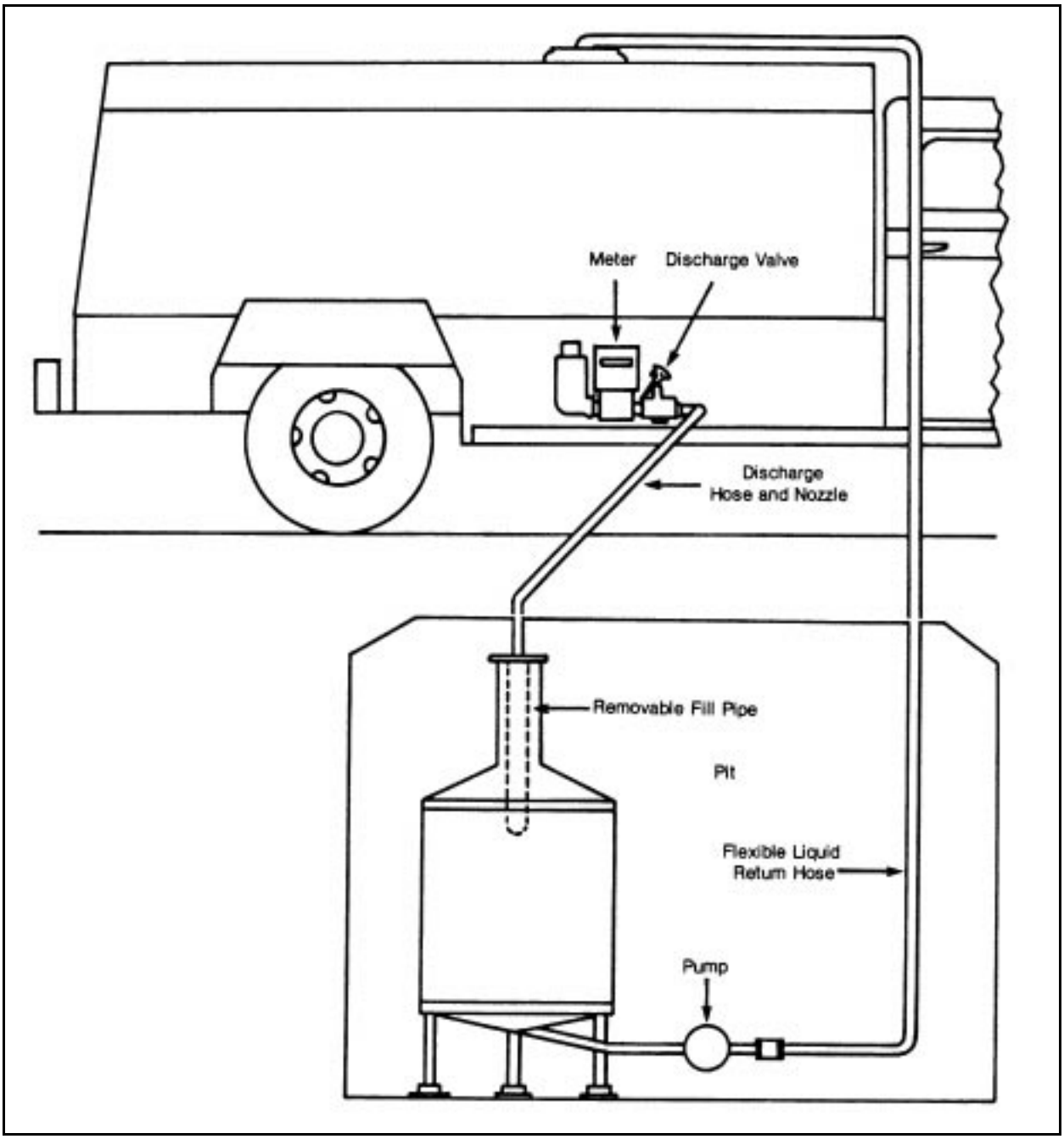


Figure 4-3. Gravity-Discharge Test Pit

Notice that a <u>return line</u> leads from the bottom of the prover back to the vehicle tank fill opening. This permits product to be returned directly to the truck at the conclusion of a test draft. You can also see that a pump installed in the return line is necessary to lift the product from the pit. In fact, this configuration is virtually identical to that typically used for power-operated systems (as shown in Figure 4-4), with product delivered through the meter and discharge hose to the top of the prover and returned at the conclusion of the test to the top of the vehicle tank with the aid of a pump.

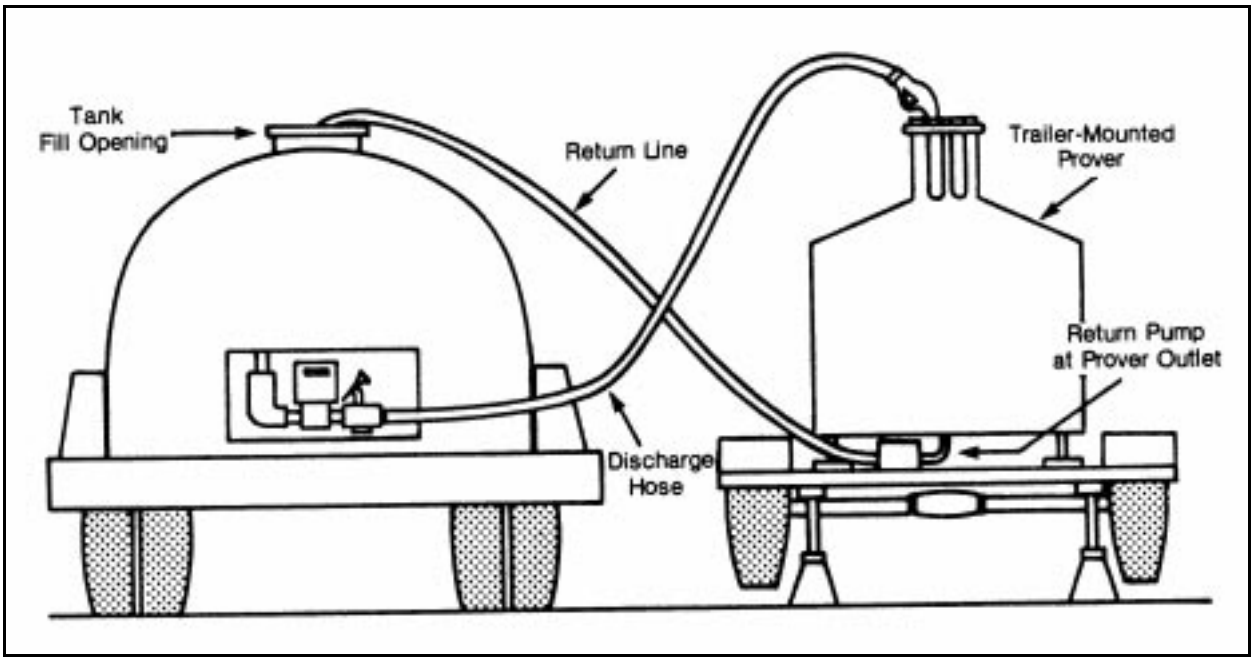


Figure 4-4. Typical Prover Configuration for Power-Operated Systems

Figure 4-5 shows a standard prover mounted on a trailer. Note that jacks are used both to level the device and to lift its weight off the trailer wheels. These are required to assure that uneven tire inflation or unbalanced suspension does not cause the prover to lose its level condition as the weight of the contents increases during a test delivery. This prover is also equipped with a ladder, which provides access for the inspector to the top of the prover, which may be 7 or 8 feet above ground level. The grounding lug furnishes a ready means of attaching a grounding cable to the prover -- an essential safety feature, as you will learn later in this chapter. These features are standard on large-capacity vehicle-mounted provers.

This example also illustrates a number of additional features that may be incorporated in the design of provers used for testing vehicle-tank meters. Several factors determine whether these features are necessary, including the size of the prover and the characteristics of the liquid product that is measured. Your instructor will describe the specific features of provers used in your jurisdiction.

The prover shown is equipped for vapor recovery. This will be necessary if the product produces toxic, polluting, corrosive, or combustive vapors, and State laws may also require vapor recovery for other products as well. The system shown here operates in a manner similar to the air eliminator in the metering system: the rising liquid level inside the container during delivery forces vapor above it through a relief valve and into a vent line, which leads back to the vehicle tank.

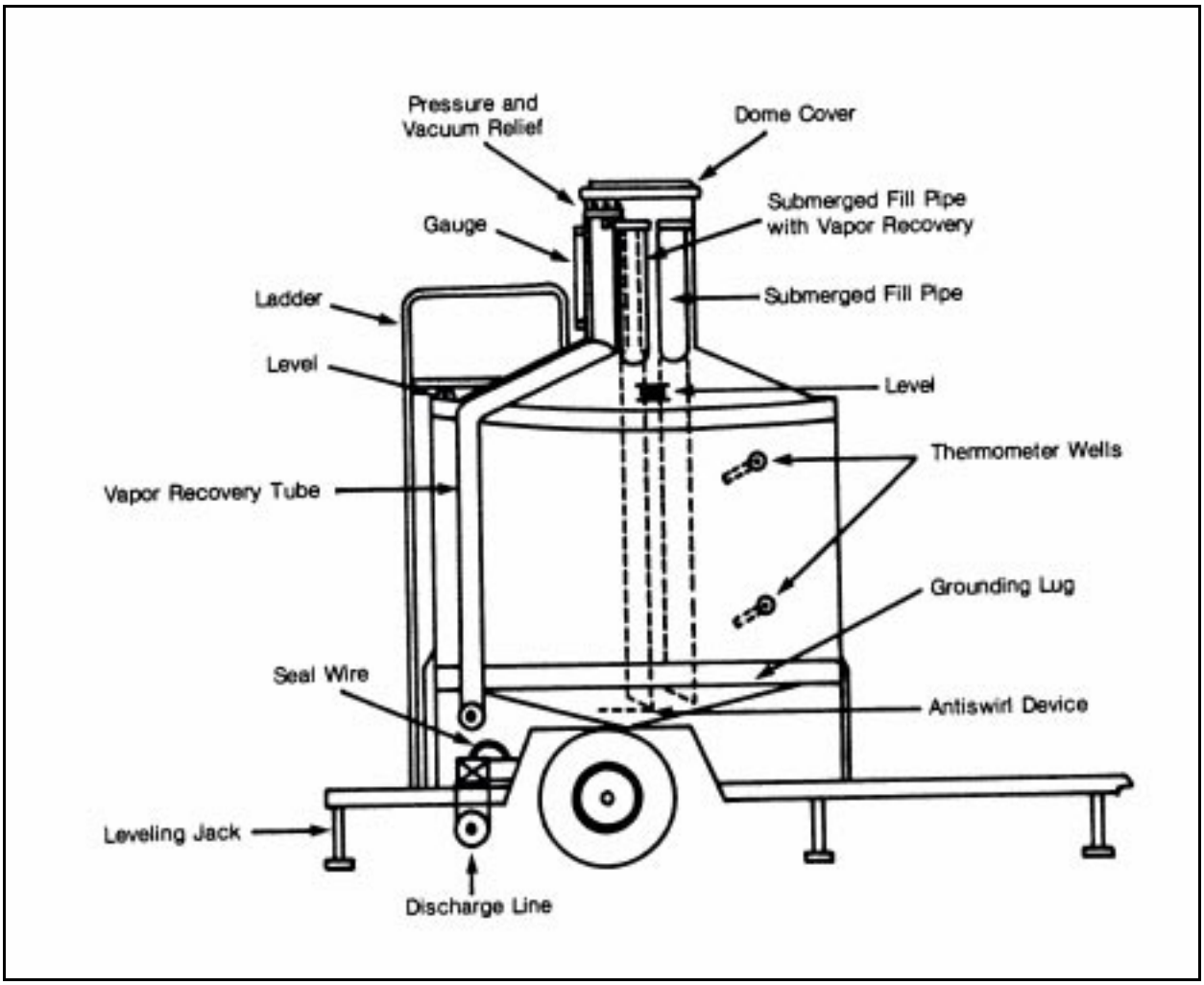


Figure 4-5. Trailer-Mounted Standard Prover Equipped for Vapor Recovery

The submerged fill pipe is used to reduce foaming and churning of product. Since it occupies space inside the container, a submerged fill pipe must be either permanently fixed in its position when the prover is calibrated or, if removable, must be securely positioned and protected by a security seal.

An antiswirl device in the prover drain performs the same function as the baffle plates in the vehicle tank, preventing the formation of a vortex which could draw air from the container into the discharge line. This is essential for the effective operation of the return pump, which may not be capable of lifting product back to the vehicle tank if large quantities of air or vapor are present in the return line.

Finally, you will notice that this prover is equipped with thermometer wells. These provide a means of inserting a thermometer to monitor or record the temperature of the product inside the prover. At least one thermometer well is required (in accordance with NIST Handbook 105-3) for provers with nominal capacities of 250 gal (1,000 L) or more and for all provers that are closed to the atmosphere, like the example shown, for vapor containment or recovery purposes.

Because liquids are subject to changes in density -- and, therefore, in the volume they occupy -- with changes in temperature, provers are calibrated to deliver their nominal capacity at a standard temperature, usually 60 °F. If the temperature of a given quantity of product in the prover is higher than this standard temperature, it will occupy more volume than it would at the reference temperature; conversely, it will occupy less volume if its temperature is lower. Under some conditions the temperature of the product may affect the accuracy of the measurement to a significant degree. We will take a closer look at the topic of temperature correction as it relates to performance tests of vehicle-tank meters in Chapter 6.

One other type of prover is used for testing vehicle-tank meters, called a double-neck or wet-bottom prover. From the example shown in Figure 4-6 you can easily see the reason for the first of these names. This prover has a neck at the bottom that corresponds to its upper neck, and both are similarly equipped with liquid level gauges. The lower gauge is used to establish an accurate zero reading before each test draft. As the prover is being emptied, the inspector watches the bottom gauge for the appearance of the top surface of the liquid. When it appears at the top of the gauge tube, the prover outlet valve is closed, halting the emptying of the prover for the appropriate drain time. Then the inspector opens the valve slightly, permitting product at the bottom of the prover to drain until the level in the lower gauge tube coincides with the zero mark on the scale plate. At this point, the outlet valve is closed again and the prover is ready to receive another draft.

Now you can see why this type of prover is referred to as a wet-bottom prover, especially if you think of the distinction between wet-hose and dry-hose metering systems that we discussed in Chapter 2. In contrast to a dry-bottom prover -- all the examples we looked at earlier are dry bottom -- in which the drain line is emptied of liquid before each draft, a wet-bottom prover retains some product in its lower neck between drafts, and is therefore "wet."

It might seem at first that wet-bottom provers are more accurate than dry-bottom provers, because the user controls the drainage while monitoring the bottom gauge. In fact this is not the case: the accuracy of both wet- and dry-bottom provers depends primarily upon observing the correct drain time for the prover. The second gauge on a bottom-fill prover is simply used to establish a zero fill point relative to the zero line in the top gauge.

Wet-bottom provers do have two advantages. The first is that the liquid retained in the lower neck prevents air from being returned to the vehicle tank. The other advantage of the wet-bottom prover is that it does not require leveling, since the capacity of the prover is established between the two gauges, which lie in the same vertical plane and thus will be affected in the same way by any out-of-level condition. Leveling the prover is a time-consuming procedure, and so this feature will make the use of the prover more efficient, especially if it must be moved from one location to another.

On the other hand, the draining procedure for wet-bottom provers involves more steps than does the relatively simple procedure for a dry-bottom prover, and this factor may offset the quick setup, especially when a number of tank trucks are tested at a single location. (In this situation the prover is only leveled once, but drained several times for each truck tested.)

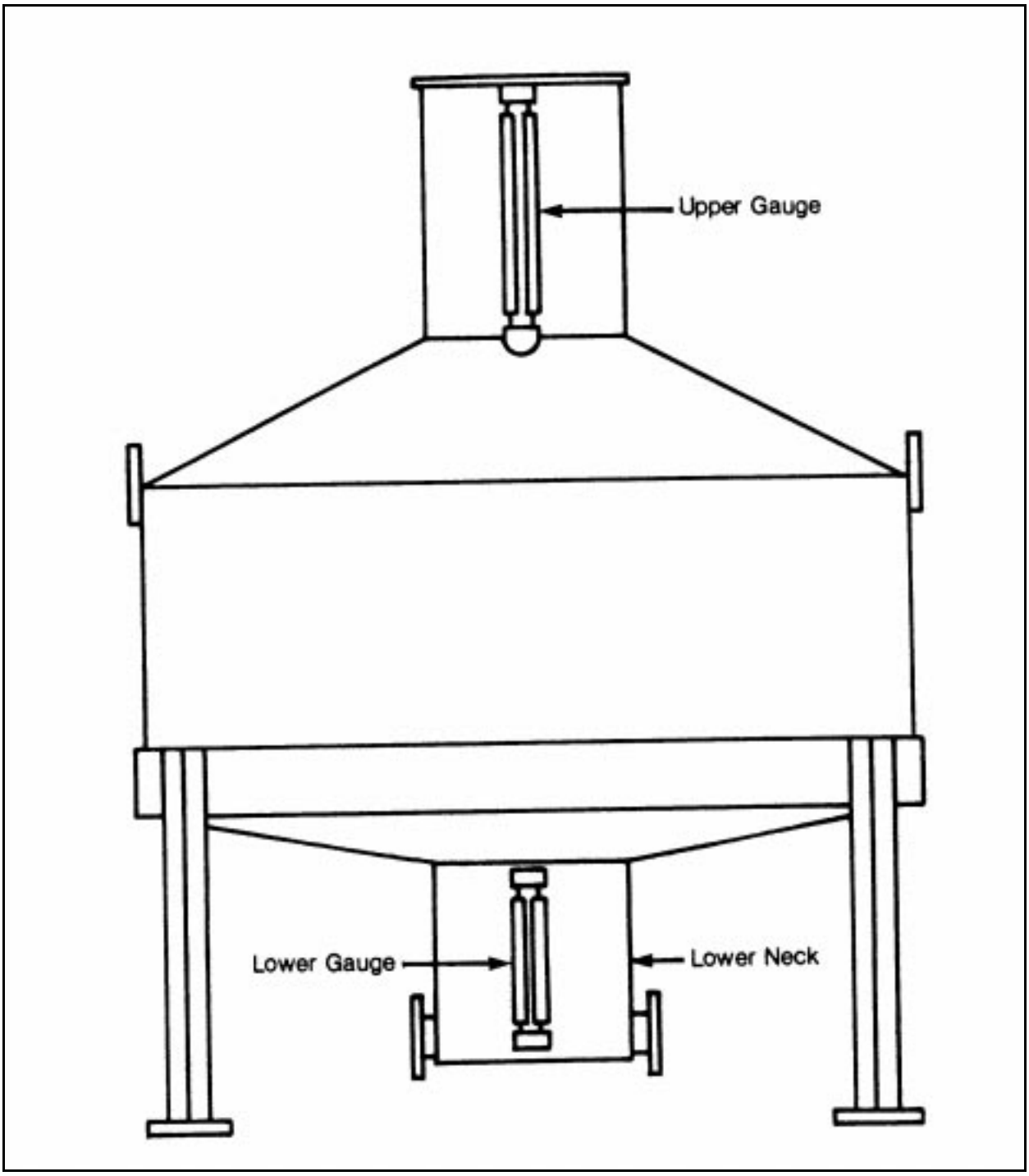


Figure 4-6. Double-Neck or Wet-Bottom Prover

Setting Up the Prover

You will learn and practice specific setup procedures for the provers used by your jurisdiction in the course of your field training. However, a general outline of the steps in setting up will help you understand the test procedures we will be discussing in Chapter 6.

1. Position the prover in a suitable location. It must be positioned where individual trucks can be brought to the prover to be tested, rather than moving the prover to the trucks. At the same time, its location should interfere as little as possible with normal business activities.

   In addition, a stable footing is required for leveling. It is preferable that the prover stand on pavement rather than on asphalt or on bare ground (unless the ground is sufficiently compacted to keep the prover from settling, or its feet from digging into the earth as it is being filled).

2. Check the security seals on the prover. This will assure you and the owner of the metering equipment that the prover has not been altered, or damaged in any way that could affect its accuracy.

3. Level the prover. This is especially important for dry-bottom provers. Spirit levels are required to be permanently installed on all provers, and must be used; leveling "by eye" is not adequate. The prover must be leveled both front-to-back and side-to-side. If it is mounted on a truck or trailer, jacks must be used to level the bed and prover together. (The prover must never be allowed to sit on the vehicle tires, even if it appears to be level when empty.)

   Always chock the trailer or vehicle on which the prover is mounted to be sure it does not roll away should the prover shift during testing. Check to be sure that the chocks are still secure when the prover is full of product.

4. Connect the prover return pump to an adequate power supply. Care should be taken that the line does not cross a high-traffic area (this may be another factor in choosing a location to set up).

5. Position the truck to be tested. The operator of the truck or an employee of the operator provided as an assistant should always move the truck and operate the system during the test. Unfamiliarity with the equipment on the part of the inspector or inadequate maintenance could result in accidental damage to the equipment. The correct location will depend on the type of system (gravity- or power-operated) and the specific installation (the meter and hose connections may be on the side of the truck or in the back, etc.). In any case, the truck should be close enough to the prover to minimize the length of hoses required to deliver, to return the product, and to enable the inspector to observe the meter indications during the testing procedure. Chocks should be placed under the vehicle's wheels to prevent any movement.

6. Ground the prover. This is an essential safety measure, especially when the test liquid is volatile or flammable. The prover can be grounded to the truck chassis or to some other suitable ground. Check to make sure that the grounding cable is in good condition

and that the grounding lug on the prover and the place where the cable is attached at the other end provide bare metal surfaces, free of corrosion or dirt.

7. Connect the discharge line from the truck to the prover inlet and the prover return line to the truck fill opening. This must be done in a manner that meets safety and air quality requirements (some products require vapor recovery equipment, etc.). If the discharge nozzle can not be coupled directly to an adapter on the prover, it must be held in place during the delivery portion of the test. Under no circumstances should the discharge line simply be fed into the top of the prover, since its presence inside the container will affect the volumetric capacity of the prover. If the truck is filled through openings that are too large to be adapted to the return line, the assistant must hold the end of the return line while product is being pumped back into the tank to prevent spillage.

8. Wet the prover. This involves filling the prover to its nominal capacity with test liquid and then draining it, observing the correct drain time. The procedure is thus identical to that employed for a test draft (described below), except that the prover is filled to its own nominal capacity, rather than to the point at which the truck register indicates delivery of that amount. And, of course, results are not official, since the dry prover will require an amount greater than its nominal capacity to fill it. Subsequent drafts will keep the prover wet, so this procedure need not be repeated unless testing is halted for a period long enough to allow the clingage to evaporate.

Test Drafts

An official test of a vehicle-tank meter requires several test drafts. In Chapter 6 you will study the purpose of each of these and how to interpret their results. For the moment, however, let's look at the basic steps involved in drawing a test draft, reading the gauge, and returning the draft, just as we did above for the setup procedure. We will assume that the prover has been set up correctly in advance.

1. Check the truck manifold valves. Only the valve for the compartment that is going to be used to deliver product for the test should be open.

2. Check the prover outlet valve. It should be closed. If it is not, the prover must be re-wet.

3. Deliver product to the prover until the register on the truck indicates the nominal capacity of the prover. If you are testing a gravity-discharge system, the delivery will be regulated by the main control valve. This should be done by the assistant provided by the operator. If the system is power-operated, the assistant will first engage the pump to the vehicle engine. The inspector then regulates the delivery from the discharge nozzle valve.

   An attempt should always be made to halt the delivery when the index of the indicator (the end of the pointer) coincides with some part of the graduation that represents the exact nominal capacity of the prover. At the same time, excessive throttling should be

avoided, since this would not occur under normal operating conditions, and might affect the performance of the meter. If the delivery is slightly "long", you may have to correct the prover reading. For example, if the register stopped at the reading shown in Figure 4-7, you would note that the delivery was long by about 1/8th of a graduated interval (measured from the center of one graduation to the center of the next). Since one such interval on this wheel equals 0.1 gal (23.1 cu in), you would need to correct for slightly less than 3 cubic inches (23.1/8 = 2.89 cu in). To make the correction, you would subtract that amount from the prover reading; this would correct the reading to make it roughly equivalent to what would be expected of an indicated delivery of exactly the nominal capacity of the prover. Of course, there is some degree of uncertainty in such readings, and it is preferable to continue the delivery until the meter reaches the next graduated interval. However, this need not be a great concern if, as in the example just described, it is relatively small in comparison to the tolerance (never less than 25 cu in for a vehicle-tank meter). If the results of the test are quite close to the applicable tolerance, you will repeat the test for confirmation in any case (some useful guidelines for repeating tests are described in Chapter 6).

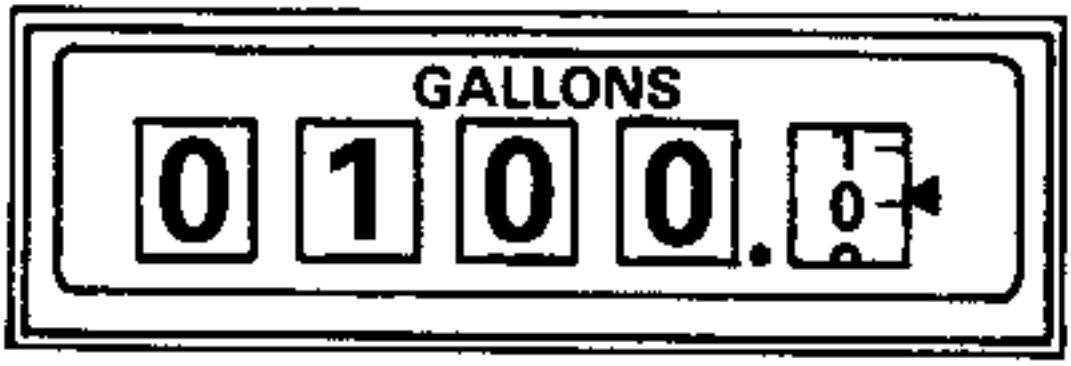


Figure 4-7. A "Long" Test Draft

4. Read the prover. If the product is one that tends to foam (like no. 2 fuel oil or diesel fuel) you will have to wait until the level inside the gauge tube stabilizes and the bubbles subside. This will usually not take more than a minute.

   In tests of gravity-discharge systems, you should take care to assure that the metering system discharge hose has sufficient time to drain into the prover before a reading is taken. If necessary, the hose should be detached from the meter outlet and held in a nearly upright position above the opening of the prover.

   When satisfied that the prover is ready to be read, position yourself so that the top surface of the liquid is at eye level. This liquid surface will be your indicator. Unless

the test liquid is opaque, you should be able to see the slight concavity in the surface that is known as the meniscus (see Figure 4-8). When reading the gauge, you should always

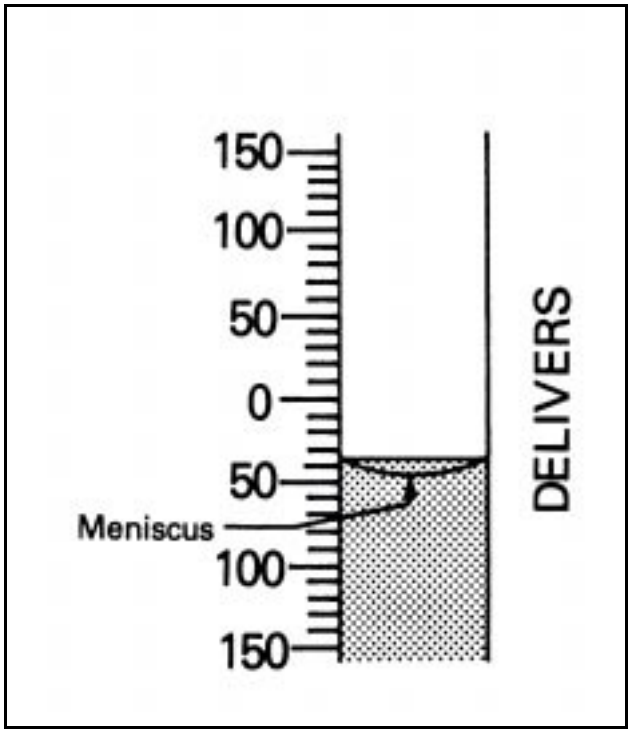


Figure 4-8. Reading the Prover Gauge

record the value of the graduation that is nearest the level you are using as an index (e.g., the bottom of the meniscus for a transparent liqiuid).

This value is the difference, in cubic inches, between the quantity actually delivered and the quantity indicated and, thus, represents the meter error for that draft.

If the index appears to be exactly between two graduations, record the even value. For example, if the bottom of the meniscus in Figure 4-8 is between the graduations representing -40 and -50 cu in, you would read the error as -40 since -40 is the even value.

You should also record the temperature of the liquid inside the prover at this time if your test procedures require temperature correction. We will discuss the use and interpretation of temperature readings in Chapter 6.

5. Return the test liquid to the vehicle tank. This is accomplished by opening the prover outlet valve and activating the return pump. The assistant provided by the operator should stand atop the vehicle and hold the end of the return line securely at the fill opening. This will prevent the end of the line from jumping out of the opening when

the flexible line is pressurized (or de-pressurized) or as a result of accidental movement of the line below.

In order to assure the accuracy of the prover for the next test draft, the correct drain procedure must be followed. A drain time is specified by the manufacturer of the prover (for many provers it is 30 seconds). The specified drain time, along with other important information regarding the construction, use, and physical properties of the prover, is required to be permanently marked on some conspicuous surface. It is usually etched or embossed on an identification plate.

The drain time is the period allowed after the cessation of flow of the product from the prover (after the discharge from the prover outlet has ceased to be a continuous stream, and has broken into a trickle) for draining residual liquid sufficient to establish a "wet" condition. At the end of the drain time, the liquid remaining inside the prover is the amount of clingage for which the prover was calibrated. It is trapped inside the prover by closing the outlet valve.

When using a dry-bottom prover, the inspector monitors flow in a sight glass installed in the discharge line, usually on the discharge side of the outlet valve. The sight glass usually contains a ball or some such device to show that liquid is flowing. The drain time begins when the inspector observes that flow has ceased and only a trickle of liquid is moving through the drain pipe. At the end of the specified time, the outlet valve is closed, and the prover is ready for the next draft.

The drain procedure for a wet-bottom prover involves several more steps. Flow is halted by the inspector when the top surface of the test liquid first appears in the top of the lower gauge tube. The drain time thus begins with the closure of the outlet valve. At the conclusion of the drain time, the valve is opened again, but only for long enough to lower the level in the gauge tube to the zero line. When the outlet valve is closed again, the prover is ready for another delivery.

It is essential that the specified drain time be observed as precisely as practicable, since this period was used to calibrate the prover to deliver its nominal capacity. Allowing either more or less time for drainage will affect the accuracy of the prover. A watch that indicates seconds or a stopwatch should always be used to monitor the drain time.

6. Empty the return line. When the prover outlet valve is closed at the end of the drain procedure, the return line will still be full of liquid. If another draft is going to be drawn from the same tank this is of no concern, since the quantity of product in the return hose has no effect on the capacity of the prover. However, after the last test draft for a particular vehicle has been measured, the return line must be emptied into the vehicle tank. The return pump, whose function is to lift product back to the tank, may not be capable of returning the liquid as the return line fills with air.

   A check valve, located at the prover end of the return line, prevents product from falling back into the prover during the drain period. This same check valve also serves to trap the product inside the return hose, so that the inspector can disconnect it at the prover end if necessary and, with the help of the assistant, lift the entire return hose to a height sufficient for gravity to drain its contents into the tank.

REPORT FORMS

Every official action you take as an inspector must be recorded, and reports of that activity are used in different ways depending on the activity. For the examination of vehicle-tank meters, you will need to keep records of:

- the meter examined,
- the findings in that examination,
- the decision on acceptability of the meter, and
- action taken as a result of that decision.

The NIST Handbook 130 Uniform Weights and Measures Law which has been adopted by the National Conference on Weights and Measures and by most States requires that adequate records be maintained; but only infrequently, if at all, do these statutes describe the details of the records.

A good report form should include the following elements:

- Be complete enough and in a suitable form so that it is the primary record; that is, it should not be necessary for someone to copy the report information onto other records.

- Provide a detailed record of the work performed by the inspector.

  In the case of examination of vehicle-tank meters, it should contain space for all the information you will gather when you follow the Examination Procedure Outline.

- Give the owner or operator of the device a clear understanding of the compliance or noncompliance of his or her equipment and the official action taken as a result of the test.

- Serve as a guide to the repairperson in the service of a rejected device.

- Provide an historical record of individual devices and establishments, with necessary data from which statistics may be derived.

- Be a simple design, easy to use, and easy to understand.

Every jurisdiction has different report forms and systems unique to that jurisdiction. Your instructor will explain the use of the report forms used in your jurisdiction.

The sample report form shown in Figure 4-9 was selected from among a number of standard forms currently in use in jurisdictions around the country that have the features described above.

NEW MEXICO DEPARTMENT OF AGRICULTURE
DIVISION OF STANDARDS AND CONSUMER SERVICES
P.O. BOX 3170 / LAS CRUCES, NEW MEXICO 88003-3170
(505) 646-1616

1351

LARGE-VOLUME PETROLEUM MEASURING DEVICE INSPECTION REPORT

PMD NO _____ COUNTY _____ DATE _____
NAME OF BUSINESS _____
ADDRESS _____
_____
MAKE OF METER _____ SERIAL NO _____
MODEL NO _____ MARKED DISCHARGE RATE MAX _____ MIN _____
ATC _____ METER APPLICATION _____ N.M. PERMIT NO _____

PRODUCT _____ CORRECTED API GRAVITY _____
TOLERANCE APPLIED MAINTENANCE _____ ACCEPTANCE _____
SEALS INTACT: REGISTER _____ COMPENSATOR _____ STANDARD SIZE _____
TOTALIZER READING BEGINNING _____ ENDING _____

TEST TYPE _____	TEST TYPE _____	TEST TYPE _____
FLOW RATE _____	FLOW RATE _____	FLOW RATE _____
COMPENSATED / UNCOMP	COMPENSATED / UNCOMP	COMPENSATED / UNCOMP
PROD / AVG	PROD / AVG	PROD / AVG
TEMP _____ / _____	TEMP _____ / _____	TEMP _____ / _____
VOL REDUCTION FACTOR _____	VOL REDUCTION FACTOR _____	VOL REDUCTION FACTOR _____
PROVER READING _____ / _____	PROVER READING _____ / _____	PROVER READING _____ / _____
CORRECTED PROVER READING _____	CORRECTED PROVER READING _____	CORRECTED PROVER READING _____
METER READING _____ / _____	METER READING _____ / _____	METER READING _____ / _____
NET METER ERROR _____ / _____	NET METER ERROR _____ / _____	NET METER ERROR _____ / _____
TEST TYPE _____	TEST TYPE _____	TEST TYPE _____
FLOW RATE _____	FLOW RATE _____	FLOW RATE _____
COMPENSATED / UNCOMP	COMPENSATED / UNCOMP	COMPENSATED / UNCOMP
PROD / AVG	PROD / AVG	PROD / AVG
TEMP _____ / _____	TEMP _____ / _____	TEMP _____ / _____
VOL REDUCTION FACTOR _____	VOL REDUCTION FACTOR _____	VOL REDUCTION FACTOR _____
PROVER READING _____ / _____	PROVER READING _____ / _____	PROVER READING _____ / _____
CORRECTED PROVER READING _____	CORRECTED PROVER READING _____	CORRECTED PROVER READING _____
METER READING _____ / _____	METER READING _____ / _____	METER READING _____ / _____
NET METER ERROR _____ / _____	NET METER ERROR _____ / _____	NET METER ERROR _____ / _____

THIS DEVICE IS: APPROVED _____ ADJUSTED _____ REJECTED _____ NSNLFT _____

	AS FOUND:	AS SEALED:		
GEAR RATIOS (A/B) (R/S)	_____	_____	SUPPLEMENTAL I.R.	_____
CALIBRATOR SETTING	_____	_____	OUT OF ORDER	_____
TOP ADJUSTOR SETTING	_____	_____	NOTICE OF VIOLATION	_____
COMPENSATOR SETTING	_____	_____	MEMORANDUM	_____

REMARKS _____
THE PRODUCT USED FOR TESTING OF THIS DEVICE WAS PROPERLY RETURNED TO STORAGE

_____ REPORT ACKNOWLEDGED

_____ INSPECTOR

Figure 4-9. Typical Report Form

SAFETY

During your field training, your instructor will spend a good deal of time talking about safety, demonstrating correct safety procedures, and having you practice them. The topic of safety on the job can never be over-stressed, especially when the job involves working with different equipment, different substances, and under different conditions every day, as yours does.

Several manufacturers of vehicle-tank meters include with their informational literature a list of specific product applications for which different models are best suited. One such list of generic products that are commonly transported in tank trucks has more than 800 entries. Needless to say, a great many of these substances are classified as hazardous. Some are volatile, some caustic, some highly flammable, some highly toxic, and some are dangerous in more than one way.

Of course, a weights and measures examination does not involve direct inspection of the product, or any handling of it. Substances, hazardous or not, are intended to remain contained within the system. However, the system will incorporate your test equipment, and some product will be moved. Under these conditions there is always some risk of leaks. Given the variety of situations that could arise -- even though none are likely to -- the inspector's most important safety equipment is his or her knowledge. You must:

- Know the physical and chemical properties of the substance you are dealing with.

- Know how the equipment used to meter the product and your own test equipment works, how it may malfunction, and how it should be operated in the event of an emergency.

- Know what to expect under a variety of different conditions so that you can anticipate dangerous situations before they develop and be prepared for them if they do.

In addition, and perhaps most important, you must know the limits of safe operation. If you are ever in doubt, you should contact your supervisor before you begin a procedure, and you should not proceed until you are confident that you can do so safely. It is always better and more efficient in the long run to be cautious than to risk injury to yourself and others or damage to property.

Your jurisdiction will have established safety guidelines and procedures. These should be studied carefully and followed to the letter, both in training exercises and in the field. The following list includes some very basic and general safety practices.

- Do not smoke or permit smoking, flame, or sparks in your work area. (Your work area comprises the space covered by the tank truck and prover, and immediately adjacent areas.)

- As you inspect the device, and throughout the examination procedure, look carefully for leaks. Report any found immediately to the operator or supervisor, and do not proceed until the source is discovered and corrected. If necessary, require that the device be taken out of service until the leak is repaired.

- Do not leave equipment unattended while in operation. You or your assistant must always be within an arm's reach of controls, and the level of product in the prover should be monitored to prevent overfill and spillage in the event that the meter is severely underregistering. If supply or return lines are not coupled at their discharge ends, they must be held in place continuously.

- Avoid inhaling fumes or vapor. Make sure that adequate provision has been made for vapor recovery if required.

- Eliminate all possible sources of electric discharge (sparks) within the work area including static electricity. Do not wear clothing that produces static (like a nylon windbreaker). Do wear rubber-soled shoes (which will also provide secure footing on wet or slippery surfaces). Report any exposed wiring on the vehicle to the operator or a supervisor, and do not proceed until the condition has been repaired.

- Always ground the prover, and make sure that the prover pump electrical supply line is in good condition and that it is protected from damage while in use.

- Beware of vehicular and pedestrian traffic around your work area. If necessary, set up barriers. Be especially careful when trucks must back into position near the prover.

- Always chock the trailer or vehicle on which the prover is mounted to be sure it does not roll away should the prover shift during testing. Check to be sure that the chocks are still secure when the prover is full of product.

- If the liquid dispensed by the metering system is highly toxic or volatile, make arrangements to test the device using a substitute test liquid that has the same general properties as the product, but is less hazardous.

This list of general precautions is not intended to replace specific safety procedures established by your jurisdiction. Your instructor will provide you with copies of these procedures and review them with you thoroughly. Do not hesitate to discuss any questions or concerns you have regarding safety with your instructor.

SUMMARY

Several important tasks must be performed before you begin an official field examination to assure that procedures on-site can be conducted efficiently, accurately, and safely. After the location is selected, suitable arrangements must be made with the owner or operator of the device(s) regarding access and assistance. The inspector must then select appropriate test equipment, and must be thoroughly familiar in particular with procedures for setting up and operating the field standard prover that will be used. Report forms are designed to facilitate the recording of essential field examination data in a form that can be clearly understood and used by the inspector, the device operator, repairpersons, and weights and measures administrators. The topic of safety on the job can not be overstressed. Field examinations should not be hazardous if proper precautions are employed, and if the inspector has a confident knowledge of the substance being measured and its properties, the equipment to be used both to measure and deliver it, and the range of circumstances that could give rise to an emergency situation.

CHAPTER 5

THE INSPECTION

CHAPTER OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Identify the components of a vehicle-tank meter system that are subject to inspection in the course of an official field examination.

2. Describe systematic inspection procedures for gravity- and power-operated vehicle-tank meters, based upon National Institute of Standards and Technology (NIST) Examination Procedure Outlines (EPO's), and any additional procedures required by your jurisdiction.

INTRODUCTION

What you have learned about the prominent role of vehicle-tank meters in the commercial marketplace should help you appreciate the importance of your jurisdiction's program of regular field examinations for meters currently in service. Similarly, the basic knowledge you have acquired about the design and operation of these sophisticated liquid-measuring devices should make it obvious that systematic procedures must be employed for inspecting and testing them. Given the complexity of the vehicle-tank metering system and the number of individual components that must function correctly to provide accurate and consistent measurement, a haphazard approach would at best be inefficient, requiring excessive time and effort to achieve complete and significant results, and thereby diminishing the overall effectiveness of the program. At worst, a haphazard approach could lead to overlooking or misinterpreting significant data, thereby compromising -- even invalidating -- the entire examination. In this chapter and those that follow you will receive a thorough introduction to examination procedures that employ a systematic approach to inspection and testing.

The purpose of an official weights and measures examination is to determine whether the device being examined meets requirements that are established by law or by legally mandated regulation. Thus, legal requirements form the basis of all examination procedures, and a thorough knowledge of applicable codes and administrative policies is as important a part of the inspector's job as knowing how to set up and use a field standard prover or how to conduct an accuracy test.

Most jurisdictions have adopted the comprehensive specifications, tolerances, and other technical requirements set forth in NIST Handbook 44. The requirements that apply to vehicle-tank meters are included in Sections 1.10 (General Code) and 3.31 (Vehicle-Tank Meters [VTM] Code) of the handbook. These codes will be referenced throughout the following discussions. Some jurisdictions have modified portions of these codes, and in some jurisdictions additional requirements have been imposed by State or

local laws and regulations. Your instructor will point out specific differences between Handbook 44 and the applicable codes in force in your jurisdiction and explain the significance of these differences.

Codes provide the basis for field procedures, but they are organized in a way that suits their primary function as legal documents, and as a result are often not very well suited to use in the field. Specific requirements that govern a particular component or feature of the metering system -- like the zero-setback mechanism -- sometimes appear at separate places in the codes, and some requirements are applicable to more than one element of the system. In recognition of the need for a more systematic organization of requirements, one that is suited to efficient field procedures, the NIST Office of Weights and Measures has developed Examination Procedure Outlines (EPO's) for many weighing and measuring devices, including vehicle-tank meters.

Figure 5-1 is an excerpt from the EPO for power-operated vehicle-tank meters. (Differences in design and operating characteristics necessitated the development of separate EPO's for gravity- and power-operated systems.) As you can see, the EPO provides a systematic organization, referencing the applicable paragraphs of the Handbook 44 codes for each of the major functional components of the system that are involved in measuring and indicating deliveries. As you will see in the next chapter, a subsequent portion of the EPO presents a step-by-step procedure for conducting a series of performance tests.

Because of its systematic organization, the EPO is a useful guide for the inspector in the field, and is also a tool that can be used in the course of conducting an examination; it can be used by the inspector as a checklist, to ensure that all the steps in the examination have been performed.

The EPO is intended as an outline of what should be considered a minimum examination procedure. When the inspector encounters a device that has features that are "new" to him or her, or in non-routine examinations (conducted in response to complaints, or when there is reason to suspect that the device is being used improperly or to facilitate fraud), further procedures are likely to be needed.

Complete Examination Procedure Outlines for both gravity- and power-operated vehicle-tank meters are included in Appendix A of this manual. These EPO's should be updated periodically to include changes in the codes or policies of your jurisdiction.

EPO No. 23

Examination Procedure Outline for

Vehicle-Tank Meters
Power-Operated

It is recommended that this outline be followed for all power-operated vehicle-tank meters – analog or digital. Nonretroactive requirements are followed by the applicable date in parentheses. Do not use this outline for testing milk metering systems.

Figure 5-1. Excerpts from Examination Procedure Outline (EPO) 23

		H-44 General Code and Vehicle-Tank Meters Code References
1.	General considerations.	
	Selection	G-S.3., G-UR.1.1., G-UR.1.2., G-UR.1.3.
	Installation	G-S.2., G-UR.2.1., G-UR.2.2., UR.1.1.
	Position of Equipment	G-UR.3.3.
	Accessibility	G-UR.2.3.
	Assistance	G-UR.4.4., G-UR.4.6
	Use and maintenance	G-UR.3.1., G-UR.4.1., G-UR.4.2., UR.2.3.
2.	Marking	G-S.1., G-UR.2.1.1., S.5.1, S.5.2.
3.	Indicating and recording elements.	
	Design	S.1.1.1.
	Units	S.1.1.2.(a), S.1.1.3.(b) and (c)
	Readability	G-S.5., G-S.6. (1/1/77), G-S.7., S.1.2., S.1.3.
	Values of intervals	G-S.5.3.
	Computing-type devices	
	Display of unit price	S.1.4.1, UR.1.2.
	Printed ticket	S.1.4.2., UR.2.2.
	Exceptions for the Sale of Aviation Fuel	UR.2.2.1.
	Money-value computations	S.1.4.3.
3.	Indicating and recording elements (cont.).	
	Advancement and return to zero	S.1.1.4., S.1.1.5., UR.2.1.
	Provision for sealing	G-S.8. (1/1/90), G-UR.4.5.
4.	Measuring elements.	
	Vapor Elimination	S.2.1.
	Security seal on adjusting mechanism	G-UR.4.5., S.2.2.
5.	Piping.	
	Directional flow valves & discharge line and valves	S.2.3., S.3.
	Antidrain valve	S.3.6.
	Leaks	G-UR.4.1.
	Facilitation of fraud	G-S.2.

An official field examination consists of four components:

- The Inspection, to determine compliance with specifications and other requirements,
- Pre-test determinations, to assure the correct application of tolerances and other test factors,
- The Test, to determine compliance with performance requirements, and
- The Evaluation of Inspection and Test results followed by approval or rejection of the device.

This division is based upon distinctions that are observed in Handbook 44 and in the EPO's. Notice that the terms "inspection," "test," "evaluation," and "examination" refer to specific and different activities (the examination comprising the other three). These distinctions will become clear as we discuss the separate components in concrete terms.

INSPECTION

The first part of the EPO is devoted to Inspection (see Figure 5-1). In the Inspection portion of the official examination, you will determine the metering system's compliance with specifications and other requirements pertaining to design, installation, and operation. The extent and emphasis of your inspection will depend on a number of factors relating to the specific device being tested and the circumstances under which it is being tested. Some of the more important factors are:

- your familiarity with the device,
- the age of the device,
- whether or not the device is of a type that has been type evaluated, and
- whether or not a complaint has been received.

Naturally, your previous experience with the particular device will affect the inspection process. If you are checking a device for the first time, you may want to perform an extensive inspection that includes a careful check of all applicable requirements in Handbook 44, including those concerned with design and installation. If you are checking a device you are familiar with, one that has been in service for some time, you may not need to spend much time on design and installation requirements; however, you will want to look for such things as fraudulent use or abuse of the equipment and inappropriate applications of the device.

The age of the device -- when it was manufactured and when it was put into commercial service -- is important because a number of requirements in Handbook 44 are nonretroactive as of a certain date. As a result, you will find that old equipment will be required to meet a different set of requirements than new equipment.

In some cases, the devices you will be testing will be of a type that has been evaluated under the National Type Evaluation Program (NTEP). NTEP is a program for determining conformance of a weighing and measuring device "type" or "model" with the relevant provisions of Handbook 44. Manufacturers voluntarily submit models of their devices for evaluation under the NTEP program. An authorized "NTEP laboratory" conducts the evaluation. When a device is found to meet all applicable technical requirements, NTEP issues a Certificate of Conformance (CC) for that device. The CC provides details of the evaluation results and device characteristics necessary for inspection and use in commerce.

Before testing a new type of device, you should determine if a model of the device has been type evaluated. If it has, you should review the device's CC to determine which features have been evaluated. Your instructor will tell you how to obtain copies of the index and of individual CCs for devices.

During the type evaluation process, extensive tests are performed in a laboratory setting to determine if a particular device model meets all applicable requirements in Handbook 44. Some of these tests are difficult to perform in the field; consequently, the existence of a CC can make your job easier -- during a field inspection, you may not need to extensively examine certain design criteria on a type evaluated device. But remember that type evaluation means that a sample of the model of the device covered by the CC has been examined, not each device; therefore, you should still review all applicable requirements when inspecting a new device. The review may simply consist of a brief visual check of an item.

Devices are designed with specific applications in mind. Some devices are designed for a narrow range of applications, whereas others have a multitude of features to satisfy many different applications. Not all features are suitable for all applications. A Certificate of Conformance will state the intended application of a device type. If you encounter a new or unusual device or feature on a device in an unusual application, it should be thoroughly tested to determine its appropriateness and to assure that it does not facilitate fraud.

Another factor that affects the nature and extent of the Inspection portion of your examination is the existence of a complaint about a particular device or the practices of a device owner or operator. You may want to perform a more extensive inspection than usual if your office has received complaints about a device or business.

As you will see in the detailed discussion that follows, most Inspection determinations are made on the basis of a careful visual examination and the inspector's experience and knowledge of the device. This does not mean, however, that the Inspection may be approached casually, or that compliance with any requirement can be taken for granted just because the device has received type approval. It is not at all uncommon to discover non-compliance in a number of areas covered in the Inspection, especially when the equipment is old or has not been properly maintained.

Furthermore, it is much more likely that modifications intended to facilitate fraud will show up in the course of a careful inspection than in performance tests.

You should also keep in mind that your inspection is not limited to visual means or any other. It is the inspector's responsibility to decide what is necessary to determine the compliance status of the device. If you have reason to believe that a correct determination requires additional testing, either in the field or under more controlled conditions, you should consult your supervisor so that appropriate arrangements can

be made. However, the cost of additional testing to the owner or operator of the equipment, including the cost of lost productivity while it is out of service, must not constitute an unreasonable burden. The decision to conduct additional testing will generally involve weighing the probability that a suspected violation will be confirmed against the cost of testing -- including the cost to the jurisdiction. So you should be prepared to explain and justify your recommendation.

The remaining sections of this chapter will present the Inspection for vehicle-tank meters. Each of the items included in the EPO's will be discussed in detail. However, in the interest of providing a basic framework for field procedures, we will begin with the General Considerations and Marking sections of the EPO, and some of the sub-headings will be presented in a modified order. (The Inspection portion of the EPO's for gravity- and power-operated vehicle-tank meters are identical; specific differences in procedure will be pointed out as we proceed.)

GENERAL CONSIDERATIONS

The items under this heading refer, for the most part, to requirements and specifications from the General Code that are necessarily broad and comprehensive in nature. They may also relate specifically to items covered elsewhere in the Inspection or Test portions of the examination. They are nonetheless important, and should not be ignored simply because they are general. On the contrary, the inspector should keep these general considerations in mind throughout the examination.

Accessibility

All elements of the system that are subject to inspection and testing must be accessible to the weights and measures inspector and to any required test equipment. For vehicle-tank meters, these elements include:

- all indicating and recording elements (register, ticket printer, totalizers, etc.)
- the meter and air eliminator, including the air vent lines for the air eliminator
- all piping between the tank compartment outlets and the discharge nozzle, and all automatic and manual controls
- tank compartment fill openings

If access to these elements is not immediately available at the time of the examination, it is the responsibility of the owner or operator to make them accessible.

G-UR.2.3. Accessibility for Inspection, Testing, and Sealing Purposes. - A device shall be located, or such facilities for normal access thereto shall be provided, to permit:

(a) inspecting and testing the device;

(b) inspecting and applying security seals to the device; and

(c) readily bringing the testing equipment of the weights and measures official to the device by customary means and in the amount and size deemed necessary by such official for the proper conduct of the test.

Otherwise, it shall be the responsibility of the device owner or operator to supply such special facilities, including necessary labor as may be needed to inspect, test, and seal the device, and to transport the testing equipment to and from the device, as required by the weights and measures official.
(Amended 1991)

In general, accessibility is not a problem for vehicle-tank meters, since the vehicle can readily be moved to a more suitable position, for example, to provide sufficient room for the prover. However, if the meter is installed in a locked cabinet, the operator must provide a key. In addition, any housing or cabinetry that encloses the piping to protect it from exposure to the elements must either be readily removable, or must be removed ahead of time so that the entire system can be inspected.

Assistance

Several steps in the examination procedures require two people to perform them safely and accurately. For example, assistance is usually required to position the vehicle correctly in relation to the prover, whether it is mounted above ground or in a pit. And when product is pumped from the prover back into tank compartments at the conclusion of a test, it is often necessary for an assistant to hold the return hose outlet securely at the tank fill pipe to prevent accidental spillage while the inspector operates the pump, observes the correct drain time, operates the prover drain valve, and disconnects the return hose from the prover.

It is also good practice (and a matter of policy in many jurisdictions) to have an experienced employee operate the metering system, while the inspector operates only the test equipment.

Most weights and measures jurisdictions assign only one inspector to a field examination, and where assistance is required, the inspector must not attempt to perform these steps alone. The General Code requires that in situations like this an assistant must be provided by the owner or operator of the device.

G-UR.4.4. Assistance in Testing Operations. - If the design, construction, or location of any device is such as to require a testing procedure involving special equipment or accessories or an abnormal amount of labor, such equipment, accessories, and labor shall be supplied by the owner or operator of the device as required by the weights and measures official.

It is obviously important that the owner or operator be notified of the need for assistance far enough in advance to allow him or her to make adequate provision. Your jurisdiction may have specific policies and procedures regarding assistance. Your instructor will explain them to you.

> **G-UR.4.6. Testing Devices at a Central Location. -**
> (a) When devices in commercial service require special test facilities, or must be removed from service for testing, or are routinely transported for the purpose of use (e.g., vehicle-mounted devices and devices used in multiple locations), the official with statutory authority may require that the devices be brought to a central location for testing. The dealer or owner of these devices shall provide transportation of the devices to and from the test location. (Added 1994)

It is equally important to provide the owner or operator sufficient notice when scheduling the testing of devices at special test facilities at a central location.

Selection

As you know, vehicle-tank meters are available in a great variety of designs to meet the needs of specific commercial applications. A number of usage factors are considered by the owner or operator in selecting the right equipment, including the physical and chemical properties of the product(s) to be dispensed and the expected range of operating conditions. For example, it is usually necessary for metering systems that handle corrosives to be made of special materials like stainless steel that will not react chemically with the product. Similarly, highly viscous products, such as asphalt emulsions, generally require meters designed for relatively high working pressures to compensate for pressure drop, especially at higher flow rates. Such products may also have to be handled at higher temperatures, which requires special design features. Or a single meter may have to make some deliveries that require relatively high discharge pressure to elevate the product to the delivery point, but other deliveries that require relatively low discharge pressure, so it will have to be designed to be accurate at either end of a range of operating conditions.

Using equipment whose design is not suitable for its application is never good practice, and will generally be more costly for the owner or operator in the long run, since components will wear more rapidly and are more likely to malfunction. But where weighing and measuring devices are concerned, the use of unsuitable equipment can also affect the accuracy of the device (as, for example, when flow rates outside the rated range of the meter must be used to develop required discharge pressure), and it is for this reason that the selection of the equipment is covered in the General Code.

> **G-UR.1.1. Suitability of Equipment.** - Commercial equipment shall be suitable for the service in which it is used with respect to elements of its design, including but not limited

to its weighing capacity (for weighing devices), its computing capability (for computing devices), its rate of flow (for liquid-measuring devices), the character, number, size, and location of its indicating or recording elements, and the value of its smallest unit and unit prices. (Amended 1974)

G-UR.1.3. Liquid-Measuring Devices. - To be suitable for its application, the minimum delivery for liquid-measuring devices shall be no less than 100 divisions, except that the minimum delivery for retail analog devices shall be no less than 10 divisions. Maximum division values and tolerances are stated in the specific codes.
(Added 1995)

Several of the specifications covered elsewhere in the Inspection relate to the suitability of the device in regard to particular elements, but it is important -- and most efficient -- to make a general assessment of the suitability of the equipment at the beginning of the examination.

Specific items of information, including maximum and minimum flow rates and use limitations, are required to be marked permanently on the device (see section on Marking later in this chapter for details). The operator's manual and/or instructions for installation that come with the meter from the manufacturer or distributor usually include a discussion of appropriate applications and will also mention specific applications that are not appropriate. If these sources are not available, or do not provide enough information to make a determination, the local distributor of the equipment, sales representative, or authorized repair service can usually answer any questions you have.

The General Code includes a specific paragraph, G-UR.1.3., to address suitability requirements for liquid-measuring devices. This paragraph specifies that the minimum delivery be no less that 10 divisions for retail analog devices and no less than 100 divisions for other liquid-measuring devices.

Of course, you will have to rely on the owner or operator to describe to you how the equipment is actually used. If you have reason to doubt the accuracy of this information, check with your supervisor about making further inquiries. You may also ask to see copies of actual delivery tickets to verify compliance with suitability and use requirements.

One specific item is covered under this heading in the EPO. This requirement establishes an upper limit for the value of the smallest unit of delivery indicated or recorded by the equipment.

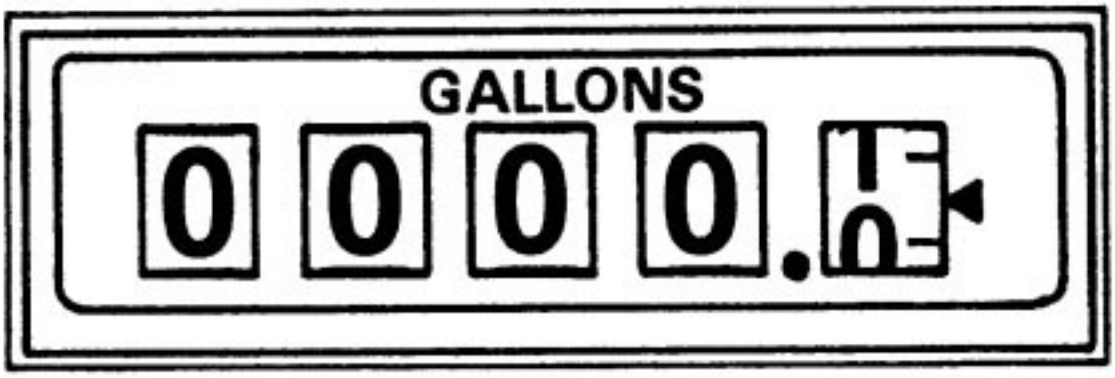
S.1.1.3. Value of Smallest Unit. - The value of the smallest unit of indicated delivery, and recorded delivery if the meter is equipped to record, shall not exceed the equivalent of:

(a) 0.5 L (0.1 gal) or 0.5 kg (1 lb) on milk-metering systems

(b) 0.5 L (0.1 gal) on meters with a rated maximum flow rate of 500 L/min (100 gal/min) or less used for retail deliveries of liquid fuel, or

(c) 5 L (1 gal) on other meters.
(Amended 1989, 1994)

The requirement for a smaller unit (0.1 gal or less) for milk-metering systems and on meters used for retail deliveries of liquid fuel relates to the manner in which these products are usually metered. Milk tankers are usually used to pick up milk from individual farmers and bring it to a dairy. In order to reduce waste, and to assure that a delivery lot will be uniformly fresh, the truck will pick up all the milk that is available at each stop. It is, of course, highly likely that this amount will be a certain number of gallons plus a fraction of a gallon. Some farmers also deliver from more than one storage tank. Requiring the smaller unit of delivery thus assures that the seller (the farmer) will be credited for all milk to the nearest 0.1 gal. The same rationale applies to home heating fuel, which is often delivered to "top off" the receiving tank, that is, until the tank is full. Again, the amount actually delivered will almost always include a fraction of a gallon. In this case, the limitation protects the buyer from the practice of rounding a fractional amount to the next highest gallon. For many other liquid products, the amount of a delivery is determined beforehand, and will usually not be in units of less than a gallon. (Note that meters may indicate and/or record smaller units than those specified, and many of them do.)



In the case of an analog register, the smallest unit indicated is the value of the smallest graduated interval. In this example, the smallest unit indicated is 0.1 gallon (0.8 pint).

Figure 5-2. Smallest Unit Indicated

A detailed procedure for inspecting indicating and recording elements covered later includes this requirement as well. At this stage of the Inspection, it is sufficient to check the smallest units on the main indicator that is mounted either on the meter itself or in the truck cab. Any meter that indicates tenths of gallons (like the one shown in Figure 5-2) will meet this requirement, regardless of the product dispensed.

Installation

Even a meter that is suitable for its application may not perform accurately and consistently if it is not installed properly. For example, the use of piping or connectors with dimensions other than those specified by the manufacturer can affect various operating characteristics of the meter, including working pressure and flow rates, and these, as you know, can affect the accuracy of the meter.

Proper installation also involves considerations of safety, security, accessibility, and environmental factors (such as air quality and pollution, as well as the effects of weather, accidental collision, and radio frequency and electromagnetic interference on the device). For these reasons, the General Code requires that the manufacturer's instructions be followed in installing the meter and accessory equipment as a means of assuring that the device performs as it is supposed to.

> **G-UR.2.1. Installation.** - A device shall be installed in accordance with the manufacturer's instructions, including any instructions marked on the device. A device installed in a fixed location shall be so installed that neither its operation nor its performance will be adversely affected by any characteristic of the foundation, supports, or any other detail of the installation.

It is neither practical nor, generally, necessary to check each item in the manufacturer's instructions. You should at least, however, determine by visual inspection whether the meter is securely mounted and, if it has electrical components, whether there is any exposed wiring. As you proceed through the examination, results from inspecting and testing particular elements may lead you to the conclusion that a substandard condition was the result of improper installation.

You should, however, check one specific item that is included in the EPO under this heading. It relates to the requirement that some means be provided to prevent operation of the device at a discharge rate in excess of the rated maximum.

> **UR.1.1. Discharge Rate**. - A meter shall be so installed that the actual maximum discharge rate will not exceed the rated maximum discharge rate. If necessary, means for flow regulation shall be incorporated in the installation, in which case this shall be fully effective and automatic in operation.

In many systems, the maximum discharge rate is effectively limited by factors such as the inside diameter of the piping and the pressure developed by gravity or by a pump (in the case of power-operated systems). However, in some systems additional means of controlling flow are necessary. This is often accomplished by a pilot-operated control valve, which is actuated either electrically or mechanically in response to a sensor located on the discharge side of the meter. The operation of such flow control valves need not concern us here. What is important in regard to the requirement is that such a device is automatic, that is, that it shuts off flow when the maximum discharge rate is exceeded without any action on the part of the operator. On the other hand, a system incorporating a flow rate indicator and manual throttling valve as its means of preventing an excessive discharge rate would not meet this requirement, since this would not be an automatic means (even though such mechanisms are appropriate for controlling flow within the rated range, and are not prohibited).

Use and Maintenance

A precision measuring device can be expected to perform accurately and reliably only if it is used and maintained properly. Two paragraphs of the General Code establish correct use and maintenance as a requirement.

> **G-UR.3.1. Method of Operation.** - Equipment shall be operated only in the manner that is obviously indicated by its construction or that is indicated by instructions on the equipment.
>
> **G-UR.4.1. Maintenance of Equipment.** - All equipment in service and all mechanisms and devices attached thereto or used in connection therewith shall be continuously maintained in proper operating condition throughout the period of such service. Equipment in service at a single place of business found to be in error predominantly in a direction favorable to the device user shall not be considered "maintained in a proper operating condition."
> (Amended 1973, 1991)

For example, the practice of inserting a ticket in the printer and leaving it there while the vehicle is being driven to a delivery location is improper (and, as you will see shortly, is specifically prohibited). Obviously, it will be difficult or impossible for the inspector to determine whether the equipment is being used properly in the course of a field examination. You may, however, question the operator about how the device is used and advise him or her of requirements; this should certainly be done when complaints have been received. It is often possible to detect inadequate maintenance from the physical condition of the equipment at the time of the inspection. Look for evidence such as excessive dirt and grease, leaks, dents, or premature wear or need for adjustment. Broken or cracked glass over the register should be cited, since it may affect the readability of indications.

The provision regarding equipment at a single location that errs predominately in favor of the owner or operator is intended to discourage the abuse of tolerances. Weighing and measuring devices are required to be adjusted as close as possible to a zero error condition, not to tolerances, which are the legal limits of inaccuracy. If the operator of a number of tank meters makes it a practice to adjust all of them as close as possible to the tolerance rather than to zero error, the cumulative effect can be a significant advantage for him or her, and a significant disadvantage to the customers, even though the tolerances only permit a small degree of error for an individual device. The system of tolerances can only be effective if it can be assumed that for a large number of devices that perform within the tolerances, some err slightly in favor of the owner, some in favor of the consumer, so that the average effect is truly insignificant.

In accordance with this requirement, an inspector can reject all metering devices at a single location even though none of them individually is out of compliance. But such an action could obviously cause considerable disruption of business, not only for the operator, but for customers who depend upon scheduled deliveries. Handbook 44 does not provide guidelines for the interpretation of this requirement; however, many jurisdictions have specific policies in regard to this requirement. Even if your jurisdiction has such a policy, you will probably be required to exercise judgment in making a determination. To provide you with more flexibility in applying G-UR.4.1. the phrase "near the tolerance limit" was removed from the General Code in 1991.

MARKING

The most authoritative source of technical information about a vehicle-tank meter -- or any other weighing or measuring device -- is the manufacturer. Because such information is often needed by the operator, by repairpersons, and by weights and measures inspectors, the name of the manufacturer must be readily available. But the company name is often not sufficient to identify the device for the purpose of obtaining specific information about it. Most manufacturers of vehicle tank meters make more than one model of meter, and some make many. Furthermore, design changes and new features are sometimes incorporated into existing models. So the only way of positively identifying a particular meter is by using a system of individual serial numbers. These three basic items of information -- the manufacturer's name, the model designation, and the serial number -- are required to be displayed clearly and permanently on the device where they will be visible without having to use a tool to dismantle the equipment. The model and serial numbers shall each be designated with a term which clearly identifies it as such. (Note that the serial number is only required for devices manufactured since the beginning of 1968.) Devices that are covered by a National Type Evaluation Program (NTEP) Certificate of Conformance (CC) must also be clearly and permanently marked with the NTEP CC number as outlined below. In addition to the required markings outlined above, nonretroactive as of January 1, 2002, remanufactured devices and remanufactured main elements must be clearly and permanently marked with the name of the last remanufacturer or distributor and the model designation assigned by the remanufacturer or distributor, if different from the original model designation.

> **G-S.1. Identification. -** All equipment, except weights and separate parts necessary to the measurement process but not having any metrological effect, shall be clearly and permanently marked for the purposes of identification with the following information:

(a) the name, initials, or trademark of the manufacturer or distributor;

(b) a model designation that positively identifies the pattern or design of the device;

(c) the model designation shall be prefaced by the term "Model," "Type," or "Pattern." These terms may be followed by the term "Number" or an abbreviation of that word. The abbreviation for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., No or No.) The abbreviation for the word "Model" shall br "Mod" or "Mod."
[Nonretroactive January 1, 2003]
(Added 2000) (Amended 2001)

[Note: Prefix lettering may be initial capitals, all capitals or all lower case.]

(d) except for equipment with no moving or electronic component parts, a nonrepetitive serial number;
[Nonretroactive as of January 1, 1968]

(e) the serial number shall be prefaced by words, an abbreviation, or a symbol, that clearly identifies the number as the required serial number; and
[Nonretroactive as of January 1, 1986]

(f) the serial number shall be prefaced by the words "Serial Number" or an abbreviation of that term. Abbreviations for the word "Serial" shall, as a minimum, begin with the letter "S," and abbreviations for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., S/N, SN, Ser. No, and S No.).
[Nonretroactive as of January 1, 2001]

(g) For devices that have an NTEP Certificate of Conformance (CC) Number or a corresponding CC addendum number, the NTEP Certificate of Conformance Number, which shall be prefaced by the terms "NTEP CC," "CC," or "Approval." These terms may be followed by the term "Number" or an abbreviation of that word. The abbreviation for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., No or No.)
[Nonretroactive as of January 1, 2003]

The required information shall be so located that it is readily observable without the necessity of the disassembly of a part requiring the use of any means separate from the device.
(Amended 1985, 1991, 1999, 2000, and 2001)

G-S.1.1. Remanufactured Devices and Remanufactured Main Elements. - All remanufactured devices and remanufactured main elements shall be clearly and permanently marked for the purposes of identification with the following information:

(a) the name, initials, or trademark of the last remanufacturer or distributor;

(b) the remanufacturer's or distributor's model designation if different than the original model designation.

[Nonretroactive as of January 1, 2002.]
(Added 2001)

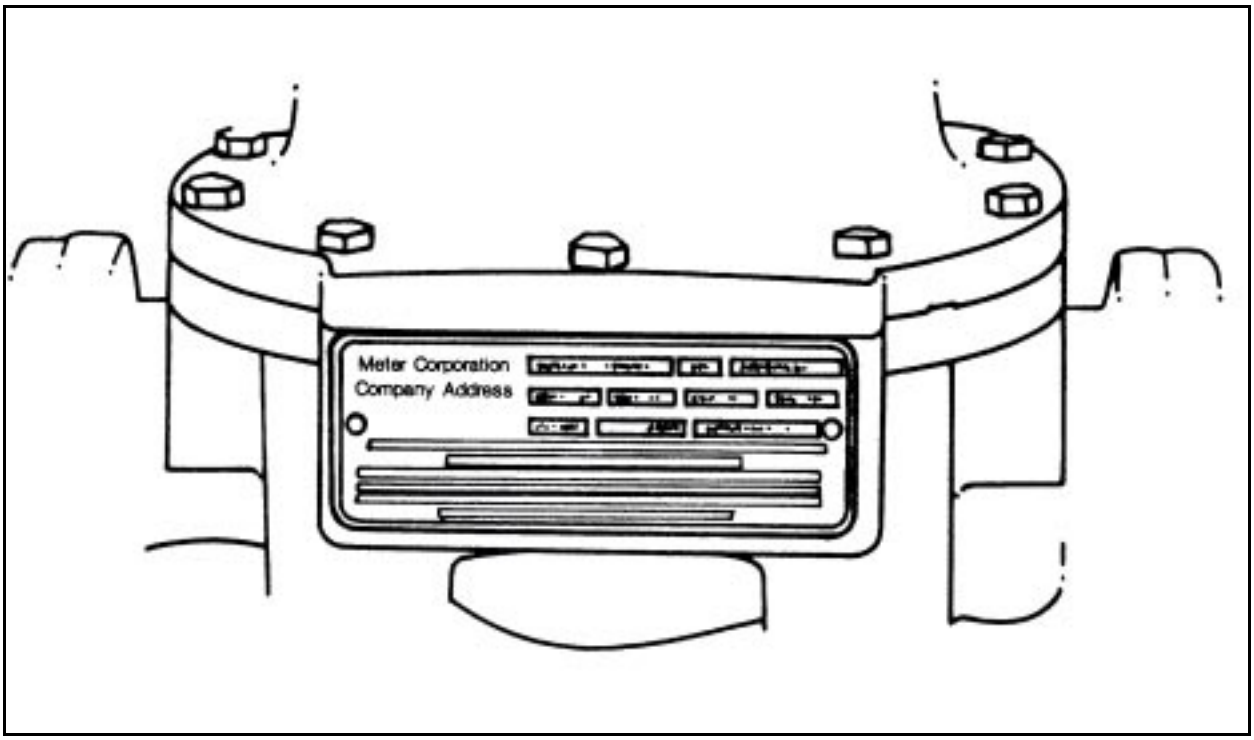


Figure 5-3. Identification Plate

Most manufacturers imprint or etch this information on a thin metal plate, which is affixed to one of the surfaces of the meter body, as in the example shown in Figure 5-3. If the register and/or ticket printer are made by a company other than the manufacturer of the meter, a separate identification plate is usually affixed to each.

This identifying information must be permanently marked. This means that it must not be removable or alterable, unless provision is made that removal or alteration will be readily evident. So an identification plate should be attached in some way that prevents its removal without mutilating or destroying it. Rivets should be used to attach the plate, not removable screws; this will prevent the plate from being replaced or transferred to another device. To prevent alteration of the imprinted information, some manufacturers use a plate made of pressure-sensitive material that will show clearly any attempt to erase original markings or alter them in any way. The use of pressure-sensitive identification plates may, however, cause problems

if the plate is located in a place where it is exposed to frequent abrasion, since markings may be accidentally obliterated.

Two specific marking requirements apply to vehicle-tank meters: these relate to limitations of use and discharge rates. We have referred to them in our discussion of General Considerations regarding selection, installation, and use and maintenance.

S.5.1. Limitation of Use. - If a meter is intended to measure accurately only liquids having particular properties, or to measure accurately only under specific installation or operating conditions, or to measure accurately only when used in conjunction with specific accessory equipment, these limitations shall be clearly and permanently stated on the meter.

S.5.2. Discharge Rates. - A meter shall be marked to show its designed maximum and minimum discharge rates. However, the minimum discharge rate shall not exceed 20 percent of the maximum discharge rate.

This information may be displayed on the same plate as the meter identification, or in another place. The reason for the limitation on the maximum discharge rate will be discussed in detail in the next chapter.

INDICATING AND RECORDING ELEMENTS

The remainder of the Inspection involves the operating components of the system: the indicating and recording elements, the measuring elements, and the piping. We turn first to the indicating and recording elements.

Design

According to Handbook 44, an indicating element is "an element incorporated in a weighing or measuring device by means of which its performance relative to quantity or money value is "read" from the device itself. . . ." A recording element permanently records such a "reading." An indicating or recording element that is used as the basis for determining the price of a commercial transaction is called a "primary" element. In general, only primary elements are covered by Handbook 44 specifications and requirements. All commercial measuring devices, including vehicle-tank meters, are required to have at least a primary indicating element.

S.1.1.1. General. - A meter shall be equipped with a primary indicating element and may also be equipped with a primary recording element.

[Note: Except for systems used solely for the sale of aviation fuel into aircraft and for aircraft-related operations, vehicle-tank meters shall be equipped with a primary recording element as required by paragraph UR.2.2.1.] (Amended 1993)

A system may also have one or more indicating elements that are not primary elements, because they are not used as the basis for the transaction. For example, many vehicle-tank meters are equipped with totalizers, which indicate cumulative quantities, and are used by the operator to monitor sales and as a means of detecting pilfering.

Except for systems used to deliver aviation fuel into aircraft and for aircraft-related operations, a vehicle-tank meter must be equipped with a ticket printer. The ticket printer must be used for all sales, and a copy of the ticket shall be left with the customer unless otherwise specified by the customer.

UR.2.2. Ticket Printer; Customer Ticket. - Vehicle-mounted metering systems shall be equipped with a ticket printer which shall be used for all sales where product is delivered through the meter. A copy of the ticket issued by the device shall be left with the customer at the time of delivery or as otherwise specified by the customer.
(Added 1993) (Amended 1994)

UR.2.2.1. Exceptions for the Sale of Aviation Fuel. - The provisions of UR.2.2. Ticket Printer; Customer Ticket shall not apply to vehicle-mounted metering systems used solely for the sale of aviation fuel into aircraft and for aircraft-related operations.
(Added 1999)

The unit of measure customarily used in sales of liquid products in the U.S. inch-pound system is the gallon. In order to prevent the confusion that would certainly arise from the use of different units by different vendors, vehicle-tank meters must be designed to indicate and record, if a recording element is employed, deliveries in terms of gallons. It should be kept in mind; however, that use of the weights and measures of the Metric System is lawful throughout the United States and deliveries may be indicated and recorded in terms of liters.

S.1.1.2. Units. -

(a) A meter shall indicate, and record if the meter is equipped to record, its deliveries in terms of liters (gallons). Fractional parts of the liter (gallon) shall be in terms of either decimal or binary subdivisions.

(b) When it is an industry practice to purchase and sell milk by weight based upon 1.03 kg/L (8.6 lb/gal), the primary indicating element may indicate in kilograms (pounds) and decimal kilograms (pounds). The weight value division shall be a decimal multiple or submultiple of 1, 2, or 5. (See S.5.5.)

Fractional parts of gallons may also be indicated or recorded, whether in terms of decimal or binary subdivisions (half-gallons, quarts, pints, etc.). As was discussed under the heading of General Considerations regarding selection of a design appropriate to its application, milk-metering systems and meters used for retail deliveries of liquid fuel must indicate deliveries using subdivisions equivalent to a 0.1 gallon or less.

Primary elements must also be designed to be reset to a definite zero indication before the commencement of a delivery. This assures that a reading of the amount actually delivered will be provided at the end of the delivery, when the transaction is completed. This provision protects both buyer and seller. If resetting to zero was not required, the buyer could not be assured of the amount received unless he or she was present to record the initial cumulative reading; because the initial reading would not be available at the conclusion of the delivery, there would be no way of verifying the amount if it was disputed. (Primary recording elements are not required to be resettable, since cumulative readings can be permanently recorded at the beginning and end of the delivery.)

S.1.1.5. Return to Zero. - Primary indicating elements shall be readily returnable to a definite zero indication. Means shall be provided to prevent the return of primary indicating elements, and of primary recording elements if these are returnable to zero, beyond their correct zero position.

Specific requirements apply to the design of indicating and recording elements to prevent any reading other than the actual amount of the delivery being displayed, either accidentally or as the result of deliberate manipulation by the operator.

S.1.1.4. Advancement of Indicating and Recording Elements. -Primary indicating and recording elements shall be susceptible to advancement only by the mechanical operation of the meter. However, a meter may be cleared by advancing its elements to zero, but only if:

(a) the advancing movement, once started, cannot be stopped until zero is reached, or

(b) in the case of indicating elements only, such elements are automatically obscured until the elements reach the correct zero position.

Most mechanical registers incorporate revolving indicating wheels. The wheels must be designed so that they can only be advanced by the mechanical operation of the meter; in other words, they can only be advanced when product is moving through the meter -- an operator can not simply advance the wheels so that they indicate an amount greater than that actually delivered. There is one exception to this requirement: resetting of the register by advancement -- without the operation of the meter -- is permitted, provided that the motion of the wheels, once begun, can not be halted until zero is reached or that the indications are hidden from view until the reset is completed. To meet this requirement, many mechanical registers are designed with shutters that cover the wheels during the reset and are raised when it has been completed.

Electronic registers generally blank out the display during the reset. Most of them incorporate a segment check feature that displays the figure 8 momentarily for all digits in the display before zeros appear. (The figure 8 contains all the segments that are used to display the other numbers: if all the segments of the 8 appear, all other numbers can be displayed correctly.)

Your inspection of the design of indicating and recording elements should consist of the following steps:

- Identify all primary indicating and recording elements.
- Determine whether the units displayed are correct (that they do not exceed the equivalent of 0.5 L (0.1 gal) or 0.5 kg (1 lb) for milk or 0.5 L (0.1 gal) for home heating fuel or 5 L (1 gal) for other products).
- Activate the reset and observe the element to verify that no indications are readable until the register shows a definite zero status.

Readability

To minimize the risk of errors and the possibility of misrepresentation, the customer, as well as the operator, must be able to read <u>and</u> understand the information provided by primary indicating and recording elements. For this reason, a number of general and specific requirements are established in Handbook 44 regarding the design, size, uniformity, and durability of primary elements that employ either analog or digital representations. Paragraph G-S.5.1 of the General Code includes the basic requirements.

G-S.5. Indicating and Recording Elements

G-S.5.1. General. - All weighing and measuring devices shall be provided with indicating or recording elements appropriate in design and adequate in amount. Primary indications and recorded representations shall be clear, definite, accurate, and easily read under any conditions of normal operation of the device.

This paragraph also provides the primary basis for evaluating the readability of primary elements during your inspection: indications and recorded representations must be "clear, definite, accurate, and easily read under any conditions of normal operation of the device." This reflects the purpose and intent of the various specific requirements that relate to these elements -- to assure that both buyer and seller can read and understand the information displayed by the device both during and at the conclusion of the transaction.

Even if the device conforms with all the specific requirements that are described below, you must satisfy yourself that indications and representations meet the general test of readability established in G-S.5.1. The only means of determining this is to observe the elements critically, not at close range, as you might when checking a specific item, but from the position from which they would normally be viewed during a delivery. From this perspective you should ask yourself: Can a customer, who may not be familiar with the equipment or its indications, both read and understand them? If the answer is negative, you must determine the specific cause of inadequate readability so that the owner or operator can be informed of what specific repairs or changes are necessary in order to bring the device into conformance with this requirement.

Several general requirements relating to readability involve the design of the elements themselves. As you will recall from our discussion in Chapter 3, two basic types of indication and representation are distinguished: analog and digital. Design requirements for these two types are necessarily somewhat different.

G-S.5.2. Graduations, Indications, and Recorded Representations.

G-S.5.2.1. Analog Indication and Representation. -Graduations and a suitable indicator shall be provided in connection with indications designed to advance continuously.

G-S.5.2.2. Digital Indication and Representation. - Digital elements shall be so designed that:

(a) All digital values of like value in a system agree with one another.

(b) A digital value coincides with its associated analog value to the nearest minimum graduation.

(c) A digital value "rounds off" to the nearest minimum unit that can be indicated or recorded.

(d) *A digital zero indication includes the display of a zero for all places that are displayed to the right of the decimal point and at least one place to the left. When no decimal values are displayed, a zero shall be displayed for each place of the indicated division. [Nonretroactive as of January 1, 1986.]*

(Amended 1973 and 1985)

Subparagraph G-S.5.2.1 simply states that an analog device must be equipped with appropriate features for this type of indication: graduations and a suitable indicator. Specific requirements relating to graduations and indicators for analog devices are included in the Vehicle-Tank Meters Code and are described below.

The first two items in the subparagraph on digital devices refer to systems which incorporate more than one primary element. If a tank truck system is equipped with both a register and a ticket printer, the values indicated and recorded must agree as specified. If both elements are digital, values displayed must agree exactly (as you will learn below, recorded representations are required to be digital). If the register is analog, values must agree to the nearest minimum graduation. For example, if the smallest graduated intervals on the register represent 0.1 gallon and the register indicates 100.05 gallons (with the pointer halfway between the 0.0 and the 0.1 graduations on the right-hand indicating wheel), a ticket produced by the printer could display a value of 100.1 gallons, since that would be the quantity indicated by the analog indicator with its pointer on the nearest graduation. The allowance is necessary because of the fundamental difference between analog and digital devices: the former indicate change continuously while the latter indicate change in increments.

For vehicle-tank meters, the requirement that a digital device "round off" to the nearest unit means that the displayed value will change when the actual delivery is about halfway between two successive indicated amounts. So, for example, if a digital register has an increment of 0.1 gallon and currently reads 100.0 gallons, this represents the actual delivery of some quantity between 99.950 and 100.049 gallons; when 100.050 gallons have been delivered, the indication will change to 100.1.

The requirement that a digital zero indication include zeros for each digit to the right of the decimal point that can be displayed and a zero for at least one place to the left of the decimal point assures that the smallest quantity that the device is capable of measuring and indicating will be apparent before delivery begins. The customer will thus be aware of the sensitivity of the device and of the minimum units that will be employed in completing the transaction.

Conformance with the general requirements for digital devices set forth in subparagraph G-S.5.2.2 can only be determined with the system in operation, and is thus most efficiently checked during the Test portion of the examination. We will refer to these procedures at the appropriate point in the Test, which is described in Chapter 6.

Three additional general requirements relate to the size and character, values, and permanence of both analog and digital indications and recorded representations.

G-S.5.2.3. Size and Character. - In any series of graduations, indications, or recorded representations, corresponding graduations and units shall be uniform in size and character. Graduations, indications, or recorded representations that are subordinate to or of a lesser value than others with which they are associated shall be appropriately portrayed or designated. (Made retroactive as of January 1, 1975.)

G-S.5.2.4. Values. - If graduations, indications, or recorded representations are intended to have specific values, these shall be adequately defined by a sufficient number of figures, words, symbols, or combinations thereof, uniformly placed with reference to the graduations, indications, or recorded representations and as close thereto as practicable, but not so positioned as to interfere with the accuracy of reading.

G-S.5.2.5. Permanence. - Graduations, indications, or recorded representations and their defining figures, words, and symbols shall be of such character that they will not tend easily to become obliterated or illegible.

On a mechanical register of the revolving wheel type, like the one depicted in Figure 5-4, each wheel represents a single digit of a decimal number. The specific values (tenths, ones, hundreds, etc.) represented by each wheel are distinguished by the relative position of the wheel (tenths to the immediate right of the decimal point, ones to the immediate left, etc.); so on this type of indicator the size and character of the numerals and graduations are generally the same (although the digits to the right of the decimal point sometimes have smaller numbers or a contrasting color background to facilitate reading). Decimal subdivisions of the values represented by any of the wheels are indicated on the next wheel to the right, except of course, for the rightmost wheel. This wheel may have subdivisions marked, as in the example shown; values are read by using the index to the right. If, as is usually the case, there is only one level of subdivision, the values of the divisions are usually obvious without literal designations.

As you inspect this type of register, observe the rightmost indicating wheel critically. The values represented by any divisions on this wheel should be clear to a customer who is not familiar with the register or its indications, and there should be no confusion between major divisions and subdivisions.

Indicators of whatever type should be protected from abrasion and accumulations of dirt and grease by a glass covering. Even with this protection, however, readings can be obscured by cracks, scratches, or dirt on the cover glass, and these conditions, though usually minor, must be remedied. If well protected, the indicators will usually meet the requirement for permanence. But you should always check the readability of the indicators anyway. In some wheel-type registers the clearance between the wheels and the reset shutter is very small, and when the mechanism wears, the closure of the shutter and/or the movement of the wheels may produce scratches or chips on the numbers and graduations that are painted on the wheels. When this process reaches the point where readability is affected, the wheels must be repainted or replaced and the shutter mechanism must be adjusted.

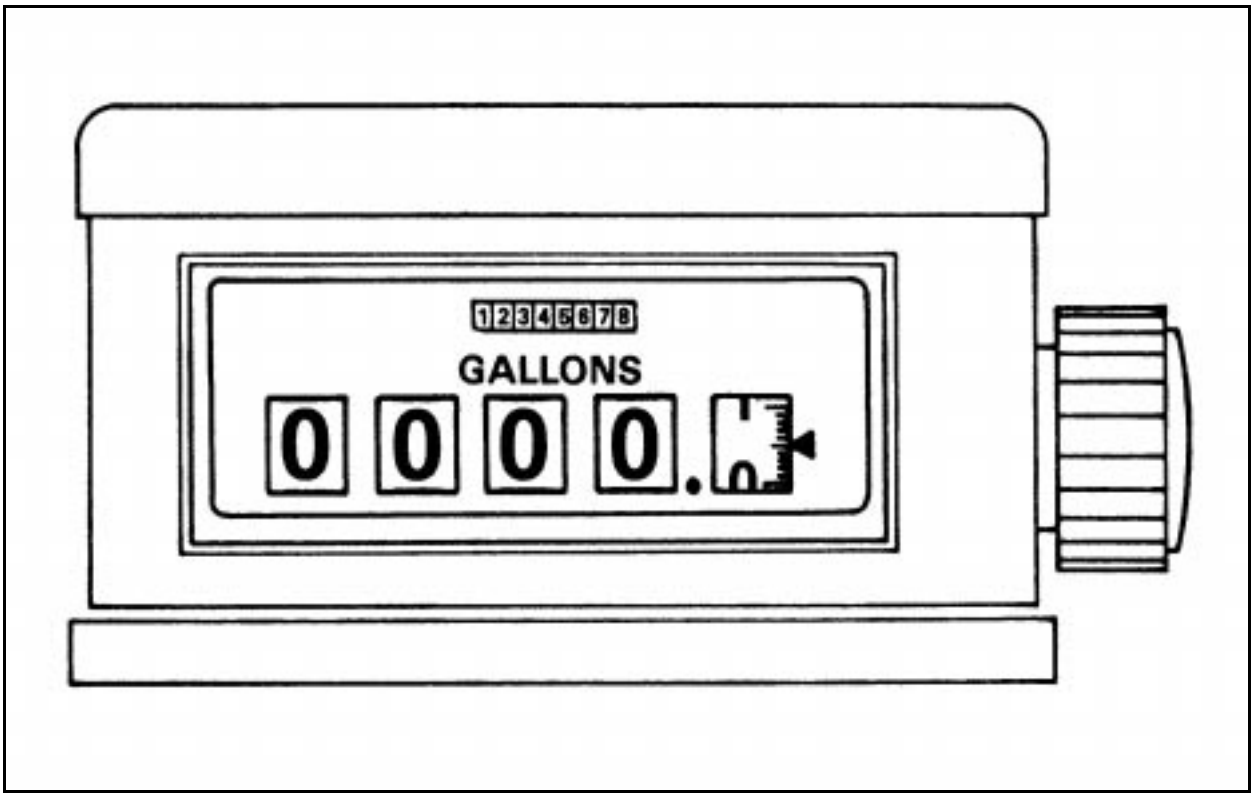


Figure 5-4. Size and Character of Indicating Elements, Mechanical Register

A vehicle-tank's metering system that is equipped with a ticket printer makes a permanent record of each commercial transaction. The numbers, symbols, lettering, and other markings on these records, referred to as recorded representations, must also be readable and understandable. One paragraph in the General Code deals specifically with recorded representations.

G-S.5.6. Recorded Representations. - Insofar as they are appropriate, the requirements for indicating and recording elements shall be applicable also to recorded representations. All recorded values shall be printed digitally.
[Made retroactive 1990] (Amended 1975)

A ticket or invoice produced by a printer includes a representation of the same information that is displayed on the register. The application of the same basic requirements to both types of indication is therefore logical. For example, since the register is required to display the units of measurement -- gallons -- a printed ticket should also provide this information. If the device is capable of computing the sale price, the printed information should also include the same unit price that is displayed on the outside of the device

(see below). In addition, the printed representation itself must meet the general requirement for readability described above.

There is, however, one way in which the printed representation and the register indication may differ: according to paragraph G-S.5.6, the recorded representation must be digital, regardless of whether the register indication is analog or digital. That is, the quantity delivered (as well as the total price and unit price if the system is of the computing type) must appear on the ticket as numbers. It would not be acceptable, for example, for the printer to show a representation of indicating wheels or a dial with graduations and an indicator, even if this is the means by which register indicates amounts and values.

A subparagraph of G-S.5.6 includes a table that sets forth correct standard abbreviations for metric units that are used on recorded representations produced by weighing and measuring devices. One abbreviation that is relevant to vehicle-tank metering systems is that for the liter, which may be represented by either L (uppercase) or 1 (lowercase).

In addition to the indications of quantity, price, units, and so on, many weighing and measuring devices have a variety of manual operating controls, switches, lights, and other features. The operator of the device may be aware from long experience of the function and correct operation of such features, but the customer must also know whether and how such features affect the indicated measurement and must also be able to monitor the operator's actions during the transaction, especially the manipulation of non-automatic control elements. For this reason, the General Code requires identifying markings and lettering for all such features, and further requires that these markings be readable.

> ***G-S.6. Marking, Operational Controls, Indications, and Features.*** *- All operational controls, indications, and features, including switches, lights, displays, pushbuttons, and other means, shall be clearly and definitely identified. The use of approved pictograms or symbols shall be acceptable. [Nonretroactive as of January 1, 1977.] (Amended 1978, 1995)*
>
> **G-S.7. Lettering.** - All required markings and instructions shall be distinct and easily readable and shall be of such character that they will not tend to become obliterated or illegible.

The number of separate features that require marking on a vehicle-tank metering system will depend largely upon the design of the system. A system equipped with only a mechanical register, like the one shown earlier in Figure 5-4, and with no such auxiliary devices as a ticket printer, preset, or automatic temperature compensator, will generally require markings only for the indicating elements themselves (graduations, number values, units, etc.) and for the reset control. On a more full-featured system, however, like the electronic register and printer shown in Figure 5-5, considerably more identifying marking and instructions will be required. Instructions actually printed on the device may be very rudimentary, like those for the ticket printer in the example below, but they should be sufficient to indicate both function and basic operation.

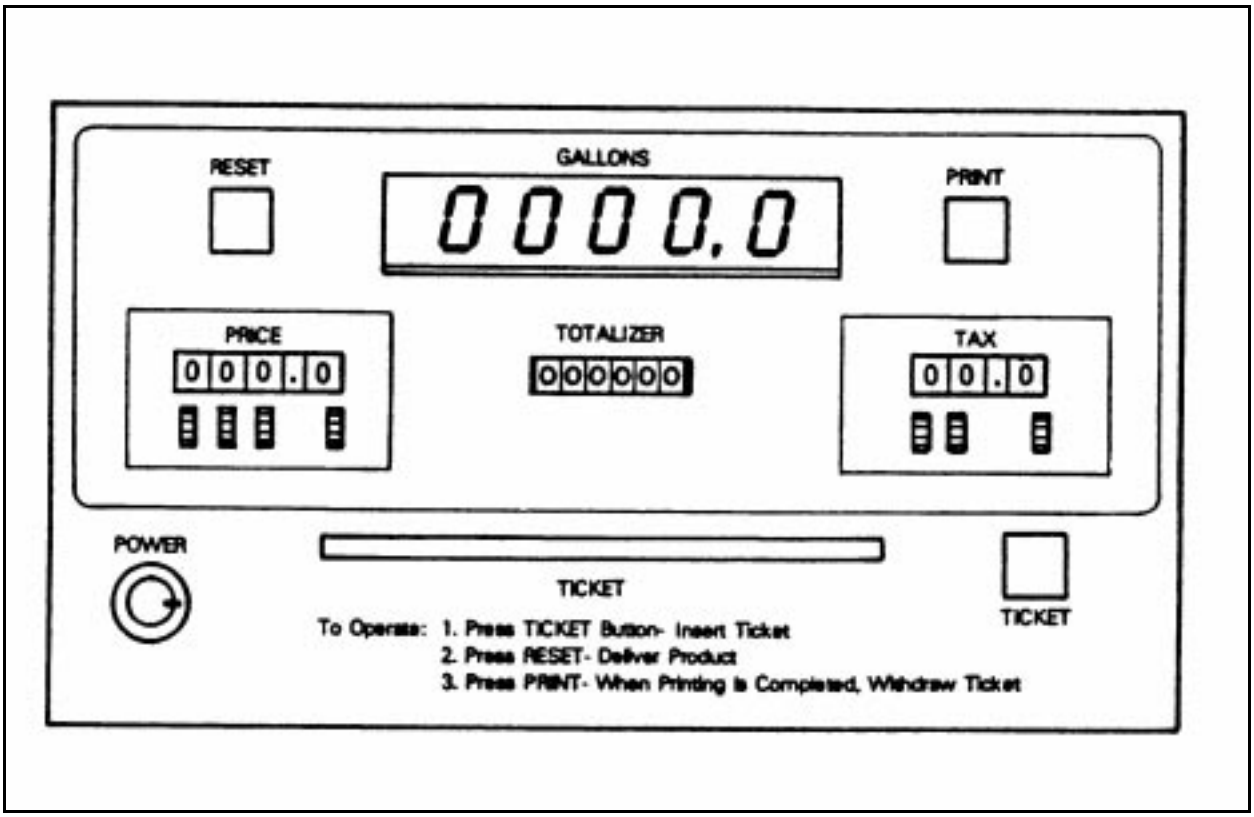


Figure 5-5. Marking of Controls and Other Features

More specific requirements regarding readability are included in the Vehicle-Tank Meters Code. Because electronic registers are digital devices, and thus do not have either graduations, indicators, or permanent values, these requirements relate primarily to mechanical type indicators.

S.1.2. Graduations.

S.1.2.1. Length. - Graduations shall be so varied in length that they may be conveniently read.

S.1.2.2. Width. - In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations, and the width of main graduations shall be not more than 50 percent greater than the width of subordinate graduations. Graduations shall in no case be less than 0.2 mm (0.008 in) wide.

S.1.2.3. Clear Interval Between Graduations. - The clear interval shall be not less than 2.5 mm (0.10 in). If the graduations are not parallel, the measurement shall be made:

(a) along the line of relative movement between the graduations at the end of the indicator, or

(b) if the indicator is continuous, at the point of widest separation of the graduations.

(Amended 1986)

S.1.3. Indicators

S.1.3.1 Symmetry. - The index of an indicator shall be symmetrical with respect to the graduations at least throughout that portion of its length associated with the graduation.

S.1.3.2. Length. - The index of an indicator shall reach to the finest graduations with which it is used, unless the indicator and the graduations are in the same plane, in which case the distance between the end of the indicator and the ends of the graduations, measured along the line of the graduations, shall be not more than 1.0 mm (0.04 in).

S.1.3.3. Width. - The width of the index of an indicator in relation to the series of graduations with which it is used shall be not greater than

(a) the width of the narrowest graduation*, and
[*Nonretroactive as of January 1, 2002]
(Amended 2001)

(b) the width of the minimum clear interval between graduations.

When the index of an indicator extends along the entire length of a graduation, that portion of the index of the indicator that may be brought into coincidence with the graduation shall be of the same width throughout the length of the index that coincides with the graduation.

S.1.3.4. Clearance. - The clearance between the index of an indicator and the graduations shall in no case be more than 1.5 mm (0.06 inch).

S.1.3.5. Parallax. - Parallax effects shall be reduced to the practicable minimum.

S.1.3.6. Travel of Indicator. - If the most sensitive element of the primary indicating element utilizes an indicator and graduations, the relative movement of these parts corresponding to the smallest indicated value shall not be less than 5 mm (0.20 in).

Figure 5-6 illustrates the specifications for the length and width of graduations and the clear interval between them (measured from the facing edges of successive graduations). Obviously,

if graduations are too thin, they may not be readable during the normal use of the equipment. But graduations must also not be too wide in proportion to the clear intervals between them. There are two reasons for this. The first is to avoid any confusion about which is the graduation and which is the interval: the graduation is conventionally thinner than the interval.

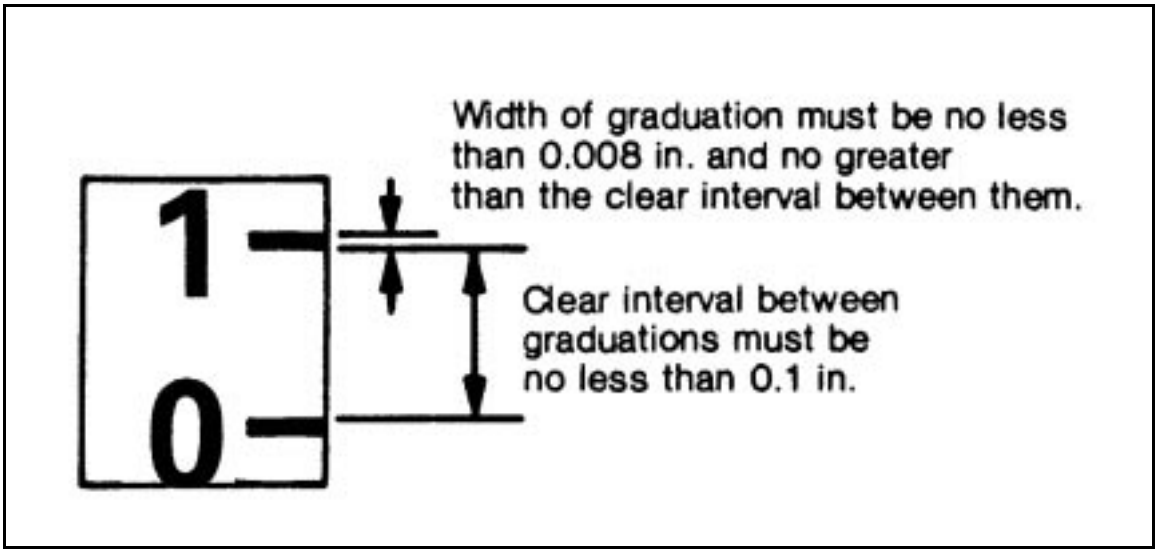


Figure 5-6. Length and Width of Graduations

The second reason has to do with the nature of a graduation. A graduation represents a division between two values, but the division itself ideally has no width and no value. Of course, for practical purposes, graduations must have some width, or they could not be read. Therefore, a minimum width (0.008 in) is specified. On the other hand, the wider the graduation in proportion to the interval between graduations, the larger the value it incorporates, and this can affect readability significantly. To see how, let us consider an example.

In accordance with the specifications of S.1.2, a graduation may be no wider than the clear interval between graduations. In the example shown in Figure 5-7, the graduations and intervals are of equal width, each one thus comprising 1/20th of the circumference of the wheel. If this is a 1/10th-gallon wheel, each complete revolution indicates 1 gallon delivered. So each interval and each graduation thus represents 0.05 gal.

If the operator follows the convenient practice of reading the exact division whenever any part of the pointer coincides with any part of the graduation, the reading could be off by as much as 0.025 gal (5.775 cu in). In our example, the operator would read 50.00 gal, whereas the actual reading is much closer to 49.98 gal. From the point of view of a delivery of 1,000 gallons of product, this amount (about 1/50th of a gallon) is obviously insignificant. However, if a weights and measures inspector is testing this meter, such a small amount can be very significant, since it is only slightly less than one-quarter of the acceptance tolerance for a 50-gallon test draft. If the inspector were to read the indication in Figure 5-7 as 50.00 gal and the prover showed a minus error within

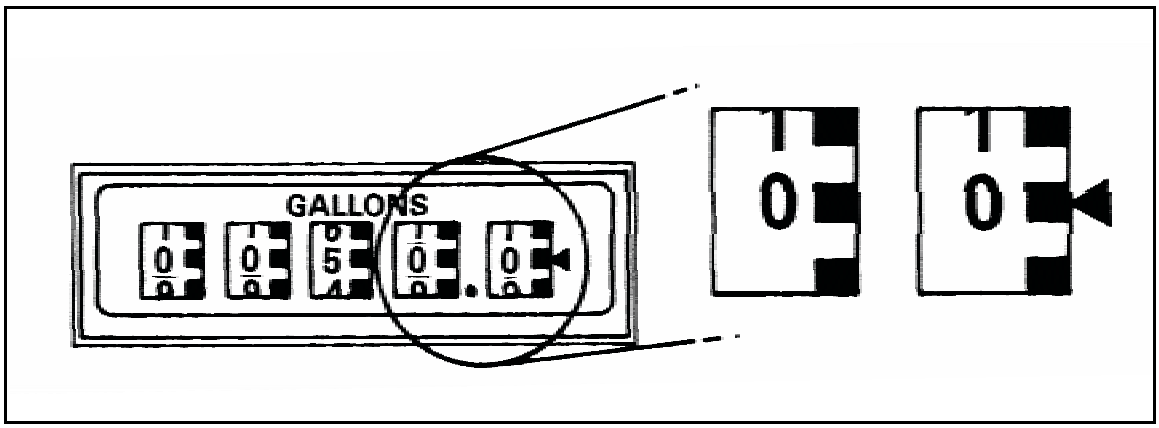


Figure 5-7. Width of Graduations

4.62 cu in of the applicable tolerance, the meter could be erroneously rejected. The inspector would obviously try to visually subdivide the graduation to gain a more accurate reading, but this could be difficult, especially if the edges of the graduation are indistinct.

It is very unlikely that you would ever encounter such a situation in the field, since the clear intervals on most indicating wheels are proportionately much wider than the graduations (commonly in a ratio of 20:1 or more). But you should understand and be able to explain the reason for the requirement if necessary. And you should always make a visual inspection to assure yourself that you are not dealing with an atypical situation. If it appears that the graduations are larger than the intervals between them, or if the smallest clear interval appears to be thinner than the point of a pencil or ballpoint pen, it may be necessary to actually measure the dimensions. Special equipment will probably be needed for this.

The index of the indicator is a pointer, which is painted (or sometimes cut out) from the sheet metal face plate that surrounds the wheels (see Figure 5-8). This design virtually eliminates parallax effects (apparent differences in the relative position of two observed objects -- in this case the wheel and the pointer -- depending on the position of the observer) since both are thus in the same plane. The center of the pointer edge that faces the graduation must be used for an accurate reading, and the center can only be readily located if the end of the pointer is symmetrical. Limiting the space between the end of the pointer and the wheel and limiting the width of the pointer also facilitate readability.

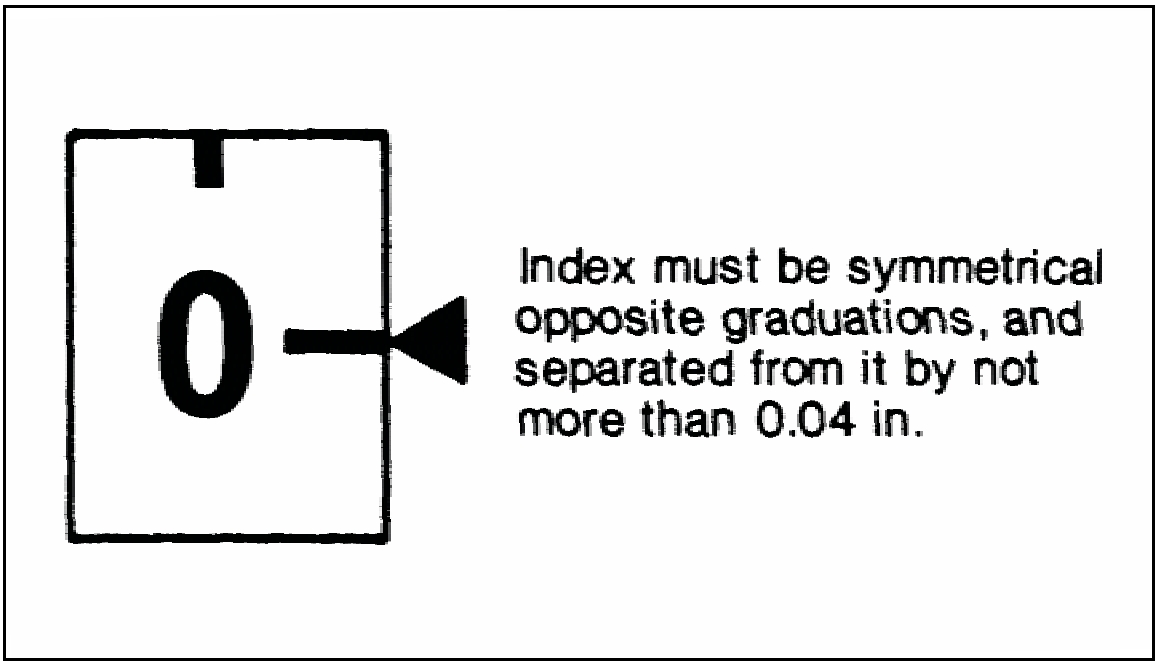


Figure 5-8. Index of the Indicator, Mechanical Register

Values of Intervals

The distance between the center of one graduation and the center of the next graduation is referred to as the graduated interval (see Figure 5-9). This interval has an associated value. In the example shown this value is 0.1 gal: the passage of the pointer through the graduated interval represents 0.1 gal of product delivered.

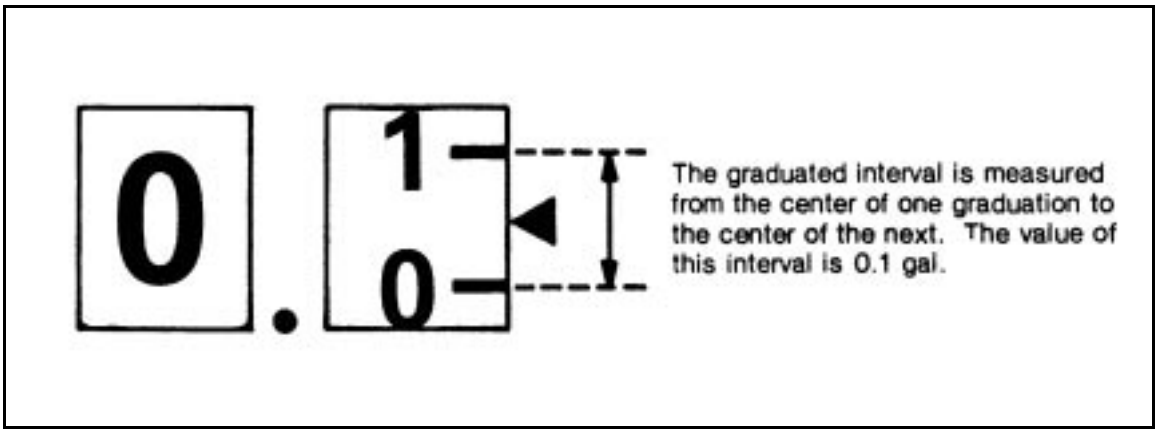


Figure 5-9. Values of Intervals

The equivalent of the graduated interval for a digital indicator is the increment. The increment is the smallest change in value that can be indicated or recorded. Two paragraphs in the General Code include requirements for graduated intervals or increments.

G-S.5.3. Values of Graduated Intervals or Increments. - In any series of graduations, indications, or recorded representations, the values of the graduated intervals or increments shall be uniform throughout the series.

G-S.5.3.1. On Devices That Indicate or Record in More than One Unit. -On devices designed to indicate or record in more than one unit of measurement, the values indicated and recorded shall be identified with an appropriate word, symbol, or abbreviation. (Amended 1978, 1986) (Made retroactive 1990)

The requirement regarding uniformity simply means that in any given series the value of the interval or increment must not change at any time. Any non-linear progression would obviously be confusing -- and could be deceptive -- especially on a wheel type indicator, since the next value may not be visible at the same time as the current value. The operator or customer must be able to determine what the next indication will be even if it can not be seen, in order to regulate the delivery. On most digital indicators, only the current value is visible at any moment.

The requirement regarding dual indications (U.S. inch-pound and metric) is intended to assure that devices so equipped are clearly and adequately marked to prevent confusion, while at the same time not discouraging conversion to the metric system.

Computing-type Devices

A computing-type device is one that indicates the total money value of the delivery, in addition to the amount. Most mechanical registers do not have this capability, primarily because of the complicated and costly design that would be required to permit variation of the unit price and to provide for the different taxing formulas -- some based on quantity, others on price -- that are in force in different jurisdictions. (Many tank trucks operate in more than one taxing jurisdiction.) Most electronic registers, on the other hand, do have full computing capability, with unit price variation and tax formulas programmable. The advantages afforded to operators will in all likelihood lead to increased use of such devices. Several specific requirements are established to assure that computing-type devices provide information that is accurate and can be readily understood by both the seller and the buyer.

One such essential item of information is the unit price of the product, which must be displayed in the same units that are indicated on the register (for example, price per gallon). This requirement also applies to a printed ticket, if the system produces one. The ticket must also display the total number of gallons delivered, including any fractional quantity (in accordance with the requirements for agreement between displayed values described above).

S.1.4. Computing-type Device.

S.1.4.1. Display of Unit Price. - In a device of the computing type, means shall be provided for displaying on the outside of the device, in a manner clear to the operator and an observer, the unit price at which the device is set to compute. (Amended 1983)

S.1.4.2. Printed Ticket. - If a computing-type device issues a printed ticket which displays the total computed price, the ticket shall also have printed clearly thereon the total quantity of the delivery, the appropriate fraction of the quantity, and the price per unit of quantity.
(Amended 1989)

UR.1.2. Unit Price. - There shall be displayed on the face of a device of the computing type the unit price at which the device is set to compute.

Computing-type systems employed with vehicle-tank meters can compute and display or record sales prices for unit prices of up to $0.999 per gallon, and some have capability for unit prices up to $9.999 per gallon. The range of total prices that can be computed will depend upon the design of the system and the unit price for which it is set to compute at any given time, but a computing-type device must in general be capable of computing a price for any delivery that is made. It must not, for example, be necessary to multiply the computed value by some factor to determine the actual price of the sale. This requirement is set forth in the Vehicle-Tank Meters Code.

S.1.4.3. Money-Value Computations. - Money-value computations shall be of the full-computing type in which the money value at a single unit price, or at each of a series of unit prices, shall be computed for every delivery within either the range of measurement of the device or the range of the computing elements, whichever is less. Value graduations shall be supplied and shall be accurately positioned. The value of each graduated interval shall be 1 cent. On electronic devices with digital indications, the total price may be computed on the basis of the quantity indicated when the value of the smallest division indicated is equal to or less than 0.2 L (0.1 gal) or 0.2 kg (1 lb).
(Amended 1979, 1989)

This paragraph also sets forth specific requirements for both analog and digital computing-type devices. Almost all such devices now in use are electronic and digital, and it is not likely that analog computing-type indicating and recording elements will ever be in common use on vehicle-tank metering systems. However, two requirements are established for analog computing-type devices: they must be equipped with graduations, and the value of each graduated interval must be one cent. The purpose of both of these requirements is to assure that indicated money values can be read accurately to the nearest cent. A smaller money value division is unnecessary and might even be confusing, since the cent is the smallest

unit of U.S. currency. A larger division would also be confusing, and might even encourage improper or fraudulent use of the equipment, since accurate readings to within one cent could not be readily obtained and verified.

The requirement for digital devices has the same general purpose. Digital computing-type devices generally perform computations based upon the number of signals transmitted by the pulser. However, the pulser is designed to generate discrete pulses at quantity divisions. For example, many pulsers are designed to generate 10 discrete pulses per revolution in their normal operating mode, with each signal causing the quantity display to be incremented by 0.1 gallon. The result is that the money-value increment -- that is, the smallest change in money value that can be displayed -- is equal to the quantity increment multiplied by the unit price.

Consider the following example, showing a succession of indicated values when the unit price is $0.99 per gallon and the quantity increment is 0.1 gallon. As you can see, the smallest change in money value that can be displayed is $0.099 (which rounds to $0.10).

Quantity	Unit Price	Total Price	Change in Price
1.0 gal	$ 0.99/gal	$ 0.99	$ 0.099
1.1 gal	0.99/gal	1.09	0.099
1.2 gal	0.99/gal	1.19	0.099
1.3 gal	0.99/gal	1.29	0.099

This will cause no problem for commercial transactions in which the customer purchases a specific quantity of product. However, if the customer wishes to purchase a certain dollar value of product, it will only be possible to display the desired amount if it is a multiple of the money-value increment. Note, for example, that a system set as in the example above will not display a total sale of exactly $1.00 (or any other whole dollar amount). Delivery of many specific dollar amounts can thus only be done by estimation, halting delivery at some indefinite point between divisions, and can not be verified.

The requirement of S.1.4.3 relating to digital devices simply states that if money-value computations are derived in this way, the quantity increment must not exceed 0.1 gallon. This has the effect of limiting the range of inaccuracy under circumstances in which the customer wishes to purchase a specific dollar amount

of product or when the halting of delivery is indefinite (for example, when a tank is "topped off", or filled to its capacity) to the dollar value of 0.1 gallon of product at its current price.

In summary, you should inspect a computing-type device to determine that the unit price is correctly displayed. Conformance with requirements relating to the information printed on a ticket (if the device is equipped with a ticket printer) and to money-value computations is most efficiently checked when the system is operating. We will, therefore, refer to these procedures again in our discussion of the Test.

Advancement and Return to Zero

Specific requirements relating to the zero reset mechanism have been covered earlier in the section on the design of indicating and recording elements. However, one user requirement has not yet been discussed.

UR.2.1. Return of Indicating and Recording Elements to Zero. - The primary indicating elements (visual), and the primary recording elements when these are returnable to zero, shall be returned to zero immediately before each delivery is begun and after the pump has been activated and the product to be measured has been supplied to the measuring system.
(Amended 1981)

Most ticket printers are designed in such a way that a new ticket cannot be printed until the register has been reset to zero. This prevents a buyer from being charged for the preceding delivery in addition to his or her own, either by accident or by design. However, vehicle-tank meters are not required to be equipped with an interlock mechanism that prevents delivery from being resumed without resetting the register after this system has been deactivated (as gas pumps are required to be). Accordingly, an unscrupulous operator could insert a ticket in the printer before reaching the buyer's location, divert a quantity of product back to the tank (by simply running the delivery hose up to the fill opening of the truck) halt the delivery without resetting the meter, drive to the buyer's location and resume delivery. If the buyer is not present to observe the register reading before delivery begins and demand that it be reset, he or she could be fraudulently charged for a quantity of product that has not left the possession of the operator. Some electronic devices incorporate a "timeout" feature whereby a ticket is automatically printed after a specified time after delivery stops.

Additionally, Handbook 44 includes a user requirement which requires that a new ticket cannot be inserted into a device until immediately before a delivery and the ticket cannot be in the device while the vehicle is in motion on public roads.

UR.2.3. Ticket in Printing Device. - A ticket shall not be inserted into a device equipped with a ticket printer until immediately before a delivery is begun, and in no case shall a ticket be in the device when the vehicle is in motion while on a public street, highway, or thoroughfare.

These user requirements are intended to prohibit such fraudulent practice. It is, however, obviously impossible for an inspector to detect this particular type of misuse during a field examination. If complaints have been received, you should remind the operator that correct use is prescribed and warn him or her of the consequences of continued misuse. If there is reason to suspect that the operator is misusing metering equipment with the intent to defraud, consult your supervisor regarding further action. In some jurisdictions, an operator suspected of such practice may be placed under surveillance.

MEASURING ELEMENTS

After our discussion of the numerous and detailed specifications relating to the indicating and recording elements of a vehicle-tank metering system, it may seem surprising to you to learn that Handbook 44 includes no specific requirements for the meter itself, except that provision be made for sealing it. Of course the system is required to perform within close tolerances, and this performance, which you will test in the course of your examination, depends to a large degree on the condition of the meter. However, the operation of most positive-displacement meters that are employed in vehicle-tank systems is so simple that there is no need to specify its design. The system is required, however, to be equipped with a means of preventing air and vapor from being metered, and the air eliminator, whose function and operation were described, is properly considered a component of the meter.

> **S.2.1. Vapor Elimination.** - A metering system shall be equipped with an effective vapor or air eliminator or other automatic means to prevent the passage of vapor and air through the meter. Vent lines from the air or vapor eliminator shall be made of metal tubing or some other suitable rigid material.
> (Amended 1993)

Inspect the vent line carefully. It must be made of a material, such as metal tubing, that cannot readily be crimped or manipulated in any other way to obstruct the passage of air and vapor, and it should not have any manually operated valves that could similarly impair its effectiveness if closed during operation of the system. Finally, check the entire length of the vent line for dents or breaks. One of the performance tests described in the next chapter is intended in part to assure that the air eliminator is functioning properly.

As mentioned, means must be provided for sealing the meter. Even though the adjustment mechanism used to calibrate the system is, strictly speaking, part of the indicating element, access to a mechanical adjustor, such as change gears, is accomplished simply by unbolting the register from the top of the meter. Accordingly, the meter and register should be sealed together. This is usually done by threading a wire seal through a hole drilled in one of the bolts that holds the register on top of the meter after the bolt has been put in place, but it may be done in any other way, provided that the register and meter cannot be separated without breaking the seal.

> ***G-S.8. Provision for Sealing Electronic Adjustable Components.*** *- A device shall be designed with provision(s) for applying a security seal that must be broken, or for using other approved means of providing security (e.g., data change audit trail available at the time of inspection), before any change that detrimentally affects the metrological integrity of the device can be made to any electronic mechanism.*
> *[Nonretroactive as of January 1, 1990.]*
>
> A device may be fitted with an automatic or a semi-automatic calibration mechanism. This mechanism shall be incorporated inside the device. After sealing, neither the mechanism nor the calibration process shall facilitate fraud.
> (Added 1985)(Amended 1989 and 1993)

S.2.2. Provision for Sealing. - Except on devices for metering milk, adequate provision shall be made for applying security seals in such a manner that no adjustment may be made of:

(a) any measurement element, and

(b) any adjustable element for controlling delivery rate when such rate tends to affect the accuracy of deliveries.

The adjusting mechanism shall be readily accessible for purposes of affixing a security seal.

G-UR.4.5. Security Seal. - A security seal shall be appropriately affixed to any adjustment mechanism designed to be sealed.

Access to the meter chamber is usually gained either by removing a cover plate or by separating the two hemispheres that comprise the housing. This access should also be sealed to prevent manipulation or adjustment of meter components, especially the moving segmenting elements that could affect the accuracy of the system.

PIPING

The piping, including a number of flow-regulating valves is, as you have learned, an important part of the metering system. When functioning correctly, it assures that the quantity of product registered is actually delivered and also helps prevent metering of air and vapor. Several specific requirements apply to piping.

One requirement is that check valves, installed (especially in power-operated systems) to prevent product from flowing backward, be automatic in design and not dependent on any action on the part of the operator. Equipment used exclusively for fueling aircraft is exempted from this requirement because these systems must be capable of defueling planes as well, sometimes under emergency conditions.

S.2.3. Directional Flow Valves. - Valves intended to prevent reversal of flow shall be automatic in operation. However, on equipment used exclusively for fueling aircraft, such valves may be manual in operation.

Because it is often used to deliver simultaneously to two tanks, equipment used exclusively for fueling aircraft is also exempted from the requirement that no means be provided for diverting product that has passed through the measuring chamber from the discharge line. Multiple delivery outlets can be installed in a discharge line (for example, to provide gravity-discharge service from either side of the truck).

However, if such an arrangement is used, a means must be provided to prevent delivery from more than one outlet at any one time. This is usually accomplished by means of a discharge manifold equipped with one or more multi-port valves that automatically close off all discharge outlets but the one selected for delivery.

S.3. Design of Discharge Lines and Discharge Line Valves. - (Not applicable to milk-metering systems).

S.3.1. Diversion of Measured Liquid. - Except on equipment used exclusively for fueling aircraft, no means shall be provided by which any measured liquid can be diverted from the measuring chamber of the meter or the discharge line therefrom. However, two or more delivery outlets may be installed if means is provided to insure that:

(a) liquid can flow from only one such outlet at one time, and

(b) the direction of flow for which the mechanism may be set at any time is definitely and conspicuously indicated.

As you know, a fundamental difference between gravity-discharge and power-operated systems involves the design of their discharge lines: gravity-discharge systems incorporate a "dry" hose, whereas power-operated systems incorporate a "wet" hose. Requirements for each of these types are included in Handbook 44, along with a general requirement regarding the discharge hose.

S.3.2. Pump-discharge Unit. - On a pump-discharge unit, the discharge hose shall be of the wet-hose type with a shutoff valve at its outlet end. However, a pump-discharge unit may be equipped also with a dry hose without a shutoff valve at its outlet end, but only if:

(a) the dry hose is as short as practicable, and

(b) there is incorporated in the discharge piping, immediately adjacent to the meter, effective means to insure that liquid can flow through only one of the discharge hoses at any one time and that the meter and the wet hose remain full of liquid at all times.

S.3.3. Gravity-discharge Unit. - On a gravity-discharge unit, the discharge hose or equivalent pipe shall be of the dry-hose type with no shutoff valve at its outlet end. The dry hose shall be of such stiffness and only of such length as to facilitate its drainage. The inlet end of the hose or of an equivalent outlet pipe shall be of such height as to provide for proper drainage of the hose or pipe. There shall be incorporated an automatic vacuum breaker or equivalent means to prevent siphoning and to insure the rapid and complete drainage.

S.3.4. Discharge Hose. - A discharge hose shall be adequately reinforced.

Notice that a power-operated system (pump-discharge unit) can also be equipped with a dry hose. This permits the system to be used efficiently for either type of delivery. However, in this case a multi-port valve similar to that described above must be installed to assure that the metered product can only be delivered through one hose at a time, and that the wet hose will not be drained between deliveries.

Notice also the requirement that a gravity-discharge system be equipped with a vacuum breaker to facilitate drainage. In Chapter 3, you learned that this requirement is usually met by venting the air eliminator into the intake of the discharge line.

Discharge hoses of either type must be reinforced to protect them from abrasion, punctures, and concussion during normal use. In addition, an adequately reinforced discharge hose will be less likely to become crimped, causing the flow of product to be obstructed.

Two requirements relate to the discharge valve. The first of these specifies that a valve controlling discharge can only be installed on a wet hose (such a valve on a dry hose could prevent complete drainage of the hose).

> **S.3.5. Discharge Valve.** - A discharge valve may be installed in the discharge line only if the device is of the wet-hose type, in which case such valve shall be at the discharge end of the line. Any other shutoff valve on the discharge side of the meter shall be of the automatic or semiautomatic predetermined-stop type or shall be operable only:
>
> (a) by means of a tool (but not a pin) entirely separate from the device, or
>
> (b) by mutilation of a security seal with which the valve is sealed open.

The second requirement also pertains specifically to wet-hose systems. It specifies that an antidrain valve must be installed to prevent the discharge hose from being drained between deliveries.

> **S.3.6. Antidrain Valve.** - In a wet-hose, pressure-type device, an effective antidrain valve shall be incorporated in the discharge valve or immediately adjacent thereto. The antidrain valve shall function so as to prevent the drainage of the discharge hose. However, a device used exclusively for fueling and defueling aircraft may be of the pressure type without an antidrain valve.

We discussed the function and operation of the antidrain valve in Chapter 3. In accordance with the preceding specification (S.3.5) the antidrain valve must be fully automatic. Again, equipment used

exclusively for fueling and defueling aircraft is exempt from this requirement, since an antidrain valve would effectively prevent defueling.

Your inspection of the system's piping should begin at the tank outlet or tank manifold and proceed along its length to the discharge nozzle. You should look carefully for leaks in the piping or at any of its connections. Leaks on the intake side of the meter are of special concern, since under certain conditions air may be drawn into the system through leaking piping or joints. The repair of leaks constitutes proper maintenance, which is required in the General Code (paragraph G-UR.4.1, quoted and discussed above under General Considerations).

When you reach the discharge line, you will determine whether the hose is of the correct type and properly equipped to maintain the correct condition of the hose (dry or wet) between deliveries. The effectiveness of the antidrain valve will be determined by testing, as described in the next chapter.

You should also make sure that the piping has not been installed in such a way as to facilitate fraud, which is explicitly prohibited by the General Code. This requirement is broad, and applies whether or not there is evidence that equipment is actually being used for fraudulent purposes. It therefore may cover situations which are not specifically dealt with elsewhere in Handbook 44.

> **G-S.2. Facilitation of Fraud.** - All equipment and all mechanisms and devices attached thereto or used in connection therewith shall be so constructed, assembled, and installed for use that they do not facilitate the perpetration of fraud.

Any installation of piping or valves that would permit liquid that has passed through the meter to be diverted from delivery to the buyer, either back to the vehicle tank or to some other place, would tend to facilitate fraud, as would any installation that could be used to drain a wet hose or retain product in a dry hose after the conclusion of a delivery. Finally, any installation that would tend to heat the product before it passes through the meter, either artificially (for example, by wrapping an electric heating coil around the piping, or submerging a heating element in the tank) or by permitting unnecessary exposure of piping to the sun, would also constitute facilitation of fraud. You should question the operator about any electrical wiring, switches, or connectors whose legitimate function is not apparent to you and about any valves or piping that appear unusual. Keep in mind that anyone who does use equipment for the perpetration of fraud will have made some attempt to conceal the abuse and any such abuse will not, in all likelihood, show up in the results of performance tests.

SUMMARY

The Inspection is the first of four components of an official field examination. Its purpose is to determine whether the system does or does not comply with a number of specifications and other requirements. An Inspection should be a systematic procedure for making separate determinations, as outlined in the Examination Procedure Outlines (EPO's) developed by the National Institute of Standards and Technology.

CHAPTER 6

THE TEST

CHAPTER OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Describe the pre-test determinations set forth in the EPO's for gravity-discharge and power-operated vehicle-tank meters,

2. Understand the purpose of each of the separate tests prescribed in the EPO's and the significance of the results obtained.

3. Describe procedures for conducting performance tests of gravity-discharge and power-operated vehicle-tank meters.

INTRODUCTION

A measuring device that conforms with all of the specific requirements relating to design, installation, maintenance, and use set forth in Handbook 44 may still not be capable of the high degree of accuracy and consistency of measurement demanded for commercial service. Thorough inspection may give you some indication of the condition of the vehicle-tank metering system you are examining, but this impression will be based upon evidence that is limited by the fact that the system is not in its operating state, and so it may even be misleading. For example, a metering system that is clean and, to all outward appearances, well maintained, may be badly worn or in need of calibration. The only way to determine for certain how the system is likely to perform is to test it under conditions that approximate as closely as possible actual service conditions. This is the purpose of the Test portion of an official examination.

In fact, the Test is comprised of several separate tests, each of which has a specific testing objective. Some of these tests are intended to determine the accuracy of the system over the range of operating conditions for which it was designed (and, presumably, is used). Others are intended to test specific elements of the system, like the air eliminator or the antidrain valve and others are designed to verify that the system is being properly maintained. You should understand not only how to perform each of these tests, but also the reasons for performing them, and how to make use of the results you obtain.

For example, you will learn in this chapter that the EPO's call for tests of the system at different discharge rates. Let us consider the reasons for this requirement. Figure 6-1 shows a typical "accuracy curve" for a vehicle-tank meter. The graph represents the performance of the system over the range of flow rates for which it was designed. However, the word "performance" must be qualified here. Meter manufacturers publish accuracy curves like this one to advertise their equipment, because they illustrate graphically the high degree of accuracy of which most positive-displacement meters are capable. Accuracy curves produced by manufacturers are generally the result of tests conducted on new equipment in a laboratory or under very controlled conditions. They therefore can not be considered to provide anything more than

a very general indication of how the equipment will actually perform when installed and operated in the field (they are in this way very much like the mileage estimates publicized by automobile manufacturers, useful for comparative purposes only).

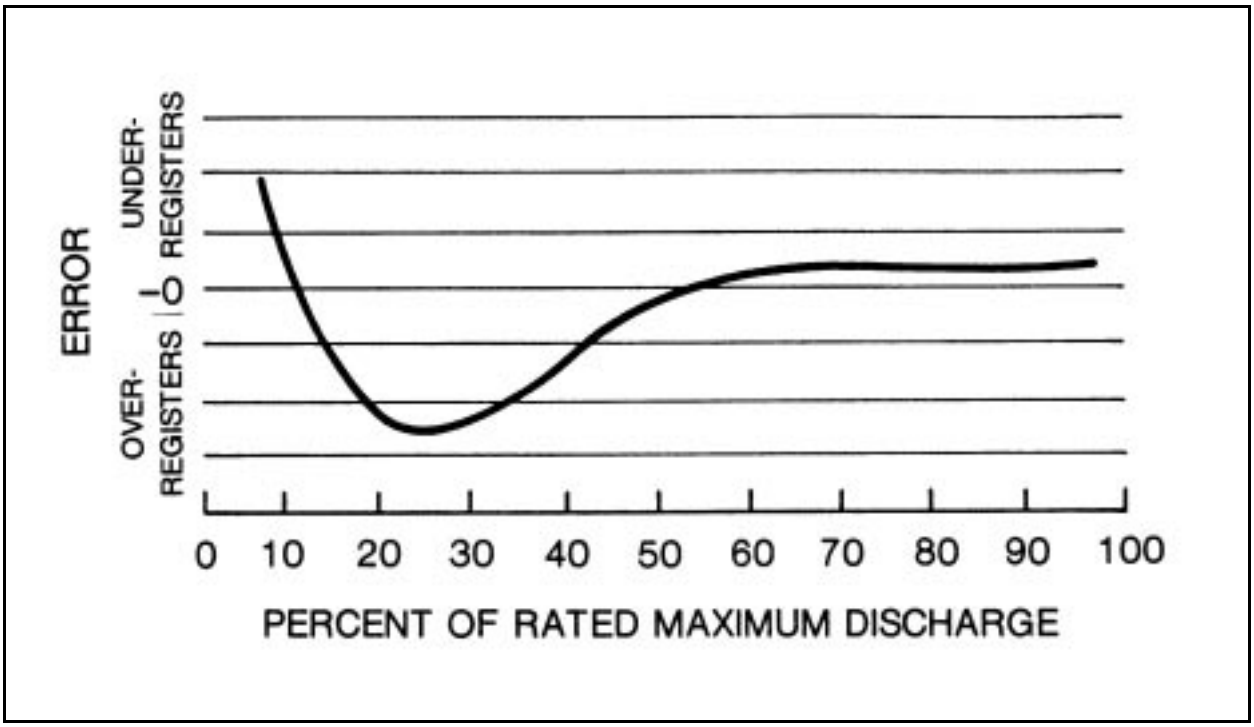


Figure 6-1. Accuracy Curve I

This graph does, however, illustrate several important general characteristics of meter performance. Notice that at very low discharge rates -- up to about 10 percent of the recommended maximum rate -- this typical system tends to "give" slightly more than at its maximum discharge rate. That is, it tends to deliver slightly more product per indicated gallon. At discharge rates between 10 percent and about 50 percent of the rated maximum, the system tends to "take" slightly -- deliver slightly less product per indicated gallon -- than at its maximum rate.

We use the terms "give" and "take" to describe these fluctuations rather than "underregister" and "overregister" because registration is a function of the system's calibration and not necessarily its performance. Power-operated vehicle-tank metering systems are operated at or near their maximum discharge rates most of the time, and gravity-discharge systems generally deliver at rates above 50 percent of their rated maximum, even at low head. So most systems are calibrated to indicate as accurately as possible at their maximum discharge rates. However, a system could be adjusted (or misadjusted) to perform as described by the curve shown in Figure 6-2, underregistering at all discharge rates, though least between about 20 percent and about 30 percent of its maximum rate. Notice that the shape of the curve has not changed, nor have the relative performance characteristics described by the terms "give" and "take": the system still gives slightly more at very low discharge rates and takes slightly more at moderate rates than at its maximum discharge rate.

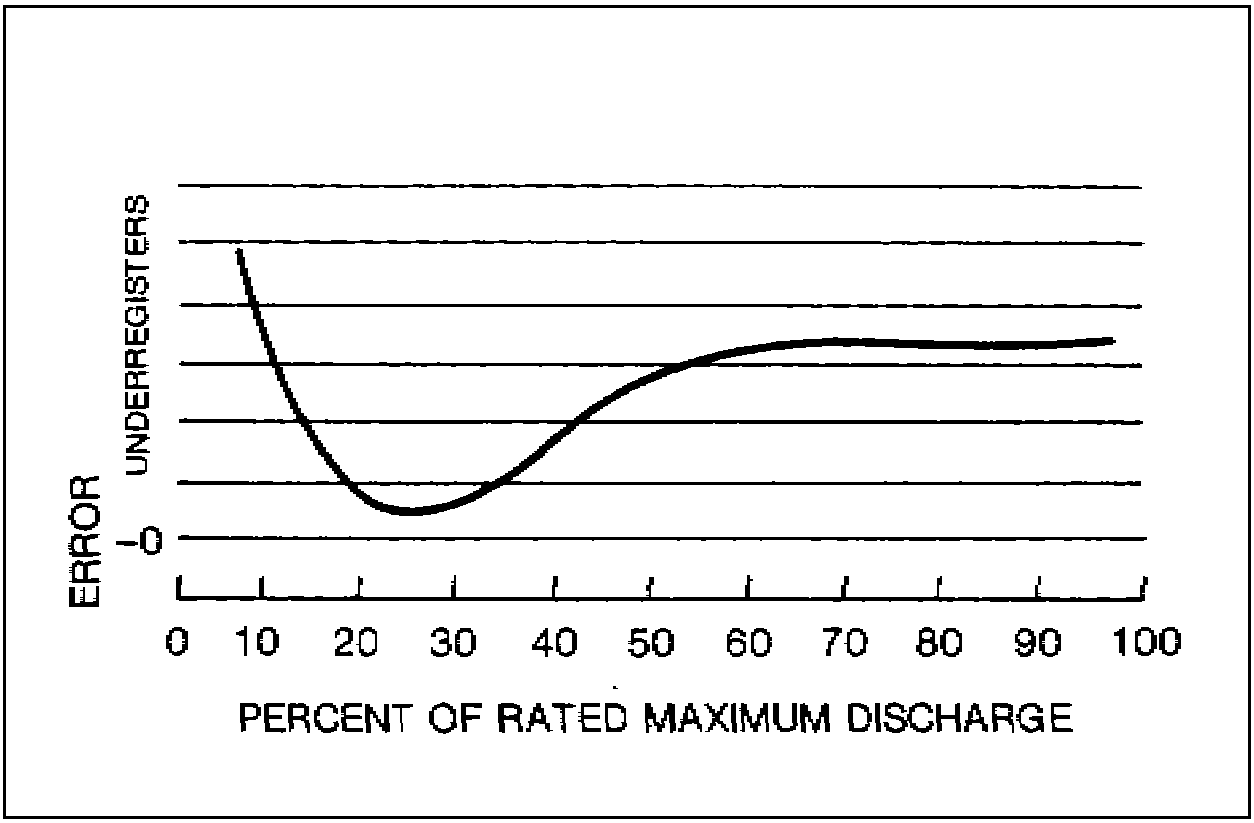


Figure 6-2. Accuracy Curve II

You can see from this discussion one reason why it is necessary to test a metering system at different delivery rates: even a system that is properly installed, maintained, and operated can be expected to perform differently at different discharge rates. Furthermore, as the example in Figure 6-2 shows, a system that performs reasonably accurately at one rate may be inaccurate when operated at other rates.

The fluctuations in performance over the range of a system's discharge rates result from several factors, but the most important of these is variation in the rate of slippage. Minute quantities of product slip continuously through the small clearances between the segmenting elements of the meter and the polished walls of the meter chamber whenever the system is operating. The rate of this slippage is, in large part, a function of the friction produced between the molecules of the flowing liquid and those of the metal surfaces with which they come in contact. The amount of this friction is different at different flow rates. The amount of slippage and mechanical friction in the meter also depends upon the characteristics of the product being measured. Consequently, meters must be tested and adjusted using the product to be metered or a liquid having similar characteristics.

The hydrodynamic and mechanical principles that underlie these flow characteristics are complex, and need not concern us here. However, keep in mind that slippage is the primary factor in the fluctuations in meter performance we have discussed, because this also relates to the second reason for testing meters at different discharge rates -- to determine the condition of the meter.

The performance curve shown in Figure 6-1 is typical of a relatively new meter. As a meter wears, its clearances gradually widen, with the result that the rate of slippage increases and the shape of the curve

itself is eventually altered. A badly worn meter will tend to give more not only at very low discharge rates, but also at moderate rates, than at its maximum rate. Thus, the actual performance of a meter tested at different discharge rates can give an indication of its condition and can thereby provide information that is useful to the operator and repairpersons in determining what corrective action is needed to restore the system to an accurate condition. A meter that is not badly worn may simply require readjustment, which will have the general effect of raising or lowering the entire performance curve. On the other hand, a badly worn meter will probably need reconditioning, the effect of which will be generally to restore the characteristic performance of the meter to a condition similar to that when it was new. We will take a closer look at the interpretation of results from performance tests at different discharge rates later in this chapter.

As you have learned, the accuracy of a vehicle-tank metering system depends upon a number of components whose functions are interdependent. For example, failure of the air eliminator to remove air and vapor from the product before it enters the meter will result in some degree of overregistration, since gases will be metered along with the liquid product. But under "normal" operating conditions malfunction of the air eliminator may be difficult to identify and isolate from other factors, or it may be offset by some other factor that tends towards underregistration, such as improper calibration. However, under the demands that arise when the tank or tank compartment is emptied during the course of a delivery, the failure of the air eliminator is likely to have a much more pronounced effect on performance. A separate test of the system under these special conditions is thus needed to determine whether it is capable of performing accurately and also to identify (or preclude) the air eliminator as the source of overall system inaccuracy.

Differences in operating characteristics between gravity-discharge and power-operated systems necessitate some differences in test procedures. These will be described in detail below. However, the basic elements of the Test are the same for both types of system:

- Tests of system performance across the range of flow rates recommended by the manufacturer.
- A test of the air eliminator, involving a delivery that exhausts the supply of product in the tank or tank compartment.
- A test of the automatic-stop (preset) mechanism, if the system is equipped with one.
- For electronic systems, a test for susceptibility to radio-frequency and electromagnetic interference (RFI/EMI).
- Tests of indicating and recording elements for comparability of indications and, in the case of computing registers, correct computation of price.

In addition, the antidrain valve on power-operated systems is tested.

We will take a closer look at each of these tests, outlining the procedures -- which you will study and practice further during your field training -- and describing the interpretation of test results. However, before we do this, we must first discuss several important determinations that you must make before any testing begins.

PRE-TEST DETERMINATIONS

Four separate sets of pre-test determinations are prescribed in the EPO's for both gravity-discharge and power-operated systems as described below. A fifth set, required for gravity-discharge systems only, will also be described.

Pretest Determinations Section of EPO:

1. Determine that the test fluid in the tank compartment is similar in character to the fluid to be measured commercially.

All liquids have distinctive physical properties, such as viscosity, gravity, vapor pressure, coefficient of thermal expansion, etc. Because these properties are associated with factors that affect the performance of a system, the properties of the substance(s) that will be measured are taken into account in selecting the appropriate equipment, and in calibrating the system after it has been installed. In most field examinations, the tank will be filled with the product that it normally holds. In some cases, however -- especially when the commercial product is extremely toxic or volatile, and would present a potential hazard if used in testing -- a non-hazardous liquid may be used, provided that it has the same general characteristics as the commercial product.

N.1. Test Liquid.

(a) A measuring system shall be tested with the liquid to be commercially measured or with a liquid of the same general physical characteristics. Following a satisfactory examination, the weights and measures official should attach a seal or tag indicating the product used during the test.
(Amended 1975)

(b) A milk measuring system shall be tested with the type of milk to be measured when the accuracy of the system is affected by the characteristics of milk (e.g., positive displacement meters).
(Amended 1989)

It is generally the responsibility of the owner or operator to assure that the liquid used in the test is either the product that is normally dispensed, or an acceptable substitute. You should ask the operator to identify the fluid in the system at the beginning of the test and whether or not it is the commercial product normally delivered, and record the response on your official report form. You will not, of course, be able to test to verify this information in the field. If you have reason to believe that the identification provided by the operator is not accurate, or that a substitute test liquid does not have the proper general physical characteristics, you should request verification from the operator or, if necessary, request a sample to take with you for further testing.

2. Determine whether the prover size is adequate.

The nominal capacity of the prover used for the Test must be no less than the amount of product that can be delivered by the system in one minute at its maximum discharge rate. If, for example, you ascertain (from the required markings on the meter) that the maximum discharge rate recommended is 184 gpm, you would need a prover with a nominal capacity of at least 184 gal (in all probability, the standard available prover size that will be adequate will have a nominal capacity of 200 gal).

This test requirement, like that quoted above for the test liquid, is included in the Vehicle-Tank Meters Code as a Note.

> **N.3. Test Drafts.** - Test drafts should be equal to at least the amount delivered by the device in one minute at its maximum discharge rate, and shall in no case be less than 180 L (50 gal) or 225 kg (500 lb).
> (Amended 1989)

The reason for this requirement is that any positive-displacement meter will perform less accurately at the very beginning and end of a delivery, because some of the energy of the moving fluid, which should be transferred directly to the indicating elements, must be used to overcome inertia (the tendency of a body that is at rest to remain at rest and of a body that is in motion at a given speed, to remain in motion at that speed). Once the meter has attained a constant rate of revolution, called a "steady state," inertial resistance is virtually eliminated until the meter must decelerate to a stop at the end of the delivery. Because the inaccuracy resulting from inertial factors will be the same for all deliveries made under the same conditions (with the same liquid at the same rate) -- provided that the meter has reached a steady state -- the effect on the accuracy of any given indicated delivery will be a function of the quantity delivered: The larger the delivery, the smaller the effect as a percentage of the quantity delivered. The fact that a meter can be expected to attain and operate at a steady state within one minute, and the fact that deliveries of less than this amount are not usual for vehicle-tank systems, provide the bases for this general requirement, which effectively establishes a minimum delivery time for any test draft.

If a gravity-discharge system is being tested, you must also determine that the prover inlet is lower than the meter outlet. If it is not, delivery may be impossible or may be interrupted before the draft is finished.

3. Determine applicable tolerances.

It is recognized that neither the measuring device being tested nor the standard used to test it is capable of errorless value or performance under all sets of operating conditions that are obtained in the field. For this reason tolerances are established to fix the acceptable range of inaccuracy for devices in commercial use. Tolerances are intended to permit measurement errors that are small enough that they cannot cause serious economic injury to either buyer or seller. At the same time, however, tolerances must not be so stringent as to make the costs of manufacturing and maintaining commercial equipment unreasonably burdensome, since these costs are ultimately passed on to the consumer. The tolerances established by code or

regulation and enforced by weights and measures jurisdictions are considered as minimum requirements by manufacturers and industries; they can, and often do, establish performance standards that are more stringent.

The specific tolerance value that applies for a particular test of a particular vehicle-tank metering system is determined by three factors:

- The amount of time the device has been in service.
- The type of test that is being performed.
- The size of the test draft.

For vehicle-tank meters -- as for all mechanical devices whose errors in performance can be expected to increase as a result of extended use -- Handbook 44 sets forth two sets of tolerances:

G-T.1. Acceptance Tolerances. - Acceptance tolerances shall apply to:

(a) equipment to be put into commercial use for the first time;

(b) equipment that has been placed in commercial service within the preceding 30 days and is being officially tested for the first time;

(c) equipment that has been returned to commercial service following official rejection for failure to conform to performance requirements and is being officially tested for the first time within 30 days after corrective service;

(d) equipment that is being officially tested for the first time within 30 days after major reconditioning or overhaul; and

(e) equipment undergoing type evaluation.
(Amended 1989)

G-T.2. Maintenance Tolerances. - Maintenance tolerances shall apply to equipment in actual use, except as provided in G-T.1.

- <u>acceptance tolerances</u> are applied to new equipment when it is first put into service, when it is returned to service after reconditioning or replacement of major components, or when adjustments or repairs have been made as the results of a weights and measures compliance action.
- <u>maintenance tolerances</u> are applied to equipment that has been in service for more than 30 days.

The acceptance tolerance for a vehicle-tank meter is specified as one-half the value of the applicable maintenance tolerance. The maintenance tolerance therefore constitutes a somewhat less stringent compliance standard; it thus allows a limited degree of deterioration in performance and generally assures a reasonable period of use before the device must be reconditioned.

Handbook 44 also specifies a set of special test tolerances, which apply to "special" tests. Special tests are tests that are made to develop the operating characteristics of the system and any special accessories or elements associated with it. Because they involve operating conditions that are not "normal" -- but which may and do occur in the field -- they permit a somewhat greater degree of inaccuracy than the values for maintenance and acceptance for "normal" tests.

The distinction between "normal" and "special" tests is set forth in two Notes included in the Vehicle-Tank Meters Code.

N.4. Testing Procedures.

N.4.1. Normal Tests. - The "normal" test of a measuring system shall be made at the maximum discharge rate that may be anticipated under the conditions of the installation. Any additional tests conducted at flow rates down to and including one-half of the sum of the maximum discharge flow rate and the rated minimum discharge flow rate shall be considered normal tests.
(Amended 1992)

N.4.2. Special Tests (Except Milk-Measuring Systems). - "Special" tests shall be made to develop the operating characteristics of a measuring system and any special elements and accessories attached to or associated with the device. Any test except as set forth in N.4.1. shall be considered a special test. Special tests of a measuring system shall be made as follows:

(a) At a minimum discharge rate of 20 percent of the marked maximum discharge rate or at the minimum discharge rate marked on the device, whichever is less.

(b) To develop the operating characteristics of the measuring system during a split-compartment delivery.

(Amended 1978)

Tolerance values for both normal and special tests are set forth in paragraph T.2 of the Vehicle-Tank Meters Code. Table 1, from paragraph T.2, sets forth tolerances for all vehicle-tank meters except milk, agri-chemical, and mass flow meters. (Tolerances for these meters are included in separate tables in T.2 in the Mass Flow Meters Code, which have not been reproduced here.)

As you can see, the value of the tolerance increases with the quantity indicated (i.e., with the size of the test draft). However, note that, expressed as a percentage of the indicated quantity, the tolerances actually decrease as the draft size increases. For example, the basic maintenance tolerance for a 100-gallon draft is 75 cu in, or 0.3246 percent, but the basic maintenance tolerance for a 200-gallon draft is 125 cu in, or

0.2705 percent. This reflects the characteristic described above, that the inaccuracy resulting from inertial factors at the beginning and the end of the draft is constant for any given size of draft, but represents a smaller proportion of the total delivery the larger the amount delivered.

Table 1. Tolerances for Vehicle-Tank Meters Except for Vehicle-Mounted Milk Meters, Agri-Chemical Meters, and Water Meters			
	Normal tests		Special tests
Indication	Maintenance tolerance	Acceptance tolerance	Maintenance and acceptance tolerance
(Gallons)	(Cubic inches)	(Cubic inches)	(Cubic inches)
50	50	25	50
Over 50	Add 1/2 cubic inch per indicated gallon over 50	Add 1/4 cubic inch per indicated gallon over 50	Add 1 cubic inch per indicated gallon over 50

Paragraph T.1 (not reproduced here) states that performance tolerances apply to errors of underregistration and overregistration.

- Underregistration is the indication of a smaller volume of product than has actually been delivered and generally favors the buyer. When the system is underregistering, the prover reading will indicate a positive (plus) error.

- Overregistration is the indication of a greater volume of product than has actually been delivered and generally favors the seller. When the system is overregistering, the prover reading will be a negative (minus) value.

You should record all applicable tolerances before beginning the Test. For a given metering system, you will need to determine one basic tolerance (either maintenance or acceptance) and the special tolerance that will apply.

4. Repeatability.

Repeatability refers to a device's capability to repeat its indications under reasonably similar conditions. In order to comply with Handbook 44, a device must be capable of repeating within prescribed tolerances its indications and recorded representations.

T.4. Repeatability. - When multiple tests are conducted at approximately the same flow rate and draft size, the range of the test results for the flow rate shall not exceed 40 percent absolute value of the maintenance tolerance and the results of each test shall be within the applicable tolerance. See also N.4.1.2. (Added 1992) (Amended 2001)

When conducting multiple tests of a vehicle-tank metering system at approximately the same flow rate, the range of test results shall not exceed 40 percent of the absolute value of *maintenance* tolerance and the results of *each* test shall be within applicable tolerance.

Consider the example of two 100-gallon normal test drafts run at approximately the same flow rate. If maintenance tolerance applies, the tolerance for each individual draft is 50 cubic inches plus 1/2 cubic inch per indicated gallon over 50. Thus, the applicable, maintenance tolerance is:

50 cubic inches + [1/2 x 50] =75 cubic inches

As specified in paragraph T.1., the tolerances apply to both errors of underregistration and errors of overregistration. Therefore:

maintenance tolerance = +/- 75 cubic inches
absolute value of maintenance tolerance = 75 cubic inches

The repeatability tolerance specified in paragraph T.4. is calculated as 40 percent of the absolute value of maintenance tolerance:

75 cubic inches x 0.40 = 30 cubic inches

If the result of the first test is -40 cubic inches and the result of the second test is +50 cubic inches, each test result is within the plus or minus the applicable +/- 75 cubic inch maintenance tolerance permitted for individual test drafts. However, the results have a range of 90 cubic inches (-40 to+50 cubic inches) which exceeds the repeatability tolerance of 30 cubic inches.

5. Note totalizer reading.

As you know, totalizers are usually not considered to be primary indicating elements, and so are not subject to the specific requirements that apply, for example, to the register and ticket printer. However, they have an important function in the Test. At the conclusion of the Test, the inspector must record on the official report form the total quantity of product that has been delivered in the course of the examination. This is necessary so that the operator can reconcile inventory figures (the product used in the Test will have been returned to the possession of the operator, but will have been metered, and so will be included in the amount shown on the totalizer as delivered). Recording the totalizer reading at the beginning and the end of the Test provides this information without the time-consuming computation required to add the quantities registered for each separate test draft. You will simply subtract the beginning reading from the ending reading: the result will be the total quantity delivered in the course of the Examination.

As mentioned earlier, one additional set of determinations must be made before testing gravity-discharge systems:

6. Determine that a compartment or compartments have a sufficient amount of product to conduct "high head" and "low head" tests.

"Head" is a technical term for the height of the top surface of the liquid product contained in the vehicle tank above the delivery point (the point where product leaves the discharge nozzle). In a gravity-discharge system, the discharge rate developed at any given point during a delivery is directly proportional to the head. So when the tank is full, the system will deliver product at a higher discharge rate than when it is one-half full, and the discharge rate will be proportionally lower still when the tank is nearly empty. In order to develop the operating characteristics of the system over its range of flow rates, the normal test of a gravity-discharge system involves drafts at "full head" (with the tank full), at "medium head" (with tank about one-half full), and at "low head" (by definition, when the tank holds about one-and-one-half times the nominal capacity of the prover). If the tank has two compartments, one should be full at the beginning of

the Test and the other compartment empty. This will allow you to regulate the quantity of product contained in the first compartment for the medium head and low head tests by returning all or part of the first test draft to the empty compartment. This transferring process can be eliminated if the tank has three or more compartments, since one can be filled to full head, one to medium head, and one to low head in preparation for the Test. If the tank is not compartmented, some suitable receiving vessel will have to be provided in which to return all or part of the test draft after the full head and other tests. In any case, you should ascertain from the operator the capacity of the tank or tank compartments and the level to which they are filled prior to the start of the Test and record this data for future reference.

THE TEST

When you have completed all Pre-test Determinations, you are ready to begin the Test. Each of the separate tests mentioned above involves drawing one or more test drafts. Because several steps in the procedure are repeated for each draft, the EPO's list these repeated operations under the heading "Test Notes." The procedures described in the Test Notes are identical for gravity-discharge and power-operated systems. Before we turn to the tests themselves, let us look at these four basic and repeated procedures.

1. Wet prover. Allow the specified drain period each time the prover is emptied.

The procedure for wetting the prover, and the necessity for observing the specified drain period when emptying it, were described in the last chapter. It bears repeating, however, that this step is essential to assure accurate test results. If the drain period is exceeded by more than a few seconds, the prover should be re-wet.

2. Exercise care so that the product temperature is the same in the prover as in the meter.

As you know, most liquids expand when heated and contract when cooled. (Water and mixtures that are predominantly composed of water are exceptions to this general rule at temperatures close to their freezing point, since water reaches its highest density -- its greatest contraction -- at about 39.1 °F, and it will expand when heated or cooled from that temperature. However, water, and most products containing water, are generally maintained in vehicle tanks at temperatures that are considerably higher than 39.1 °F, and so will, for all practical purposes, follow the general rule). Depending on the physical properties of the test liquid, a relatively small increase in temperature can have an effect on the volume of a test draft that is significant for testing purposes. For example, the approximate coefficient of cubical expansion for gasoline is 0.0006 per °F. This means that one gallon of gasoline will expand by about 0.0006 gal for every degree Fahrenheit that its temperature is raised. If the temperature of a test draft of 100 gallons was to increase by as little as 2 °F over its temperature when it passed through the meter, the total effect would thus be:

gallons	x	coefficient of cubical expansion	x	temperature change (°F)	=	volume change
100	x	.0006	x	2	=	0.12 gal
						= 27.72 cubic inches

This amount represents nearly three-quarters of the basic acceptance tolerance for a 100-gallon draft, and so could quite obviously lead to an erroneous determination.

The amount of temperature change that occurs under a given set of test conditions will depend upon a number of variables, including environmental factors (the difference between the temperature of the product in the system and the ambient temperature of the prover, the overall dimensions, design, and material of the

prover, the presence of wind, sun, precipitation, etc.), the size of the draft, and the elapsed time of the draft, measured from the beginning of flow from the discharge nozzle to the reading of the prover gauge. The total effect of the temperature change will depend upon the physical properties of the test liquid, primarily its coefficient of thermal expansion.

The number and variability of these factors make it practically impossible to predict the effect of temperature change under any particular set of test conditions. So the only way to determine whether the effect will be significant on test results is to record the temperature of the product at the meter and inside the prover at the time when a reading is taken. Most provers with calibrated capacities in excess of 200 gal are equipped with thermometer wells, which will facilitate determining the temperature of the product inside the prover. However, vehicle-tank meters are not required to be equipped with temperature sensing and indicating devices, so precise calculations based upon the temperature of the product as it is being measured are generally not possible.

If temperature measurements are available from both the meter and the prover, you should record them routinely. You should also ascertain the coefficient of expansion for the test liquid, either from the operator, or from appropriate liquid measurement tables. This will enable you to determine the effect of temperature change on the product by performing the calculation illustrated above. A similar computation must be made to adjust for the change in the capacity of the prover that will result from its being heated or cooled by the product to a temperature that differs from the one for which it was calibrated (usually 60 °F). The net result can then be subtracted from the prover reading to obtain the corrected error for the draft.

If you are not able to obtain accurate temperature readings of the product at the meter, the best you can do is to control, as far as possible, the factors that cause temperature change under test conditions. Avoid testing outdoors under extreme climatic conditions of any kind (temperature, wind, rain, etc.) and, if possible, avoid positioning the prover in full sun. The factor that is most controllable by the inspector is the elapsed time of the test. You should take prover readings as soon as possible after delivery is completed. If a test must be interrupted for an extended period of time and the results are close to the applicable tolerance (within 20%), it may be advisable to repeat the test. If these precautions are taken, it is unlikely that sufficient temperature change will occur during the course of the delivery to significantly affect test results.

3. Record totalizer indications before and after each draft to determine proper operation.

Since the totalizer will provide the basis for your calculation of the total quantity of product delivered during the Test, you should check its accuracy against the register for each test draft. The reason for repeating this check is that any discrepancy between the quantity indicated on the register and the quantity determined by subtracting the totalizer reading at the beginning of the draft from the ending reading may be attributable to a malfunction of the totalizer or of the register. If the discrepancy is consistent for each draft, either the totalizer or the register (or both) will require repair or recalibration. Inconsistency will usually indicate a mechanical problem in one element or the other, often the result of dirt or other foreign material in a gear train, or of excessive wear. Unless the totalizer is used as a primary indicating element, there is no tolerance for this check. Its results will, however, indicate whether the total delivery information you provide for the operator may be gathered using the totalizer, and the results may also be useful for diagnostic purposes.

4. After each test draft:

    a. print ticket if device is so equipped

    b. if computing type, check price computations on indicator and on recorded representations

c. check all indicated and recorded values for proper comparability

If the system you are examining is equipped with a ticket printer, or if its register is of the computing type, all additional indications or recorded values must be checked for correctness.

The requirements relating to the information displayed on a printed ticket and the form in which this information is displayed were described in Chapter 5. To review:

- The ticket must show the total volume of the delivery in gallons and fractions of a gallon. If the system is of the computing type, the ticket must also show the unit price at which the system is set to compute and the computed total price.

- All recorded representations must be digital.

- All recorded representations must be readable.

- Recorded representations must agree with register indications exactly if the register is digital, or with the closest analog scale division if the register is analog.

- If the system is of the computing type, the money-value division must be one cent if the device is analog, or based upon a quantity-value division of 0.1 gallon or less if the device is digital.

In addition, the Vehicle-Tank Meters Code establishes a requirement for agreement between the computed price and the price computed mathematically (that is, by multiplying the indicated quantity by the unit price).

S.1.4.4. Money Values, Mathematical Agreement. - Any digital money-value indication and any recorded money value on a computing-type device shall be in mathematical agreement with its associated quantity indication or representation to within one cent of money value.

The allowance of one cent in the variation between the computed price and the price computed mathematically is intended to provide for the rounding of computed values to the nearest whole cent.

Again, the purpose of repeating these procedures after each test draft is to determine whether errors in indication or recording are consistent or inconsistent. Because consistent error generally indicates incorrect calibration and inconsistent error will indicate a mechanical (or electronic) malfunction, the results obtained may assist the operator and repairpersons to identify and isolate specific problems.

Tests to Develop the Operating Characteristics of the System

As explained in the introduction to this chapter, the characteristic accuracy curve of positive displacement meters necessitates performance tests over the range of discharge rates for which a particular system is designed and used.

The discharge rate of a gravity-discharge system varies with the level of liquid in the vehicle tank or tank compartment. (As you learned earlier, the discharge rate is proportional to the height of the liquid surface above the discharge point -- the head -- and not the weight of the product in the tank.) For example, a system

that delivers about 120 gallons per minute when the tank is full may deliver about 90 gallons per minute when the tank is approaching empty. The average discharge rate of any particular delivery will thus depend upon the level of product at the beginning of the delivery and the level of the product remaining at its conclusion. Because the average discharge rate of any delivery can be relatively high, low, or intermediate, and because the meter can be expected to perform differently at different flow rates, a gravity-discharge system is tested at high, medium, and low "head" (in fact, the relative levels specified apply more accurately to the tank level than to the head itself, which includes the vertical drop from the bottom of the tank to the discharge point).

The procedure for setting up these tests was described earlier under Pre-test Determinations. A single draft is drawn and the error recorded for each level specified. Timing the drafts will give you an approximate figure for the average rate of delivery. This should be done at least for the "high head" test, to determine whether the maximum rate developed by the system in use exceeds the recommended maximum rate marked on the device. As described in last chapter, Vehicle-Tank Meters Code, paragraph UR.1.1, requires that the actual rate <u>not</u> exceed the recommended rate.

Since all three drafts are drawn under conditions that pertain to normal commercial deliveries, they are designated "normal tests" for a gravity-discharge system, and the normal tolerance thus applies to the error observed.

In the case of a power-operated system, on the other hand, the discharge rate can be regulated, usually by the operator, using the discharge valve at the nozzle. Most power-operated systems are calibrated to measure deliveries most accurately at maximum flow, because it is at this rate that they are normally operated. However, because the system <u>can</u> be operated at lower rates and because, as you know, the rate can have a significant effect on performance, two test drafts are required.

The first is drawn at full flow (discharge nozzle wide open). This is the "normal test" of the system, and the basic tolerance applies to the results obtained. As for gravity-discharge systems, this delivery should be timed, to determine that the actual maximum discharge rate does not exceed the recommended rate.

The second draft is drawn at the system's recommended minimum rate (as marked on the meter), or at 20 percent of the maximum recommended rate, whichever is lower. Because the conditions under which this test is conducted are not "normal," it is designated a special test, and the special tolerance is applied to the results. This draft <u>must</u> be monitored with a watch or a stopwatch to assure that the correct rate is being maintained. Your instructor will demonstrate a technique for monitoring the slow flow delivery. Because this test can be expected to take about 5 times as long as the normal test, you must beware of the factor of time as it affects changes in volume due to temperature change and/or evaporation.

When performing repeatability tests great care must be taken to ensure that the conditions of the tests are identical. For example, the ability to halt the delivery when the register is at a scale division and the inspector's ability to read the prover and correct for any error, as described in Chapter 4, might have an effect on the degree of uncertainty in the reading officially recorded that is on the order of a single scale division.

As explained in the introduction, the difference between results for the maximum and minimum flow rates tested will provide a general indication of the condition of the meter. In general, the greater the difference in results the more likely that the meter is badly worn and in need of repair. The difference observed is likely to be less for gravity-discharge systems than for power-operated systems because even at "low head" the gravity-discharge system will still be operating at or above 50 percent of its maximum recommended discharge rate.

You should note also that the manner in which the tolerances are applied for these tests -- individually to the recorded error for each draft, rather than to the difference in recorded errors -- makes it possible that a system with a badly worn meter could receive approval under certain circumstances.

For example, consider the following results for tests conducted on a power-operated system employing a 100-gallon prover:

	recorded error
normal test	- 72 cu in
special slow flow test	+ 96 cu in

The applicable tolerances for these tests will be 75 cu in and 100 cu in, respectively. So the system is within tolerance for both tests and, assuming that it meets all other requirements, may be approved. However, the observed meter error for the two sets of tests suggests that the meter is badly worn, and probably is in need of reconditioning (note that an attempt to recalibrate the meter to reduce the observed error at either end of the flow range will in all probability push performance at the other end outside the tolerance).

The policies and procedures of some jurisdictions provide for rejecting a system found to be in this condition on the grounds that it does not meet the maintenance requirement set forth in the General Code (G-UR.4.1). Your instructor will explain your jurisdiction's policies in this regard to you. But whether the system is rejected or approved, you should be prepared to discuss your interpretation of test results with the operator at the conclusion of the test. If the device is permitted to remain in service, you should also make a note of its condition, and of the information provided to the operator.

The Split Compartment Test

This is a test of the capability of the air elimination component of the system to prevent air and vapor from entering the meter under the most demanding of circumstances -- when the fuel supply is exhausted and air floods the intake line rapidly. Under service conditions, this occurs when a tank compartment is emptied while a delivery is in progress. If the tank is multi-compartmented, and supply of the same product is available from another compartment, the operator closes off the manifold valve to the empty compartment and opens the valve to the new compartment without discontinuing the delivery (the pump generally remains engaged throughout this process, and the register is not reset). A similar situation occurs if the truck has only a single compartment or if supply of the product being delivered is not available from another compartment in a multi-compartmented tank. The difference is that under service conditions the operator of a single-compartment tank will terminate delivery when the supply has been exhausted, and the transaction will be completed on the basis of the quantity delivered to that point. Since accurate measurement under all of these circumstances depends upon the proper function of the air eliminator, the same "split compartment" test is applied to both single- and multi- compartmented vehicle tanks. However, the procedures are necessarily different, at least in part.

In either case, delivery to the prover is begun from a compartment containing less than one-half the nominal capacity of the prover at the system's full flow rate. When this supply of product is exhausted, the air eliminator should close the intake to the meter, preventing registration of air. The register should then stop and hold its current indication. If it does not, some air/vapor is leaking through the shut-off valve into the meter.

At this point, the test of a multi-compartmented tank will proceed as under normal service conditions: the pump will be left engaged while the manifold valve to the empty compartment is closed, and the valve to a compartment containing sufficient product to complete the draft is opened. The draft is then completed and the error recorded, as for the tests described above.

In the case of a single-compartment tank, additional product must be added to the tank to complete the test. This may be supplied from another truck or from a terminal. If no source of additional supply is available at the operator's location, you must arrange to perform at least this portion of the Test at a distribution site, or elsewhere. Sufficient product to complete the draft must be added with the pump disengaged if the system is power-operated, or with the control valve closed in the case of a gravity-discharge system. This will have the effect of interrupting the delivery. However, this is exactly what would happen under service conditions: the delivery would be discontinued and the single-compartment truck would be driven back to be refilled. In addition, if the delivery is not halted at this point, product splashing into the bottom of the empty tank and being drawn directly into the supply line will likely include far more entrained air than it would under normal conditions (since delivery would resume only after the tank was filled and the vehicle driven to another delivery location). For the same reason, the product should also be allowed to settle briefly in the tank, especially if it is susceptible to foaming, like no. 2 fuel oil. However, keeping in mind the possible effects of temperature change and evaporation on product already in the prover, this rest period should be kept to a minimum. Delivery is resumed, of course, without resetting the meter, and continued until the register indicates the nominal capacity of the prover. The error for the draft is then recorded from the prover in the usual way.

Ideally, of course, results for the split compartment test would be identical to those obtained from a normal test of the system, indicating that no air or vapor had been permitted to enter the meter when the supply of product was exhausted. However, it is recognized that even a system that is properly designed, installed, and maintained may permit a small amount of air/vapor to pass through the meter under these common, but extreme operating conditions. For this reason, the more liberal special tolerance applies to results of the split compartment test. This tolerance applies to the error observed for the test, not to the difference between the errors observed for the split compartment and the normal test(s). The reason for this is that the test error reflects what can be expected of a delivery made under service conditions, and this is the degree of error that would affect the final transaction between buyer and seller. However, it is important to remember that although its objective is to determine the capability of the air eliminator, the split compartment test is still a test of the entire metering system, of which the air eliminator is one functional component. For this reason, applying the tolerance in the prescribed manner could, under certain circumstances, permit a system with a badly functioning air eliminator to be approved.

For example, let us consider a maintenance test of a system using a 100-gallon prover. The basic tolerance will therefore be +/- 75 cu in, and the special tolerance +/- 100 cu in. Suppose that we record an error of + 70 cu in for the normal test and an error of -95 cu in for the split compartment test. Technically, the system is within tolerance for both tests and, assuming that it meets all other requirements, should receive approval. However, all (or nearly all) of the difference of 165 cu in between results for the two tests may be attributable to malfunction of the air eliminator. If the system were adjusted without servicing the air eliminator, it could be expected to overregister considerably, especially under delivery conditions that approximate the test, but also, perhaps, under less severe normal operating conditions.

As a general rule, the greater the difference between the results obtained for the normal test and the split compartment test of a vehicle-tank metering system, the stronger the indication that the air eliminator is not functioning properly, and is in need of repair.

As in a situation where test results indicate a meter that is technically in compliance but which test results show to be badly worn, the policies and procedures of your jurisdiction might dictate rejecting a system found to be in this condition, on the grounds that it does not meet the maintenance requirement set forth in the General Code (G-UR.4.1). However, even if the system must be approved, you should inform the operator of this condition and make a written note of it, so that you or another inspector can follow up at the next scheduled examination.

Because any failure of the air eliminator should result in some degree of overregistration, you might expect any divergence between normal and split compartment test results to be in that direction. Although this is generally the case, you should be prepared to encounter the opposite situation, when test results indicate that the system is actually "giving" slightly more for the split compartment test. This should not be a cause of concern (unless the difference is extreme), and will, in fact, be an indication that the air eliminator is functioning excellently. The effect will be due to factors related to the test conditions, and especially to the fact that the meter will be started and stopped twice in the course of the test, rather than once, as in the normal test. As you will remember from our earlier discussion, inertial factors account for a certain amount (usually relatively small) of error at the beginning and end of each delivery -- generally in the direction of underregistration. The conditions of the split compartment test will double this effect.

RFI/EMI Test

All weighing and measuring devices that have electronic components are subject to the effects of radio frequency and electromagnetic interference (RFI/EMI). These two types of interference have different sources, but are basically the same in their nature and their effects.

The passage of electric current through a conductor creates a magnetic field around the conductor. If the direction, amplitude, or intensity of the current changes, the magnetic field surrounding the conductor changes in response. This changing magnetic field is then capable of inducing a current in another conductor located within the field (see Figure 6-3). The same effect can be achieved by changing the position of the conductor relative to a stationary magnetic field (this is the basic principle employed in electric power generation).

The circuitry of electronic devices consists of conductors that carry electrical signals. For example, you will recall from our discussion in Chapter 3 that in electronic registers, discrete signals generated by the transducer (pulser) driven by the revolving meter shaft are transmitted through wiring to the CPU, where they are interpreted. If this wiring, or the circuitry of the transducer or the CPU, were to be brought into contact with a changing electromagnetic field, extraneous current could be produced. This extraneous current could either interfere with the pulses generated by the transducer, rendering them unrecognizable as signals or, under certain conditions, it could produce additional pulses that might be interpreted as signals. In either case, the accuracy of the measuring device would obviously be impaired.

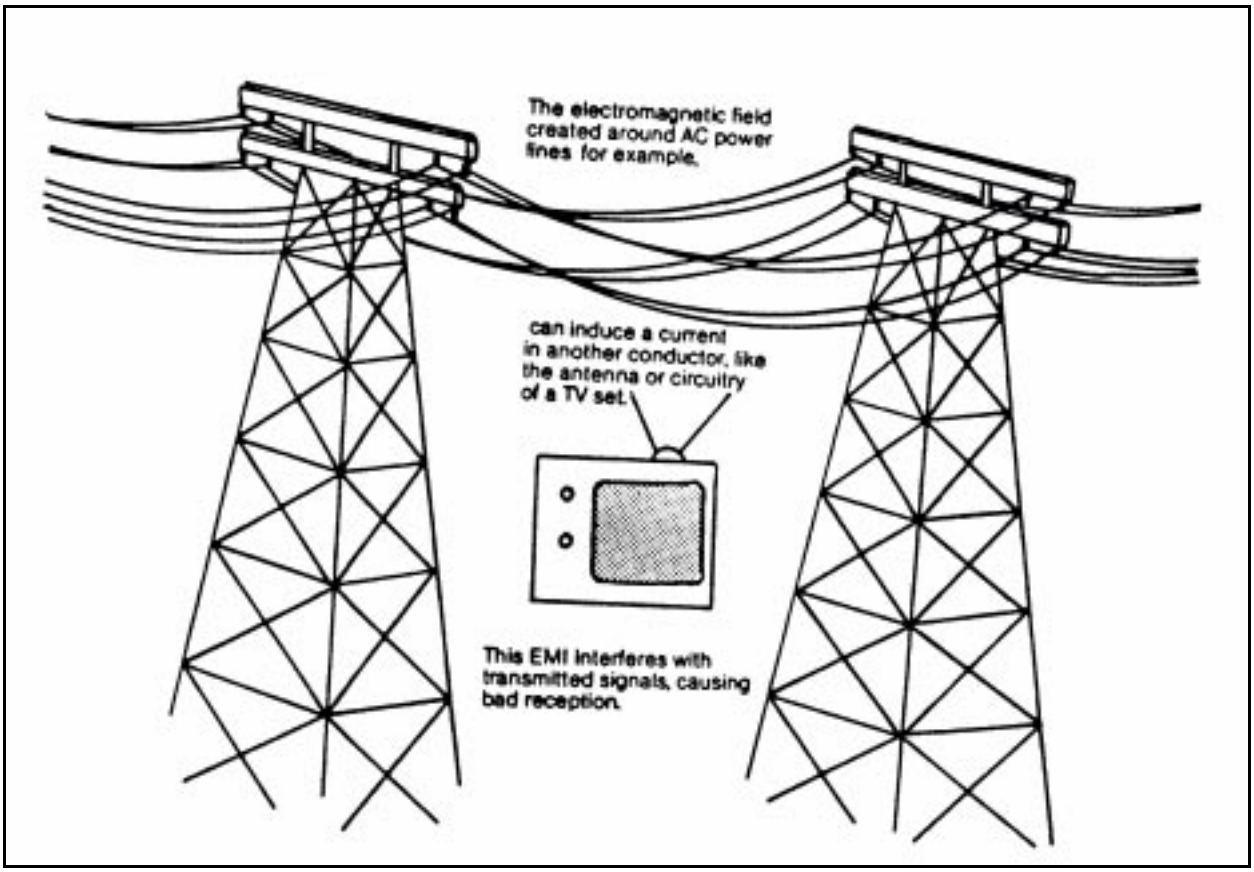


Figure 6-3. Electromagnetic Interference

Under normal operating conditions, vehicle-tank metering systems are exposed to electromagnetic fields produced from a variety of sources. Among these are:

- radio-frequency transmitters from nearby broadcast facilities and mobile transmitters, like CB and commercial band two-way radios and mobile phones (RFI)
- generators, including those driven by vehicle engines to provide a continuous power supply (EMI)
- electrical discharge ignition (spark plugs) (EMI)
- power supply lines (EMI)
- appliances that have electric motors, like air conditioners and refrigeration systems, compressors, etc. (EMI)

The components of electronic indicating and recording elements are designed in such a way as to be protected from interference from RFI and EMI under normal operating conditions. However, if these protections are defective or improperly installed, or if the equipment is located in a place where it is exposed to extraordinary amounts of RFI or EMI (for example, next to the transmitting facility of a commercial radio

or TV station), interference may occur. It is for this reason that electronic vehicle-tank metering systems should be tested for the effects of RFI/EMI.

The purpose of the testing procedure is not to determine the presence of RFI/EMI, but to determine whether the device is adequately protected from its effects, as required by Handbook 44. Several sections in the General Code include requirements that relate to RFI/EMI; these are listed below.

G-N.2. Testing with Nonassociated Equipment. - Tests to determine conditions, such as radio frequency interference (RFI), that may adversely affect the performance of a device shall be conducted with equipment and under conditions that are usual and customary with respect to the location and use of the device. (Added 1976)

G-UR.1.2. Environment. - Equipment shall be suitable for the environment in which it is used including but not limited to the effects of wind, weather, and RFI.
(Added 1976)

G-UR.3.2. Associated and Nonassociated Equipment. - A device shall meet all performance requirements when associated or nonassociated equipment is operated in its usual and customary manner and location.
(Added 1976)

G-UR.4.2. Abnormal Performance. - Unstable indications or other abnormal equipment performance observed during operation shall be corrected and, if necessary, brought to the attention of competent service personnel.
(Added 1976)

Note that G-N.2. states that, when testing with nonassociated equipment, only "usual and ordinary" equipment may be used and that devices may be tested only under conditions that are usual and customary for their operation and service.

To conduct an RFI or EMI test, turn on the suspected source (when testing a vehicle-tank meter, you might, for example, turn on the vehicle's CB radio, if it is equipped with one) and then conduct a Normal Test as described above. Recorded results from this test should be compared to those obtained for the earlier Normal Test. If discrepancies are found, the susceptibility of the equipment to the RFI or EMI source can then be identified.

Test of the Preset Mechanism (if so equipped)

Systems used to make partial-load deliveries are often equipped with an automatic-stop mechanism, which will halt the delivery when a preset quantity of product has been dispensed. If the metering system you are examining does have a preset, its operation must be tested. This is accomplished by setting the preset for a pre-determined quantity and operating the system until the automatic mechanism trips the shutoff valve. The register indication (<u>not</u> the indication on the preset) is then compared to the pre-determined quantity. In accordance with the EPO's, the register must show that delivery was halted within one-half the minimum interval indicated on the register (usually 0.1 gal) for analog devices and within one increment for digital devices.

Because this is a test of the preset mechanism only, and not the measuring or indicating elements of the system, it is not necessary to deliver to the capacity of the prover. You should, however, preset the device for a delivery of at least 30 gallons and dispense at full flow. You should also observe the system closely as the delivery is approaching its conclusion. The shutoff should be smooth and the register should come to rest without jumping. An abrupt, jarring shutoff will indicate that the shutoff valve is not functioning properly (as described in Chapter 3). The resulting hydraulic shock transmitted back to the meter can cause accelerated wear and may cause erratic registration.

Antidrain Valve Test (power-operated systems only)

The final test prescribed in the EPO for power-operated systems is a test of the antidrain valve, which prevents the discharge hose in a power-operated system from being drained. As described in Chapter 3, the valve is calibrated to check flow when pump pressure is no longer present. The requirement for this test is included in the Vehicle-Tank Meters Code.

> **N.4.3. Antidrain Valve Test.** - The effectiveness of the antidrain valve shall be tested after the pump pressure in the measuring system has been released and a valve between the supply tank and the discharge valve is closed.

At the conclusion of the preceding test draft, disengage the pump from the vehicle engine, raise a length of the discharge hose above the level of the meter, and attempt to deliver product into the plastic bucket. A small amount of product remaining in the discharge nozzle may be expected to issue from the nozzle. However, this flow should diminish and cease altogether after 30 seconds. If flow continues, or if you notice any change in the register indication, the antidrain valve is malfunctioning.

Additional Tests

The tests described above are those prescribed in the Examination Procedure Outlines for gravity-discharge and power-operated vehicle-tank metering systems. Your jurisdiction may require additional tests as part of an official field examination. Your instructor will describe any additional procedures to you.

SUMMARY

The purpose of the Test component of an official field examination is to determine whether the system being examined can perform within acceptable limits of inaccuracy (tolerances) under conditions that approximate, as nearly as possible, actual service conditions. The Test is comprised of several distinct procedures, each with specific objectives: some procedures are designed to develop the operating characteristics of the system, others to test the performance of specific elements. Before testing begins, a number of Pre-test Determinations must be performed to establish applicable tolerances and other test factors. Guidelines for Test procedures are provided in the EPO's. Interpretation of results obtained from various Test procedures can provide device operators, repairpersons, and weights and measures jurisdictions with important information regarding the current condition of the equipment tested.

CHAPTER 7

POST-TEST TASKS

CHAPTER OBJECTIVES

Upon completion of this Chapter, you should be able to:

1. Review and evaluate results of the field examination to determine compliance.

2. Determine the appropriate compliance action to be taken based upon evaluation of examination results.

3. Describe administrative procedures for notifying the owner of the action taken and any steps that must be taken to bring devices into compliance.

4. Describe procedures for affixing security seals, inspection stickers, and other markings.

5. Understand procedures for completing and submitting report forms and other documentation.

INTRODUCTION

After you have completed all the steps outlined in the Test portion of the EPO, several post-test tasks remain to be performed. Three major tasks are specified in the EPO's, as shown in Figure 7-1.

Security seal -- Apply physical seal or other approved means to secure adjusting mechanism. Note pertinent information from audit trail, if applicable.. . . . G-S.8., G-UR.4.5.

Note on the official report the amount of product dispensed during test.

After all equipment at a location has been tested, review results to determine compliance with equipment maintenance and use of adjustments. . . . . G-UR.4.1, G-UR.4.3.

Figure 7-1. Post-Test Tasks Specified in the EPO's

A few additional steps are necessary to complete the examination from an administrative point of view. To summarize, the major post-test tasks include:

- installation of the security seal on the meter adjustment mechanism (if removed) or documentation of audit trail information (if applicable)
- evaluation of all examination results
- determination of appropriate compliance action
- notification of the owner or operator of the device(s) of examination results
- marking the device(s) to indicate approval or rejection
- completion and submission of examination report forms and other required documentation

These post-test tasks will be described in the remaining sections of this chapter.

THE SECURITY SEAL

Some jurisdictions require that a new security seal be installed on the meter adjustment mechanism at the conclusion of each field examination. Others require a new seal only when a meter is examined for the first time, when the meter has been examined after required adjustments have been made, or if the seal is found to be damaged or broken. Your instructor will explain your jurisdiction's policy to you.

The adjusting mechanism for some mechanical registers is located between the register and the meter, and so is not accessible unless the two components are detached. The most efficient means of sealing such a system is to thread the security seal wire through a hole drilled through one of the bolts that fastens the register to the meter after the bolt is installed.

The seal is then affixed to the two ends of the security seal wire using, in the case of a lead-type seal, a special applicator called a sealing press. Your instructor will demonstrate the use of the sealing press in the classroom session devoted to this chapter. For some types of seals, a special locking clamp, which cannot be opened again without mutilating or destroying the seal, is snapped into place over the security seal wire. Other types of seals are affixed by threading the end of the security seal wire (which has small, raised ridges) through a hole in the seal; the ridges on the wire and the design of the seal prevent the wire from being pulled out without mutilating or destroying the seal.

When the security seal is properly installed, it should not be possible to detach the register from the meter without either cutting the wire or mutilating or destroying the seal.

The adjustor on most electronic registers is located behind a metal panel or cover on one side of the register. It is generally sealed by passing the seal wire through holes in the panel or cover and the register chassis.

Since the amendment of G-S.8. in the General Code in 1989 other approved means, such as an audit trail, may be used as a form of security. A review of the device's Certificate of Conformance will provide necessary information on sealing the device.

EVALUATING EXAMINATION RESULTS

Throughout the Inspection and Test you will have recorded results for each item. Since approval or rejection will depend upon these results, you should at this point review all items and identify any for which non-compliance has been determined. The most efficient means of doing this is to use a checklist that indicates compliance or non-compliance with each requirement, specification, or performance tolerance examined.

The report form used by your jurisdiction may provide such a checklist. If it does not, or if the list is not sufficiently comprehensive or specific, you may wish to use the EPO's, noting compliance or non-compliance for each item as you proceed.

DETERMINATION OF COMPLIANCE ACTION

Your evaluation of examination results should provide the basis for determining the appropriate compliance action. Separate determinations must be made for each meter examined at a location.

The first step is quite straightforward: you determine whether the device examined should be approved or rejected. To receive approval, the device must be "correct." In accordance with the General Code, this means that all items inspected or tested are in conformance with applicable requirements, specifications, and performance tolerances. Non-conformance for any item will generally lead to rejection (a specific class of exceptions to this general rule will be discussed below).

The inspector may, at his or her discretion and in accordance with jurisdiction policy, permit the owner or operator to make minor corrections at the time of the examination and grant approval if these corrections bring the device into full compliance. For example, dirt or grease obscuring the identification plate may be removed. However, all corrections requiring mechanical adjustment or reconditioning should be made by a qualified repairperson, and should be checked by the owner before reinspection of the device.

If approval is granted, this determination should be indicated on the official examination report. The report should then be signed by the inspector and a copy given to the owner for his or her records. In most jurisdictions, a notice or sticker showing the date of the examination and noting that the device has been approved is placed on the device itself or in some other conspicuous location.

If the device is not "correct," two compliance options are available: repair or rejection. The difference between these two non-approval categories is that rejection requires that the device be removed from service, while a repair notice permits continued use. A repair notice is granted for a non-conforming device only under the following special circumstances:

- The device is accurate -- that is, it conforms with applicable tolerances and other performance requirements -- but requires repair to meet some other requirement. For example, broken glass above the indicating elements will not impair the dispenser's accuracy, but does require repair.

- The device is inaccurate, but the inaccuracy will consistently favor the consumer. In this case, the owner must be informed of the extent of the inaccuracy so that he or she can decide whether to leave the device in service.

- The device is inaccurate, but removal from service as the result of a rejection notice would cause serious hardship to the general public. Though relatively rare, this situation does occur, especially in less populated areas that are served by small operators. For example, if fuel oil service in a rural county is provided by an operator with only one or two tank trucks, taking one of these vehicles out of service in the middle of winter, even for a matter of days, might cause a severe hardship to customers on its route. This exception should only be granted when the hardship is very clear, and outweighs the potential injury to the public that might result from overcharging. When there is any doubt, you should seek guidance from your supervisor.

A repair notice does not free the owner from the obligation of conforming with all requirements. It simply permits the device to be kept in operation until repairs are made. The notice should specify a number of days allowed for repairs to be completed. This period should be kept to a minimum. At the end of that time, if repairs have not been satisfactorily completed, a rejection notice may be issued.

If the device is not correct and a repair notice is not appropriate, a rejection notice must be issued. This notice should specify whether the device is to be removed from service temporarily (until required corrections are made) or permanently.

Upon rejection, the device is officially under control of the weights and measures jurisdiction -- even if it is allowed to remain physically at the commercial location -- until approval is granted. A nonremovable tag should be affixed to the device indicating that it has been removed from service. Procedures in some jurisdictions also require that a seal be installed on a rejected device in such a way as to physically prevent the operation of the device. Your instructor will explain any such procedures to you.

If repairs or reconditioning are required, the rejection notice should specify the number of days allowed. If corrections have not been satisfactorily completed by that time, you may order removal. You must exercise judgment in such cases; if a good faith effort has been made to effect repairs and the delay is unavoidable (for example, because needed replacement parts have not arrived from the distributor), an extension of time may be granted.

A removal order should be issued if the device must be physically removed from its location. The removal may be temporary or permanent.

- The device may be removed temporarily if required corrections have not been made satisfactorily or on time. The device should be removed if the inspector has reason to believe that the owner or operator intends to operate it fraudulently or in violation of laws and regulations, or if a court action is to be undertaken that may require the device as evidence. In any case, you must provide the owner with a receipt before physically removing the device from his or her property.

- A permanent removal order is issued if it is determined that the device is not suitable for the service for which it is being used. For example, a meter that is not capable of making its usual deliveries without exceeding its rated working pressure should be permanently removed from that service, though it might be installed by the operator on another vehicle

that is used for service for which the meter is suitable. When a permanent removal order is issued, the device remains under the control and possession of the owner. He or she is simply required to remove it from its current, improper service.

Finally, a condemnation order requires that the device be removed and destroyed. Such action is normally only appropriate in the rare circumstance that the device is unrepairable. In most cases, vehicle-tank meters can be corrected by repairing or reconditioning components. So a condemnation order for these devices will generally be necessary only when the owner has decided that repair will not be cost-effective (for example, when the cost of required repairs to an aging meter exceeds its value, or when replacement of the complete unit is preferable). A condemnation order may also be issued if a device seized as the result of a removal order is not claimed by the owner.

NOTIFYING THE OWNER OR OPERATOR

When you have determined an appropriate compliance action, you must notify the owner or operator of the disposition and discuss it with him or her. In the case of a non-compliance action, the owner or operator of the device must understand:

- why the action is being ordered
- what will happen as a result of the order (temporary or permanent removal from service, physical removal, condemnation, etc.)
- what actions must be taken to bring the equipment into compliance
- when corrections must be completed and the date and procedure for re-examination
- the consequences of failing to comply with the compliance order

You must give the owner or operator a copy of the official inspection report that indicates specific items of non-conformance. He or she should sign the report to establish its receipt: this signature does not necessarily indicate acceptance of the findings.

You should make every effort to explain specifically and in detail what is wrong with the device. It is not, however, your responsibility to troubleshoot mechanical or electrical problems or recommend specific repair procedures, and you should avoid doing so. Nor is it proper to recommend a repairperson or service by name, since this might be misconstrued as an official endorsement. Under no circumstances should you make repairs or adjustments yourself.

If the compliance order must be approved by your supervisor or some other official, indicate the recommendation you will be making and explain exactly what will happen if that recommendation is approved. If the owner can request reconsideration or appeal of a compliance order, you should explain the procedures for doing so. Remember that your purpose is to ensure that accurate and correct devices are used in the marketplace, not to mete out punishment for violations by administrative means. You must avoid imposing unreasonable or excessive burdens on sellers of products and services.

MARKING THE DEVICE

As mentioned above, each device examined should bear some indication of the date of the examination and the disposition (approval or rejection, etc.). Appropriate markings (stickers, tags, seals, etc.) affixed to the device or in some other conspicuous place provide assurance for customers and protect them from accidental or deliberate use of non-approved equipment. This marking should be performed immediately upon your determination of disposition and before you leave the examination site.

Your instructor will show you the various markings used by your jurisdiction and tell you how and where each of them should be applied.

REPORT FORMS AND RECORDKEEPING

Your instructor will show you how to complete the examination report forms that are used by your jurisdiction and will tell you how and when they should be submitted. In addition, other types of documentation or information may be appropriate. Examples of such additional recordkeeping are logs of telephone calls, conversations, or written correspondence with owners or operators, repairpersons, and supervisors. You will also find it useful to keep notes of problems encountered in the field and the compliance history of particular devices or operators.

Accurate, systematic, and comprehensive recordkeeping is as important a part of your job as the correct use of test equipment, mastery of examination procedures, or knowledge of codes and regulations.

SUMMARY

The last phase of a field examination begins with the evaluation of Inspection and Test results, followed by a decision whether to approve or reject the meter, order repairs, remove the device from the operator's possession, or condemn it for commercial use. Once you have decided which action to take, your decision is written on the examination report and a copy, signed by you, is given to the owner or operator, who must also sign it. The meter is then tagged or sealed to indicate the action taken. The last step in the examination is to be sure that all report forms and other recordkeeping tasks are completed. The examination is then completed.

CHAPTER 8

FIELD TRAINING

CHAPTER OBJECTIVES

Upon completion of this Chapter, you should:

1. Understand the objectives of the field training component of this course.

2. Understand how field training is conducted, how long it will last, and what will be expected of you.

3. Understand the basis and procedures for evaluation of your performance during and at the conclusion of field training.

4. Understand the certification process for weights and measures inspectors in your jurisdiction.

INTRODUCTION

The next step in your study of vehicle-tank meters is field training. You will learn how the training will be conducted, how long it lasts, and what competencies you will be expected to acquire.

Since training schedules vary, your instructor will give you specific information about your field training program.

Field Training - Director Supervision

"Hands-on" field training is designed to reinforce what the inspector has learned about inspecting, testing, and evaluating vehicle-tank meters. During this training, the inspector will perform each step in a field examination of a device under the supervision of the instructor. The instructor will demonstrate and explain a procedure, then the inspector will perform that procedure. When this phase of the training program is completed, the inspector's field performance will be evaluated. The instructor will discuss the evaluation results with the inspector.

Field Training - Indirect Supervision

After demonstrating the ability to perform all procedures, the inspector will conduct field examinations under the supervision of the instructor or a certified inspector. The role of the instructor will be to observe and offer assistance, if needed.

Additional certified inspectors may be used as observers during this period. If so, they will complete an evaluation after each observation. The primary purpose of this phase is to expose the new inspector to

problems that may be encountered in the field and to give him or her the experience needed to function independently.

At the end of this phase, the inspector receives a final evaluation. At this stage one of three decisions must be made:

1. The inspector has clearly demonstrated that he or she has acquired the knowledge and achieved the level of qualifications necessary to meet the requirements for certification, or

2. The inspector has demonstrated weaknesses in some areas in which training should be repeated, or,

3. The inspector has demonstrated that he or she is unable to acquire the level of knowledge or degree of expertise necessary to test the devices covered by the module.

SUMMARY

The field training phase of the inspector's study of vehicle-tank meters provides "hands-on" training. The inspector will receive step-by-step instruction in inspecting, testing, and evaluating devices. Then the inspector will perform examinations under the supervision of the instructor. If the inspector successfully completes this phase of the training program, he or she will be eligible for certification.

Appendix A

NIST Examination Procedure Outline No. 23

Vehicle-Tank Meters
Power-Operated

EPO No. 23

Examination Procedure Outline for

Vehicle-Tank Meters
Power-Operated

It is recommended that this outline be followed for all power-operated vehicle-tank meters – analog or digital. Nonretroactive requirements are followed by the applicable date in parentheses. Do not use this outline for testing milk metering systems, or gravity-discharge vehicle tank meters.

SAFETY NOTES

When excerpting this Examination Procedure Outline for duplication, the "Safety Considerations" section and the "Glossary of Safety Key Phrases" should be duplicated and included with the outline.

The inspector is reminded of the importance of evaluating potential safety hazards prior to an inspection and taking adequate precautions to avoid personal injury or damage to the device. The inspector should read and be familiar with the introductory section on safety found at the beginning of this publication. As a minimum, the following safety precautions should be noted and followed during the inspection. Definitions of each reminder are found in the "Glossary of Safety Key Phrases" at the back of this publication.

Many policies and regulations will vary from jurisdiction to jurisdiction. It is essential that the inspector or serviceperson be aware of all safety regulations and policies in place at the inspection site and to practice the safety policies established by the inspector's or serviceperson's employer. The safety reminders included in this EPO contain general guidelines for safety. These guidelines are useful in alerting inspectors and servicepersons to the importance of taking adequate precautions to avoid personal injuries. These guidelines can only be effective in mitigating safety hazards if inspectors and servicepersons receive training in hazard recognition and controls.

Clothing

Electrical Hazards

Emergency Procedures

Eye Protection

Fire Extinguisher

First Aid Kit

Grounding

Ignition Sources

Lifting

Location
also: **Wet/Slick Conditions, Chemicals, Hazardous Materials,**
Petroleum Products, Obstructions

Material Safety Data Sheets (MSDS)

Nature of Product

Personal Protection Equipment
e.g. Safety Shoes, Safety Aprons, Gloves, Hard Hat, etc. if deemed necessary

Safety Cones/Warning Signs

Static Discharge

Switch Loading

Traffic

Transportation of Equipment

EPO No. 23

Inspection:

Safety First !!!

Check the inspection site carefully for safety hazards and take appropriate precautions

Check to be certain that the ground surface of the inspection site is sufficiently strong and rigid to support the Prover when it is filled with product – don't forget to chock the wheels of the prover

Learn the nature of hazardous products used at or near the inspection site – obtain and read Copies of MSDS's

Know emergency procedures and location and operation of fire extinguisher and emergency shut-offs

Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns

Use caution in moving in wet, slippery areas and climbing on prover, storage tanks, and vehicles

Use personal protection equipment and clothing appropriate for the inspection site

If leaks, spills, or exposed wiring cause hazardous testing conditions it is recommended that the testing be discontinued until the unsafe conditions are corrected

Be sure that a first aid kit is available and that it is appropriate for the type of inspection activity

		H-44 General Code and Vehicle-Tank Meters Code References
1.	General considerations.	
	Selection	G-S.3., G-UR.1.1., G-UR.1.2., G-UR.1.3.
	Installation	G-S.2., G-UR.2.1., G-UR.2.2., UR.1.1.
	Position of Equipment	G-UR.3.3.
	Accessibility	G-UR.2.3.
	Assistance	G-UR.4.4., G-UR.4.6
	Use and maintenance	G-UR.3.1., G-UR.4.1., G-UR.4.2., UR.2.3.
2.	Marking	G-S.1., G-UR.2.1.1., S.5.1, S.5.2.
3.	Indicating and recording elements.	
	Design	S.1.1.1.
	Units	S.1.1.2.(a), S.1.1.3.(b) and (c)
	Readability	G-S.5., G-S.6. (1/1/77), G-S.7., S.1.2., S.1.3.
	Values of intervals	G-S.5.3.
	Computing-type devices	
	Display of unit price	S.1.4.1, UR.1.2.
	Printed ticket	S.1.4.2., UR.2.2.
	Exceptions for the Sale of Aviation Fuel	UR.2.2.1.
	Money-value computations	S.1.4.3.

EPO No. 23

Inspection (Cont.):

3. Indicating and recording elements (cont.).
   - Advancement and return to zero..... S.1.1.4., S.1.1.5., UR.2.1.
   - Provision for sealing ..... G-S.8. (1/1/90), G-UR.4.5.

4. Measuring elements.
   - Vapor Elimination..... S.2.1.
   - Security seal on adjusting mechanism..... G-UR.4.5., S.2.2.

5. Piping.
   - Directional flow valves and discharge line and valves ..... S.2.3., S.3.
   - Antidrain valve..... S.3.6.
   - Leaks ..... G-UR.4.1.
   - Facilitation of fraud..... G-S.2.

Pretest Determinations:

1. Determine that the test fluid in the tank compartment is Similar in character to the fluid to be measures ..... N.1.

2. Test Drafts: determine if the prover size is adequate ..... N.3.

3. Tolerances.
   - Applicable requirements..... G-T., T.1.
   - Tolerance values ..... T.2.
   - Agri-chemicals..... T.3.
   - Repeatability ..... T.4.

4. Note totalizer reading

Test Notes:

Wear appropriate personal protection equipment such as petroleum-resistant, nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, eye protection (to prevent injury from splashed product), and a hard hat (to prevent injury from overhangs and projections)

Use proper grounding procedures

Be sure that prover is equipped with an explosion proof motor

Carefully inspect electrical supply lines to test equipment for wear and damage; correct potentially hazardous conditions before use

Device operator should be present at all times during test – the operator (not the inspector) should operate the device under test

Never leave equipment unattended while it is in operation

Test Notes (cont.):

1. Wet prover. Allow a 30-second drain period each Time prover is emptied.

2. Evaporation and Volume Change: exercise care so the product temperature is the same in the prover as at the meter..... N.2.

3. Record totalizer (s) indication before and after each draft to determine proper operation

4. After each test draft:
   a. Print a ticket (if so equipped)..... G-S.5.6.
   b. If computing type, check price computation on indicator and on recorded representations..... G.S.5.6., S.1.4.2., S.1.4.3., S.1.4.4.
   c. Check for agreement between indicators ..... G-S.5.2.2.

Test:

If supply or return lines are not coupled at their discharge ends, they must be held in place continuously while product flows through the line

Use proper lifting techniques to lift and move equipment

Be aware of and attempt to eliminate potential ignition sources in or near the inspection site

Be aware of vehicular and pedestrian traffic in the area

1. Normal test--full flow, basic tolerance..... N.4.1., T.2.

2. Special test--slow flow, special tolerance ..... N.4.2.(a), T.2.

   If either test result is close to or outside the applicable tolerance, repeat the test.

3. Special test – split compartment, special tolerance..... S.2.1., N.4.2.(b), T.2.
   a. Start test (normal flow rate) from a compartment containing less test fluid than one-half the capacity of the prover and with pump in operation and pressure to the discharge nozzle.
   b. Permit test to continue until lack of fluid supply causes meter register to stop absolutely.
   c. With pump in operation, shut manifold valve (or disconnect whip-hose connection) from now empty compartment
   d. Open valve from compartment with adequate supply of fluid to complete test.

4. RFI/EMI test (electronic equipment only)..... G-N.2., G-UR.1.2., G-UR.3.2., G-UR.4.2.
   Radio frequency interference (RFI)
   Electromagnetic interference (EMI)

EPO No. 23

Test (cont.):

5. Check automatic stop mechanism. ..... G-UR.4.1.
   The device should stop the flow within
   one-half the minimum interval indicated

6. Check effectiveness of antidrain valve..... S.3.6., N.4.3.
   (with pump pressure off line)

7. Security seal ..... G-UR.4.5.

   Record on the official report the number of gallons of product dispensed during test.

Avoid switch loading!
Test devices dispensing low-vapor pressure products (e.g., diesel fuel, kerosene)
Before testing devices dispensing high-vapor pressure products (e.g., gasoline)

8. After all equipment at a location has been tested,
   review results to determine compliance with:
   Maintenance of Equipment..... G-UR.4.1.
   Use of Adjustments.. ..... G-UR.4.3.

Take precautions to isolate equipment when
Transporting it to avoid exposure to hazardous fumes

Appendix B

NIST Examination Procedure Outline No. 24

Vehicle-Tank Meters
Gravity-Discharge

EPO No. 24

Examination Procedure Outline for

Vehicle-Tank Meters
Gravity-Discharge

It is recommended that this outline be followed for all gravity-discharge vehicle-tank meters – analog or digital. Nonretroactive requirements are followed by the applicable date in parentheses. Do not use this outline for testing milk metering systems, or power-operated vehicle tank meters.

SAFETY NOTES

When excerpting this Examination Procedure Outline for duplication, the "Safety Considerations" section and the "Glossary of Safety Key Phrases" should be duplicated and included with the outline.

The inspector is reminded of the importance of evaluating potential safety hazards prior to an inspection and taking adequate precautions to avoid personal injury or damage to the device. The inspector should read and be familiar with the introductory section on safety found at the beginning of this publication. As a minimum, the following safety precautions should be noted and followed during the inspection. Definitions of each reminder are found in the "Glossary of Safety Key Phrases" at the back of this publication.

Many policies and regulations will vary from jurisdiction to jurisdiction. It is essential that the inspector or serviceperson be aware of all safety regulations and policies in place at the inspection site and to practice the safety policies established by the inspector's or serviceperson's employer. The safety reminders included in this EPO contain general guidelines for safety. These guidelines are useful in alerting inspectors and servicepersons to the importance of taking adequate precautions to avoid personal injuries. These guidelines can only be effective in mitigating safety hazards if inspectors and servicepersons receive training in hazard recognition and controls.

Clothing

Electrical Hazards

Emergency Procedures

Eye Protection

Fire Extinguisher

First Aid Kit

Grounding

Ignition Sources

Lifting

Location
also: **Wet/Slick Conditions, Chemicals, Hazardous Materials,**
Petroleum Products, Obstructions

Material Safety Data Sheets (MSDS)

Nature of Product

Personal Protection Equipment
e.g. Safety Shoes, Safety Aprons, Gloves, Hard Hat, etc. if deemed necessary

Safety Cones/Warning Signs

Static Discharge

Switch Loading

Traffic

Transportation of Equipment

EPO No. 24

Inspection:

Safety First !!!

Check the inspection site carefully for safety hazards and take appropriate precautions

Check to be certain that the ground surface of the inspection site is sufficiently strong and rigid to support the Prover when it is filled with product – don't forget to chock the wheels of the prover

Learn the nature of hazardous products used at or near the inspection site – obtain and read Copies of MSDS's

Know emergency procedures and location and operation of fire extinguisher and emergency shut-offs

Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns

Use caution in moving in wet, slippery areas and climbing on prover, storage tanks, and vehicles

Use personal protection equipment and clothing appropriate for the inspection site

If leaks, spills, or exposed wiring cause hazardous testing conditions it is recommended that the testing be discontinued until the unsafe conditions are corrected

Be sure that a first aid kit is available and that it is appropriate for the type of inspection activity

H-44 General Code and Vehicle-Tank Meters Code References

1. General considerations.
   - Selection ..... G-S.3., G-UR.1.1., G-UR.1.2., G-UR.1.3.
   - Installation ..... G-S.2., G-UR.2.1., G-UR.2.2., UR.1.1.
   - Position of Equipment ..... G-UR.3.3.
   - Accessibility ..... G-UR.2.3.
   - Assistance ..... G-UR.4.4., G-UR.4.6.
   - Use and maintenance ..... G-UR.3.1., G-UR.4.1., G-UR.4.2., UR.2.3.

2. Marking ..... G-S.1., G-UR.2.1.1., S.5.1, S.5.2.

3. Indicating and recording elements.
   - Design ..... S.1.1.1.
   - Units ..... S.1.1.2.(a) , S.1.1.3.(b) and (c)
   - Readability ..... G-S.5., G-S.6. (1/1/77), G-S.7., S.1.2., S.1.3.
   - Values of intervals ..... G-S.5.3.
   - Computing-type devices
     - Display of unit price ..... S.1.4.1, UR.1.2.
     - Printed ticket ..... S.1.4.2., UR.2.2.
       - Exceptions for the Sale of Aviation Fuel ..... UR.2.2.1.
     - Money-value computations ..... S.1.4.3.
   - Advancement and return to zero ..... S.1.1.4., S.1.1.5., UR.2.1.

EPO No. 24

Inspection (Cont.):

3. Indicating and recording elements (cont.).
   Provision for sealing ..... G-S.8. (1/1/90), G-UR.4.5.

4. Measuring elements.
   Vapor Elimination..... S.2.1.
   Security seal on adjusting mechanism..... G-UR.4.5., S.2.2.

5. Piping.
   Directional flow valves and discharge line and valves ..... S.2.3., S.3.
   Leaks ..... G-UR.4.1.
   Facilitation of fraud..... G-S.2.

Pretest Determinations:

1. Determine that the test fluid in the tank compartment is
   Similar in character to the fluid to be measures ..... N.1.

2. Determine that a compartment or compartments have a sufficient
   amount of product to conduct "high head" and "low head" tests.

3. Test Drafts: determine if the prover size is adequate and
   that the prover inlet is lower than the meter outlet ..... N.3.

4. Tolerances.
   Applicable requirements..... G-T., T.1.
   Tolerance values ..... T.2.
   Agri-chemicals..... T.3.
   Repeatability ..... T.4.

4. Note totalizer reading

Test Notes:

Wear appropriate personal protection equipment such as petroleum-resistant, nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, eye protection (to prevent injury from splashed product), and a hard hat (to prevent injury from overhangs and projections)

Use proper grounding procedures

Be sure that prover is equipped with an explosion proof motor

Carefully inspect electrical supply lines to test equipment for wear and damage; correct potentially hazardous conditions before use

Device operator should be present at all times during test – the operator (not the inspector) should operate the device under test. Do not leave equipment unattended while in operation

EPO No. 24

Test Notes (cont.):

1. Wet prover. Allow a 30-second drain period each Time prover is emptied.

2. Evaporation and Volume Change: exercise care so that the product temperature is the same in the prover as at the meter..... N.2.

3. Record totalizer (s) indication before and after each draft to determine proper operation

4. After each test draft:
   a. Print a ticket (if so equipped)..... G-S.5.6.
   b. If computing type, check price computation on indicator and on recorded representations..... G.S.5.6., S.1.4.2., S.1.4.3., S.1.4.4.
   c. Check for agreement between indicators ..... G-S.5.2.2.

Test:

If supply or return lines are not coupled at their discharge ends, they must be held in place continuously while product flows through the line

Use proper lifting techniques to lift and move equipment

Be aware of and attempt to eliminate potential ignition sources in or near the inspection site

Be aware of vehicular and pedestrian traffic in the area

1. Normal test--full flow (high head, full compartment), basic tolerance..... N.4.1., T.2.

2. Normal test – full flow (medium head, one-half full compartment), basic tolerance..... N.4.1., T.2.

3. Normal test – full flow (low head, one and one-half times prover capacity in compartment), basic tolerance..... N.4.1., T.2.

4. Special test – split compartment, special tolerance..... S.2.1., N.4.2. (b) , T.2.
   a. Start test (normal flow rate) from a compartment containing less test load than one-half prover capacity.
   b. Permit test to continue until lack of fluid supply causes meter register to stop absolutely.
   c. Shut manifold valve (or disconnect whip-hose connection) from now empty compartment
   d. Open valve from compartment with adequate supply of fluid to complete test.

5. RFI/EMI test (electronic equipment only)..... G-N.2., G-UR.1.2., G-UR.3.2., G-UR.4.2.
   Radio frequency interference (RFI)
   Electromagnetic interference (EMI)

EPO No. 24

Test (cont.):

6. Check automatic stop mechanism. ..... G-UR.4.1.
   The device should stop the flow within
   one-half the minimum interval indicated

7. Security seal ..... G-UR.4.5.

Record on the official report the number of gallons of product dispensed during test.

Avoid switch loading!
Test devices dispensing low-vapor pressure products (e.g., diesel fuel, kerosene)
Before testing devices dispensing high-vapor pressure products (e.g., gasoline)

After all equipment at a location has been tested,
review results to determine compliance with equipment
maintenance and use of adjustments ..... G-UR.4.1., G-UR.4.3.

Take precautions to isolate equipment when
Transporting it to avoid exposure to hazardous fumes