Chapter 4

Safety

Objectives

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

1. Describe the properties of LPG products that necessitate strict adherence to established safety procedures when examining metering systems in the field.

2. Identify items of safety equipment and their use, including protective clothing and fire extinguishers.

3. Describe specific safety procedures that must be observed when examining LPG liquid-measuring equipment.

4. Describe emergency procedures, including firefighting.

Introduction

Safety has a prominent place in the training of anyone who works with LPG products. This chapter is intended to provide a first orientation to a topic that your instructors, supervisors, and colleagues in weights and measures will review, reinforce, and restate again and again.

There is, of course, every reason for this emphasis. You are undoubtedly aware that there are certain hazards associated with LPG products, and you may have read or heard accounts of serious accidents involving them. You should also, however, be aware that the metering systems you inspect and the test equipment you use in the field have been designed, constructed, and installed in strict accordance with codes and regulations that are intended to safeguard both persons in the workplace and the general public from hazardous substances. In addition, the people who operate this equipment are taught how to use it correctly and how to react to hazardous malfunctions.

As a result, the likelihood of an accident occurring during the examination of an LPG liquid-measuring device is not inherently greater than the risk of an accident occurring during the examination of many other types of weighing and measuring devices. What makes the topic of safety so crucial is not the risk of an accident occurring, which is small in a properly designed and operated facility, but the potential for serious consequences as the result of any accident involving LPG liquid.

The most important safety equipment you will carry into the field with you will be your knowledge. You must:

- KNOW the physical and chemical properties of the substances you are dealing with.

- KNOW how your test equipment and the system used to meter and dispense the product work, how they may malfunction, and how they should be operated in case of an emergency.

- KNOW what to expect under the variety of conditions that may occur in the field so that you can anticipate dangerous situations before they develop and take steps to avoid them.

- KNOW how to deal with an emergency if it should occur, and primarily how to protect yourself, those around you, and the general public.

Some of this knowledge you will acquire from study and in the classroom, some from observing experienced inspectors perform field procedures using correct safety practices, some from demonstrations of emergency measures, and much from practicing under the supervision of your instructor or another certified inspector.

This chapter will present an introduction to each of these important areas of skill and knowledge. We will also look briefly at standard safety equipment. This chapter is intended, however, only as an orientation to the topic of LPG safety. Your instructor will describe other safety training required by your jurisdiction.

Properties and Hazards of LPG Products

What makes these substances capable of causing catastrophic damage and injury are their physical and chemical properties. We have discussed most of these properties already; in fact, the very characteristics that account for the prominence of LPG products in the marketplace are those that also account for their hazards. Let us review these properties and the hazards associated with them.

As you learned in Chapter 2, propane and butane have boiling points that are below normal atmospheric temperatures (-44 °F and +32 °F, respectively), and are thus maintained in their liquid states at ambient temperatures in the atmospheric range under pressure (on the order of 100 psi for propane and 12 psi for butane at 60 °F). When introduced into the atmosphere (from a leak, for example) propane will boil instantly, as will butane if the temperature is above 32 °F.

You will also recall from our earlier discussion that both of these products expand in volume many times when they are transformed from their liquid to their gaseous states (propane occupies about 270 times as much volume as a gas as it does as a liquid; butane about 234 times as much). This characteristic, which as you know accounts for the economic advantages of these products, can also be a source of hazard if they are released into the atmosphere under uncontrolled conditions.

Since leaking LPG liquid will boil in the immediate vicinity of the leak, it will have a refrigerant effect on the surrounding air and anything else it comes in contact with. As a result, boiling LPG liquid can cause burns upon contact with the skin or eyes. For this reason, all personnel handling the product wear protective goggles and gauntlet-style gloves during LPG transfers.

Both propane and butane are heavier than air. This means that the vapor will tend to sink to low-lying areas on the ground and concentrate there, especially if there is no breeze to promote dissipation of the gas. It is for this reason that LPG tanks or cylinders should never be placed next to a basement window, and LPG installations should not be located on low-lying ground.

It is also for this reason that, as a rule, a burning jet of LPG vapor (as might result from a leak or from a popping relief valve) should not be extinguished until the source of the leak can be stopped: if the flame is allowed to burn it will consume the vapor as it is emitted; if it is extinguished, the escaping vapor may collect in much larger and more dangerous concentrations elsewhere.

In its natural state, LPG is odorless. However, for safety reasons, an odorant (such as ethyl mercaptan) is added to LPG used as a heating fuel or for engine fuel so that its presence can be detected. The odor produced is distinctive, and in the course of your training you should be given an opportunity to smell it, so that you will recognize this warning that LPG is escaping.

Because they are stored under pressure and because they expand in volume so rapidly upon vaporization, any significant release of these products is likely to produce relatively high concentrations of flammable gas. Furthermore, the release may be rapid and initially difficult to control.

Of course, the most dangerous situation that can arise is one in which the storage container ruptures, resulting in an explosive release of vapor. There is very little chance of this happening spontaneously because LPG storage tanks are designed to maintain their structural integrity at internal pressures (up to at least 1,000 psi) that are 7 or 8 times normal operating pressures and 4 times those pressures that would cause the tank pressure relief valves to open. Conditions that threaten the structural integrity of the system usually result from prolonged exposure of the container to direct flame impingement upon the vapor space of the tank shell. Such failure of the tank shell will not result from simple exposure of the tank to fire. To understand this a little better, let us consider what happens inside a storage tank when it is exposed to fire.

A fire, whether from leaking product that has ignited or from some other burning material, is most likely to occur around the lower region of the storage tank, and its heat will therefore be transferred most directly to the portion of the tank that contains liquid product. As long as product remains enclosed within the system there is no possibility of ignition, since there will be no oxygen in the tank to produce a flammable mixture. However, as the heat of the fire is conducted through the container wall to the liquid product, it will quickly elevate the temperature of the liquid.

As the temperature of the liquid rises, some of it will vaporize, increasing the pressure inside the tank. Eventually, the pressure in the tank will reach a point that could threaten the integrity of the tank. To prevent such a point from being reached, the system is equipped with one or more pressure relief valves, which are designed to open when the internal pressure of the container reaches a predetermined level, resulting in a controlled venting of product vapor to the atmosphere and relieving pressure inside the tank. This venting may itself pose some hazard, but this will be minimal in comparison to the hazard that would result from rupture of the container.

The valve(s), as you may remember from our discussion in Chapter 3, are designed to close automatically as soon as the pressure in the tank is reduced to a reasonable level. The valve(s) will open again if necessary to prevent the build-up of excessive pressure in the tank.

On rare occasions, tanks have been known to rupture violently because of concentrated flame impingement on the vapor space of the tank. Since there is no liquid phase in the immediate area of the flame impingement to cool the exposed metal, the temperature of the tank will increase rapidly in a comparatively small area, resulting in a weak spot in the tank shell, which ultimately becomes the point of initiation of failure of the shell.

In the unlikely event that a tank does rupture, anyone in the area surrounding the ruptured tank, even those wearing protective clothing, would be in danger. Consequently, if there is any indication that a tank is about to rupture, the area should be cleared immediately.

The primary hazard of LPG is from fire. Both propane and butane may be ignited relatively easily by flame, spark, or static discharge. Ignition of propane or butane clouds frequently results in damage very similar to an explosion, especially if the vapor was in a confined space. Secondary ignition is a potential hazard if the fire is extinguished before the fuel supply can be shut off. As mentioned above, flame impingement on the tank (especially on the vapor space) also poses a very serious situation.

A cardinal rule of fighting LPG fires is to place first priority on cooling the tank (and piping, if appropriate) to reduce the build-up of internal pressure. The fire itself should be extinguished only if the source of fuel can be controlled. If the fire is extinguished before the source of fuel is controlled, re-ignition can occur, often with more serious consequences than would have happened with the original fire. Failure to observe this practice has been the cause of serious accidents which otherwise could have been avoided. Handling fires and other topics related to emergency procedures will be discussed in more detail shortly.

Combustion of propane or butane requires air (oxygen); both of these products have rather narrow limits of flammability in air (these represent the proportions of air and gas that will burn). For example, the limits for propane are 2.2 percent and 9.6 percent propane in air; that is, if a mixture of air and propane consists of less than 2.2 percent or more than 9.6 percent propane, it will not burn. The limits of flammability for butane in air are even narrower (1.9 percent and 8.6 percent). This property contributes to the safety of LPG products since a combustible concentration of gas in air is relatively difficult to produce or maintain unless it is artificially controlled. Even so, any unintentional release should be treated as a potentially dangerous situation.

Emergency Equipment

The following items of safety equipment must be available whenever you examine an LPG liquid-measuring system. We will discuss the use of this equipment later in this chapter. Since you must carry most of these items with you when you go into the field, it is good practice to prepare a checklist, which can be consulted in advance.

- Fire extinguishers. Different types of fire extinguishers are used for fighting different types of fires. One or more portable dry chemical extinguishers, suitable for at least Class B fires (flammable liquids and vapors) and Class C fires (electrical) is recommended. The extinguisher(s) should have a total capacity of at least 20 lb dry chemical and should be available at all times. The extinguisher(s) should be tested and renewed periodically following manufacturer's instructions to assure that they are in good working order. You must not depend upon the operator's fire extinguishers, even though fire codes require them to be available.

- First aid kit. The first aid kit you carry with you should be appropriate for inspecting LPG meters and should contain supplies necessary for treating injuries while emergency medical aid is on its way. Contact your department safety officer or local OSHA representative to determine what items should be contained in your kit. Again, the operator should be equipped with a suitable first aid kit, but you must be able to rely upon your own.

- Protective gloves, with gauntlets suitable for use with LPG, should be worn whenever you handle LPG metering equipment to protect your hands and lower arms from exposure to vapor leaks. Since a small amount of vapor is emitted under normal conditions every time a connector is removed, these gloves are not emergency equipment but should be worn at all times.

- Protective goggles or safety glasses should be worn whenever working around mechanical equipment. They are especially important for examinations of LPG metering equipment to protect your eyes from contact with vapor.

- Caution signs must be positioned before you begin examination procedures to prevent vehicles or pedestrians from moving through the area you are working in. The signs may be painted to read "Hazardous Area -- Flammable Gas -- No Visitors -- No Smoking", etc. Safety cones are also useful in helping to isolate the testing area.

- Phone numbers of the local fire department, emergency medical facility, and other appropriate public safety agencies must be available. You should carry a card or notebook with these emergency numbers at all times.

- A continuous supply of water must be available at the test site and in close enough proximity to the equipment being tested that it can be effectively used to cool the storage tank and prover vapor spaces in the event of a fire.

This list of safety equipment should be considered as a minimum. Your instructor will describe to you other items that are required or recommended by your jurisdiction.

Routine Safety Practices

Most dangerous situations involving LPG products can be avoided by strictly observing routine safety practices in the field at all times. These include proper use and maintenance of test

equipment, as described in Chapter 5, and a thorough understanding of the operation of the metering equipment, a topic to which you have been introduced in earlier chapters. Whenever possible, you must be able to anticipate critical situations before they actually occur and be prepared to deal with them if they do.

The following guidelines should be observed at all times. This list is intended to acquaint you with general safety practices and does not include every specific situation that may occur.

- DO NOT SMOKE or permit smoking within 100 feet of your test area. If employees refuse to comply with your request that they observe this basic safety practice, halt the test immediately and ask to speak to a supervisor. Any means of producing flame or sparks should also be prohibited in this 100-foot safety area.

- As you inspect the device, be on the lookout for leaks. Report any found immediately to the operator and do not proceed with your examination until the cause of the leak is discovered and repaired. If the leak cannot be stopped, terminate the examination and notify the owner of the equipment that it should be removed to a safe area for prompt service.

- Report to the operator immediately any exposed electrical wiring on or near the metering equipment. As with leaks, do not continue your examination procedures until the problem has been corrected.

- Never leave equipment unattended while in operation or when set up for operation. You should not leave the work area until your examination is complete and your equipment has been disconnected from the metering system and secured.

- Eliminate all possible sources of electrical discharge (sparks) within the work area, including static electricity. Do not wear clothing made of synthetic fibers or any other material that tends to produce static electricity. Synthetic materials should also be avoided because they will melt in the presence of high heat and will stick to the skin, causing serious burns.

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

- Always ground your prover with a grounding cable (see Chapter 5), and make sure that the electrical supply line for the prover pump is in good condition and protected from damage while in use. Do not cut off the grounding prong on your prover power cord.

- Make sure that all connections you make to the metering system are tight and that valves and other control devices are in their proper position before commencing to dispense product (see Chapter 5).

- NEVER disconnect an LPG hose without first removing the liquid or vapor within the connection between the two shutoff valves. This liquid or vapor must be bled off slowly to

prevent a build-up of static charge and/or refrigeration of liquid contained between the two valves. (Be sure to check again for possible ignition sources and eliminate them before bleeding off the lines!)

- If any practice on the part of the operator, or any procedure required by your jurisdiction arouses concerns about safety, discuss it with the appropriate supervisor immediately and before resuming operations in the field.

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

Emergency Procedures

Proper installation, operation, and maintenance of metering equipment and your own test equipment, together with strict observance of routine safety procedures in the field, will minimize the chance of a situation arising that calls for emergency measures. As long as the hazardous substances you are dealing with remain contained within the metering system and your test prover and pressures and temperatures are maintained within normal ranges, the products themselves pose virtually no threat to you.

However, as mentioned at the beginning of this chapter, the reason for stressing safety when working with LPG products is not the inherent risk that an accident will occur, but the very serious consequences that may ensue in the remote event that one does occur.

If a critical situation develops, it is likely to develop very quickly -- far too quickly for you to consult procedures that you are unfamiliar with and have never had to use before. Accordingly, you must review and practice emergency procedures periodically and be conscious at all times of the need to be prepared for what you haven't yet seen or anticipated.

In general, the owner or operator of the metering system is responsible for the equipment and the safety of those who work with it. If an examination is being conducted on the owner's property, trained personnel and equipment should be available to deal with any emergency. In that event, your role should be to stand by to assist as requested and to take whatever steps are necessary to safeguard yourself and your test equipment. However, emergency situations develop quickly, and you should be prepared to take appropriate actions as necessary while waiting for assistance.

Once again, the following represent the major emergency procedures you should master. You will practice these and other appropriate procedures during the course of your field training.

As the fire triangle in Figure 4-1 shows, three elements must be present to start or sustain a fire of any kind. These three elements are fuel, oxygen (air), and a source of ignition, such as flame or sparks. If any one of these three elements is absent, there will be no fire.

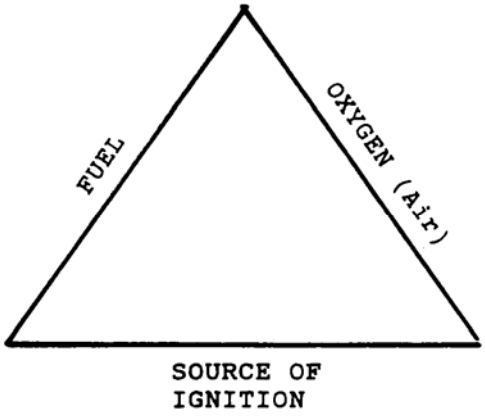

Figure 4-1. The fire triangle.

In the event of a leak of product to the atmosphere from either the metering system or the proving system, two of the three necessary elements in the fire triangle (air and fuel) will already be present.

If there is a significant or continuous leak, but no source of ignition, the primary concerns are to stop the emission of fuel and to prevent ignition. Actions should be taken to:

- Halt the emission of fuel immediately (as noted earlier, your role should be to assist the trained personnel provided by the equipment owner if requested, unless for some reason they are unable to take the necessary actions). Summon others on the scene or emergency services if necessary.

- Turn off all pumps and motors that are operating, including those on the prover.

- Survey the safety area for any possible source of ignition. Observe quickly where the vapor is likely to settle, taking into consideration any wind and the terrain. If any source of potential ignition is present and can be removed, do so immediately.

- When emergency personnel arrive, yield control of the situation to them and stand by. Keep all employees or onlookers who are not needed to deal with the situation at least 200 feet away from the area of the leak.

- Water should be sprayed across the path of the vapor cloud to promote its dispersal.

- If the leak cannot be stopped by closing valves, continue to monitor the situation carefully, warning people away from the area, watching for possible sources of ignition, and maintaining water flow across the vapor path.

Under no circumstances should you attempt either to move the equipment or ignite an LPG leak without explicit instructions from qualified safety personnel. Depending upon the situation, these

steps may be appropriate, but should not be undertaken except by experienced personnel. If the vapor cloud becomes extensive and does not dissipate, prepare to evacuate any affected areas.

If there is fire, the situation may become more critical, depending upon the type of fire and its proximity to the storage tank. In addition to the measures described above for policing the safety area, summoning assistance, and watching for vapor leaks, decisions must be made about the appropriate strategy for stabilizing the situation and preventing it from deteriorating further. It may be necessary for the inspector to make some of these decisions very quickly, and perhaps before help has arrived.

It must first be determined whether the fire poses an immediate threat to the storage tank (or prover). If the fire is sufficiently far away, the first priority should be its extinction.

- If the origin of the fire is electrical and the power source can be shut off, this should be done. If the fire is relatively small, a dry chemical extinguisher should be sufficient to put it out.

- If solid material, such as wood, is on fire, water is the best means of extinguishing it. However, water should never be sprayed on a burning petroleum substance or any other burning liquid. Nor should water be sprayed directly on an electrical fire unless the electrical source has been switched off.

If the fire does threaten the storage tank and/or prover, the first priority is to cool the tank(s) by spraying them with water to reduce pressure buildup as much as possible.

- The water should be sprayed on all sides of the upper part of the container, even if the flame is closer to the bottom. The reason for this is that while the portion of the tank containing the liquid will be kept relatively cool by the refrigerant effect of the boiling liquid and by drainage of the water spray, the vapor space will not be cooled by these factors. Cooling the vapor space by spraying it directly will promote some condensation, and the water spray will conduct heat away from the container, which will have the effects of reducing internal temperature and pressure and also minimizing reduction in strength of the container from exposure to heat. The larger the volume of water that is sprayed on the container, the greater the cooling effect on both the contents and the container itself.

- If the pressure relief valve on top of an LPG tank opens, the stream of vapor will probably be ignited by the fire. If sufficient water is available, water spray should be directed to the area, but in such a way as to avoid extinguishing the flame from the relief valve.

- If some material external to the system is on fire, first attention should be given to cooling the LPG tank shell, with particular attention to the vapor space of the tank. Water runoff from the vapor space will cool the lower part of the tank. If additional personnel and water streams are available, they can be directed at controlling the fire, but the most and first attention should be paid to cooling the vapor space.

- If it is possible to move a source of flame away from the truck, this should be done. If it is possible to move the tank to a safe distance from the flame, this is obviously desirable.

As mentioned above, cooling the vapor space should never be neglected in order to fight a fire in proximity to the storage tank. Since danger of rupture arises from the combination of pressure buildup and the weakening of the container, this process is crucial to prevent a serious situation from developing into a critical one.

Any metering system or prover involved in a situation requiring emergency procedures like those described above should be taken out of service immediately and inspected and tested thoroughly before being returned to the field. This is, of course, absolutely essential for any equipment that has been involved in a fire.

Summary

The potential for very serious consequences as a result of any accident involving LPG products necessitates thorough knowledge of safety procedures and continuing training and review of safety topics.

The hazards of LPG products are a function of their physical properties, especially their characteristically large expansion in volume as they change from their liquid to their gaseous states, their latent heat of vaporization, their relatively low kindling temperatures, and high flame temperatures in air. Injuries can result from burns, from the refrigerant effect of boiling liquid LPG, or from trauma caused by an explosion.

Strict observance of routine safety procedures minimizes the risk of accidents occurring. The owner or operator has primary responsibility for dealing with emergency situations, but the inspector must be prepared to deal with circumstances in which he or she will have to take actions before assistance has arrived.

Three elements are required for any combustion to occur: fuel, oxygen (air), and a source of heat sufficient for ignition. If an LPG leak occurs in the absence of a source of ignition, highest priority must be devoted to halting the emission and avoiding ignition. In the event of ignition, either of leaking product or of some other material, priority should be given to cooling the vapor space of storage tanks to control pressure buildup. Any equipment involved in a serious accident must be thoroughly tested before being returned to service.