PROPANE education & research COUNCIL

Converting Vehicles to Propane Autogas
Part 3: Installing and Operating Dispensers

PROPANE EXCEPTIONAL ENERGY®

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Caution

Propane fuel dispenser installers should read and follow standards for design and installation of propane dispensers and comply with state and local code requirements adopted by the jurisdiction where a dispenser is installed, serviced, operated and maintained. For most locations in the United States, the minimum requirements can be found in NFPA 58, Liquefied Petroleum Gas Code, and related sections of NFPA 30A, Code for Motor Fuel Dispensing Facilities and Repair Garages, and NFPA 70, National Electrical Code. These codes direct the installer and operator to follow Original Equipment Manufacturer (OEM) instructions for installation, operation and maintenance of dispenser components.

Scope of This Course

This course, covering the design, installation and operation of fueling stations, is Part 3 of a suite of courses on retrofitting, servicing and fueling highway vehicles that run on propane autogas. [1] Part 1 covers the installation of fuel tanks, transfer lines and fittings. Part 2 covers the installation of under-hood components.

This material is intended to provide focused refresher training for dispenser installers, as well as training for new propane vehicle fleet managers, maintenance personnel and drivers who operate propane autogas dispensing systems. See Chapter 5 for guidelines on operating a dispenser.

Among the factors highlighting the need for more and better-designed propane autogas dispenser installations in the United States are:

- Increased domestic supplies of propane coming on-stream at prices competitive with gasoline, gasoline/ethanol mixtures and diesel fuel;
- Advances in propane automotive fuel-system technology that provide power and mileage comparable to those of conventional engine fuels and require a higher level of refueling dispenser performance;
- Efforts by fleet operators to realize the environmental and economic benefits of propane available through federal and state government incentives; and
- Recent changes in EPA alternative-fuel certification regulations that make it easier to introduce new propane autogas technologies in the United States at both the original equipment manufacturer and aftermarket levels.

The growing number of propane fleet vehicles means that additional user-friendly propane dispensers are needed to service fixed-base private fleets and public users through installations at fleet-maintenance facilities, truck stops, propane marketers' outlets and service stations.

Chapter 1 presents the characteristics of propane engine fuel, followed in Chapter 2 by graphical illustrations of the challenges presented by current propane vehicle refueling operations. Chapters 3 and 4 present options for designing dispenser installations, focusing on code requirements and the operating requirements for individual system components. Chapter 5 outlines dispenser operation for fleet mechanics, drivers and other personnel who refuel propane autogas vehicles.

Four appendices provide additional safety, technical and customer-service information. Appendix A is a Material Safety Data Sheet for propane. Appendix B provides a glossary of terms. Appendix C includes sample planning documents and a checklist for dispenser installers. Appendix D specifies the minimum separation distance between propane equipment and equipment approved for NEC (National Electrical Code) Class 1, Group D use.

1 "Propane autogas" or "autogas" is the term used internationally to refer to propane used as an engine fuel to propel over-the-road vehicles.

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Credits

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CleanFUEL USA, Figures 21, 22

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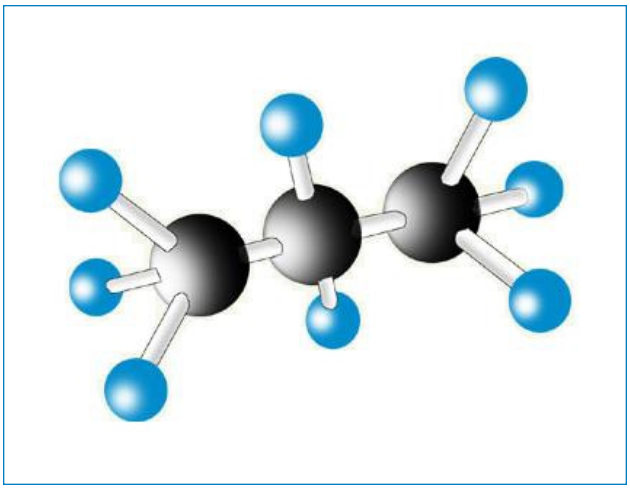
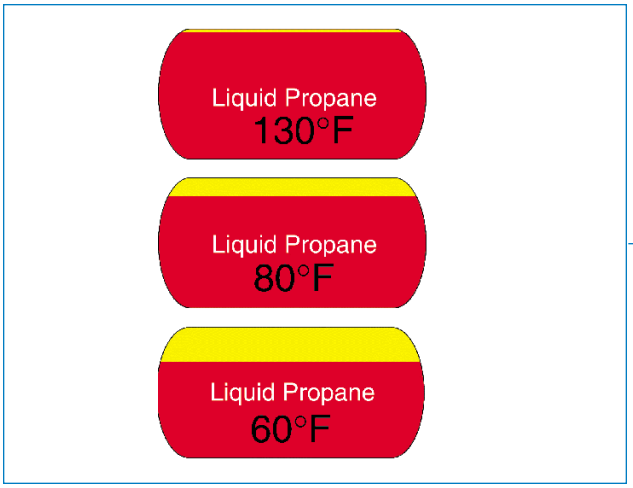
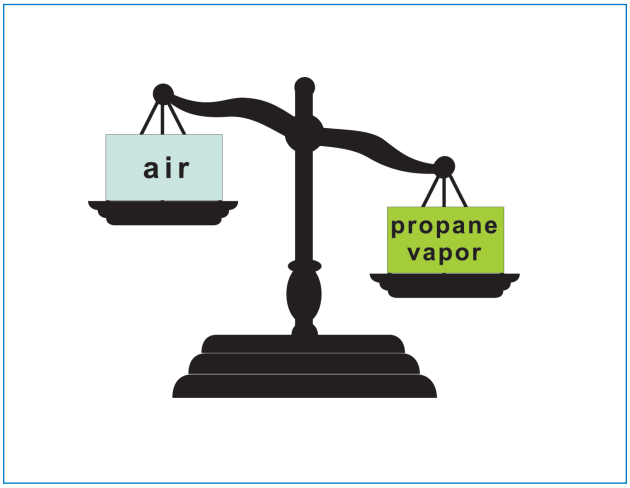






Chapter One

PROPANE CHARACTERISTICS AND SAFETY CONSIDERATIONS

CHAPTER 1: PROPANE CHARACTERISTICS AND SAFETY CONSIDERATIONS

1.1 Physical Properties of Propane

Propane is a hydrocarbon classified as a liquefied petroleum gas (LPG). It is a petroleum by-product manufactured during the refining of raw crude oil and during the processing of natural gas. Stored under moderate pressure, propane can be maintained as a liquid and carried on-board a vehicle in amounts that maintain or increase the vehicle's normal range between refuelings.

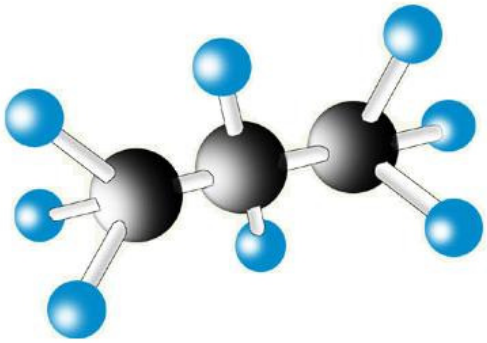


Figure 1. Propane Molecule (C_3H_8)

Propane dispensing and vehicle fuel systems are sealed systems that operate at higher pressures than gasoline or diesel systems.

Properties of propane include:

Propane is non-toxic and colorless with no defining natural odor. A chemical odorant, usually ethyl mercaptan, is added to propane to help warn people of leaks.[1]

Ignition Temperature; Flammability Limits. Propane's ignition temperature is higher than gasoline's. Propane requires a minimum temperature of 920°F to ignite. The minimum temperature required to ignite a gasoline-in-air mixture is approximately 660°F. Mixtures of between 2.15 percent and 9.6 percent propane in air are flammable. These lean and rich ratios are called the Lower Flammability Limit (LFL) and Upper Flammability Limit (UFL), respectively.

Specific Gravity. Specific gravity provides a way to compare the weight of liquids and gases. The specific gravity of a liquid is defined as the weight of a given volume of the liquid compared to the weight of the same volume of water, measured at the same temperature and pressure. The specific gravity of water is arbitrarily defined as 1.0. The specific gravity of propane liquid is approximately 0.504, meaning that gallon for gallon propane weighs about half as much as water.

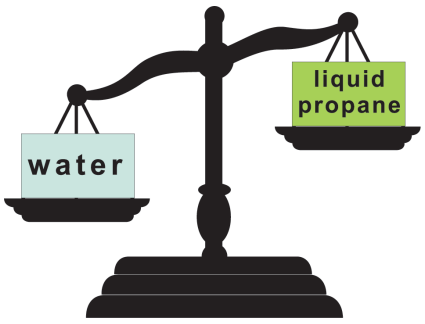


Figure 2. Propane liquid is lighter than water.

1 Odorants may not provide adequate warning of gas leaks in every situation. Some people are not able to smell odorants either temporarily or at any time, due to temporary or permanent health conditions.

Similarly, the specific gravity of a gas (vapor) is defined as the weight of a given volume of the vapor compared to the weight of the same volume of air, measured at the same temperature and pressure. The specific gravity of air is arbitrarily defined as 1.0. The specific gravity of propane vapor is 1.50, meaning that a cubic foot of propane vapor weighs about half again as much as a cubic foot of air.

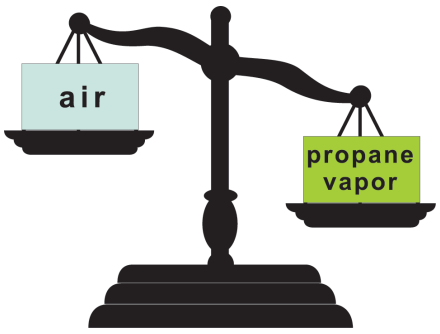


Figure 3. Propane vapor is heavier than air.

Propane liquid released to the atmosphere will quickly vaporize, and the vapor will settle at ground level in still air. Propane vapor will dissipate in moving air, but may settle in underground spaces such as sewers, service pits or basements.

Expansion Ratio, Liquid to Vapor. If propane liquid is released into the air, it quickly vaporizes and expands to 270 times its original volume.

Therefore, a liquid propane leak can be more hazardous than a vapor leak, due to the expanding vapor cloud.

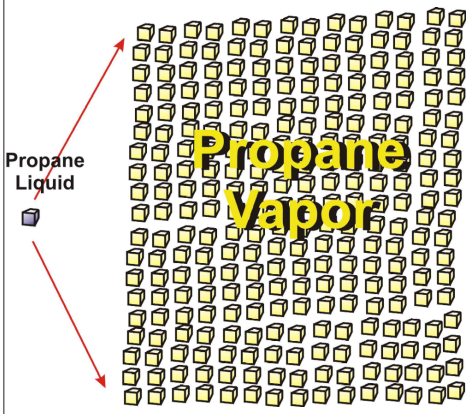


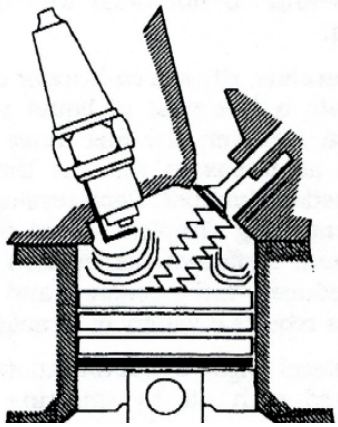
Figure 4. Liquid to Vapor Expansion

Liquid Propane. Like other liquids, propane liquid is not easily compressed. Movement of liquid propane from one sealed container to another requires energy to create an area of higher pressure than the pressure of the receiving container. In a propane dispensing system the pressure differential between the dispenser's supply tank and the vehicle's fuel tank is produced by a propane pump.

Octane Rating. Octane ratings measure a fuel's resistance to detonation. Propane's octane rating is higher than that of any premium gasoline.

Detonation occurs when the pressures inside the combustion chamber become too great for the fuel to burn evenly. Instead of a smoothly expanding flame front inside the cylinder, multiple flame fronts are formed and collide with one another, producing a sharp pinging or spark knock that signals detonation. Vibration created by these colliding flame fronts can quickly damage an engine.

Figure 5. Engine Cylinder and Detonation



Pump octane is the rating posted on a fuel dispenser. It is calculated as R + M/ 2 = P, or the sum of research octane and motor octane divided by 2 equals pump octane. The pump octane method yields average results of:

- Regular unleaded gasoline = 87 octane
- Mid-grade unleaded gasoline = 89 octane
- Premium unleaded gasoline = 91-93 octane
- Propane (HD-5) = 100-105 octane

Temperature/Pressure Relationship. Propane stored under pressure assumes the temperature of its surroundings.

- Propane in an aboveground tank assumes the temperature of the air surrounding the tank (ambient air temperature). As the ambient air temperature increases, two things happen inside the tank: (1) the propane liquid becomes warmer and expands in volume, and (2) additional liquid boils (vaporizes), increasing the vapor pressure.
- Examples of typical propane vapor pressures at various temperatures are:

Temperature	Pressure
70°F	130 psig
100°F	203 psig
130°F	300 psig

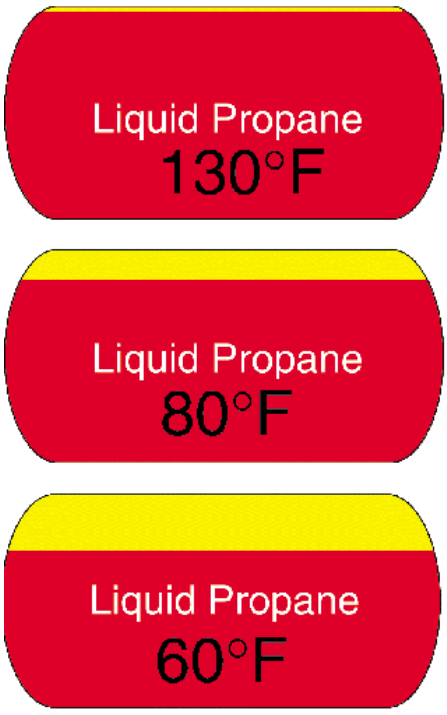


Figure 6. Propane liquid expands as increased temperature.

Propane containers are protected against expansion of liquid propane at high ambient temperatures by:

- Allowing a vapor space for liquid expansion (20 percent by volume for an engine fuel tank), and
- Installing a pressure relief valve in the vapor space of the container.

Vapor Pressure. Propane's vapor pressure depends on its temperature. Figure 7 shows this relationship, known as the vapor pressure index (VPI).

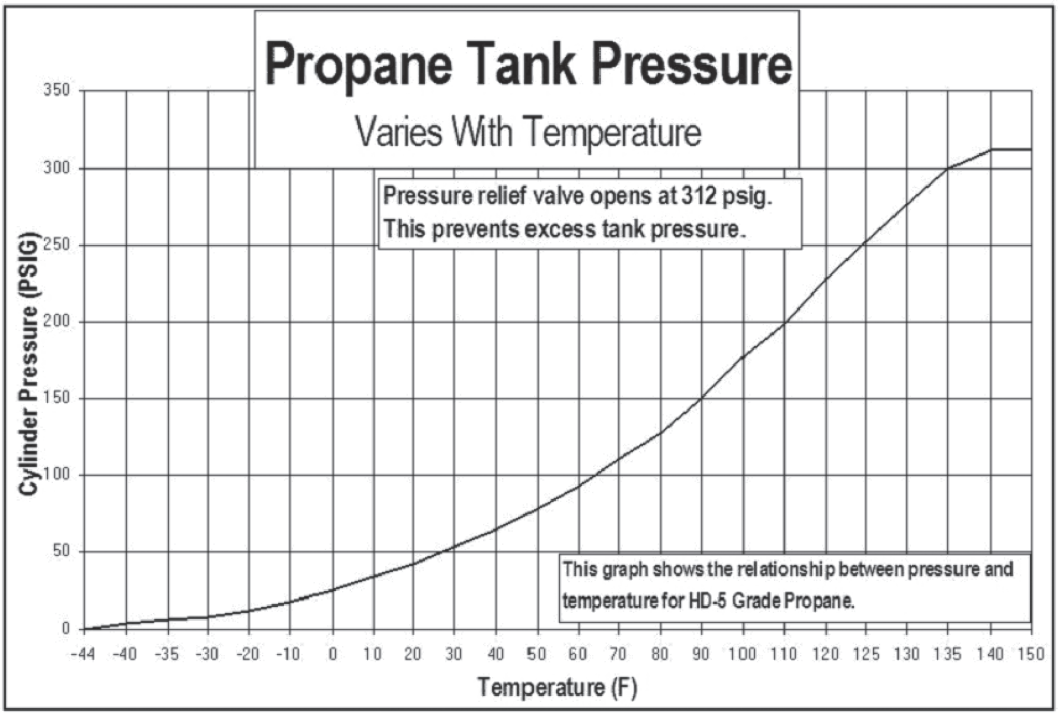


Figure 7. Vapor Pressure of HD-5 Propane

1.2 Workplace Hazards of Propane to Persons Installing, Maintaining or Using Propane Autogas Dispensers

Fire Hazard. Propane is highly flammable. If released to the atmosphere, it will ignite in the presence of air and an ignition source.

Caution

The only way to stop a propane fire is to stop the flow of gas to the flame. If a propane fire occurs that cannot be immediately extinguished by the activation of emergency shutdown controls, immediately evacuate the area and call 911 from a safe location.

Health Hazards

Inhalation. Brief inhalation of propane vapor will typically cause no long-term damage. Prolonged inhalation of 100 percent propane vapor will result in oxygen deprivation. Like other industrial gases such as acetylene, propane vapor is an asphyxiant. Inhaling propane liquid will cause immediate death due to freezing of bronchial tissues and asphyxiation.

Figure 8. Frost on Vinyl Glove-Protected Hand

Contact With Propane Liquid. When released to any pressure below storage pressure, propane expands and absorbs heat from its surroundings, i.e., it boils, and its temperature decreases temporarily. If the pressure is allowed to drop to zero, propane will auto-refrigerate to its boiling point, –44°F. For this reason, contact with liquid propane can cause immediate frostbite.

Pressure Hazards. Propane must be stored in pressure vessels that meet exacting code requirements. Use of materials not compatible with propane and/or not rated for propane service may result in structural failure resulting in fragmentation and high-velocity propulsion of projectile material. Severe injuries or death can result.

1.3 Personal Protective Equipment

Exposure to liquid propane may be prevented by wearing protective gloves and suitable clothing, including safety eyewear. Release of propane under pressure may produce nozzle-blast noise that may damage hearing.

Eye Protection: Safety Glasses or Goggles
Hand Protection: Vinyl Gloves

Hearing Protection: Acoustical Ear Muffs

Figure 9. Personal Protective Equipment

Additional information about the physical properties of propane, hazards presented by propane, and personnel protection measures is presented in a Material Safety Data Sheet (MSDS) located in Appendix A of this training guide. Federal Occupational Health and Safety Administration (OSHA) regulations require employers to make MSDS readily accessible to employees in workplaces where chemical hazards are present.

Review of Chapter 1

Directions: Select from the list below the response that most correctly completes each of the following statements. Write the letter of your choice in the space provided. Answers may be used more than once.

A.	-44	J.	vapor pressure
B.	heavier	K.	frostbite
C.	203	L.	0.5
D.	highly flammable	M.	1.50
E.	PPE	N.	lighter
F.	non-toxic	O.	270
G.	15.5	P.	higher
H.	natural gas	Q.	non-flammable
I.	MSDS	R.	1.5

___ 1. Propane vapor is _____ than air.

___ 2. The specific gravity of propane liquid is _____ times that of water.

___ 3. Propane expands _____ times in volume when it boils and changes from liquid to vapor.

___ 4. The specific gravity of propane vapor is _____.

___ 5. Propane is produced by the processing of crude oil and/or _____.

___ 6. Propane liquid is _____ than water.

___ 7. The boiling point of propane liquid at normal atmospheric pressure is _____ degrees F.

___ 8. The ignition temperature for propane is _____ than the ignition temperature of gasoline.

___ 9. Liquid propane can cause _____ if it comes into contact with body tissues.

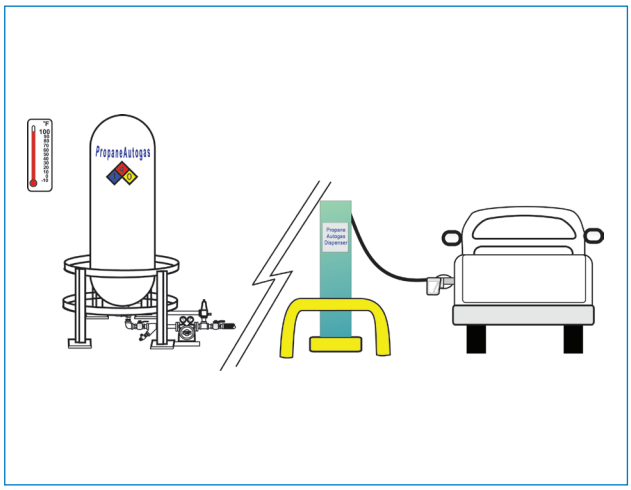
___ 10. Regarding propane's hazards, propane vapor is _____ and a small quantity may briefly be inhaled without long-term health effects.

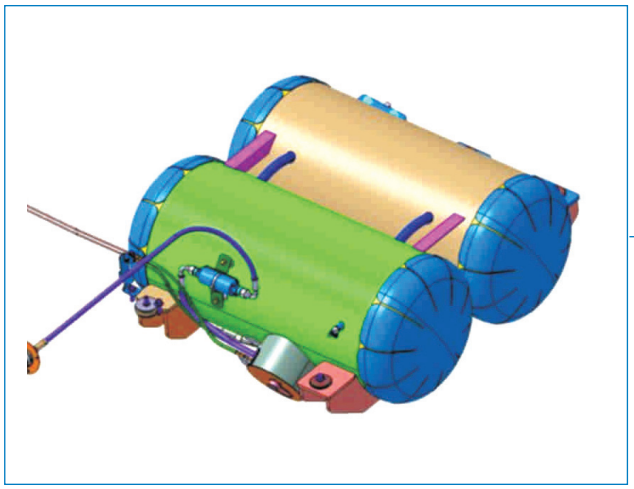
___ 11. Employees can review information about hazards, fire prevention measures, and personnel protection measures associated with propane by reading the _____.

___ 12. Propane released to the atmosphere in the presence of air and an ignition source is _____.

___ 13. Propane's _____ increases as its temperature increases.

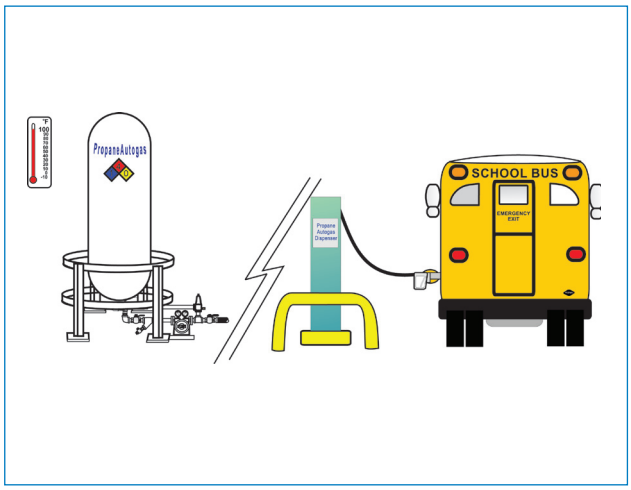
___ 14. Propane's vapor pressure in a sealed container is about _____ psig at 100°F.





Chapter Two

New Propane Vehicle Fuel Systems



CHAPTER 2: NEW PROPANE VEHICLE FUEL SYSTEMS

Propane industry news story headlines in 2011 included many like these:

- *Nantucket Energy and Mississippi's Coast Transit Authority partners with Alliance Autogas to convert portions of their fleets to run on propane.*
- *Blue Bird partners with Ford and Roush CleanTech to develop its latest Type C school bus that runs on propane autogas.*
- *Coast Transit Authority, the primary mass-transportation provider in the Gulfport-Biloxi metropolitan area, converts four buses to propane in partnership with Alliance AutoGas.*
- *Roush CleanTech delivers 21 propane autogas-fueled Ford E-Series cargo and cutaway vans to ARS/Rescue Rooter.*
- *Houston Independent School District rolls out 25 propane autogas buses and CleanFUEL USA dispenser using grants from the Texas Railroad Commission, the Texas Commission on Environmental Quality, and the U.S. Department of Energy's Clean Cities stimulus program.*

Headlines like these reflect the increasing importance of propane autogas to fleet operators as they seek to reduce costs of operation and environmental impact. New fuel-system technologies contribute to this growth by improving the performance of propane engines, making them economically competitive with conventional fuels, while providing the benefit of cleaner exhaust emissions.

2.1 Operating Characteristics of Liquid Propane Injection Systems for Engines Requiring Higher Refueling Differential Pressures Compared to Previous Dispensers

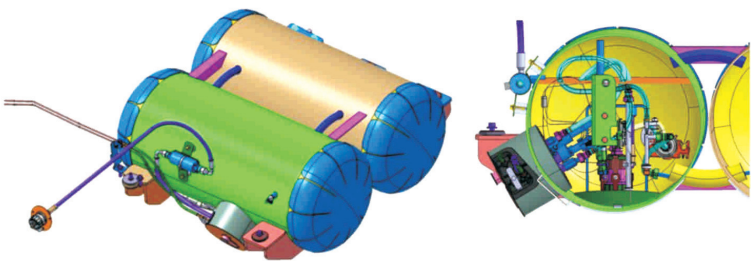


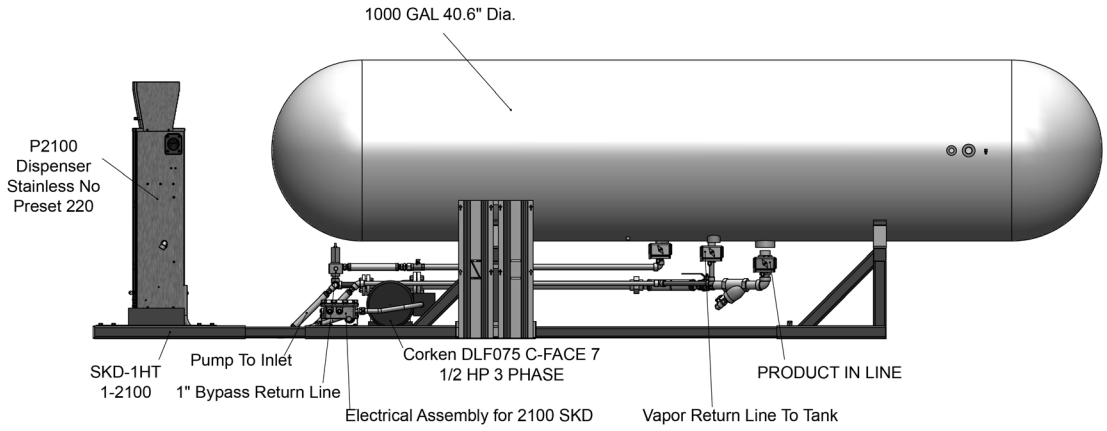
Figure 10. Engine Fuel Filler Line, Tank and Internal Devices

Liquid propane fuel injection (LPI) systems for dedicated propane vehicles are one reason for recent advances in propane vehicles' performance and fuel economy. These systems are relatively new to the United States.

LPI systems require higher refueling pressures, due to:

- Heated propane returning to the fuel tank from the engine;
- Filling line restrictions, including an in-line fuel filter; and
- Heat generated in the fuel tank by the electric fuel pump and other components.

Autogas refueling dispensers must be up to the task if the owners and operators of LPI-equipped vehicles are to realize the potential savings and community good will propane vehicles offer. Dispensers must be user-friendly, reliable, and capable of delivering propane into the tank of one or more vehicles at required volumes and pressures. Dispensers that marginally met the needs of propane marketers' fleets in the past will not meet the needs of today's fleet customers.



2.2 Operating Scenarios

To understand current fleet customers' requirements, examine the dispenser operating scenarios given on the following pages. As you look at the scenarios, remember the following critical points.

- Pressures in a propane liquid transfer system vary according to temperature, product supply pressure, system restrictions, flow rate, component wear and other factors.
- Pressure requirements vary from one vehicle to the next.
- Pressure values in the scenarios, as in real-life situations, are not absolute and may differ from values encountered in the field with specific vehicles and/or dispenser systems.

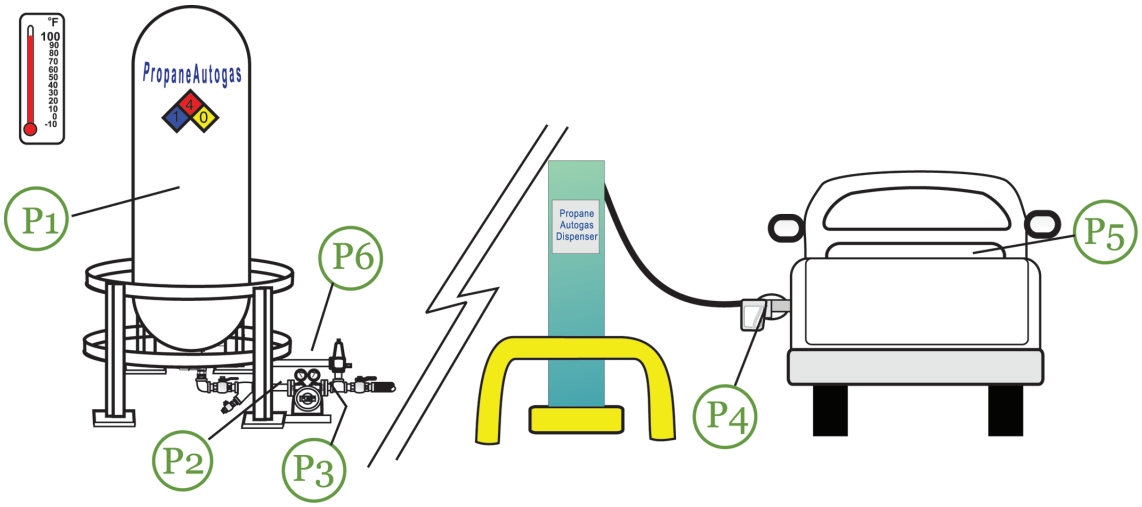
2.2.1 Scenario 1. In-Bed Engine Fuel Tank on Liquid Fuel Injection Pickup

Scenario 1A

A propane liquid fuel injection (LPI) pickup is connected to an autogas dispenser on a 100°F day.

Initial conditions for pressure readings:

• Pump is off	• Hose end valve is closed
• Engine fuel tank is 20 percent liquid filled	• Bypass valve is closed



P1	203	psig* Supply Container		P4	203	psig Hose End Valve
P2	203	psig Pump Inlet		P5	263	psig Engine Fuel Tank (LPI)
P3	203	psig Pump Outlet		P6	203	psig Bypass to Supply Tank

* pounds per square inch gauge

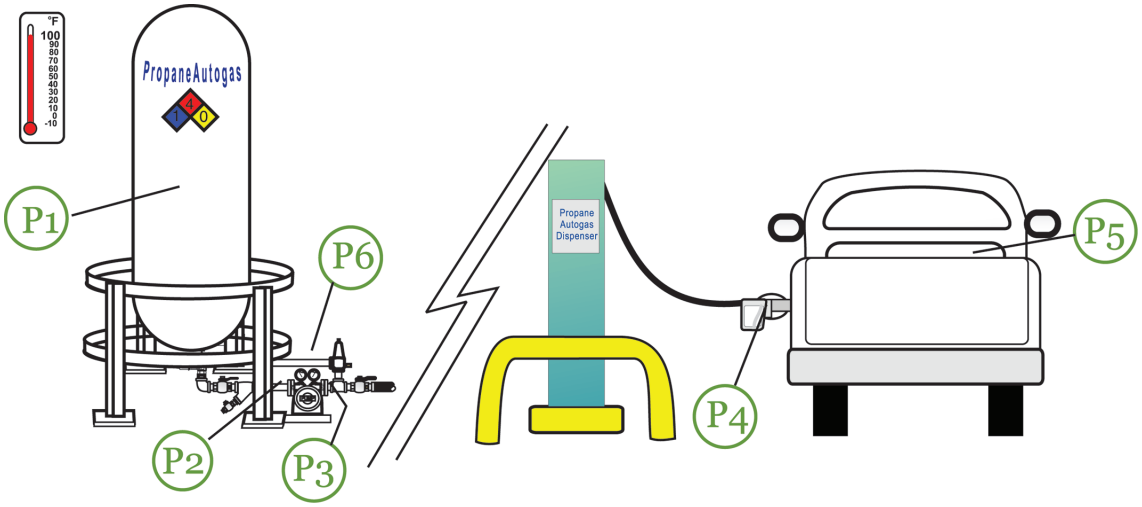
Why is P5 higher than any other pressure in the dispenser section of the system at the start of the refueling operation?

Scenario 1B

A propane liquid fuel injection (LPI) pickup is connected to an autogas dispenser on a 100°F day.

Subsequent conditions for pressure readings:

• Pump is on	• Hose end valve is closed
• Engine fuel tank is 20 percent liquid filled	• Bypass valve is closed



P1	203	psig Supply Container		**P4**	348	psig Hose End Valve
P2	203	psig Pump Inlet		**P5**	263	psig Engine Fuel Tank (LPI)
P3	348	psig Pump Outlet		**P6**	203	psig Bypass to Supply Tank

If the given conditions (pump on, hose end valve closed, bypass valve closed) in the dispenser section of the system at the start of the refueling operation remain as shown at the top of the page, would you expect a momentary change in pressure at any point in the dispenser section?

_____

If your answer is "yes," where would you expect to see a change? _____

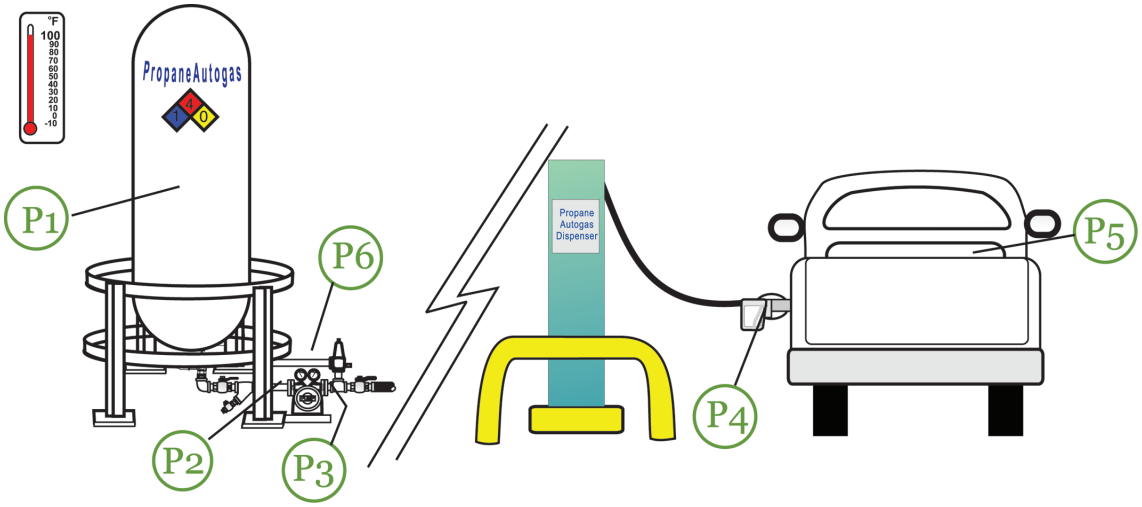
_____

Scenario 1C

A propane liquid fuel injection (LPI) pickup is connected to an autogas dispenser on a 100°F day.

Subsequent conditions for pressure readings:

• Pump is on	• Hose end valve is open
• Engine fuel tank is 20 percent liquid filled	• Bypass valve is closed/open



P1	203	psig Supply Container		**P4**	335	psig Hose End Valve
P2	203	psig Pump Inlet		**P5**	275	psig Engine Fuel Tank (LPI)
P3	335	psig Pump Outlet		**P6**	213*	psig Bypass to Supply Tank

*Pressure reflects slight return flow with bypass valve partially open.

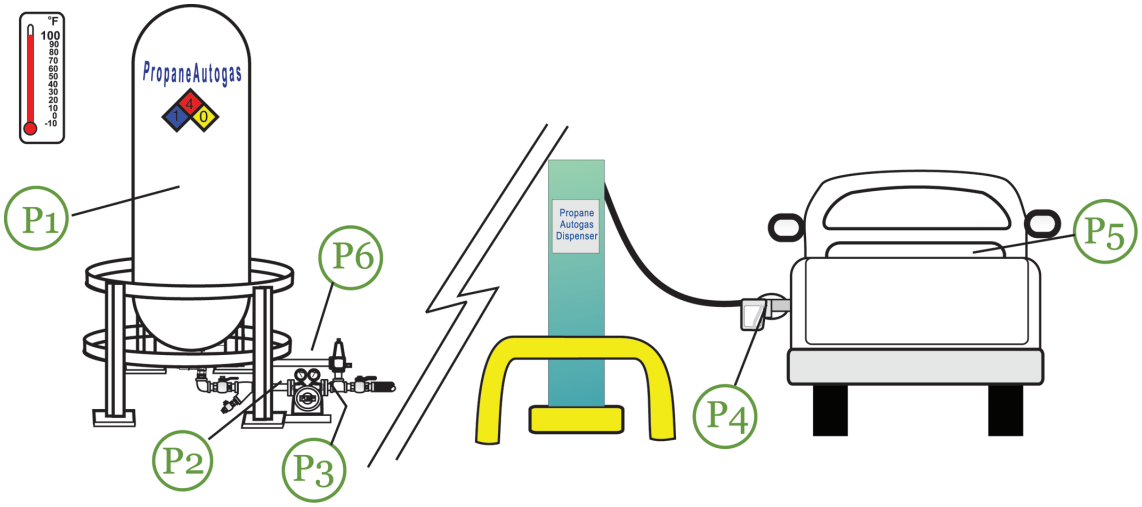
If the bypass valve were fully open, would you expect the pressure at P6 to be higher or lower?

Scenario 1D

A propane liquid fuel injection (LPI) pickup is connected to an autogas dispenser on a 100°F day.

Subsequent conditions for pressure readings:

• Pump is on	• Hose end valve is open
• Engine fuel tank is 60 percent liquid filled	• Bypass valve is closed/open



P1	203	psig Supply Container		**P4**	340	psig Hose End Valve
P2	203	psig Pump Inlet		**P5**	285	psig Engine Fuel Tank (LPI)
P3	340	psig Pump Outlet		**P6**	220	psig Bypass to Supply Tank

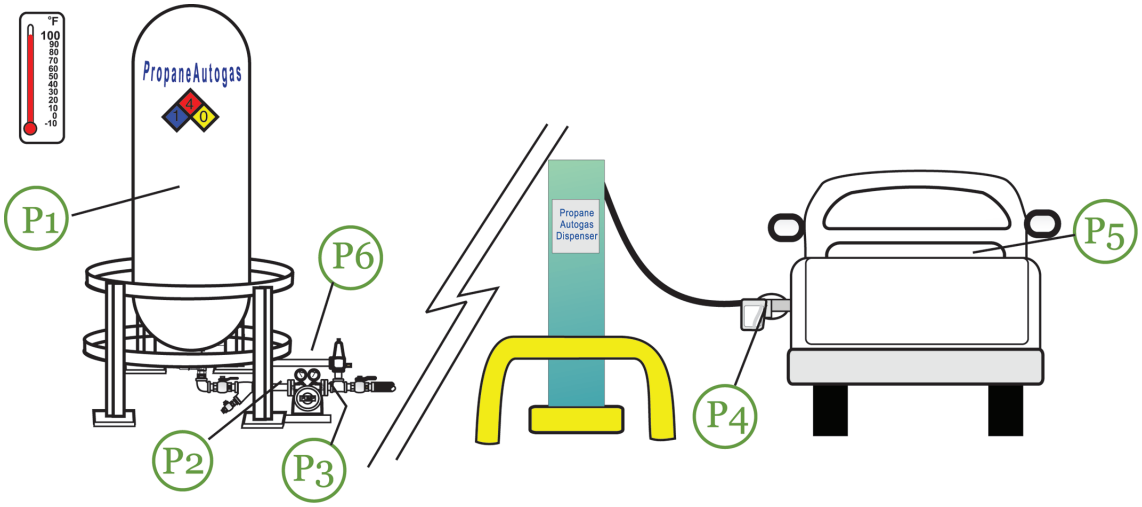
What would account for the difference in pressure at **P5** in this part of the refueling operation compared with the pressure at **P5** in the same part of the refueling operation on the previous page (Scenario 1C)?

Scenario 1E

A propane liquid fuel injection (LPI) pickup is connected to an autogas dispenser on a 100°F day.

Subsequent conditions for pressure readings:

• Pump is on	• Hose end valve is open
• Engine fuel tank is 80 percent liquid filled	• Bypass valve is open



P1	203	psig Supply Container		**P4**	348	psig Hose End Valve
P2	203	psig Pump Inlet		**P5**	300	psig Engine Fuel Tank (LPI)
P3	348	psig Pump Outlet		**P6**	233	psig Bypass to Supply Tank

What would account for the difference in pressure at **P5** and **P4**? _____

_____

_____

_____

_____

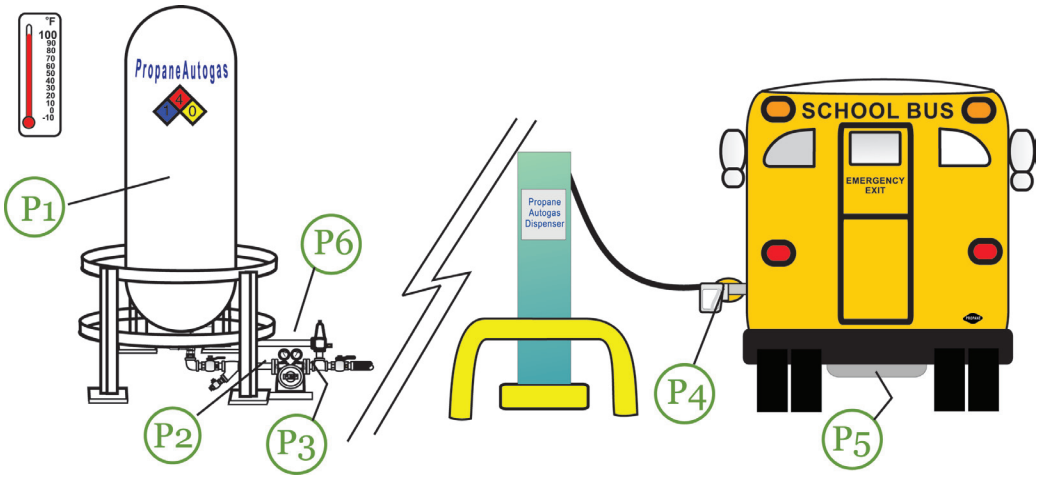
2.2.2 Scenario 2. Underbody Engine Fuel Tank on Liquid Fuel Injection School Bus

Scenario 2A

A propane liquid fuel injection (LPI) school bus is connected to an autogas dispenser on a 100°F day.

Initial conditions for pressure readings:

• Pump is off	• Hose end valve is closed
• Engine fuel tank is 15 percent liquid filled	• Bypass valve is closed



P1	203	psig Supply Container		P4	203	psig Hose End Valve
P2	203	psig Pump Inlet		P5	280	psig Engine Fuel Tank (LPI)
P3	203	psig Pump Outlet		P6	203	psig Bypass to Supply Tank

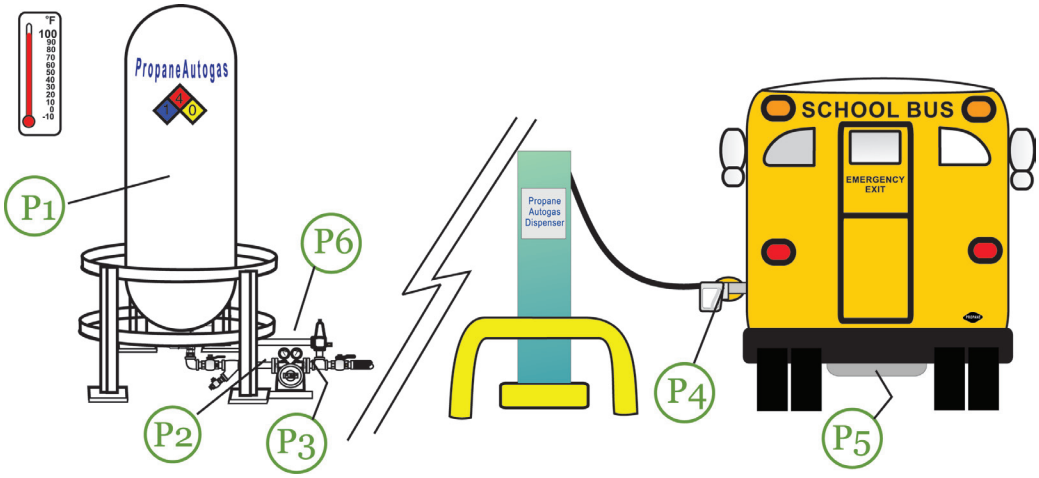
What could account for the difference in pressure in the school bus engine fuel tank compared with the engine fuel tank of the pickup in Scenario 1A?

Scenario 2B

A propane liquid fuel injection (LPI) school bus is connected to an autogas dispenser on a 100°F day.

Subsequent conditions for pressure readings:

• Pump is on	• Hose end valve is open
• Engine fuel tank is 50 percent liquid filled	• Bypass valve is closed



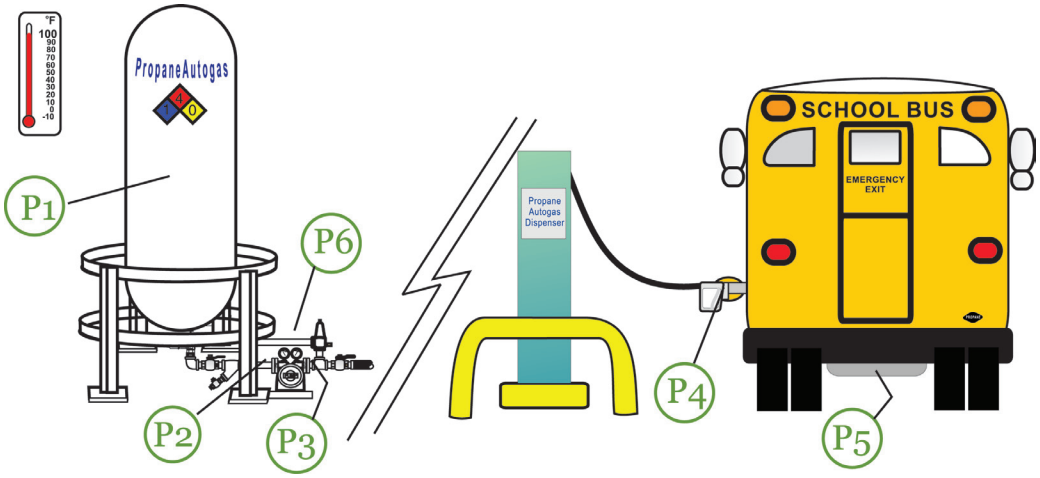
P1	203	psig Supply Container		P4	300	psig Hose End Valve
P2	203	psig Pump Inlet		P5	300	psig Engine Fuel Tank (LPI)
P3	348	psig Pump Outlet		P6	203	psig Bypass to Supply Tank

Scenario 2C

A propane liquid fuel injection (LPI) school bus is connected to an autogas dispenser on a 100°F day.

Subsequent conditions for pressure readings:

• Pump is on	• Hose end valve is open
• Engine fuel tank is 80 percent liquid filled	• Bypass valve is open



P1	203	psig Supply Container		**P4**	340	psig Hose End Valve
P2	203	psig Pump Inlet		**P5**	300	psig Engine Fuel Tank (LPI)
P3	345	psig Pump Outlet		**P6**	233	psig Bypass to Supply Tank

What would account for the difference in pressure at **P5** and **P4**?

_____

_____

What should happen next in the dispenser section to protect components from unnecessary wear and to avoid wasting electricity?

_____

_____

_____

Review of Chapter 2

Directions: Select from the list below the response that most correctly completes each of the following statements. Write the letter of your choice in the space provided. Answers may be used more than once.

A. radiant heat from road surfaces
B. 203 psig
C. bypass
D. 300 psig
E. 345 psig
F. in-tank fuel pump
G. restrictions in the engine fuel tank filler line

_____ 1. Two causes of under-body-mounted engine fuel tank pressure higher than the pressure in a dispenser supply tank are _____$_1$ and _____$_2$.

_____ 2.

_____ 3. The _____ limits the dispenser delivery pressure against a closed hose end valve or an engine fuel tank's overfilling prevention device.

_____ 4. In the scenarios presented, the highest pressure shown for the vehicle engine fuel tank is _____.

_____ 5. In addition to higher engine fuel tank pressures, LPI vehicles require higher dispenser refueling differential pressures due to _____.

_____ 6. Propane stored in a container under pressure at 100°F will have a pressure of approximately _____.

Chapter Three

Dispenser System Components

CHAPTER 3: DISPENSER SYSTEM COMPONENTS

An autogas dispenser system consists of:

- One or more supply containers;
- Tank valves, fittings and piping;
- Pump and bypass circuit;
- Dispensing meter and control unit, associated hoses, hose end valves and pull-away protection devices;
- Electrical system;
- Emergency shutdown system; and
- Auxiliary equipment, such as a fire extinguisher.

Figure 11. Supply Container, Pump and Bypass

Figure 12. Dispenser Meter and Control Unit

Figure 13. Emergency Shutdown Station and Fire Extinguisher

The design and layout of a dispenser installation must be fitted to the customer's needs and specific site requirements. The installation shown is capable of refueling two vehicles at the same time and would be suitable for a private fleet or a public service station. For a large bus fleet a larger supply tank, access to two sides of the dispenser unit, or other modifications might be necessary. A transfer bulkhead may also be required (see Appendix C).

3.1 Supply Containers

For most dispensers, an aboveground ASME tank is preferable to a mounded or buried underground tank. Aboveground tanks cost less to install, are more accessible for maintenance, and involve less complicated installation requirements. Aboveground tanks are also cheaper and faster to move if the customer needs to relocate the facility.

NPFA 58, *Liquefied Petroleum Gas Code*, limits to 30,000 gallons the aggregate (total) water capacity of supply tanks for dispensing stations that are not located in LP-gas bulk plants, industrial plants or industrial applications.[1] Fire protection must be provided for installations with an aggregate water capacity of more than 4,000 gallons, as specified in a written fire safety analysis for the installation.[2]

Site requirements or jurisdictional authorities may necessitate an underground or vertical supply tank installation. Neither of these challenges should be viewed as insurmountable.

Underground and mounded containers must be installed in accordance with NFPA 58 provisions requiring corrosion protection and testing.[3]

Vertical tank installations must meet the fire-protection provisions of NFPA 58, 2011 edition, §6.6.4 and the structural requirements of NFPA 58, 2011 edition, §5.2.4.3 relating to seismic (earthquake) and wind-loading forces.

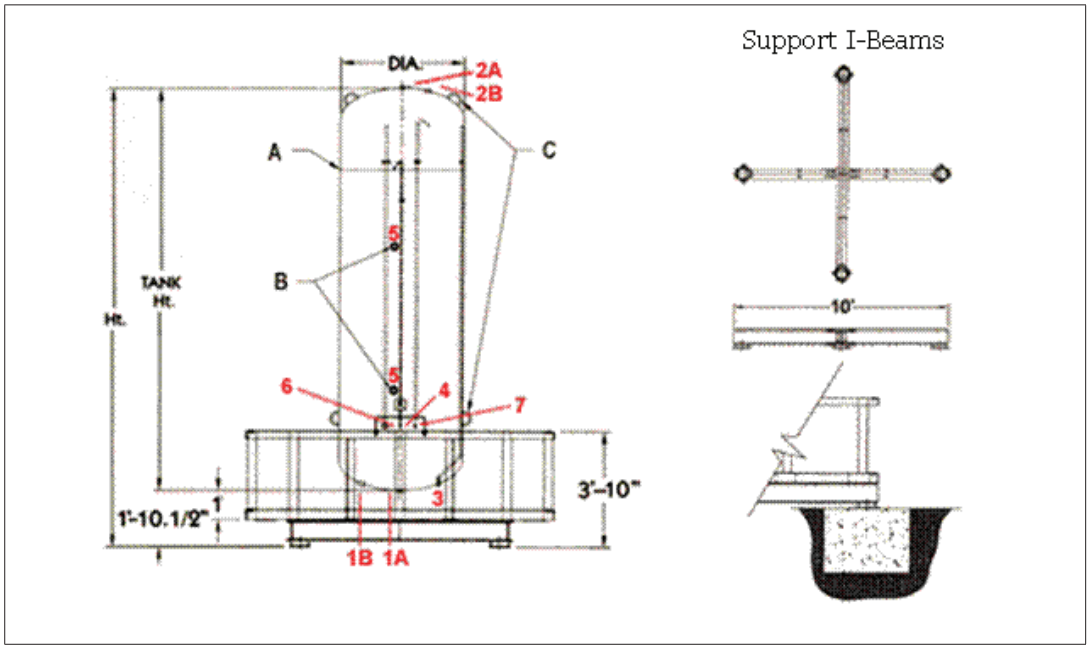


Figure 14. Vertical Tank Specification Drawings and Foundation Partial Detail

1 NFPA 58, 2011 ed., §5.2.1.9

2 NFPA 58, 2011 ed., §§6.25.3.1 and 6.25.3.2

3 NFPA 58, 2011 ed., §6.6.1-6.6.3 as applicable to buried or mounded installations

Warning: The foundation partial detail drawing shown in Figure 14 is not the manufacturer's actual foundation plan. Obtain and use the actual foundation plan provided in the manufacturer's installation instructions for the specific tank you plan to install.

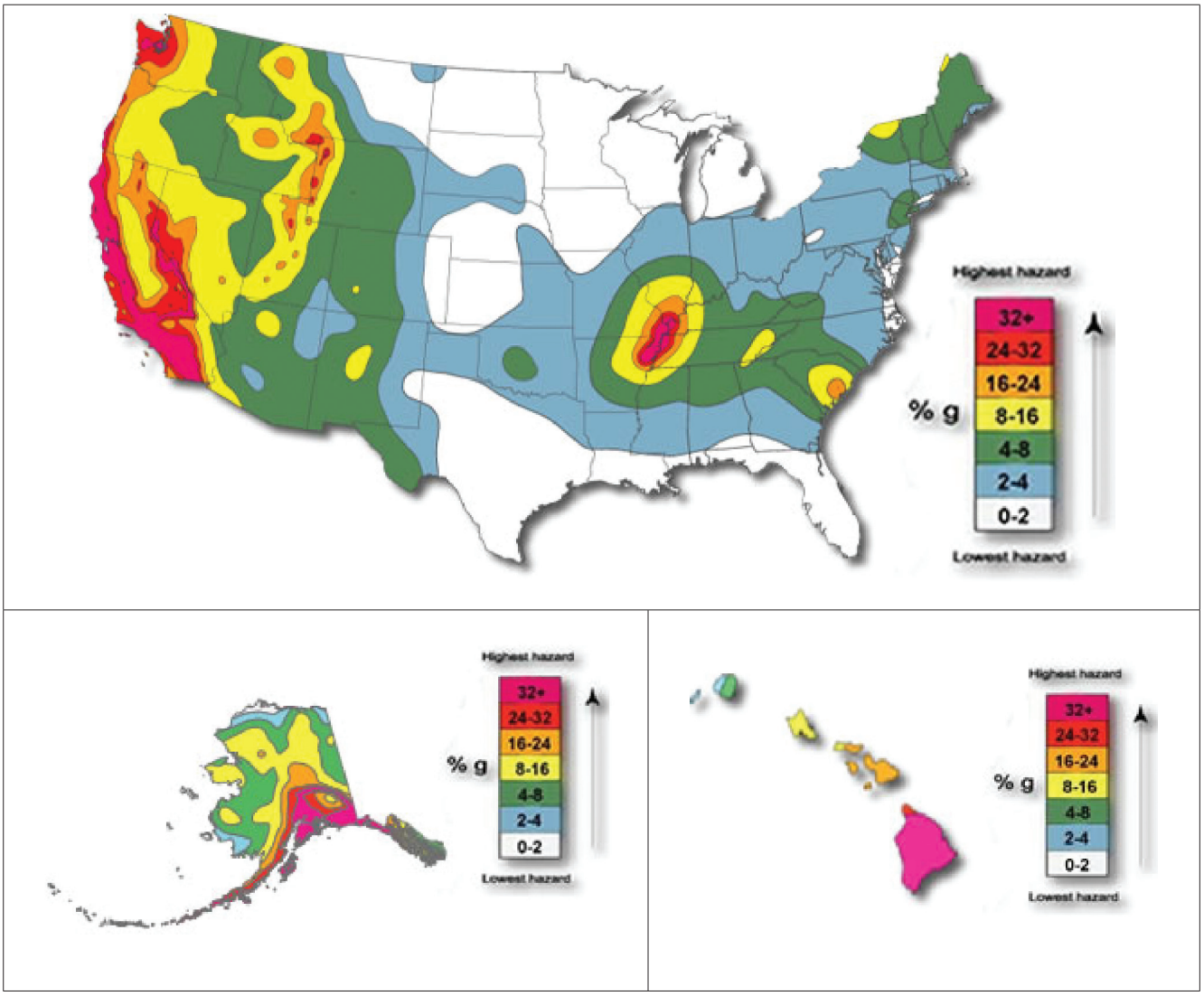


Figure 15. Probabilistic Seismic Hazard Maps
Source: U.S. Geological Survey

3.2 Pump and Bypass Fundamentals

Selecting a properly sized and rated pump and bypass system is critical to any successful dispenser installation. A pump that capably supplies propane at the proper pressure and volume for a single-hose dispenser unit may not provide the proper volumes and pressures needed to supply two 2-hose dispenser units.

Always follow the pump manufacturer's instructions for selecting, installing, and completing initial operational checks of a dispenser system. New or unusual system installations, such as those with underground storage tanks, merit a conversation with the pump manufacturer's product specialist to prevent costly and potentially embarrassing mistakes.

NFPA 58, 2011 ed., §6.17.2, Pump Installation, sets out the minimum requirements for pump and bypass equipment. The standard requires pumps to be installed in accordance with the pump manufacturer's instructions.[4]

3.3 Pump Installations--Aboveground Tanks

Applying the practices shown in the following illustrations will go a long way towards installing a dispensing system that reliably satisfies a customer's refueling needs. These general principles work with various manufacturers' propane pumps, whether the pump is a regenerative turbine, gear or vane type.

1. Always locate the pump below the tank—never above the liquid level.

2. The tank's excess flow valve (EFV) should have a flow rate of 1½ to 2 times the capacity of the pump. Do not use an EFV without knowing its flow capacity.

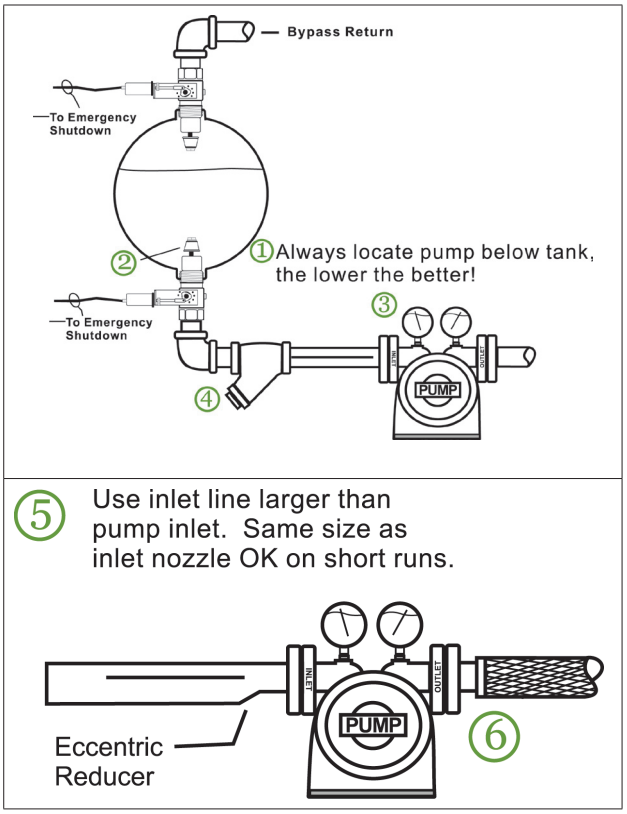
3. Install a liquid-filled pressure gauge at the inlet nozzle of the pump.

4. Install a Y-type strainer on the inlet line of the pump. Use a 20-mesh screen for a turbine pump and a 40-mesh screen for a vane or gear pump.

5. An eccentric swage should be installed, flat side up, at the pump inlet nozzle to change the line size.

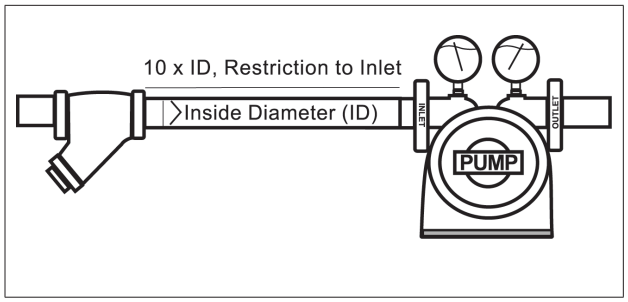
6. A flexible connection should be used at the pump inlet and/or outlet connection to accommodate piping strains.

7. If the outlet piping exceeds 50 feet in length, a check valve should be installed near the pump outlet.



4 NFPA 58, 2011 ed., §6.17.2.1

8. The nearest restriction to the pump inlet should be no closer than 10 times the diameter of the pipe.

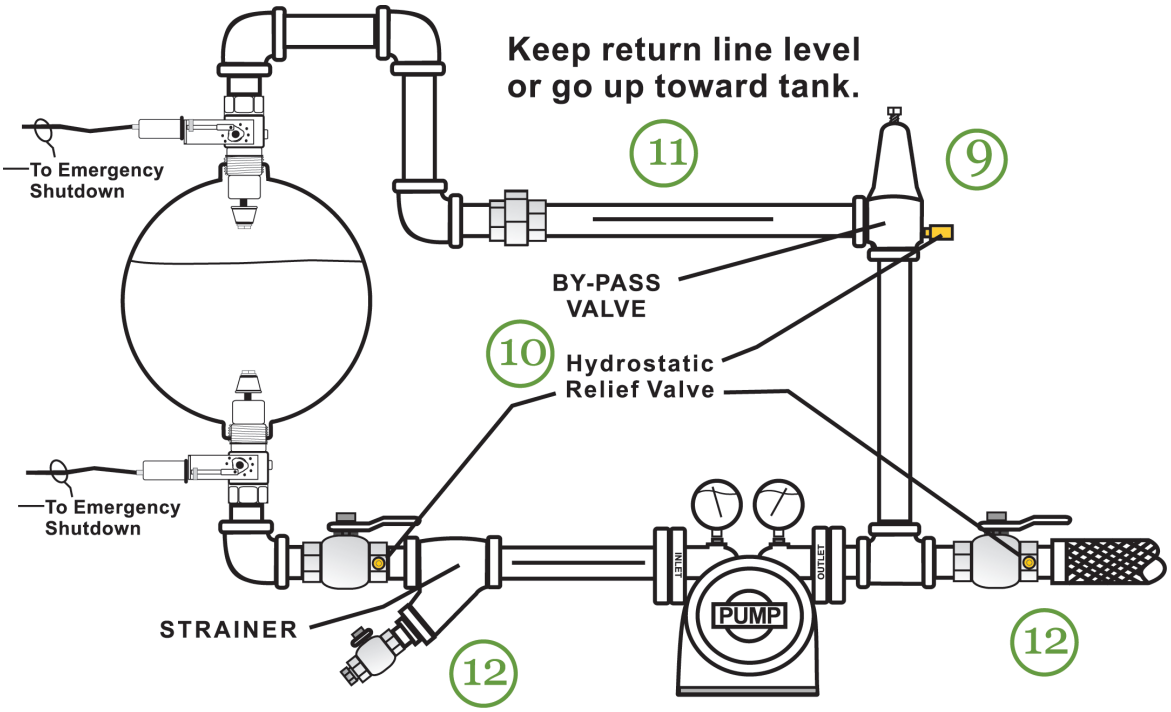


9. NFPA 58 requires an external bypass valve to be installed in the piping between the pump discharge nozzle and the supply tank for pump recirculation. Consult the pump manufacturer for instructions on setting the discharge pressure of the bypass valve (350 psig maximum system pressure).

10. A hydrostatic relief valve must be installed in the outlet piping and in any piping section where liquid propane can be trapped between closed valves or cannot return to the supply tank.

11. The bypass line should rise uninterrupted to an opening in the vapor space of the storage tank. The tank fitting should be either an excess flow valve or a vapor return valve; it should never be a filler valve or a back check valve.

12. To isolate the strainer, pump and bypass valve for service, full-port ball valves with tapped openings for hydrostatic relief valves are recommended. A suitable drain valve may be installed in the bottom of the strainer body. The drain valve must be closed and its outlet plugged when not in use for servicing the strainer, pump or other fitting.



13. Follow the pump manufacturer's recommendations to match the motor horsepower rating to the pump and the dispenser's operating conditions. Wherever possible use a 3-phase electric motor. If 3-phase electrical power is not available on the site, the use of an "add-a-phase" (variable frequency drive) is recommended for increased motor life and lower initial and longer-range operating costs.

14. Properly locating line valves, piping unions or flanges, and an explosion-proof electrical conduit union facilitates maintenance and replacement of pump circuit components.

15. Initial operational checklists should include at least the following:

    - Inspecting for the adequacy of pump/motor foundation support and mounts;
    - Inspecting for piping flexibility and support;
    - Checking for leakage;
    - Verifying correct pump/motor rotation;
    - Setting the bypass valve for proper opening pressure and securing the load spring adjustment as directed in the manufacturer's instructions;
    - Verifying that the pump motor can be turned on or off as appropriate, at the circuit breakers and disconnect box, manual electrical switch, emergency shutdown station, and as directed by the dispenser on/off switch and "off" by the time-out selector switch.

3.4 Dispenser Cabinets and Metering Devices

Dispenser cabinets and metering devices are available to meet the needs of different applications. Dispenser options generally include the following:

Small Fleet, Fixed-Base Operation

- Simple dispenser on tank skid, horizontal or vertical supply tank;
- Single or two-vehicle refueling;
- Meter reading on dispenser only;
- Fleet vehicle/operator card reader.

Figure 16. Horizontal Tank Skid and Dispenser Meter/ Control Unit

Figure 17. Horizontal Tank Skid and Dispenser Meter/ Control Unit

Large Fleet, Fixed-Base Operation

- Remotely located dispensers supplied by one or more supply tanks (up to aggregate 30,000 gallons water capacity);
- Single or two-vehicle refueling;
- Fleet vehicle/operator card reader;
- Data downloadable at the dispenser only, or networked with other locations via the Internet.

Figure 18.
Vertical Tank, Single-Vehicle Dispenser and Meter/ Control Unit

Public Service Station

- Single or multiple remotely located dispensers supplied by one or more supply tanks (up to aggregate 30,000 gallons water capacity);
- Single or two-vehicle refueling;
- Credit, debit, fleet fuel supplier card reader and interactive keypad;
- Data uploadable and downloadable via the Internet.

Figure 19. Self-Service Hose-End Valve Interlock Switch

Figure 20. Customer Credit Card Interface and Display Panel

Each dispenser option and feature must be considered in the dispenser design and layout, especially for dispensers that need data-communication capability.

3.5 Meters and Metering Options

Meters for autogas dispenser applications vary depending on the number of vehicles refueled at the dispenser and the data and communication capabilities needed. Two-vehicle refueling dispensers may incorporate a modular design with two separate vapor eliminators/tank pressure sensing lines and differential valves and separate data-communication links.

Figure 21. Single-Customer Configuration

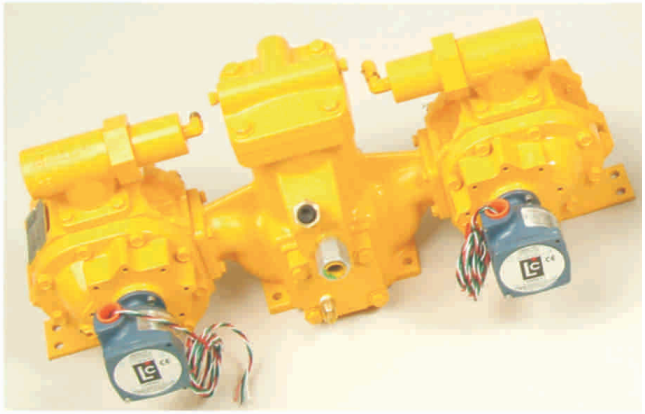


Figure 22. Two-Customer Configuration

3.6 Hose, Hose-End Valve, Emergency Shutdown Systems

Dispenser Hose

The minimum working pressure of dispenser hose is 350 psig with a safety factor of 5 to 1, meaning that the burst pressure rating of the hose is 1,750 psig. The hose must be continuously marked with at least the following information:

- LP-GAS HOSE or LPG HOSE (PROPANE was acceptable in editions of NFPA 58 prior to the 2011 edition);
- Minimum working pressure;
- Manufacturer's name or coded designation;
- Month or quarter and year of manufacture (new requirement in 2011 edition of NFPA 58); and
- Product identification (new requirement in 2011 edition of NFPA 58).

Hose assemblies, after the application of couplings, must have a design capability of not less than 700 psig. If a pressure test of a hose assembly is performed [by the hose assembly manufacturer or assembler], it must be pressure-tested at 120 percent of the maximum working pressure (350 psig minimum) of the hose, i.e., a test pressure of 420 psig for the assembly.

At the time of installation, hose assemblies must be leak-tested at not less than the operating pressure of the system in which they are installed. This requirement of NFPA 58 may be met using leak-detection solution applied at each hose connection with the dispenser pump operating.[5]

The length of dispenser hoses is limited to 18 feet, unless a longer length is approved by the authority having jurisdiction.

When the hose is not in use, it must be secured to prevent damage.[6]

An emergency breakaway device (Figure 23) that will retain liquid on both sides of the breakaway point must be installed and secured.[7]

Figure 23. Emergency Breakaway Device

5 NFPA 58, 2011 ed., §5.9.6.4, (A) through (E)

6 NFPA 58, 2011 ed., §6.24.4.1 (1) and (3)

7 NFPA 58, 2011 ed., §6.24.4.2

Hose-End Valve

The hose end valve used to connect to vehicle filler valves must be a listed quick-acting shutoff type.[8]

For dispensers installed in service stations where other liquid or gaseous fuels are dispensed, the dispensing nozzle of the hose end valve must not release more than 2 cm^3 (0.12 in^3) of liquid upon disconnection.[9]

Dispenser liquid piping and the dispensing hose must be provided with hydrostatic relief valves where liquid propane can be trapped between closed valves that prevent it from returning to the dispenser supply tank.[10]

Figure 24. Hose-End Valve with Minimum-Loss Nozzle

NFPA 58 requires an excess-flow check valve or differential back pressure valve to be installed in or on the dispenser at the point where the dispenser hose is connected to the liquid piping.[11] Typically this requirement is met by the differential valve of the dispenser meter.

Emergency Shutdown Systems

The liquid withdrawal opening on the dispenser supply tank must be equipped with either:

- An internal valve fitted for remote closure and automatic shutoff using thermal (fire) activation, or
- A positive shutoff valve located as close to the container as practical in combination with an excess-flow valve installed in the container, plus an emergency shutoff valve that is fitted for remote closure and installed downstream in the line as close as practical to the positive shutoff valve. [12]

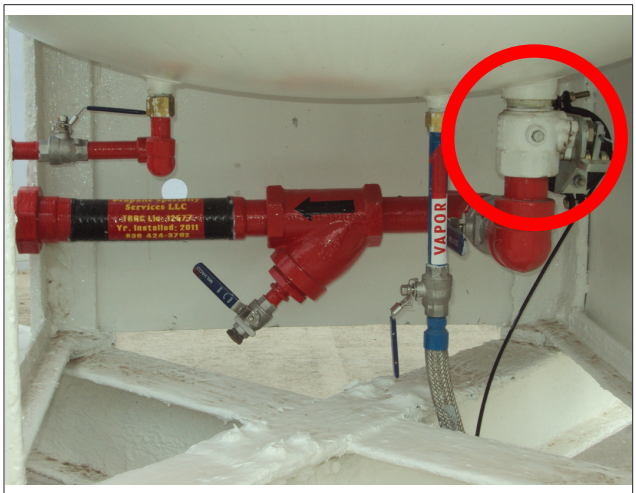


Figure 25. Internal Valve With Automatic Shutoff

8 NFPA 58, 2011 ed., §6.24.3.13

9 NFPA 30A, 2008 ed., §12.5.1

10 NFPA 58, 2011 ed., §6.24.3.6

11 NFPA 58, 2011 ed., §6.24.3.5

12 NFPA 58, 2011 ed., §6.24.3.8

An identified and accessible remote emergency shutoff device must be located not less than 3 feet or more than 100 feet from the dispenser. When activated, the device must be able to stop the flow of gas from the supply tank. [13]

To shut off electrical power to the dispenser in the event of a fire, accident or other emergency, an identified and accessible switch or circuit breaker must be installed not less than 20 feet or more than 100 feet from the dispenser.[14]

Both emergency shutoff functions (gas and electricity) may be combined into a single emergency activation device.

Figure 26. Emergency Shutoff

13 NFPA 58, 2011 ed., §6.24.3.9

14 NFPA 58, 2011 ed., §6.24.3.14

Review of Chapter 3

Directions: Select from the list below the response that most correctly completes each of the following statements. Write the letter of your choice in the space provided.

A. 1½ to 2
B. underground tanks
C. hydrostatic relief valve
D. flexible connection
E. single and two-customer
F. pump manufacturer's
G. 100 feet
H. 10 times
I. setting and securing bypass adjustment
J. quick shutoff
K. fire safety analysis
L. liquid on both sides
M. 30,000
N. vertical
O. 3-phase
P. 350 psig
Q. 4,000

___ 1. NFPA 58 limits the aggregate water capacity of dispenser supply tanks that are not located in bulk plants or industrial plants to _____ gallons.

___ 2. A dispenser with a supply tank aggregate water capacity of _____ gallons must be provided fire protection as indicated in a _____.
2 3

___ 3.

___ 4. Corrosion protection and testing of the corrosion protection are required for buried _____ and piping.

___ 5. In addition to fire-protection requirements, _____ tank installations must consider seismic and wind loading forces.

___ 6. NFPA 58 requires pumps to be installed in accordance with the _____ installation instructions.

___ 7. The supply tank excess flow valve (EFV) should have a flow rate of _____ times the capacity of the pump.

___ 8. A _____ should be used at the pump inlet and/or outlet to accommodate piping strains.

___ 9. The nearest restriction to the pump inlet should be no closer than _____ the diameter of the pipe.

___ 10. A _____ must be installed in any piping section where liquid propane can be trapped between closed valves and/or cannot return to the supply tank.

___ 11. The electric motor for a pump should match the horsepower rating and motor type specified by the pump manufacturer, and a _____ motor should be used wherever possible.

___ 12. A step in the initial dispenser operational check list is _____ as directed in the manufacturer's instructions.

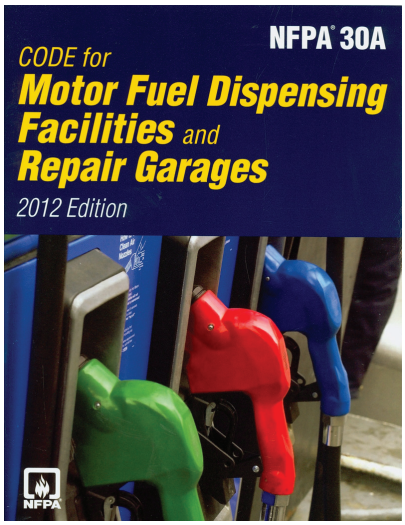
___ 13. Dispenser meters are available in _____ configurations.

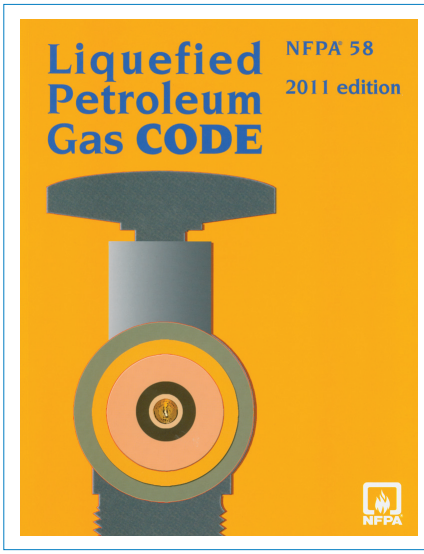
___ 14. The minimum working pressure of dispenser hose is _____, and NFPA 58 required markings must be continuously visible along the full length of the hose.

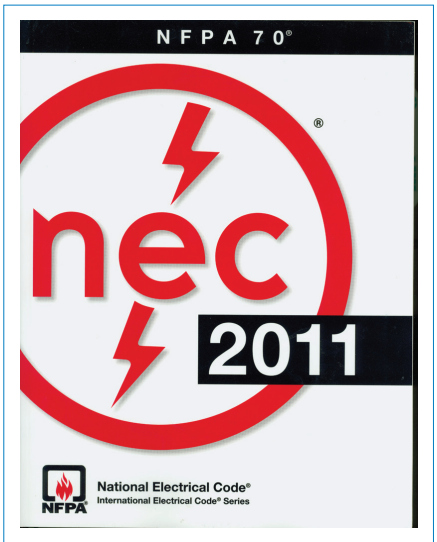
___ 15. Dispenser hose-end valves must be _____ types.

___ 16. An identified and accessible remote emergency shutoff device which when activated can stop the flow of gas from the supply tank must be located not less than 3 feet or more than _____ from the dispenser.

___ 17. An emergency breakaway device that retains _____ of the breakaway point must be installed and secured in the dispenser hose.







Chapter Four

Code Requirements for Propane Dispensers

CHAPTER 4: CODE REQUIREMENTS FOR PROPANE DISPENSERS

4.1 NFPA 58, *Liquefied Petroleum Gas Code*

Code requirements for dispensers are found in several locations in NFPA 58. In the 2011 edition, specific dispenser requirements are located primarily in §6.24, Vehicle Fuel Dispenser and Dispensing Stations.

Fire-protection planning requirements are located in §6.25. A written fire safety analysis is required for new dispenser installations. Fire protection, as determined in the fire safety analysis, must be provided for supply tanks with aggregate water capacity over 4,000 gallons.

Requirements for dispenser supply tanks are located in:

- Chapter 5, LP-Gas Equipment and Appliances, and
- Chapter 6, Installation of LP-Gas Systems.

NFPA 58 specifically requires dispensers to be installed according to their manufacturer's installation instructions.

4.2 NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*

Where a propane autogas dispenser is installed at a multiple-fuel refueling station, the installation is subject to the provisions of NFPA 30A, Chapter 12, Additional Requirements for CNG, LNG, Hydrogen and LPG.

Both NFPA 58 and NFPA 30A require physical and security protection for aboveground and underground tanks and dispensers. Both codes require corrosion protection for buried tanks and piping.

Physical protection requirements for aboveground tanks in service stations are located in NFPA 30A (2012 ed.), §4.3.7.

Figure 27 illustrates the minimum separation distances that apply to propane autogas dispensers at multiple-fuel refueling stations. Always consult local jurisdictional requirements before installing any dispenser.

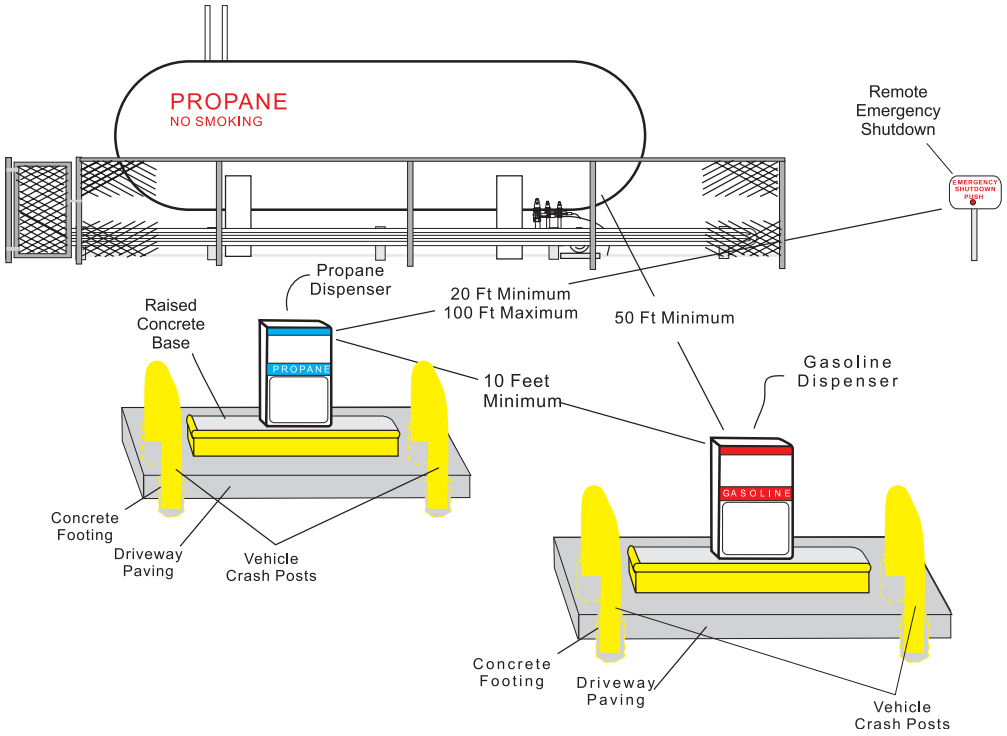


Figure 27. NFPA 30A Minimum Tank and Dispenser Separation Distances

4.3 NFPA 70, *National Electrical Code*

Dispenser installations must comply with the requirements of the National Electrical Code (NEC). The most important information for dispenser installers related to complying with the NEC can be found in NFPA 58, §6.22.2, Electrical Equipment.

In particular, installers should be familiar with the parts of Table 6.22.2.2, Electrical Area Classification that apply to dispenser installations. See Appendix D of this training guide.

A key to determining electrical classification compliance is the location of Class I, Group D fixtures and electrical seal-offs at the boundaries of the classification areas. Seal-offs are designed to prevent gas vapor from migrating into other electrical and communication systems' wiring areas away from the dispenser. Once wiring is installed, seal-offs must be filled with a fire-retardant putty to perform their function.

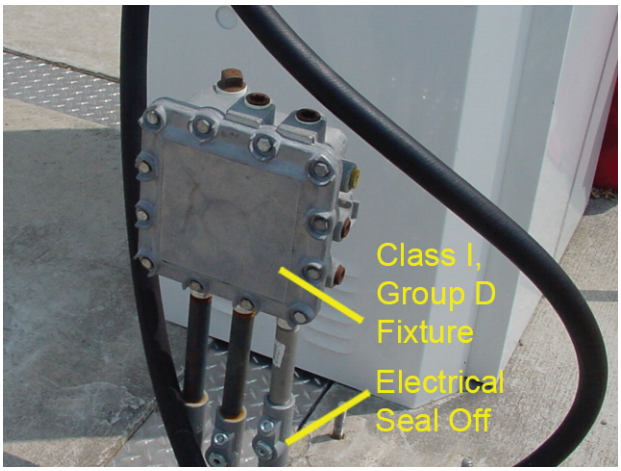


Figure 28. Explosion-Proof Electrical Fixture and Seal-Offs

4.0

Review of Chapter 4

Directions: Select from the list below the response that most correctly completes each of the following statements. Write the letter of your choice in the space provided.

A. 2 cubic centimeters (2 cm^3)
B. 20 feet
C. fire-retardant putty
D. electrical seal-offs
E. NFPA 30A
F. 10 feet
G. NFPA 58
H. 100 feet
I. raised concrete footing
J. fire safety analysis

___ 1. Specific code requirements for dispensers are primarily found in a section of _____ entitled Vehicle Fuel Dispenser and Dispensing Stations.

___ 2. A written _____ is required for a new dispenser installation.

___ 3. Chapter 12 of _____ applies to propane dispensers installed where other liquid or gaseous fuels are dispensed (i.e., at a multiple-fuel service station).

___ 4. For propane dispensers installed in multiple-fuel service stations, the dispensing nozzle of the hose-end valve must not release more than _____ of liquid upon disconnection.

___ 5. NFPA 30A requires that a propane dispenser must be separated from a gasoline dispenser by at least _____.

___ 6. Physical protection measures for dispensers installed under provisions of NFPA 30A include installing vehicle crash posts and installing the dispenser on a _____.

___ 7. Remote emergency shutdowns for a dispenser installed under provisions of NFPA 30A must be no closer to the dispenser than _____ and no farther away than _____.
7 8

___ 8.

___ 9. To prevent gas vapor from migrating into other electrical and communication wiring, _____ are required.

___ 10. Once electrical wiring is installed, seal-offs must be filled with _____.

Chapter Five

Propane Dispenser Operation

CHAPTER 5: PROPANE DISPENSER OPERATION

5.1 General Precautions for Propane Dispenser Operators

NFPA 58, *Liquefied Petroleum Gas Code*, requires each person who fills or services a propane engine-fuel system to be trained.[1] State and local jurisdictional authorities may require additional dispenser operator training.

Some dispenser suppliers program their public refueling stations and their fleet dispensers to recognize a magnetic strip card for each person trained to operate their dispenser. Without the required training and card, the dispenser will not allow refueling operations to begin.

Dispenser operators must comply with all instructions posted at the dispenser.

Figure 29. Trained Dispenser Operator

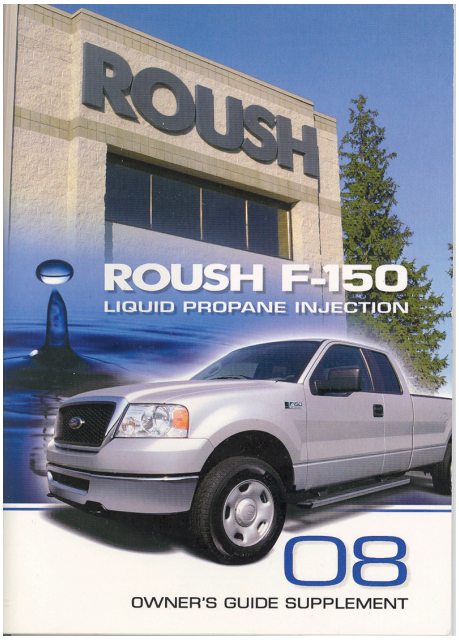


Figure 30. Manufacturer's Instructions

In addition to completing all training required, dispenser operators should read and follow the vehicle's and/or fuel-system manufacturer's refueling instructions and operating manuals for each vehicle they refuel or drive. Pay particular attention to specific warnings such as the following:

1 NFPA 58, 2011 ed., §11.2 Training

WARNING
Before refueling, extinguish all open flames and smoking materials. Ensure that no electrical sparks are present.

WARNING
The fuel system is under pressure (as much as 300 psi) at all times. Ensure that there is adequate ventilation around the dispensing area. Do NOT use bare hands to check for a leak—propane liquid is extremely cold (44° below zero Fahrenheit) as it turns to vapor. Contact can cause severe frostbite.

WARNING
Stop refueling if there is any difficulty with the refueling process or the dispensing equipment. Notify the station operator at once.

5.2 Refueling Preparations

Bi-Fuel Vehicles

Some bi-fuel vehicles must start on gasoline and then can change over to operate on propane autogas.

Figure 31. Bi-Fuel Vehicle Propane Fill Connection

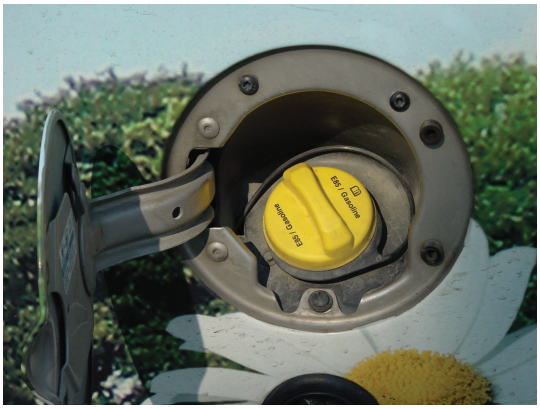


Figure 32. Bi-Fuel Vehicle Gasoline Fill Connection

Before shutting down the engine to refuel with propane, verify that there is enough fuel in the gasoline tank to restart the engine. If necessary, refuel the gasoline tank first.

General Preparations Applicable to Any Vehicle

1. **Locate Dispenser Safety and Emergency Features**

   Upon arrival at the refueling dispenser, find the emergency shutdown station.

   - Be sure that you have a clear path to move from the dispenser to the emergency shutdown.
   - Read the emergency instructions posted.
   - If you have any question about the meaning of the instructions or how to activate the control, ask the station operator for assistance.
   - Verify that there are no apparent problems with the dispensing equipment before proceeding.

Figure 33. Emergency Shutdown Station

2. **Following state, local code, fleet or vehicle owner procedures, verify that no one is in the vehicle during refueling operations, and that all ignition sources are eliminated.**

   Extinguish all standing pilots and/or turn off electronic igniters on water heaters, cooking appliances, and coffeemakers. These actions are particularly important when refueling recreational vehicles, catering trucks and mobile kitchens.

   School buses and other passenger vehicles should be vacated during refueling.

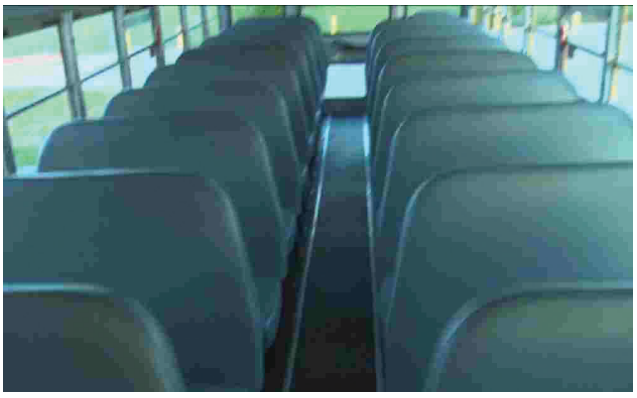


Figure 34. School Bus Vacated During Refueling

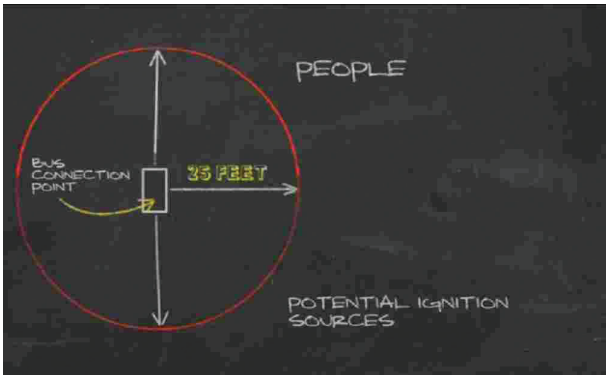


Figure 35. Potential Ignition Sources

3. Remove the Filler Valve Dust Cover and Check the Seal

The dispenser hose end valve and nozzle make a leak-tight seal with the vehicle filler valve by compressing a flat gasket or O-ring.

Figure 36. Filler Valve Dust Cover

Figure 37. Filler Valve Dust Cover

This seal must be in place and not damaged to prevent leakage of liquid propane during refueling.

- Remove the filler valve dust cap.
- Inspect the flat gasket or O-ring for breaks, tears or cuts.
- If the seal is damaged or missing, do not proceed with refueling until it is replaced.

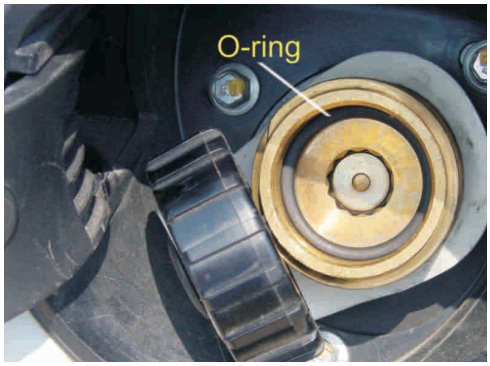


Figure 38. Filler Valve O-Ring

5.3 General Steps for Operating an Autogas Dispenser

1. Remove the hose-end valve/nozzle from the dispenser.

The hose-end valve's mounting/retention brackets may be different from the type shown here.

2. **Tighten the nozzle onto the vehicle's filler valve by turning to the right (clockwise) until it cannot be turned any more.**

   Test the seal for a leak-tight connection by momentarily squeezing, then releasing the valve handle trigger.

   If no leakage is seen or heard, the seal is good. Proceed with the refueling operation. If leakage is detected by sight or sound, re-tighten the nozzle and test again. If a gas-tight seal is not possible, do not refuel until the O-ring or gasket is replaced.

3. **Activate the dispenser by using a fleet ID or credit card, or by entering any required operator and vehicle information.**

4. **Zero the meter or press the Start button to begin pump and meter operation.**

5. **Begin fuel transfer by squeezing the trigger on the hose-end valve handle. Continue holding it open until the vehicle's overfilling prevention device stops the flow.**

   Except in the event of an emergency, the dispenser operator must remain at the refueling point throughout the operation of the dispenser.

   NOTE: When the overfilling prevention device stops the flow, some nozzles will vent a small quantity of gas trapped between the vehicle's filler valve and the nozzle.

6. **Release the hose end valve handle.**

7. **Loosen the nozzle approximately 1/8 of a turn (counter-clockwise) until you can hear a quick release of gas trapped between the nozzle and the vehicle filler valve if the release did not occur automatically.**

8. **After all trapped gas is released and you cannot hear or see further release, completely disconnect the nozzle.**

9. **Secure the hose-end nozzle in the dispenser cabinet.**

   The hose-end valve's mounting/retention brackets may be different from the type shown here.

10. **Record any required fleet vehicle refueling information, or remove and retain the transaction receipt as required.**

5.4 Restarting the Vehicle After Refueling

WARNING

Do not enter the vehicle, attempt to start the engine, or drive the vehicle if you can hear, see, or smell propane leaking in or around the vehicle.

Start the vehicle as directed in the manufacturer's operating manual. For example, the starting instructions for a 2008 Roush F-150 LPI pickup emphasize immediately releasing the key switch after turning the switch to position 4 to begin the start cycle. When starting a warm engine, there will be a delay after releasing the key before the starter begins to operate. The delay is normal and will last between 2 and 10 seconds, depending on the temperature of the fuel. Under severe operating conditions, the delay could be up to 20 seconds.

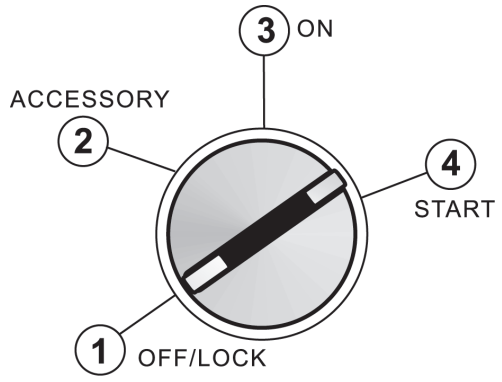


Figure 39. Ignition Switch

Some bi-fuel vehicles will only start on gasoline and then change over to propane autogas operation.

In most cases, if either of these vehicle types will not start due to a malfunction, the problem will be indicated by features on the instrument control panel. If an unusual instrument panel condition is seen during engine start-up, consult the vehicle owner's manual.

Review of Chapter 5

Directions: Select from the list below the response that most correctly completes each of the following statements. Write the letter of your choice in the space provided.

A. vehicle's overfilling prevention device/ 80 percent stop-fill valve
B. clear path to move between
C. propane engine-fuel system
D. school buses and passenger vehicles
E. RVs, catering trucks, or mobile kitchens
F. bi-fuel
G. in the event of emergency
H. instrument control panel
I. read the posted instructions
J. each vehicle
K. bare hand
L. enter, attempt to start, or drive the vehicle

___ 1. Training each person who fills or otherwise services a _____ is a requirement of NFPA 58, *Liquefied Petroleum Gas Code*.

___ 2. Dispenser operators should read and follow refueling instructions for _____ they drive or refuel.

___ 3. Never check for a propane leak using your _____.

___ 4. Some _____ vehicles' engines will only start on gasoline.

___ 5. Before refueling _____, verify that all gas appliance standing pilots and/or electronic igniters are turned off.

___ 6. During refueling operations _____ should be vacated.

___ 7. With regard to a dispenser's emergency shutdown station, the operator should _____ and be sure there is a _____ the dispenser and the emergency shutdown station.
7
8

___ 8.

___ 9. Except _____ , the dispenser operator must remain at the refueling point during the whole time the dispenser is operating.

___ 10. In a propane autogas refueling operation, the flow of fuel is stopped by the _____ and/ or by releasing the trigger on the hose-end valve handle.

___ 11. Never _____ if you can hear, see, or smell propane leaking in or around the vehicle.

___ 12. Without regard to normal delays in starting, if there is a malfunction preventing the vehicle from starting, the problem will usually be indicated on the _____.

Appendices

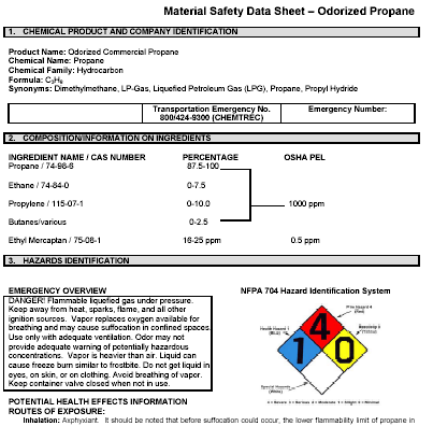
APPENDIX A: MATERIAL SAFETY DATA SHEET

Material Safety Data Sheet

Odorized Propane

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: Odorized Commercial Propane
Chemical Name: Propane
Chemical Family: Hydrocarbon
Formula: C3H8
Synonyms: Dimethylmethane, LP-Gas, Liquefied Petroleum Gas (LPG), Propane, Propyl Hydride
Transportation Emergency No.: 800/424-9300 (CHEMTRAC)


Material Safety Data Sheet – Odorized Propane

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: Odorized Commercial Propane
Chemical Name: Propane
Chemical Family: Hydrocarbon
Formula: C_3H_8
Synonyms: Dimethylmethane, LP-Gas, Liquefied Petroleum Gas (LPG), Propane, Propyl Hydride

	Transportation Emergency No. 800/424-9300 (CHEMTREC)	Emergency Number:

2. COMPOSITION/INFORMATION ON INGREDIENTS

INGREDIENT NAME / CAS NUMBER	PERCENTAGE	OSHA PEL
Propane / 74-98-6	87.5-100	
Ethane / 74-84-0	0-7.5	1000 ppm
Propylene / 115-07-1	0-10.0	
Butanes/various	0-2.5	
Ethyl Mercaptan / 75-08-1	16-25 ppm	0.5 ppm

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW
DANGER! Flammable liquefied gas under pressure. Keep away from heat, sparks, flame, and all other ignition sources. Vapor replaces oxygen available for breathing and may cause suffocation in confined spaces. Use only with adequate ventilation. Odor may not provide adequate warning of potentially hazardous concentrations. Vapor is heavier than air. Liquid can cause freeze burn similar to frostbite. Do not get liquid in eyes, on skin, or on clothing. Avoid breathing of vapor. Keep container valve closed when not in use.

NFPA 704 Hazard Identification System

POTENTIAL HEALTH EFFECTS INFORMATION
ROUTES OF EXPOSURE:
Inhalation: Asphyxiant. It should be noted that before suffocation could occur, the lower flammability limit of propane in

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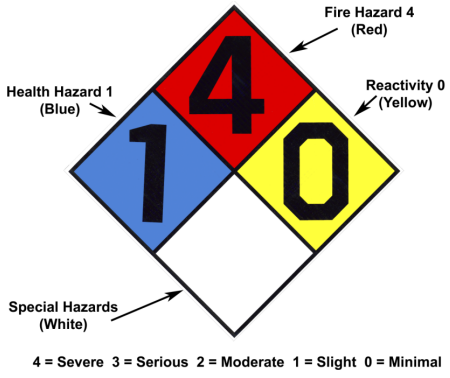

POTENTIAL HEALTH EFFECTS INFORMATION

Routes of Exposure:
Inhalation: Asphyxiant. It should be noted that before suffocation could occur, the lower flammability limit of propane in air would be exceeded, possibly causing both an oxygen-deficient and explosive atmosphere. Exposure to concentrations >10% may cause dizziness. Exposure to atmospheres containing 8%-10% or less oxygen will bring about unconsciousness without warning, and so quickly that the individuals cannot help or protect themselves. Lack of sufficient oxygen may cause serious injury or death.
Eye Contact: Contact with liquid can cause freezing of tissue.
Skin Contact: Contact with liquid can cause frostbite.
[Skin Absorption]: None.
[Ingestion]: Liquid can cause freeze burn similar to frostbite. Ingestion not expected to occur in normal use.
Chronic Effects: None.
Medical Conditions Aggravated by Overexposure: None.
Other Effects of Overexposure: None.
Carcinogenicity: Propane is not listed by NTP, OSHA or IARC.

4. FIRST AID MEASURES

INHALATION:
Persons suffering from lack of oxygen should be removed to fresh air. If victim is not breathing, administer artificial respiration. If breathing is difficult, administer oxygen. Obtain prompt medical attention.
EYE CONTACT:
Contact with liquid can cause freezing of tissue. Gently flush eyes with lukewarm water. Obtain medical attention immediately.
SKIN CONTACT:
Contact with liquid can cause frostbite. Remove saturated clothes, shoes and jewelry. Immerse affected area in lukewarm water not exceeding 105°F. Keep immersed. Get prompt medical attention.
INGESTION: If swallowed, get immediate medical attention.
NOTES TO PHYSICIAN: None.

5. FIRE-FIGHTING MEASURES

FLASH POINT: -156°F (-104°C)
AUTOIGNITION: 842°F (432°C)
IGNITION TEMPERATURE IN AIR: 920-1120°F
FLAMMABLE LIMITS IN AIR BY VOLUME: Lower: 2.15% Upper: 9.6%
EXTINGUISHING MEDIA: Dry chemical, CO2, water spray or fog for surrounding area. Do not extinguish fire until propane source is shut off.

SPECIAL FIRE-FIGHTING INSTRUCTIONS: Evacuate personnel from danger area. Evacuated personnel should stay upwind, and away from tank ends, and move to a distance at least 1 mile or more away from containers subject to direct flame. Immediately cool container(s) (especially upper half) with water spray from maximum distance and the sides of containers, taking care not to extinguish flames. If flames are extinguished, explosive re-ignition may occur. Stop flow of gas, if possible without risk, while continuing cooling water spray.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Propane is easily ignited. It is heavier than air; therefore, it can collect in low areas while dissipating. Vapors may be moved by wind or water spray. Vapors may move to areas where ignition sources are present and ignite, flashing back to the source. Pressure in a container can build up due to heat and container may rupture if pressure relief devices should fail to function.

HAZARDOUS COMBUSTION PRODUCTS: In typical use in properly adjusted and maintained gas appliances--None. If propane combustion is incomplete, poisonous carbon monoxide (CO) may be produced. Defective, improperly installed, adjusted, maintained, or improperly vented appliances may produce carbon monoxide or irritating aldehydes.

6. ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED: Evacuate the immediate area. Eliminate any possible sources of ignition and provide maximum ventilation. Shut off source of propane, if possible. If leaking from container or valve, contact your supplier and/or fire department.

7. HANDLING AND STORAGE

HANDLING PRECAUTIONS: Propane vapor is heavier than air and can collect in low areas that are without sufficient ventilation. Leak-check system with a leak detector or approved solution, never with flame. Make certain the container service valve is shut off prior to connecting or disconnecting. If container valve does not operate properly, discontinue use and contact supplier. Never insert an object (e.g., wrench, screwdriver, pry bar, etc.) into pressure relief valve or cylinder cap openings. Do not drop or abuse cylinder. Never strike an arc on a gas container or make a container part of an electrical circuit. See [Section] 16.

OTHER INFORMATION for additional precautions.

STORAGE PRECAUTIONS: Store in a safe, authorized location (outside, detached storage is preferred) with adequate ventilation. Specific requirements are listed in NFPA 58, *Liquefied Petroleum Gas Code*. Isolate from heat and ignition sources. Containers should never be allowed to reach temperature exceeding 125°F (52°C). Isolate from combustible materials. Provide separate storage locations for other compressed and flammable gases. Propane containers should be separated from oxygen cylinders, or other oxidizers, by a minimum distance of 20 feet, or by a barrier of non-combustible material at least 5 feet high, having a fire rating of at least 1 hour. Full and empty cylinders should be segregated. Store cylinders in upright position, or with pressure relief valve in

vapor space. Cylinders should be arranged so that pressure relief valves are not directed toward other cylinders. Do not drop or abuse cylinders. Keep container valve closed and plugged or capped when not in use. Install protective caps when cylinders are not connected for use. Empty containers retain some residue and should be treated as if they were full.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS
Ventilation:
Provide ventilation so propane does not reach a flammable mixture.

Ignition Source Control:
Electrical wiring in liquid transfer areas must be Class I, Group D, and explosion-proof. Other possible ignition sources should be kept away from transfer areas. NO SMOKING signs should be posted at all approaches and entries to transfer areas. Transfer and storage areas must be kept free of flammables, combustibles and vegetation.

RESPIRATORY PROTECTION (SPECIFY TYPE)
General Use: None.
Emergency Use:
If concentrations are high enough to warrant supplied-air or self-contained breathing apparatus, then the atmosphere may be flammable (See Section 5). Appropriate precautions must be taken regarding flammability.
PROTECTIVE CLOTHING:
Avoid skin contact with liquid propane because of possibility of freeze burn. Wear gloves and protective clothing which are impervious to the product for the duration of the anticipated exposure.
EYE PROTECTION:
Safety glasses are recommended when filling and handling cylinders.
OTHER PROTECTIVE EQUIPMENT:
Safety shoes are recommended when handling cylinders.

9. EXPOSURE CONTROLS/PERSONAL PROTECTION

BOILING POINT: @ 14.7 psia = -44°F
SPECIFIC GRAVITY (DENSITY) OF VAPOR (Air = 1) at 60°F: 1.50
SPECIFIC GRAVITY OF LIQUID (Water = 1) at 60°F: 0.504
VAPOR PRESSURE: @ 70°F = 127 psig @ 105°F = 210 psig
EXPANSION RATIO (from liquid to gas @ 14.7 psia): 1 to 270
SOLUBILITY IN WATER: Slight, 0.1 to 1.0%
APPEARANCE AND ODOR: A colorless and tasteless gas at normal temperature and pressure. An odorant has been added to provide a strong unpleasant odor.

ODORANT WARNING: Odorant is added to aid in the detection of leaks. One common odorant is ethyl mercaptan, CAS No. 75-08-01. Odorant has a foul smell. The ability of people to detect odors varies widely. In addition, certain chemical reactions with material in the propane system, or fugitive

propane gas from underground leaks passing through certain soils can reduce the odor level. No odorant will be 100% effective in all circumstances. If odorant appears to be weak, notify propane supplier immediately.

10. STABILITY AND REACTIVITY

STABILITY: Stable.

Conditions to avoid: Keep away from high heat, strong oxidizing agents and sources of ignition.

REACTIVITY:
Hazardous Decomposition Products: Products of combustion are fumes, smoke, carbon monoxide and aldehydes and other decomposition products. Incomplete combustion can cause carbon monoxide, a toxic gas, while burning or when used as an engine fuel.

Hazardous polymerization: Will not occur.

11. TOXICOLOGICAL INFORMATION

Propane is non-toxic and is a simple asphyxiant; however, it does have slight anesthetic properties and higher concentrations may cause dizziness.

[IRRITANCY OF MATERIAL]: None
[SENSITIZATION TO MATERIAL]: None
[REPRODUCTIVE EFFECTS]: None
[TERATOGENICITY]: None
[MUTAGENICITY]: None
[**SYNERGISTIC MATERIALS]:** None

12. ECOLOGICAL INFORMATION

No adverse ecological effects are expected. Propane does not contain any Class I or Class II ozone-depleting chemicals (40 CFR Part 82.) Propane is not listed as a marine pollutant by DOT (49 CFR Part 171).

13. DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD:
Do not attempt to dispose of residual or unused product in the container. Return to supplier for safe disposal.

Residual product within process system may be burned at a controlled rate, if a suitable burning unit (flare stack) is available on site. This shall be done in accordance with federal, state and local regulations.

14. TRANSPORTATION INFORMATION

DOT SHIPPING NAME: Liquefied Petroleum Gas
HAZARD CLASS: 2.1 (Flammable Gas)
IDENTIFICATION NUMBER: UN 1075
PRODUCT RQ: None
SHIPPING LABEL(S): Flammable gas
IMO SHIPPING NAME: Propane
PLACARD (When Required): Flammable gas

IMO IDENTIFICATION NUMBER: UN 1978
SPECIAL SHIPPING INFORMATION:
Container should be transported in a secure, upright position in a well-ventilated vehicle.

15. REGULATORY INFORMATION

The following information concerns selected regulatory requirements potentially applicable to this product. Not all such requirements are identified. Users of this product are responsible for their own regulatory compliance on a federal, state [provincial] and local level.

U.S. FEDERAL REGULATIONS:
EPA - Environmental Protection Agency

CERCLA - Comprehensive Environmental Response, Compensation and Liability Act of 1980 (40 CFR Parts 117 and 302):
Reportable Quantity (RQ): None

SARA - Superfund Amendment and Reauthorization Act

• SECTIONS 302/304: Require emergency planning on threshold planning quantities (TPQ) and release reporting on reportable quantities (RQ) of EPA extremely hazardous substances (40 CFR Part 355).
Extremely Hazardous Substances: None
Threshold Planning Quantity (TPQ): None

• SECTIONS 311/312: Require submission of material safety data sheets (MSDSs) and chemical inventory reporting with identification of EPA-defined hazard classes (40 CFR Part 370). The hazard classes for this product are:
IMMEDIATE: Yes
PRESSURE: Yes
DELAYED: No
REACTIVITY: No
FLAMMABLE: Yes

• SECTION 313: Requires submission of annual reports of release of toxic chemicals that appear in 40 CFR Part 372.

Propane does not require reporting under Section 313.

40 CFR PART 68 Risk Management for Chemical Accidental Release

TSCA - Toxic Substance Control Act
Propane is not listed on the TSCA inventory.

OSHA - Occupational Safety and Health Administration
29 CFR 1910.119: Process Safety Management of Highly Hazardous Chemicals.

FDA - Food and Drug Administration

21 CFR 184.1655: Generally recognized as safe (GRAS) as a direct human food ingredient when used as a propellant, aerating agent and gas.

16. OTHER INFORMATION

SPECIAL PRECAUTIONS: Use piping and equipment adequately designed to withstand pressures to be encountered.

NFPA 58 *Liquefied Petroleum Gas Code* and OSHA 29 CFR 1910.110 require that all persons employed in handling LP-gases be trained in proper handling and operating procedures, which the employer shall document. Contact your propane supplier to arrange for the required training. Allow only trained and qualified persons to install and service propane containers and systems.

WARNING: Be aware that with odorized propane, the intensity of ethyl mercaptan stench (its Odor) may fade due to chemical oxidation (in the presence of rust, air or moisture), adsorption or absorption. Some people have nasal perception problems and may not be able to smell the ethyl mercaptan stench. Leaking propane from underground lines may lose its odor as it passes through certain soils. While ethyl mercaptan may not impart the warning of the presence of propane in every instance, it is generally effective in a majority of situations. Familiarize yourself, your employees and customers with this warning and other facts associated with the so-called odor-fade phenomenon. If you do not already know all the facts, contact your propane supplier for more information about odor, electronic gas alarms and other safety considerations associated with the handling, storage and use of propane.

Issue Date: November, 2001 ISSUE INFORMATION

This material safety data sheet and the information it contains is offered to you in good faith as accurate. Much of the information contained in this data sheet was received from outside sources. To the best of our knowledge this information is accurate, but the Propane Education and Research Council does not guarantee its accuracy or completeness. Health and safety precautions in this data sheet may not be adequate for all individuals and/or situations. It is the user's obligation to evaluate and use this product safely, comply with all applicable laws and regulations and to assume the risks involved in the use of this product.

NO WARRANTY OF MERCHANTABILITY, FITNESS FOR ANY PARTICULAR PURPOSES, OR ANY OTHER WARRANTY IS EXPRESSED OR IS TO BE IMPLIED REGARDING THE ACCURACY OR COMPLETENESS OF THIS INFORMATION, THE RESULTS TO BE OBTAINED FROM THE USE OF THIS INFORMATION OR THE PRODUCT, THE SAFETY OF THIS PRODUCT, OR THE HAZARDS RELATED TO ITS USE.

The purpose of this MSDS is to set forth general safety information and warnings related to the use of propane. It is not intended to be an exhaustive treatment of the subject, and should not be interpreted as precluding other authoritative information or safety procedures which would enhance safe LP-gas storage, handling or use. Issuance of this MSDS is not intended nor should it be construed as an undertaking to perform services on behalf of any party either for their protection or for the protection of third parties. The Propane Education and Research Council assumes no liability for reliance on the contents of this material safety data sheet.

APPENDIX B: GLOSSARY

ASME American Society of Mechanical Engineers. ASME sets manufacturing standards for propane autogas containers, including standards for maximum design pressure, testing, marking and fabrication. Propane containers that are designed, tested, marked, and fabricated in accordance with ASME standards are referred to as "tanks" and are marked with the ASME cloverleaf seal.

Autogas The international term for LP-gas mixtures used to propel highway vehicles. In the U.S., autogas is at least 90 percent propane, and the terms "autogas," "propane," and "propane autogas" are used interchangeably. Elsewhere "autogas" may refer to mixtures of propane and butane in various proportions. See also HD-5.

Autostop
A float-actuated valve inside a propane fuel tank that automatically prevents the tank from being filled past the 80 percent liquid level. See OPD.

Bi-Fuel Describes a vehicle that can operate on either of two fuels, one at a time, e.g., either autogas or gasoline

.

Dual-Fuel
Describes a vehicle that can operate on a mixture of two fuels at the same time, e.g., autogas and diesel.

EPA Environmental Protection Agency. The federal agency that sets and enforces air-quality standards, including standards for emissions from motor vehicles.

Explosion-Proof
An electrical system made up of Class I, Group D electrical fixtures and components. Such a system is generally called "explosion-proof." In reality, the individual parts of the system are not explosion-proof; rather, they are designed and built to momentarily retain the rapidly expanding hot gases produced inside them if a combustible mixture inside the electrical system is ignited by electrical spark or mechanical action, and then control the spread of hot gases to the outside environment.

HD-5 Propane autogas that meets the specification defined in Gas Processors Association (GPA) Standard 2140-97, Liquefied Petroleum Gas Specifications and Test Methods. The specification is incorporated as "special duty propane" in ASTM D-1835, Standard Specification for Liquefied Petroleum (LP) Gases.

The letters HD in HD-5 stand for "Heavy Duty," and the number 5 represents the maximum percentage of propylene allowed in the fuel blend. HD-5 must be at least 90 percent propane and may contain up to 2.5 percent butane and heavier hydrocarbons by

liquid volume. HD-5 must be essentially free from oily residues and other contaminants such as sulfur. A maximum vapor pressure of 208 psig at 100°F (Reid method) effectively limits ethane content.

HD-10 Unofficial term for LPG with up to 10 percent propylene that meets the specifications set out in the California Code of Regulations, Title 13, Section 2292.6.

Hose-End Valve
The dispenser valve and nozzle that connects to a vehicle's propane engine fuel tank for refueling.

Hydrocarbon
Any organic compound consisting entirely of hydrogen and carbon. Propane is a hydrocarbon made up of three carbon atoms and eight hydrogen atoms (C_3H_8).

LPG Liquefied Petroleum Gas. Any material having a vapor pressure not exceeding that allowed for commercial propane that is composed predominantly of the following hydrocarbons, either by themselves or as a mixture: propane, propylene, butane (normal or iso-butane) and butylene.

LPI Liquid Propane Injection. A technology in which propane liquid instead of propane vapor is injected into the intake manifold of an engine.

NFPA National Fire Protection Association. NFPA publishes codes and standards that are adopted by many U.S. jurisdictions. NFPA 58: Liquefied Petroleum Gas Code, includes standards on propane dispensers.

OEM Original Equipment Manufacturer. May refer to the manufacturer of a vehicle, a fuel system or dispenser system, or an individual fuel-system or dispenser-system component.

OPD Overfilling Prevention Device. A safety device designed to provide an automatic means to prevent the filling of a container in excess of the maximum permitted filling limit. For most propane containers the maximum permitted filling limit is approximately 80 percent by volume at 40°F.

Tank A propane container that has been designed, tested, marked, and fabricated in accordance with ASME standards. Propane tanks are marked with the ASME cloverleaf seal.

APPENDIX C: DISPENSER INSTALLATION PLANNING DOCUMENTS

The sample documents for pre-installation dispenser planning in this Appendix C are not meant to replace any installing company forms. Other documents may be required for new installations by local jurisdictional authorities as part of their review or permitting processes.

NFPA 58 states that installations with storage systems that have an aggregate water capacity of more than 4,000 gallons, utilizing a 1½ inch or larger liquid transfer line and a 1¼ inch or larger pressure-equalizing vapor line, must be equipped with emergency shutoff valves (ESVs). In practical terms, a transfer bulkhead is also needed to secure the required ESVs (and/or back check valve) within 20 feet of the nearest end of the hose or swivel connections used to fill the storage tanks.

NFPA 58 also requires installers to prepare a fire safety analysis (FSA) for newly installed propane dispensers. A *Fire Safety Analysis Manual for LP-Gas Storage Facilities* is available for download from the Propane Education and Research Council at www.propanesafety.com. Dispenser installers may find individual forms in the FSA Manual helpful.

An important first step in designing the dispenser installation is an analysis of the customer's present and projected future needs.

PROPANE AUTOGAS CUSTOMER PROFILE

Customer _____ Date _____

Contact Name _____ Location and Phone _____

Installation Location _____ City, State _____

Dispenser Purpose: ☐ Fleet Vehicles ☐ Fleet Vehicles/Industrial Truck
☐ Public Multiple Fuel Station ☐ Other (describe below)

_____

_____

_____

Number and Types of Fleet Vehicles:	____	School Bus	____	Pickup	____	Van
	____	Pass. Car	____	Med. Truck	____	
Estimated Daily Miles Each Vehicle Type:	____	School Bus	____	Pickup	____	Van
	____	Pass. Car	____	Med. Truck	____	
Days Driven Weekly Each Vehicle Type:	____	School Bus	____	Pickup	____	Van
	____	Pass. Car	____	Med. Truck	____	
Estimated mpg for Each Vehicle Type:	____	School Bus	____	Pickup	____	Van
	____	Pass. Car	____	Med. Truck	____	

Notes and Comments:

_____

_____

_____

PROPANE DISPENSER INSTALLATION PLAN **page 1 of** _____

Customer : _____ Plan Date : / /

Installation Address : _____ Prepared by: _____

_____

_____

City: _____ State: _____ Zip Code: _____

Authority Having Jurisdiction: _____ Permit Required? ☐ Yes ☐ No

Contact:: _____

Fire Safety Analysis (FSA) Completed ☐ Yes ☐ No Date Submitted: / /

FSA Approved / / Permit Issued / /

Dispenser Type: ☐ Fleet Vehicles ☐ Fleet Vehicles/Industrial Truck
☐ Public Multiple Fuel Station ☐ Other (describe below)

_____

Existing Electrical Power Supply
(Check all that apply.)

☐ Single Phase
☐ 120V only

☐ 240V

☐ Three-Phase
☐ 240V
☐ 480V
☐ ____V

Sketch of Site: (Show distances to important buildings, property lines that can be built upon, location of electrical power supply, any existing fuel storage and dispensing equipment, proposed location of propane containers, propane dispenser meter and control units, remote shutdown stations, vehicle traffic protection required, and other important features.)

PROPANE DISPENSER INSTALLATION PLAN page 2 of _____

Estimated Weekly Propane Usage (Check and calculate all that apply.)

☐ **Service Station** 15 gal x _____vehicles x 7 days = _____ gallons per week

☐ **Fleet** (avg) _____ gal x _____ vehicles x _____ days = _____ _____ gallons per week

☐ **Ind. Truck** 8 gal. x _____ lift trucks x _____ shifts/day x _____ days = _____ _____ gal. per week

ASME Dispenser Tank Size Needed

Weekly Delivery: Use weekly usage number from above.	**If 400 gal or less, ☐ 500 gal. W.C.**	**401 to 800 gal, ☐ 1000 gal. W.C.**	**801 to 1000 gal, ☐ 1200 gal. W.C.**
	Over 1000 gallons per week, ☐ _____ gallons W.C.		
Twice a Month: Double weekly usage number from above.	**If 400 gal or less, ☐ 500 gal. W.C.**	**401 to 800 gal, ☐ 1000 gal. W.C.**	**801 to 1000 gal, ☐ 1200 gal. W.C.**
	Over 1000 gallons per week, ☐ _____ gallons W.C.		
Monthly Delivery: Multiply weekly usage number from above x 4.	**If 400 gal or less, ☐ 500 gal. W.C.**	**401 to 800 gal, ☐ 1000 gal. W.C.**	**801 to 1000 gal, ☐ 1200 gal. W.C.**
	Over 1000 gallons per week, ☐ _____ gallons W.C.		

ASME Dispenser Tank Type Needed

☐ Single Horizontal ☐ A.G. ☐ U.G.	☐ _____Horizontals ☐ A.G. ☐ U.G.	☐ Single Vertical

Pump Required **Bypass Valve** Model No. _____

_____ in. dia.

☐ Regenerative Turbine	Model: _____ _____ gpm, _h.p., _ ph. _____
☐ Side Channel	Model: _____ _____ gpm, _h.p., _ ph. _____
☐ Sliding Vane	Model: _____ _____ gpm, _h.p., _ ph. _____
☐ Gear Pump	Model: _____ _____ gpm, _h.p., _ ph. _____

Other Equipment Required: ☐ ____ ea Single-Veh. Meter Cabinet ☐_____ ea 2-Veh. Meter Cabinet

☐ _____ea Meter Cab. Pedestal☐ ____ ea. Breakaway Device ☐ ___ ea. Hose Assemblies w/ End Valves

☐ _____ea. Fire Extinguisher ☐ _____ea. Remote Shutdown Station ☐ Purging Station ☐ Trans. Bulkhead

☐ _____ea. ESVs _____2” ☐ ___ea. ESVs _____1¼”

Other:

Dispenser Installation Checklist	
☐	Complete Propane Installation Plan
☐	Select dispenser components and auxiliary equipment
☐	Obtain electrical system bid from licensed electrical contractor
☐	Complete materials and labor costing and finalize installation agreement
☐	Complete Site Plan, Permit Application, and Fire Safety Analysis as needed
☐	Layout installation at the site, prepare foundation forms, trenches, and place and pressure-test any buried piping and anode for cathodic protection if used (obtain inspections as needed)
☐	Place concrete reinforcement steel, hole boxes or PVC chases, and tank securement J-bolts or sleeved bolts, then pour foundations (obtain inspections as needed)
☐	Install storage supply tank(s) according to manufacturer's instructions
☐	Install vehicle protective crash posts, guard rails and/or fencing (2 gates properly located)
☐	Install pump (and meter, if applicable) according to manufacturer's recommendations
	☐ All piping is steel schedule 80 of diameter recommended by manufacturer or approved copper tubing for small diameter meter sensing line
	☐ Pump mounting, external bypass valve, strainer, flexible sections are according to manufacturer recommendations. ☐ Pipe union provided for pump service
☐	Dispensing cabinet installed according to manufacturer's instructions
☐	Hoses max. 18 feet, hose-end valves, and breakaway coupling installed and protection provided
☐	Piping pressure tested for leakage at normal operating pressure
☐	Class I, Group D, electrical fixtures, conduit and wiring installed (obtain inspection as needed)
	☐ Wiring proper AWG size to meet pump manufacturer's recommendations for motor hp, electrical power supply and length of run
	☐ Sealing fittings installed; filled with a suitable sealing compound
	☐ Electrical union located at pump motor connection for motor service
	☐ Emergency shutdown marked and proper
☐	Start up
	☐ Pump rotation is correct (have electrician switch wire leads if not); drive guard in place
	☐ If applicable, scales are properly assembled, shipping blocks removed; counterpoise weights and holder are proper; ☐ scales checked for proper "zero" and measurement of a known weight
	☐ Operating personnel are trained and training documented according to company standard operating procedures, NFPA 58, and any applicable state or local regulations

APPENDIX D: ELECTRICAL AREA CLASSIFICATION

Parts of NFPA 58, Table 6.22.2.2, Electrical Area Classification, Related to Propane Dispensers

Part	Location	Extent of the Classified Areaa	Equipment Shall be Approved for NEC Class I[a], Group D[b]
A	Unrefrigerated containers other than cylinders and ASME vertical containers of less than 1000 pounds water capacity	Within 15 feet in all directions from connections, except connections otherwise covered in Table 6.22.2.2	Division 2
F[c]	Pumps, vapor compressors, gas–air mixers and vaporizers (other than direct-fired or indirect-fired with an attached or adjacent gas-fired heat source		
	Outdoors in open air at or above grade	Within 15 feet in all directions from this equipment and within the cylindrical volume between the horizontal equator of the sphere and grade	Division 2
G	Vehicle fuel dispenser	Entire space within dispenser enclosure, and 18 inches horizontally from enclosure exterior up to an elevation 4 feet above dispenser base; entire pit or open space beneath dispenser	Division 1
		Up to 18 inches above ground within 20 feet horizontally from any edge of enclosure (Note: For pits within this area, see part H of this table.)	Division 2
H	Pits or trenches containing or located beneath LP-Gas valves, pumps, vapor compressors, regulators, and similar equipment		
	Without mechanical ventilation	Entire pit or trench	Division 1
		Within 15 feet in all directions from pit or trench when located outdoors	Division 2
K[c]	Cylinder filling—Outdoors in open air	Within 5 feet in all directions from a point of transfer	Division 1
		Beyond 5 feet but within 15 feet in all directions from point of transfer and within the cylindrical volume between the horizontal equator of the sphere and grade	Division 2
	Indoors with ventilation	Within 5 feet in all directions from a point of transfer	Division 1
		Beyond 5 feet and entire room	Division 2

a The classified area shall not extend beyond an unpierced wall, roof, or solid vapor-tight partition.
b See Article 500 Hazardous (Classified) Locations, in NFPA 70, *National Electrical Code*, for definitions of classes, groups and divisions.
c See A.6.22.2.2.

Figure 1 illustrates the terms used in the descriptions of classified areas:

- "Cylindrical volume,"
- "Horizontal equator of the sphere" (radius of 5 feet and 15 feet, and
- "Grade" (referring to ground level).

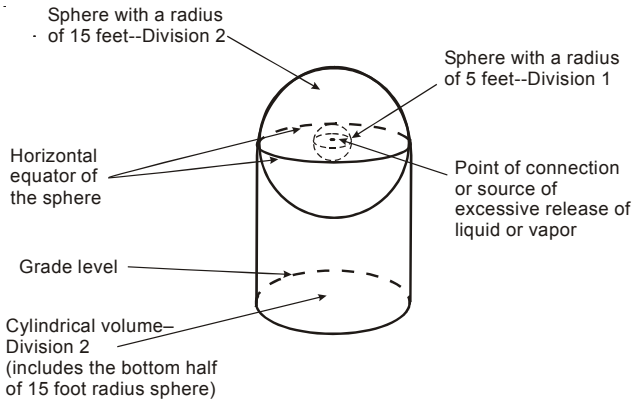

Figure 1. Extent of Electrically Classified Area
NFPA 58 (2011 ed.), Annex A, Figure A.6.22.2.3

Divisions in electrical area classifications are based upon the likelihood that a flammable mixture of materials may be present in the area. The likelihood of a flammable mixture being present varies from continuously to not at all. The NEC defines Class I, Division 1 hazardous locations as locations in which:

1. Ignitable concentrations of flammable gases or vapors can exist under normal operating conditions; or
2. Ignitable concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or
3. Breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

The NEC defines Class I, Division 2 locations as those locations:

1. In which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of abnormal operation of equipment; or
2. In which ignitable concentrations of gases or vapors are normally prevented by positive mechanical ventilating equipment, and which might become hazardous through failure or abnormal operation of the ventilating equipment; or
3. That are adjacent to a Class I, Division 1 location, and to which ignitable concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation for a source of clean air, and effective safeguards against ventilation failure are provided.

APPENDIX E: INSTRUCTIONAL MATERIAL

Review of Chapter 1, page 7

1-B; 2. L; 3–O; 4–M; 5–H; 6–N; 7–A; 8–P;
9–K; 10–F; 11–I; 12–D; 13–J; 14–C

Scenario 1A, page 12

Why is **P5** higher than any other pressure in the dispenser section of the system at the start of the refueling operation?

1. The pressures in the dispenser section are produced by ambient temperature only.
2. Pressure in the vehicle's engine fuel tank is higher due to the heat generated by the in-tank fuel pump & engine-heated propane returning to the tank.

Scenario 1B, page 13

If the given conditions... remain as shown... would you expect a monetary change in pressure at any point in the dispenser section?

Yes

If you answer is "Yes", where would you expect to see the change?

P6 should rise in pressure when the by-pass valve begins to open.

Some customers or installers will refer to the pressure between **P2** and **P3** with the pump operating as the differential pressure. It is the pump differential pressure with the pump operating; however, system differential pressures will vary at different points in the transfer system as the refueling operation progresses resulting in changing [back] pressures, and as system components vary flow.

Scenario 1C, page 14

If the by-pass valve were fully open, would expect the pressure at P6 to be higher or lower?

Higher, but only slightly. In the scenario as shown above, because the pressure at P1 is 203 psig, the pressure at P5 is 275 psig with the by-pass valve partially opened and partial back flow occurring. 213 psig is temporarily the differential pressure for the system at the time and under the conditions show.

Scenario 1D, page 15

What would account for the difference in pressure at P5 in this part of the refueling operation compared with the pressure at P5 in the part of the refueling operation on the previous page (Scenario 1C)?

Higher pressure propane liquid is entering the engine fuel tank; part of the flow is diverted back to the supply tank through the by-pass circuit.

Scenario 1E, page 16

What would account for the difference in pressure at P5 and P4?

The engine fuel tank's overfilling prevention device has closed to stop the flow into the engine fuel tank; the same pressures would be seen if the hose end valve closed.

Scenario 2A, page 17

What could account for the difference in pressure in the school bus engine fuel tank compared with the engine fuel tank of the pickup in Scenario 1A?

Radiant heat from road surfaces is added to ambient air heat, producing a hotter under-body fuel tank temperature for the school bus compared to the bed-mounted pickup engine fuel tank. Also, heated propane liquid returning to the fuel tank from the school bus engine may be hotter than the heated propane liquid returning to the pickup fuel tank.

Scenario 2C, page 19

What would account for the difference in pressure at P5 and P4?

The engine fuel tank overfilling prevention device has stopped propane flow.

What should happen next in the dispenser section to protect components from un-necessary wear and to avoid wasting electricity?

An electric time-out/meter sensing switch should shut down the pump after the vehicle's overfilling prevention device stops flow into the engine fuel tank.

Review of Chapter 2, page 20

1– A; 2– F; 3– C; 4– D; 5– G; 6– B

Review of Chapter 3, pages 34-35

1–M; 2–Q; 3–K; 4–B; 5–N; 6–F; 7–A; 8–D;
9–H; 10–C; 11–O; 12–I; 13– E; 14–P; 15– J; 16– G; 17–L

Review of Chapter 4, page 40

1– G; 2–J; 3–E; 4–A; 5–F; 6–I; 7–B; 8–H;
9–D; 10–C

Review of Chapter 5, page 49

1–C; 2–J ; 3–K; 4–F; 5–E; 6– D; 7–I; 8–B;
9–G; 10–A; 11–L; 12–H

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