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TRAINING FOR COST-EFFECTIVE, CODE-COMPLIANT, MAINTENANCE FACILITIES

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CODE REQUIREMENTS AND BEST PRACTICES: PROPANE

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Background

As the commercial deployment of alternative fuel vehicles has continued to grow and large businesses begin to deploy significant fleets, it is apparent that the cost of maintenance facility modifications can be a deciding factor in a company's decision to adopt alternative fueled vehicles (AFVs). Additionally, building designers that are not experienced with alternative fuels may exacerbate the issue by providing unnecessarily high construction quotes for modifying or building a maintenance facility and some AHJs may not allow upgrades at all because of a lack of gaseous fuel education. Even for experienced fleets, the costs of a maintenance facility upgrade can be restrictive.

The objective of this project is to develop and provide training for Authorities Having Jurisdictions (AHJ), designers, fire officials, and other stakeholders regarding planning and permitting needs as well as common sense best practices for alternative fueled vehicles (AFVs) maintenance and repair facilities. A secondary goal is to provide safety training to emergency response personnel stationed near the facilities.

The project will accomplish these objectives through the use of multiple outreach and training tools – on-site training seminars, facility tours, reports, and online resources. This consortium of tools will cover three fuels – natural gas, hydrogen, and propane. This report will cover applicable codes and standards for maintenance facilities that serve the alternative fuel industry, and will go on to report on issues with these codes and best practices that a facility can implement to become code compliant. The focus of this report will be on requirements and best practices that relate specifically to propane.

1.1 Accidental Release

Propane, also known as autogas when used as on-road motor fuel, is non-toxic and odorless in its natural state. At the point of use, propane has a distinct smell due to the addition of an odorant that aids in leak detection. Propane for vehicle fueling is typically stored and transported in a liquid state, but it will readily revert to a gas when vented. Unlike other gaseous alternative fuels that are less dense than air, propane gas is heavier than air and tends to accumulate in low areas if undisturbed, remaining at or near floor level much like liquid fuel vapors. Propane is much more likely to be affected by air currents within a facility, and will rapidly disperse throughout a facility.

Methods of protection for propane vehicle maintenance facilities are similar to those used for gasoline or diesel vehicles. It is likely that a gasoline or diesel garage that complies with applicable codes will be compliant with propane requirements as well. Despite the requirements for propane and liquid fuel maintenance facilities being similar, this does not mean that an existing gasoline or diesel garage is automatically up to code to properly mitigate the risks associated with propane. Facility personnel must understand the properties and characteristics, and safety precautions and procedures relating to propane, and what to do in the case of a propane leak.

1.2 Risk Mitigation

Propane is flammable, but only within a narrow range of air to propane mixtures. If propane is present in amounts between 2.2%–9.6% by volume and it encounters an ignition source, the gas may ignite. The rapid expansion of ignited gas can damage equipment and injure nearby facility personnel. The specific properties of propane are reported in the appendix of this report.

Every leak, at some point in time and space, will produce a condition within this flammability range. Risk mitigation involves preventing leaks from occurring, reducing ignition sources that could ignite flammable mixtures, and rapidly diluting flammable mixtures. This is accomplished through proper installation of equipment and proper observation of safety procedures. The following sections will explain in detail how a maintenance facility can follow established guidelines and use common sense to ensure safety and code-compliance.

Applicable Codes and Standards

There are a number of codes and ordinances dealing with the design and use of a propane vehicle maintenance facility. The primary documents used by AHJs concerning propane maintenance facilities are the same as for liquid fuel facilities: NFPA 30A – Code for Motor Fuel Dispensing Facilities and Repair Garages, and the appropriate sections of the International Fire Code. NFPA 58 – Liquefied Petroleum Gas Code applies in some specific scenarios. If significant building modifications are planned as part of an upgrade, additional building codes may apply.

These documents contain similar (or in many cases identical) language. In addition to the documents listed above, many states and local authorities have their own preferences. It is essential to recognize that all of these documents provide valid and safe methods for facility design, but the AHJ will make the final determination of which codes are applicable at the time of installation in each case.

Authorities Having Jurisdiction

It is critical to talk to your local or state authorities having jurisdiction when deciding to construct a new facility or modify your existing facility to work with autogas. AHJs are responsible for enforcing the codes and regulations that have been adopted by the jurisdiction. AHJs may have other state and local requirements in addition to the national codes, and they determine which regulations are applicable to your facility. If AHJs are not involved early in the process it could lead to costly building modifications later! When designing or modifying an existing repair facility independent design consultants could be beneficial in determining the factors that might impact your repair facility.

NFPA 30A Code for Motor Fuel Dispensing Facilities and Repair Garages (2018)

Maintenance and repair facilities that service both propane vehicles and vehicles fueled by gasoline or diesel have similar requirements, but this does not mean that garages that currently service diesel and gasoline vehicles are automatically up to code to service propane vehicles. The building itself may not be up to the latest codes, and there are some specific precautions that need to be taken specifically for propane.

An AHJ may determine that the applicable code in effect is NFPA 30A. NFPA 30A governs automotive repair garages and fuel-dispensing facilities of all fuel types. For almost all propane-related requirements, NFPA 30A defers to NFPA 58. In the rare case that propane fueling is done indoors, there are separate sections in NFPA 30A for maintenance facilities that also dispense fuel, and there are sections that deal specifically with gaseous fuels. Maintenance and repair facilities that service propane vehicles must adhere to applicable portions of the codes in effect at the time of installation - NFPA 30A and NFPA 58 or the International Fire Code (IFC), which is discussed in the following section.

In order to assess if modifications are required, it is necessary to determine if a garage is a major garage or a minor garage. NFPA 30A and its counterpart, the IFC, are the primary code documents that cover the classification of maintenance garages into major and minor facilities. Full definitions as presented in NFPA 30A are:

1. A major repair garage is defined as:

   A building or portions of a building where major repairs, such as engine overhauls, painting, body and fender work, and repairs that require draining of the motor vehicle fuel tank, are performed on motor vehicles, including associated floor space used for offices, parking, or showrooms.

Any work that involves service on the vehicle fuel system also falls into this category.

2. A minor repair garage is defined as:

   A building or portions of a building used for lubrication, inspection, and minor automotive maintenance work, such as engine tune-ups, replacement of parts, fluid changes (e.g., oil, antifreeze, transmission fluid, brake fluid, air conditioning refrigerants, etc.), brake system repairs, tire rotation, and similar routine maintenance work, including associated floor space used for offices, parking, or showrooms.

Any work that involves service on the vehicle fuel system is not permitted in a Minor Repair Garage.

NFPA 30A Chapter 7 deals with general requirements for maintenance garages. This includes protections in case of fire, ventilation requirements that can draw away vapors, and heating appliances that have the potential to ignite flammable vapors.

Pits and Subfloors

Below-grade areas, such as subfloor work spaces and pits are subject to different requirements than the rest of a garage because both propane and liquid fuel vapors can collect there and pose a suffocation and fire hazard. NFPA 30A deals with this issue in section 7.4.5. It specifies that the materials of construction must be non-combustible, and the means of egress for pits and subfloor work areas need to meet NFPA 101, Life Safety Code. The ventilation rate for the pit must be at least one cubic foot per minute of fresh air per square foot of floor area (0.3 cubic meters per minute per square meter) whenever the building is occupied or a vehicle is parked over this area. This ventilation should have its intake within 12 inches of the floor.

Sprinkler Systems

Fixed fire protection (i.e. an automatic sprinkler system) is required in maintenance facilities as defined in section 7.4.6. This section defers to NFPA 13, Standard for Installation of Sprinkler systems. A garage must comply with fire protection requirements if: vehicles are serviced in the basement of the building, if the garage is a single story and exceeds 1115 square meters (12,000 sq. ft.), or the garage is two or more stories in height, including basements, and any of the floors exceeds 930 square meters (10,000 sq. ft.).

Electrical Classification

Chapter 8 of NFPA 30A defers to NFPA 70 on matters of electrical classification. Different areas within a garage may be classified differently, and the classifications may be dependent on ventilation in that area. Specific ventilation requirements are also defined within Chapter 8.

Class 1 Division 1 areas are spaces in which flammable gasses or vapors, in this case from propane, are determined to be a hazard and are likely to exist. Class I, Division 2 areas are spaces in which flammable gasses or vapors may exist under abnormal conditions.

In major repair garages, any space within an unventilated pit or subfloor work area is Class 1, Division 1, and electrical appliances within these areas need to be rated as such. If the pit is ventilated at a rate of 1 cubic foot per minute per square foot of floor area, and the intake for this ventilation is within 12 inches of the floor, (as in section 7.4.5) the pit can be classified as Class 1, Division 2.

All areas above grade within 18 inches of the floor are classified as Class 1 Division 2. The exception to this is if the floor is ventilated at a rate of 1 cubic foot per minute per square foot of floor space, and the intake for this ventilation is within 12 inches of the floor. In this case, the area within 18 inches of the floor is unclassified. The area above 18 inches is unclassified.

Areas adjacent to classified locations in which propane or liquid fuel vapors are unlikely to be released, such as offices, stock rooms, switchboard rooms, and other similar locations, can be considered unclassified as long as they are mechanically ventilated at a rate of four or more air changes per hour. Alternatively, they can be designed with positive air pressure or effectively sealed off by walls or leak-free partitions.

In minor repair garages, unventilated pits and below-grade areas are Class 1, Division 2. Unventilated areas within 18 inches of the floor that are also within three feet of the edge of a pit or below-grade area are also Class 1, Division 2 in a minor garage. These areas can be unclassified if ventilated at a rate of 1 cubic foot per minute per square foot of floor space with an intake that is within 12 inches of the floor.

In an area designated as Class I, Division 2, all electrical wiring, conduits, junction boxes, and electrical appliances must be either explosion proof or relocated so that they are not within the hazard zone. Most garages that handle liquid fuels will already comply with this requirement. Class I, Division 2 status can be obtained if conduits or junction boxes are provided with seal-offs, which create a physical barrier that minimizes the passage of gases from traveling freely through the conduit and will prevent the migration of vapors into the conduits. The use of seal-offs in lieu of relocation must be approved by the AHJ.

According to NFPA 30A, low-voltage wiring and containing conduits may be exempt from the Class I, Division 2 requirements if they are determined to be non-sparking. Examples of potentially exempt low- voltage wiring and containing conduits include loudspeaker and security camera wiring; wiring used for data transmission; alarms; and wiring used for similar applications (Figure 23). However, the AHJ must approve the low-voltage wiring; otherwise, it may be considered hazardous and subject to Class I, Division 2 requirements.

The most important concept to consider is that propane, like liquid fuel vapors, will collect near the floor and in below-grade areas. Heat or spark producing appliances such as refrigerators and water heaters need to be removed from these areas. Proper ventilation may allow an area to be considered unclassified, but removing sparking appliances is still a good practice to employ.

Chapter 12 of NFPA 30A includes specific requirements for propane-dispensing facilities that also dispense liquid fuels. With the exception of the case where a propane dispenser is installed on the same island as a gasoline or diesel dispenser, NFPA 30A defers to NFPA 58. For propane dispensers installed on the same island as liquid fuel dispensers, NFPA 30A includes guidelines for electrical classification, guidelines for placement of propane storage, and guidelines for placement and operation of propane dispensing equipment.

Sources of Ignition: Sparking Appliances

Any sparking appliance presents an added risk of ignition, and as a best practice, these appliances should be given extra consideration. A best practice is to place them as far as possible from vehicle service areas, and if possible place them in well-ventilated office areas. Lights, heaters, welding torches, and grinders all present obvious spark risks. Refrigerators, ventilation fans, garage door openers, cranes, pumps, and air compressors all present less obvious spark risks.

Sources of Ignition: Heat-producing appliances

Heat-producing appliances often contain hot surfaces that may ignite a mixture of flammable vapors. For this reason, only approved devices may be used in maintenance garages. Solid fueled stoves, salamanders, improvised furnaces, or space heaters are not permitted in areas where fueling or maintenance are performed.

Heat-producing appliances are permitted in areas adjacent to Class I, Division 2 areas that have been sealed against the inflow of flammable vapors. Class I areas are spaces made hazardous by the presence of flammable gases. Division 2 indicates that the flammable gasses are only present in abnormal situations.

Small openings for piping or conduit in barriers between Class I Division 2 areas and unclassified areas need to be sealed. Intake air for the heating system needs to be taken from outside the facility. In certain cases, with AHJ approval, gas or liquid-fueled heating appliances may be used in storage rooms provided they are above 18 inches above the floor. They may be used in fueling or service locations provided they are at least 8 feet above the floor. Heaters must use fuel of the type and quality specified by the manufacturer. Electrical heating appliances are subject to the requirements in Chapter 8.

Figure 1: Properly sealed conduit. Photo courtesy of Gladstein, Neandross & Associates, NREL

NFPA 58 Liquefied Petroleum Gas Code (2017)

If your jurisdiction has adopted NFPA 30A and NFPA 58 for repair garages that repair propane-fueled vehicles, the requirements in NFPA 58 that pertain to maintenance garages are essentially just procedures involving the vehicle. There are no specific structural requirements beyond the existing standards for traditional liquid fuel repair garages and maintenance facilities. Propane gas detection equipment is not required for repair garages and maintenance facilities that service propane-autogas-fueled vehicles.

Section 6.23.9 dictates special requirements for vehicles that carry propane for purposes other than propulsion, such as a diesel-powered propane delivery truck. Before vehicles like this enter a garage, the fuel system must be leak free, and not filled beyond certain limits in Chapter 7. The fuel container shutoff valve must be shut, except when required to carry out tests or repairs. The vehicle carrying this system should not be parked near open pits, flames, or other points of potential ignition.

Section 9.7.3.6 outlines similar requirements for vehicles that carry propane for their own propulsion. The fuel system must be leak free, with the shutoff valve closed unless the engine is required to operate during the repair. These vehicles also should be parked away from open pits, flames, or other heat sources.

International Fire Code

The IFC has more general requirements for propane in section 61, but for most sections that mention propane vehicles, the IFC refers back to NFPA 58. The exception is for propane vehicles that are assembled in membrane enclosures or tents. IFC outlines the following requirements in section 3104.18.4:

- The quarter-turn shutoff valve or other shutoff valve on the outlet of the CNG or LP-gas container shall be closed and the engine shall be operated until it stops. Valves shall remain closed while the vehicle is indoors.
- The hot lead of the battery shall be disconnected.
- Dual-fuel vehicles equipped to operate on gasoline and CNG or LP-gas shall comply with this section and Sections 3104.18.1 through 3104.18.5.3 for gasoline-powered vehicles.

Best Practices

Ventilation

When installing a new ventilation system, or upgrading an outdated one, proper ventilation system design can avoid burdensome electrical classification requirements. If a garage ventilation system is up to code for gasoline or diesel fuel maintenance, it should be up to code for propane maintenance. It's important to remember that propane vapors will collect in low areas. Ventilation system intakes must be located within 12 inches of the floor, but should be located as low as possible. Ventilation intakes should not be obstructed by other equipment, and sparking equipment should be kept away from the floor. These precautions will prevent the need for Class 1 Division 2 equipment in electrically classified areas.

Below-grade areas, such as subfloor work spaces and pits are subject to different requirements than the rest of a garage because both propane and liquid fuel vapors can collect there and pose a suffocation and fire hazard. The ventilation rate for pits and similar low-lying areas must be at least one cubic foot per minute of fresh air per square foot of floor area (0.3 cubic meters per minute per square meter) whenever the building is occupied or a vehicle is parked over this area. This ventilation should have its intake within 12 inches of the floor.

Early Coordination with Local Authorities

When propane garage owners were asked what one piece of advice they would give to someone beginning a facility upgrade for propane, the most common answer was a counterintuitive one: Involve your local authority as early as possible.

It may seem that involving another party early in the process would add complication, but garage owners reported that the benefits outweighed any drawbacks of extra scrutiny. In some cases, reaching out early avoided procuring unnecessary equipment and removed uncertainty from the upgrade process. In other situations, contacting the local authority early on led to a thorough review indicating that no modifications were necessary.

Draining the Fuel Tank

The fuel storage system on a propane vehicle may need to be evacuated or purged in preparation for fuel system modification or repairs. Though the code documents require this, they do not prescribe a method for doing so. The following sections provide background information on how to perform evacuation or purging using safe, compliant methods. If at any point you find yourself unsure about how to safely defuel a specific vehicle or piece of equipment, stop work and contact your fuel provider for further guidance.

The following best practices described for informational purposes, and action should not be taken without first having a conversation your propane provider.

Tank Components

The fuel storage system in a propane vehicle consists of one or more durable steel fuel tanks. These tanks are much more puncture resistant than gasoline tanks and can be located in the vehicle's trunk, under the side panel of a van or bus, underneath the rear of the vehicle, or in the bed of a pickup truck.

Every propane container is equipped with a pressure relief valve to protect from tank overpressure. If the pressure inside the container for any reason exceeds pressure rating of the relief valve, the valve will discharge some vapor, reducing the internal tank pressure to a safe level. The pressure relief valve is located in the vapor space of the propane fuel tank.

Each propane fuel tank has a liquid service valve. This valve is the controlling mechanism allowing propane gas to flow from the fuel tank and into the vehicles' fuel line. The liquid service valve also contains a secondary valve, the excess flow valve. This valve shuts off the flow of propane if there is a rupture in the propane fueling system between the fuel tank and the vehicle's engine.

The fixed liquid level gauge, sometimes referred to as a bleeder valve, is connected to a tube that extends into the tank at the maximum tank filling level to monitor the propane tank fuel level. The float gauge alerts the driver to the approximate liquid fuel level in the propane tank. As the float gauge mechanism resides inside the fuel tank, it cannot be removed for service if the tank is under pressure.

Each tank also possesses an overfilling prevention device, or OPD. The OPD is a safety device designed to provide an automatic means of preventing the filling of the tank in excess of the maximum filling limit. Knowing these essential tank components will ensure you understand propane fuel tank design for purge or evacuation procedures.

Safety Precautions

Before starting a purging or evacuation process, be sure you are working in a safe environment without potential ignition sources or accelerants. Understand the proper equipment to use, and use the correct personal protective equipment, including eye protection, reinforced footwear, long sleeves, pants that cover the ankles, and insulated gloves. When working with propane it is important to remember its refrigerating effect and other potentially hazardous characteristics.

As with all motor fuels, personnel involved in propane handling must know and follow fire prevention rules and procedures. Fire extinguishers can keep a small incident from becoming a major accident. Any technician working with propane systems is responsible for understanding the location, rating, maintenance, and appropriate use of fire extinguishers per their company's established emergency guidelines.

When undergoing repairs that will not affect the fuel system, a propane vehicle should have its fuel system leak tested before entering the repair and maintenance facility to reduce the chance for a propane leak inside the building. When performing service on the propane fuel container and its valves, evacuation and purging of propane fuel tanks is a necessary procedure.

Purging and Evacuation

The most obvious difference between purging and evacuation is what is being removed from the tank. Purging removes air or water vapor from the tank. Purging procedures are designed for tanks that do not have propane in them, such as a new tank or a tank that has been taken out of service and left open to the atmosphere.

Fuel tanks must be purged before installation. New or completely empty tanks must be purged of air and moisture before being filled with liquid propane and put into service. Purging is necessary to remove excess air that could affect the pressure inside the tank, resulting in propane venting from the pressure relief valve. Purging the tank of air and moisture is also important to prevent inaccurate air fuel mixtures that can result in poor vehicle performance.

Tank evacuation is meant to remove propane from a fuel tank installed in an operating vehicle so that the vehicle tank can be serviced. The evacuation process will take the internal tank pressure down to ambient air pressure. Once ambient pressure has been reached, the bleeder valve should be open as some propane can still be present in the tank.

All evacuation and purging operations should occur outdoors or in well-ventilated areas. Because propane is heavier than air, all evacuation and purging procedures should be done away from any in-ground service pits, ditches, drains, or any other low-lying area where propane vapor could collect. The evacuation and purging procedures should only be performed by qualified, trained professionals. Contact your propane supplier before attempting evacuation.

Propane Evacuation Methods

It is important to empty propane fuel tanks prior to any tank service, including work on the fuel pump, fuel filter, fuel tank level sending unit, tank valve maintenance or replacement, or any internal tank switches or sensors.

There are three different methods for propane tank evacuation: venting, flaring, and reclaiming. The procedure your company adopts will be based on corporate policy, established safety procedures, and the guidelines set by your local authorities having jurisdiction.

Venting

Venting involves attaching a propane vent stack to the propane fuel tank and venting the propane into the atmosphere. Propane should be vented slowly through the stack by opening the service valve, allotting enough time for the propane to fully vent and disperse. Vent stacks should be at least 15 feet tall. Venting of propane should never be done at ground level. Consult your local authorities having jurisdiction and your propane supplier before attempting venting procedures.

Flaring
Flaring a propane tank is like venting, except the propane is burned off using a stack burner rather than venting the fuel to the atmosphere. Because flaring involves igniting propane, you must follow basic safety precautions when undertaking this procedure. The burner should always be positioned at least 25 feet from the tank being emptied, any ignition source, dispenser, other propane storage, or buildings; and leak testing of all necessary hoses and connections should be done before initiation of the flaring process. As with venting, you should consult your local authorities having jurisdiction and propane supplier before attempting flaring operations.

Reclaiming
Reclaiming propane from a fuel tank involves pumping the fuel from the source tank into a second storage tank using specialized pumping equipment. Propane evacuation pumps are ideal for removing fuel from a fuel tank, because they can remove not only the liquid from the tank but some evacuation systems can also remove the vapor pressure. When transferring propane to a second tank, the holding cylinder must be monitored so it does not exceed the 80% full mark or the target tank's pressure rating. Using an evacuation pump is the preferred method of evacuation because they are air-operated, thus reducing ignition sources around the evacuation site, they reclaim the propane for future use, and they are more environmentally friendly. Venting and flaring propane requires advanced skills for proper implementation, while reclaiming with the proper equipment can be performed by any trained automotive technician.

Tank Purging Methods

There are two different methods for propane tank purging: a vacuum purge and a vapor purge.

Vacuum Purge
Vacuum purging involves removing air and moisture from the propane fuel tank by using a vacuum pump to creating a vacuum on the tank. Once the vacuum has been reached, you can then introduce 15psig of propane vapor into the container to prepare it for service.

Vapor Purge
Vapor purging involves venting the contents of the tank to the atmosphere by feeding propane vapor from a fuel source into the tank. This vapor purge method works by displacing any existing air or moisture in the tank.

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Appendix: Properties of Conventional and Alternative Fuels

Compound	Formula	Density (lb/ft^3) Gases @ STP	Auto-Ignition Temperature (°F)	Lower Flammability Limit (LFL) %	Upper Flammability Limit (UFL) %
CNG (Methane)	CH_4 (majority)	0.0447	1,004	5.3	15.0
Propane	C_3H_8	36.2	850-950	2.2	9.5
Gasoline	C_8H_{18}	46.4	495	1.4	7.6
Diesel	-	52.4	600	1.0	6.0
Hydrogen	H_2	0.0056	1,050-1,080	4.1	74.00
Air	-	0.0806	-	-	-