AFV/EV Safety Training: Automotive Recycling

Instructor's Manual

National Alternative Fuels Training Consortium

A Program of

West Virginia University

No currently available LNG tank can keep LNG from warming and expanding over time. When LNG warms and expands, it occupies approximately 600 times the volume that the liquid fuel occupies, and must be released. LNG is not a viable fuel source for fuel system configurations that spend the majority of time parked.

Typically, LNG vehicles are larger and seen more often in heavy-duty applications, due to the size required for the tanks and due to the lack of long-term fuel storage capabilities (see **Figure 15**). It is less common to see light-duty LNG vehicles.

Figure 15: *LNG-powered bus used for public transportation. Source: NREL.*

Fuel System Configurations

There are three main types of fuel system configurations that can use natural gas. These include dedicated, bi-fuel, and dual-fuel vehicles.

- Dedicated means that the vehicle has been purposefully-built to run only on natural gas (see **Figure 16**).

Figure 16: *The 2013 Honda Civic NGV is an example of a dedicated natural gas vehicle. Source: Honda.*

- Bi-fuel is a term used to describe a vehicle that has two separate fueling systems, one that utilizes natural gas and one that utilizes conventional gasoline. This is the most common type of natural gas vehicle conversion.
- Dual-fuel refers to a vehicle that can accommodate both natural gas and conventional diesel in two separate tanks but that come together in one combustion system. The most common type of these vehicles include mostly heavy-duty applications.

Natural Gas Pressure Components

For a CNG vehicle, there is a pressure relief device (PRD) fitted to the side of the cylinder valve body or near the valve body. Its purpose is to release the entire contents of the cylinder when the internal pressure exceeds a set point, typically 4500 psi (310.3 bar) or 5000 psi (344.7 bar). All PRDs are rendered useless after they have been activated; therefore, they must be replaced and the tank inspected before reuse. Non-trained individuals should not remove or tamper with PRDs.

PRDs should not be confused with PRVs, described next.

For an LNG vehicle, pressure relief valves (PRVs) are installed on the tank as safety features. (PRVs also are used with other liquid and vapor fuel storage systems such as liquefied petroleum gas tanks.) The natural gas is cryogenically cooled to a liquid and stored under pressures, typically less than 230 psi (15.8 bar), as opposed to CNG tanks, where pressures are up to 3600 psi (248.2 bar).

Without refrigeration, LNG will slowly vaporize as ambient temperatures warm the dewar. PRVs are used to regulate the vapor pressure within the tank. As the vapor pressure increases beyond a set point, the valve automatically opens, venting some natural gas. This process has a cooling effect on the LNG and allows the internal pressure to lower below the set point. These valves operate automatically with temperature and pressure to maintain equilibrium conditions within the dewar.

LNG tanks typically have two PRVs for safety. The first typically relieves pressure at 230 psi (15.8 bar). The second, as an additional fail-safe, relieves pressure at a set point of 350 psi (24.1 bar). The PRVs (see **Figure 17**) are spring-loaded, self-resetting valves. They will open if the set pressure is reached and will self-reset once pressure drops below the set pressure. Normal release of LNG may occur daily with fluctuations in temperature and lack of use, but new tanks can store LNG for weeks without major fuel loss.

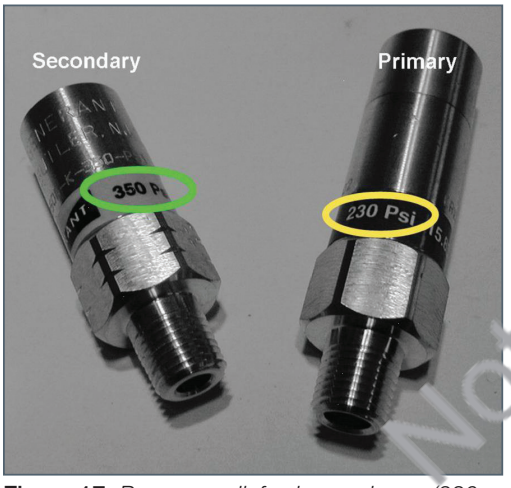

Figure 17: *Pressure relief valves: primary (230 psi, 15.8 bar) on right, secondary (350 psi, 24.1 bar) on left. Source: NAFTC.*

Natural Gas Cylinder Valves

Currently, there are two basic designs of valve assemblies for CNG vehicles, but their functions are the same: to shut off the flow of gas from the cylinders. The two types of cylinder valves are manually operated and electrically operated (see **Figure 18**).

Figure 18: *Two styles of CNG cylinder valves. Source: NAFTC.*

When a manual cylinder valve is shut off, fuel cannot escape from the cylinder, but fuel can still pass through the valve if the valve port is plumbed in parallel with other cylinders or to a fuel supply line.

An electrically operated CNG cylinder valve is controlled by one or a combination of the following: the ignition switch, the engine control module, or other electrical control circuitry. Some electrically controlled valves incorporate a manual override that provides a means to open or close the valve in the event of an electrical failure.

Natural Gas Manual Shutoff Valves

For CNG vehicles, manual shutoff valves (also commonly referred to as quarter turn valves) are typically ball-type valves with an internal configuration very similar to that of a cylinder valve (see **Figure 19**). In most cases, the valve is installed near, under, or below the vehicle operator's door or near the high-pressure regulator. The rationale for this placement is to have a readily accessible shutoff valve in times of an emergency or equipment failure. This valve also can be located in other areas and has to be clearly labeled according to the National Fire Protection Association (NFPA). The manual shutoff valve for an LNG vehicle (see **Figure 20**) is located in the liquid supply line.

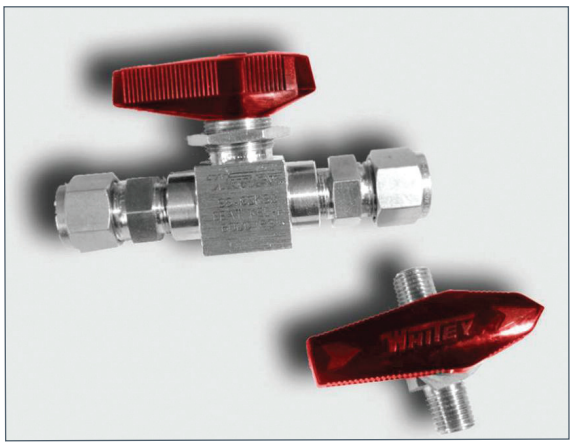

Figure 19: *Manual shutoff valves for CNG vehicles. Source: NAFTC.*

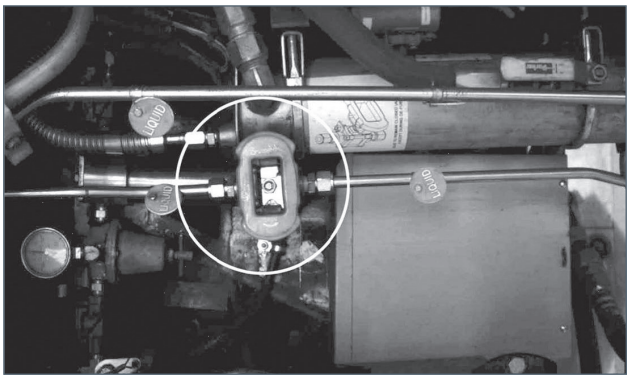

Figure 20: *LNG manual shutoff valve located on the liquid supply line. Source: NAFTC.*

Natural Gas Backflow Check Valve and Excess Flow Valve

For an LNG vehicle, the backflow check valve (see **Figure 21**) prevents LNG from leaving the tank by flowing out the fill pipe. The valve is normally closed and opens only when fuel is forced into the tank from the dispenser. A flapper valve is forced shut by the fuel in the tank. The dispenser shuts off the fuel flow when it senses liquid pressure (that is, when the tank reaches 90% capacity). The excess flow valve prevents too much LNG from flowing to the engine in case of a broken connection. The valve is designed (and marked with an arrow) to allow fuel to flow in only one direction.

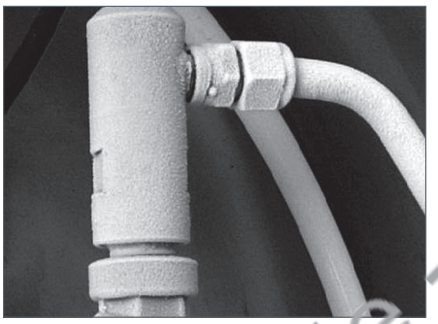

Figure 21: *Backflow check valve. Source: NAFTC.*

Types of Natural Gas Fueling

There are two main types of compressed natural gas fueling – fast-fill and time-fill. Fast-fill takes around 5-7 minutes (depending on the CNG tank size) and vehicles can pull up and be filled one after another (just like conventional gasoline and diesel vehicles). Time-fill is much longer and can take between 4-8 hours. Private fleets may utilize an on-site time-fill station for vehicles to be re-fueled in between working hours.

LNG is a cryogenic liquid fueling system that uses special dispensing equipment and requires additional safety precautions.

The images below show both a CNG and LNG dispensing nozzle (see **Figures 22** and **23**).

Figure 22: *CNG dispensing nozzle. Source: NREL.*

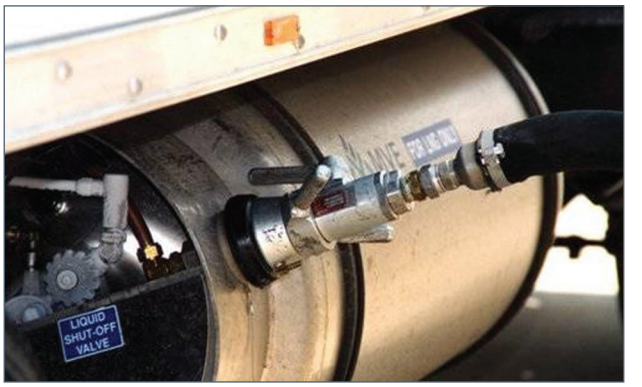

Figure 23: *Specially designed LNG nozzle. Source: NREL.*

Propane

Propane is a byproduct of natural gas or crude oil refining, and is commonly called liquefied petroleum gas (LPG). When used as an alternative fuel in vehicles, propane is called autogas. In this material, the use of propane in on-road and off-road use is referred to as propane for easier clarification.

At normal temperatures and pressures, propane is a gas, but it can be turned into a liquid at a temperature of -44°F (-42°C). This temperature is not low enough, however, to qualify propane as a cryogenic liquid, like liquefied natural gas (LNG). Propane is also easily liquefied by the application of modest pressures — between 100 and 200 pounds per square inch (psi) — and is stored under pressure inside a tank (see **Figure 24**).

Figure 24: *Propane tanks. Source: NAFTC.*

Under normal outdoor temperatures, propane expands rapidly into gas. For example, one cubic foot of propane evaporates and produces 270 cubic feet of propane gas. Propane gases will expand when heat is applied. If stored inside a container, this expansion will increase the pressure inside the container, which is typically vented to the atmosphere.

According to the U.S. Department of Energy's Alternative Fuels Data Center (AFDC), under pressure, propane becomes a liquid with a density 270 times greater than when it is in a gaseous form. A gallon of propane has about 75% of the energy of one gallon of gasoline. Propane is a clean-burning fossil fuel that can be used to power vehicles with an internal combustion engine (ICE). In liquid form, tanks have the ability to contain much more fuel than they would otherwise be able to contain. Propane tanks are filled to approximately 80% of total volume capacity because propane expands under higher temperatures.

Propane Vehicle Components

Propane vehicles employ different components that are not used in conventional vehicles. First, and most importantly, is the propane storage tank. In most cases, the propane storage tank is mounted in the trunk of propane conversion vehicles. Beyond the tank, vehicles also use pressure relief valves, regulators, filters, fuel locks, and modified fuel injection systems.

Fuel Injection System

There are two types of propane fuel-injection systems available: vapor and liquid injection. In both cases, propane is stored as a liquid in a relatively low-pressure tank (between 100 and 200 psi).

Older Vapor Systems

When older gasoline vehicles that use throttle bodies or carburetor systems are modified to run on propane, components include a regulator and vaporizer. These components allow for stored liquid propane in the fuel tank to vaporize into gaseous form and be regulated to the proper pressures/flows. These are commonly seen in older forklift and stationary engine applications that utilize propane.

Propane must be converted back into a gas before it enters the combustion chamber. This process is done through the use of a device called a vaporizer, which utilizes ambient air or engine coolant to warm the propane. A vaporizer works in conjunction with a mixer to allow for the delivery and mixing of gaseous propane with the incoming intake air. The engine then burns the gaseous propane and air mix to power the vehicle.