Safety Booklet

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Clean Cities
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National Alternative Fuels Training Consortium
A Program of West Virginia University

Clean Cities Learning Program

Alternative Fuel and Advanced Technology Vehicles Curricula, Training, and Education and Outreach Activities

Automotive Recycling

How to Use This Material (READ FIRST)

This material has been developed to present a full range of information related to automotive recycling. While it is recommended that users read the entire module, the material has been arranged into three main sections. Each section can be utilized individually or as one collective module.

Preface: The Importance of Alternative Fuels and An Introduction to Alternative Fuels and Advanced Technology Vehicles

This section provides an explanation on why automotive recyclers need to be aware of the growing number of alternative fuel and advanced technology vehicles that can be found on roadways today. This material serves as a basic primer to understanding the need for alternative fuels and advanced technology vehicles, as well as introductory information on the specific alternative fuels and vehicles that utilize them.

The main types of alternative fuel and advanced technology vehicles discussed include:

- Biodiesel
- Ethanol
- Natural Gas
- Propane
- Hydrogen
- Electric Drive (HEVs, PHEVs, BEVs, and FCEVs)

Section 1: General Automotive Recycling Operations and Best Practices

This section provides general information on automotive recycling operations, relating to overall best practices. This section does not specifically address alternative fuel and advanced technology vehicle specifics; however, special boxes do refer users to the relevant specific alternative fuel and advanced technology vehicle information as presented in the section on Alternative Fuel and Advanced Technology Vehicle Specifics.

Section 2: Alternative Fuel and Advanced Technology Vehicle Specifics

This section specifically discusses the unique considerations that automotive recyclers need to know when working with an alternative fuel or advanced technology vehicle.

The material is arranged into relevant topics and then divided into sections for each main type of alternative fuel and advanced technology vehicle: Biodiesel, Ethanol, Natural Gas, Propane, Hydrogen, and Electric Drive (HEVs, PHEVs, BEVs, and FCEVs).

Users may jump immediately to this section and learn valuable take-away information or can use this section as a reinforcement and summary of the earlier material.

For more information, please contact the National Alternative Fuels Training Consortium (NAFTC) at naftc@mail.wvu.edu or (304) 293-7882.

IMPORTANT NOTE:
The guidance and information in this booklet are not meant to take the place of vehicle or equipment manufacturer guidelines and/or emergency response guides, and are not intended to supersede other information, requirements, or regulations provided by manufacturers, the insurance industry, safety officials, or other applicable standards and recommended practices.

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National Alternative Fuels Training Consortium
A Program of West Virginia University

Introduction – Automotive Recycling

Ever since vehicles were first manufactured in the early 1900s, they have been reused and recycled. When an automobile is no longer usable, it generally ends up in the hands of an automotive recycling facility. Automotive recyclers play a valuable role by recovering, rebuilding, and reselling usable parts from worn out or damaged vehicles, as well as recycling materials that cannot be used in their present form. They make it easy for consumers to find clean, used parts for all types of vehicles. Even though waste generation is sometimes unavoidable, vehicle recyclers improve the quality of our environment through best practices for effective vehicle waste management.

The vehicle recycling industry is a multi-billion dollar per year business. According to the Auto Remarketing Corporation, vehicles are the number one recycled product in the U.S. Approximately 10 million vehicles are recycled annually. Three-fourths of the material in vehicles is currently recycled. At least 95% of all vehicles scrapped in the U.S. are collected for reuse and recycling, compared to only 55% of aluminum cans.

Today's new vehicle technologies bring new challenges to the automotive recycling industry.

The U.S. Energy Information Administration (EIA) estimates that in 2011 there were nearly 11 million alternative fuel vehicles in the United States. Just like with conventional automobiles, these alternative fuel and advanced technology vehicles will end up in automotive recycling facilities. While these vehicles are different than most conventional vehicles, they are fundamentally safe. Even so, it's important that recycling operations understand how these vehicles are different and how to properly and most efficiently process them for reuse or recycling.

This material will outline best practices for handling alternative fuel and advanced technology vehicles from the automotive recycler point of view.

The Importance of Alternative Fuels

Petroleum is the most consumed energy source in the U.S. Current consumption levels are higher than domestic production levels. As a result, a significant amount of petroleum is imported from other countries. According to the Energy Information Administration (EIA), the U.S. spends $297 billion per year, or $5.7 billion per week, on petroleum imports. Transportation accounts for a large portion of U.S. energy consumption (see **Figure 1**).

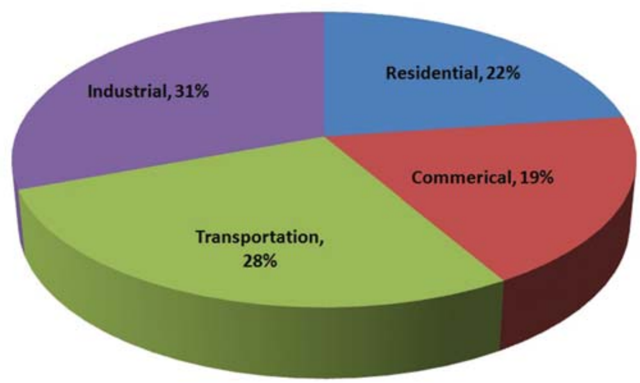


Figure 1: *End-use shares of total energy consumption, 2010. Source: EIA Annual Energy Review 2011.*

The reliance of the transportation sector on petroleum sources is alarming but emphasizes an opportunity to focus on alternative solutions, such as alternative fuel and advanced technology vehicles, to reduce U.S. petroleum consumption.

Reducing Emissions

Vehicle emissions can have negative effects on air quality as well as on human health. On a global scale, the use of fossil fuels is the chief contributor of anthropogenic (caused by human activity) greenhouse gas (GHG) emissions. The main GHG of concern is carbon dioxide (CO_2).

On a national scale, transportation activities account for the second largest portion of CO_2 emissions in the U.S. This emphasizes the nation's opportunity to significantly reduce GHG emissions through the use of alternative fuels and reduced petroleum consumption.

The Need for Alternative Fuel and Advanced Technology Vehicles

Alternative fuel and advanced technology vehicles have evolved significantly over the years. The production and use of these vehicles has been driven by multiple forces, including federal and state regulations, consumer acceptance, and consumer demand.

Federal Requirements

First enacted by Congress in 1975, the purpose of Corporate Average Fuel Economy (CAFE) standards is to reduce energy consumption by increasing the fuel economy of cars and light-duty trucks. The act was passed in response to the 1973 Oil Embargo. The near-term goal was to double new car fuel economy by model year 1985. The current goal of 27.5 MPG has been in place for years, but the current administration has nearly doubled the standard through 2025. **Figure 2** shows the CAFE standards for light-duty passenger cars from its inception to the 2025 goal of more than 50 MPG.

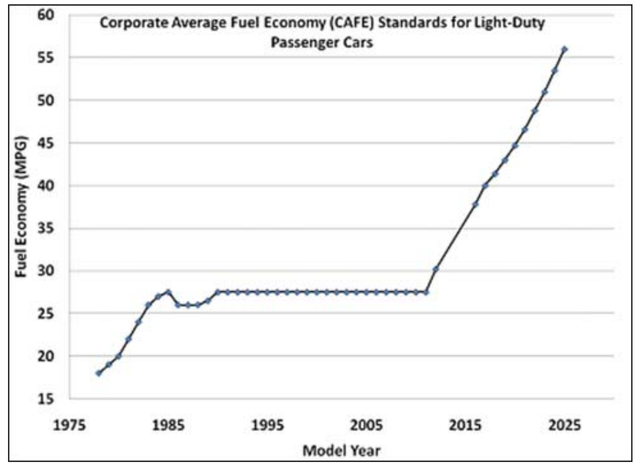


Figure 2: *CAFE fuel economy standards for passenger cars. Source: National Highway Traffic Safety Administration (NHTSA).*

The Energy Policy Act of 1992 (EPAct 1992) was enacted with the purpose of reducing U.S. dependence on imported petroleum and improving air quality by addressing all aspects of energy supply and demand. EPAct 1992 encourages the use of alternative fuel and advanced technology vehicles through voluntary and regulatory activities and approaches carried out by the U.S. Department of Energy (DOE). Voluntary activities to promote alternative fuel and advanced technology vehicles, mainly focused on local efforts, are implemented primarily through the U.S. DOE Clean Cities Initiative. EPAct 1992 regulations require that certain federal, state, and alternative fuel provider fleets build an inventory of alternative fuel vehicles (AFVs).

In 2010, the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) jointly issued a final rule that requires vehicle manufacturers of passenger cars, light-duty trucks, and medium-duty passenger vehicles to improve fleet-wide fuel economy and reduce fleet-wide GHG emissions annually. These regulations are more stringent in comparison with past fuel economy standards and will likely push automobile manufacturers to produce more alternative fuel and advanced technology vehicles.

State and Local Requirements

In addition to the federal requirements that apply to state fleets, most states have enacted regulations related to alternative fuel and advanced technology vehicle acquisitions, as well as alternative fuel use. While not subject to federal regulations, municipal fleets are often required to use alternative fuel and/or fuel efficient vehicles as a result of local regulations and directives. For example, the New York City Administrative Code requires that at least 80% of the New York City light-duty, non-emergency fleet, and 20% of bus fleets operated in New York City, are alternative fuel vehicles.

Consumer Acceptance

Many groups and individuals make up the network necessary to support the alternative fuel and advanced technology vehicles industry, including:

- Current and prospective users (fleets, consumers)
- Vehicle and component manufacturers
- Fuel industry representatives (infrastructure developers, producers, etc.)
- Government officials
- Automotive service technicians
- First responders
- Tow truck and roadside assistance providers
- Automotive recycling personnel

Ensuring that these groups and individuals are properly informed about the key aspects of the vehicles, fuels, and technologies is essential to the continued success of alternative fuel and advanced technology vehicles.

Myths and misinformation related to alternative fuel and advanced technology vehicles can spread quickly and have negative effects on the industry as a whole. Education, outreach, and training are critical elements to ensure that all individuals and groups involved, including potential future users of alternative fuel and advanced technology vehicles, are presented with an accurate picture of the industry.

Consumer Demand

Consumer interest in alternative fuel and advanced technology vehicles is growing as a result of many factors, including higher conventional fuel costs, more vehicle options, improved technology and reliability, and an increasing concern for the environment. Vehicle manufacturers listen to consumer demand and have begun developing new vehicle technologies. For example, General Motors responded to consumer concerns about the limited vehicle range of battery electric vehicles with its Chevrolet Volt by using an onboard generator powered by gasoline to extend the vehicle's range.

These driving forces have combined to create demand and transform markets, leading to a steady increase in the number of AFVs on the road (see **Figure 3**). In 2012, J.D. Power and Associates forecasted that hybrid electric vehicles (HEVs) could represent 9% of the U.S. vehicle market share by 2015. The number of registered HEVs in the U.S. grew to nearly two million in 2012, according to the Electric Drive Transportation Association (EDTA).

Many of the vehicles on the road are produced by original equipment manufacturers (OEMs) and are engineered to use alternative fuels. Other vehicles can be converted to use alternative fuels. These vehicles are typically referred to as aftermarket conversions or retrofits. The EPA and the California Air Resources Board certify aftermarket conversions to ensure the vehicles meet applicable emissions standards. One thing is certain: alternative fuel and advanced technology vehicles are here today and here to stay. They will continue to evolve, incorporating improved technology and adapting to the changing market.

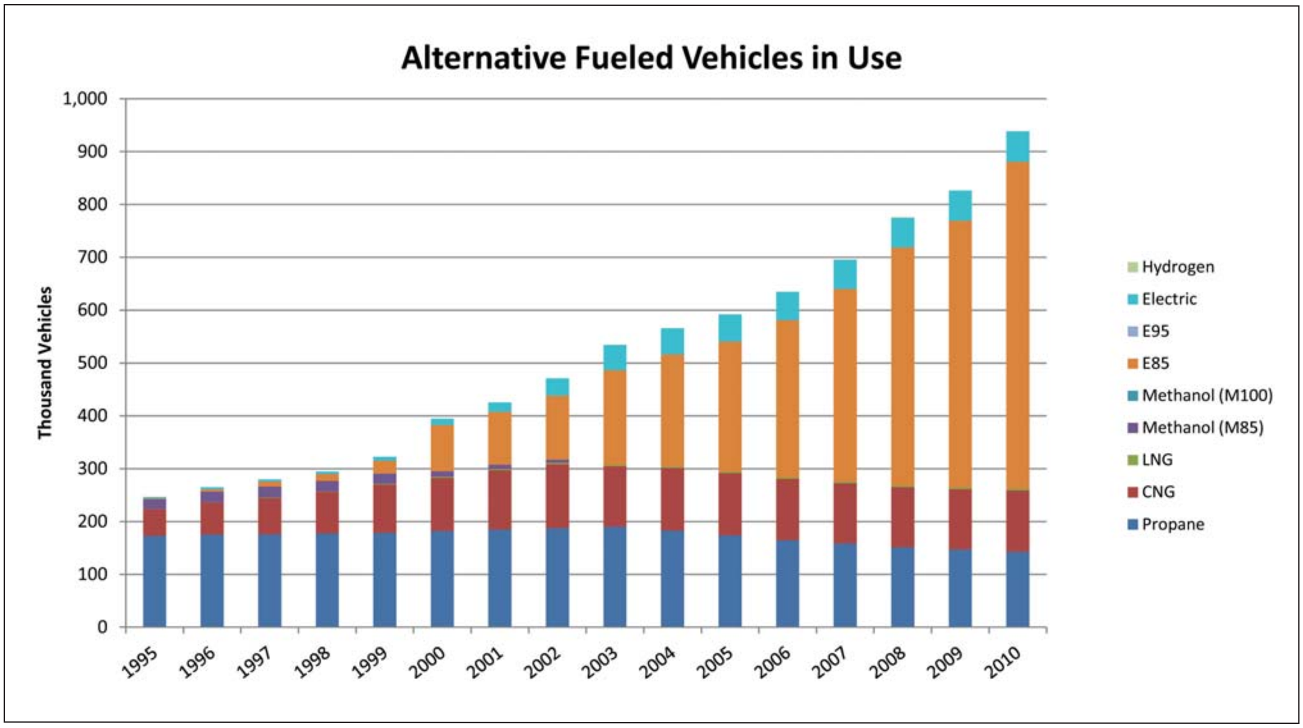


Figure 3: *This chart shows the number of alternative fuel vehicles (AFVs) in use in the United States between 1995 and 2010. The number of AFVs in use has been increasing steadily during the past 15 years, largely due to federal policies that encourage and incentivize the manufacture, sale, and use of vehicles that use non-petroleum fuels. AFVs in widest use today are those that run on E85, propane, electricity, and compressed natural gas. Note: "E85 vehicles" includes only fleet-based vehicles and excludes vehicles with E85 fueling capability that are owned by individuals. Source: EIA's Annual Energy Review/AFDC.*

Summary

As fuel prices continue to rise and consumers and fleet managers become more environmentally conscious, alternative fuel and advanced technology vehicles will continue to become more widely available. The EPA continues to mandate lower emissions regulations, while the CAFE standards continue to increase, resulting in new research and developments.

Notes

An Introduction to Alternative Fuel and Advanced Technology Vehicles

There are more than a dozen types of alternative fuels either in production or under development. Those most commonly used include: biodiesel; ethanol; natural gas; propane; hydrogen; and electricity (electric drive).

Biodiesel

Biodiesel is a domestically produced fuel made from organic materials and feedstock, such as soybeans, animal fat, and recycled organic waste. The most common blend of biodiesel is B20 – 20% biodiesel and 80% conventional diesel. Biodiesel is used in compression-ignited engines (diesel).

Biodiesel can be used in most diesel engines model year 1994 or newer. The most common vehicle applications include heavy-duty trucks, buses, and farm equipment. Most biodiesel vehicles are identified by either looking at the fuel cap or badging near the fuel cap (see **Figures 4** and **5**).

Figure 4: *Diesel gas cap. Source: NAFTC.*

Biodiesel Vehicle Components

The main components of a biodiesel vehicle are similar to those of a conventional vehicle. A biodiesel vehicle has an internal combustion engine (ICE), a transmission, drivetrain, and fuel storage system. The fuel is converted into energy that then powers the vehicle.

The ICE of a biodiesel vehicle converts diesel, biodiesel, or blends of both into mechanical energy, and is usually the same size as the ones found in conventional diesel vehicles. The ICE in a conventional vehicle is sized to produce power for the peak load of the vehicle.

Figure 5: *Biodiesel identification. Source: NAFTC.*

The transmission in a diesel vehicle, approved for use with biodiesel, is responsible for changing the gear ratio between the ICE and the drive wheels as the vehicle accelerates. This ensures that the ICE can supply sufficient torque (twisting force) to the drive wheels in order for the vehicle to start moving and accelerate to the desired speed with maximum efficiency.

The drivetrain in a diesel vehicle, approved for use with biodiesel, is made up of the brakes, axles, and the differentials. The brakes slow down or stop the vehicle, and the differentials act as the final gear reduction in the vehicle, transmitting power through the axles to the wheels and allowing the vehicle to be steered.

Ethanol

Ethanol, like biodiesel, is also domestically produced, usually from corn. Ethanol is a clean-burning, high octane fuel for use in specialized spark-ignited engines (gasoline). The most common blend of ethanol is E85. Vehicles that are E85 (a high-level gasoline blend containing 51% to 83% ethanol, depending on geography and season) compatible are called flexible fuel vehicles (FFVs). FFVs are capable of operating on any ethanol blend between E0 and E85.

Most FFVs are identified by special vehicle badging on or near the fuel port (see **Figure 6**). All conventional gasoline engines can use up to 10% ethanol. In fact, around 97% of all gasoline sold in the U.S. contains some ethanol (see **Figure 7**).

Figure 6: *E85 cap on a flexible fuel vehicle. Source: NAFTC.*

Figure 7: *Fuel pump label for fuels that contain up to 10% ethanol. Source: NAFTC.*

Ethanol/Flexible Fuel Vehicle Components

FFVs have special onboard diagnostic systems and sensors that determine the fuel blend, enabling the vehicle to operate safely and effectively on higher-level ethanol blends. FFVs can run on E85 gasoline or any blend of the two without adverse effects on fuel system materials, on-board diagnostics (OBD) systems, or driveability.

For the most part, FFVs are identical to conventional gasoline vehicles. There are only two major differences: the engine calibration and the fuel management system.

Since E85 has less energy than gasoline by mass, the computer tells the fuel injectors to administer more fuel to the engine. The injectors must be capable of accommodating the extra fuel requirement. While ethanol is a fantastic cleaning agent for fuel systems (most fuel injector cleaners and water removers are ethanol based), running it over an extended period of time may cause damage to o-rings and seals. FFVs have the appropriate seals to accommodate E85.

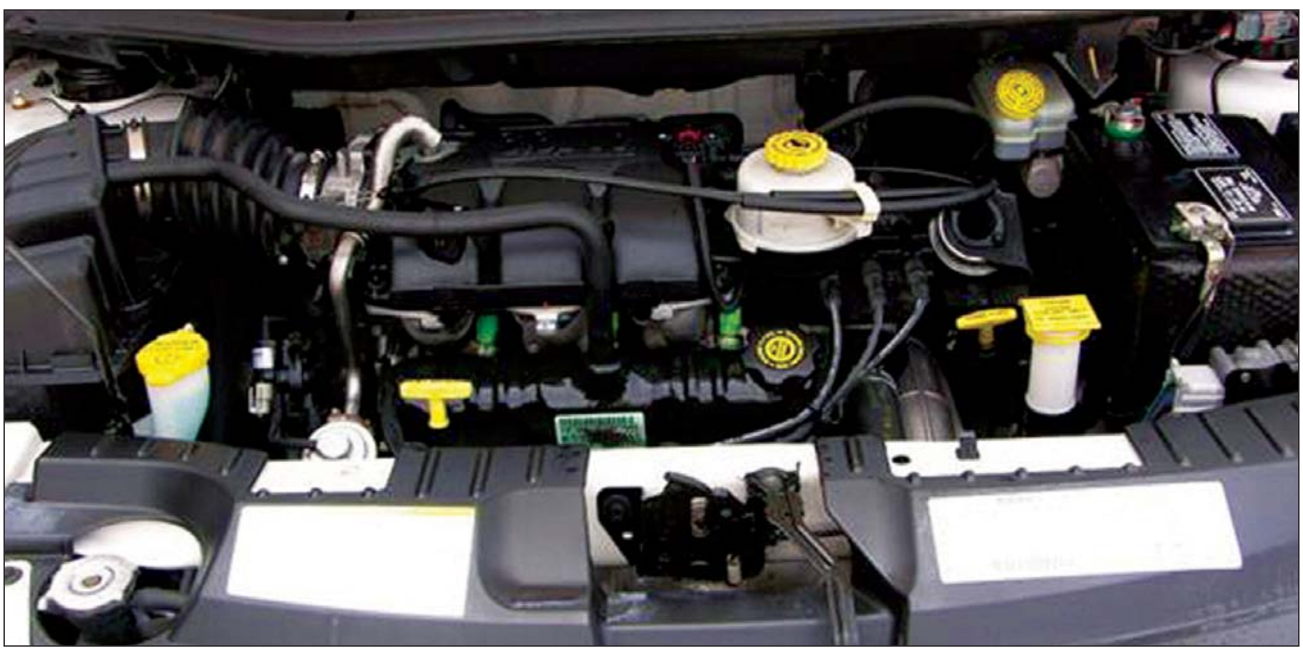


Figure 8: *Flexible fuel vehicle engine. Source: NAFTC.*

Engine Calibration

FFVs can run on a fuel that has a higher octane rating than conventional gasoline. However, FFVs are calibrated to accommodate for this difference. The ICE of a flexible fuel vehicle converts gasoline, ethanol, or a blend of both into mechanical energy (see **Figure 8**). The internal combustion engine in an ethanol vehicle is usually the same size as the ones found in conventional gasoline vehicles.

Fuel Management Systems

E85 is a highly corrosive fuel. Without a properly treated fuel system, it may cause damage to fuel lines, storage systems, injectors, and even the exhaust systems of certain vehicles. In order to make ethanol a viable fuel source, the vehicle must be capable of handling the fuel's corrosive nature. Ethanol fuel also contains less energy than conventional gasoline.

Ethanol is a very high octane fuel that replaces the additives used in gasoline as octane enhancers. Since ethanol contains about 35% oxygen by weight, it oxygenates the fuel. Adding oxygen to a fuel mixture makes it burn more completely, thus reducing harmful tailpipe emissions.

Natural Gas

Natural gas is a clean-burning fossil fuel that is comprised mostly of methane. It is readily available in two forms: compressed natural gas (CNG) and liquefied natural gas (LNG).

Compressed Natural Gas

Natural gas normally arrives at a fueling station via pipes lines and is then compressed in tanks before being pumped into a CNG tank via a dispenser.

CNG is pressurized up to 3600 pounds per square inch (psi). CNG is stored very stably over longer periods of time.

A typical natural gas vehicle requires one or more CNG cylinders. Vehicle range can vary depending on the size of the CNG tank. CNG tanks are classified as Type 1, Type 2, Type 3, or Type 4, depending on their composition.

Type 1 cylinders are the heaviest, and Type 4 are the lightest in terms of weight for volume of CNG stored; Type 2 and 3 cylinders fall in between (see **Figures 9** to **13**).

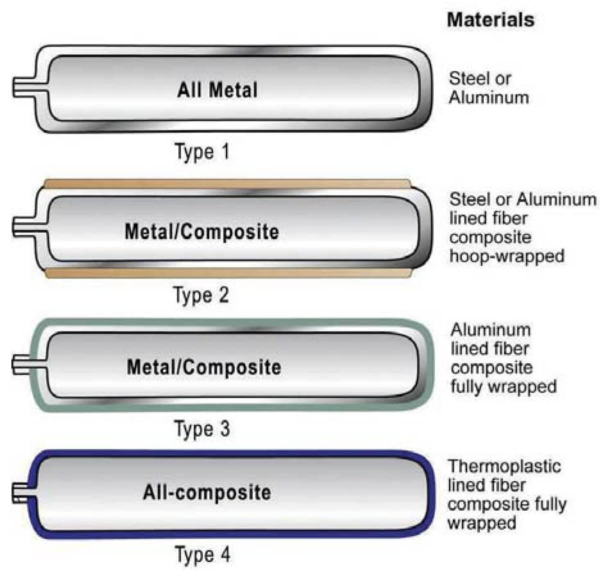


Figure 9: *The composition of CNG cylinders used in vehicles. Source: NAFTC.*

Notes

Figure 10: *Photo of Type 1 cylinder. Source: NAFTC.*

Figure 11: *Photo of Type 2 cylinder. Source: NAFTC.*

Figure 12: *Photo of Type 3 cylinder. Source: NAFTC.*

Figure 13: *Photo of Type 4 cylinder. Source: NAFTC.*

The typical CNG tank for a conventional vehicle can hold the equivalent of 8-24 gallons of gasoline. CNG cylinders should be inspected every three years or 36,000 miles and after any accidents.

Liquefied Natural Gas

LNG is cryogenic, meaning it can't exist as a liquid at ambient temperature. Therefore, its temperature is lowered to a liquid state and then it is stored in insulated containers called dewars (see **Figure 14**). LNG is produced by cooling natural gas to a temperature below -260°F (-162°C) at normal atmospheric pressure. It is pressurized for onboard storage to decrease the required temperature and extend the amount of time it can spend in liquid form. If spilled, LNG will pool on the ground or floor, but will evaporate into a gas.

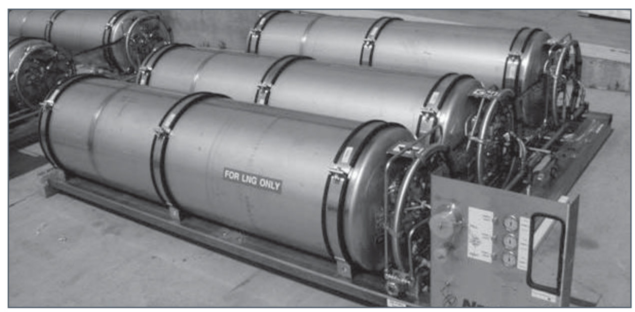


Figure 14: *LNG storage tanks, called dewars. Source: NAFTC.*

LNG tanks are designed for fairly low operating pressures, typically less than 250 psi (17.2 bar). To protect the tank from rupturing because of overpressure, pressure relief valves (PRVs) release some vapor when the maximum pressure is reached.

LNG tanks can hold a tremendous amount of fuel but also require a great deal of space and thermal insulation. Vehicles that can benefit from LNG are typically larger vehicles, like trucks and buses.

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.

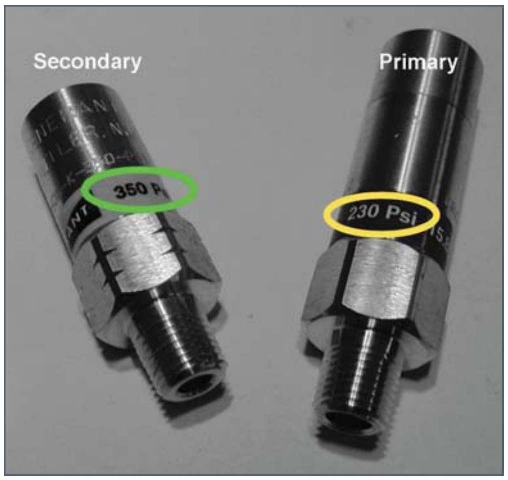


Figure 17: *Pressure relief valves: primary (230 psi, 15.8 bar) on right, secondary (350 psi, 24.1 bar) on left. Source: NAFTC.*

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.*

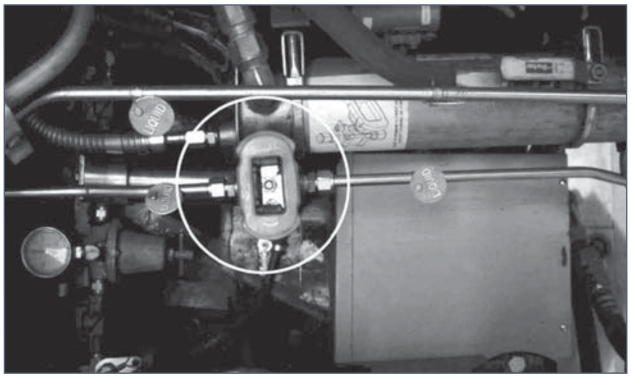


Figure 20: *LNG manual shutoff valve located on the liquid supply line. Source: NAFTC.*

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.

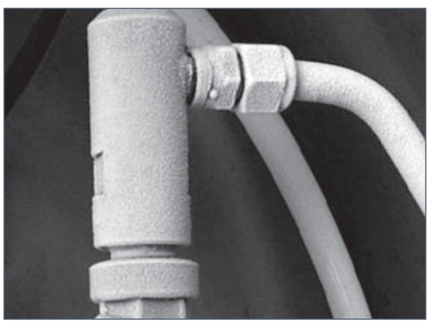


Figure 21: *Backflow check valve. Source: NAFTC.*

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.*

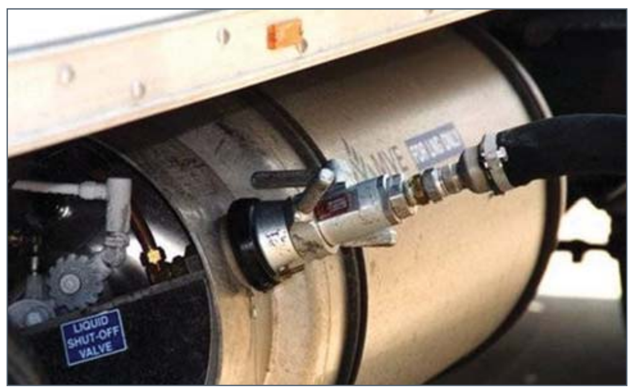


Figure 23: *Specially designed LNG nozzle. Source: NREL.*

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.

Regulator

A propane regulator is a device that will increase or decreae the flow of fuel based upon how much fuel is required for the engine speed and load (see **Figure 25**). A regulator for gaseous fuel works off of a vacuum. The more fuel that is used, the more suction is applied to the regulator. The regulator makes sure that there is a continuous flow of gas to the engine without allowing excess. In many cases, regulators and vaporizers are combined in the same device.

Figure 25: *Propane regulator. Source: NAFTC.*

Vapor Injectors

As emissions regulations have become more stringent and accurate engine controls have increased, the vapor system has evolved to include multipoint vapor injectors similar to multipoint gasoline injection systems. This advanced system allows for increased performance from propane engines. For dedicated systems, the gasoline electronic fuel injectors are replaced with gaseous electronic propane injectors. Conventional fuel injectors deliver liquid fuels which have certain lubricative properties. Gaseous electronic propane injectors, on the other hand, utilize different designs to accommodate the delivery of dry gases. Vapor systems such as these also require higher flow rates because gaseous propane is about 270 times less dense than the propane within the tank. Vapor or gas injectors require the use of a regulator to reduce from tank level pressure.

Unlike older vaporizer/mixer systems, the pressure of the vapor is still maintained at higher-than-intake pressures, typically on the order of 60 psi (4.08 bar). These pressures allow for propane to become gaseous, but still have a greater density than propane gas at ambient conditions. These systems were common among propane or bi-fueled vehicles near the turn of the century. The last commercially available bi-fuel vehicle to consumers was the 2004 propane bi-fuel Ford F150.

Newer Fuel Injection Systems: Liquid Propane Injection

Since the early 2000s, American auto manufacturers have produced only limited propane vehicles, which are mainly for fleet applications. However, propane-powered vehicles continue to evolve with aftermarket companies and overseas advancements in technologies. The current propane vehicle technology utilizes liquid propane injection. This is different from early gas/vapor injection systems. The liquid propane, which is much denser, provides better performance through the increased energy density of the fuel flow and the cooling effect of a liquid fuel. These systems are nearly identical to the operation of multipoint gasoline fuel injection systems.

A propane fuel pump is typically located in the tank and delivers pressurized liquid propane to the fuel rail in the engine compartment. The liquid fuel is fed into the back of electronically controlled fuel injectors and delivered into the intake in liquid form. Like common gasoline systems, the excess pressurized fuel is returned to the propane storage tank via fuel return lines. An example of this technology is shown in a beta version of a Chrysler-produced propane-fueled vehicle (see **Figure 26**).

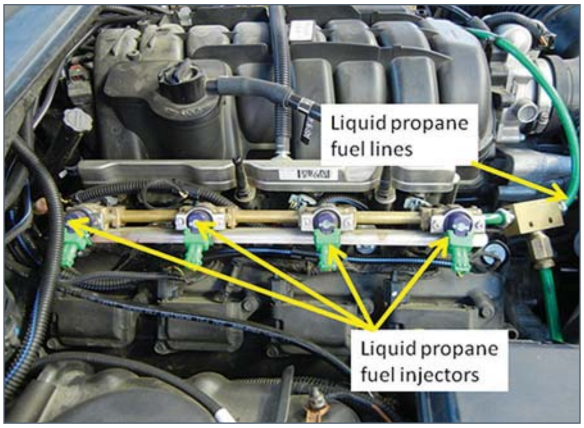


Figure 26: *Liquid propane fuel injection system on Chrysler beta vehicle. Source: NAFTC.*

Propane Fuel Storage System

The fuel storage system in a propane vehicle consists of one or more durable steel fuel tanks that store the propane fuel for the vehicle's engine. These tanks are 20 times more puncture-resistant than gasoline tanks. There is normally a manual shutoff on these tanks for removal and servicing. The fuel storage system can be located in a vehicle's trunk area, under the side panel of a van or school bus, on the frame, or in the bed of a pickup truck. These tanks increase the weight of a retrofitted gasoline vehicle. In bi-fuel propane vehicles, the fuel system consists of a high-strength propane tank (see **Figure 27**) as well as a conventional gasoline fuel tank.

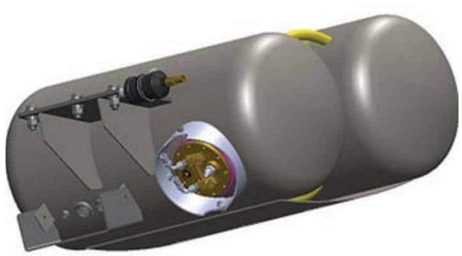


Figure 27: *Propane fuel tanks. Source: EERE.*

Propane Pressure Relief Valve

Every propane fuel tank is equipped with an internal spring-type pressure relief valve (PRV). These valves open automatically to vent vapor if internal tank pressure exceeds the discharge pressure set point (see **Figure 28**). The PRV is positioned above the liquid, in the vapor space, to ensure that the valve will discharge only vapor. It is designed to relieve a given volume of vapor at a set pressure. If the pressure inside the container reaches a certain level, the PRV will discharge some vapor, reducing the internal pressure to a safe level. For example, if the tank's normal pressure is 80 psi (5.5 bar) but the pressure has been increased to 85 psi (5.86 bar), the PRV will open to release 5 psi (0.36 bar) from the tank. PRVs must be vented to the outside of the vehicle. Individuals should not remove or tamper with any PRV. These valves should not be confused with pressure relief devices (PRDs), used on compressed natural gas tanks.

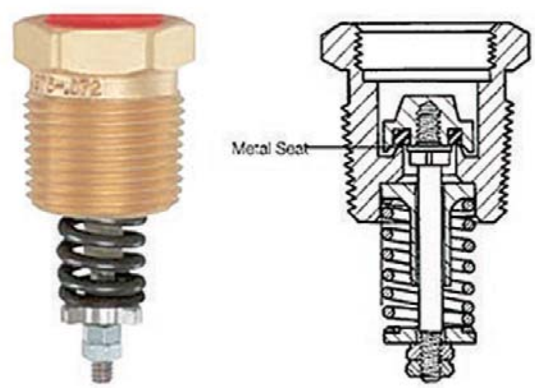


Figure 28: *Pressure relief valve. Source: NAFTC.*

Solenoid Shutoff Valve

The propane solenoid shutoff valve is the electronic valve that verifies that the petroleum gas will not flow when the vehicle is not in use. Most of these valves run on a 12 DCV system in order to make sure that no fuel may be used when the key is not in the ignition.

Fuel Lock

A fuel lock is a device that will automatically shut off the flow of fuel from the tank to the engine if contaminants are discovered in the fuel. Fuel locks are typically combined with the propane filter.

Fuel System Configurations

Propane can be used in two main types of fuel system configurations – dedicated and bi-fuel. (Dual-fuel propane vehicles are being developed. Updates to this booklet will include this information; details were not available at time of printing.)

- Dedicated means that the vehicle has been purposefully-built to run only on propane.
- Bi-fuel is a term used to describe a vehicle that has two separate fueling systems that utilize propane and conventional gasoline (see **Figure 29**).

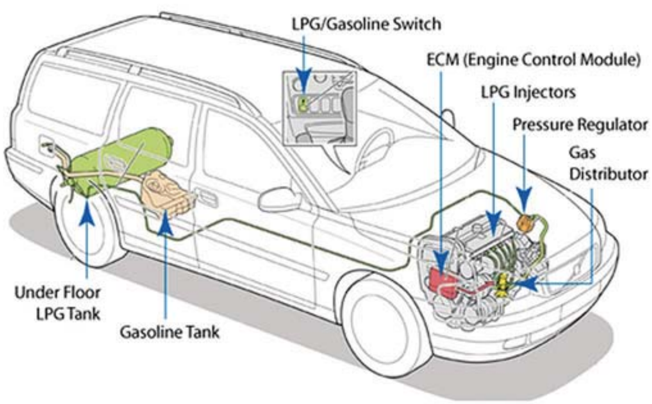


Figure 29: *Bi-fuel propane vehicle. Source: AFDC.*

Propane is most commonly used in warehouse equipment, such as forklifts (see **Figure 30**). It may also be commonly seen in medium-duty trucks, due to the propane tank being able to be stored in the cargo area (see **Figure 31**).

Figure 30: *Propane warehouse equipment. Source: NAFTC.*

Figure 31: *Propane-powered vehicle. Source: NAFTC.*

Hydrogen

When used as transportation fuel, hydrogen can propel a vehicle either through combustion (like in an internal combustion engine) or by powering a fuel cell. In both cases the main by-products are heat and water. This makes hydrogen-powered vehicles an environmentally conscious option for consumers. Fuel cell vehicles may also be considered a type of electric drive vehicle, referred to as fuel cell electric vehicles (FCEVs).

A fuel cell is a device that electrochemically produces energy by separating the protons and electrons in a hydrogen molecule by channeling their flow, and creating an electrical current (see **Figure 32**). FCEVs utilize multiple fuel cells to create a fuel stack.

Hydrogen vehicles are mostly in the prototype stage. The only commercially available hydrogen vehicle currently available for lease is the limited production Honda FCX Clarity available only in California (see **Figure 33**). In Spring 2014, the 2015 Hyundai Tucson FCV is scheduled

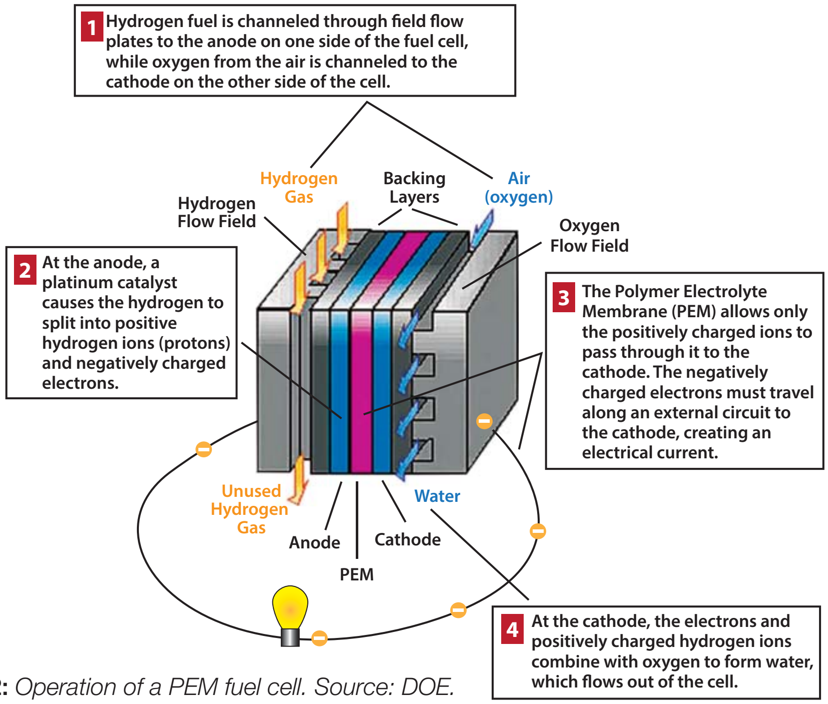


Figure 32: *Operation of a PEM fuel cell. Source: DOE.*

to be available for lease to consumers in Los Angeles or Orange County, CA only. However, the future of hydrogen vehicles remains positive and it is extremely likely that more hydrogen and hydrogen-powered vehicles will be seen on U.S. roadways soon. Many manufacturers have announced plans for offering fuel cell vehicles, some as soon as 2015.

Hydrogen is used as a gaseous fuel, unlike gasoline, which is a liquid fuel. This means that hydrogen enters the engine or PEM type fuel cell as a gas, while gasoline is injected as a liquid. However, hydrogen may be stored onboard as a pressurized gas or as a liquid.

Onboard storage has been a challenge for hydrogen vehicles. This is because the volume of hydrogen gas for typical driving ranges is large compared to the volume of gasoline required for the same range. An advantage of onboard storage of hydrogen gas, on the other hand, is that it is very safe. Advances in composite tanks utilizing carbon fiber have allowed for this level of safety.

One method for storing hydrogen is cryogenically. Cooling hydrogen to –420°F (–250°C) causes it to condense to its liquid state. Cryogenic storage is common in the bulk transportation of hydrogen.

On the other hand, cryogenic storage is not common for many of the demonstrated hydrogen fuel vehicles. In these cases, storage in liquid form reduces the required tank volume due to its increased volumetric energy density.

Unlike an oil spill on land or at sea, a hydrogen spill presents very little danger of environmental damage. As with any cryogenic substance, special precautions must be taken to prevent damage or injury from handling these liquids.

Figure 33: *Honda FCX Clarity. Source: NAFTC.*

Like all chemical elements, hydrogen can exist as a solid, liquid, or gas. Compression makes hydrogen denser so that it can be stored in a gaseous state and used for fuel. Storage vessels capable of containing hydrogen at 10,000 pounds per square inch (psi) are generally used. Many demonstration models, however, are operating and fueling with pressures of 5000 psi (350 bar).

Hydrogen also can be transported and stored as a liquid. However, liquid hydrogen is a cryogenic fluid. This means that it can exist as a liquid only at very cold temperatures. As it warms, liquid hydrogen vaporizes (turns into gas) and expands to about 800 times its liquid volume. Because of this, specialized equipment and safety procedures for storage must be observed while handling liquid hydrogen. In a motor vehicle, only hydrogen gas is burned in the internal combustion engine (ICE). Previous experience with liquefied natural gas vehicles shows that this is both possible and safe. Demonstration vehicles have safely utilized onboard liquid hydrogen storage.

Differences Between Hydrogen and Conventional Vehicles

There are two ways hydrogen may be used as a fuel. Hydrogen can be burned in an ICE or it may be used to produce electricity in a fuel cell. In both cases, the main byproducts are heat and water. This makes hydrogen-powered vehicles an environmentally conscious option for consumers.

Hydrogen ICE

The combustion chamber and cooling system of conventional ICE engines require modification to control difficulties with premature ignition. Hydrogen ICEs require the use of superchargers or turbochargers to supply sufficient quantities of air (boost) to the combustion chamber. Special fuel injectors and fuel delivery rails are needed to transfer hydrogen gas into the combustion chamber.

The internal combustion engine of a hydrogen vehicle burns hydrogen gas as its fuel to create energy. This energy then powers the vehicle. While the fuel system in a hydrogen vehicle is significantly different, the engine itself is comparable to conventional engines (see **Figure 34**).

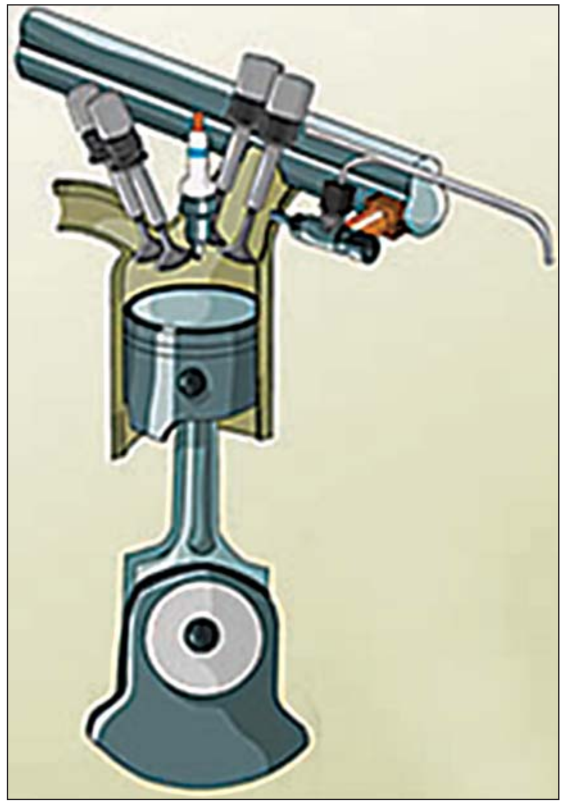


Figure 34: *Hydrogen internal combustion engine components. Source: NAFTC.*

The internal components of the engine are basically the same with some timing and compression ratio differences. Hydrogen-powered vehicles require very low ignition energy in order to ignite the air-fuel mixture. One drawback to hydrogen's low ignition energy, however, is that hot gases and hot spots in the combustion chamber can serve as sources of ignition, leading to the problem of premature ignition (better known as engine knock). Preventing premature ignition is one of the central challenges in using a hydrogen ICE.

Fuel Cells

A fuel cell is a device that electrochemically produces energy by separating the protons and electrons in a hydrogen molecule and channeling their flow to create an electrical current. The electricity can be used to power the vehicle's electric motor(s). Fuel cells are extremely efficient, even more so than hydrogen ICEs, and can greatly reduce air pollution.

There are different types of fuel cells. In vehicles, the typical fuel cell is a proton exchange membrane (PEM). This type of fuel cell creates electricity by using a combination of hydrogen, oxygen, electrodes, a catalyst, and a special polymer membrane. An FCEV uses a fuel cell stack that is made up of multiple PEM fuel cells (see **Figures 35** and **36**).

Figure 35: *Cutaway view of a fuel cell. Source: NAFTC.*

Hydrogen Vehicle Components

ICE-Powered Vehicles

Since hydrogen-powered internal combustion engine (ICE) vehicles are very similar to conventional vehicles, the main engine components are the same: hydrogen-powered ICE vehicles have an internal combustion engine, transmission, drivetrain, and fuel storage system, though the fuel storage system is significantly different. The ICE of a hydrogen vehicle burns hydrogen gas as its fuel, which is converted into energy. This converted energy then powers the vehicle. The functions of the transmission and drivetrain in a hydrogen-powered vehicle are identical to those in a conventionally fueled vehicle.

Fuel Cell Electric Vehicles

Hydrogen fuel cell vehicles (FCEVs) are very similar to other electric drive vehicles. These vehicles require the use of a motor/generator, high-voltage battery pack, and fuel storage system. Electric motors do not require complex transmissions since they can regulate their speed and maintain a constant amount of torque. As hydrogen travels through the fuel cell to generate electricity, that electricity is transferred to the high-voltage battery pack, and/or to the motor to propel the vehicle.

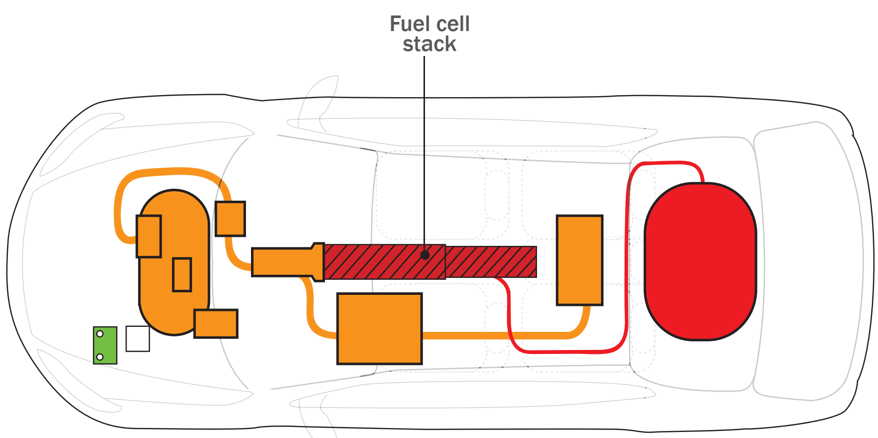


Figure 36: *Fuel cell vehicle schematic showing fuel cell stack. Source: NAFTC.*

Electric Drive Vehicles

Electric drive refers to an advanced technology vehicle that utilizes electricity as an energy source. This energy can be stored onboard in the form of batteries or it can be generated from internal combustion engines (ICEs), fuel cells, or plugged into the electrical grid to charge onboard batteries for additional all electric range.

The main types of electric drive vehicles include: HEVs, PHEVs, BEVs, and FCEVs.

- Hybrid electric vehicles (HEVs) utilize conventional gasoline as well as a battery source to power the drivetrain. An example of an HEV is the Toyota Prius (see **Figure 37**).

Figure 37: *The Toyota Prius Second Generation, one of the most notable examples of an HEV. Source: NAFTC.*

- Plug-in hybrid electric vehicles (PHEVs) utilize conventional gasoline, but can also be directly plugged into the electrical grid to charge onboard batteries for additional all electric range. An example of a PHEV is the Chevrolet Volt (see **Figure 38**). The Volt is also often referred to as an extended range electric vehicle.

Figure 38: *An example of a PHEV, the Chevrolet Volt. Source: NAFTC.*

- Battery electric vehicles (BEVs) run only on battery power, and therefore do not rely on conventional gasoline. These types of vehicles are sometimes referred to as zero emission vehicles. The Nissan LEAF is an example of a BEV (see **Figure 39**).

Figure 39: *An example of a BEV, the Nissan LEAF. Source: NAFTC.*

- Fuel cell electric vehicles (FCEVs) utilize fuel cells to create onboard electrical energy to power the vehicle. The Honda Clarity is an example of an FCEV.

Electric Drive Batteries

There are several different options when it comes to storing the energy that EVs use. Battery technologies have been under development for several decades, and new types are being introduced. Lead acid batteries, nickel metal hydride (NiMH) batteries, and lithium-ion (Li-ion) batteries are currently the most commonly used batteries. Research is being conducted to find batteries that are lighter and have greater energy storage capacity. Recent research suggests that lithium-polymer (Li-poly) batteries and zinc-air batteries will prove to be efficient energy storage sources, providing driving ranges similar to conventional vehicles and shorter charge times.

Lead Acid Batteries

Conventional vehicles all use lead acid batteries to power the engine starter, lights, and accessories. These batteries are most commonly 12VDC batteries. The systems are typically termed low-voltage since they operate at less than 60VDC. Lead acid batteries are found as traction batteries in earlier production electric vehicles, such as the 1990s GM EV-1 and also in home conversion and industrial EVs.

Nickel Metal Hydride Batteries

Nickel metal hydride (NiMH) batteries are frequently used in EVs. They have an excellent energy density, long life cycle, and high levels of abuse tolerance. The disadvantages of using NiMH batteries include the relatively high cost of their raw materials and their reliance on corrosive liquid electrolyte.

Lithium-Ion Batteries

Lithium-ion batteries are used in all types of electric drive vehicles, including FCEVs, HEVs, PHEVs, and BEVs. Lithium-ion batteries are the battery of choice in current BEVs, such as the Nissan LEAF, due to their high energy storage capacity and good power-to-weight ratio, and decreasing cost.

Lithium batteries are the newest technology and show great potential for long-range electric vehicles. There are several different lithium chemistries vying for prominence in the electric drive vehicle marketplace, each with various advantages and disadvantages.

The battery pack in a BEV (see **Figure 40**), is composed of a large number of individual cells that are arranged in parallel and/or series to provide the voltage and current requirements for the system.

Figure 40: *Close-up of an electric vehicle battery pack. Source: NAFTC.*

Notes

Electric Drive Vehicle Components

The main vehicle components used in an electric drive vehicle include a controller, motor/generator, and a high-voltage battery pack (see **Figure 41**).

The first, and possibly most important component, is the battery pack. This is the main electrical storage device for the vehicle. Beyond providing traction power to turn the wheels, this battery pack (see **Figure 42**) also provides power to other high-voltage onboard electrical systems or low-voltage systems such as cabin heating and air conditioning (A/C). In addition, the vehicle uses what is known as a DC to DC converter (which converts high voltage to low voltage) to operate normal vehicle components such as lights, instruments, and audio systems. These battery packs are typically made up of several small battery cells connected in series and/or parallel to produce the adequate voltage and current. Components above 60VDC are typically labeled as high voltage. Most conventional vehicle electrical systems are low voltage and operate at 12VDC.

Figure 41: *Main electric vehicle components. Source: NAFTC.*

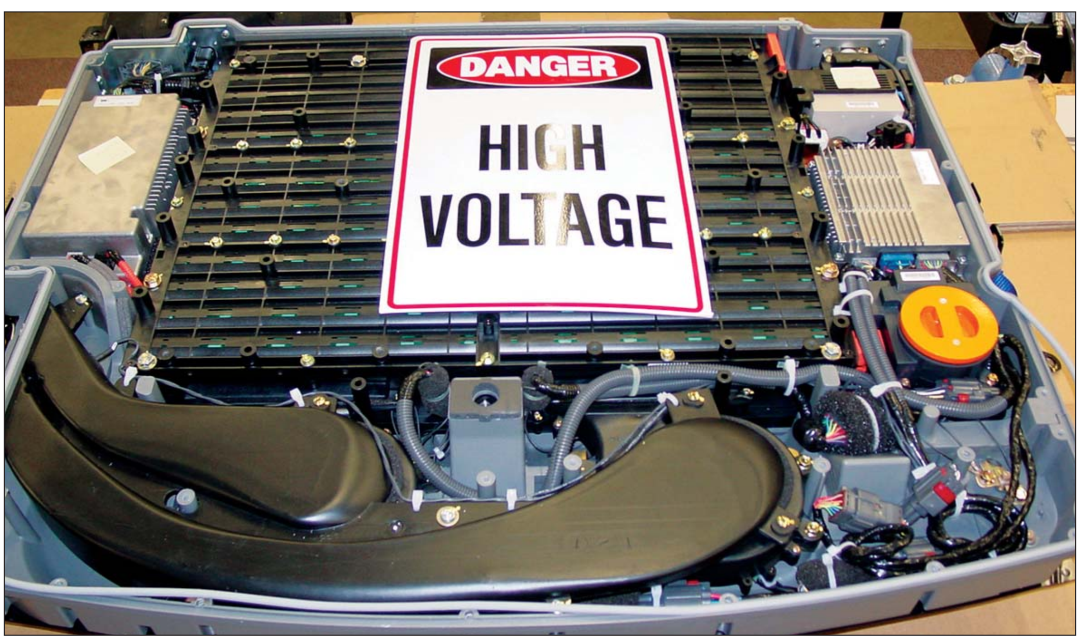


Figure 42: *High-voltage battery and cooling system. Source: NAFTC.*

The second major component of an electric drive vehicle is the controller. This device helps to control the flow of electricity between the battery and the electric motor/generator. By doing this, the controller can send power from the battery to the motor/generator when needed, and can send power from the motor/generator to the battery when regenerative braking (conversion of energy from braking into electricity) takes place.

The third component of an electric drive vehicle is the electric motor/generator (MG). This device is also known as the electric drive motor or the electric traction motor. This motor actually turns the vehicle's wheels. As the vehicle brakes, this motor/generator can also capture the energy of the slowing wheels and store that energy in the battery pack.

Dashboard

The dashboard of an electric drive vehicle looks almost identical to that of a conventional vehicle, only with modern styling to make it appealing (see **Figure 43**). Normally, either alongside or in place of a fuel gauge, there is a gauge indicating how much battery energy remains in the vehicle.

There are also a series of lights or gauges to help the vehicle operator know when their driving practices are conserving energy or using it quickly. These systems help the vehicle operator to achieve the highest fuel economy possible.

Sound

Electric drive vehicles are extremely quiet in comparison to conventional vehicles when running in electric only mode. Because of this, a pedestrian may not realize that a vehicle is approaching them. Automotive manufacturers have begun to offer what are being referred to as "Vroom-tones" for electric drive vehicles. These systems make artificial engine noises (or any sound the operator chooses to download) to indicate to pedestrians that a vehicle is approaching. However, the silence of these vehicles is also a benefit in congested areas or enclosed spaces.

Figure 43: *Chevrolet Volt dash and instrument panel. Source: NAFTC.*

General Automotive Recycling Operations and Best Practices

See Alternative Fuel and Advanced Technology Vehicle Specifics on pages 29-60.

Each state may have differing definitions of what constitutes an automotive recycling operation. In some instances, an automotive junk yard may be equivalent to an automotive recycling facility. In other states, there is a distinct difference between the two. Some automotive recycling facilities are official automotive recyclers, complete with shredding and crushing services (see **Figure 44**). Yet others focus primarily on parts removal and perhaps even auto repair. What does remain constant is the basic understanding and social responsibility of handling regulated substances and wastes. There are several types of environmental concerns that are regulated in this industry, such as groundwater contamination, surface and storm water contamination, soil contamination, and air pollution. As a result, fluid management and overall storage is of growing importance, particularly with alternative fuels and advanced technology vehicles.

Figure 44: *There are several environmental concerns regulated in the automotive recycling industry. Source: ARA.*

Before reviewing the specifics of alternative fuel and advanced technology vehicles, let's first review the general best practices of an automotive recycling operation.

While each state may have their own code of compliance for automotive recycling facilities, the following list of best practices is a recommended starting point. **It is advisable to consult with your local and state jurisdictions for additional guidance.**

Incoming Car Inspection/Processing

One of the first things that should be done with all incoming vehicles is an appropriate incoming inspection. This allows the vehicle to be properly identified as a conventional vehicle or as an alternative fuel or advanced technology vehicle, and the components to be properly dismantled and stored. This is important whether the vehicle is going to be stored and/or crushed.

This includes:

- Identifying vehicle type – conventional or alternative fuel/advanced technology.

The first step of the inspection process should be to determine if the vehicle is an alternative fuel or advanced technology vehicle, as these vehicles have several unique features that will require specialized attention. See section on Identifying Alternative Fuel and Advanced Technology Vehicles starting on page 29.

- Inspecting incoming vehicles for leaks from engines, radiators, transmissions, differentials, fuel tanks, and damaged areas. Be careful to **NOT** tip vehicles on their sides, as this may allow the fluids to spill from the vehicle. In the event of a leak or a possible leak, place drip pans under the areas to collect all possible fluids.

Spills can occur with alternative fuel and advanced technology vehicles, as with any other vehicles; however, the fuels and/or other specialized fluids found in high-voltage batteries and other components can require specialized attention. See section on alternative fuel and advanced technology vehicle Spills and Leaks starting on page 43.

- Removing the fuel, refrigerants (CFCs), and low-voltage (12VDC) batteries as soon as possible. Remove mercury switches from hood/trunk and ABS sensors.

Clean Cities Learning Program

See Dismantling Alternative Fuel and Advanced Technology Vehicles section with information on removing alternative fuel and advanced technology vehicle components starting on page 50.

- Draining **ALL** fluids from vehicles before crushing or storing. This includes all fluids contained in the engines, radiators, transmissions, heater cores, brake lines, differentials, all lines and hoses, fuel tanks, air conditioning units and window washing fluid tanks. Remove and capture refrigerants (CFCs) as required by the federal Environmental Protection Agency (EPA).

See section with information on alternative fuel and advanced technology vehicle Spills and Leaks starting on page 43.

Dismantling

While some vehicle components may be recycled and appropriate for re-sale, it's still important to follow standard procedures for dismantling any vehicle, in particular alternative fuel and advanced technology vehicles.

See Dismantling Alternative Fuel and Advanced Technology Vehicles section with information on removing alternative fuel and advanced technology vehicle components starting on page 50.

Air Bags

Most new cars come equipped with air bags. The propellant used in air bags is sodium azide, a potentially hazardous substance that is dangerous if inhaled and that may burn exposed skin. If the airbag has been deployed, it's safe to leave the air bag in the vehicle, as deployed air bags **DO NOT** pose a risk to human health or the environment. If the air bags are undeployed, there are special considerations to review.

SPECIAL NOTE:
Air bags in alternative fuel and advanced technology vehicles are the same as for conventional vehicles.

12-Volt Batteries

A typical 12-volt automobile battery contains 18-20 pounds of lead and 11 pounds of sulfuric acid. These lead-acid batteries can pose serious health and environmental hazards. It is the job of the automotive recycler to determine the appropriate course of action to take: to recycle the 12-volt battery, return it to the battery manufacturer, or handle it as hazardous waste.

SPECIAL NOTE:
It's important to note that lead acid batteries are exempt from hazardous waste regulations if recycled or returned to a battery distributor or manufacturer and documentation is maintained.

In addition to standard 12-volt batteries, electric drive vehicles have high-voltage batteries which require specialized attention. See section on Advanced Technology Vehicle Electrical System and Components for information on these specialized components, including batteries, starting on page 34.

Fuel and Fuel Filters

It's imperative that you first identify the type of vehicle (**see incoming car inspection**) to understand the type of fuel that may be present in the vehicle.

Fuel and fuel tanks should be removed as soon as possible after the vehicle enters the facility.

Some alternative fuel vehicles, particularly natural gas, propane, and hydrogen, require specialized attention in removing the fuel and/or tanks. See section on Dismantling Alternative Fuel and Advanced Technology Vehicles starting on page 50 for information.

Keep in mind that some fuel tanks, particularly the gaseous fuels vehicle types (natural gas – both CNG and LNG — propane, and hydrogen) may not be removed until the cylinder is defueled.

Defueling should always be performed outdoors. Bi-fuel and dual-fuel systems may mean that multiple fuels are present. Common examples may include:

- CNG and conventional gasoline
- LNG and conventional gasoline
- CNG and diesel

For additional information on specific alternative fuels and their fuel properties, see section An Introduction to Alternative Fuel and Advanced Technology Vehicles starting on page 8.

Determine if fuel is reusable or waste fuel. Fuel that has been deemed reusable can be used in facility or employee vehicles, but check with your own state or local requirements. Label containers clearly as "reusable fuel" or "waste fuel."

Remember to keep all fuels separate and labeled. Store the fuel in closed, leak-proof containers. **DO NOT** mix fuels!

Be sure to drain excess fuel from filters. Used fuel filters should be stored in separate, fireproof containers marked "used fuel filters only." Fuel filters should be handled as hazardous waste and disposed of accordingly. Some landfills will take used fuel filters if they are punctured and drained for 24 hours. Check with your local landfill for information.

Lead Parts

Lead is a well-known toxic substance. Even small amounts of lead can be enough to contaminate an entire truckload of auto fluff (material leftover after shredding). Therefore, it's imperative that all lead parts are removed from vehicles prior to being crushed or shredded.

SPECIAL NOTE:
According to the Electric Drive Transportation Association, each year the automotive recycling industry collects and reuses or recycles 96% of all lead acid batteries. 50% or more of the lithium in an electric vehicle's battery can be recycled. See the information on Advanced Technology Vehicle Electrical System and Components starting on page 34.

Waste Handling, Storage and Disposal Practices

Keep each waste separate and never mix waste streams. Mixing often results in fewer or no recycling opportunities or reuse options, all of which means that disposal or recycling costs will be higher. Mixing wastes might even cause a chemical reaction that could produce an explosion, fire, or toxic gases.

Focus on recycling the appropriate wastes. Proper storage of waste is extremely important.

See section on Alternative Fuel Vehicle Fuel Storage and Components for more information starting on page 34.

Crushing

The following best practices should be followed:

- Vehicles should be adequately drained prior to crushing in order to minimize the volume of waste fluids to manage. The automotive recycling owner is responsible for the waste.

- Collect the fluids that drain from the crusher reservoir and dispose of them properly. The fluids and residue are generally hazardous waste.

WARNING!
ALWAYS *defuel any vehicle prior to dismantling or crushing. Potential exists for tremendous safety hazard, as tanks or cylinders could be under extreme pressure.*

For additional information, see the section on Crushing Alternative Fuel and Advanced Technology Vehicles starting on page 58.

Alternative Fuel and Advanced Technology Vehicle Specifics

Refer to the accompanying Safety Procedures Guide for quick information on recycling alternative fuel and advanced technology vehicles.

Identifying Alternative Fuel and Advanced Technology Vehicles

Biodiesel

Biodiesel can be used in most diesel engines model year 1994 or newer. The most common vehicle applications include heavy-duty trucks, buses, and farm equipment. Most biodiesel vehicles are identified by either looking at the fuel cap or badging near or around it (see **Figures 45** and **46**).

Figure 45: *Diesel gas cap. Source: NAFTC.*

Figure 46: *Biodiesel identification. Source: NAFTC.*

Examples of common biodiesel vehicles include:

- Chevrolet - Silverado 2500/3500 (2012)
- Chevrolet - Silverado HD 2500/3500 (2013)
- Ford - F-250/F-350 Super Duty (2012)
- Ford - F-450 Super Duty (2012)
- Ford - F-250/F-350 Super Duty (2013)
- GMC - Cab Chassis 3500 (2013)
- GMC - Savana 2500/3500 (2012)
- GMC - Savana 2500/3500 (2013)
- GMC - Sierra 2500/3500 (2012)
- GMC - Sierra HD 2500/3500 (2013)
- Ram - 2500/3500 (2013)
- Ram - 2500/3500 HD (2012)

Note: Biodiesel can be used in vehicles manufactured after 1994 that are equipped with diesel engines.

For a complete list of vehicles, visit afdc.energy.gov/fuels/

Ethanol

The most common blend of ethanol is E85 (a high-level gasoline blend containing 51% to 83% ethanol depending on geography and season).

Vehicles that are E85 compatible are called flexible fuel vehicles (FFVs). All conventional gasoline engines can use up to 10% ethanol. In fact, around 97% of all gasoline sold in the U.S. contains some ethanol (see **Figure 47**). Most FFVs are identified by special vehicle badging on or near the fuel port (see **Figures 48, 49**, and **50**).

Figure 47: *Fuel pump label for fuels that contain up to 10% ethanol. Source: NAFTC.*

Figure 48: *E85 cap on a flexible fuel vehicle. Source: NAFTC.*

Figure 49: *Ford flexible fuel vehicle badge. Source: NAFTC.*

Figure 50: *GM flexible fuel vehicle badge. Source: NAFTC.*

Examples of common flexible fuel vehicles include:

- Audi A4/A5
- Audi Q5
- Audi Quatro
- Bentley Continental
- Buick LaCrosse
- Buick Lucerne
- Buick Regal
- Cadillac Escalade
- Cadillac SRX
- Chevrolet Avalanche
- Chevrolet Equinox
- Chevrolet Express
- Chevrolet HHR
- Chevrolet Impala
- Chevrolet Malibu
- Chevrolet Silverado
- Chevrolet Suburban
- Chevrolet Tahoe
- Chrysler 200
- Chrysler 300
- Chrysler Town & Country
- Dodge Avenger
- Dodge Challenger
- Dodge Charger
- Dodge Durango
- Dodge Grand Caravan
- Dodge Journey
- Dodge Ram 1500
- Ford Crown Victoria LX
- Ford E-150/E-250
- Ford Escape
- Ford Expedition
- Ford F-150
- Ford Focus
- Ford Fusion
- GMC Savana 1500
- GMC Sierra 1500
- GMC Sierra CK
- GMC Terrain
- GMC Yukon
- GMC Yukon Denali
- Jeep Grand Cherokee
- Lincoln Navigator
- Lincoln Town Car
- Mazda Tribute
- Mercedes-Benz C300
- Mercury Grand Marquis
- Mercury Mariner
- Mercury Milan
- Nissan Armada
- Nissan Titan
- Ram 1500
- Ram CV
- Saab 9-5 Turbo4
- Toyota Sequoia
- Toyota Tundra
- Volkswagen Routan

For a complete list of vehicles, visit
afdc.energy.gov/fuels/

Natural Gas

Natural gas is a clean-burning fossil fuel that is comprised mostly of methane. It is readily available in two forms: compressed natural gas (CNG) and liquefied natural gas (LNG). CNG is pressurized and is dispensed at fueling stations that are similar to conventional fueling stations. LNG is cryogenic, meaning it can't exist as a liquid at ambient temperature. Therefore, it's stored in insulated containers called tanks.

There are three main types of vehicles 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 51**).
- Bi-fuel is a term used to describe a vehicle that has two separate fueling systems that utilize natural gas and conventional gasoline. This is the most common type of natural gas vehicle conversion.

Figure 51: *The 2013 Honda Civic NGV is an example of a dedicated natural gas vehicle. Source: Honda.*

- Dual-fuel refers to a vehicle that can accommodate a blend of natural gas and conventional diesel. The most common type of these vehicles include mostly heavy-duty applications.

Typically, LNG vehicles are larger and seen more often as heavy-duty applications, due to the size required for the tanks and inefficient long-term storage of LNG (see **Figure 52**). It is less common to see light-duty LNG vehicles.

Figure 52: *LNG-powered bus used for public transportation. Source: NREL.*

Figure 53: *Labels for natural-gas powered vehicles. Source: NAFTC.*

The most common way to identify a natural gas vehicle is to look for a green or blue "NGV" label on the rear door or the trunk area. In Utah, for example, CNG vehicles have a "Clean Fuel, Clean Air" sticker on the license plate (see **Figure 53**).

Examples of common natural gas vehicles include:

- Chevrolet Express 2500/3500
- Chevrolet Silverado HD 2500
- Ford E-150/E-250/E-350
- Ford F-250/F-350 Super Duty
- Ford Transit Connect CNG
- GMC Savana 2500/3500
- GMC Sierra HD 2500
- Honda Civic
- Honda Civic GX
- Honda Civic NGV
- Ram 2500
- Vehicle Production Group MV-1

Note: There have been thousands of vehicles converted to natural gas. These conversion vehicles may not have the badge marks of a factory manufactured alternative fuel vehicle, but they will have identifying fuel ports, tanks, lines, and gauges.

For a complete list of vehicles, visit **afdc.energy.gov/fuels/**

Propane

Propane is commonly called liquefied petroleum gas (LPG) or autogas when used in vehicles. In this material, the use of propane in on-road and off-road use is referred to as propane for easier clarification.

Propane can be used in two main types of vehicles – dedicated and bi-fuel. (Dual-fuel propane vehicles are being developed. Updates to this booklet will include this information; details were not available at time of printing.)

- Dedicated means that the vehicle has been purposefully-built to run only on propane.
- Bi-fuel is a term used to describe a vehicle that has two separate fueling systems that utilize propane and conventional gasoline (see **Figure 54**).

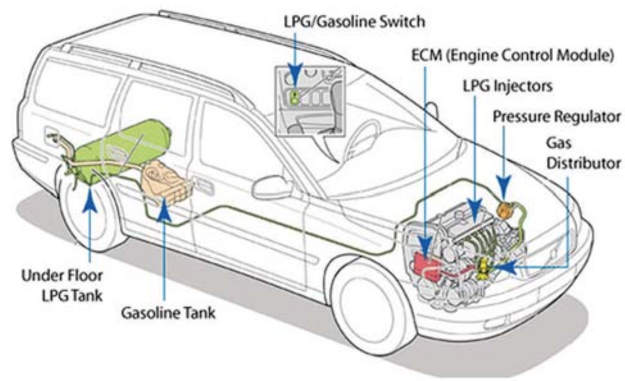


Figure 54: *Bi-fuel propane vehicle. Source: AFDC.*

Propane vehicles are commonly available in light- and medium-duty applications (see **Figure 55**). Propane is also used in off-road vehicles such as forklifts, material handling equipment, etc.

Figure 55: *A medium-duty propane-powered vehicle. Source: NAFTC.*

To identify a propane vehicle, look for a blue decal, usually located on the rear of a vehicle (see **Figure 56**). Instead of a gas nozzle, there may be a fueling port. The fuel filler may have two ports for fueling both propane and gasoline if it is a converted vehicle.

Figure 56: *Decal for propane-powered vehicle. Source: NAFTC.*

Examples of common medium-duty propane vehicles include:

- Chevrolet Express G4500
- GMC Savana
- Ford Transit Connect Propane
- Ford F-450 Pickup (Roush)

In addition, there are a significant amount of light-duty propane conversion vehicles. Examples of these vehicles include:

- Chevrolet Sierra
- Chevrolet Yukon
- Ford Crown Victoria
- Ford E-150/E-250/E-350 Van (Roush)
- Ford Expedition
- Ford F-150 Pickup (Roush)
- Ford F-250 Pickup (Roush)
- Ford F-350 Pickup (Roush)
- GMC Avalanche
- GMC Savanna
- GMC Silverado
- GMC Suburban
- GMC Tahoe
- Lincoln Mark
- Lincoln Navigator
- Lincoln Town Car
- Mercury Grand Marquis

Note: There are many vehicles converted to propane. These vehicles may not have the badge marks of a factory manufactured alternative fuel vehicle, but they will have identifying fuel ports, tanks, lines, and gauges.

For a complete list of vehicles, visit afdc.energy.gov/fuels/

Hydrogen and Hydrogen-Powered Vehicles

When used as transportation fuel, hydrogen can create energy to propel a vehicle either through combustion (like in an internal combustion engine) or as a fuel cell. Fuel cell vehicles may also be considered a type of electric drive vehicle, referred to as a fuel cell electric vehicle (FCEV).

Hydrogen vehicles are mostly in the prototype stage. The only commercially available hydrogen vehicle currently available for purchase is the Honda FCX Clarity (see **Figure 57**). However, the future of hydrogen vehicles remains positive and it's extremely likely that more hydrogen and hydrogen-powered vehicles will be seen on U.S. roadways soon.

Figure 57: *Honda FCX Clarity. Source: NAFTC.*

To identify a hydrogen vehicle, look for a blue and white compressed hydrogen decal on the back right side or on the rear hatch of a vehicle. A "fuel cell power" and "FCX" logo are also located on the driver's and passenger's doors of the Honda Clarity. Also, the fueling port will look different (see **Figure 58**).

Figure 58: *Honda FCX Clarity. Source: NAFTC.*

Examples of common hydrogen vehicles include:

- Honda FCX Clarity
- Hyundai Tucson FCV*
- Mercedes-Benz F-Cell

**Available Spring 2014*

Note: Aftermarket conversion vehicles may not have the badge marks of a factory manufactured alternative fuel vehicle, but they will have identifying fuel ports, tanks, lines, and gauges.

For a complete list of vehicles, visit **afdc.energy.gov/fuels/**

Electric Drive Vehicles

Electric drive refers to an advanced technology vehicle that utilizes electricity as an energy source. This energy can be created by the vehicle and stored onboard in the form of batteries or it can be generated from internal combustion engines (ICEs), fuel cells, or plugging into the electrical grid to charge on-board batteries for additional all electric range.

IMPORTANT NOTE:

If the vehicle is equipped with a remote start, high voltage may be present in the system if the ignition is off.

The main types of electric drive vehicles include: HEVs, PHEVs, BEVs, and FCEVs.

- Hybrid electric vehicles (HEVs) utilize conventional gasoline as well as a battery source to power the drivetrain. An example of an HEV is the Toyota Prius (see **Figure 59**).

Figure 59: *Toyota Prius Second Generation, one of the most notable examples of an HEV. Source: NAFTC.*

- Plug-in hybrid electric vehicles (PHEVs) utilize conventional gasoline, but can also be directly plugged into the electrical grid to charge on-board batteries for additional all electric range. An example of a PHEV is the Chevrolet Volt (see **Figure 60**). The Volt is also often referred to as an extended range electric vehicle.

Figure 60: *An example of a PHEV, the Chevrolet Volt. Source: NAFTC.*

- Battery electric vehicles (BEVs) run only on battery power, and therefore do not rely on conventional gasoline. These types of vehicles are sometimes referred to as zero emission vehicles. The Nissan LEAF is an example of a BEV (see **Figure 61**).

Figure 61: *An example of a BEV, the Nissan LEAF. Source: NAFTC.*

- Fuel cell electric vehicles (FCEVs) utilize fuel cells to create onboard electrical energy to power the vehicle. An example of an FCEV is the Honda Clarity.

To identify an electric drive vehicle, look for badging on the rear of the vehicle (see **Figures 62** and **63**), as well as under the hood area. Under the hood you should also be able to see **ORANGE** high-voltage cables.

Figure 62: *Examples of vehicle badging. Source: NAFTC.*

Figure 63: *An example of under the hood badging on the Chevrolet Volt. Source: NAFTC.*

Examples of common electric drive vehicles include:

Hybrid Electric

- Acura ILX
- Audi Q5 Hybrid
- BMW Active Hybrid 3
- BMW Active Hybrid 5
- BMW Active Hybrid 7
- BMW Active Hybrid 7L
- BMW Active Hybrid X6
- Buick LaCrosse Hybrid
- Buick Regal Hybrid
- Cadillac Escalade Hybrid
- Chevrolet Malibu LS
- Chevrolet Silverado 1500 Hybrid
- Chevrolet Silverado C/K 1500
- Chevrolet Tahoe Hybrid
- Ford C-MAX
- Ford Escape Hybrid
- Ford Fusion Hybrid
- GMC Sierra 1500 Hybrid
- GMC Sierra C/K 1500
- GMC Yukon 1500 Hybrid
- GMC Yukon Denali 2WD/AWD
- Honda Accord Plug-in Hybrid
- Honda Civic Hybrid
- Honda CR-Z Hybrid
- Honda Insight
- Honda Insight LX Hybrid
- Hyundai Sonata Hybrid
- Infiniti M35h Hybrid
- Kia Optima Hybrid
- Lexus CT 200h
- Lexus ES 300h
- Lexus GS 450h
- Lexus HS 250h
- Lexus LS 600h
- Lexus RX 450h
- Lincoln - MKZ Hybrid
- Mazda - Tribute Hybrid
- Mercedes-Benz - E400
- Mercedes-Benz ML450 4Matic Hybrid
- Mercedes-Benz S400 Hybrid
- Mercury Mariner Hybrid
- Mercury Milan Hybrid
- Nissan Altima Hybrid
- Porsche Cayenne S Hybrid
- Porsche Panamera S Hybrid
- Toyota Avalon
- Toyota Camry Hybrid
- Toyota Highlander Hybrid
- Toyota Prius 10
- Toyota Prius C
- Toyota Prius Hybrid
- Toyota Prius V
- Volkswagen Jetta Hybrid
- Volkswagen Touareg Hybrid

Battery Electric

- Chevrolet Spark
- Coda Automotive - CODA
- Fiat 500e
- Ford Azure Transit Connect
- Ford Focus EV
- Honda FIT EV
- Mitsubishi i-MiEV
- Nissan Leaf
- Scion iQ EV
- Smart ForTwo
- Tesla Motors Model S
- Tesla Motors Roadster
- Tesla Motors Roadster 2.5
- Toyota RAV 4 EV
- Wheego Electric Cars, Inc. – LiFe

Plug-in Hybrid Electric

- Chevrolet Volt
- Fisker Karma
- Ford C-MAX ENERGI
- Ford Fusion ENERGI
- Toyota Prius Plug-in

Fuel Cell Electric

- Honda FCX Clarity
- Mercedes-Benz F-Cell

Note: Aftermarket conversion vehicles may not have the badge marks of a factory manufactured alternative fuel vehicle, but they will have identifying fuel ports, tanks, lines, and gauges.

For a complete list of vehicles, visit
afdc.energy.gov/fuels/

For vehicle specifics and additional information regarding cut zones and where the alternative fuel and advanced technology vehicle components are located, download the free QRG app, or refer to Owner's Manual or OEM Emergency Response Guide from OEM website.

Advanced Technology Vehicle Electrical System and Components

Electrical Systems

An electric drive vehicle has two separate electrical systems.

The low-voltage (12-volt DC) system is used to power lights and accessories, and provides control voltage for the critical system control electronics. The low-voltage system is the same as the 12-volt system in standard, conventional vehicles.

A high-voltage system (voltage > 60 volts) is comprised of the electric motor, motor controllers, cooling fans, pumps, and a large battery pack. The sealed battery pack will also contain electric components to control battery charging and discharging. These components comprise the battery management system (BMS). The high-voltage system will have voltages present that may exceed 400 volts, and there may be as much as 600 volts present internally in the sealed unit within an electronic component at any given time during operations.

Powering Down an Advanced Technology Vehicle

Once you have identified the vehicle as an electric drive vehicle, you should check to see if the vehicle ignition has been turned off. If the ignition is off, the "On" button (start/stop or power button) will not be lighted and the dashboard and screens will not be lighted. Remove the key from the ignition. If the vehicle is equipped with a smart key (or proximity key), it should be removed at least 25 feet (7.62 meters) away from the vehicle to ensure that the vehicle does not accidentally start . Keep in mind that the possibility exists that there could be a second smart key (see **Figure 64**).

Figure 64: *Smart key. Source: NAFTC.*

Advanced Technology Batteries

Advanced technology vehicles, in particular electric drive vehicles, often contain multiple batteries, such as the regular 12-volt battery, in addition to the high-voltage battery packs (see **Figure 65**). In some instances, the 12-volt battery is located under the hood and the high-voltage battery pack is located under the rear cargo area. In other vehicles, both batteries are located together. It is imperative to **NOT** compromise the high-voltage battery pack.

High-Voltage Battery Pack

The high-voltage battery pack stores high-voltage electricity provided by the ICE or obtained through regenerative braking. This stored electrical energy is used to assist with propelling the vehicle or operating high-voltage components.

Lead Acid Batteries

In addition to the SLA (starter, lights, accessories), lead acid batteries are found in earlier production electric vehicles such as the EV-1 and also in home conversions as energy storage batteries. The hazards of lead acid chemistries involve toxic chemicals, lead, arsenic, antimony, and concentrated acid electrolytes. Lead acid batteries may also produce potentially harmful gases when overcharged or overheated.

If the lead acid battery is exposed to heat from a fire, it could vent explosively due to the breakdown of the acid electrolyte, which forms gaseous hydrogen. This hydrogen gas can be ignited by a stray spark or a shorted wire, or it can combust spontaneously due to excessive temperatures.

Figure 65: *High-voltage battery and cooling system. Source: NAFTC.*

HEALTH CONCERNS (Lead Acid Batteries)

If a lead acid battery spill occurs due to inversion or breach of the case, an absorbent should be used to prevent seepage into ground water. If the case is ruptured during a crash, the mist from sulfuric acid/electrolytes could cause difficulty in breathing and irritate eyes and skin. Use water spray to knock down mist.

Nickel Metal Hydride Batteries

Nickel metal hydride (NiMH) batteries are most frequently used in HEVs. NiMH batteries have an excellent power density, long life cycle, and abuse tolerance. Upon rapid discharge (as in a short circuit, where a direct connection is made between the positive and negative poles of the internal or external battery, potentially caused by crushing or rupturing of the metal cell casing), NiMH batteries will build heat and pressure and vent a flammable electrolyte. This can be ignited by a stray spark or a shorted wire, or can combust spontaneously due to excessive temperatures.

HEALTH CONCERNS (Nickel Metal Hydride Batteries)

Contact with caustic, alkali electrolyte made of KOH (potassium hydroxide), causes severe burns and may cause deep penetrating ulcers or irreversible damage. Ingestion causes severe burns to the mouth and perforation of the digestive track. Abdominal pain, vomiting, and potentially death will accompany the burns. In the event of contact, flush repeatedly with water and seek immediate medical attention.

Lithium-Ion Batteries

This technology is most frequently used in fuel cell electric vehicles (FCEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs). In addition, as HEV technologies continue to evolve, it appears likely that some form of lithium-ion battery will be the technology of choice for future HEVs, due to their high energy storage capacity and good power-to-weight ratio. Lithium batteries can rupture or ignite when exposed to high temperature. A short-circuited battery may cause the cell to overheat and possibly to catch fire.

HEALTH CONCERNS (Lithium-Ion Batteries)

If electrolyte comes in contact with the eyes, rinse with tap water for 15 minutes and seek medical attention. If electrolyte comes in contact with the skin, wash with soap and water. No toxic gases are emitted under normal conditions. In a fire situation, if gas is inhaled, move immediately to fresh air and seek medical attention.

Battery Fires in a High-Voltage Battery Pack

IMPORTANT NOTE:

Remember that lead acid, NiMH, and lithium batteries, if ruptured or exposed to extreme temperatures, can ignite or combust spontaneously.

In the case of a battery fire, use only a Class ABC powder type fire extinguisher. **NEVER** open a sealed battery pack.

A Type 1 Class D fire extinguisher may be used to smother the fire. Another option is to let the battery burn itself out. It's important to note that fumes from a burning battery pack may be toxic. Take special precautions to avoid direct contact with the skin and eyes and ingestion or inhalations of acid mist. A light water spray can be used to abate toxic chemicals in the air.

IMPORTANT NOTE:

Also remember there is **ALWAYS** *high voltage present in the high-voltage battery pack.*

High-Voltage Safety Systems

Electric drive vehicles have some high-voltage safety systems built in, including warning placards, color coding, and service disconnects.

IMPORTANT NOTE:

Remember that high-voltage batteries are located within a protective case. **DO NOT** *attempt to remove the cover or cut into the battery to extinguish the fire. Batteries in some electric vehicles contain an electrolyte that is very corrosive. Lead acid batteries have a sulfuric acid-water solution as the electrolyte. NiMH batteries contain potassium hydroxide as the electrolyte solution.*

Warning Placards

All electric drive vehicles have caution and warning labels to identify potential hazards. Each vehicle is different, but high-voltage components on electric drive vehicles should always be marked with a warning label (see **Figure 66**).

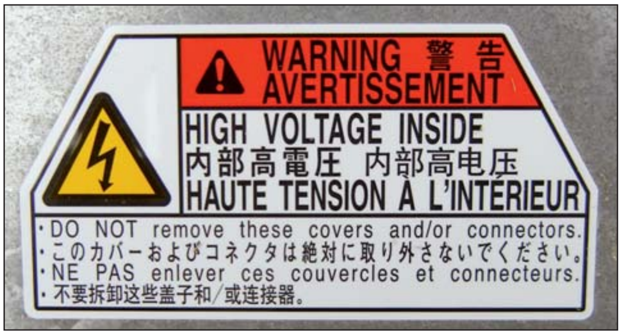


Figure 66: *High-voltage placard. Source: NAFTC.*

Warning placards are visible under the hood and near high-voltage areas.

Color Coding

All electric drive vehicles have a high-voltage electrical system and high-voltage cables that are color-coded with **ORANGE** insulation, which is resistant to chemicals and abrasion. The **ORANGE** coloring adheres to the automotive electrical standards developed by the Society of Automotive Engineers (SAE) (see **Figure 67**). If a harness section is covered in **ORANGE** plastic, there is at least one high-voltage wire or cable in that section.

Figure 67: *High-voltage cables under the hood of a hybrid electric vehicle. Source: NAFTC.*

Most HEV systems will have between 244 to 650 volts DC in the high-voltage cables. The high-voltage system in an HEV will have **ORANGE** or **BLUE** cables that may be visible under the hood or along the chassis outside and under the passenger compartment. By industry standard, **ORANGE** cables are used to identify high voltage.

> *Highly visible **ORANGE** cables and cable covers identify the high-voltage system. The **ORANGE** cables indicate a high voltage > 60VDC or 30VAC.*

> ***BLUE** cables may be present to indicate an intermediate voltage of 30-60VDC or 15-30VAC.*

There are **NO** color code standards for voltages below the threshold of high voltage. Some OEMS, however, have used **BLUE** colored cables to identify intermediate voltage (above low voltage and below high voltage) for their HEV systems.

By SAE standards, the **BLUE** intermediate voltage cables are **NOT** high voltage. However, there is a higher potential for burns, shock, and electrocution than with a low-voltage current.

> **WARNING!**
> *It is imperative to remember to* **NEVER** *cut an **ORANGE** or **BLUE** cable.*

Service Disconnects

All electric drive vehicles should have a manual high-voltage service disconnect for safety. It will be located in a different position depending on the make and model of the vehicle. The service disconnect is used to shut down the high-voltage system (using proper personal protection equipment) in an emergency situation (see **Figure 68**).

Figure 68: *Hybrid high-voltage system disconnect. Source: NAFTC.*

This method of disarming the high-voltage system will put you at the high-voltage source, so proper protective equipment (PPE) — high-voltage rated rubber gloves and face shield — must be used when working around high voltage.

WARNING!
Service disconnects shut down the high-voltage system and should be used as a LAST RESORT — only if the automotive recycling personnel is unable to turn off the ignition or cut the 12-volt battery cables and the vehicle is still energized. Proper PPE (high-voltage rated rubber gloves and face shield) MUST be used.

Safety Considerations with Advanced Technology Batteries

If contact with the high-voltage system cannot be avoided, personal protective equipment (PPE) such as a splash shield or safety goggles, high-voltage gloves, an apron or overcoat, and rubber boots are required when handling batteries.

In the event of a damaged or compromised battery, a self-contained breathing apparatus should be worn to safeguard against thermal, electrical, respiratory and skin/eye hazards.

Finally, remember to remove any metal objects, including jewelry and watches, as these objects are conductors of electricity.

Alternative Fuel Vehicle Fuel Storage and Components

When an alternative fuel vehicle arrives at an automotive recycling facility, it's important that the automotive recycler first understands what exactly makes these vehicles and fuel storage tanks different from their conventional vehicle counterparts.

Biodiesel

Most of the standard storage and handling procedures used for petroleum diesel can also be used for biodiesel. The fuel should be stored in a clean, dry, dark environment. Recommended materials for storage tanks include aluminum, steel, polyethylene, polypropylene, and Teflon, but not concrete-lined storage tanks. If possible, the storage tank should not include any copper, brass, lead, tin, zinc, or rubber fittings (practically speaking, brass ball valves are used by many with no major ill effect).

Since biodiesel is an organic liquid, the use of an algaecide or fungicide additive is recommended whenever the fuel is stored during warm weather. Storage time for biodiesel blends up to B20 should be limited to six months for best performance.

Ethanol

Ethanol should be treated in the same manner as conventional gasoline. Like gasoline, alcohol-based fuels are liquid at ambient pressures and temperatures. The equipment used to store gasoline and diesel fuels is the same equipment used for alcohol-based fuels, with modifications in some materials.

Natural Gas

Compressed Natural Gas (CNG)

CNG storage cylinders are classified by the U.S. Department of Transportation (USDOT) by the materials used in their construction:

Type 1 – high strength steel or aluminum

Type 2 – steel or aluminum liner, hoop-wrapped with composite

Type 3 – steel or aluminum liner, fully wrapped with composite

Type 4 – thermoplastic liner, fully wrapped with composite

Figure 69 shows the CNG cylinders used in vehicles along with their composition. CNG storage cylinders range from 3000 to 3600 psi. USDOT and NGV2 cylinders range from 10 to 20 inches in diameter with lengths from 35 to 84 inches and weights between 55 and 550 pounds.

A typical natural gas vehicle requires one or more CNG cylinders. Vehicle range will vary depending on the size of the CNG tank.

Type 1 cylinders are the heaviest, and Type 4 are the lightest in terms of weight for volume of CNG stored; Type 2 and 3 cylinders fall in between (see **Figures 70** to **74**).

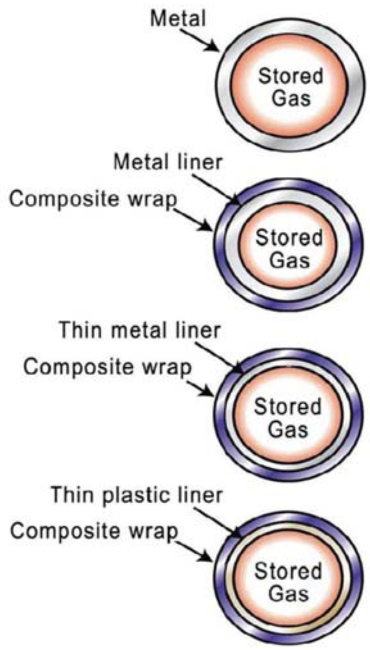


Figure 69: *Cross-section of CNG cylinders used in vehicles. Source: NAFTC.*

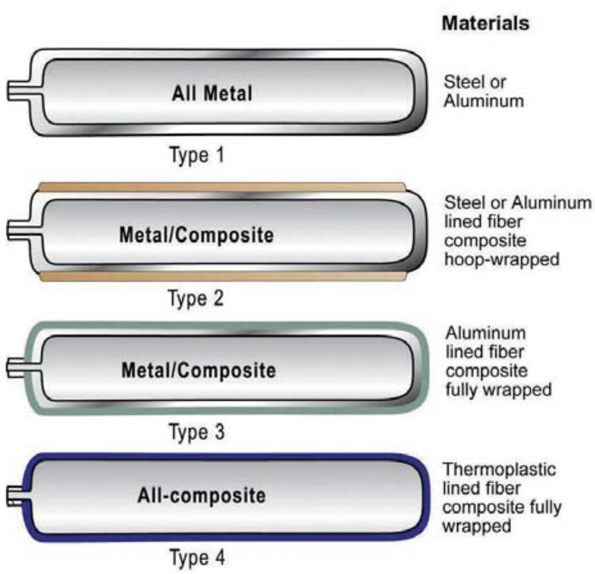


Figure 70: *The composition of CNG cylinders used in vehicles. Source: NAFTC.*

Figure 71: *Photo of Type 1 cylinder. Source: NAFTC.*

Figure 72: *Photo of Type 2, steel-lined cylinder. Source: NAFTC.*

Figure 73: *Photo of Type 3 cylinder. Source: NAFTC.*

Figure 74: *Photo of Type 4 cylinder. Source: NAFTC.*

Cylinder Tank Inspections

In its NGV2 Standard, the American National Standards Institute (ANSI), limits the life of a cylinder to 15/20/25 years depending on the type, and requires a visual inspection of the cylinder at least every three years. The Federal Motor Vehicle Safety Systems (FMVSS) 304 standard requires inspection every three years or 36,000 miles, whichever comes first.

Also, all high-pressure cylinder fuel tanks should be inspected after a collision.

Liquefied Natural Gas (LNG)

An LNG vessel or tank for storage outside of the vehicle is called a dewar. The dewar serves as the fuel storage tank, which is similar to a diesel and gasoline storage tank (see **Figure 75**).

LNG is stored in a cryogenic state. To turn methane into a liquid, it must be brought down to a very low temperature—less than -259°F (-162°C). LNG is stored at pressures above atmospheric—typically 85-180 psi (5.9-12.4 bar) although this is far less than the pressure of CNG at 3000 or 3600 psi (207-248 bar).

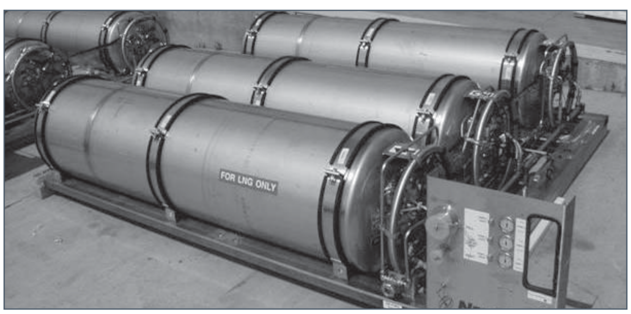


Figure 75: *LNG storage tanks, called dewars. Source: NAFTC.*

LNG vehicle tanks must be filled only to 90% of their rated capacity to allow the gases to expand and contract as the temperature changes.

LNG tanks typically weigh between 98 and 615 pounds (44 and 279 kilograms). They range from 16 to 28 inches (41 to 71 centimeters) in diameter, with lengths from 32 to 90 inches (81 to 229 centimeters). Dome heads are usually either 26

Figure 76: *Cutaway of LNG tank showing dual walls and insulation. Source: NAFTC.*

or 28 inches (66 or 71 centimeters) in diameter, although other diameters can be custom made.

The LNG vehicle tank is a well-insulated container with an outer shell and an inner vessel (see **Figure 76**). A tank can keep LNG below 230 psi (15.8 bar), the primary vent pressure, for three or more weeks if the initial fuel temperature is low enough.

Propane

There are two types of fuel storage cylinders used to store propane on board vehicles:

- U.S. Department of Transportation (USDOT) cylinders
- American Society of Mechanical Engineers (ASME) pressure vessels

The USDOT cylinders are available in one, two, or three pieces. The ASME cylinders are pressure vessels that are used more widely today. ASME cylinders are rated at 312.5 psi (21.5 bar) and have a burst pressure (safety factor) four times their rated pressure.

The maximum aggregate tank capacity for a passenger-carrying vehicle is 200 gallons in order to minimize the fire hazard in case of an accident.

Fuel tank sizes, ranging from 20 gallons up to 40 gallons, are commonly used for passenger cars.

The tank is usually installed in the trunk or beneath the vehicle. Propane vehicle fuel tanks are designed to be filled to 80% capacity to allow for thermal expansion. Propane is affected by heat and pressure in much the same way as water.

As long as it is kept at a temperature below its normal boiling point, it will remain a liquid.

There are two important points to note about tank ports on motor fuel cylinders. First, each service valve is marked for either vapor or liquid service. These markings indicate that the opening has an attached dip tube that runs to the liquid or vapor space of the cylinder. Second, all tank ports may not be used. In this case, the unused ports must have a male plug installed in the opening.

The USDOT and ASME require that cylinder information be permanently marked on the cylinder (see **Figures 77** and **78**). This information is stamped on the outside of the neck ring or on the cylinder body itself. In some cases, the information is stamped on a metal plate, and the plate is attached to the cylinder.

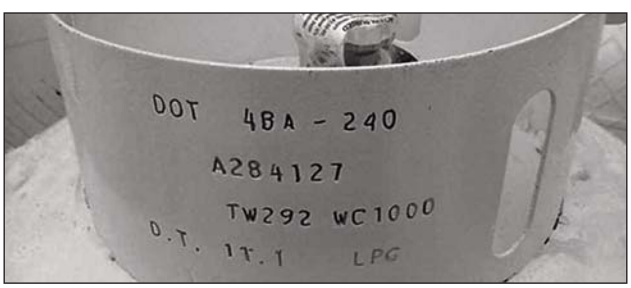


Figure 77: *Propane cylinder with information on neck ring. Source: Superior Energy Systems.*

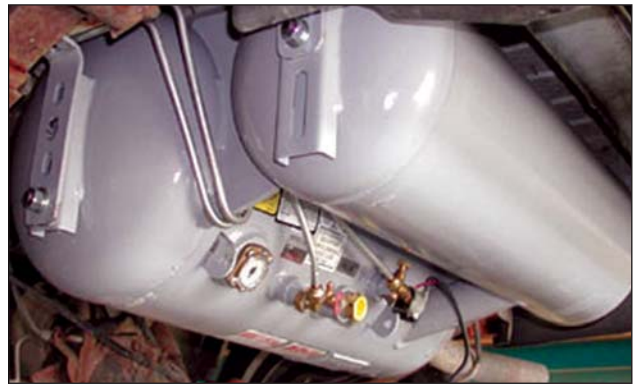


Figure 78: *Propane cylinder with information on body. Source: AFDC.*

IMPORTANT NOTE:
The greatest hazard of propane containers exposed to fire or extreme heat is ***BLEVE*** *(boiling liquid/ expanding vapor explosion).*

In addition, when propane containers become compromised, the fuel converts from a liquid to a vapor that could rapidly produce a sizable vapor cloud. This vapor cloud may ignite and flash back to the fuel source.

Hydrogen-Powered Vehicles

Hydrogen vehicles are either powered by internal combustion engines (ICEs) or a fuel cell. The basic difference between a hydrogen ICE and a fuel cell is that fuel cells are solid state devices that generate electrical energy to drive an electrical motor, and the ICE combusts the hydrogen to produce rotational torque.

Both ICE and fuel cell systems use compressed air and gas as the oxidant. In an FCEV, the air is compressed by an external compressor. In an ICE, air is compressed internally through the reciprocating action of the piston (see **Figure 79**).

IMPORTANT NOTE:
Some research and development work is being done using liquid hydrogen as a fuel source. If you should encounter one of these vehicles, use similar procedures and precautions as LNG.

Figure 79: *Hydrogen internal combustion engine compartment. Source: NAFTC.*

Both types of vehicles store hydrogen on board in high pressure cylinders. The fuel storage systems in hydrogen ICE and FCEVs consist of one or more U.S. Department of Transportation (USDOT) approved pressurized cylinders, several hydrogen sensors, and fuel interface equipment.

Both ICE and fuel cell systems require cooling, although the ICE operates at much higher temperatures than the fuel cell. The ICE is 10% to 30% efficient, and PEM fuel cells are 60% to 80% efficient, with electric motors being about 92% efficient.

The function of the drivetrain in an ICE hydrogen vehicle is identical to that of a conventional vehicle. The FCEV produces electricity and the drivetrain uses high-voltage electricity to power the transaxles or individual wheel motors.

Hydrogen Fuel Cell Electric Vehicles (FCEVs)

When a vehicle employs a fuel cell to produce electrical current by using hydrogen, it is a hydrogen FCEV. This differs from a battery electric vehicle. The FCEV uses batteries for back-up electric support similar to traditional vehicles, and the batteries are recharged as part of the vehicle's operational system.

Hydrogen Storage

Due to its low viscosity and low molecular weight, hydrogen is difficult to contain. High pressure hydrogen must be placed in containers designed specifically for that purpose (see **Figure 80**).

Figure 80: *Hydrogen fuel cylinder. Source: NAFTC.*

These durable, puncture-resistant cylinders are made of stainless steel or aluminum wrapped in carbon fiber. Hydrogen-powered buses consume far more hydrogen per mile due to weight. These vehicles use multiple storage cylinders and can store up to 50 kg of hydrogen on board.

IMPORTANT NOTE:
Most of today's demonstration hydrogen vehicles use cylinders that store hydrogen as a gas. Compressed hydrogen gas can be stored at up to 10,000 psi (700 bar) and liquid hydrogen up to 100 psi (7 bar) at -423°F (-253°C). Hydrogen storage technologies have been developed to store more hydrogen – up to 26 lbs (13 kg) – to allow for greater distances between refueling.

Electric Drive Vehicles

While conventional gasoline remains the primary fuel source for HEVs and PHEVs, hydrogen powers fuel cell electric vehicles.

See section on Advanced Technology Vehicle Electrical System and Components for additional information on different types of batteries and the high-voltage system, etc. starting on page 34.

Spills and Leaks

Even by routinely following the necessary safety precautions to prevent an alternative fuel spill or leak, it is still possible for a spill or leak to occur. The accidental release of liquids and other chemicals from vehicles make up a large number of pollution incidents each year. Many spillages can be prevented, but in the event of a spill, it's important to control it to minimize its effects. This will allow for minimal environmental harm. It is necessary for automotive recyclers to be knowledgeable on how to deal with these spills. First, remember that alternative fuels are not unsafe (no more so than traditional diesel and petroleum), but are just different than conventional fuels. By understanding the unique fuel properties and characteristics, automotive recycling facilities may be best prepared in the event of an emergency.

Overall Best Practices

Spills are one of the most common themes of potential containment. It's important to properly process liquids and fluids, to prevent them from evaporating, and to maintain the necessary equipment to prevent leaks and spills.

Consider placing a platform or step next to storage drums so as to prevent the need to raise lift pans and the potential for a spill. Don't forget to seal around all floor drains. Never discharge wastewater to the ground, dry wells, or septic systems.

- Keep all chemicals in closed, covered, or sealed containers. Liquid storage containers need secondary containment.
- Always use funnels or pumps when transferring or dispensing chemicals.
- **LABEL** everything (including small spray bottles) to avoid cross-contamination. This will facilitate recycling.

IMPORTANT NOTE:

There should be no smoking, flares, sparks, or flames in the immediate area. All equipment used when handling the product must be grounded. **DO NOT** *touch or walk through spilled material.*

Biodiesel/Ethanol Spills

When dealing with biodiesel or ethanol spills, first eliminate all ignition sources. **NEVER** store either fuel type near ignition sources, such as stoves and welding equipment.

Stop the leak if you can do so without risk. Prevent entry into waterways, sewers, basements, or confined areas. A vapor-suppressing foam may be used to reduce vapors. Absorb or cover the leaked fuel with dry earth, sand, or other noncombustible material and transfer to containers.

Use clean nonsparking tools to collect absorbed material. For large spills, dike far ahead of liquid spill for later disposal. Water spray may reduce vapor but may not prevent ignition in closed spaces.

When released in soil, biodiesel naturally biodegrades. When released in water, biodiesel is insoluble and degrades rapidly and fairly extensively. It is estimated to degrade at a rate approximately four times faster than petroleum diesel – 85% of pure biodiesel is expected to degrade within 28 days. When released into the air, biodiesel combustion produces carbon monoxide and carbon dioxide, along with thick smoke. When released to sewers and wastewater, biodiesel may be high in free fatty acids and glycerol and can have a biochemical oxygen demand, which can disrupt wastewater treatment plant operations.

When released in soil, ethanol biodegrades rapidly. When released in water, ethanol blends mix with it, and at high enough concentrations of water, the ethanol will separate from the gasoline. Ethanol is rapidly biodegraded in groundwater and surface water. When released into the air as a result of a spill or fire, ethanol vapor, like gasoline vapor, is denser than air and tends to settle in low areas. However, ethanol vapor disperses rapidly. When released to sewers and wastewater, ethanol will volatilize and rapidly biodegrade. The potential decrease in dissolved oxygen as a result of ethanol degradation can upset microbial functions at wastewater treatment plants. The potential flammability hazard must be addressed when ethanol is released to a sanitary or storm system.

Natural Gas Spills

Most tanks prohibit gaseous fuels from leaking, but if there is a leak on the high-pressure side – between the storage and the regulator, the leak will vent quickly since the fuel is under pressure. A possible remedy is the 1/4 turn valve for shutting down a leak (a 1/4 turn valve in the high-pressure fuel line stops fuel flowing from the tank to the regulator). To check if the fuel has finished venting, it is recommended to look for waves going into the air, a smell, or hissing sound. If any of these are present, back away and allow the fuel to continue venting.

In most applications, the regulator is located beneath the hood of the car. If this is the case, and there is a leak on the low-pressure side of the regulator, it could take a significant amount of time for all of the fuel to vent from the system. To check if the fuel has finished venting, it is recommended to look for waves going into the air, a smell, or hissing sound. If any of these are present, back away and allow the fuel to continue venting.

If LNG is spilled, it vaporizes. The natural gas vapors are initially heavier than air and they form a cloud close to the ground, which is pushed downwind and eventually dissipates.

CNG, however, is lighter than air, which further enhances its safety. Unlike other fuels such as diesel or gasoline, which are heavier than air, and pool on the ground, creating a fire hazard and potential pollution to waterways, CNG will disperse rapidly upwards into the atmosphere and dissipate.

Propane Spills

Propane is heavier than air. Because of this, in case of a leak, the fuel will fall to the ground and dissipate. If the vehicle is in a low-lying area, the fuel may pool around the vehicle and not dissipate quickly. On hot days, the safety relief valve on a propane tank may open slightly, allowing excess pressure to vent. If the relief valve is opened, the protective cap will be removed from the top of the valve as a result of the pressure buildup. **DO NOT LOOK INTO THE RELIEF VALVE OR TAP IT WITH ANYTHING**. Doing so may cause the relief valve to open all the way. The relief valve is doing what it was designed to do. One way to remedy the situation; however, is to cool the tank down by spraying water from a garden hose on the surface of the tank. This will generally cause the relief valve to close.

Notes

Hydrogen Spills

If any possibility exists that hydrogen might be collecting in a closed structure, wait for the hydrogen to dissipate, if possible, and initiate procedures to remove all ignition sources safely. Hydrogen leaks generally originate from valves, flanges, diaphragms, gaskets, and various types of seals and fittings. For leaks that are relatively small and controllable, use the shutoff valve; for leaks that are uncontrollable, shut off the supply source and evacuate the area.

If a hydrogen leak is suspected and the flow of hydrogen cannot be stopped, the chances of igniting the hydrogen are remote, but precaution should be taken not to create a situation that would potentially ignite the hydrogen. Because hydrogen flames are nearly invisible in daylight, and hard to detect, special flame detectors should be utilized at all times (see **Figure 81**).

Possible ignition sources might include electrical sources, such as static electricity or electric charge from operating equipment; mechanical sources, including impact, friction, or metal fracture; or thermal sources, such as an open flame, high-velocity jet heating, hot surfaces, or vehicle exhaust.

Liquid hydrogen leaks should be easy to detect without additional equipment and can be recognized by a cloud or frost or ice crystals on the outside of the cylinder or pipeline.

Small spills of hydrogen disperse quickly, but any spill should be considered as a potential fire hazard. Large spills cause ground freezing. As hydrogen warms up, it will vaporize quickly. Evacuate the area until spill has dissipated.

Liquid hydrogen poses greater risks than compressed hydrogen due to its cryogenic capabilities. Direct contact with liquid hydrogen, cold vapor, or cold equipment can cause serious tissue damage. Hydrogen is stored as a liquid at -423°F, a temperature that can cause cryogenic burns or lung damage.

Advanced Technology Vehicle Spills

Advanced technology vehicles (electric drive) contain many of the same kind of fluids as conventional vehicles, with the exception of fluids that are used in the high-voltage battery packs.

Lead Acid Batteries

If a lead acid battery spill occurs due to inversion or breach of the case, an absorbent should be used to prevent seepage into ground water. If the case is ruptured, the mist from sulfuric acid/ electrolytes could cause difficulty in breathing and irritate eyes and skin. The hazards of lead acid chemistries involve toxic chemicals, lead, arsenic, antimony, and concentrated acid electrolytes. Use water to spray or knock down the mist.

Nickel Metal Hydride Batteries

The NiMH electrolyte is a caustic alkaline (pH 13.5) that is damaging to human tissues. The electrolyte, however, is absorbed in the cell plates and will not normally leak out even if the battery is cracked. In the unlikely event the electrolyte does leak, it can be easily neutralized with a dilute boric acid solution or vinegar.

Lithium-Ion Batteries

The electrolyte used in the Li-ion battery cells is a flammable organic electrolyte. The electrolyte is absorbed into the battery cell separators. Even if the battery cells are crushed or cracked, it is unlikely that liquid electrolyte will leak. Any liquid electrolyte that leaks from a Li-ion battery cell quickly evaporates.

Additional information on High-Voltage Battery Packs can be found starting on page 35.

Risk of Fire

Due to the very nature of different types of vehicles and automotive components being stored, automotive recyclers must be aware of the potential of fires and the risk of fires spreading.

Biodiesel Vehicle Fires

Diesel and kerosene – the two major fuels used in biodiesel blending – are highly flammable with flash points that are much higher than biodiesel. Even biodiesel blends have flash points high enough to pose significant fire risks when handled improperly. Treat biodiesel fires as you would a diesel fire if you are unaware of the type or blend.

IMPORTANT NOTE:
Biodiesel burns with a bright white flame that is nearly invisible in daylight. The flame may appear yellow if there are impurities in the air like dust, sodium from ocean spray, etc. A pure biodiesel flame will not produce smoke. In addition, a biodiesel flame has lower luminosity than a diesel flame. Adding to the challenge is the fact that a biodiesel vehicle may be operating on any percentage blend of biodiesel and petro-diesel.

In the event of a fire, biodiesel can be extinguished with dry chemicals, foam, halon, CO_2, or water spray. Care should be taken when using water to put out a biodiesel fire, as water can spread the flammable liquid.

Ethanol Vehicle Fires

Class B flammable liquid tactics with foam will be required to extinguish ethanol fires. The best recommendation is to use alcohol-resistant aqueous film-forming foam (AR-AFFF) because it will work on both polar solvents and hydrocarbons.

Proper application is critical for foam. The key to foam application is to apply the foam as gently as possible to minimize agitation of the fuel and creation of additional vapors. The most important thing to remember is to **NEVER** plunge the foam directly into the fuel.

IMPORTANT NOTE:
It is common for an ethanol fire to start up again after you think the fire has been put out. This is because ethanol burns at very high temperatures and can smolder. Water is ineffective against ethanol because it is water soluble. In fact, water may help the fire to spread.

For ethanol-fueled vehicles, if the fuel system can be isolated, put out the fire with traditional means. However, if the fuel system cannot be isolated, let the fire burn. Concentrate on keeping the fire from spreading into other areas or neighboring objects.

IMPORTANT NOTE:
Ethanol burns with a clear or blue flame that is nearly invisible in daylight. The flame may appear yellow if there are impurities in the air like dust, sodium from ocean spray, etc. Ethanol flames have a lower radiant heat transfer, which should be a safety advantage when trying to contain an ethanol fire.

Natural Gas Vehicle Fires

LNG and CNG both have a low flash point (the lowest temperature at which the fuels can vaporize to form an ignitable mixture in the air). Once a fire starts, natural gas can burn at a very high temperature. If the fire has been burning for a sustained period of time, the fire can be very difficult to suppress because of the heat. Flames can burn in a strong wind and be stretched out away from their source by a number of feet. Concentrate on keeping the fire from spreading into other areas or neighboring objects. Keep away from pressure relief device vents until the fire is extinguished.

A leak from the high pressure side of a CNG fuel system could produce a high velocity cold gas jet. As the jet travels, the concentration of the gas drops as it mixes with ambient air. A release could cause injury from flying debris, the high jet momentum, or exposure to the extremely cold gas near the release point.

IMPORTANT NOTE:
The greatest hazard of LNG containers that are exposed to fire or extreme heat is **BLEVE** *(boiling liquid/expanding vapor explosion).*

In addition, when LNG containers become compromised, the fuel converts from a liquid to a vapor that could rapidly produce a sizable vapor cloud, which in turn may ignite and flash back to the fuel source.

The high velocity jet can create high intensity noise, alerting emergency response personnel to a gas leak problem and/or its location. If the gas jet comes in contact with a spark, a high temperature jet fire or "torch fire" can cause serious burns and structural damage. Remember, however, that the gas-to-air mixture has to be within the 5% to 15% range for ignition to take place.

IMPORTANT NOTE:
If the flame is extinguished without stopping the fuel flow, the air/fuel mixture may reignite.

To extinguish a CNG fire, you should do the following:

- Cut off the fuel flow if you can access it without danger to yourself or others. This will usually extinguish a natural gas fire by depriving it of the source of fuel.
- With small fires, use dry chemical or carbon dioxide.
- For large fires, use water spray or fog. Move containers from fire area if you can do it without risk.
- Use high expansion foam to reduce the intensity of the fire.

To extinguish an LNG fire, you should do the following:

- Cut off the fuel flow if you can access it without danger to yourself or others. This will usually extinguish a natural gas fire by depriving it of the source of fuel.
- With small fires, use dry chemical or carbon dioxide.
- Use high expansion foam to reduce the intensity of the fire.

LNG reacts violently when water is applied; the reaction warms the liquid to boiling, creating more gas vapor. Adding water to an LNG liquid fire will intensify it.

Propane Vehicle Fires

Propane has a low flash point (the lowest temperature at which it can vaporize to form an ignitable mixture in air). Once a fire starts, it can burn at a very high temperature. If the fire has been burning for a sustained period of time, the fire can be very difficult to suppress because of the heat. Flames can burn in a strong wind and be stretched out away from their source by a number of feet. Concentrate on keeping the fire from spreading into other areas or neighboring objects. Keep away from pressure relief device vents until the fire is extinguished.

To extinguish a propane fire, you should do the following:

- With small fires, use dry chemical or carbon dioxide.
- For large fires, use water spray or fog. Move containers from fire area if you can do it without risk.

- Ensure that the fire has been successfully suppressed. Propane fires burn very hot and can smolder. This type of fire may continue to burn after it appears the fire has been successfully suppressed.
- If the flame is extinguished without stopping the fuel flow, the air/fuel mixture may reignite.
- Direct water flow at the point of flame impingement so that the internal tank pressure of the burning tank drops to the point where the pressure relief valve closes and the tank valve can be manually closed.

Figure 82: *Hydrogen flame detected by broom. Source: AFDC.*

Hydrogen and Hydrogen-Powered Vehicle Fires

Because the hydrogen flame is nearly invisible in daylight and hard to detect, special flame detectors should be utilized at all times (see **Figure 81**). A UV optical sensor that detects a pale blue flame is an excellent piece of equipment to have on hand to sense the presence of a hydrogen flame. If this is not available, the next best "tool" is a common straw broom (see **Figure 82**).

Figure 81: *A thermal conductivity sensor, catalytic combustion sensor, or electrochemical sensor can be helpful in detecting an alternative fuel fire, as many of these fuels have flames that are nearly invisible. Source: NAFTC.*

The flame may appear yellow if there are impurities in the air like dust, sodium from ocean spray, etc. A pure hydrogen flame will **NOT** produce smoke.

The best way to handle a hydrogen fire is to let it burn under control until the hydrogen flow can be stopped or the fire is burned out. If the hydrogen gas has ignited, call 911 and stay back a safe distance and allow the hydrogen gas-fed fire to burn until the hydrogen completely vents to the atmosphere. During this time, crews may utilize a water stream or fog pattern from a maximum distance to prevent exposures or to control the path of smoke, taking care not to extinguish hydrogen-fed flames. Small fires can be extinguished with carbon dioxide or dry chemical extinguishers. Daylight fires can be detected by heat waves. If fire is extinguished before all the gas burns off, watch for gas pockets that may suddenly reignite.

When dealing with a hydrogen fuel cell electric vehicle, the high-voltage battery can release dangerous gases even after the fire is extinguished. Also, remember that an FCEV's high-voltage battery **ALWAYS** has voltage.

IMPORTANT NOTE:

If the fire is large, evacuate the area and let hazmat contain it.

Electric Drive Vehicle Fires

In the case of a high-voltage battery pack fire, use only a Class ABC powder type fire extinguisher. **NEVER** open a sealed battery pack. A Type 1 Class D fire extinguisher may be used to smother the fire. Another option is to let the battery burn itself out. Take special precautions to avoid direct contact with the skin and eyes and ingestion or inhalation of acid mist. A light water spray can be used to abate toxic chemicals in the air.

Also, with electric drive vehicles, it is important to remember that even though conventional gasoline remains the primary fuel for many of these vehicles, hydrogen powers fuel cell electric vehicles.

IMPORTANT NOTE:

Remember that high-voltage batteries are located within a protective case. **DO NOT** *attempt to remove the cover or cut into the battery to extinguish the fire. Batteries in some electric vehicles contain an electrolyte that is very corrosive. Lead acid batteries have a sulfuric acid-water solution as the electrolyte. NiMH batteries contain potassium hydroxide as the electrolyte solution.*

Notes

Dismantling and Recycling Alternative Fuel and Advanced Technology Vehicles

When a motor vehicle is declared a total loss and repair is either not feasible or possible, the vehicle must be properly dismantled and recycled (see **Figure 83**). Automotive recycling operations include the shredding and crushing of remaining automotive components.

While there are shared characteristics to conventional vehicles, alternative fuel vehicles have different components that must be understood before cutting into or dismantling them for end of life recycling.

The first step of the inspection process should be to determine if the vehicle is an alternative fuel or advanced technology vehicle, as these vehicles have several unique features that will require specialized attention. See section on Identifying Alternative Fuel and Advanced Technology Vehicles starting on page 29.

Figure 83: *The dismantling and recycling of vehicles at the end of their useful life to salvage usable spare parts has created a large vehicle dismantling industry. Source: ARA.*

As with any vehicle, it is important to conduct an appropriate inspection upon receipt of the vehicle. This enables you to identify which type of alternative fuel or advanced technology vehicle you are dealing with and permits you to assess the vehicle's safety situation. This is important regardless of the dismantling or recycling plans for the vehicle. Once the inspection has been completed and the type of vehicle identified, it is recommended that the vehicle be labeled to indicate the specific type of alternative fuel or advanced technology vehicle, to ensure the safety of anyone coming in contact with the vehicle.

When approaching an electric drive vehicle, first make sure the vehicle is off (when running in electric mode the vehicle may make no noise). Also, all actions need to be made taking into consideration that the vehicle has a high-voltage system.

If the high-voltage system has not already been disabled, you should disable it before beginning dismantling procedures.

Since forklifts and other types of machinery are routinely used in automotive recycling facilities to move disabled vehicles, it's important to understand where the fuel lines, pressurized tanks, and high-voltage systems are located so automotive recyclers do not mistakenly puncture or compromise an internal vehicle component that may not be visibly noticeable from the outside. This is why the proper labeling of alternative fuel vehicles once initially accepted and processed at the automotive recycling facilities is a necessary safety and best practice.

IMPORTANT NOTE:

Upon receipt of an alternative fuel or advanced technology vehicle, confirm that the vehicle ignition is off and isolate the fuel system. For information on isolating the fuel system, see dismantling information for specific types of alternative fuel and advanced technology vehicles, provided on the following pages. Also, keep in mind that if the vehicle has a high-voltage system, it likely is equipped with a smart key device. At the point of arriving at an automotive recycling facility, this device will not likely be nearby, but the automotive recycler needs to understand that it exists and how it can affect the operation of the vehicle (see page 35 for additional information on the smart key).

For vehicle specifics and additional information regarding cut zones and where the alternative fuel and advanced technology vehicle components are located, download the free QRG app, or refer to Owner's Manual or OEM Emergency Response Guide from OEM website.

Biodiesel Vehicles

Biodiesel vehicles are similar to conventional diesel and gasoline vehicles and the same general procedures should be followed.

Shutdown/Isolate Fuel System

- If not done upon receipt of vehicle, before beginning to dismantle a biodiesel-fueled vehicle, isolate the fuel system by first cutting the negative cable(s) and then cutting the positive cable(s) of the 12-volt auxiliary battery. You should remove 3-4 inches from both the positive and negative battery cables.

Defueling

- Defueling requirements are the same as gasoline or diesel fueled vehicles.

Removing Components

- **DO NOT** cut through the bottom of the vehicle below the floor line. Fuel lines and fuel storage are commonly located below the floor line.

Ethanol Vehicles

Ethanol (flexible fuel) vehicles are similar to conventional diesel and gasoline vehicles and the same general procedures should be followed.

Shutdown/Isolate Fuel System

- If not done upon receipt of vehicle, before beginning to dismantle an ethanol-fueled vehicle, isolate the fuel system by first cutting the negative cable(s) and then cutting the positive cable(s) of the 12-volt auxiliary battery. You should remove 3-4 inches from both the positive and negative battery cables.

Defueling

- Defueling requirements are the same as gasoline or diesel fueled vehicles.

Removing Components

- **DO NOT** cut through the bottom of the vehicle below the floor line. Fuel lines and fuel storage are commonly located below the floor line.

Natural Gas Vehicles

The main differences between natural gas vehicles and conventional vehicles are the storage cylinder tanks. Compressed natural gas (CNG) and liquefied natural gas (LNG) utilize a slightly different type of storage tank. These types of storage cylinders include built-in safety valves and pressure-relief components. While these tanks are extremely safe, extra care should be taken to not puncture or compromise a CNG or LNG tank.

CNG storage cylinders range from 3000 to 3600 psi. USDOT and NGV2 cylinders range from 10 to 20 inches in diameter with lengths from 35 to 84 inches and weights between 55 and 550 pounds. A typical natural gas vehicle requires one or more CNG cylinders, each containing approximately 1,200 standard cubic feet (SCF) of natural gas weighing from 115 to 250 pounds, depending on the material used (see **Figure 84**).

Outside of a vehicle, LNG storage vessels are called dewars. Installed in a vehicle, they are called tanks. A dewar or tank is an insulated vessel that stores extremely low temperature, cryogenic liquids. When handing a cryogenic liquid, it's advisable to use protective gloves, as frostbite can occur. However, a tank on a vehicle is not refrigerated. Once the fuel is pumped into the tank, the temperature is only controlled by the tank's insulation and the pressure inside the tank. As the fuel sits in the tank, the temperature will continue to rise. After time passes and the

LNG warms above the boiling point of methane, it will turn into methane gas. This is why tanks have a pressure relief device.

Shutdown/Isolate Fuel System

- If not done upon receipt of vehicle, before beginning to dismantle a natural gas-fueled vehicle, isolate the fuel system by first cutting the negative cable(s) and then cutting the positive cable(s) of the 12-volt auxiliary battery. You should remove 3-4 inches from both the positive and negative battery cables.

Defueling

CNG

- Modern CNG systems often equip CNG cylinders with an automatic solenoid shutoff valve. Special tools are necessary for safe and sure venting of cylinders equipped with a solenoid valve. The solenoid shutoff valves prevent fuel from flowing out of the cylinder unless the engine is running or after an incident.
- Occasionally, solenoid valves will fail, preventing them from venting when they should; the fine pilot orifices in the valves get plugged with debris or ice; or the valve vents gas for a while and then stops before the cylinder is empty.
- A vent stack is required to release the natural gas in a safe location, ensuring that it is released outdoors into the air so it can disperse without ignition of the gas. Venting CNG directly from a vehicle can build up a static electricity charge and ignite the gas, destroying the vehicle. Regulations require that any venting system be approved by the "Authority Having Jurisdiction," which is generally the fire marshal.
- If the vehicle is fitted with a special connection to transfer the fuel from the vehicle to a station approved for direct refueling, the vehicle can be defueled using this equipment and the manufacturer's instructions.
- Different vehicle designs will also have systems to allow the piping to be depressurized.
- **DO NOT** make any piping disconnections before the fuel pressure is fully released.
- **DO NOT** puncture or cut a CNG cylinder unless the cylinder is being removed from service.

IMPORTANT NOTE:
CNG cylinders require special attention. There have been serious incidents when a cylinder valve was removed because the tank was considered to be fully emptied, but still contained pressurized gas. While under pressure, CNG tanks can launch several hundred yards. Seek specific vehicle instructions from the vehicle manufacturer. If these instructions cannot be located, seek assistance from a qualified natural gas vehicle technician.

LNG

IMPORTANT NOTE:
LNG defueling requires specialized equipment to empty the tank. Contact your local LNG supplier for assistance.

- When emptying the fuel, do not allow direct contact or breathe in, as the -260°F temperature can cause cryogenic burns or lung damage.

Removing Components

IMPORTANT NOTE:
It is very important that damaged or end of life cylinders are not fraudulently returned to service. After purging the tank of fuel, cut the neck off of the tank or cut the cylinder in half. Many steel cylinders and liners are coated with a zinc-rich ("cold galvanizing") primer; therefore, use a respirator and take other precautions as you would when welding or cutting galvanized steel.

After fuel is completely removed, remove the fuel, tank, and fuel lines prior to cutting with hydraulic tools near the fuel system components.

- **DO NOT** place yourself in line with the valve as you remove it.
- **DO NOT** puncture or cut an LNG tank (unless the tank is being removed from service).
- If handling an LNG tank, use protective gloves, as frostbite can occur.
- Take special care when moving vehicles with a forklift to avoid damaging high-pressure lines or puncturing the CNG storage container.

> **IMPORTANT NOTE:**
> *CNG cylinders may be damaged in accidents or their service life may expire before the vehicle is recycled. CNG cylinders are designed, tested, and labeled for a maximum service life and must be safely disposed of at their end of life.*

Propane Vehicles

Propane vehicles work much like gasoline-powered vehicles with spark-ignited engines. There are two types of propane vehicles, dedicated and bi-fuel (see **Figure 84**). Dedicated propane vehicles are designed to run only on propane, while bi-fuel propane vehicles have two separate fueling systems that enable the vehicle to use either propane or gasoline. There are also two types of fuel-injection systems available, vapor injection and liquid propane injection. In both types, propane is stored as a liquid in a relatively low-pressure tank.

At normal temperatures and pressures, propane is a gas, but it can be turned into a liquid at a temperature of -44ºF (-42ºC). Propane is stored as a liquid in a relatively low-pressure tank (about 150 pounds per square inch).

Shutdown/Isolate Fuel System

- If not done upon receipt of vehicle, before beginning to dismantle a propane-fueled vehicle, isolate the fuel system by first cutting the negative cable(s) and then cutting the positive cable(s) of the 12-volt auxiliary battery. You should remove 3-4 inches from both the positive and negative battery cables.

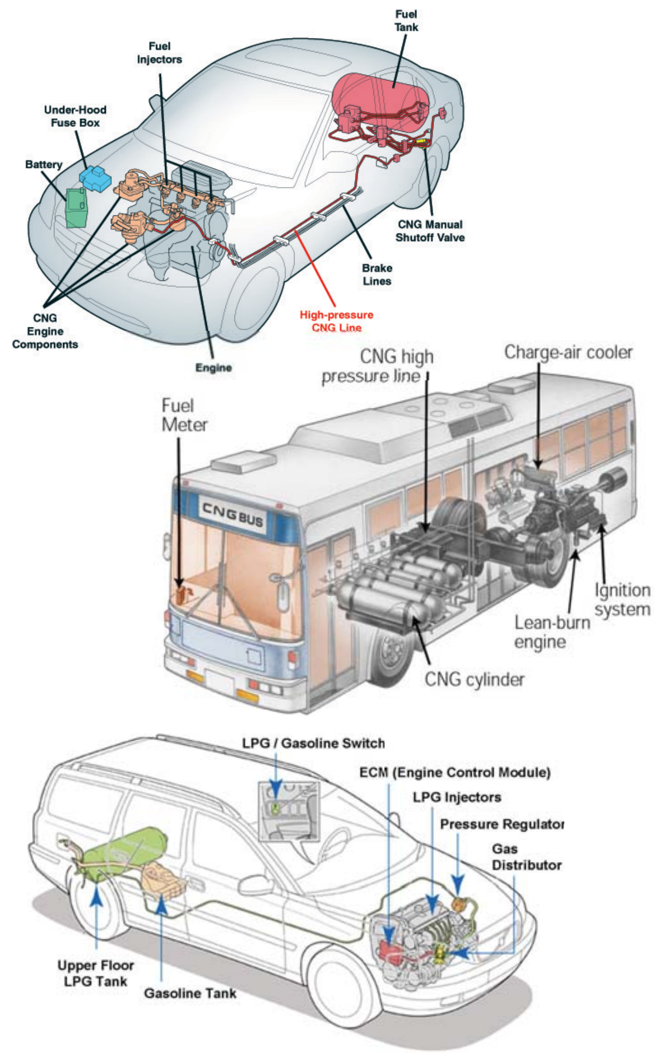


Figure 84: *Honda Civic GX cutaway (top); heavy-duty vehicle cutaway (middle); propane vehicle cutaway (bottom). Source: DOE.*

Defueling

- Remove the fuel prior to beginning the dismantling of the vehicle.
- Specialized equipment is required to empty the propane tank. Contact your local propane supplier for assistance.
- **DO NOT** make any piping disconnections before the fuel pressure is fully released.
- If handling a propane tank, use protective gloves, as frostbite can occur.

- When emptying fuel, do not allow direct contact or breathe in the fumes.

Removing Components

- After the fuel is removed, remove the tank and fuel lines prior to cutting with hydraulic tools near the fuel system components.
- **DO NOT** puncture or cut a propane tank.

Hydrogen Vehicles

There are two main types of hydrogen vehicles, those that utilize an internal combustion engine (ICE) and those that use proton exchange membranes (PEM) as the electric source for fuel cells that power the vehicle.

Both types of hydrogen vehicles store hydrogen on board in pressurized tanks. Hydrogen sensors are included that can detect if hydrogen is present in the air, and if it is, can then initiate a system shutdown. Hydrogen tanks have pressure relief devices as additional safety features. Most hydrogen vehicles have two vents, one each on the top and the bottom of a vehicle. The purpose is to prevent a hydrogen tank from extreme pressure build up. When the vents are functioning, there may be a “hissing” sound.

As a word of caution, the hydrogen that escapes from the pressure relief device (PRD) vent is under high pressure and may self-ignite. The PRD component activates only if there is excessive temperature or pressure in the hydrogen tank (see **Figure 85**).

Figure 85: *Location of hydrogen tank PRD vent. Source: NAFTC.*

IMPORTANT NOTE:

It is essential that the location of the PRD vent be identified before beginning any operation on a hydrogen vehicle. Listen for venting hydrogen, and watch for thermal waves that could signal a hydrogen flame.

Since fuel cell electric vehicles (FCEVs) are a type of electric drive vehicle, it is important to be aware of the high-voltage battery system in addition to the fuel.

For information on dismantling electric drive vehicles and their high-voltage system, see the information starting on page 55.

Shutdown/Isolate Fuel System

- If not done upon receipt of the vehicle, before beginning to dismantle a hydrogen-fueled vehicle, isolate the fuel and high-voltage systems by first cutting the negative cable(s) and then cutting the positive cable(s) of the 12-volt auxiliary battery. You should remove 3-4 inches from both the positive and negative battery cables.

WARNING!

*Many hydrogen-fueled vehicles are fuel cell electric vehicles and therefore have a high-voltage system. The high-voltage system may remain powered for up to 10 minutes after the vehicle is shut off or disabled. To prevent serious injury or death from severe burns or electric shock, avoid touching, cutting, or opening any **ORANGE** high-voltage power cable or any high-voltage component.*

- Turning off the ignition disables the high-voltage system. However, some vehicles are equipped with a smart key, also called a proximity key. When the smart key is within about 25 feet (7.62 meters) of the vehicle, the low-voltage system is enabled.

Defueling

IMPORTANT NOTE:
The discharge of hydrogen from fuel storage tanks can be accomplished through a closed transfer system or an approved method of atmospheric venting.

- Remove the fuel prior to beginning the dismantling of the vehicle.
- Specialized equipment is required to empty the hydrogen tank. Contact your local hydrogen supplier or maintenance provider for assistance.
- **DO NOT** make any piping disconnections before the fuel pressure is fully released.

WARNING!
Hydrogen is stored in cylinders with up to 10,000 psi. Disconnecting a fuel line under high pressure can result in severe injury or death.

Removing Components

- After the fuel is removed, remove the hydrogen tank and fuel lines prior to cutting with hydraulic tools near the fuel system components (see **Figure 86**).
- **DO NOT** cut the **ORANGE** electric cables, the high-voltage NiMH or lithium-ion battery pack, or the fuel cell stack.
- **DO NOT** cut through the bottom of the vehicle below the floor line. Hydrogen fuel lines, high-voltage electrical lines, batteries, and fuel cell units are commonly located below the floor line.
- **DO NOT** puncture or cut a hydrogen tank.
- Take special care when moving with forklift to not damage or puncture fuel cell, batteries or other high-voltage or electrical lines, or high pressure lines or hydrogen storage container.

Electric Drive Vehicles

All electric drive vehicles have a high-voltage electrical system and high-voltage cables that are color-coded with **ORANGE** or **BLUE** insulation, which is resistant to chemicals and abrasion. If a harness section is covered in **ORANGE** plastic, there is at least one high-voltage wire or cable in that section.

Most electric drive vehicle systems will have between 244 to 650 volts DC in the high-voltage cables. The high-voltage system **ORANGE** or **BLUE** cables may be visible under the hood or along the chassis outside of the passenger compartment. By industry standard, **ORANGE** cables are used to identify high-voltage and **BLUE** cables to identify intermediate-voltage.

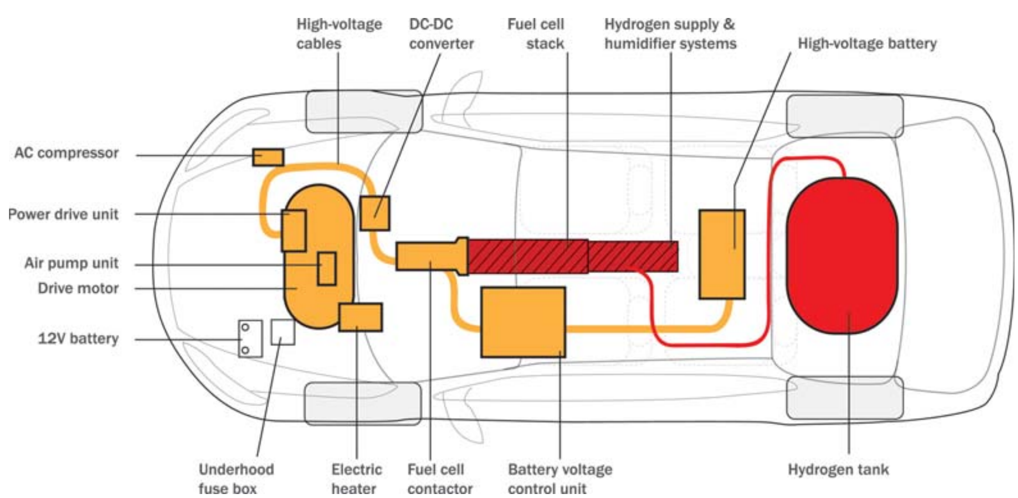


Figure 86: *Cutaway view of fuel cell vehicle. Source: NAFTC.*

In addition, many electric drive vehicles have a fuel tank, and therefore defueling is also necessary. While conventional gasoline remains the primary fuel for these vehicles, hydrogen powers fuel cell electric vehicles.

WARNING!
It is imperative to remember to **NEVER** *cut an* ***ORANGE*** *or* ***BLUE*** *cable.* ***BLUE*** *cables indicate an intermediate voltage of 30-60VDC or 15-30VAC.* ***ORANGE*** *cables and* ***ORANGE*** *covers identify the high-voltage system. The* ***ORANGE*** *cables indicate a high-voltage greater than 60VDC or 30VAC.*

All electric drive vehicles should have a manual high-voltage service disconnect for safety (inertia impact switches—see **Figure 87**). It will be located in a different position depending on the make and model of the vehicle. The service disconnect is used to shut down the high-voltage system (see **Figure 88**).

Figure 87: *Inertia impact switch. Source: NAFTC.*

Figure 88: *Hybrid high-voltage system disconnect. Source: NAFTC.*

Shutdown/Isolate Fuel System

WARNING!
Electric drive vehicles have a high-voltage system. The high-voltage system may remain powered for up to 10 minutes after the vehicle is shut off or disabled. To prevent serious injury or death from severe burns or electric shock, avoid touching, cutting, or opening any ***ORANGE*** *high-voltage power cable or any high-voltage component.*

- If not done upon receipt of the vehicle, before beginning to dismantle an electric drive vehicle, ensure that vehicle is off and isolate the fuel and high-voltage systems by first cutting the negative cable(s) and then cutting the positive cable(s) of the 12-volt auxiliary battery. You should remove 3-4 inches from both the positive and negative battery cables.
- Turning off the ignition disables the high-voltage system. However, some vehicles are equipped with a smart key, also called a proximity key. When the smart key is within about 25 feet (7.62 meters) of the vehicle, the low-voltage system is enabled.
- All hybrid vehicles should have a manual high-voltage service disconnect switch/plug for safety. It is used to shut down the high-voltage system. Wearing high-voltage insulating gloves, remove the service disconnect switch/plug.
- Apply insulating tape to the socket of the service disconnect switch/plug grip to insulate it.

- Remove the service plug from the area to prevent other staff members from reinstalling it while the vehicle is being dismantled.
- Near the high-voltage system, place a sign that says "Caution: High-voltage. **DO NOT** touch!"

Defueling

- Remove any fuel prior to beginning the dismantling of the vehicle.
- If powered by gasoline, follow those standard defueling requirements. If powered by hydrogen, see the information on hydrogen defueling.

Removing Components

WARNING!

High voltage is always present in the high-voltage battery pack.

- **DO NOT** cut any **ORANGE** or **BLUE** cables, the high-voltage battery pack, airbag charge cylinders in the supplemental restraint system, or the inverter/converter.
- **DO NOT** cut through the bottom of the vehicle below the floor line. High-voltage electrical lines and batteries are commonly located below the floor line.
- Take special care when moving with forklift to not puncture batteries or other high-voltage components or damage high-voltage electrical lines.

IMPORTANT NOTE:

Remember that high-voltage batteries are located within a protective case. Batteries in some HEVs contain electrolytes that are very corrosive. Lead acid batteries have a sulfuric acid-water solution as the electrolyte. NiMH batteries contain potassium hydroxide as the electrolyte solution.

- With the exception of the high-voltage battery, remove components following similar procedures to conventional vehicles.
- For removal of the high-voltage battery, take extreme caution and follow the manufacturer's removal instructions.

WARNING!

When removing high-voltage battery: Be sure to wear high-voltage insulating gloves when handling high-voltage parts. Even if the vehicle is shut off and the relays are off, be sure to remove the service plug grip before performing any further work. Power remains in the high-voltage electrical system for 10 minutes even after the high-voltage battery pack is shut off because the circuit has a condenser that stores power. Make sure that the tester reading is at 0 volts before touching any high-voltage terminals which are not insulated. The SRS may remain powered for up to 90 seconds after the vehicle is shut off or disabled. To prevent serious injury or death from unintentional SRS deployment, avoid cutting the SRS components.

Recycling High-Voltage Battery Packs

Since electric drive vehicles are somewhat new to the U.S. auto market, only a few have ended up in automotive recycling facilities. As electric drive vehicles become increasingly common and the recycling of electric drive vehicle components, such as high-voltage battery packs, will likely increase significantly.

This increase in battery recycling would keep the hazardous materials found in high-voltage battery packs from becoming an environmental hazard. According to the U.S. DOE Alternative Fuels Data Center, work is now under way to develop battery-recycling processes that minimize the life-cycle impacts of using lithium-ion and other kinds of batteries in vehicles. But not all recycling processes are the same:

- Smelting: Smelting processes recover basic elements or salts. These processes are operational now on a large scale and can accept multiple kinds of batteries, including lithium-ion and nickel-metal hydride batteries. Smelting takes place at high temperatures,

  and organic materials, including the electrolyte and carbon anodes, are burned as fuel or reductant. The valuable metals are recovered and sent to refining so that the product is suitable for any use. The other materials, including lithium, are contained in the slag, which is now used as an additive in concrete.
- Direct recovery: At the other extreme, some recycling processes directly recover battery-grade materials. Components are separated by a variety of physical and chemical processes, and all active materials and metals can be recovered. Direct recovery is a low-temperature process with minimal energy requirement.
- Intermediate processes: The third type of process is between the two extremes. Such processes may accept multiple kinds of batteries, unlike direct recovery, but recover materials further along the production chain than smelting does.

Crushing Alternative Fuel and Advanced Technology Vehicles

Preparing an alternative fuel or advanced technology vehicle for crushing is very similar to preparing conventional vehicles. The vehicle is stripped of working parts that can be resold and then is sent to the crusher (see **Figure 89**). In addition to general best practices that you should continue to follow based upon your experience with conventional vehicles, below are best practices specific to alternative fuel or advanced technology vehicles:

- Drain all fluids, including alternative fuels – biodiesel; ethanol; natural gas; propane; or hydrogen.
- Remove all batteries (12-volt and high-voltage) and fuel tanks/fuel storage systems.

Figure 89: *Once a vehicle reaches the automotive recycling facility, it goes through several steps before finally being crushed into scrap metal. Source: ARA.*

See previous section on Dismantling Alternative Fuel and Advanced Technology Vehicles for additional information.

For vehicle specifics and additional information regarding cut zones and where the alternative fuel and advanced technology vehicle components are located, download the free QRG app, or refer to Owner's Manual or OEM Emergency Response Guide from OEM website.

Safety and First Aid

Biodiesel

In case of contact with biodiesel, immediately flush skin or eyes with running water for at least 20 minutes. Wash skin with soap and water. In case of burns, immediately cool affected skin for as long as possible with cold water.

If biodiesel is ingested, drink one to two glasses of water. **DO NOT** give anything by mouth to an unconscious person. Seek immediate medical attention.

Ethanol

In case of contact with ethanol, immediately flush skin or eyes with running water for at least 15 minutes. Wash skin with plenty of water. Remove contaminated clothing and wash before reuse. Seek immediate medical attention.

If ethanol is inhaled, seek fresh air. If the person is not breathing, provide artificial respiration. **DO NOT** use mouth-to-mouth resuscitation. If necessary, provide additional oxygen once breathing is restored. Seek immediate medical attention.

If ethanol is ingested, **DO NOT** induce vomiting. Drink two to four glasses of milk. **DO NOT** give anything by mouth to an unconscious person. Seek immediate medical attention.

Natural Gas

Since natural gas is a simple asphyxiant, in high concentrations it will displace oxygen from the breathing atmosphere, particularly in confined spaces.

In the event of natural gas (CNG and LNG) inhalation, seek fresh air. If the person is not breathing, provide artificial respiration. If necessary, provide additional oxygen once breathing is restored. Seek immediate medical attention.

Inhalation of high concentrations of natural gas may cause central nervous system depression such as dizziness, drowsiness, headache, and similar narcotic symptoms, but no long-term effects. Numbness, a “chilly” feeling, and vomiting have been reported from accidental exposures to high concentrations.

LNG is a cryogenic fuel and can cause additional health hazards. Also, contact with flowing CNG can cause additional health hazards. In the case of blistering, frostbite or freeze burns, seek immediate medical attention. The risk of ingestion is extremely low. However, if oral exposure occurs, seek immediate medical attention.

In case of eye burns due to the combustion of natural gas, cover eyes to protect from light. Seek immediate medical attention.

Propane

Contact with propane can cause frostbite. Cryogenic burns may result in blistering or deep tissue damage and should be promptly treated by a physician. Flush frozen tissue with plenty of tepid water (**DO NOT** use hot water). Seek immediate medical attention.

Since propane is a simple asphyxiant, exposure can cause dizziness, shortness of breath, drowsiness, headaches, confusion, decreased coordination, and vomiting.

In the event of inhalation, seek fresh air. If the person is not breathing, provide artificial respiration. If necessary, provide additional oxygen once breathing is restored. Seek immediate medical attention.

Eye contact can freeze the eye. Immediately flush with gently flowing, lukewarm water. Cover both eyes with sterile dressing and seek immediate medical attention.

Hydrogen

Hydrogen may be a simple asphyxiant. It should be noted that before suffocation could occur, the lower flammability limit of hydrogen in air would be exceeded, possibly causing both an oxygen-deficient and explosive atmosphere.

Exposure to moderate concentrations may cause dizziness, headache, nausea, and unconsciousness.

Exposure to atmospheres containing 8-10% or less oxygen will quickly bring about unconsciousness without warning, leaving individuals unable to protect themselves.

Lack of sufficient oxygen may cause serious injury or death. Immediately seek fresh air and then medical attention.

Contact with flowing hydrogen can cause additional health hazards. In case of blistering, frostbite, or freeze burns, seek immediate medical attention. Risk of ingestion is extremely low. However, if oral exposure occurs, seek immediate medical attention.

Electric Drive Vehicles

Breathing battery electrolyte vapors may cause severe respiratory problems, including severe irritation of the mouth, throat, esophagus, and the stomach.

If skin contact occurs, remove contaminated clothing and flush the affected areas with plenty of water for at least 20 minutes.

If inhalation occurs, seek fresh air. If the person is not breathing, provide artificial respiration. If necessary, provide additional oxygen once breathing is restored. Seek immediate medical attention.

If battery electrolytes are ingested, **DO NOT** induce vomiting. Dilute by giving large volumes of water or milk. Get immediate medical attention. **DO NOT** give anything by mouth to an unconscious person.

If electrolytes come in contact with eyes, flush with plenty of water for at least 20 minutes. Seek immediate medical attention.

Notes

Automotive Recyclers Association

http://www.a-r-a.org/

Since 1943, the Automotive Recyclers Association (ARA) has been an international trade association which has represented an industry dedicated to the efficient removal and reuse of automotive parts, and the safe disposal of inoperable motor vehicles.

American Salvage Pool Association

http://www.aspa.com/index.cfm

ASPA is the voice of the automotive remarketing industry.

Members are salvage pools, fleet companies, rental car companies, insurance companies and firms/vendors engaged in business related to the total loss vehicle and property industry.

U.S. Environmental Protection Agency

http://www.epa.gov/

The products and practices used by auto salvage businesses have the potential to pollute the land, groundwater, and the air. The EPA's environmental policy requires actions to reduce, treat, or eliminate pollutants.

Alliance of Automobile Manufacturers

http://www.autoalliance.org/

The Alliance of Automobile Manufacturers is a leading advocacy group for the auto industry, representing 77% of all car and light truck sales in the United States, including the BMW Group, Chrysler Group LLC, Ford Motor Company, General Motors Corporation, Jaguar Land Rover, Mazda, Mercedes-Benz USA, Mitsubishi Motors, Porsche, Toyota, Volkswagen Group of America and Volvo Cars North America. It is headquartered in Washington, DC, with offices in Sacramento, California and Detroit, Michigan.

U.S. Department of Energy Clean Cities Program

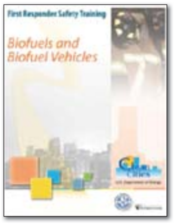
http://www1.eere.energy.gov/cleancities/

The U.S. DOE Clean Cities advances the nation's economic, environmental, and energy security by supporting local actions to reduce petroleum consumption in transportation.

National Alternative Fuels Training Consortium (NAFTC)

http://www.naftc.wvu.edu or http://afvsafetytraining.com/

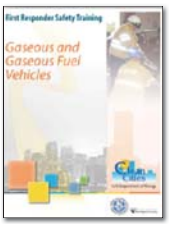
The National Alternative Fuels Training Consortium (NAFTC), a program of West Virginia University, has been promoting and providing education on alternative fuel and advanced technology vehicles since 1992. Presently offering more than 25 courses and workshops, the fuel-neutral organization plays a key role in providing education to numerous audiences on these new technology vehicles. The NAFTC consists of National and Associate Training Centers located nationwide from Maine to California. Each center provides Training with Impact through its experienced instructors and real-world shop facilities. Numerous other members from small business, government, and industry also support the NAFTC's mission.



First Responder Safety Training: Biofuels (biodiesel and ethanol) and Biofuel Vehicles

This workshop covers two biofuels (biodiesel and ethanol) and will properly train and educate first responders on the chemical properties, manufacturing and production, biofuel vehicles, infrastructure, transport, stations, and handling, as well as first responder procedures related to biofuels (biodiesel and ethanol) and biofuel vehicles. First responders will also learn how they should approach and assess an incident, required personal protective equipment for responding to an incident, general fire fighting measures, and extrication.

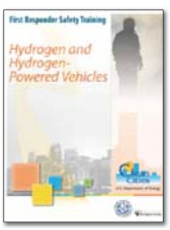
ISBN 978-1-933954-33-2



First Responder Safety Training: Gaseous Fuels (natural gas and propane) and Gaseous Fuel Vehicles

This workshop covers two gaseous fuels (natural gas and propane) and introduces the different types of gaseous fueling stations and station safety systems. First responders will also learn how to recognize compressed natural gas, liquefied natural gas, liquefied petroleum gas, their properties, current gaseous fuel vehicles, and their vehicle components. This workshop reviews how first responders should approach and assess an incident, required personal protective equipment for responding to an incident, general fire fighting measures, and extrication.

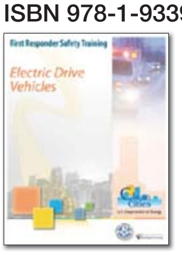
ISBN 978-1-933954-34-9



First Responder Safety Training: Hydrogen and Hydrogen-Powered Vehicles

This workshop introduces first responders to hydrogen properties, describes current hydrogen-powered vehicles, and explains the various hydrogen-powered vehicle components. This workshop introduces the different types of hydrogen fueling stations and describes fueling station safety systems. First responders will also learn how they should approach and assess an incident, required personal protective equipment for responding to an incident, general fire fighting measures, and extrication.

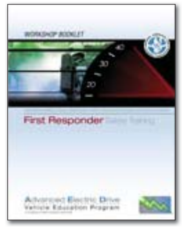
ISBN 978-1-933954-35-6



First Responder Safety Training: Electric Drive Vehicles

With the ever-increasing popularity of hybrid electric vehicles (HEVs), these vehicles are in every city and town in America. Although as safe as conventional vehicles, these high-voltage HEVs pose a new set of concerns for first responders, especially when approaching an accident scene. This workshop introduces first responders to HEVs, plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), fuel cell electric vehicles (FCEVs), and describes their history, explains their characteristics and configurations, and their safety features and extraction procedures.

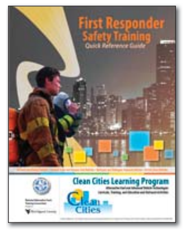
ISBN 978-1-933954-36-1



Electric Drive Vehicle First Responder Safety Training

This course covers all electric drive vehicles while detailing what first responders need to know when responding to accidents involving one of these vehicles. It addresses vehicle history, operations, battery technologies, infrastructure, and first responder procedures, such as vehicle identification, personal protective equipment, and extrication.

ISBN 978-1-933954-42-4



Quick Reference Guide

The Quick Reference Guide is a useful supplemental publication for the complete First Responder Safety Training curricula. Information in this guide has been developed to help the first responder identify and respond to an alternative fuel vehicle or advanced technology vehicle at the scene of an accident. This guide has been derived from information provided by automotive manufacturers' emergency response guides and therefore differs from vehicle to vehicle.

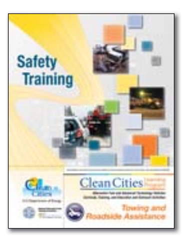
ISBN 978-1-933954-39-4

QRG Mobile App

The mobile app version of the quick reference guide allows emergency personnel to have at their fingertips all the advanced electric drive vehicle information contained in the hard copy flipbook. The app is available on Apple and Android devices.

First Responder Safety Training Online Course (Electric Drive Only)

The online course is a self-paced class that gives first responders the technical knowledge they need to safely respond to an incident involving an advanced electric drive vehicle. The training includes quizzes, tests, interactive learning activities, animations, and other online-based educational tools to best educate first responders.



Safety Training - Towing and Roadside Assistance

This material presents a full range of information related to towing and roadside assistance. It covers information on the Importance of Alternative Fuels, An Introduction to Alternative Fuels and Advanced Technology Vehicles, General Practices and Alternative Fuel and Advanced Technology Vehicle Specifics, and Towing and Roadside Assistance.

Disclaimer

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All published versions of this Automotive Recycling safety booklet, including both printed and electronic formats thereof and all associated videos, supplementing documents, and related electronic links, are provided as a public service by the National Alternative Fuels Training Consortium (NAFTC), a program of West Virginia University, under a grant from the U.S. Department of Energy Clean Cities Program under Award Number DE-EE0001696.

The information contained in this manual was obtained from sources believed to be reliable and is based on technical information and experience currently available at the time of writing.

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Comments and suggestions are invited from all users for consideration by the NAFTC in connection with such review. Please send all comments to the NAFTC, to the attention of the Executive Director.

The guidance and information in this guide are not meant to take the place of vehicle or equipment manufacturer guidelines and/or emergency response guides, and are not intended to supersede other information, requirements, or regulations provided by manufacturers, the insurance industry, safety officials, or other applicable standards and recommended practices.

This document does not take the place of and should not be confused with federal, state, provincial, or municipal specifications or regulations, insurance requirements, or safety codes.

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The National Alternative Fuels Training Consortium (NAFTC) is working in partnership with the U.S. Department of Energy (DOE) Clean Cities Program to develop and disseminate the turn-key Clean Cities Learning Program to raise awareness and foster a greater understanding of alternative fuels, alternative fuel vehicles, and advanced vehicle technologies through a targeted outreach and education effort. This program enables Clean Cities Coalitions and other stakeholders to better implement petroleum reduction technologies by advancing the use of alternative fuels, alternative fuel vehicles, advanced vehicle technologies, and idle reduction technologies through state-of-the-art curricula, training, and education and outreach materials, all of which are disseminated by the NAFTC and U.S. DOE Clean Cities.

Training courses include...

Petroleum Reduction Technologies

Designed specifically to raise awareness and foster a greater understanding of alternative fuels, alternative fuel vehicles, advanced vehicle technologies, petroleum reduction technologies, fuel economy and idle reduction, and related technologies. Workshops available on the following topics:

- Biodiesel
- Ethanol
- Natural Gas
- Propane
- Electric Drive
- Hydrogen
- Fuel Economy
- Idle Reduction
- Fleet Applications

First Responder Safety Training

Designed specifically to reduce the risks taken by first responders when responding to an incident involving alternative fuels, alternative fuel vehicles, and advanced technology vehicles.

4-hour workshops available on the following topics:

- First Responder Safety Training: Biofuels (biodiesel and ethanol) and Biofuel Vehicles
- First Responder Safety Training: Gaseous Fuels (natural gas and propane) and Gaseous-Fuel Vehicles
- First Responder Safety Training: Hydrogen and Hydrogen-Powered Vehicles
- First Responder Safety Training: Electric Drive Vehicles

Safety Training

Designed specifically to reduce the risks taken by automotive recycling, and towing and roadside assistance personnel when dealing with alternative fuels, alternative fuel vehicles and advanced technology vehicles.

- Automotive Recycling
- Towing and Roadside Assistance

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Clean Cities
U. S. Department of Energy

The U.S. DOE Clean Cities Program is a government-industry partnership designed to reduce petroleum consumption in the transportation sector by advancing the use of alternative fuels and vehicles, idle reduction technologies, hybrid electric vehicles, fuel blends, and fuel economy measures.

www.naftc.wvu.edu/cleancitieslearningprogram
www.cleancities.energy.gov

The National Alternative Fuels Training Consortium is the only nationwide alternative fuel and advanced technology vehicles training organization in the U.S.

National Alternative Fuels Training Consortium

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