

Alternative Fuel Technology - Propane

Editor's note: In previous issues of Tech News, we discussed Alternate Fuel Technology goals, provided an AFV market overview, discussed alcohol and natural gas-fueled vehicles. This issue deals with liquified petroleum gas (propane) and LPG-powered vehicles. For more information, please contact Bob Rodriguez at ASE. Phone: 703-713-3086. E-mail: brodriguez@asecert.org.

If you're a technician from the Southwest U.S., chances are you already know about propane-powered vehicles and equipment. But if you're in the automotive profession and are not yet familiar with propane vehicles, read on. In this article we'll explain the basics of liquified petroleum gas (LPG), or more simply "propane," and of propane-powered vehicles. Hopefully, you'll come to appreciate the relative safety, economy, and clean performance gaseous propane offers.

Overview

Farmers and construction outfits have used propane trucks, tractors, and other equipment since the '20s and '30s, and many automotive techs are somewhat familiar with propane. In the '70s, some OEs called for making "propane enrichment" carburetor adjustments; and we routinely use propane to find elusive vacuum leaks or to check fuel mixture problems. Propane motorfuel is used widely overseas, and here in the U.S. an esti-

Fleet operators especially benefit from propane's relatively low bulk price. Plus, centralized on-site propane refueling offers reduced pilferage and potential energy security in the event of a petroleum shortage. Some federal, state, and local government fleets use propane vehicles to comply with EPA mandates since propane is considered an alternative fuel, and private fleet operators may likewise choose propane to take advantage of financial incentives promoting its use. Check the Web [www.afcd.doe.gov] for programs which help fleets to recover incremental propane vehicle and fuel purchasing costs.

Propane Conversions

Presently most over-the-road propane vehicles are bi-fuel vehicles converted from gasoline. Bi-fuel means the driver can select either gasoline or propane depending on which fuel is available and less costly. A number of reputable suppliers offer propane conversion components and fuel systems to the marketplace.

The lion's share of earlier conversions were bolt-on, open-loop carbureted systems. Unfortunately, improper kit or component selection and/or installation sometimes caused tailpipe emissions to go up, rather than down. The EPA's expected reaction dealt a blow to many converters and kit suppliers who could not afford to EPA certify their equipment to specific OE engines.

Today, however, closed-loop gaseous and liquid propane fuel injection systems with adaptive electronics enable conversion kit suppliers to comply; they have taken steps to correct the problem or even to certify their conversion systems. Some suppliers are "qualified vehicle modifiers" (tier-one suppliers) who install their systems on OE vehicles; they often sell kits to the aftermarket as well. Such systems are used in conjunction with OE sensors, actuators and powertrain electronics, thus allowing vehicles to remain OBD-II compliant. A variety of light and medium duty OE bi-fuel and dedicated propane vehicles are available.

Fuel Definitions and Characteristics

LPG contains about 90% propane, with small concentrations of ethane, butane, propylene, and other gases.



Schwan's has the largest propane powered fleet in the country, with 98% of its 3000-plus delivery vehicles running on propane.

Propane is primarily a bi-product of natural gas, but is also extracted from crude oil. At atmospheric pressure, propane remains a vapor down to -44° F. Under moderate pressure (typically well below 200 psi at 70° F) propane shrinks to a liquid 270 times more dense than when gaseous, making it ideal for compact on-board vehicle storage. If vented, it boils off as a gas.

Propane is safer (slower burning, higher ignition temperature) than gasoline, and because of its relatively simple chemical makeup (C₃H₈), it is potentially cleaner burning. Oil & filter changes can be extended when engines are run exclusively on propane. Likewise, longer engine life (often 180,000-200,000 miles) is expected. Winter start-ups are easier with gaseous propane, but during hot weather, propane displaces already thin intake air which leads to hot start "enleantment." There's also a potential loss of power at WOT with a 5-15% lower volumetric efficiency. While this hurts bi-fuel vehicle performance, dedicated propane vehicles can run higher CRs to maximize propane's 104 octane rating and recover some lost power. Propane lacks lubricity, so some OEs use hardened valves/seats and guides; nor does propane provide for intake cooling, as do vaporizing liquid fuels.

Liquid propane is pumped on-board under pressure and is stored under 200 psi in one or more moderate-sized steel tanks. Propane's "storage ratio" to gasoline is roughly 1.1 to 1, thus a bi-fuel propane vehicle tank doesn't take up as much cargo space as tanks for CNG. If exposed to summer heat and sunshine, propane tank temperatures/pressures can rise radically. These conditions are handled by the tank's 20% "expansion volume" and the vehicle's fuel pressure regulator(s). Because propane gas is not visible, suppliers add an odorant, mercaptan, to enable human detection. As with gasoline vapors, propane is heavier than air, so gas leakage may collect in low places such as service pits; building codes may mandate floor-located detection equipment.

Refueling Infrastructure

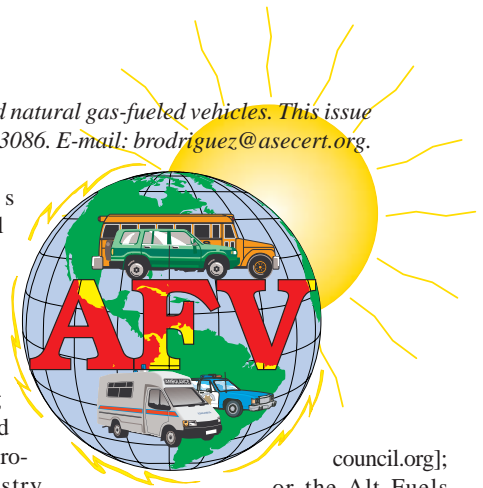
Propane is distributed by rail and truck to local retailers. Modern propane dispensing equipment, similar in appearance to gas pumps, is designed for simple emissions and error-free refueling at a rate of about 12-18 gallons/minute. Propane refueling sites are found at public fill stations and truck stops in certain areas of the country, at equipment rental outlets, and at RV dealers and some campgrounds. Prices vary widely. Some bulk suppliers of propane offer direct retailing. LPG for rural domestic and farm use is normally trucked in and stored on site.

While the actual propane content of such fuel may vary, LPG intended for motorfuel use must be of high quality (>88% propane minimum) with little sulfur, paraffin, or olefin content. The implementation of

propane's HD-5 fuel quality standard, calling for 95% propane, is still being debated within the propane industry, and as yet no nationwide distribution system exists for propane as a motorfuel.

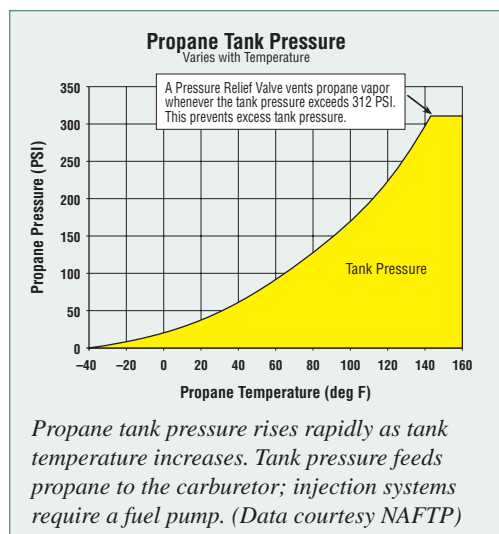
Want to Learn More about Propane Motorfuel?

There's a great deal to learn about propane fuel and vehicles. In-depth information is available both from vehicle OEs, and from fuel associations and the DOE. Start on the Web with the Propane Education and Research Council: [www.perc.org]; the Propane Vehicle Council [www.propane



council.org]; or the Alt Fuels Data Center: [www.afcd.doe.gov]. Consider attending the annual Propane Vehicle Conference or the Clean Cities Conference to learn more. These conferences offer "ride-n-drive" opportunities so you can become familiar with propane vehicles—vehicles which you'll ultimately diagnose and repair along with your customers' other fleet vehicles, vehicles which are helping us meet EPA mandates for clean air and EPA mandates for AFV use.

Future issue(s): Electric Vehicles, Hybrid Electric Vehicles, and Fuel Cell Vehicles.



estimated 270,000 propane-powered vehicles are on the road. Non-road propane "industrial trucks" (forklifts, tugs, etc.) amount to another 395,000 ... that's a lot of vehicles!

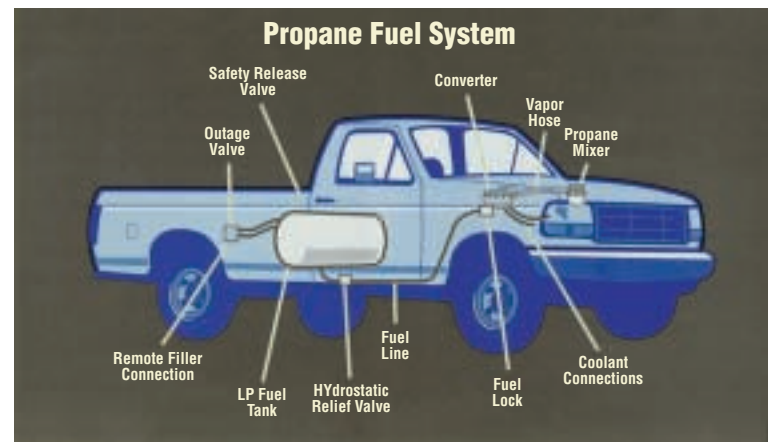
Applications

Propane fuel has long been known for its portability, making it the bottled fuel-of-choice for outdoor recreational use, for rural homes, and for countless industrial and commercial customers. Propane as a motorfuel is often used by fleets for powering tractors and tugs, pickups, delivery trucks, police vehicles, shuttle vans, school buses, coaches, and fire/rescue equipment. Propane provides almost the same range as gasoline and much more than that of CNG, ethanol, or methanol.

U-haul is installing retail propane vehicle refueling sites such as these with an eye on nationwide availability.



Refueling a propane vehicle is quick and easy: the standardized 'no-bleed' nozzle screws in place for emission-free fueling.



Propane fuel systems may be carbureted as shown here, but the newest systems use gaseous or liquid propane injection for improved performance (Chart courtesy: Western Propane Gas Association)

Nuts and Bolts

Aside from the fuel, emissions, and electrical system components, you won't see much difference between a gasoline vehicle and one running on propane. Where a bi-fuel gasoline/propane vehicle has two distinct fuel systems, the dedicated propane vehicle has only propane components which include:

Propane Tank(s)

Propane tanks are constructed of steel and are typically charged to 80% capacity. The remaining volume is for gas expansion caused by ambient heat (see chart). A fully charged tank will show a wide range of pressure, typically from 50 psi when cool to 175 psi when warm. Generally, the tank pressure relief valve vents at 312 psi.

Usually the tanks are located under the vehicle along/between the frame rails. Light-duty pickups might have them in the pickup bed; medium duty vehicles may have them behind the cab or along the frame rail. The fuel-fill connection for receiving pressurized propane is gas tight and prevents VOC emissions.

Shutoff Valves

An externally accessible shutoff valve (see vehicle schematic) must be installed, and a visible label is required to indicate its location. An ignition or engine-controlled fuel shut-off valve serves to seal off the fuel supply when the engine is not running.

Regulators

Propane fuel systems use a pressure-reducing regulator, possibly serving as a "vaporizer" as well. The regulator is likely warmed with engine coolant (to prevent freeze-up). The regulator drops tank pressure to fuel rail pressure for injected fuel, or to essentially atmospheric pressure for carbureted systems, allowing liquid propane to change to a vapor.

Fuel Delivery System (Simplified)

Propane may be fed into the intake system via a variable venturi "mixer" which sits above the bi-fuel vehicle's gasoline throttle body or carburetor. Sometimes gaseous fuel is released to the intake stream through a fixed venturi "fuel ring" or "spray bar" in the intake. Other systems may use a sequence of EFI-controlled fuel injectors (appearing similar to gasoline EFI port injectors) for central-point injection of gaseous propane. Newer multi-point gaseous and liquid propane injection systems help to restore power lost due to lower volumetric efficiency on propane (see main text).

Beyond the intake of propane and air, the process is as with gasoline. Gaseous fuels place higher demands on the ignition system, and a modified timing curve (advanced) is required for the slower/longer burn time of propane. Propane's different burn characteristics require that adaptive powertrain electronics be added, yet systems must remain OBD-II compliant and certify under clean air regulations.