

Alternative Fuel Systems - CNG 101

NATURAL GAS AS A MOTOR FUEL

Natural gas is an abundant energy source that most of us know of from its use as a heating fuel. However, natural gas has long been in use as a motor fuel, dating back as far as the earliest Otto-cycle engines. The benefits to the use of natural gas include lower emissions, lower fuel costs, a large domestic supply – which contributes to our national security, and its adaptability to modern internal combustion engine systems. Early use of natural gas as a motor fuel was curtailed by the inability to provide adequate on-board storage in a sufficient quantity to meet the needed range of drivers. As a result, the now common fuels, gasoline and diesel, achieved widespread use due to their energy content being in a denser liquid state. Natural gas continued to be used as a fuel source on stationary equipment where a continual supply could be provided through underground pipelines.

In the late 1970's and early 1980's, the oil embargo and the resultant energy crisis in the U.S. spurred new interest in alternative fuels that could reduce our dependence on foreign imports. New methods were developed which would allow natural gas to be compressed and stored in containers fitted to an automobile. Compressor stations were built which delivered Compressed Natural Gas (CNG) at pressures up to 3600 psi. Engine upfit systems were designed and installed, and the modern Natural Gas Vehicle (NGV) was born. There are now over 130,000 NGV's on U.S. highways, both dedicated and bi-fuel versions, with more on the way. Most recently, the lower emission's benefit of natural gas has been a strong influence in its use. With reductions in hydrocarbons (HC), oxides of nitrogen (NOx), and lower amounts of carbon dioxide (CO₂) natural gas is leading the way as an alternative fuel.

CHARACTERISTICS OF NATURAL GAS

Natural gas is primarily methane (CH₄). This makes natural gas a very friendly fuel for the environment. Methane as a hydrocarbon is considered non-reactive. That means hydrocarbon emissions of natural gas do not react with sunlight to create smog. CNG is non-toxic, non-carcinogenic, and non-corrosive. Natural gas is also lighter in weight than air. This provides for an increased safety factor as any leakage will quickly dissipate into the atmosphere reducing the risk of a potential explosion as compared to liquid fuels which pool on the ground, or pollute our ground waters. When used as an engine fuel, the Society of Automotive Engineers (SAE) has established a standard minimum methane content of 95% (SAE J1616).

COMPRESSED NATURAL GAS (CNG)

Natural gas is found in large underground fields much like crude oil. However, due to its gaseous state overland transport of natural gas is not feasible. Rather, extensive underground pipelines were developed to carry it from the wellhead to customers thousands of miles away. Most U.S. households have access to a source of natural gas from a Local Distribution Company (LDC). These local pipelines provide gas at pressures ranging from 4-50 psi.

To provide natural gas at pressures up to 3600 psi, special compressor stations are necessary. The CNG station compresses, filters, stores, and delivers fuel to a natural gas vehicle (NGV) in either of two ways, a fast fill or a time fill. Fast filling provides for quick and convenient refueling with a slight reduction in volume due to the heat rise of the gas during compression. Time filling allows for complete filling of the storage tank, but over a longer time --- up to eight hours. Small time-fill dispensers are available, which, when attached to a consumer's household gas line can refill a vehicle overnight. Both types of fuel delivery systems are regulated by standards established by the National Fire Protection Administration (NFPA).

CAUTION - HIGH PRESSURE

CNG vehicles carry natural gas stored at pressures up to 3600 psi. And even though NGV's are inherently safe, extra caution should be used when performing any service or maintenance operation. Leakage of high-pressure gas can cause serious injury. Never attempt to service a CNG vehicle until the system pressure has been safely vented. Always vent system pressure in a well-ventilated area.

CHARACTERISTICS OF A NATURAL GAS VEHICLE (NGV)

As most of us are more accustomed to driving gasoline or diesel powered vehicles it may be helpful to point out some of the minor differences between liquid fueled engines and those that operate on a gaseous fuel.

First, most liquid fueled engines require some form of a fuel delivery pump to transport the fuel from the tank to the engine. When operating on CNG a fuel pump is not used. Instead, system pressure provides for delivery of the fuel. CNG vehicles have at least one pressure regulator, which maintains a steady supply of fuel regardless of fluctuations in system pressure. Second, the ignition system must deliver a slightly higher voltage to ignite the gaseous mixture versus the liquid droplets that make up the normal charge of gasoline. Finally, CNG is high in octane. With octane ratings up to 130, ignition timing may be increased without resulting in spark knock.

Modern NGV's use closed-loop computer controlled technology to provide lower emissions and excellent driveability. Some equipment manufacturers offer fuel injection versions to provide even more precise mixture control. With the latest certification processes implemented by the U.S. EPA and other regulatory agencies, systems are required to be calibrated for specific engine family applications. When a properly calibrated CNG system is correctly installed, many drivers cannot notice a difference in the vehicle's driving characteristics.

VOLUME AND RANGE

Natural gas quantity is normally stated or measured in Standard Cubic Feet (SCF) while liquid fuels such as gasoline or diesel are sold in liquid gallons. To provide a simple way to compare CNG fuel mileage with gasoline fuel mileage the CNG industry adopted a standard measurement called the Gasoline Gallon Equivalent (GGE) The standard states that 124 scf of natural gas is equal to 1 gallon of liquid gasoline (135 scf for diesel). CNG storage tank manufacturers specify the GGE rating for each size of storage tank they produce. When filled to capacity a 10-gge tank provides the same operating range as 10 gallons of gasoline.

LNG

Liquefied natural gas, or LNG, is natural gas in its liquid form. When natural gas is cooled to minus 259 degrees Fahrenheit (-161 degrees Celsius), it becomes a clear, colorless, odorless liquid. LNG is neither corrosive nor toxic. Natural gas is primarily methane, with low concentrations of other hydrocarbons, water, carbon dioxide, nitrogen, oxygen and some sulfur compounds. During the process known as liquefaction, natural gas is cooled below its boiling point, removing most of these compounds. The remaining natural gas is primarily methane with only small amounts of other hydrocarbons. Liquefying natural gas results in the purest form of methane when heated back to a gas.

For heavy-duty applications requiring long-range capability and large volumes of on-board fuel storage, LNG provides all the benefits of clean burning natural gas in a liquid form. LNG vehicles are essentially natural gas vehicles that store methane as a liquid. LNG vehicles include a heat exchanger installed between the fuel tank and the engine to warm the liquid and convert the fuel back to a gaseous state.

This article appears with permission, courtesy of BAF Technologies

