

LNG Fact Sheet

WHAT IS IT?

When natural gas is cooled to a temperature of approximately -260°F at atmospheric pressure it condenses to a liquid called liquefied natural gas (LNG). One volume of this liquid takes up about 1/600th the volume of natural gas at a stove burner tip. LNG weighs less than one-half that of water, actually about 45% as much. LNG is odorless, colorless, non-corrosive, and non-toxic. When vaporized it burns only in concentrations of 5% to 15% when mixed with air. Neither LNG, nor its vapor, can explode in an unconfined environment.

COMPOSITION

Natural gas is composed primarily of methane (typically, at least 90%), but may also contain ethane, propane and heavier hydrocarbons. Small quantities of nitrogen, oxygen, carbon dioxide, sulfur compounds, and water may also be found in "pipeline" natural gas. The liquefaction process removes the oxygen, carbon dioxide, sulfur compounds, and water. The process can also be designed to purify the LNG to almost 100% methane.

HOW IS IT STORED?

LNG tanks are always of double-wall construction with extremely efficient insulation between the walls. Large tanks are low aspect ratio (height to width) and cylindrical in design with a domed roof. Storage pressures in these tanks are very low, less than 5 psig. Smaller quantities, 70,000 gallons and less, are stored in horizontal or vertical, vacuum-jacketed, pressure vessels. These tanks may be at pressures anywhere from less than 5 psig to over 250 psig. LNG must be maintained cold (at least below -117°F) to remain a liquid, independent of pressure.

HOW IS IT KEPT COLD?

The insulation, as efficient as it is, will not keep the temperature of LNG cold by itself. LNG is stored as a "boiling cryogen," that is, it is a

very cold liquid at its boiling point for the pressure it is being stored. Stored LNG is analogous to boiling water, only 470° colder. The temperature of boiling water (212°F) does not change, even with increased heat, as it is cooled by evaporation (steam generation). In much the same way, LNG will stay at near constant temperature if kept at constant pressure. This phenomenon is called "autorefrigeration". As long as the steam (LNG vapor boil off) is allowed to leave the tea kettle (tank), the temperature will remain constant.

If the vapor is not drawn off, then the pressure and temperature inside the vessel will rise. However, even at 100 psig, the LNG temperature will still be only about -200°F.

HAVE THERE BEEN ANY SERIOUS LNG ACCIDENTS?

First, one must remember that LNG is a form of energy and must be respected as such. Today LNG is transported and stored as safely as any other liquid fuel. Before the storage of cryogenic liquids was fully understood, however, there was a serious incident involving LNG in Cleveland, Ohio in 1944. This incident virtually stopped all development of the LNG industry for 20 years. The race to the Moon led to a much better understanding of cryogenics and cryogenic storage with the expanded use of liquid hydrogen (-423°F) and liquid oxygen (-296°F). LNG technology grew from NASA's advancement.

In addition to Cleveland, there have been two other U.S. incidents sometimes attributed to LNG. A construction accident on Staten Island in 1973 has been cited by some parties as an "LNG accident" because the construction crew was working inside an (empty, warm) LNG tank. In another case, the failure of an electrical seal on an LNG pump in 1979 permitted gas (not LNG) to enter an enclosed building. A spark of indeterminate origin caused the building to explode. As a result of this incident, the electrical code has been revised for the design of electrical seals used with all flammable fluids under pressure.

WHAT IS CNG?

Compressed natural gas (CNG) is natural gas pressurized and stored in welding bottle-like tanks at pressures up to 3,600 psig. Typically, it is the same composition of the local "pipeline" gas, with some of the

water removed. CNG and LNG are both delivered to the engines as low pressure vapor (ounces to 300 psig). CNG is often misrepresented as the only form natural gas can be used as vehicle fuel. LNG can be used to make CNG. This process requires much less capital intensive equipment and about 15% of the operating and maintenance costs.

WHAT IS LPG?

Liquid petroleum gas (LPG, and sometimes called propane) is often confused with LNG and vice versa. They are not the same and the differences are significant. LPG is composed primarily of propane (upwards to 95%) and smaller quantities of butane. LPG can be stored as a liquid in tanks by applying pressure alone. LPG is the "bottled gas" often found under BBQ grills. LPG has been used as fuel in light duty vehicles for many years. Many petrol stations in Europe have LPG pumps as well.

Typical Components of Industry Gas Streams

Names	Components											
	CO2	H2S	N2	C1	C2	C3	iC4	nC4	iC5	nC5	C6	C7+
Inert Gas	x		x									
Acid Gas	x	x										
LNG			x	x	x	x	x	x				
Natural Gas	x	x	x	x	x	x	x	x	x	x	x	x
LPG					x	x	x	x				
Natural Gasoline						x	x	x	x	x	x	x
NGL					x	x	x	x	x	x	x	x
Condensate (Stabilized)							x	x	x	x	x	x

Definitions of Words and Terms Used in the Gas Processing Industry

Cricondenbar	The highest pressure at which liquid and vapor phases can exist at equilibrium in a multicomponent system.
Cricodentherm	The highest temperature at which liquid and vapor phases can exist at equilibrium in a multicomponent system.
GPM	Preferably Gal/Mcf (gallons per thousand cubic feet): This term refers to the content in natural gas of components which are recoverable or recovered as liquid products.
Mcf	An abbreviation for one thousand cubic feet of gas.
MMscf	An abbreviation for one million cubic feet of gas.
RVP (Reid Vapor Pressure)	The vapor pressure of a material measured by the Reid Method and apparatus as detailed in ASTM Test Procedure D-323.
Wobbe Number	A number proportional to the heat input to a burner at constant pressure. In British practice, it is the gross heating value of a gas divided by the square root of its gravity. Widely used in Europe, together with a measured or calculated flame speed, to determine interchangeability of fuel gases.
Heating Value (Heat of Combustion)	The amount of heat obtained by the complete combustion of a unit quantity of material. The gross, or higher, heating value is the amount of heat obtained when the water produced in the combustion is condensed. The net, or lower, heating value is the amount of heat obtained when the water produced in the combustion is not condensed.

Gas Properties and Pre-Treating for LNG

Components	MW	Boiling Temp		Freezing Temp		Gas Purity to LNG
		(°C)	(°F)	(°C)	(°F)	
Nitrogen	28.013	-195.80	-320.44	-209.90	-345.82	<1% (Note 1)
CO2	44.010	-78.50	-109.30	-56.60	-69.88	<50-100ppmv (Note 2)
H2S	34.080	-85.55	-121.99	-60.35	-76.63	<4ppmv
Methane	16.043	-161.49	-258.68	-182.48	-296.46	
Ethane	30.070	-88.63	-127.53	-183.27	-297.89	
Propane	44.097	-42.07	-43.73	-187.69	-305.84	
i-Butane	58.124	-11.73	10.89	-159.60	-255.28	
n-Butane	58.124	-0.50	31.10	-138.35	-217.03	<2%
Neo-Pentane	72.151	9.50	49.11	-16.55	2.21	<5ppmv
i-Pentane	72.151	27.85	82.13	-159.90	-255.82	
n-Pentane	72.151	36.07	96.93	-129.72	-201.50	<0.1%
n-Hexane	86.178	68.74	155.73	-95.35	-139.63	<0.5%
Mcyclopentan	84.162	71.81	161.26	-142.46	-224.42	
Benzene	78.115	80.10	176.18	5.53	41.96	1-10ppmv (Note 2)
Cyclohexane	84.162	80.74	177.33	6.55	43.80	1-10ppmv (Note 2)
Mcyclohexane	98.190	100.93	213.68	-126.59	-195.87	
Toluene	92.141	110.63	231.13	-94.91	-138.84	
E-Benzene	106.169	136.19	277.13	-94.98	-138.96	
p-Xylene	106.169	138.85	281.93	13.26	55.87	
m-Xylene	106.169	139.10	282.39	-47.87	-54.17	
o-Xylene	106.169	144.41	291.94	-25.18	-13.33	
n-C7	100.206	98.43	209.17	-90.61	-131.10	
n-C8	114.233	125.67	258.20	-56.80	-70.23	
n-C9	128.260	150.79	303.42	-53.52	-64.33	
H2O						<0.5ppmv
Mercury						<0.01microgram/Nm3
						<10Nanogram/Nm3

Note: 1. Limited by product specifications for particular projects

Note: 2. Depends on overall composition