Insight Article

Do you know your LNGs from your LPGs?

The article "LNG newbuilding in a nutshell" in the last issue of Gard News provided an overview of LNG carriers' newbuilding activities. This article has a more technical look at LNG and LPG carriers.

Published 06 October 2009

The first commercial transport of liquefied natural gas (LNG) was conducted in January 1959 when the METHANE PIONEER carried an experimental cargo of LNG from Lake Charles to Canvey Island. The METHANE PIONEER was a converted World War II Liberty freighter. In 1964 the first commercial shipments of LNG commenced between Algeria and the United Kingdom. From 1964 various trade routes were established but due to the high start-up cost of the terminals and vessels a unique trade developed in which the parties involved built long-term partnerships with little or no external market pressures to influence charterparty rates.

In the current economic climate the viability of LNG as a fuel source has increased and with the depletion of local stocks of LNG we are in the second generation “dash for gas” with the explosion in the number of planning applications for LNG terminals and vessel orders necessary to service those terminals. It is now likely that the future LNG market for ships will mirror that of the products and crude sectors.

Modern liquefied petroleum gas (LPG) production goes back to the early 1900s with the Rockgas Production Co. selling bottled gas for residential use. This type of bottled gas still uses a combination of propane and butane today but the gas is much cleaner and is more refined. With the growing demand for LPG, so came the need for the bulk movement of LPG. The first purpose-built LPG carrier was the British-built AGNITA, delivered in 1931. However, the first ship to carry LPG in bulk was the NATALIE O WARREN, which started operation in 1947 on a regular route from Houston to New York.

What is LNG and what is LPG?

The IMO defines gas as being “liquids having a vapour pressure exceeding 2.8 bar at a temperature of 37.8° C”. The interaction of any gas within a container is governed by Boyle’s law. Boyle’s law states that: PV = KT, where: P= Pressure V= Volume K= Constant T= Temperature Changing one of the values results in a change to the other values. Imagine a bicycle pump being used to inflate a tyre: the mechanical energy is used to compress or change the volume, which results in a change of pressure and the generation of heat. All gas tankers apply Boyle’s law to carry their cargo safely from one port to another.

LNG is predominantly made up of methane. It is a colourless, clear fluid with no odour. It is carried at atmospheric pressure and at a temperature of -160° C. It is carried as a liquid in order to maximise the carrying capacity of the ship. LNG expands approximately 600 times when changing from liquid to gas. LNG carried as a liquid must either be stored under pressure or very cold. It can be either heavy or light, depending on its heat content.

LPG is predominantly made up of propane and butane. It is also a colourless, clear fluid with no odour. It is carried either at these gases’ boiling point temperatures of -42.3° C (propane) and -0.5° C (butane), or under pressure at ambient temperature.

Chemical gases

It is not unusual for LPG vessels to carry bulk chemicals that have similar properties to that of LPG. Such gases include ammonia, vinyl chloride monomer, butadiene, ethylene and isoprene. Each chemical will require different handling procedures and the carrier must always refer to any carriage instruction given by cargo interests and the safety information published on the correct handling methods. The majority of chemicals carried on the LPG ships are part of the extended hydrocarbon (aromatic) family.

Hazards associated with the carriage of flammable cryogenic liquefied gases

There are particular hazards associated with the carriage of cryogenic liquids, that is, liquids carried at low temperatures and liquids that evolve vapours which may become flammable. Ships designed to carry these products are specifically designed to contain, monitor and maintain the product in its loaded state. To be entirely correct, liquefied gases are not flammable. As with any other hydrocarbon, it is the vapour released from the liquefied gas that burns, rather than the liquid itself. In order to ignite the vapour released from the liquefied gas, it is necessary to have a combination of gas to air of 5 to 15 per cent. This narrow band is the only region in which combustion will be supported. The hazards associated with hydrocarbon products are commonly known and most people are familiar with the harmful effects of prolonged contact with hydrocarbons. Being in a gaseous form the products described above tend to have a more acute effect, entering the bloodstream rapidly if inhaled. In addition, as with any gas allowed to build up within a confined space, eventually the gas will reduce the available oxygen within the space rendering a harmful atmosphere for anyone who enters it. It should be noted that each gas has its own individual properties and associated hazards. Reference should be made to the specific hazardous materials data sheet. Neither LNG nor LPG are known to be irritants, toxic or have narcotic effect.

Associated Hazards:
– Flammable with oxygen – Toxic systemic in varying quantities – Carcinogenic in small trace quantities – Asphyxiates due to lack of oxygen – Polymerisable when unstable – Very cold in liquid phase – Reactive with other elements – Narcotic effect in small quantities – Irritant in small quantities

The chemical gases pose their own individual risks, being generally unsustainable in their natural state, so stabilising chemicals are added which are often highly toxic in very small quantities. Again, it is necessary for people handling these products to be given proper safety information and advised of proper handling techniques.

The liquefied hydrocarbon gases are not explosive; however, they are flammable. The most significant danger arises from boiling liquid expanding vapour explosion (BLEVE). This is not a typical ignition-sourced explosion, but rather the result from a large and sudden release of pressurised liquid. However, experiments undertaken during the past 35 years have resulted in the design of containment systems which reduce the likelihood of this type of accident occurring. Also, a BLEVE can not occur in a refrigerated vessel.

Incidents

Like many vessels caught up in the First Gulf War, a gas tanker was hit by rockets and although she suffered a breach of her containment systems, she remained afloat and, following salvage work, the majority of the cargo was saved. More recently a gas tanker suffered an engine room fire off Hong Kong and burnt vigorously for many days. During this time the cargo containment system maintained its integrity and eventually the vessel was salvaged with her cargo intact. Theses incidents show that the containment system can withstand significant pressure and, combined with crew competence, make the gas fleet very safe.

LNG carriers design and construction

Traditionally the LNG fleet has comprised vessels with cargo tanks of a free-standing spherical or prismatic design. Due to the cryogenic nature of the cargo, it is necessary for the containment system to be built from special metals and other materials which can withstand very cold temperatures without succumbing to cold brittle fractures. The spherical tanks are constructed from aluminum or in some cases 9 per cent nickel steel. The membrane tanks are constructed of a laminate of invar and insulation material. In both designs the cargo tanks are incapable of withstanding high pressure and the pressure or boil off is controlled by being channeled off to provide fuel for the vessel’s propulsion. Both systems have their merits and drawbacks and the shipowner will choose a specific design to meet his individual requirements.

The last LNG ship to be scrapped was in 1977 and reports indicate the life span of these ships could be extended to 50 years. This is testament to the high level of maintenance of these vessels and the dedication and experience of the staff both on board and ashore.

LPG carriers design and construction

Fully-refrigerated

This type of ship tends to have prismatic tanks and carry LPG cargoes and some chemical cargoes. It is normal for fully-refrigerated vessels to be of the VLCC size with cargo capacity in excess of 100,000 cubic metres. The cargo in the ships is carried at ambient pressure and in a fully-refrigerated condition. The vessels are fitted with a reliquefaction plant which is capable of maintaining the temperature of the cargo.

Semi-refrigerated

These ships are commonly referred to as semi-pressure ships and are generally built with either bi-lobe or horizontal cylindrical tanks capable of withstanding pressure up to 10 bar. The vessels are fitted with a reliquefaction plant capable of maintaining the temperature and pressure of the cargo. With sizes ranging up to 20,000 cubic metres, the ships generally carry both LPG and chemical cargoes and are usually employed on a tramp trade.

A sub-group of semi-refrigerated vessels is the ethylene carriers, which carry this product at -104° C. These vessels are amongst the most sophisticated afloat and are designed to carry multiple grades with redundant cargo separation and independent reliquefaction plant to avoid cross- contamination.

Fully-pressurised

These ships generally operate on coastal trades. They have horizontal cylindrical tanks which are capable of withstanding internal pressures of 20 bar and are capable of carrying cargoes such as propane at ambient temperature. Due to the construction requirements of the cargo containment systems, these vessels are restricted in size to approximately 6,000 cubic metres.

In-built safety systems

The design of gas tankers of every type is currently regulated by the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code). The purpose of the Code is to provide an international standard for the safe carriage by sea of bulk liquid gases and certain other substances. The Code prescribes the design, construction and equipment carried on board the vessels. The level of in-built safety systems on gas tankers far outstrips that of a conventional tanker. Each ship must be fitted with a water spray system capable of protecting the accommodation, manifolds and tank domes. A fixed dry chemical powder fire-fighting system must be fitted, capable of supplying 45 seconds of continuous powder to the deck area. Depending on the size of the vessel two systems may be required. Gas monitoring systems are fitted to the ships to detect leaks. The ships are designed to withstand significant levels of damage while remaining afloat with the cargo containment system intact.

What the future holds

Two possible designs have been suggested, with estimated first production in 2010: Compressed Natural Gas (CNG) and Natural Gas Hydrates (NGH). Both systems are initially intended for regional and near coastal trade, with possible shuttle tanker capabilities. CNG has been likened to a mobile pipeline with the ship's cargo containment system being made up of a series of 30" pipelines capable of withstanding the high pressures generated by carrying LNG at ambient temperatures (methane has a pressure of 44 bar at a temperature of -82º C). NGH is intended to trap the gas molecule in freezing water – the pellets can then be carried safely at -20º C. Both systems are intended for use on small gas fields that currently are uneconomical to develop. Only the future will tell what further developments will be seen within the gas industry and the technical advances that will be made.

Any comments to this article can be e-mailed to the Gard News Editor .

Gard News is published quarterly by Gard AS, Arendal, Norway.