Liquefied Gas Carriers - Ship Types

Profile of the world gas fleet

The current fleet of liquefied gas ships in service is approximately 1,100, of which about 800 are LPG carriers, with over 200 LNG carriers and approximately 90 ethylene carriers making up the remainder.

Gas carriers are divided into two main groups.

- Liquefied Petroleum Gas (LPG) Carriers, which are designed to carry mainly butane, propane, butadiene, propylene, vinyl chloride monomer (VCM) and are able to carry anhydrous ammonia.

- Liquefied Natural Gas (LNG) Carriers, which are designed to carry liquefied natural gas (which is mostly methane).

Gas carriers are classed in three types based on hazard potential:

- type 1G, designed to carry the most hazardous cargoes
- type 2G and 2PG, designed to carry cargoes having a lesser degree of hazard
- type 3G, designed to carry cargoes of the least hazardous nature.

Gas carrier types

All gas cargoes are transported in liquid form (i.e., they are not carried as a gas in its vapour form) and, because of their physical and chemical properties, they are carried either at:
- pressures greater than atmospheric, or at
- temperatures below ambient, or a combination of both.

Therefore, gas carriers are generally grouped as follows:
- Fully Pressurised
- semi-pressurised and refrigerated
- fully refrigerated

Note. These grouping names are more prevalently used when discussing the classes and types of LPG carriers rather than LNG carriers.

Recap on Tank Types used

Type 'A': Constructed of plain surfaces (prismatic tanks)
Type 'B': Spheres
Type 'C': Cylindrical pressure vessels

(Note. These tanks are used where appropriate, regardless of gas carrier type)

Fully Pressurised Ships

These were the first generation of ships to carry liquefied gases.
The ships have a cargo capacity up to ~3,500 m³.

These ships carry the cargo in spherical or cylindrical steel tanks, designed for a working pressure of 17.5 kg/cm². This corresponds to the vapour pressure of propane at 45°C, which is the maximum ambient temperature in which the ship is likely to operate.

No means of temperature or pressure control is necessary.

The tanks are generally Type C spheres and no secondary barrier is required. A double bottom is constructed for ballast water. The hold space around the cargo tanks does not need to be inerted.

Advantages
- They are built with ordinary grades of steel as the cargo is carried at ambient temperature and no insulation is required
- no reliquefaction plant is required
- operations are simpler.

Disadvantages
- Due to their shape, the use of underdeck space cannot be optimised
- high design pressure requires considerable tank wall thickness, with consequent increase in displacement weight and cost
- the weight in tons of cargo carried is lower than for a refrigerated ship of similar size, due to cargo density difference
- as the diameter of the tanks increases, the wall thickness increases to withstand the same pressure. The decreasing ratio of cargo carried to weight of tank makes this solution uneconomical over long haul routes.

General description
These vessels are fitted with a refrigeration plant that provides a fully refrigerated ability while having a high design pressure for the cargo tanks (Pressure vessels), albeit below that required for fully pressurised carriage. The tanks are cylindrical in shape and of a thinner construction than the pressurised vessels.

Cargo capacity
Semi-pressurised, semi-refrigerated ships (which are now quite rare) ranged up to 5,000 m³ in size. Their
construction is based on carrying propane at a pressure of 8.5 kg/cm², and a temperature of -10°C.

Semi-pressurised, fully-refrigerated ships generally range up to 15,000 m³. They can be designed to carry the full range of cargoes in cylindrical or spherical tanks and are designed for a minimum service temperature of -48°C and a working pressure of approx 5 to 8 kg/cm².

Temperature control
The reliquefaction plant on these vessels generally has a substantial capacity and can, if required, load the cargo as a gas and then reliquefy it onboard. They are able to heat or cool the cargo during loading operations, or while at sea, and are also able to raise the temperature of the cargo when discharging.

Where a reliquefaction plant is fitted it will allow a reduction in the wall thickness of the tanks.

Note. The thicker the insulation surrounding the tank the less work the reliquefaction plant is required to do.

Construction
The inner hull volume is used more efficiently than the fully pressurised vessels and the number of tanks varies from 2-6.

A double bottom is constructed for ballast water and the hold space around the cargo tanks does not need to be inerted.

Advantages
Their advantages over fully-pressurised ships are:

- More cargo can be carried in a tank of the same capacity
- A tank of the same capacity is lighter and cheaper to build
- Much larger and more economical ships can be constructed.
Fully refrigerated

General Description
The economic advantages of transporting LPG and ammonia in a fully refrigerated, non-pressurised condition are more evident for longer haul and larger quantity cargoes. The self-supporting prismatic shape of the cargo tanks allows for a better utilisation of the available hold space than the type of ships described previously. The tanks are usually designed for a maximum working pressure of about 0.28 kg/cm² (280 millibars) and a minimum working temperature of -50°C making them suitable for the carriage of butane, butadiene, VCM, ammonia, propane and propylene.

Cargo capacity
The ships are typically in the range 15,000 m³ – 85,000 m³, with three common sizes for LPG/Ammonia trades of 30,000 m³, 52,000 m³ and 80,000m³.

Temperature control
The trend for longer voyages has imposed a demand larger ships, and with the increasing size of the ship, the pumping and refrigeration plant capacity has increased proportionally.

Construction
The tanks nearly extend to the full width of the ship, with ballast in the double bottom and upper hopper or wing tanks. These tanks normally have a centreline bulkhead fitted with two equalizing valves. You should be cautious should these vessels develop a list alongside as the tanks carry a large free surface area and if the vessel has problems with the ballast or levelling the cargo during load they can quickly list over to 2 or 3°.
**Ethylene Carrier**

**General Description**
Ethylene carriers are a special type of gas carrier that can transport ethylene fully-refrigerated at its atmospheric pressure boiling point of -104°C. Such ships are often built for specific trades. Many ethylene carriers can also carry LPG cargoes, which increases their flexibility.

**Cargo Capacity**
Cargo capacity depends on the trade for which the vessel was constructed and range from 1,500 - 15,000 cubic metres.

**Temperature Control**
Thermal insulation and a high capacity reliquefaction plant is fitted on this type of vessel.

**Construction**
Ethylene Carriers have Containment systems can either be Type C, Type B or Type A prismatic free-standing.

If Type C pressure vessel tanks are used, then no secondary barrier is required.
If Type B is used a partial secondary barrier is required.
If Type A is used a full secondary barrier is required. Because of the cargo temperature of -104°C, the hull cannot be used as a secondary barrier in this case and a separate secondary barrier must be fitted.

For reasons of economy, Type C tanks have predominated in this trade.

Ballast is carried in a full double bottom and wing tank ballast system.
LNG Carriers

General Description
LNG carriers are generally specialised ships transporting LNG at its atmospheric pressure boiling point of approximately -162°C, depending on the cargo grade.

These ships are usually dedicated vessels, but some smaller examples may also carry basic LPG cargoes. If an LNG ship is capable of carrying basic LPG cargoes, a reliquefaction plant is installed to handle the boil-off LPG cargo vapours.

Cargo capacity
LNG carriers were typically in the range 80-135,000 m³ up until 2006.

In 2006 the first LNG ships of over 200 and 250,000 m³ were being constructed for the new LNG trains being constructed in Qatar.

Temperature control
LNG is liquefied by refrigeration to -162°C and this process is carried out ashore, before the cargo is loaded onto the ship.

LNG carriers are fully insulated because it is not cost effective to liquefy methane onboard (2006, though the first vessels with reliquification plants may appear in the next few years).

As the ship has no reliquification plant any boil-off vapours are burned as fuel gas in the the engine room.

Construction
The cargo containment systems will generally be either:
- Membrane systems (Gaz Transport / Technigaz) previously described.
  (A full secondary barrier with inerted spaces is required for the membrane system) This system has a primary and secondary barrier that is constructed of a thin material and an insulation layer.
- Type B (Moss Rosenberg)
  (The Type B spherical tank requires only a partial secondary barrier)

A full double-bottom and side tank ballast system is fitted to all LNG ships.

Membrane (Gaz Transport or Tecnigaz)

There are two membrane systems in use. In both cases the insulation is fitted directly into the inner hull and the primary barrier consists of a thin metal membrane less than one millimetre thick.
secondary barrier and they are separated by plywood boxes of perlite insulation. Similar boxes are fitted between the secondary barrier and the inner hull. Loading is transmitted through the insulation to the ship structure. No centreline division is possible in this type of tank. The other system, developed by Technigaz, has a stainless steel membrane as the primary barrier while the secondary barrier is included in the insulation, which consists of load bearing balsa and mineral woods.

Gaz Transport and Technigaz are now known as "GTT" (Gaz Transport Technigaz) since the companies merged.

**Moss Tanks**

Spherical tanks are generally produced in aluminium or 9% nickel steel. The sphere is welded to a steel skirt that is connected to the hull of the ship and is then free to expand and contract as necessary.

Insulation is fitted to the outside shell of the sphere but no secondary barrier is regarded as necessary across the upper part of the sphere. However, below the sphere, an aluminium drip tray, together with splash plates, provides secondary protection for the hull.