Chapter 24 –
Liquefied Natural Gas (LNG)

A liquefied natural gas carrier (LNGC) is a ship with a specialised containment system, designed for carrying LNG in bulk. These ships have heavily insulated, temperature controlled tanks which keep the methane in a liquid state at approximately minus 162°C (–162°C).

LNGCs have been operated since the 1950s. In 1959, the *'Methane Pioneer'* carried the first experimental LNG cargo and, in 1964, British Gas at Canvey Island received the inaugural cargo from Arzew on the *'Methane Princess'*. These two ships formed the core of the Algeria to UK project and the project-based nature of LNG shipping continued until the end of the 1990s. Ships were built specifically for employment within the projects, acting as a floating pipeline between seller and buyer.

Since the year 2000 the demand for LNGCs has grown exponentially. Ship sizes have also drastically increased, with the Q-Max Qatargas ships now topping the scales at 266,000 m^3 capacity and 345 m in length.

One unique aspect of an LNGC is that it generally burns the LNG cargo on board as fuel and retains LNG 'heel' on completion of unloading for the ballast passage. This is required not only for propulsion, but also to ensure the vessel arrives cold at the next loading port. A warm LNGC takes approximately 12 hours to 'cool down', which adds considerable time to loading operations, compared to arriving cold.

24.1 LNG Quality

LNG is clear and colourless, comprising mainly methane but with a percentage of constituents such as ethane, butane, propane and nitrogen. It is produced from either gas wells or oil wells and, at the point of production, the gas is processed to remove impurities. The degree to which this is achieved depends on the facilities available, but typically it results in LNG with between 80 and 97% methane content. The resulting LNG can, therefore, vary in quality from loading terminal to loading terminal or from day to day.

Other physical qualities that can change significantly are the specific gravity and the calorific value of the LNG, which depend on the characteristics of the gas field. The specific gravity affects the deadweight of cargo that can be carried in a given volume. LNG is typically bought and sold on the basis of the number of million British thermal units (MMBtu) transferred and, therefore, the calorific value affects both the monetary value of the cargo and the energy obtained from the boil-off gas fuel.

These factors have significance in commercial arrangements and gas quality is checked for each cargo, usually in a shore-based laboratory by means of gas chromatography.

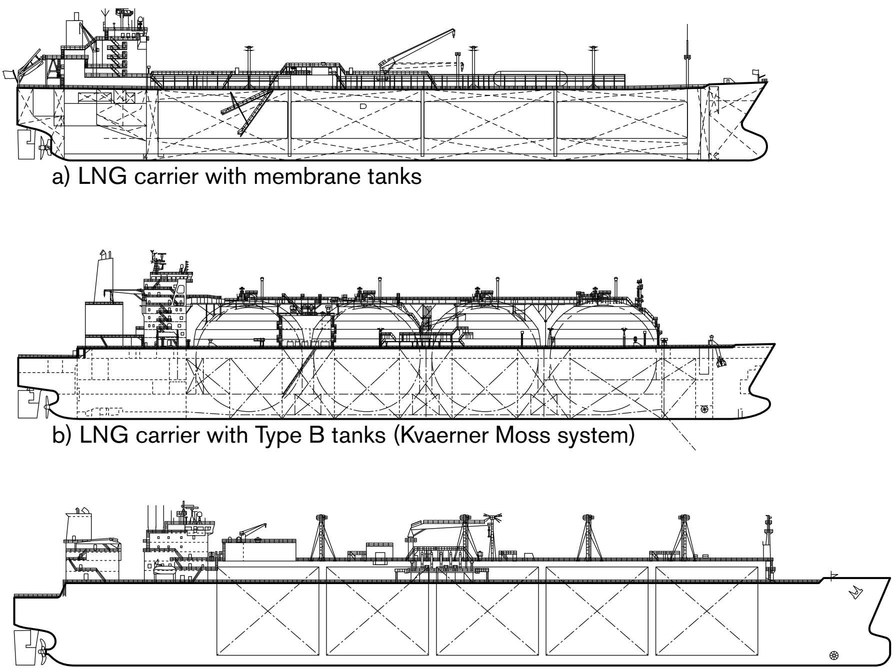
Figure 24.1: LNGC with Type B tanks (Kvaerner Moss system).

Gas quality is also significant from a shipboard perspective. LNGs that have a high nitrogen content naturally allow nitrogen to boil off preferentially, particularly at the beginning of the loaded passage (nitrogen having an atmospheric boiling point of minus 196°C (–196°C)). Methane also boils off preferentially to other heavier components of the LNG such as ethane and propane and this, combined with the boil-off of nitrogen, results in the boil-off gas being used as fuel having a lower calorific value than the bulk LNG cargo from which it originates. This has the reverse effect on the bulk LNG cargo, which increases in calorific value as the lighter components boil off preferentially over the course of laden voyage. Towards the end of a ballast passage, when the remaining heel has all but been consumed, the remaining liquids tend to be high on the heavier components such as the LPGs. This raises the boiling point of the remaining cargo and has a detrimental effect on the cooling capabilities of the LNG heel when used to spray-cool the cargo tanks in readiness for the next cargo.

LNG vapour is flammable in air and, in case of leakage, codes require an exclusion zone to allow natural dispersion and to limit the risk of ignition of a vapour cloud. Fire hazards are further limited by always handling the product within oxygen-free systems. Unlike oil tankers under inert gas, or in some cases air, LNGCs operate with the vapour space at 100% methane. LNG vapour is non-toxic, although in sufficient concentration it can act as an asphyxiant.

The good combustion qualities of LNG make it attractive as a fuel at electric power stations. It is also a 'clean' fuel. It burns producing little or no smoke, and nitrous oxide and sulphur oxide emissions are far better (in terms of environmental damage) than can be achieved when burning normal liquids such as low sulphur fuel oil. Natural gas has become attractive to industry and governments striving to meet environmental targets set under various international protocols such as the Rio Convention and the Kyoto Protocol. The practice of firing marine boilers on LNG provides the further environmental advantage of lesser soot blowing operations and fewer carbon deposits (see Section 24.4).

24.2 The LNG Fleet



a) LNG carrier with membrane tanks

b) LNG carrier with Type B tanks (Kvaerner Moss system)

c) LNG carrier with membrane tanks

Figure 24.2: Gas carrier types.

Early LNGCs had carrying capacities of about 25,000 m^3. This swiftly rose to about 75,000 m^3 for the Brunei LNG project and later ships settled on 125,000 m^3. For some years, this remained the norm, giving a loaded draught of about 11.5 m, thus stretching the port facilities of most discharge terminals to their limits. Since then, however, there has been a steady incremental increase in size, usually maintaining the loaded draught (although this has increased marginally to about 12.0 m) but increasing the beam, resulting in a standard ship size of about 175,000 m^3. In the main, LNG ports and terminals have adapted accordingly. At the end of 2004, the first orders were placed for LNGCs of more than 200,000 m^3 for the Qatar LNG project and currently there are 45 LNGCs trading with a capacity in excess of 200,000 m^3, with 14 of these having a capacity of between 260,000 and 266,000 m^3 (known as Q-Max). At the other end of the scale is the relatively recent *'Pioneer Knutsen'*, trading at only 1,100 m^3 capacity from a facility near Bergen to customers on the Norwegian west coast.

Large modern LNGCs have dimensions approximately as follows:

Capacity (m^3)	145,000	215,000	266,000
Length	295 m	315 m	345 m
Beam	48 m	50 m	54 m
Loaded draught	12 m	12 m	12.2 m

Table 24.1: LNGC dimensions.

LNG has a typical density of only 420 kg/m^3 which allows ships, even when fully laden, to ride with a high freeboard. They never appear very low in the water as a fully laden oil tanker may do. Ballast draughts are maintained close to laden draughts and, for a ship having a laden draught of 12 m, a ballast draught of 10 m is likely. This means that, for manoeuvring in port in windy conditions, the ships are always susceptible to being blown to the leeward side of the channel, and restrictions on port manoeuvring usually apply with extra tug power commonly specified.

The cargo tanks of LNGCs are thermally insulated and the cargo is carried at or near atmospheric pressure. Cargo tanks may be free standing spherical, or of the membrane type, or prismatic in design. In the case of membrane tanks, the cargo is contained within thin-walled tanks of Invar (a nickel-iron alloy) or stainless steel. The tanks are anchored to the inner hull in appropriate locations and the cargo load is transmitted to the inner hull through the intervening thermal insulation.

All LNGCs have a watertight inner hull and most tank designs are required to have secondary containment capable of safely holding any leakage for a period of 15 days. The simplicity and reliability of stress analysis of the spherical containment designs means that a full secondary barrier is not required, but splash barriers and insulated drip trays protect the inner hull from any leakage that might occur in operation.

No insulation system is 100% efficient and the heat from thermal leakage through the insulation is removed from the cargo by allowing the cargo to evaporate (boil-off). The boil-off gas must be removed from the cargo tanks to ensure that the tanks are maintained at or near atmospheric pressure.

While the majority of LNGCs in operation do not feature a liquefaction plant, an increasing number of new build designs are including these on board. This decreases wastage of cargo boil-off which is beneficial from both a commercial and an operational perspective.

The older propulsion systems for LNGCs were steam turbines supplied by high-pressure boilers. This provided a reliable, low maintenance propulsion system that was capable of burning any combination of gas and conventional fuel in the ship's boilers. The low thermal efficiency of conventional steam turbines has led to the development of a number of alternative propulsion systems that include re-heat steam turbines, which have a higher thermal efficiency than conventional steam turbine systems, and also dual fuel diesel electric (DFDE) systems. LNGCs with DFDE propulsion are equipped with up to four medium-speed diesel generators that provide electrical power to large electric propulsion motors, typically driving a single shaft and propeller through a reduction gearbox. The diesel generators are capable of running on either gas or marine gas oil (and also in some designs, heavy fuel oil) and are therefore able to utilise boil-off gas from the ship's cargo tanks as fuel. The most recent development in propulsion systems for LNGCs is direct drive, gas-injected, slow-speed diesel engines that are more fuel efficient than either steam or DFDE. Two designs are currently available, one working on the Otto process, using low-pressure fuel injection, and the other working on the diesel process using high-pressure fuel injection. The latter requires a gas injection pressure of approximately 300 barg and, where boil-off gas is used as fuel, it is delivered to the engine(s) by a large multistage reciprocating compressor. The compressor also provides the gas pressure required for a partial reliquefaction system in circumstances where not all of the boil-off from the cargo tanks is required as fuel for propulsion.

Figure 24.3: LNGC with Type B tanks (Kvaerner Moss system).

24.3 Cargo Handling

The process of liquefaction is one of refrigeration and, once liquefied, the gas is stored at atmospheric pressure at its boiling point of minus 162°C (–162°C). At loading terminals, any boil-off from shore tanks can be reliquefied and returned to storage. However, on ships this is not usually the case and for the majority of LNGCs not fitted with reliquefaction systems it is the practice to burn boil-off gas in the ship's boilers or engines to provide fuel for propulsion. Depending on the comparative cost of fuel oil, this may be supplemented by either fuel oil or additional natural gas produced by vaporising LNG using a heat exchanger, a process known as 'forcing', to meet the total fuel requirement of the passage.

Cargo volumes at the discharge port will not match those loaded and LNGCs are outfitted with sophisticated means of cargo measurement, referred to as the custody transfer system (CTS) and used in preference to shore tank measurements. These systems normally provide for highly accurate measurement of tank ullages, temperatures and pressures while the tanks themselves are specially calibrated by a Classification Society to a fine degree of accuracy. The system may automatically apply corrections for trim and list using equipment calibrated in dry-dock. The resulting cargo volumes, corrected for the expansion and contraction of the tanks, are normally computed automatically by the system.

Cargo tank design requires carriage at atmospheric pressure and there is little to spare in tank design for over or underpressures. The extent to which pressure build-up can be contained in a ship's tanks is very limited in the case of membrane cargo tanks, although this is normally not a problem as, at sea, the ship is burning boil-off as fuel. In port, the ship has its vapour header connected to the terminal vapour return system. However, there are short periods between these operations when pressure containment is necessary. This is managed by efficient shipboard operations that prevent all possible discharges to atmosphere, apart from minor escapes at pipe flanges, etc. This is part of the design criteria for the class, as it is recognised that methane is not only flammable but is also a greenhouse gas (GHG) that is more than 20 times as damaging to the atmosphere than the equivalent volume of CO_2 over a 100 year period. Over a 20 year period, methane has about 80 times the impact of CO_2.

Boil-off gas (BOG) is limited by tank insulation and newbuilding contracts specify the efficiency required. Usually, this is stated in terms of a volume boil-off per day under set ambient conditions for sea and air temperature. The guaranteed maximum figure for boil-off would normally be about 0.15% of cargo volume per day, although newer ships are capable of achieving closer to 0.10% per day.

While at sea, vapours bound for the boilers or engines must be boosted to the engine room by a low-duty compressor via a vapour heater. The heater raises the temperature of the boil-off to a level suited for combustion and to a point where cryogenic materials are no longer required in construction and where any gas leakage will be lighter than air and so cannot collect in the engine room bilges. LNGCs with high-pressure, gas injected, slow speed diesel engines direct the boil-off gas to the engines via a multistage reciprocating compressor. The boil-off then enters the engine room suitably warmed, but first passes an automatically-controlled master gas valve before reaching an array of control and shutoff valves for direction to each burner or engine. As a safety feature, the gas pipeline through the engine room is of annular construction, with the outer pipe purged and constantly checked for methane ingress. In this area, operational safety is paramount and sensors will trigger shutdown of the master gas valve in alarm conditions. For steam ships, a vital procedure in the case of a boiler flameout is to purge all gas from the boilers before attempting re-ignition. Without such care, boiler explosions are possible and occasional accidents of this type have occurred.

24.4 Cargo Care

The majority of LNG shippers and receivers have a legitimate concern over foreign bodies getting into tanks and pipelines. The main concerns are the risk of valve blockage, eg an old welding rod becomes lodged in a valve seat, damage to the cargo tanks on membrane ships or damage to the cargo pumps' bearings. Such occurrences are not unknown when a ship is discharging first cargoes after newbuilding or recently having come from dry-dock. Accordingly, and despite the economic impact of increased discharge time, it is common practice to fit filters at the ship's liquid manifold connections to prevent any such material from entering the shore system. The ship normally supplies filters fitting neatly into the manifold piping.

Even small particulate matter can cause concerns and the carryover of silica gel dust from inert gas dryers is one example. Another possible cause of contamination is poor combustion in IG plants with ships' tanks becoming coated with soot and carbon deposits during gas-freeing and gassing-up operations. Subsequently, the contaminants may be washed into gas mains. Cargoes can even be rejected on the basis of this. Tank cleanliness is vital and, particularly after dry-dock, tanks must be thoroughly vacuumed and dusted.

An LNG manifold is fitted with a strainer, which prevents any debris from entering the cargo containment system. Debris is particularly common when a loading terminal has been built or has recently undergone maintenance. Cargo equipment can be damaged, and the cargo can even be declared off spec, if debris is found within the cargo/system.

Figure 24.4: Debris recovered from the ship's manifold strainers after loading a commissioning cargo at a new LNG export terminal.

A cargo was once rejected in Japan when, resulting from a misoperation, steam was accidentally applied to the main turbine with the ship secured alongside the berth. The ship broke out from the berth, but fortunately the MLAs had not been connected. This action was sufficient however for cargo receivers to reject the ship, and the cargo could only be delivered after a specialised STS transfer operation had been accomplished. At the time, STS transfer of LNG had only ever been carried out on a few occasions as the operation requires perfect weather, great care and specialist equipment.

Another case of cargo rejection, this time resulting in a distressed sale, involved a shipment to Cove Point in the USA, where the strict requirements that prevail on in-tank pressures on arrival at the berth were not adhered to. The ship had previously been ordered to reduce pressure for arrival.

Pressure reduction is a difficult job to perform satisfactorily and, if it is to be successful, the operation must progress with diligence throughout the loaded voyage by maintaining the cargo tanks at a minimal operational pressure using a compressor to encourage maximum cargo evaporation. This cools the cargo and reduces the saturated vapour pressure (SVP). The process of drawing vapour from the vapour space at the last moment is ineffective because such short-term action will have little effect on reducing the cargo temperature and associated SVP and, once gas burning stops, the vapour space will return to its high equilibrium pressure. The process of reducing the temperature of the cargo and its equivalent SVP on the loaded passage is known as 'cargo conditioning'. In extreme conditions, particularly on short passages, where the amount of boil-off required to condition the cargo is more than that required as fuel, the ship may have to 'dump' excess gas either by steam dumping via the ship's boilers or by use of the gas combustion unit (GCU) on DFDE and diesel-powered LNGCs. Most LNG charterparties require the shipowner to warrant a daily loaded boil-off rate, which may not be achievable where the ship is required to condition the cargo on the loaded passage. In these instances, to avoid a subsequent claim for excess boil-off, the ship's Master should request direct instructions from the charterer with regard to cargo conditioning requirements for the voyage.

Back loading of LNG cargoes from traditional import terminals where the quantity of LNG in storage from long-term supply contracts exceeds the current local pipeline or end user requirements, has become more common in the last decade. This presents the crew of an LNG ship with a number of challenges. The cargo may have come from a number of shore tanks and original sources and the final detailed composition and density of the LNG may not be known until after the cargo has been loaded. The cargo may also be significantly warmer and have a higher saturated vapour pressure than LNG typically loaded at a dedicated LNG export terminal. To ensure that the cargo temperature and associated tank pressures are capable of being maintained within safe limits, particularly during the early part of the loaded passage, it may be necessary to return significant volumes of gas back to the terminal to assist in conditioning the cargo during the loading period. This is typically assisted by the slow loading rate associated with this type of operation, but may be frustrated by the limited capacity of the terminal to receive vapour back from the ship. The key to a successful operation is detailed prior planning between the ship, the charterer, the supplier and the terminal and clear and documented agreement on operational procedures.

LNGCs engaged in a traded LNG market may occasionally be required to carry a number of 'parcels' of LNG loaded at different terminals. In addition to the standard stowage considerations in respect of draught, trim, hull stresses and sloshing limitations on intermediate tank filling levels, the crew of an LNG ship must also consider the risk of rollover where cargoes of different densities and compositions are loaded into the same tank. Shore tanks in LNG receiving terminals are typically provided with top and bottom filling lines and recirculation facilities to promote the mixing of batches of LNG with different compositions and densities loaded into the same tank. This is not the case with LNGCs, which are limited to bottom filling only. Stratification may occur where a heavier LNG, ie an LNG with a higher percentage of ethane and propane, is loaded under a lighter LNG with a higher methane content in the same tank. When stratification occurs, the normal convection currents resulting from heat ingress through the tank insulation are restricted to the individual layers rather than throughout the full depth of the cargo, as is the case where the tank contains a single, homogeneous LNG composition. The top, lighter layer evaporates to the vapour space and, due to the preferential evaporation of methane, becomes progressively denser. The lower, denser layer warms up though heat ingress through the cargo tank insulation, becoming progressively less dense. When the densities of the two layers become similar, the convection currents in the lower layer are able to break through the upper layer to the liquid surface, thus breaking down the stratification, referred to as rollover. The trapped heat in the lower layer may now be released, resulting in a sudden and massive increase in vapour generation and tank pressure causing the tank safety valves to lift and, in extreme cases, overpressure damage to the tank. The risk of rollover can be eradicated by ensuring that each parcel of LNG is loaded into a separate tank.

Where the LNG parcels are loaded into separate tanks but are discharged to a single receiving terminal, the receiver may require the cargo to be received into the terminal with a homogeneous composition. This is to ensure that sampling equipment on the terminal unloading line is able to gather an accurate sample of the average composition of the entire cargo throughout the course of the unloading operation. The composition of the cargo derived from sample analysis determines the price paid for the LNG received. This will require the cargo officer of the LNGC to plan and adjust the unloading rates from individual tanks to achieve a homogeneous blend at the ship's manifolds throughout the unloading.

Rollover may also be a risk where a heavy cargo is loaded under significant quantities of lighter LNG heel. This is not normally an issue with LNGCs on a liner trade and loading at a single export terminal, as the heel will 'weather' on the ballast passage and will always be denser than the cargo to be loaded. It may be an important consideration for LNGCs engaged in an LNG trading market and it is recommended that the *Liquefied Gas Handling Principles on Ships and in Terminals*, published by the Society of International Gas Tanker and Terminal Operators (SIGTTO) (Reference 50) is consulted.

24.5 Ship Care

Most standard materials brought into contact with LNG become highly brittle and fracture. For this reason, pipelines and containment systems are built from the preferred materials of aluminium, Invar (a nickel-iron alloy) and stainless steel. However, these materials do not commonly feature over the ship's weather decks, tank weather covers or hull and so care must be taken to ensure that LNG is not spilt. A spill of LNG will cause significant damage to the decks or hull, normally necessitating emergency dry-docking. Accidents of this nature have resulted in extended periods off-hire, but fortunately there have been no reports of serious injury to personnel.

For cargo operations, a manifold 'water curtain' is established. This usually involves the use of the fire main system to allow a flow of water to cascade down the side of the ship in the vicinity of the manifold. If cargo were to leak or spill from the manifold connections of either the ship or the shore, the water curtain would prevent the cold LNG from coming into contact with the steel of the hull.

Figure 24.5: Brittle fracture of a ship's deck resulting from an LNG spill.

LNGCs are double-hulled ships specially designed and insulated to prevent leakage and rupture in the event of an accident such as grounding or collision. Although sophisticated in control and expensive in materials, they are simple in concept. Mostly, they carry LNG in just four, five or six centreline tanks. Only a few have certification and equipment for cross trading in LPG and/or ethylene. LNG is carried at atmospheric pressure and, although there are four current methods of constructing seaborne LNG tanks, only two are in majority usage. These are the spherical tanks of Moss design and the membrane tanks from Gaztransport or Technigaz (two French companies, now amalgamated as GTT). A number of shipbuilders have their own licensed designs for cargo containment systems based on membrane, spherical or self-supporting prismatic tanks. In each design, the cargo tanks are contained within the double hull with the space between the inner and outer hull being used as ballast water tanks.

Courtesy of Moss Maritime

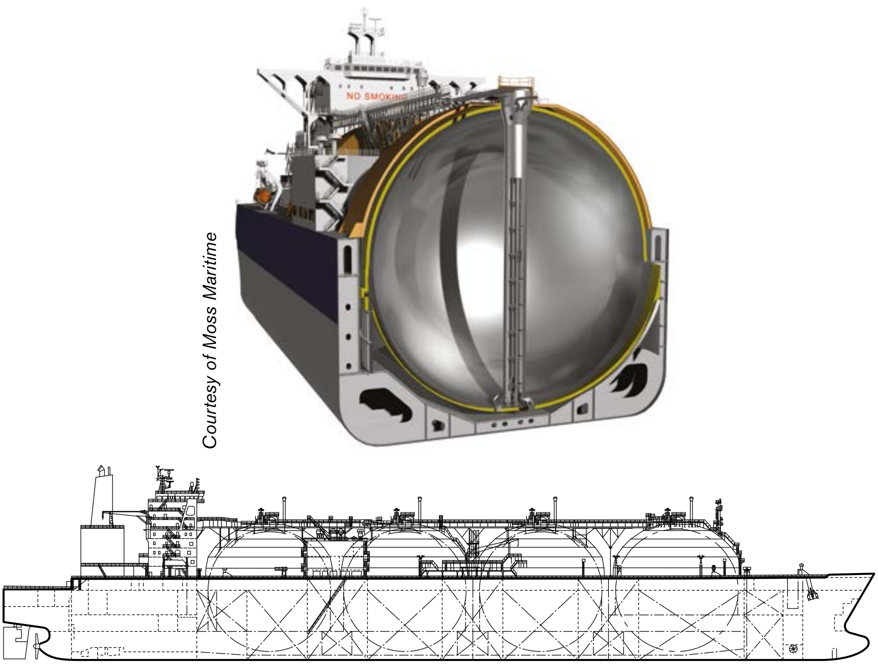


Figure 24.6: Moss design.

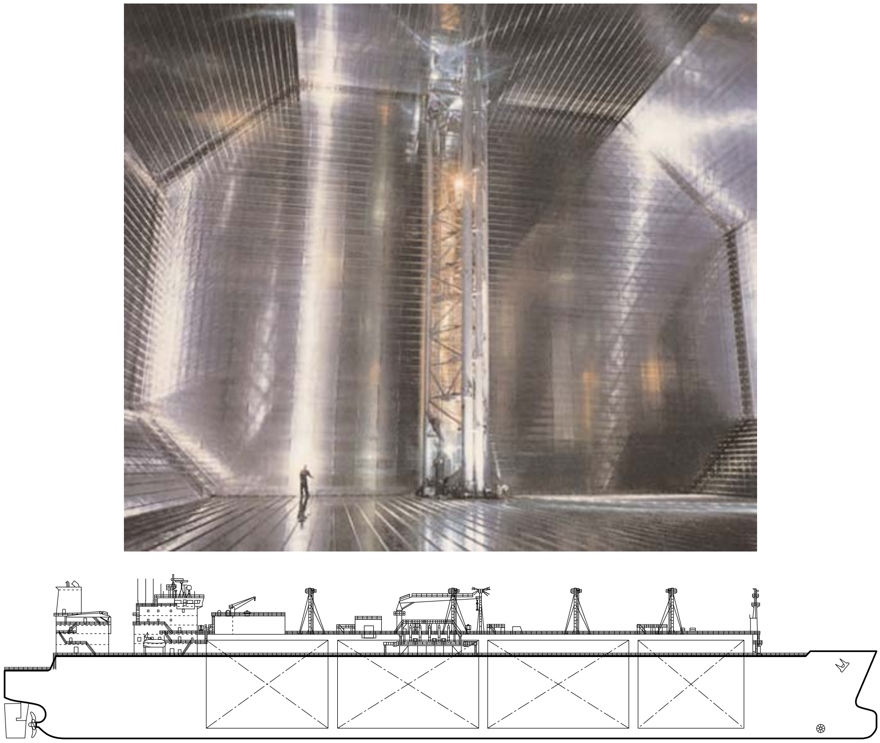


Figure 24.7: Membrane design (GTT).

A small number of spherical tanks are constructed from 9% nickel steel but the majority are constructed from aluminium. A disadvantage of the spherical system is that the tanks do not fit the contours of a ship's hull. LNGCs with spherical containment systems also have a greater lightship displacement than an equivalent membrane ship of the same cargo capacity. In general terms, for two LNGCs of the same carrying capacity, a ship of Moss design will be about 10% longer. It will also have its navigating bridge set at a higher level to comply with SOLAS requirements for visibility from the navigation bridge. However, spherical tanks are robust and relatively simple to install in comparison to the membrane system, with its complication of twin barriers and complex construction requiring in excess of 70 km of precision welding.

The mass of a spherical LNG tank requires a longer cooldown time and a larger amount of LNG to cool down to be ready for loading than an equivalent size membrane tank. Spherical tanks do not, however, have the same restrictions on filling levels that apply to membrane tanks. The large free surface in partially filled membrane tanks may result in damaging overpressures on the membranes and supporting insulation from sloshing motions of the cargo when the LNGC is working in a seaway. The double containment requirements for membrane LNGCs ensure that any damage to the primary membrane will be retained by the secondary membrane and will not prejudice the integrity of the inner hull. Any LNGC suffering damage to the primary membrane will, however, need to be taken out of service for repairs, resulting in lost availability, lost revenue and expensive repair costs. To avoid the risk of sloshing damage, membrane tanks have restrictions imposed by the respective Classification Society on filling levels in the cargo tanks when the LNGC is at sea. The sloshing restrictions typically require the cargo filling level to be either less than 10% of the height of the tank, or greater than 70% of the height of the tank when the LNGC is at sea, with guidance to avoid heavy rolling and pitching, where possible, when tank levels are close to these limits. This may require careful planning on the part of the cargo officer and the Master in circumstances where a long loaded voyage with slack tanks is contemplated, or where a large heel is required for an extended ballast passage.

The demand for LNGCs with spherical containment systems has declined due to the many advantages of membrane based ship types.

Figure 24.8: LNGC with Moss (spherical) tanks.

Figure 24.9: LNGC with membrane tanks.

LNGCs fitted with slow-speed diesel propulsion and burning heavy fuel oil require reliquefaction plants on board to handle boil-off gas (see Section 24.3). All diesel systems require back-up gas disposal facilities – also known as gas combustion units (GCUs) – for occasions when either the reliquefaction plants are not available to process boil-off gas or, in the case of LNGCs with DFDE and gas-injected direct drive diesel propulsion, where the ship's fuel requirement is less than the boil-off generated by the cargo.

LNGCs are expensive to build, but are valuable assets with some hulls and containment systems built with a 40-year fatigue life. Shipowners and ship managers alike recognise this and, assisted by inspection regimes, the overall quality of LNG tonnage is maintained to a high standard.

As some of the older LNGCs reach the end of their lifespan, and where the cost of ongoing maintenance begins to outweigh the cost of running the ship, it has become more common to convert a ship into a floating storage and regasification unit (FSRU).

To ensure that the quality of older LNG tonnage is maintained, many charterers require a Condition Assessment Programme (CAP) rating of the hull and cargo system from a reputable Classification Society for LNGCs older than 15 or 20 years.

24.6 Terminals, FSRU and STS

The cost and the time taken to construct LNG import terminals has led to the development of FSRUs, which are, typically, conventional seagoing LNGCs fitted with onboard regasification systems. An FSRU is designed to regas LNG from its cargo tanks and discharge the resultant high-pressure gas (80 to 100 barg) directly to an end receiver, typically a power plant, or into a gas distribution network. The FSRU enables natural gas to be delivered to a new end user in a shorter time frame and with less capital investment than would be the case with a conventional land-based regas terminal. An FSRU also requires a smaller footprint in a busy port area than a conventional land-based terminal and, when a particular contract has been completed, the FSRU can either be relocated to another project or returned, in the interim, to the LNG trade.

The regas capacity of a modern FSRU is similar to that of a medium size land-based regas terminal with throughput in the region of 3 million tonnes of LNG per annum. The gas is either discharged across a conventional jetty through a high-pressure hard arm or via a submerged turret mooring system into a subsea pipeline. Some FSRUs are converted from existing LNGCs and are de-engined and maintained permanently on station while a significant number are capable of trading as standard LNGCs in between regas contracts. In either case, when an FSRU is on station as a regas facility, it is kept supplied with LNG from standard LNG tankers via a double banked ship to ship transfer (STS) operation, using either flexible hoses or conventional marine loading arms (MLAs). This may be accomplished with the FSRU on station at the jetty or on the turret mooring or at a transshipment location close to the regas station.

The facilities provided for LNG STS transfer are similar in principal to those provided on a conventional LNG jetty. The two ships maintain a common emergency shutdown (ESD) and communications link and the transfer system, whether MLAs or flexible hoses, is fitted with a quick release facility that, in turn, is linked to a position monitoring system. The position monitoring system ensures that the cargo transfer is automatically stopped and the hoses or hard arms disconnected before the relative movement of the two ships exceeds the operating limits of the transfer system.

Courtesy of Excelerate Energy

Figure 24.10: Transshipment of LNG to an FSRU on a regas berth.

24.7 LNG as a Fuel

With the introduction of Environmental Control Areas (ECAs), an advantage of using boil-off gas as fuel is that natural gas provides a clean fuel solution with virtually zero sulphur content. Such is the appeal of natural gas as a clean fuel that LNG is now being increasingly considered as a fuel for ferries and other ships engaged in short sea trades in ECA areas. This concept was recognised in the IMO's Gas Codes from the very earliest days and, with the appropriate safety equipment in place, the regulations allow LNG to be burnt in ships' boilers or engines. This is not the case for LPG, where reliquefaction equipment is a fitment, but specifically because LPGs are heavier than air gases and their use in engine rooms is disallowed. This situation may change with the IGF Code, which may eventually allow for the safe use of low flashpoint fuels other than natural gas.

24.8 Society of International Gas Tanker and Terminal Operators (SIGTTO)

Valuable assistance in the preparation of these chapters has come from SIGTTO.

SIGTTO is the leading trade body in this field and has 213 members (December 2020), covering nearly 90% of the world's LNG fleet and 50% of the LPG fleet. SIGTTO members also control most of the terminals that handle these products.

SIGTTO's stated aim is to encourage the safe and responsible operation of liquefied gas tankers and marine terminals handling liquefied gas; to develop advice and guidance for best industry practice among its members and to promote criteria for best practice to all who have responsibilities for, or an interest in, the continuing safety of gas tankers and terminals.

Further details on activities and membership are available at www.sigtto.org