LNG "Technical Ship Management Issues"

Kishore Rajvanshy

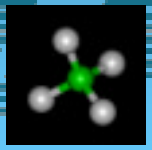
Managing Director
Fleet Management Limited

What is LNG?

Natural Gas is a FOSSIL FUEL and comes from Reservoirs beneath the earths surface

1) As associated Gas (When it comes as a product with Crude oil)

2) As Unassociated Gas (When found by itself)



The Main Constituent is METHANE (CH4)

What is LNG?

Composition of LNG

It very much depends on where you find it (Source)

Constituents	Algeria	Libya	Brunei	North Sea	Iran	Alaska
Methane	86.3	66.8	88.0	85.9	96.3	99.5
Ethane	7.8	19.4	5.1	8.1	1.2	0.1
Propane	3.2	9.1	4.8	2.7	0.4	-
Butane	0.6	3.5	1.8	0.9	0.2	-
Pentane and other	0.1	1.2	0.2	0.3	0.2	-
Nitrogen	-	-	0.1	0.5	1.3	0.4
Carbon dioxide	-	-	-	1	-	-

Properties of LNG

The Key Properties of Natural Gas :

Colourless

Odourless

Non Corrosive

Non explosive in open spaces

Why do we use Natural Gas

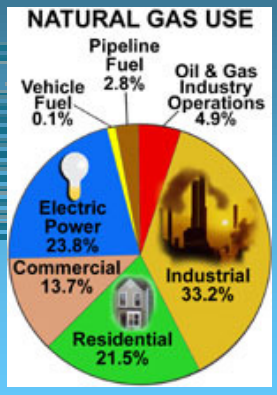
Over the past few years, the use of Natural Gas is increasing in popularity and becoming the fuel of the future:

- Depleting sources of commercial fuel
- Growing lobby against pollution of Air and Sea
- Nuclear Fuel could not take off (Strong lobby and risks)
- Jane Fonda …"suddenly we had a new champion for the cause"
- Value of LNG increased – more profitable to use.

USES OF LNG

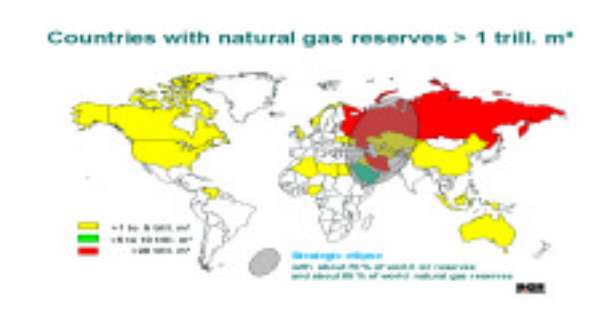
Typically Natural Gas is used as

- Pipeline Fuel
- Fuel for Electric Power generation
- Industrial
- Residential
- Commercial



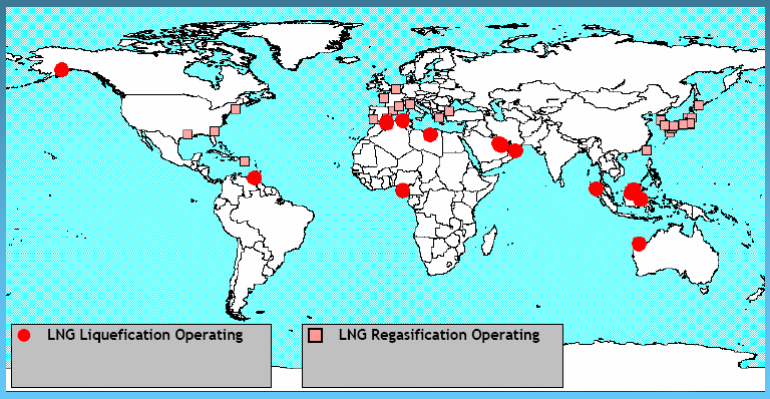
Sources of LNG

Where is it usually found??



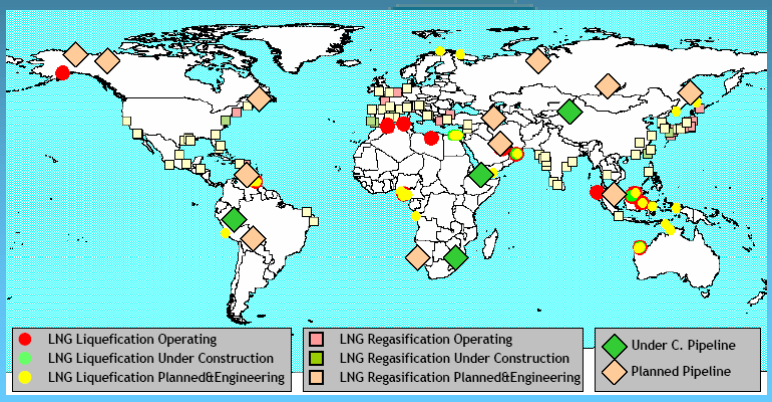
Sources ….and the Markets

Where is it usually found



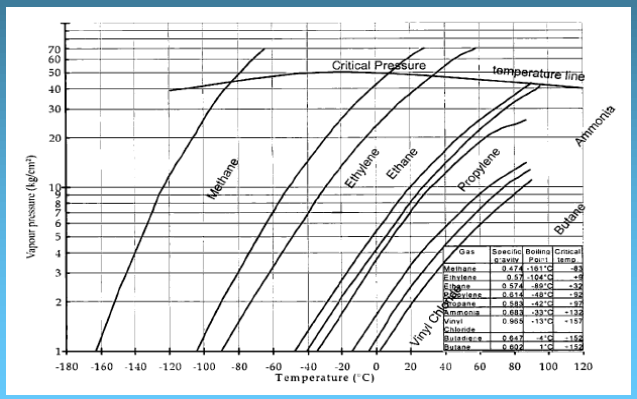
Sources ….and the Markets

Where is it usually found



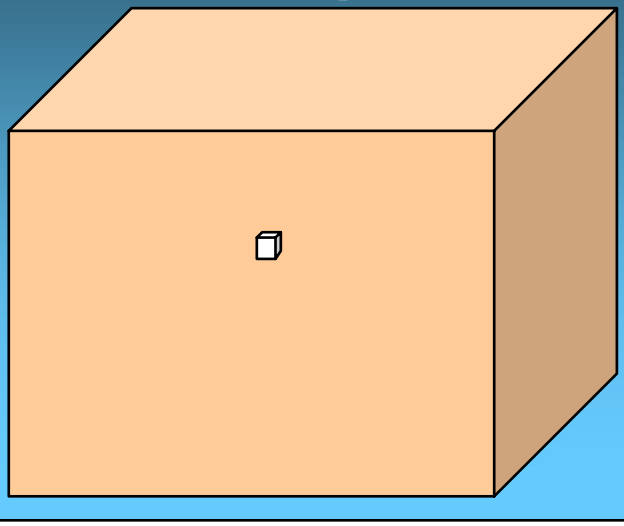
The Properties…….

Vapour Pressure vs. Temperature curve



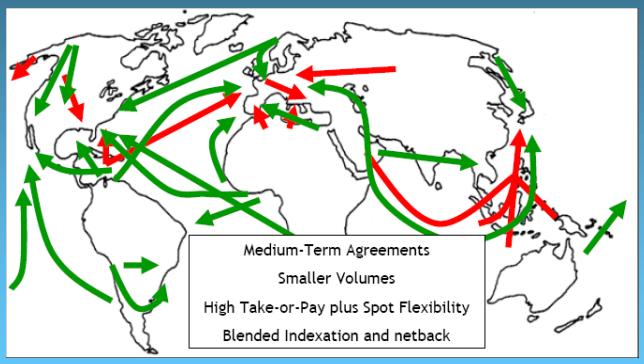
Why carry in Liquid form in LNG Ships

LNG Transformation when liquefied to 1/600 in volume



Sources ….and the Markets

Moving LNG to its markets – Ships have to be used.



LNG Ships

Traditionally contracts are long term (15+ Years)

The ships are purpose built for loading at the Liquifaction plant as well for discharging at the re-gasification terminal.

Caters to the physical requirements of the contract, the trade and the ports.

LNG Ships

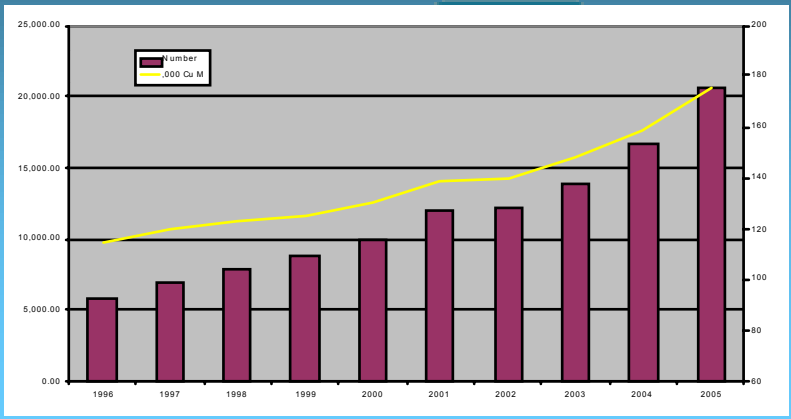
The first LNG ship was a conversion ship – Normarti was converted and renamed as Methane Pioneer in 1957

First two ships originally contracted for LNG were the Methane Princess and Methane Progress and first cargo carried in 1964

Methane Princess scrapped in 1986 and Methane Progress in 1997

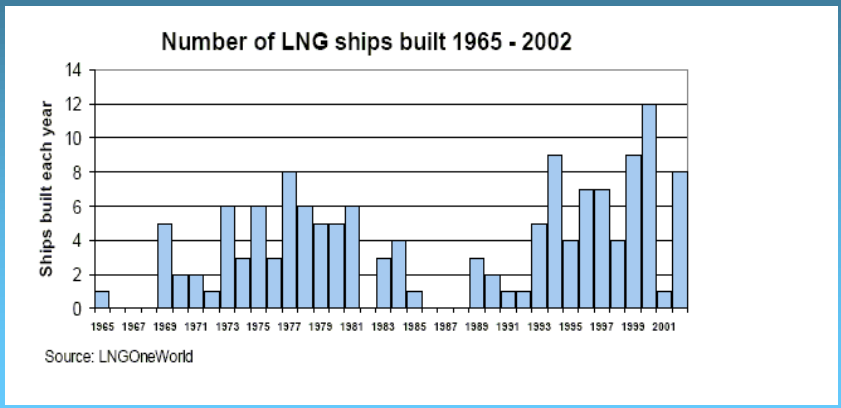
LNG Ships

There has been a huge spurt of growth of LNG carriers in the recent years



LNG Ships

After an Initial initiative, there was a lull for a long period before LNG ships were ordered again.



LNG Ships

Current Fleet Profile:

- Less than 40,000 m3 — 13 vessels
- Between 40-60,000 m3 — 6 vessels
- Between 60-100,000 m3 — 15 vessels
- Between 100 – 140,000 m3 — 134 vessels
- Above 140,000 m3 — 8 vessels

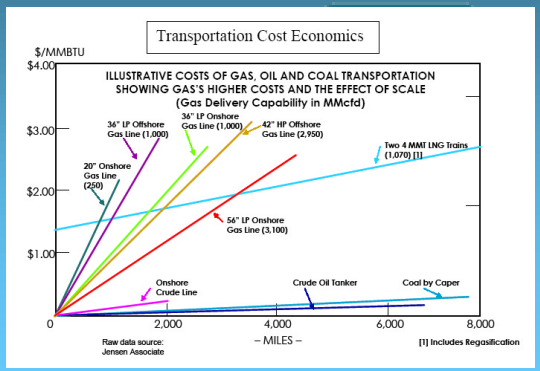
Total fleet size = 176 vessels.

Vessels from 27,000 m3 grew to 115,000 m3 to 140,000 m3 to recently ordered 215,000 m3 and the next line would be the 230,000 m3 followed by 250,000m3 vessels.

LNG Ships

The commercial impact – Transportation economics

- Assume a vessel of 145,000 m3 fully loaded and being carried,

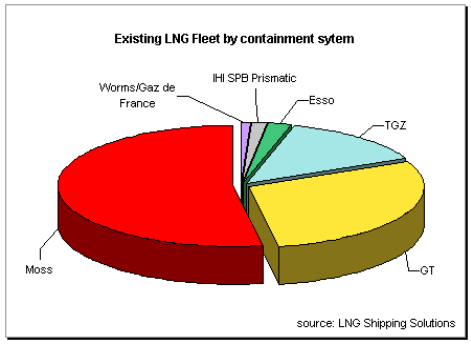


= 145,000 * 22.6 mbtu @ selling price of say 4.5 USD/mmbtu,
The value of cargo is over 15 million USD.

LNG Ships

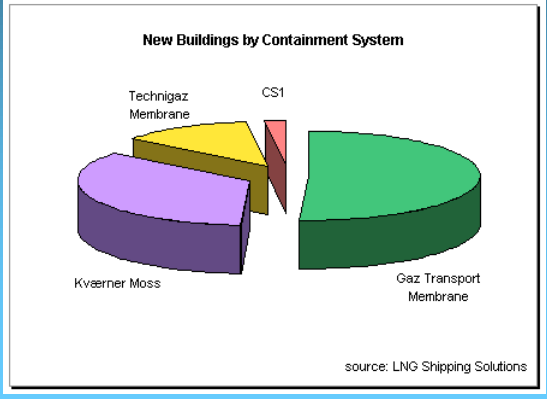
Presently the main Containment systems of the vessels;

There are three most popular design. There are numerous other designs, but the industry believes in time & tested methods for such a capital intensive project



LNG Ships

This is soon going to change as majority ships being ordered are of membrane types



LNG Ships

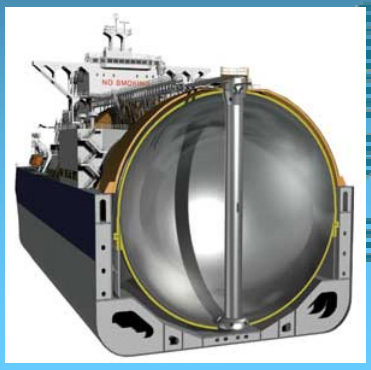
Containment system requirements

- Governed by the IGC code.
- Need to withstand temps as low as minus 162 deg C
- The cargo is a Type 1 cargo
- The secondary barrier should be capable of withstanding a leak in the primary containment for 15 days.
- The insulation provide should minimize boil-off

LNG Ships

Moss Spherical Containment system

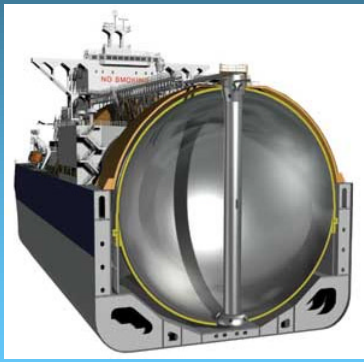
These ships are called LNG carriers – As they carry the sphere that contains LNG.



- Built with Aluminum alloy Al-5083
- Largest dome is about 33,000 m3 with 40 m as diameter weighs 900MT.
- The thickest part is the Equatorial Ring of 170 mm, otherwise the thickness varies between 30mm in the "north" to 58 mm in "South".
- Insulation is of Sipro or Kawasaki type.
- Annular space between sphere and insulation is fed with N2

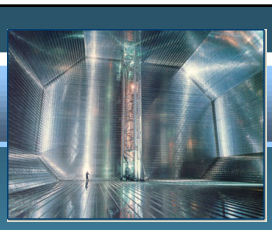
LNG Ships

Moss Spherical Containment system



- Usually has only a Partial barrier
- Pressure is usually around 0.25 bar but to a maximum of 0.7 bar
- The structural transition joint (STJ) in the equatorial ring acts as the gradient to allow use of normal ship building steel in ships hull.
- There will be a 260mm contraction on a 40m dia sphere.

LNG Ships



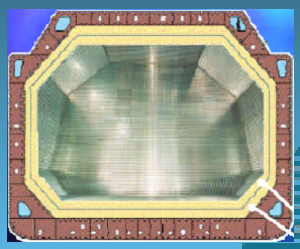
Membrane System – GTT 96.

These ships are called LNG tankers – The hull structure supports the membranes

- Built with Invar (36% Nickel Iron alloy)
- 0.7 mm thick membrane, but corners are 1.5 mm thick
- Primary and secondary membrane are the same
- Insulation is of Perlite with a total thickness of 540mm.
- The membranes are connected to hull hence they are prone to fatigue (max 120 N/m2).

LNG Ships

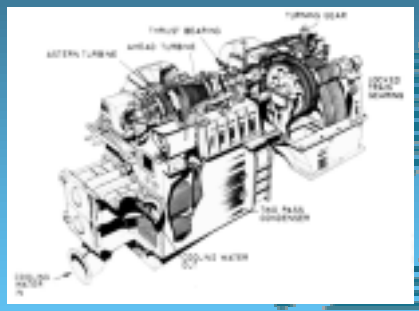
Membrane System – GTT MAK III.



- Built with corrugated Stainless steel
- 1.2 mm thick primary membrane and secondary membrane made of glass cloth with Aluminum foil in-between.
- Primary Insulation is of PUF 270mm thick
- The structure is not connected to the hull hence no fatigue strength required for the membranes.

LNG Ships – Machinery

LNG is self cooling when carried close to its boiling temp at atm conditions. There is no need to cool it down for its carriage.

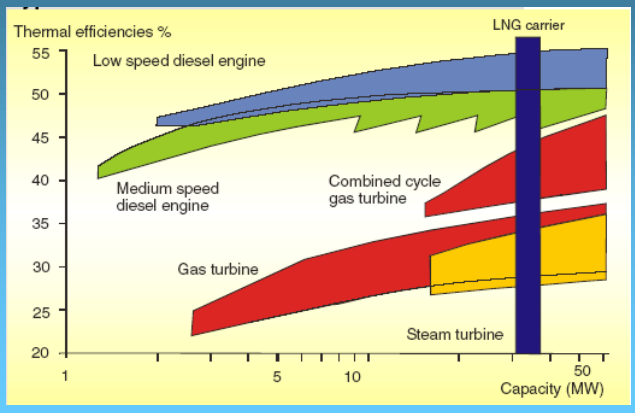


- Until recently – almost all propulsion systems were designed with Steam turbines using vessels boil off
- The boil off is utilized as its prohibited to be released into the atmosphere except in designated areas.

- A boil off of 0.15% per day is achievable with the insulation system and the improvement in technology has allowed for as low as 0.1% boil off.
- Due to increase in cost of LNG, its more sensible to use alternative propulsion means as well as due to scarcity of crew with steam tickets.

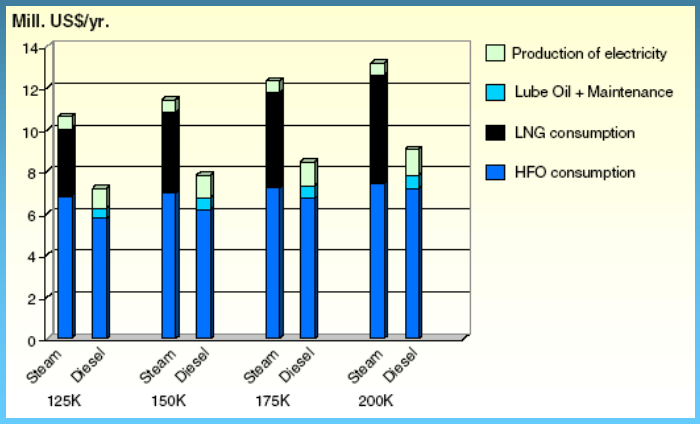
Prime Movers

The emergence of alternate propulsion systems for LNG carriers.



Prime Movers

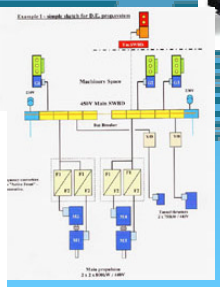
The emergence of alternate propulsion systems for LNG carriers.



LNG Ships – Machinery

Alternative Propulsion Systems

- Slow Speed Diesel
- Diesel Electric
- Dual fuel system
- Gas Turbines



LNG Ships – Machinery

Various Systems on the tanker that require proper maintenance

- Heavy Duty and Low Duty Compressors
- Cargo Heat exchangers
- Cargo pumps
- Spray pumps
- Vaporizers

Day to Day Challenges

The greatest challenge is to find Crew – Engine Crew who have Steam licenses. (Not many in the world).

When compared to the operational requirements of LPG and Ethylene, LNG's don't require tank cleaning, changing cargo's

Adherence of Safety is of utmost importance.

Millions of Dollars are invested in LNG plants by Oil Majors. Public perception and acceptance is the key.

The monitoring of the leakage from the containment system is very important

Day to Day Challenges

Loading operations.

The ships systems are checked by the Mate and the Cargo Engineer for ensure all precautions and line up is correct.

The air inside manifold is displaced with N2.

Loading commences at 70 m3/hr to allow cooling of the shore and ship lines and liquid is directed to the warmer areas on the vessel and tanks. Cool down is complete when lines are at –100 deg C.

Cargo rate increased to 1000m3/hr and in steps of 1000m3/hr every 5-10 minutes increased to the max rate 10,000 m3./hr.

Pressure in tank to always be below 0.22 bar (High Alarm)

Vapor flows back to terminal, HD compressors should be running before tank pressure reached 0.19 bar.

Day to Day Challenges

Discharging operations.

- The ship arrives with lines already cooled down
- Upon berthing connect up vapour then the liquid lines.
- Shore arms are cooled down using the cool down vales between the ESD and double shut off valves
- Cargo rate increased to 10,000-11,000 m3/hr, by adjusting the pumps in the cargo tanks
- The tank pressure should not come too low, hence vapour from shore is fed back in the cargo tanks.
- Pumps insulation resistance is continuously monitored and if less than 1 M ohm then trip occurs.

Day to Day Challenges

Docking to Docking cleaning.

Need to monitor the Hold pressure very carefully.

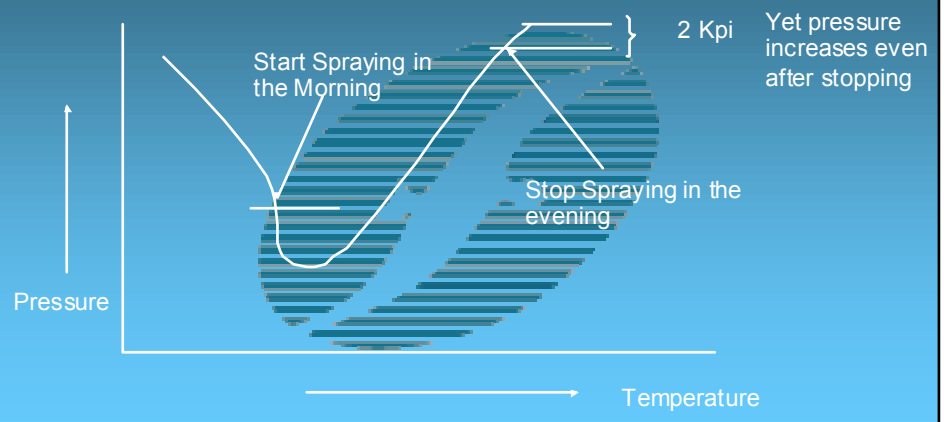
- Cargo Hold Relief Valves lift at 0.15 bar
- Vaccum not permissible, vents open to allow atmospheric air if –0.08 bar
- Hold Low pressure at –0.02 bar
- Hold High Pressure at 0.12 bar
- Differential pressure between hold and tank not to exceed 0.05 bar
- Alarm if differential is 0.03
- If differential is 0.04 bar then all cargo pumps, IG trip.

Need to monitor the Tank pressure too.

- In moss type 0.22 bar if High Pressure Alarm
- When 0.23 bar the venting of gas through forward riser
- When 0.25 bar individual tank relief vales lift and ESD activates.

LNG Intentional Curve

Need to control boil –off rate in order to use for propulsion



When vapor reduces, then adopt the "Intentional Curve".

Safety Features

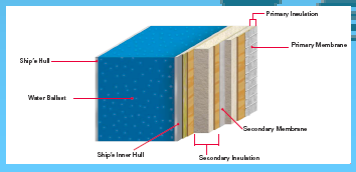
The LNG Industry is perhaps the most safety conscious of all the industries in the world.

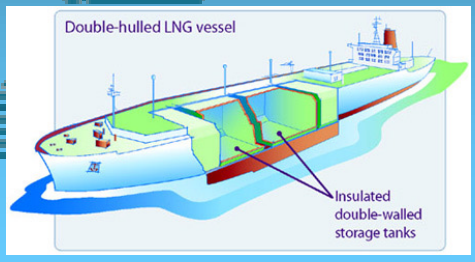
The sharing of information is extensive and improvements are rapidly deployed across the industry.

Safety Features

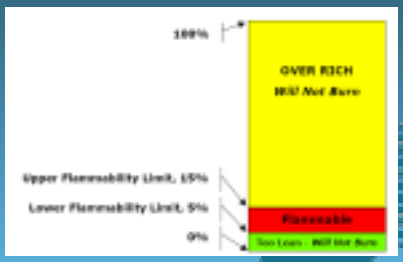
Primary FOUR SYSTEMS in all LNG facilities

- PRIMARY CONTAINMENT
- SECONDARY CONTAINMENT
- SAFEGUARD SYSTEMS
- SEPARATION DISTANCE





Safety Features



Cannot have an Explosion if there is a Puncture in the Containment system

Auto Ignition temperature is higher than all other Gases we generally deal with.

Fuel	Autoignition Temperature, °F
LNG (primarily methane)	1004
LPG	850-950
Ethanol	793
Methanol	867
Gasoline	495
Diesel Fuel	Approx. 600

Safety Features

LNG Spill becomes a vapour rapidly.

Reliquefaction

This is regarded as the way forward.

a) Space – Saving, compact arrangement.

b) Economic saving is pre-cooling by LNG spray pumps.

c) Ecological Ship Operation.

d) Increased process reliability and performance (no moving parts)

e) Safe operation


Thank You