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Risk Assessment & Loss Prevention for LNG Ships

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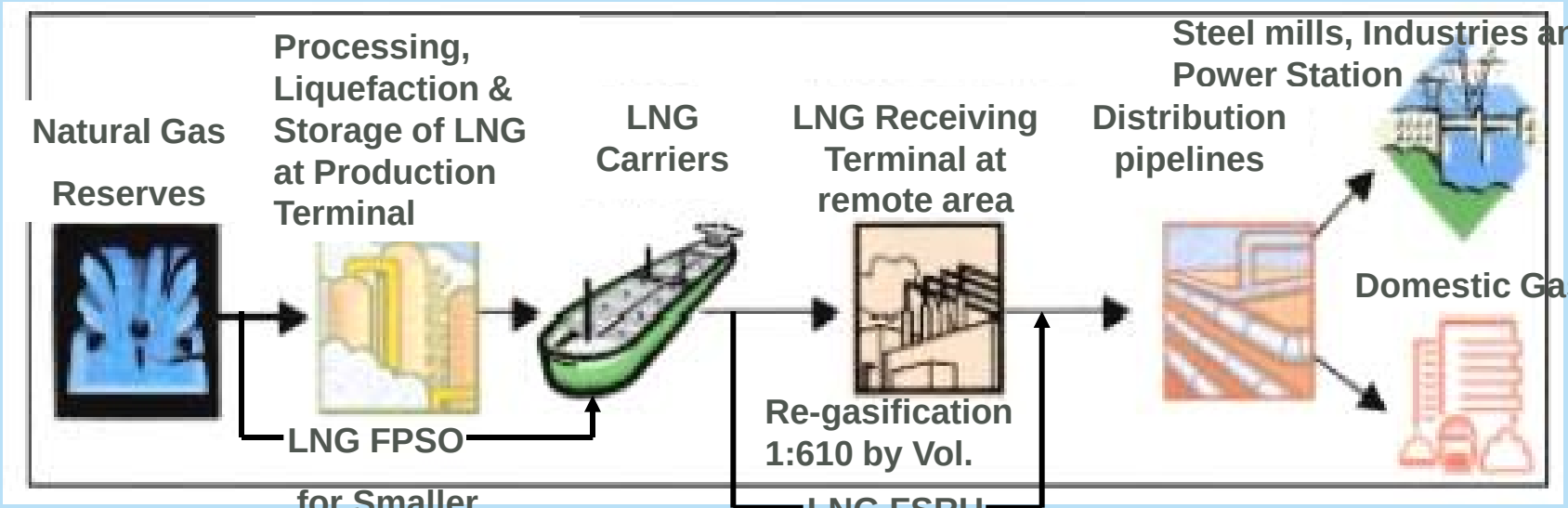
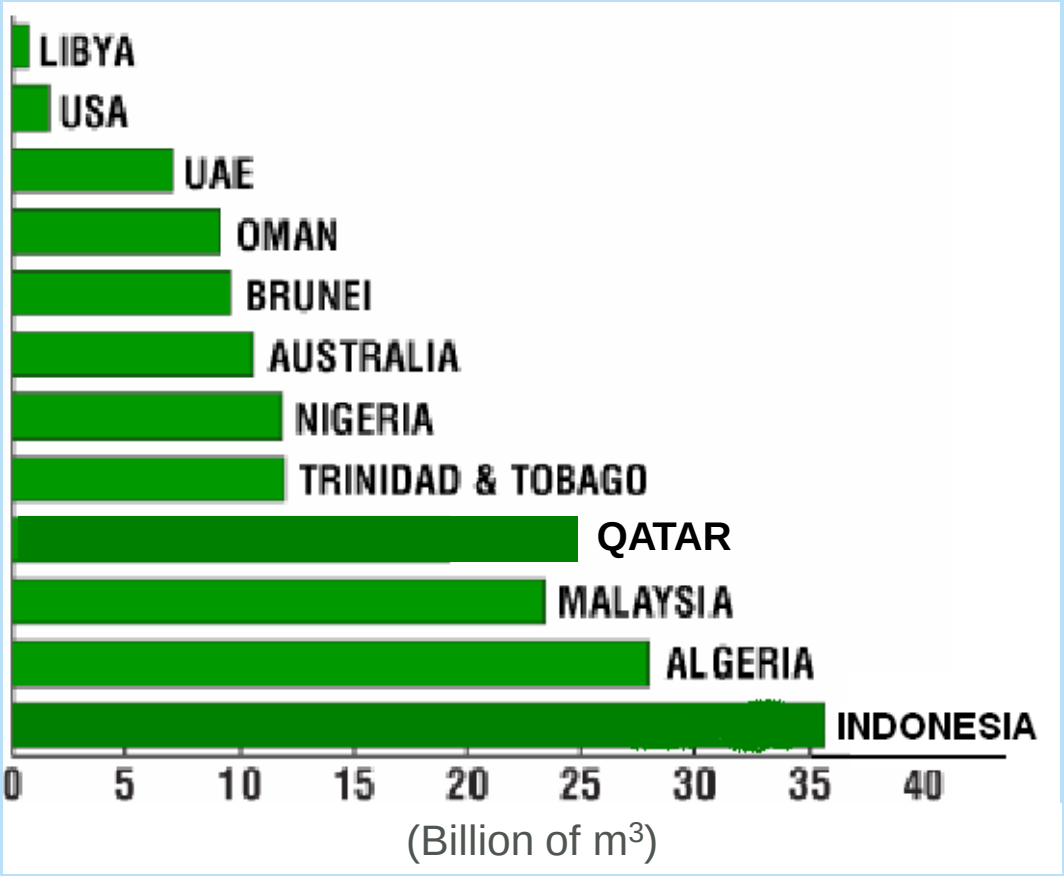
Loss Prevention through Risk Assessment Surveys of LNG Carriers

Contents:

- LNG (Liquefied Natural Gas)
- LNG Production and Receiving Terminals in the world
- Types of LNG Carriers (Spherical, Membrane)
- Shipyards (Building and Repairing Ship Yards in the world)
- Risks and Casualties to LNG Carriers
- New Developments
- Loss Prevention for LNG Carriers


Natural Gas
Reserves
Processing, Liquefaction & Storage of LNG at Production Terminal
LNG Carriers
LNG Receiving Terminal at remote area
Distribution pipelines
Steel mills, Industries and Power Station
Domestic Gas
LNG FPSO
for Smaller Reserves at sea
Re-gasification 1:610 by Vol.
LNG FSRU
for temporary sites or for flexibility

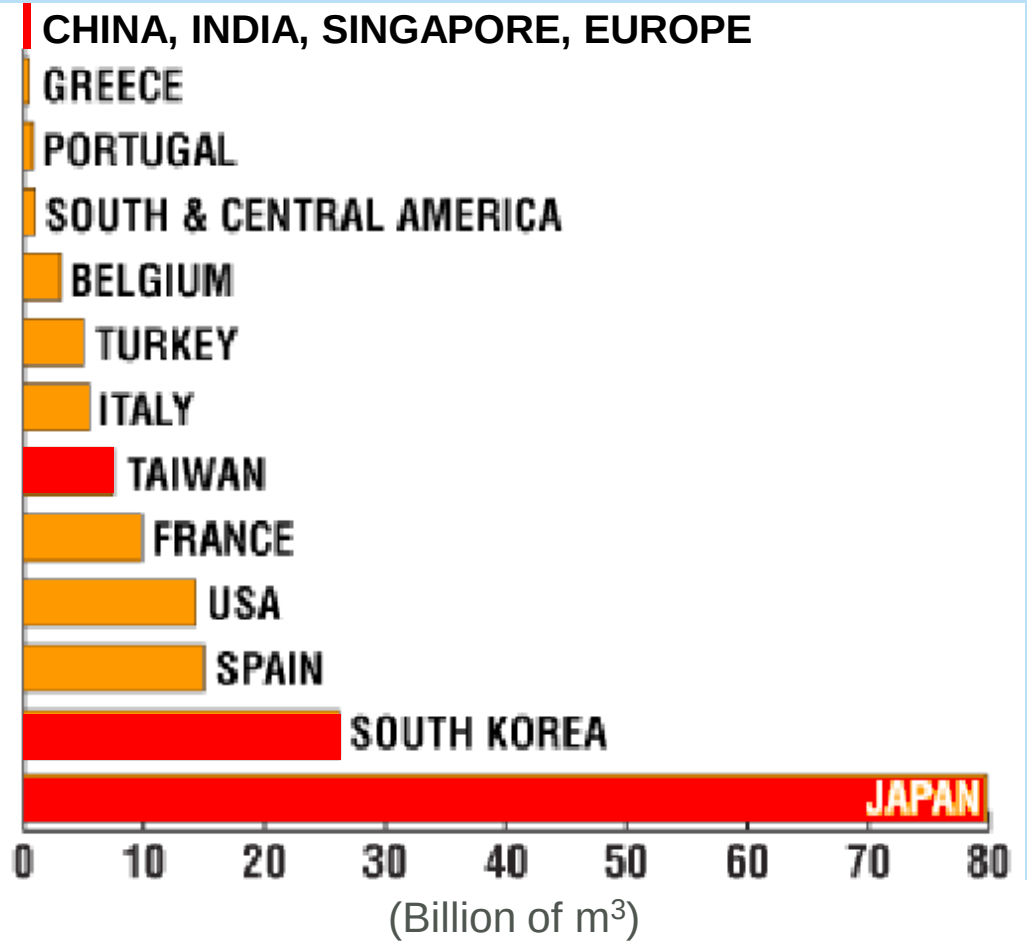
LNG Exporting Countries (LNG Loading Terminals)



A very rough estimates

- LNG export from countries with gas
- More natural gas reserves have been found in Russia, Europe, Iran and other countries.
- Russia and North Sea have Gas Reserves supplying Europe by piped GNG
- LNG export is faster and more flexible than pipeline gas.

LNG Importing Countries



A very rough estimates

- The major LNG importing countries are in Asia.
- Europe and USA are increasing their use and import of LNG.
- LNG is a better Fossil Fuel with less SOx Emission. The Air is cleaner with the use of LNG for power generation in Japan and Korea

Processing and Liquefaction LNG/LPG Terminal

- Processes and Liquefies GNG (Natural Gas) to LNG (-160 C) and NGL (Natural Gas Condensates- Production of 60% of world LPG).
- LNG/LPG is stored in tanks for loading onto a LNG/LPG Carrier.
- Transport to overseas by LNG/LPG Carriers.

LNG Receiving and Regasification Terminal

- LNG receiving terminals:
- Receive LNG cargo from LNG Carriers.
- Storage in LNG tanks.
- Regasifies LNG to GNG. (1:620 by volume)
- GNG supply to Steel Mills, Power Stations, Industries and Homes.
- GNG is a Cleaner Fuel

Types of LNG Carriers

- No. of Crew: About 30 per Ship
- Life Span: About 40 years or more
- Construction period: About 2 to 2 ½ years

Membrane type of LNG Carrier (GTT Mark III, NO 96 and CSI)

Standard: 125-150,000m^3

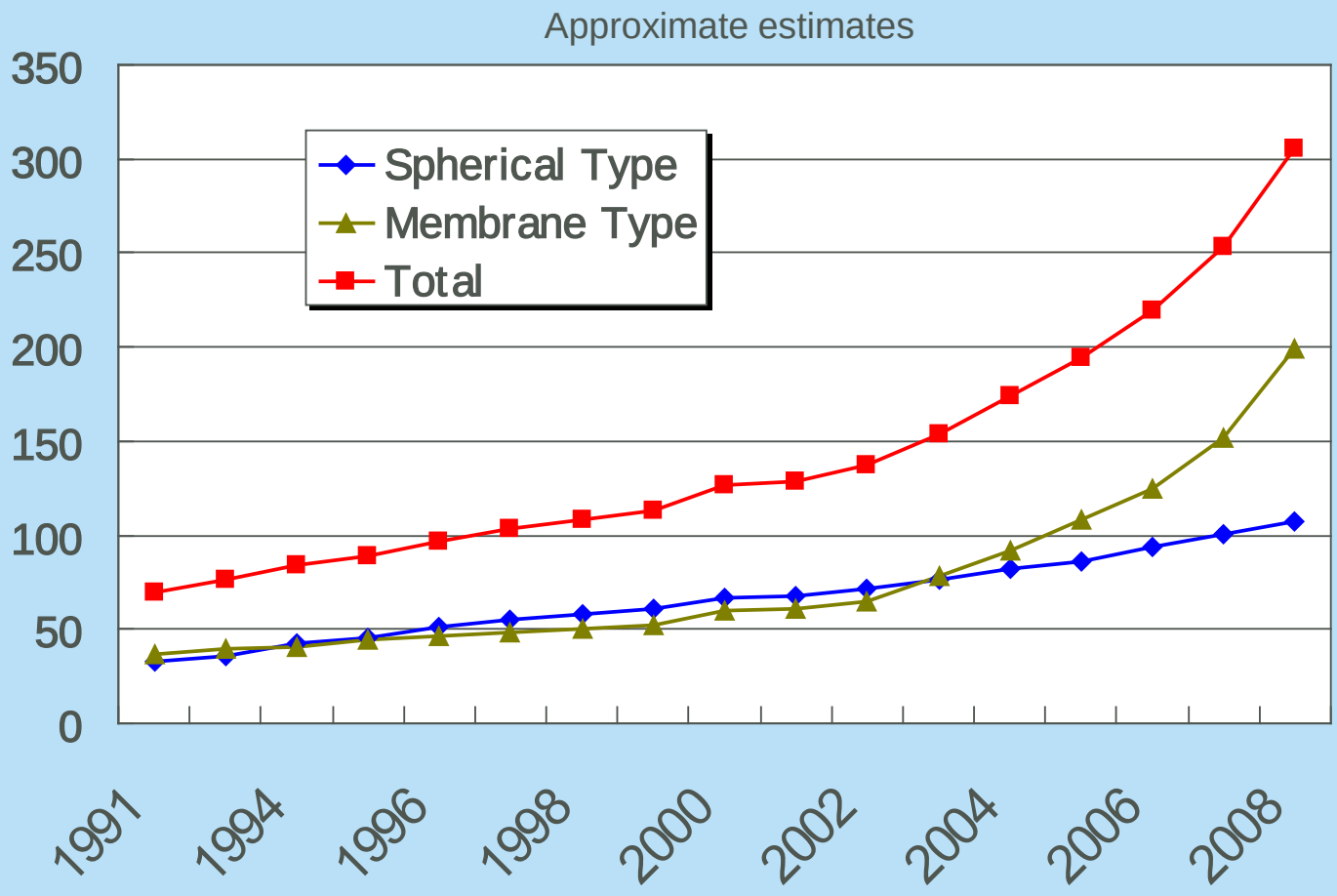
Q-Flex: 210-217,000m^3

Q-Max: 250,000m^3

Moss - Spherical type of LNG Carrier

Sizes:- 125-145,000m^3

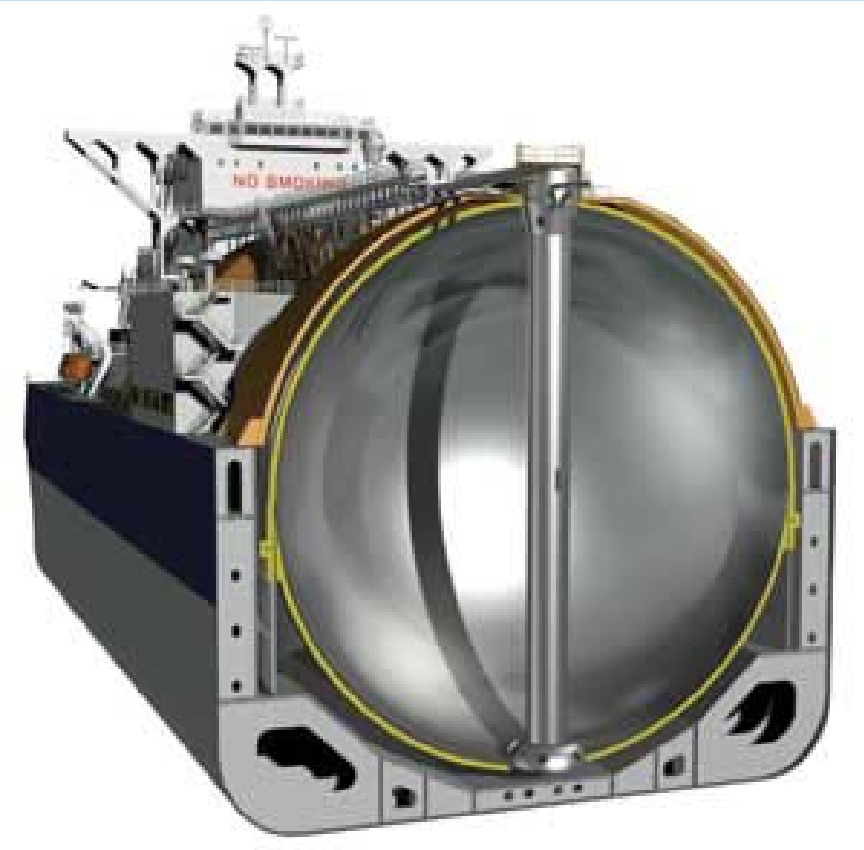
Number of LNG Carriers in operation



Moss Spherical Type of LNG Carrier

- Almost 40% the LNG carriers in the world are of the Spherical type.
- 80% of LNG carriers trading to Japan are of the Spherical type.

Moss Spherical Type of LNG Carriers



- Aluminum Alloy Spherical tank of 50 to 100 mm thick Aluminum Alloy plates.
- 40m in diameter.
- “Self Supporting”
- 40% of the world’s LNG carriers are of this type
- Smaller Collision and Grounding area

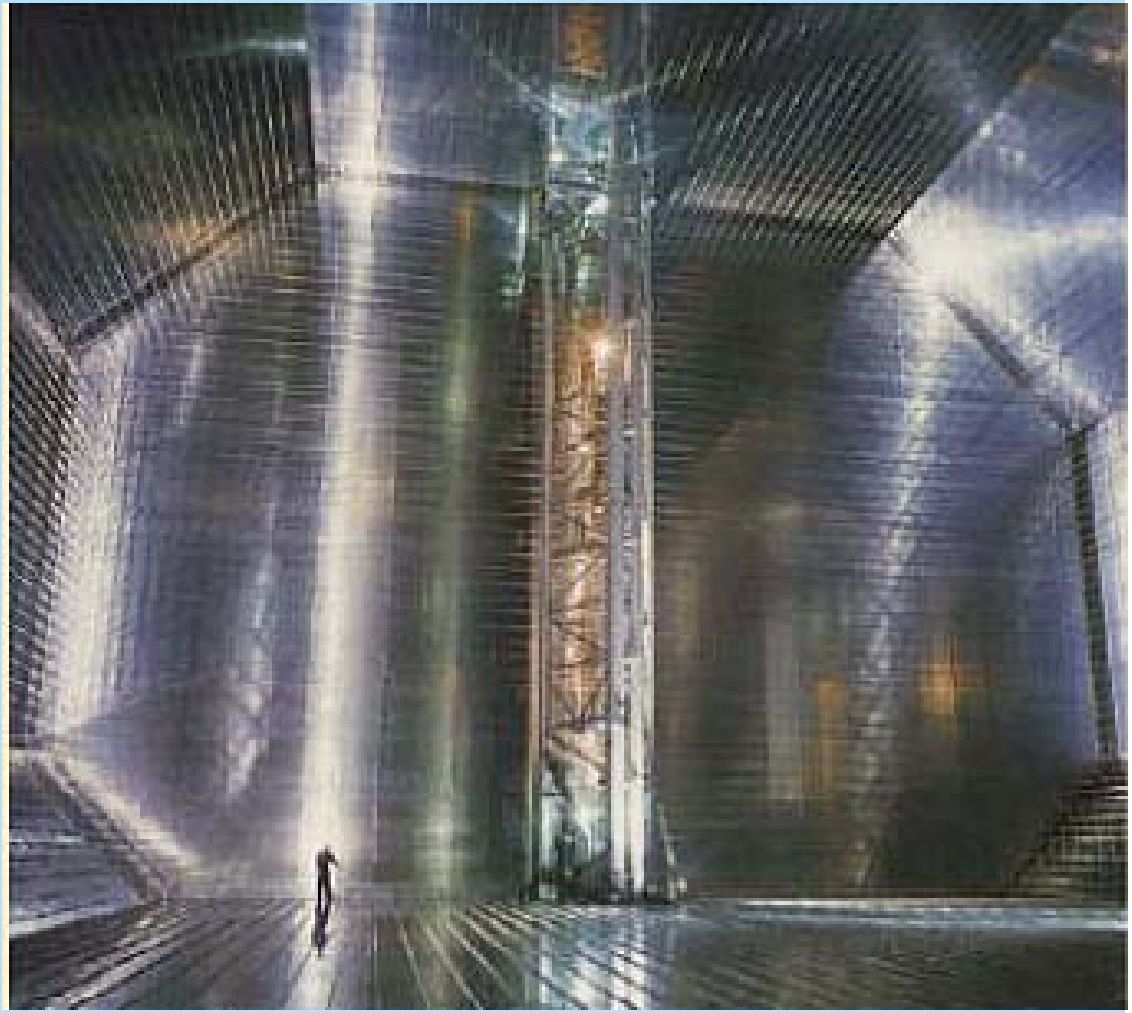

Aluminum spherical tank of about 40m - 45m in diameter

GTT MEMBRANE Type of Carrier

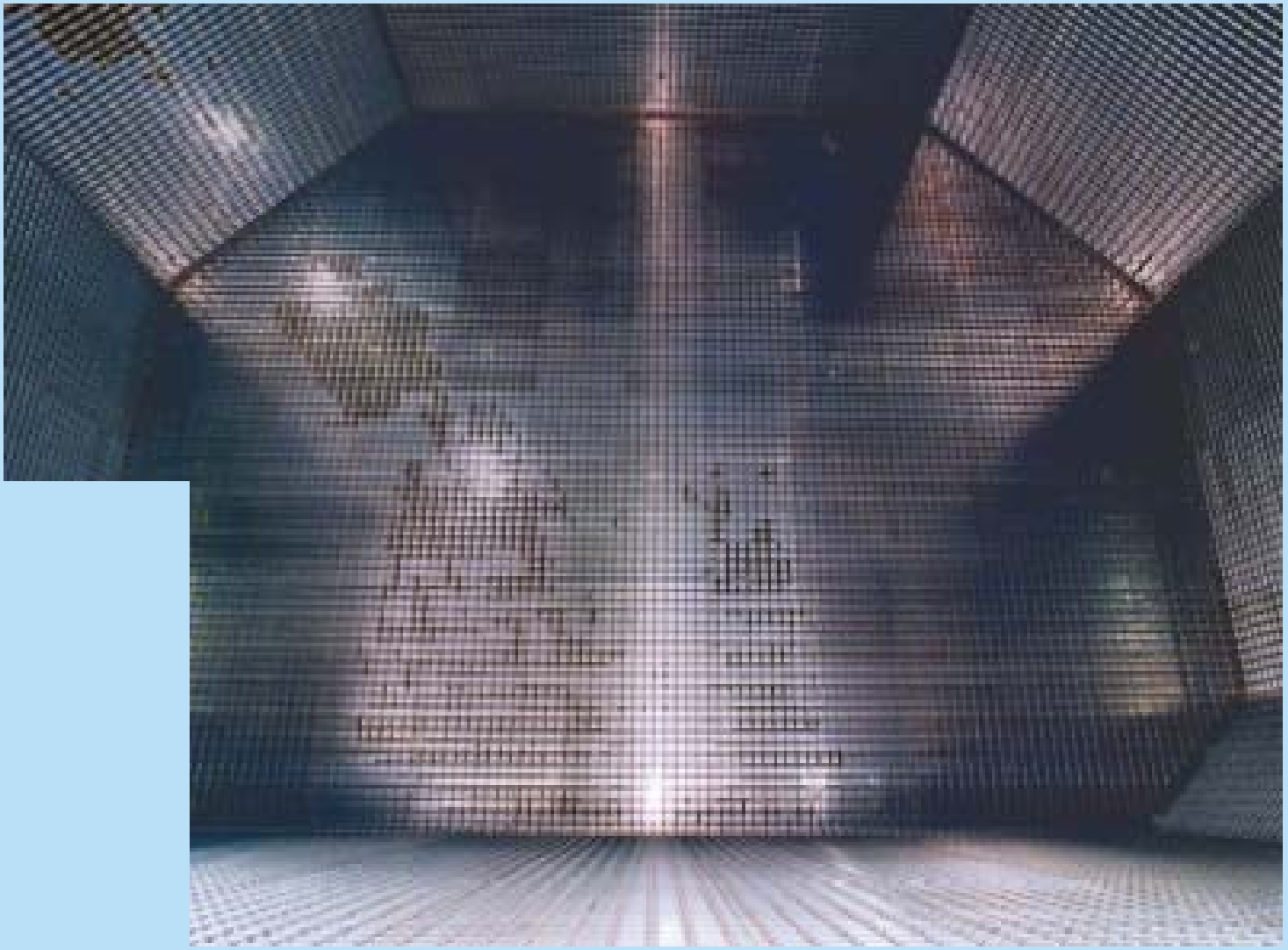
GTT MEMBRANE Type of LNG Carrier

- Primary membrane holds cargo.
- Secondary membrane prevents leakage.
- Primary & secondary insulation to maintain cargo temperature at –161 C
- Ship’s hull to support tank.
- 80% of the world’s LNG carriers under construction are of membrane type. Shorter building time in dry dock.
- More potential Collision and Grounding Contact Areas.
- Almost 60% of the LNG Carriers in the World.

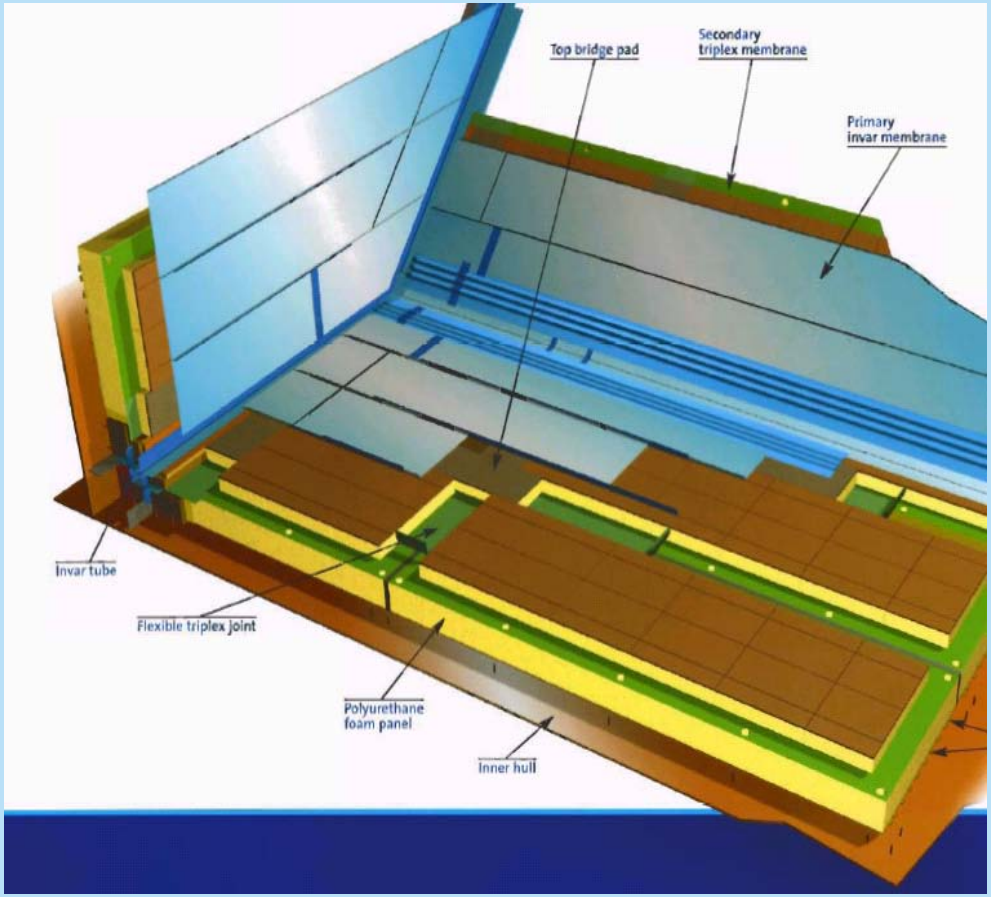
No.96 Membrane System of LNG Cargo Tank – Shining and Flat Surface



MARK III System of LNG Cargo Tank – Less Shining and Corrugated Stainless Steel Surface



CS1 Membrane System



- New Design (Two ships in operation)
- Combination of Mark III & No. 96.
  - Nickel-steel (invar) (0.7 to 1.5 mm) primary membrane.
  - Glass cloth/Aluminum foil/Fiber Glass cloth Aluminum/glass “Triplex” secondary membrane.
  - Fabricated Polyurethane insulation panels with “Triplex” from workshop
  - Glue problem occurred at Secondary Membrane on 1st Ship

Current Shipyards Building LNG Carriers

- **China (NO 96)**
  - Hudong Zhonghua Shipyard
- **Japan (Moss, GTT- NO 96, Mark III and SPB)**
  - Kawasaki Shipbuilding
  - Koyo Shipyard, Imabari
  - Mitsubishi Heavy Industries
  - Mitsui Engineering
  - Universal Shipbuilding
  - Ishikawajima-Harima Heavy Industries
- **Korea** (Moss, GTT NO 96 and Mark III
  - Daewoo
  - Hyundai Heavy Industries
  - Samsung Heavy Industries
  - Hanjin Heavy Industries
  - STX Shipbuilding

    (80% of world's LNG carriers are under construction in Korea.)
- **France (GTT NO 96, Mark III and CS1)**
  - Aker Group of Shipyards
- **Spain (GTT NO 96 and Mark III)**
  - Puerto Real Shipyard

- Special Training and licensing required.

LNG Ship Repair Yards

The current boom of shipbuilding has also brought forth an expansion of ship repair yards mainly under home port or home doctor concept.

- **Japan**
  - Mitsubishi Heavy Industries
  - Kawasaki Heavy Industries
  - Ishikawajima-Harima Heavy Industries
  - Universal Shipyards
  - Mitsui Engineering and Shipbuilding
- **Singapore**
  - Sembawang Group of shipyards
  - Keppel Group of shipyards
- **Malaysia**
  - Malaysia Shipbuilding & Engineering (MHHE)
- **European Yards.**
  - Sobrena-France.
  - Izar Carenas-Spain.
  - Blohm & Voss-Hamburg.
  - CMR-Italy.
  - San Giorgio del Porto-Italy.
  - Lisnave-Portugal.
- **Middle East.**
  - Dubai Dry-docks.

- Special Trainings and Licensing are required.

Losses during construction to date…

Major construction casualties

(Millions of $$$$)

Delivery delayed.

- **1980 – Three LNG carriers in a shipyard in USA – Total Constructive Loss. Due to cargo tank insulation failure.**
- **2005 – One LNG Ship in a Shipyard in France – Insulation system failure. Long delays in delivery.**
- **2005 – Fire in cargo tank. Due to welding of reinforcement on Pump column.**
- **Bulging of primary and secondary barriers during tests.**
- **2003 – Six part completed vessels hulls damaged during Typhoon in Korea**
- **2005/2006/2007 – Failures of cargo containment system of LNG carriers in operations due to defects during construction.**

…and New Risks to Underwriters during Construction

- New Technologies bring New Risks
- More shipyards are building LNG Carriers.
- Shortage of skill and trained workers
- Increasing use of Sub-contractors

(Proactive Shipowner and Shipyard Project Teams Skill Base can make a big difference in the Risk Profile and Quality during construction of LNG Carriers)

JH 143 Surveys are recommended to assess all this!

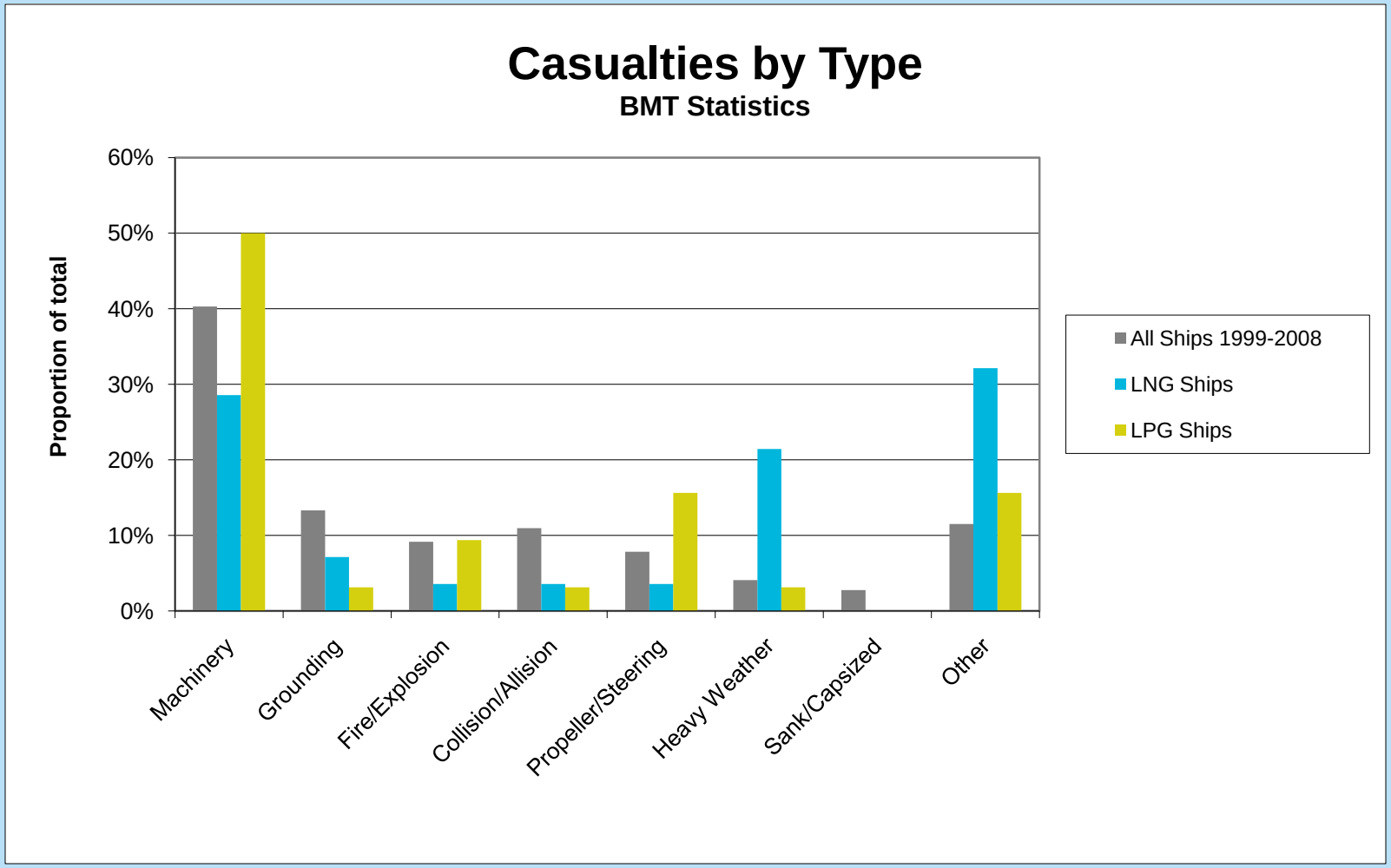
JH 143 Shipyard Risk Assessment Surveys of LNG Carriers Under Construction in China

Risks peculiar to LNG Carriers in Operations

- Unloading/Loading – Operation error
- Sudden pull-away and damage of loading/discharging arms and human injury
- Cracking of ship's steel hull due to spill of LNG (super cold shock of -161 degrees C)

Note:-

The repair cost and repair period as a result of ordinary perils (collisions etc) are greatly increased if Cargo Tank is damaged.


Casualties by Type
BMT Statistics
Proportion of total
60%
50%
40%
30%
20%
10%
0%
Machinery
Grounding
Fire/Explosion
Collision/Allision
Propeller/Steering
Heavy Weather
Sank/Capsized
Other
All Ships 1999-2008
LNG Ships
LPG Ships

Past Losses of LNG Carriers

Major and Minor Casualties on LNG Carriers over the last 30 years.

- 1979 - grounding in Japan due to weather - 2,000 tons of steel, 4 months of repair and US$12 Million
- 1979 - water ballast tank leak to insulation space of a cargo tank – ½ year of repair
- 1979 - over pressure of insulation spaces causing building of membrane – 9 months of repair
- 1980 - grounding at Gibraltar – 2,500 tons of steel and deformation of cargo tanks: 1 ½ years of repair and 1st ship-ship transfer of LNG in history
- 1989 - broke away from LNG Terminal due to very strong gale damaging to No. 1 cargo tank, deck deformation and loading arms – 10 months of repair
- 2004 - grounding in Korea due to navigation error – 200 tons of steel, 8 months of repair and Millions of US$ 12million
- 2005 - sloshing damage in a LNG tank due to heavy weather and with partially loaded LNG tank – 6 months of repair and Millions of US$8 million
- 2006 - sloshing damage during ballast voyage with minimum LNG, 4 months repair
- 2005/2006/2007 containment failures requiring 2 months of repair

1980 LNG “X” grounding at Gibraltar – 2,500 tons of steel and deformation of cargo tanks: 1 ½ years of repair and 1st ship to ship transfer of LNG in history

2004 - LNG “Y” grounding in Korea due to navigation error– 200 tons of steel, 8 months of repair and Millions $

A minor crack (less than 1 meter long) due to grounding impact on the steel bulkhead in a cofferdam between No. 1 and No. 2 cargo tanks caused sea water ingress into No. 1 cargo tank

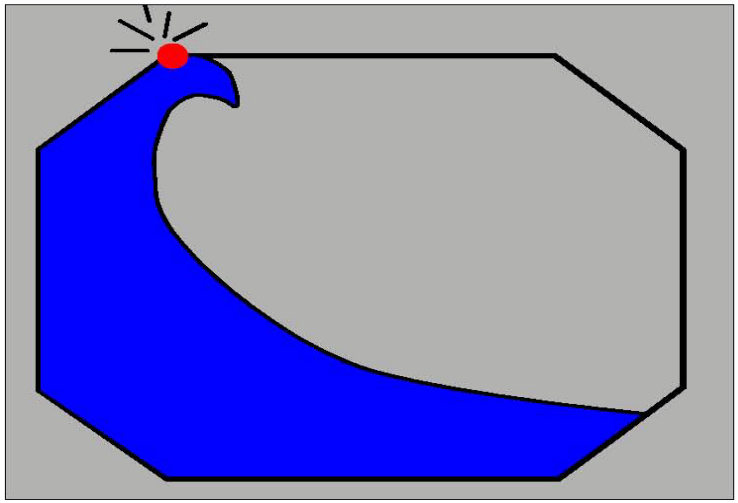
Result: Seawater ingress into cargo tank and LNG Cargo Pumps Immersed in Seawater

Resulting rust on the Primary and Secondary Invar Steel Membranes of the cargo tank after being soaked in seawater and moisture

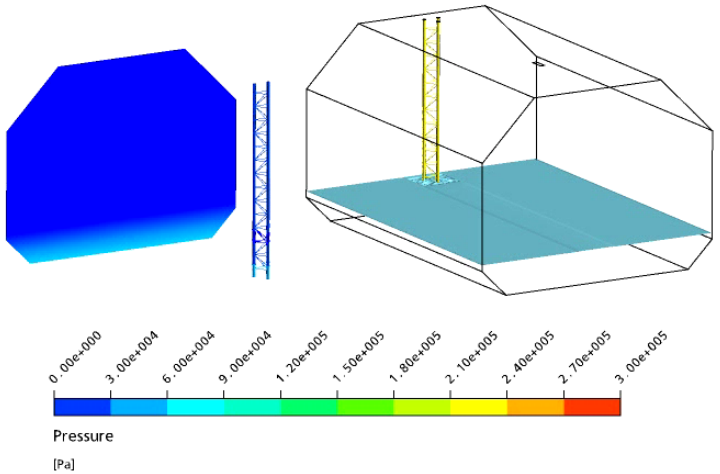
Resulting primary and secondary insulation boxes soaked in seawater

Floating LNG Receiving Terminal

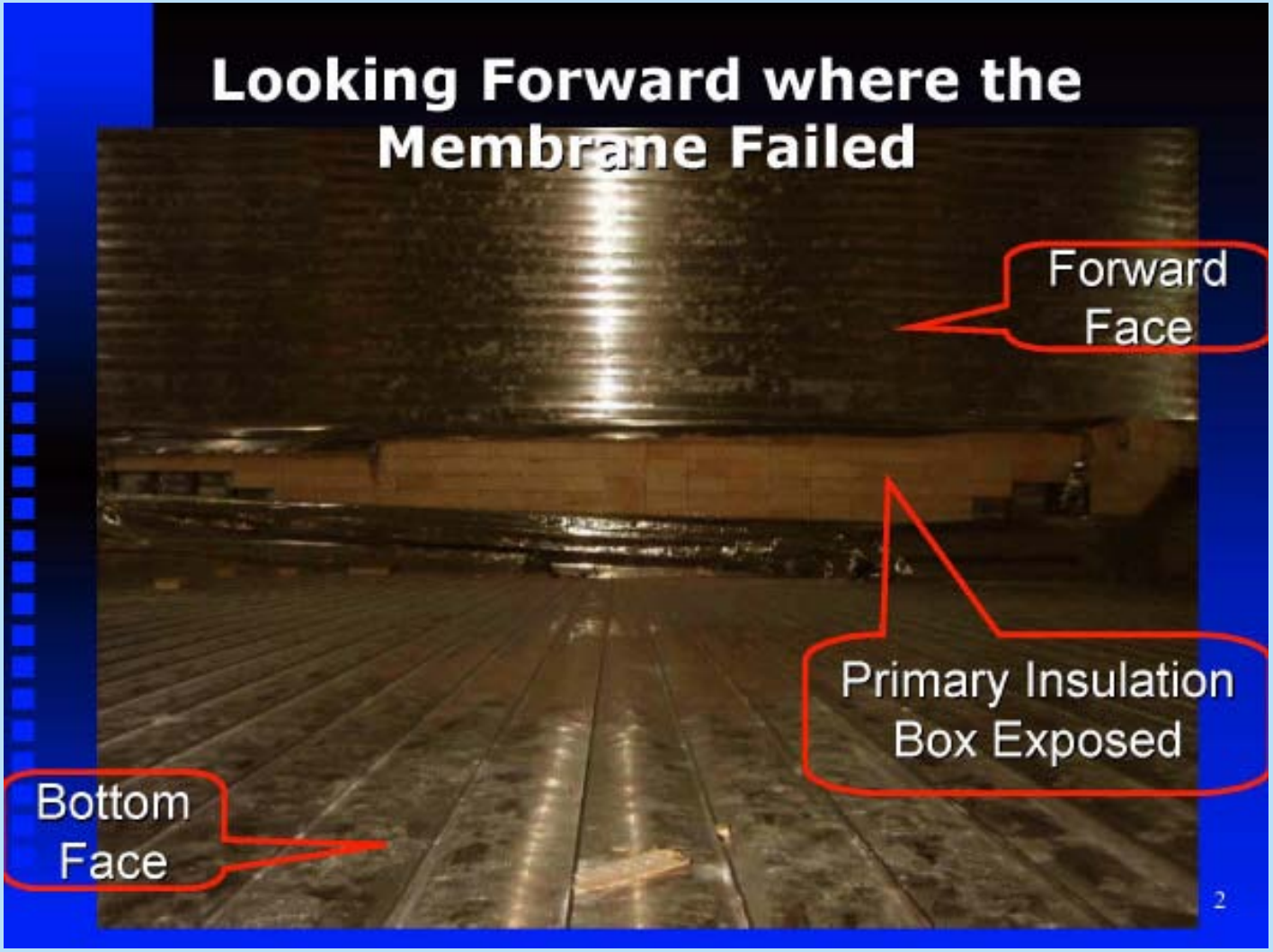
SLOSHING PHENOMENA



The sloshing phenomena occur when the ship motions coincide with the natural frequency of the liquid motion in the tanks. The build-up of violent motion is due to frequency, not amplitude.



BMT Fast LNG Sloshing Simulator



2005 LNG “X” Sloshing damage in an LNG tank due to heavy weather and being partially loaded– 6 months of repair and Millions of $

Another close-up view of sloshing damage in a LNG tank

Secondary barrier leak “Triplex” Membrane failure on LNG Carriers in Operations (N2 leak detected during operations) Two Months or More of Repair Period

Separation due to failure of “Glue”

“Triplex” Membrane-made of (glass cloth/ Aluminum foil/ glass cloth) as secondary barrier

Bulging of Invar Membrane of LNG Carrier during Testing at Construction or After Repair

Special staging (12 levels) from bottom to top of a cargo tank for repairs (thousands of pieces of special stage materials similar to the staging in building construction)

Study of Fire Risk on LNG Carrier due to LNG leak – Conclusion was Unlikely

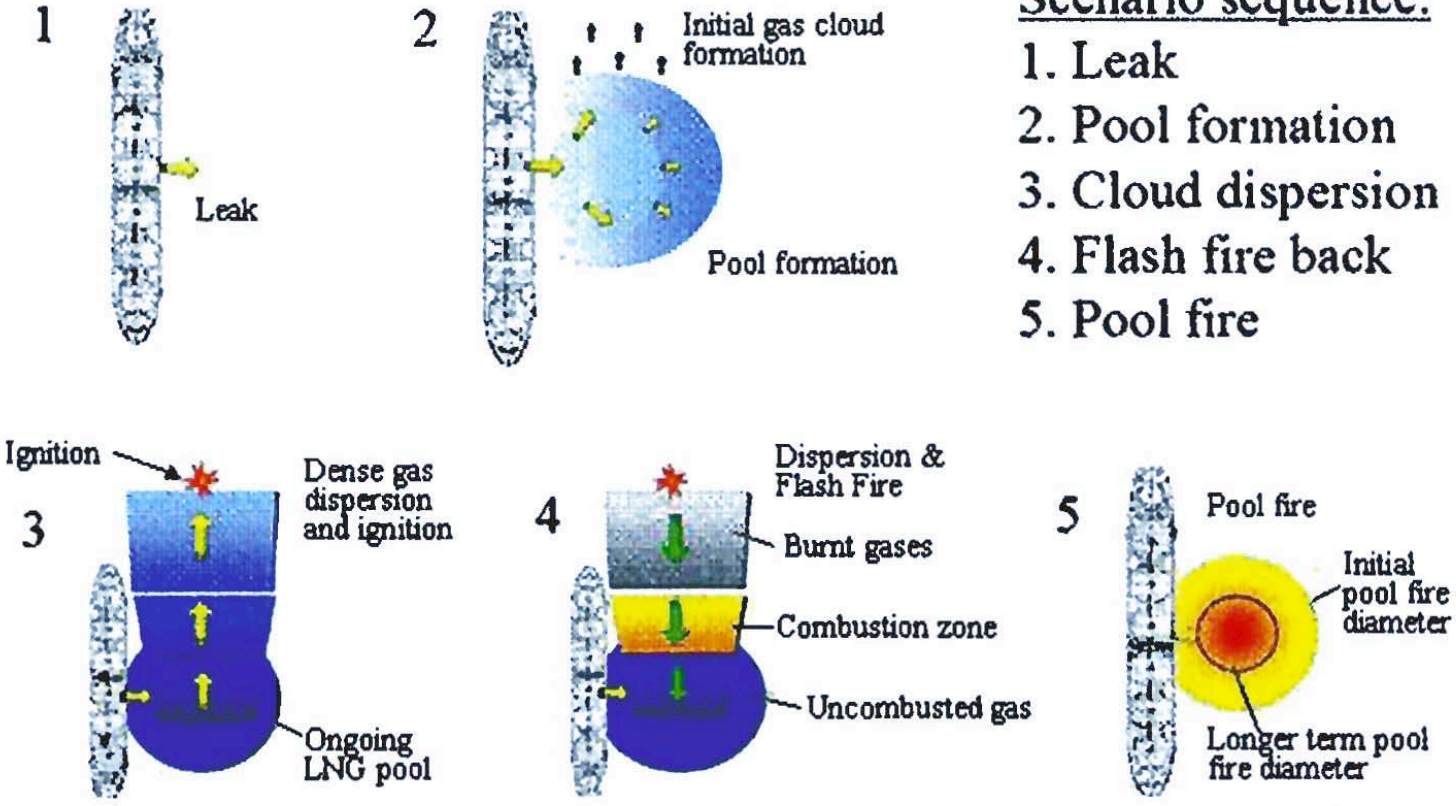
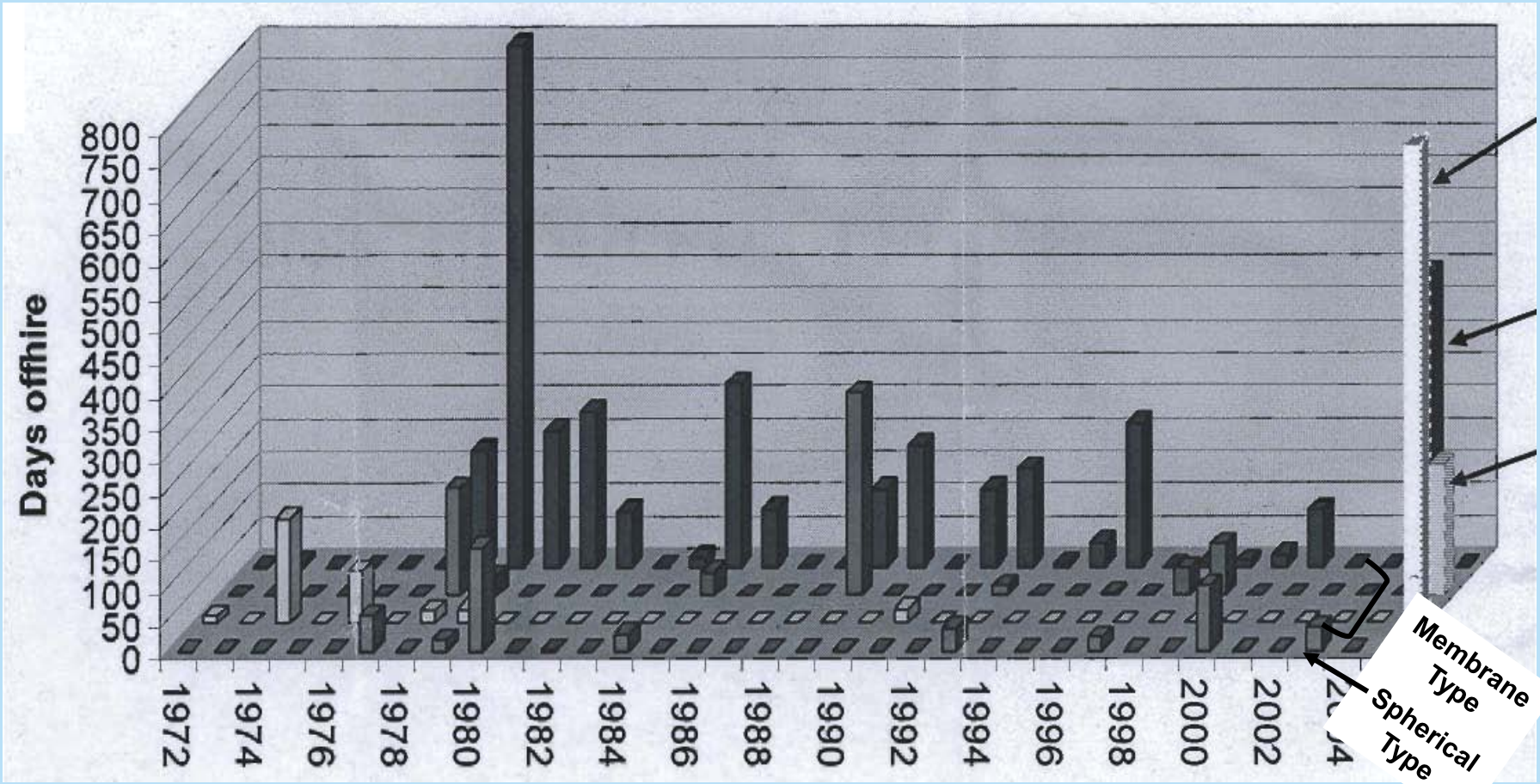


Figure 1. LNG Event Sequence for Consequence Modelling

OFFHIRE Statistics of LNG Carriers (Up to 2006)



Existing Loss Prevention on LNG Carriers in operation

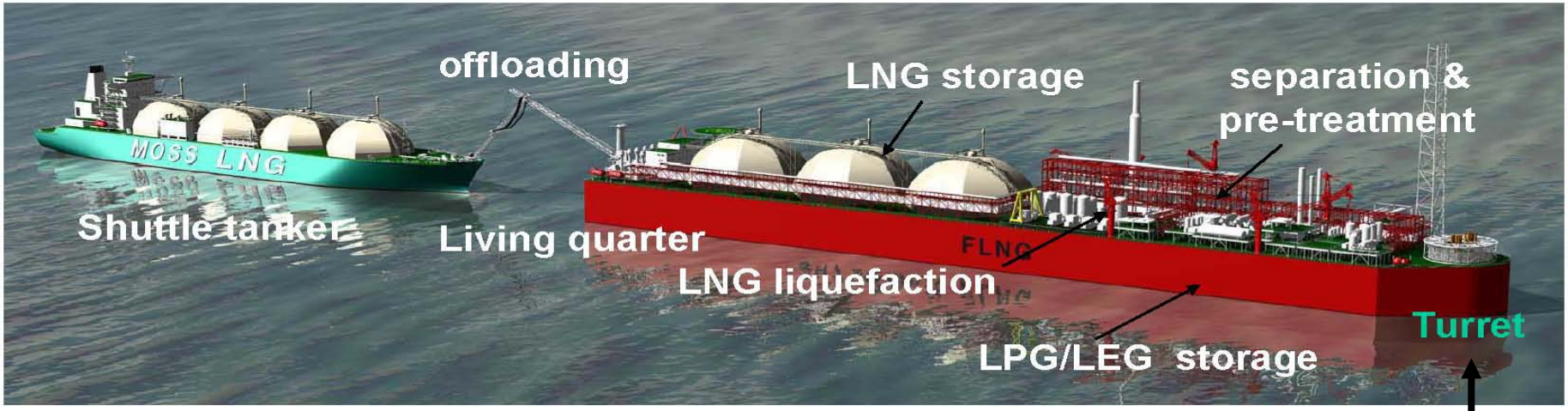
- Safe Operations:
- Safety, Security, Operational and Management Inspection/Audit:
- Home Doctor
- Longevity Studies
- Use of Manufacturer's Service Engineers
- Water Ballast Tank Re-Coating
- Pre-employment crew security screening
- Continuous Crew and ship managers training
- Proper exclusion and buffer zones
- Terrorist Risk Prevention, ISPS

However, Shortage Of Experienced LNG Crew !

And New Technologies bring New Risks

- Dual Fuel Diesel Engine Propulsion Systems (in operation)
- Dual Fuel Diesel Engines + Electric Motors propulsion system (Under construction)
- Reliquefication Plant (in operation)
- Re-gasification plant (in operation)
- New Cargo Containment System (CS I and so on....)
- LNG FPSO (Floating Production Storage and Offloading)
- LNG FSRU (Floating Storage Regasification Unit) (in operation)
- CNG (Compressed Natural Gas) Carriers

New Technology: LNG FPSO - Floating Production Storage Offloading (Under Design/ Construction Stage for Smaller Reserves)



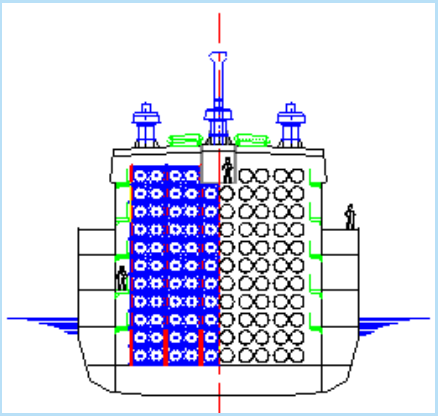
LNG storage :	180 - 250,000 m^3	Length:	300 - 450 m	Raw
LNG production:	2 - 5 MMTPA/	Breadth:	50 - 70 m	Natural
	290 - 730 MSCFD	Design life:	40 years	Gas

New: LNG FSRU (In Operation, Under Conversion and Construction)

- New construction of LNG FSRU
- Conversion from existing LNG Carrier in Sembawang Shipyard
- No. of Crew on board: About 30
- Life Span: About 40 years
- Temporary Sites

CNG Carriers???...

BMT Concept Design



CONCLUSION:

Recommended Measures to Reduce Risk and Loss Prevention on LNG Carriers in Construction and Operation

- JH 143 Shipyard Risk Assessment Survey
- Entry and Routine Condition Surveys
- JH 115A/JH 722 general condition/structural surveys
- JH2006/010 A, B,C, Engine room and office management and condition surveys

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Xie Xie, Arigatogozaimasu and Thank You!!

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