NORWEGIAN TRAINING CENTER

Basic Training for Service on Ships Subject to the IGF Code

COURSE HANDOUT

1. **ENVIRONMENTAL CHALLENGES AND EMISSION RESTRICTIONS AT SEA**
2. **INTRODUCTION TO LNG TECHNOLOGY**
3. **PHYSICAL PROPERTIES AND CHARACTERISTICS OF FUELS**
4. **FIGHTING GAS FIRE**
5. **OVERVIEW OF LNG BUNKERING OPERATION**
6. **HAZARD, SAFETY AND PREPAREDNESS**

"We stand for excellence"

NORWEGIAN TRAINING CENTER

Explanatory Note:

The content of this course material is, by and large, adopted from the LNG Fuelled Ships Basic Safety Training developed and being offered by the Norwegian University of Science and Technology. The Norwegian Training Center (NTC) have entered into cooperation with the Norwegian University of Science and Technology for the rights/license to offer the training and use the corresponding course materials.

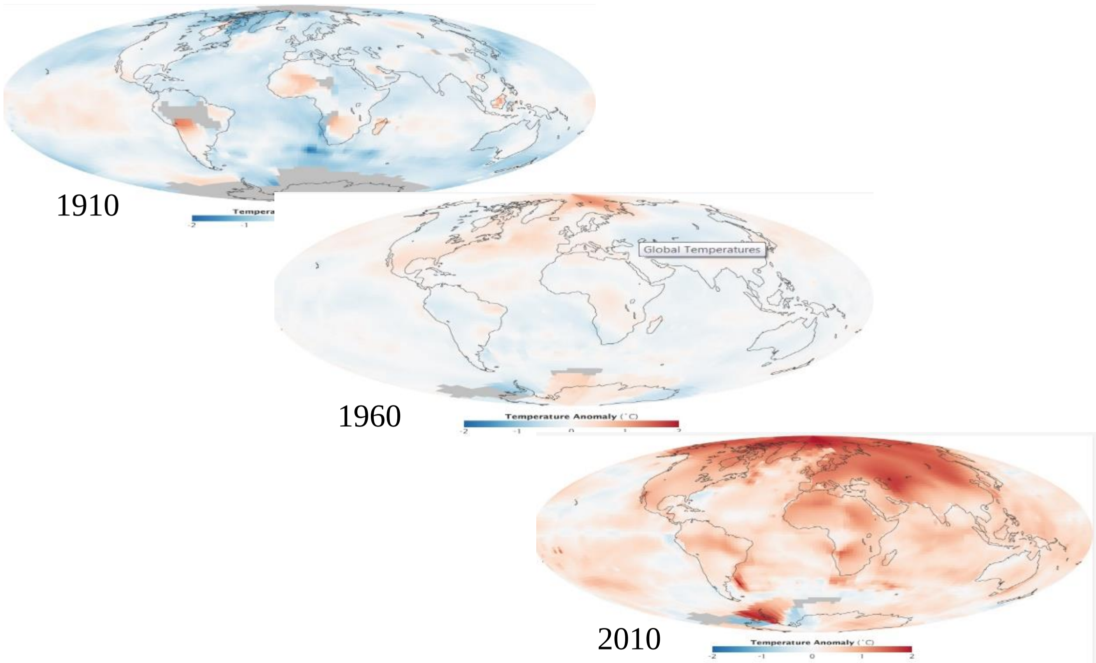
Accordingly, this material has been arranged and structured in accordance with the document template and specifications being implemented by NTC.

TOPIC 1: ENVIRONMENTAL CHALLENGES AND EMISSION RESTRICTIONS AT SEA

1.1 AIR POLLUTION FROM SHIPS: GLOBAL AND LOCAL CONDITIONS

GLOBAL CONDITIONS

- Visibility and consequences of air pollution
- Greenhouse gases (CO2, CH4)



LOCAL CONDITIONS

- Visibility and consequences of air pollution
- Harmful to human health (NOx, SOx)

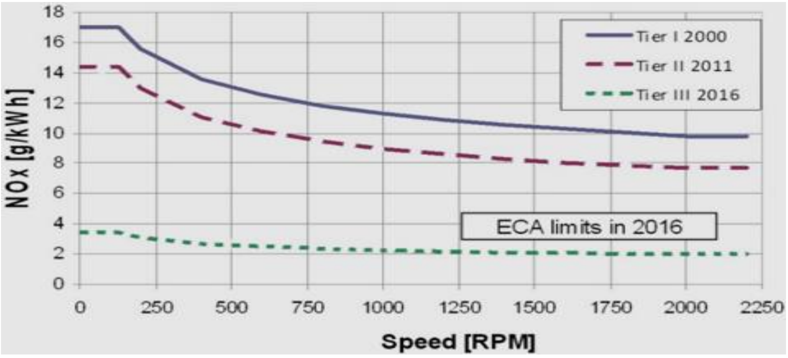
TOPIC 1: ENVIRONMENTAL CHALLENGES AND EMISSION RESTRICTIONS AT SEA

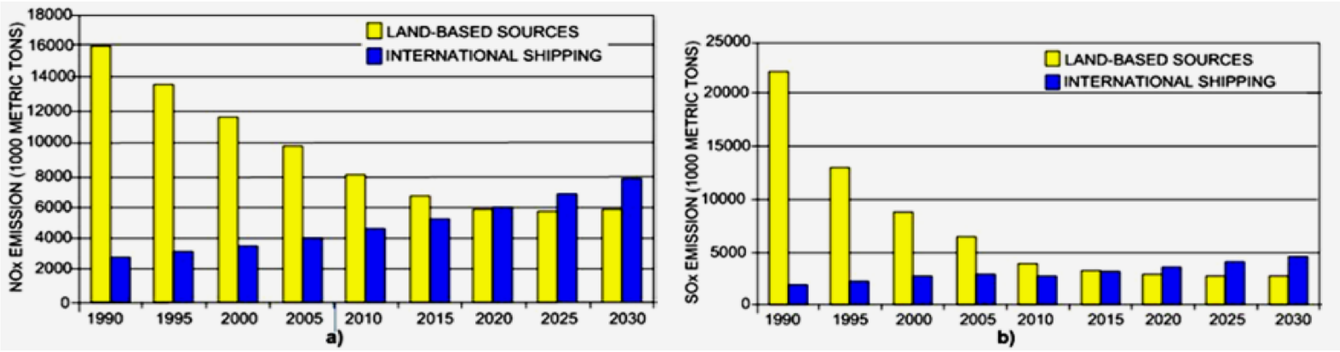
1.2 MARITIME EMISSION CONTROL – IMO MARPOL ANNEX VI

MARITIME EMISSION CONTROL

Low sulphur fuels (2015-)
Inland waterways & harbours< 0.1% S
ECA < 0.1% S

IMO – ECA 2016: NOx < 2 g/kWh

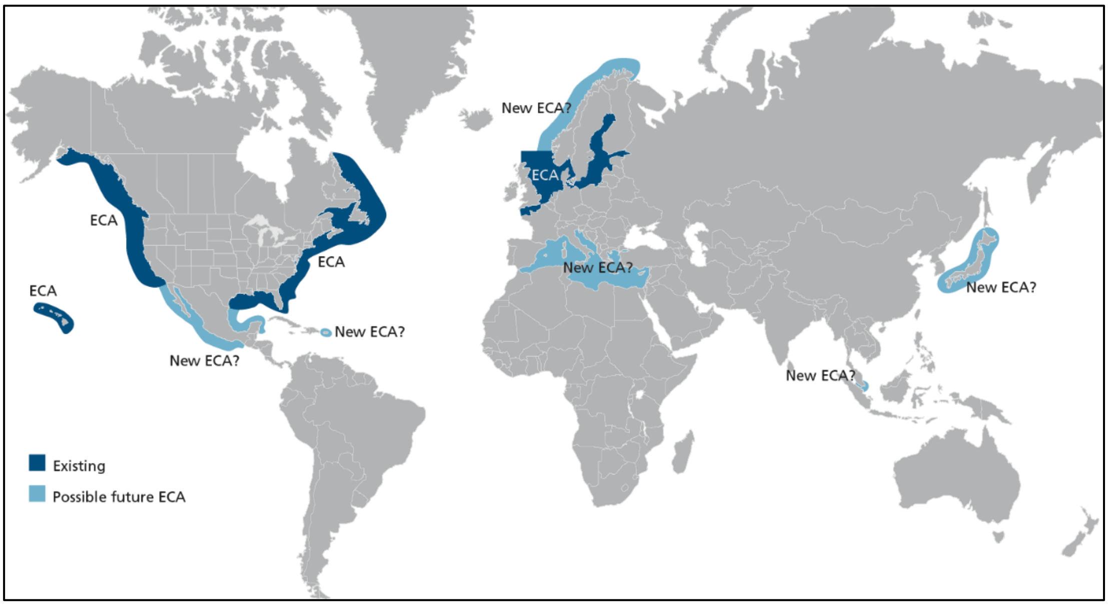


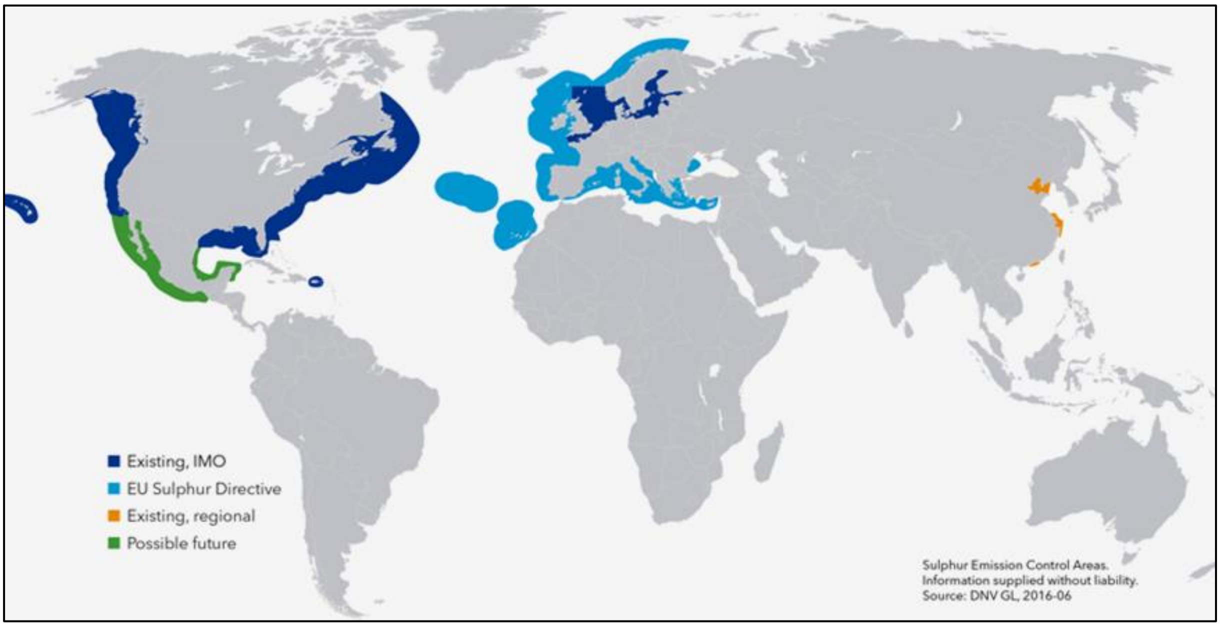


Notes:

TOPIC 1: ENVIRONMENTAL CHALLENGES AND EMISSION RESTRICTIONS AT SEA

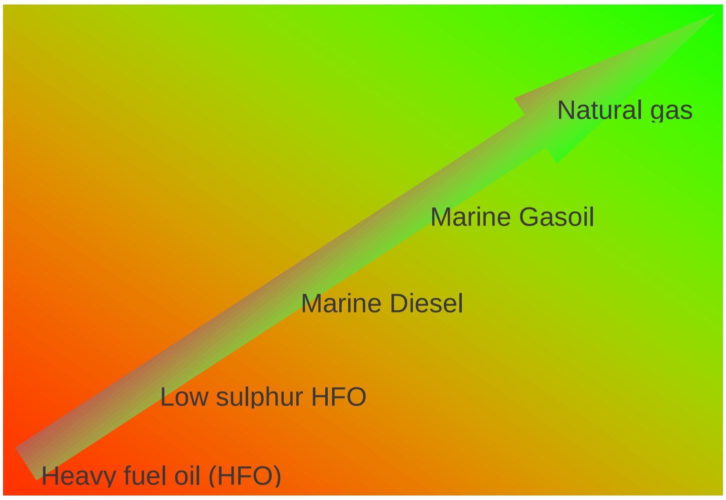
IMO MARPOL Annex VI - SOx /NOx emission





Notes:

1.3 CLEANER ENERGY / ALTERNATIVE FUELS

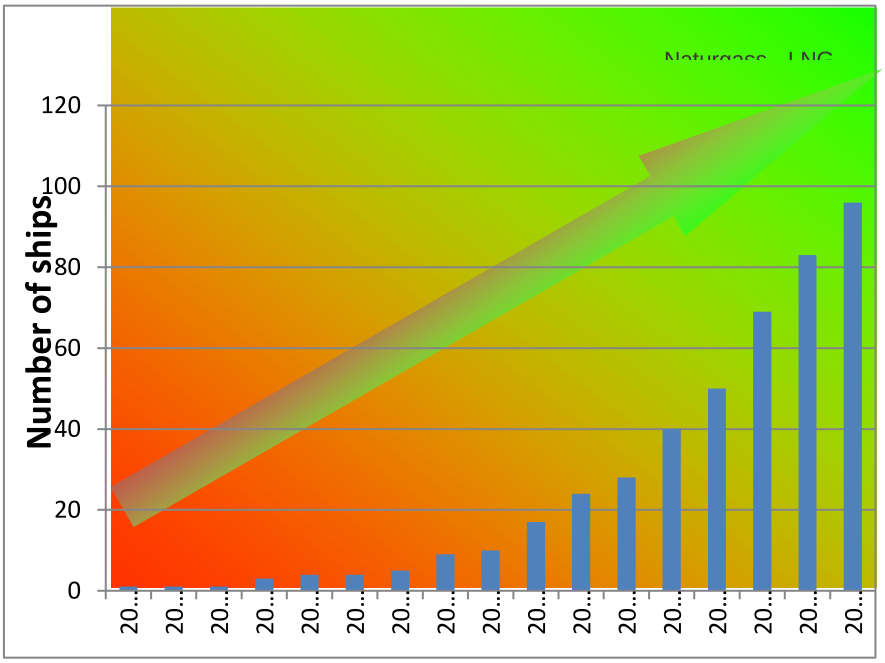


H2

BIO

Renewable alternatives…   Wind, solar, wave….

Fast growing LNG fuelled ship fleet



Approx. 102 ships in operation (mar.2017)

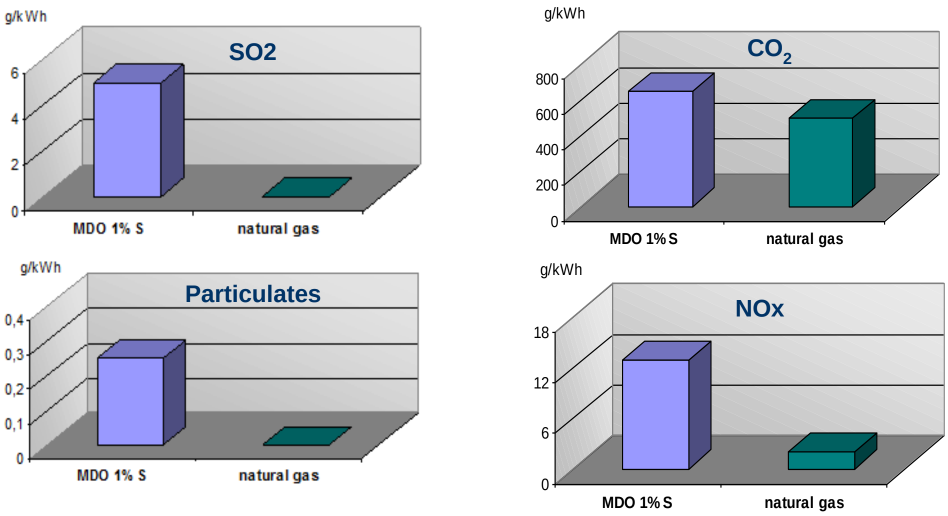
Notes:

TOPIC 1: ENVIRONMENTAL CHALLENGES AND EMISSION RESTRICTIONS AT SEA

Exhaust Emission - LNG vs. MDO

- Sulphur emission is eliminated
- Particulate matters is close to zero
- CO_2 is reduced by 26%
  (Due to unburned methane the net reduction of greenhouse gases are in the range of 0% -15% for sailing ships today)
- NOx is reduced by 80-90%

Fuel	CO_2 *[g/kWh]*	NOx *[g/kWh]*	SO_x *[g/kWh]*	PM *[g/kWh]*
HFO (3,5%S)	580-630	9-12	13	1,5
MDO (0,5%S)	580-630	8-11	2	0,25-0,5
MGO (0,1%S)	580-630	8-11	0,4	0,15-0,25
LNG	450	2	0	~0



Notes:

OVERVIEW OF THE IGF CODE

INTERNATIONAL CODE OF SAFETY FOR SHIPS USING GASES OR OTHER LOW-FLASHPOINT FUELS (IGF CODE)

CONTENTS

Notes:

6 FUEL CONTAINMENT SYSTEM

6.1 Goal

6.2 Functional requirements

6.3 Regulations – General

6.4 Regulations for liquefied gas fuel containment

6.5 Regulations for portable liquefied gas fuel tanks

6.6 Regulations for CNG fuel containment

6.7 Regulations for pressure relief system

6.8 Regulations on loading limit for liquefied gas fuel tanks

6.9 Regulations for the maintaining of fuel storage condition

6.10 Regulations on atmospheric control within the fuel containment system

6.11 Regulations on atmosphere control within fuel storage hold spaces (Fuel containment systems other than type C independent tanks)

6.12 Regulations on environmental control of spaces surrounding type C independent tanks

6.13 Regulations on inerting

6.14 Regulations on inert gas production and storage on board

7 MATERIAL AND GENERAL PIPE DESIGN

7.1 Goal

7.2 Functional requirements

7.3 Regulations for general pipe design

7.4 Regulations for materials

8 BUNKERING

8.1 Goal

8.2 Functional requirements

8.3 Regulations for bunkering station

8.4 Regulations for manifold

8.5 Regulations for bunkering system

Notes:

9 FUEL SUPPLY TO CONSUMERS

9.1 Goal

9.2 Functional requirements

9.3 Regulations on redundancy of fuel supply

9.4 Regulations on safety functions of gas supply system

9.5 Regulations for fuel distribution outside of machinery space

9.6 Regulations for fuel supply to consumers in gas-safe machinery spaces

9.7 Regulations for gas fuel supply to consumers in ESD-protected machinery spaces

9.8 Regulations for the design of ventilated duct, outer pipe against inner pipe gas leakage

9.9 Regulations for compressors and pumps

10 POWER GENERATION INCLUDING PROPULSION AND OTHER GAS CONSUMERS

10.1 Goal

10.2 Functional requirements

10.3 Regulations for internal combustion engines of piston type

10.4 Regulations for main and auxiliary boilers

10.5 Regulations for gas turbines

11 FIRE SAFETY

11.1 Goal

11.2 Functional requirements

11.3 Regulations for fire protection

11.4 Regulations for fire main

11.5 Regulations for water spray system

11.6 Regulations for dry chemical powder fire-extinguishing system

11.7 Regulations for fire detection and alarm system

Notes:

Notes:

Notes:

TOPIC 2: INTRODUCTION TO LNG TECHNOLOGY

2.1 DESIGN AND OPERATIONAL CHARACTERISTICS OF SHIPS SUBJECT TO THE IGF CODE

WHAT is LNG?

Liquefied Natural Gas, or LNG, is defined as:

"Natural gas in liquefied form as a result of lowering the temperature to below its boiling point of approximately -162° Celsius (about -260° Fahrenheit)"

LNG consists mainly of methane (CH_4), with minor amounts of other hydrocarbons (ethane, propane, butane and pentane. By liquefying the methane gas, LNG takes up only $1/600_{th}$ of the volume of natural gas in its gaseous state, which means the gas can be distributed around the world more efficiently. By comparison, compressed natural gas (CNG) takes up around $1/100_{th}$ of the volume of natural gas in its gaseous state, depending on the actual pressure.

Main general physical and chemical characteristics of LNG

Colour	Colourless
Odour	Odourless
Molecular weight	16.0425 g
Density	6.67151E-4 kg/m3 (at 20° Celsius)
Boiling point	-161.48° Celsius
Vapour density	0.55 (relative to air)

During transport the temperature should be below the boiling point. Because LNG is extremely cold it requires special cryogenic equipment, procedures and training of the personnel involved. Due to the relatively low energy density of LNG (in MJ/l) it requires more onboard storage capacity than conventional fuels.

Notes:

Fire Hazard Properties

The gas is flammable in volume concentrations between 4.5% and 16.5% in air, but auto-ignition only occurs at high temperatures.

Fire hazard properties of LNG and other fuels

Properties		Petrol (100 Octane)	Diesel	Methane (LNG)	Propane (LPG)
Flash point (°C)		<-40	>62		
Flammability in air	Lowest concentration in air (%)	1.4	0.6	4.5	2.1
	Highest concentration in air (%)	7.6	7.5	16.5	9.5
Auto-ignition temperature (°C)		246-280	250-300	537	480

Notes:

Cryogenic: adjective

- **Relating to low temperatures.**
- **Requiring or suitable to cryogenic storage**
- **Pertaining to the production or use of extremely low temperatures.**
- **Pertaining to cryogenics**

Cryogenics:

Science concerned with the production and maintenance of temperatures much below normal, down to almost absolute zero, and with various phenomena that occur only at such temperatures.

The science and technology of phenomena and processes at low temperatures, defined arbitrarily as below 150 K (-190°F). Phenomena that occur at cryogenic temperatures include liquefaction and solidification of ambient gases; loss of ductility and embrittlement of some structural materials such as carbon steel; increase in the thermal conductivity to a maximum value, followed by a decrease as the temperature is lowered further, of relatively pure metals, ionic compounds, and crystalline dielectrics (diamond, sapphire, solidified gases, and so forth); decrease in the thermal conductivity of metal alloys and plastics; decrease in the electrical resistance of relatively pure metals; decrease in the heat capacity of solids; decrease in thermal noise and disorder of matter; and appearance of quantum effects such as superconductivity and superfluidity. *See* **Electrical resistivity**, **Specific heat**, **Superconductivity**, **Superfluidity**, **Thermal conduction in solids**

Notes:

TOPIC 2: INTRODUCTION TO LNG TECHNOLOGY

Home > LNG

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Safety

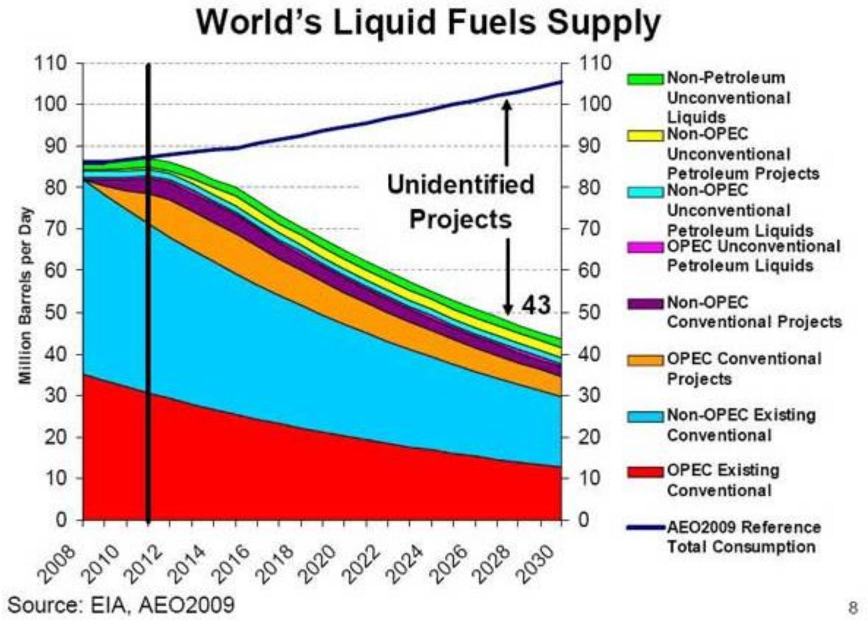
The cryogenic characteristics of LNG may pose a risk to humans and materials if not handled carefully. If ignited, a gas cloud resulting from LNG release may lead to several types of fire or an explosion at flammable methane concentrations.

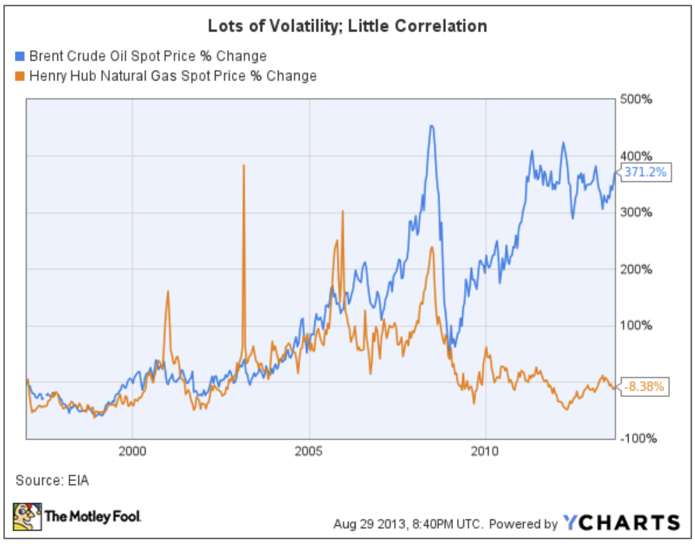
Notes:

TOPIC 2: INTRODUCTION TO LNG TECHNOLOGY

Future scenarios…? …2020…2030….

- Extended emission control areas (ECA) ?
- Increasing fuel prizes?
- Transformation to cleaner energy ?
- Emission taxes (CO_2, SOx, NOx, PM…?
- ???

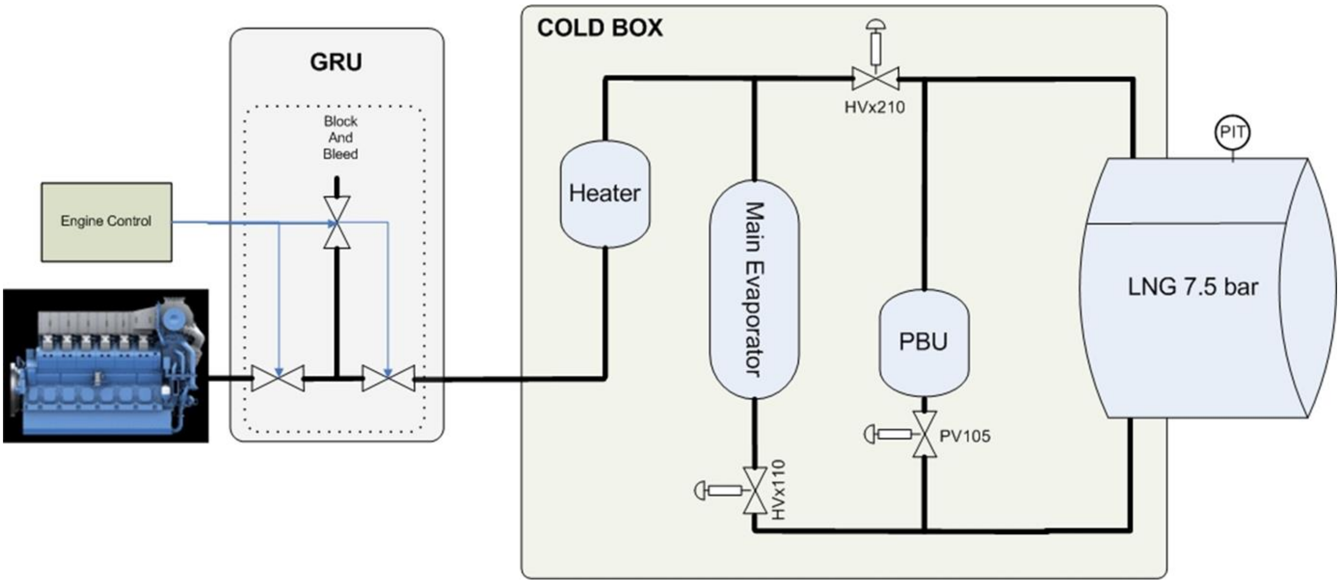




Notes:

COMPONENTS IN A LNG FUEL SYSTEM

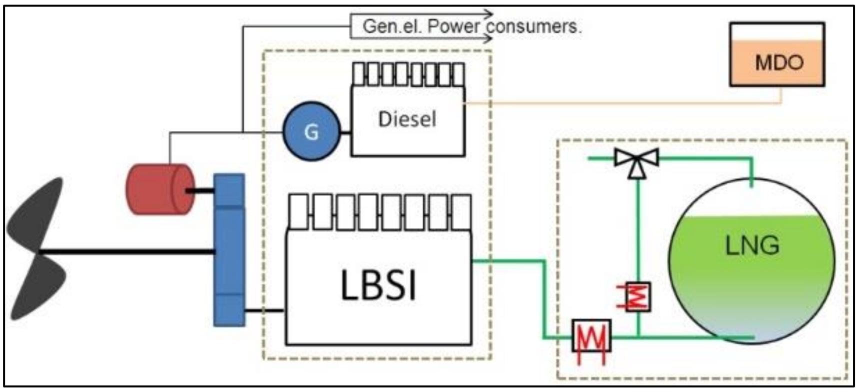
- Storage tank
- Fuel supply system
- Gas regulating unit
- Power plant



Notes:

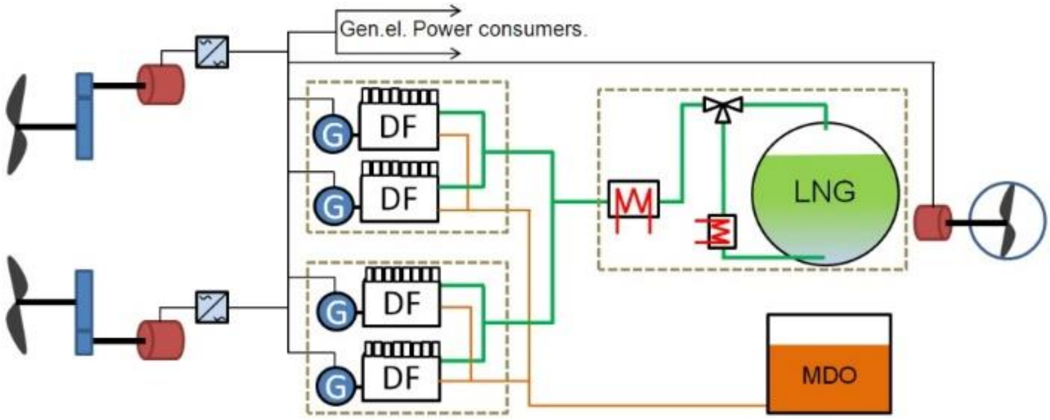
LNG FUELLED PROPULSION POWER SYSTEMS

«Hybrid»



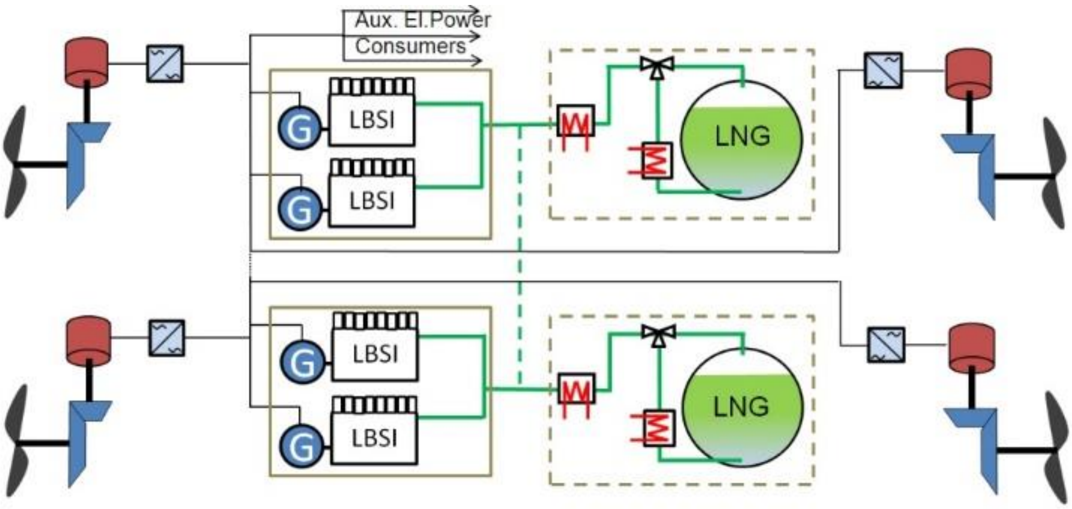
Notes:

«Dual Fuel»



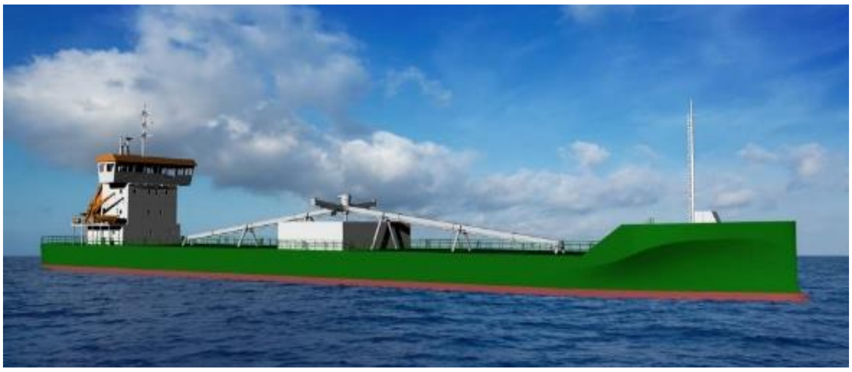
Notes:

«Gas only»



Notes:

LNG POWERED VESSELS UNDER CONSTRUCTION



Notes:

Examples of LNG Fuelled Ships

Matson (Container vessels)
Matson has signed a contract with a US shipyard for the construction of 2 vessels 3,600 TEU each equipped with dual-fuel engines. These vessels are Jones Act and are intended for trade between the US West Coast and Hawaii.

Fjord Line (Cruise ferry)
MS Stavangerfjord (2013) and MS Bergenfjord (2014), both classed to DNV GL, are cruise ferries with a capacity of 1,500 people and 600 cars. Both vessels operate between Norway and Denmark and perform LNG bunkering operations in both ends.

Tarbit Shipping AB (Tanker)
The 25,000 dwt product tanker Bit Viking was the first vessel ever to undergo a conversion from Heavy Fuel Oil (HFO) to Liquefied Natural Gas (LNG) operation. The vessel is DNV GL classed, has Wärtsilä engines two 500 m^3 LNG fuel tanks and is most environmentally friendly product tanker in the world.

AGA (LNG bunker vessel)
Seagas, the first LNG bunker vessel in operation, is classed by DNV GL and supplies LNG to M/S Viking Grace, while she is berthing at Stockholm. Fiskerstrand Verft AS converted the former car ferry M/F 'Fjalir' (build in 1974) into an LNG bunkering vessel. The conversion was completed in March 2013 and the vessel, was named LNG/C 'Seagas',.

SeaRoad (RoRo vessels)
SeaRoad's order for a new LNG-powered RoRo ferry under DNV GL class marks the first-ever order placed from Australia. This vessel will be used on the Melbourne - Devonport (Tasmania) route and is the world's first RoRo ferry designed to carry reefer containers and hazardous cargo side-by-side. The LNG bunkering process for this vessel will include mobile tanks which will be loaded upon arrival in port, and then secured in place aboard the ship as part of the fixed fuel supply system for the main engines Delivery is expected in Q3 2016.

Notes:

TOPIC 2: INTRODUCTION TO LNG TECHNOLOGY

Fjord1 (Ferry)

MF 'Glutra' is the worlds first gas ferry to operate on LNG. The vessel is DNV GL class and marked the first development of rules for gas-fuelled vessels. The company started operating 'Glutra' in Møre og Romsdal County in 2000. The ferry route serving the coastal trunk road in Rogaland and Hordaland Counties has since 2007 been served by five such ferries from Fjord1. The magazine "Skipsrevyen" awarded the prize "Ship of the Year 2000" to Glutra's owner and operator Møre og Romsdals Fylkesbåtar and to the Langstein Yard of Tomrefjord, Norway for their newbuilding of M/F Glutra.

Eidesvik Shipping AS (PSV/OSV)

Designed by Wärtsilä ship Design, classed by DNV GL and built by Kleven Verft AS in Norway, the 'Viking Energy' is the world's first LNG-powered supply vessel. The vessel was delivered in April 2003, and is chartered to Statoil for delivering supplies to oil and gas platforms in the North Sea. The vessel has dual-fuel engines installed and can operate both on LNG and liquid fuel.

Simon Møkster Shipping AS (PSV/OSV)

"Stril Pioner" together with 'Viking Energy' are the first gas-fuelled supply (PSV) vessels in North Sea operation and has been operating for Statoil since delivery, July 2003. The vessel has dual-fuel engines installed and can operate both on LNG and liquid fuel.

Crowley (ConRo vessels)

Crowley Maritime has ordered two LNG Fuelled ConRo vessels with DNV GL class at US Shipyard. These vessels are Jones Act and are intended for the USA – Puerto Rico trade

United Arab Shipping Company (Container vessels)

United Arab Shipping Company (UASC) has ordered 17 LNG Ready container vessels. Eleven vessels of 14,000 TEU and six of 18,000 TEU. The first LNG Ready vessel is already scheduled for delivery in November 2014. DNV GL has worked closely with UASC and the yards in order to make the first ultra large LNG Ready container vessels reality.

Buquebus (High Speed Craft)

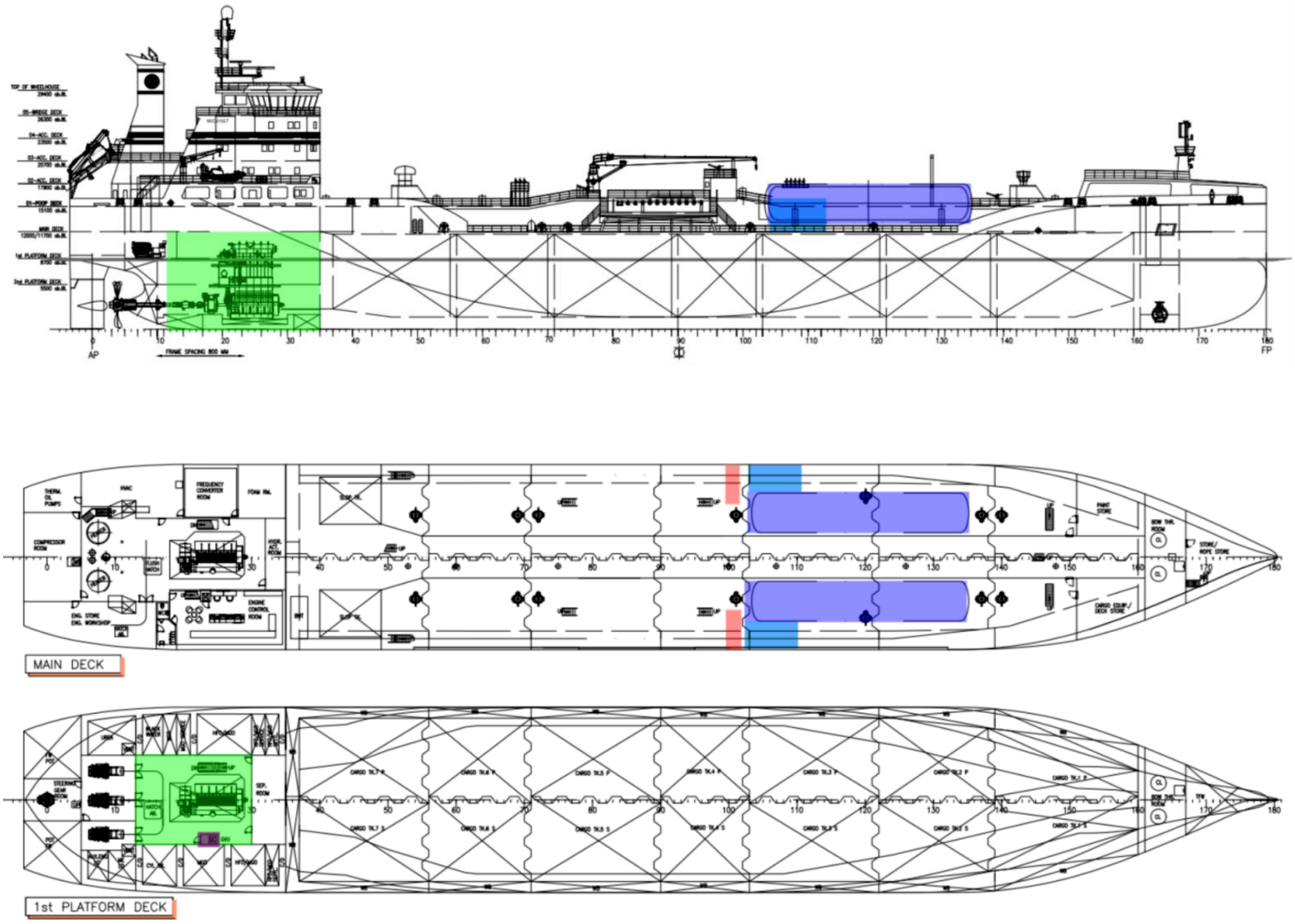
'Francisco', classed in DNV GL, entered service with Buquebus in South America in 2013. The vessel operates between Buenos Aires and Montevideo at 50 knots fully loaded (1,000 passengers and 150 cars). It is the first vessel to have been built under the HSC (High Speed Craft) Code with power by gas turbines using natural gas as the primary fuel.

Notes:

TOPIC 2: INTRODUCTION TO LNG TECHNOLOGY

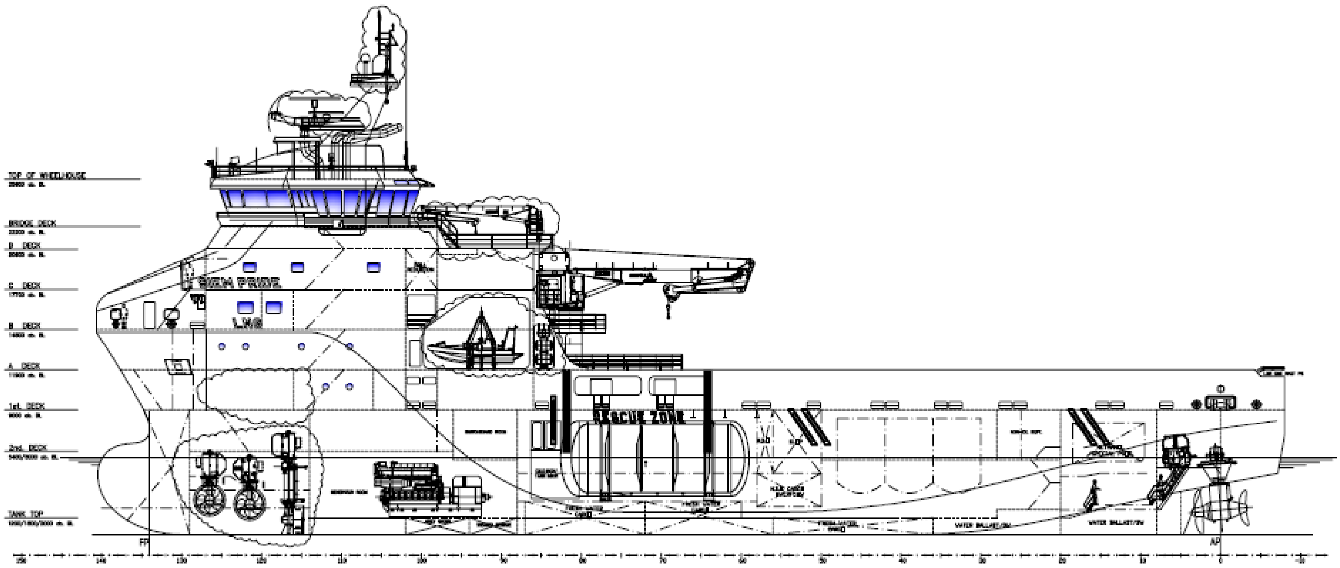
2.1 FUEL SYSTEM AND FUEL STORAGE SYSTEM

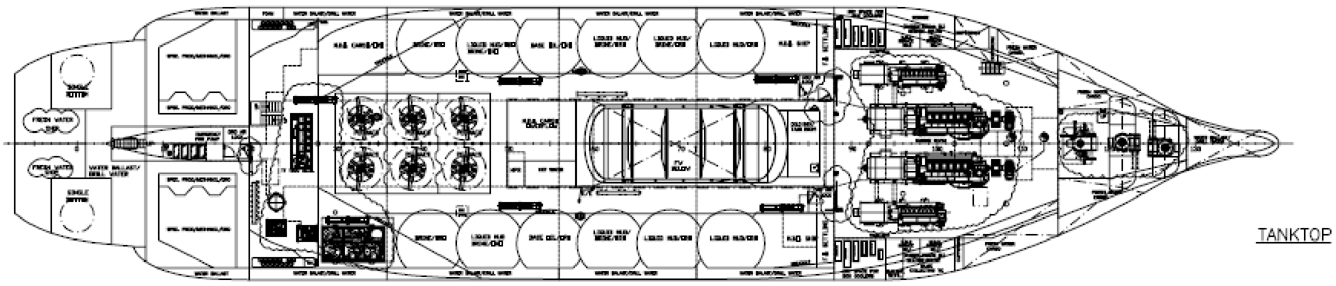
LNG Arrangement example



Notes:

LNG Arrangement PSV





Notes:

LNG Properties

- Liquid below -163ºC and atmospheric pressure
- Consists of 90-100% Methane (CH_4)
- Low density gas - «lighter» than air and mixes easily
- Density in Liquid phase approx. 430 kg/m3
- Energy density pr. volume are approx. 60% of marine diesel fuels

Excellent fuel properties and clean emissions !
(complies with IMO TIER III emission requirements)

LNG Safety Issues

- Gas leaks => explosive hazards and poisoning
- LNG leaks => thermal damage, explosive hazards, frostbites
- Pressure build-up, fractures and leakage due to «vapour lock»
- Irregular operation due to system complexity and safety measures

Marine LNG fuelled engines developed since 1984

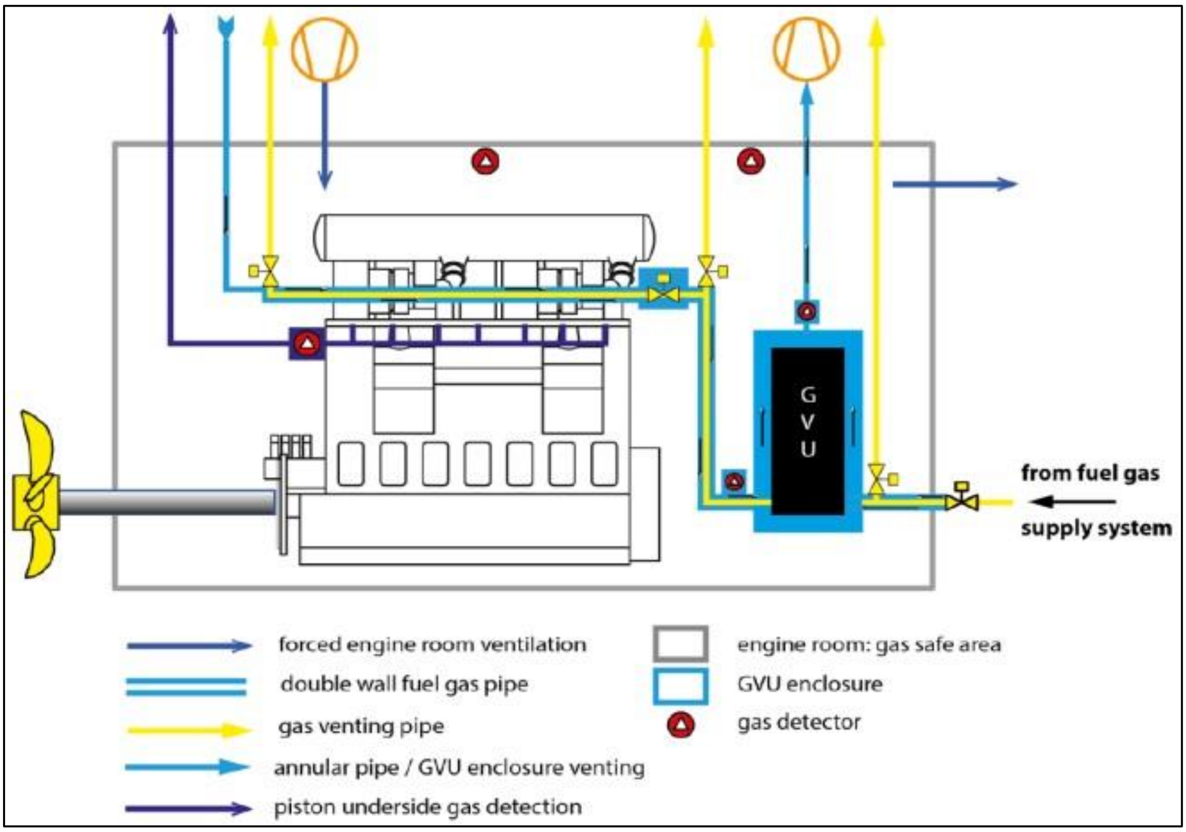
Wartsila Vasa32

Rolls-Royce K-type

Rolls-Royce B-type

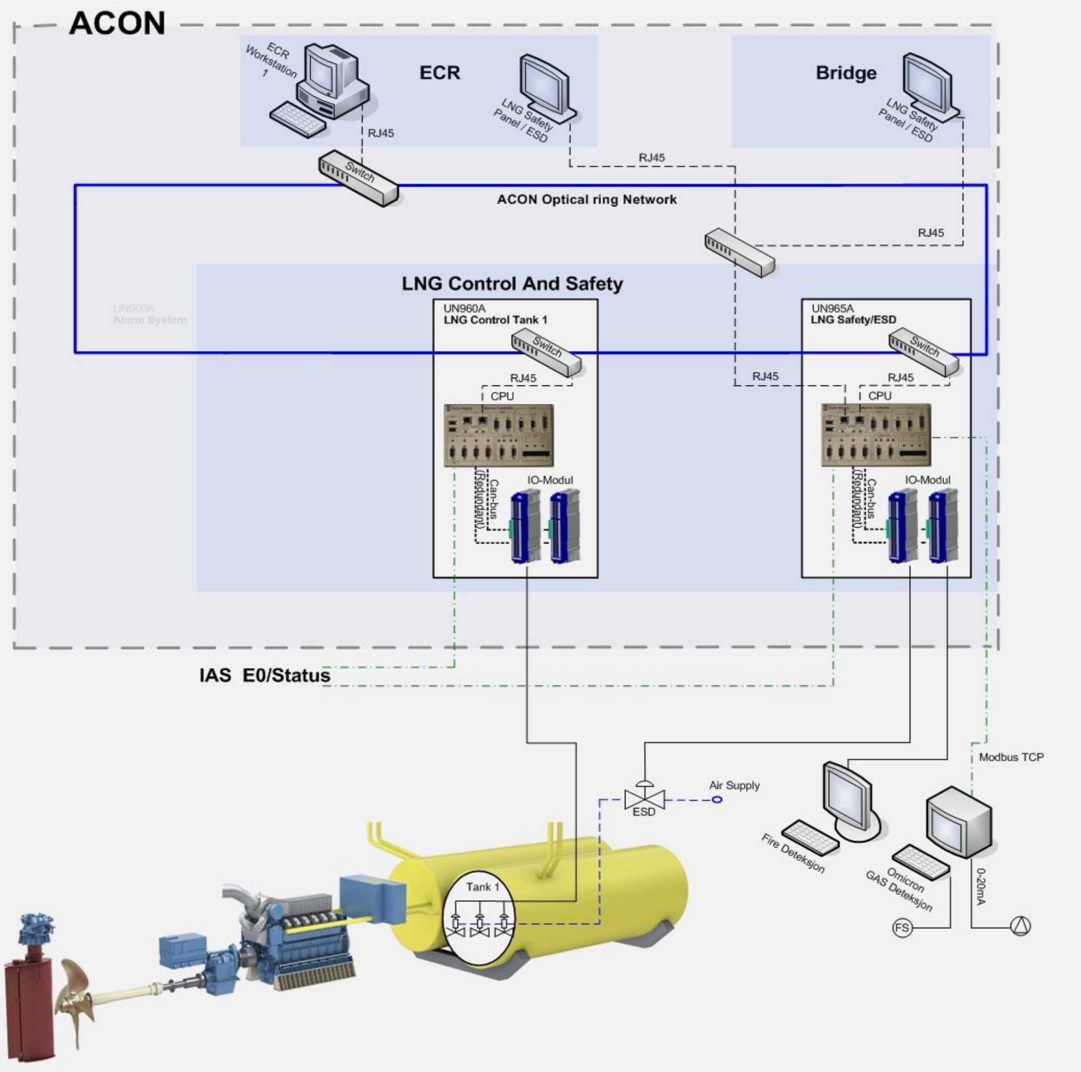
Notes:

Gas Safety and Ventilation Systems



«Double barrier systems» and safe ventilation

Notes:


ACON
ECR Workstation 1
ECR
LNG Safety Panel / ESD
Bridge
LNG Safety Panel / ESD
RJ45
Switch
ACON Optical ring Network
LNG Control And Safety
UN960A
LNG Control Tank 1
UN965A
LNG Safety/ESD
CPU
Can-bus (Redundant)
IO-Modul
IAS E0/Status
Modbus TCP
Air Supply
ESD
Fire Deteksjon
Omicron GAS Deteksjon
0-20mA
FS
Tank 1

Notes:

LNG Bunkering

Trailer to Ship

- Simple and flexible
- Low capacity (55m^3 / trailer)
- Some safety issues

Shore to ship

- Increased capacity
- Improved safety
- Reduced flexibility

Notes:

Ship to Ship

- Necessary for large capacities
- Flexible
- Some safety issues

Bunkering

Something Wrong ?

Yes?

What ?

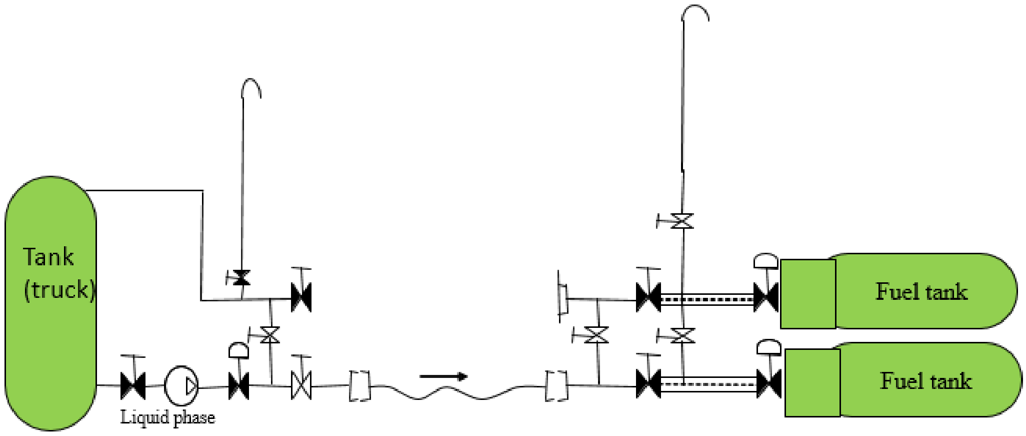
Notes:

Key points for bunkering:

- Preparations
- Connection of bunker hose
- Pressure testing and purging with Nitrogen
- Cooling of bunker line and hose
- Bunkering
- Draining of the bunker hose
- Purge bunker hose and line with Nitrogen (gas freeing)
- Release pressure and disconnect hose
- Disconnect, seal of the flange and clean up.

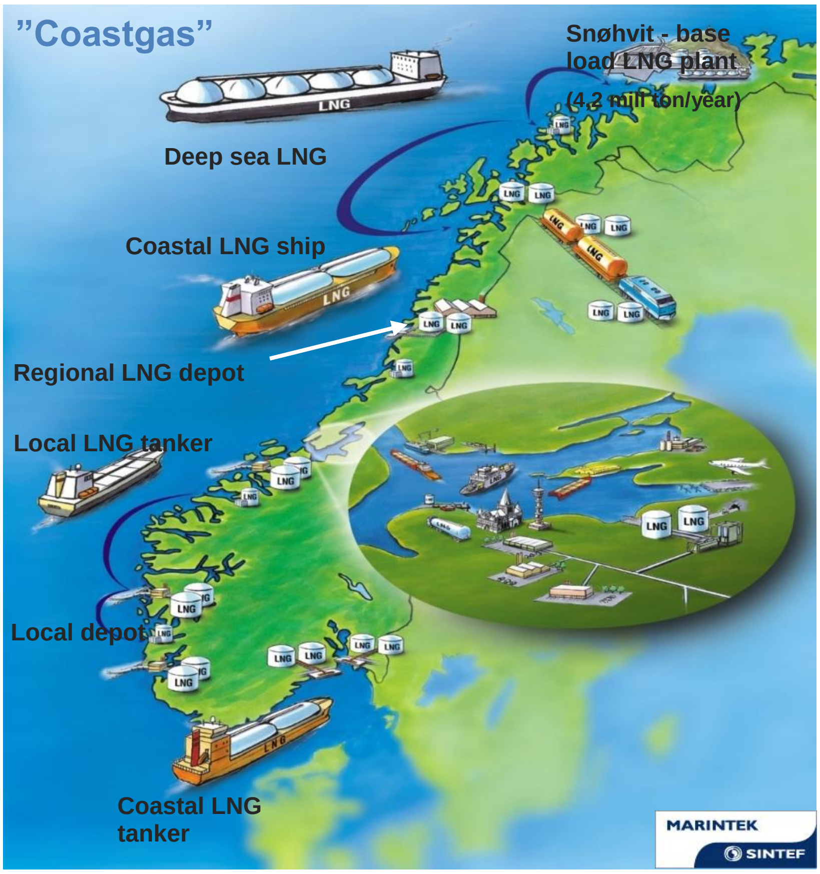
Bunkering

- Transfer lines/hoses
- Standardized connectors
- Ground cable
- Gas return ?
- Protective trays
- Procedures and communication



Notes:

LNG Fuel Infrastructure



Covering the long coast of Norway

- LNG source

Base load LNG to receiving terminals
Small scale LNG production plants (4) 10.000-300.000 ton/year

- LNG distribution

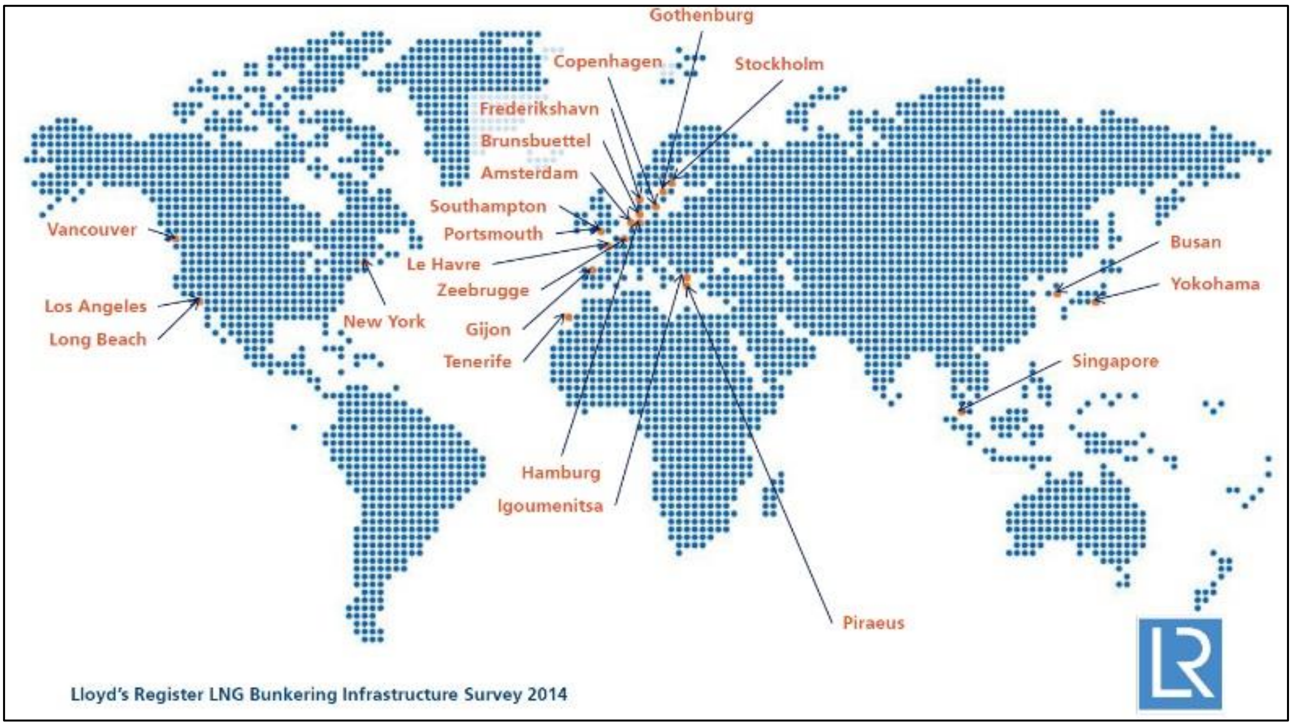
Coastal tankers (1000 m^3 – 7500 m^3)
Trailers (50m^3), rail or local pipeline

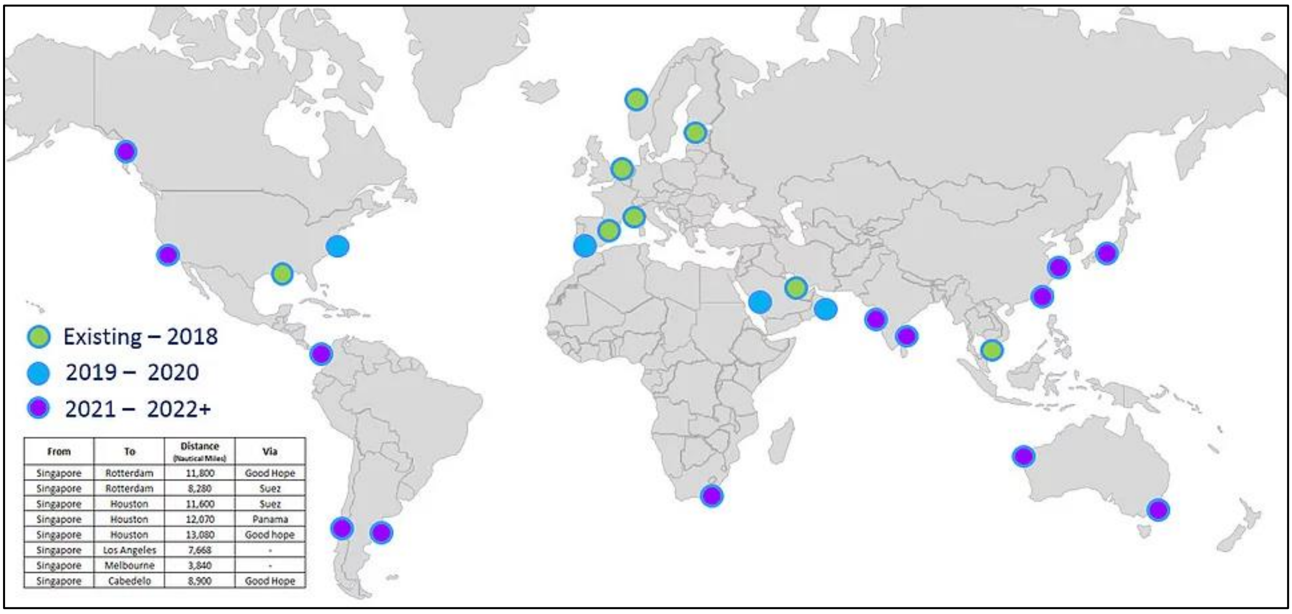
- LNG terminals

(~40) 100m^3 - 6500m^3 LNG

Notes:

Global LNG Bunkering





From	To	Distance (Nautical Miles)	Via
Singapore	Rotterdam	11,800	Good Hope
Singapore	Rotterdam	8,280	Suez
Singapore	Houston	11,600	Suez
Singapore	Houston	12,070	Panama
Singapore	Houston	13,080	Good hope
Singapore	Los Angeles	7,668	-
Singapore	Melbourne	3,840	-
Singapore	Cabedelo	8,900	Good Hope

Notes:

LNG Fuel Technology

- ✓ ***Environmental friendly and energy efficient***
- ✓ **Important energy source (alternative fuel)**
- ✓ **High safety standard – double and triple barriers**
- ✓ **Suitable for short-sea shipping**
- ✓ **Important element in «Hybrid» propulsion systems**

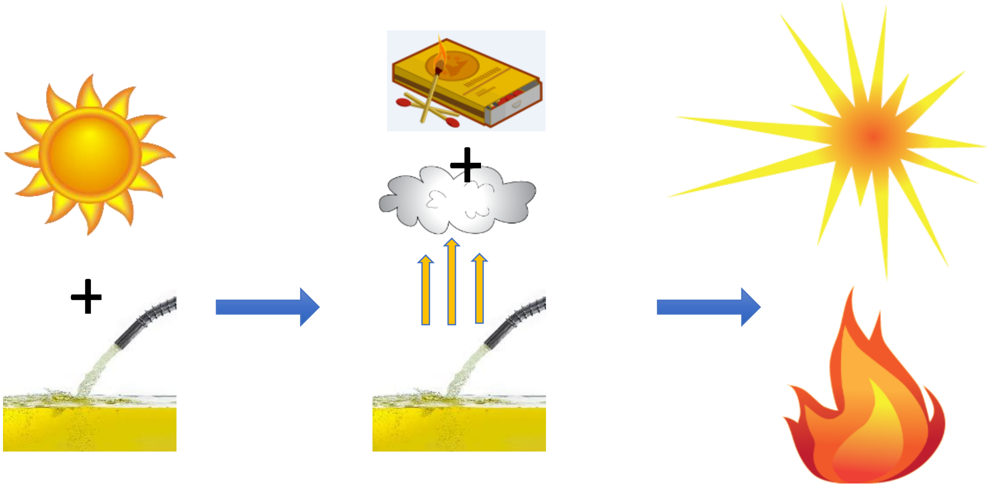
- ➢ **Lacking efficient infrastructure**
- ➢ **Some challenges related to transport, storage and handling**
- ➢ **Low «energy density»**

Notes:

GENERAL PRINCIPLE OF FIRES

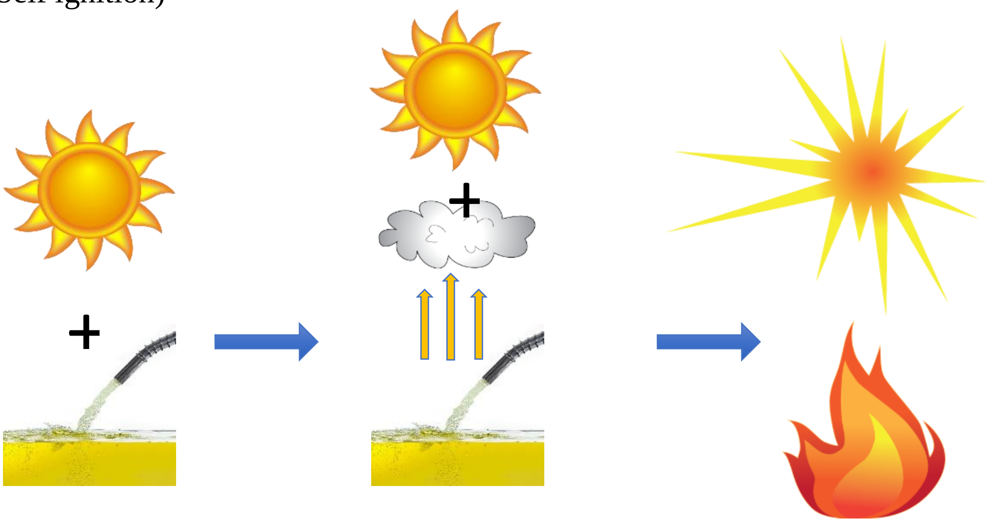
- Flashpoint:

  Flashpoint is the lowest temperature where vapors from a liquid can ignite, when applying an ignition source.



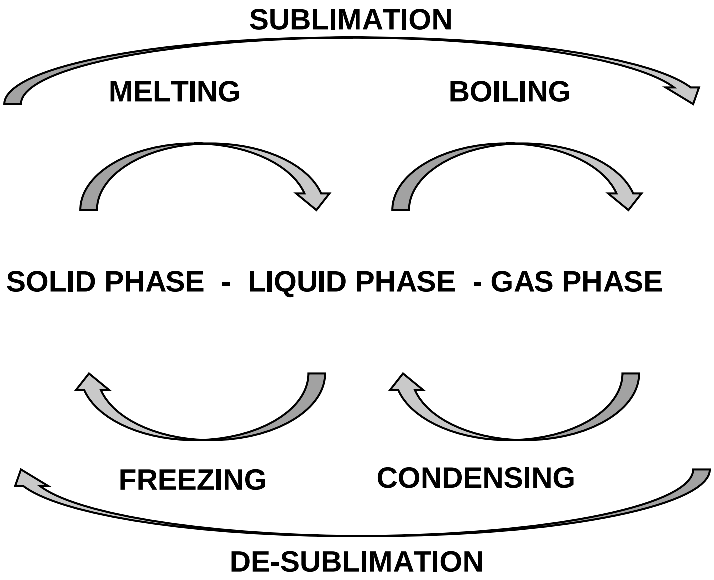
- Ignition temperature:

  Ignition temperature is the lowest temperature where the material can ignite, without any ignition source. (Self ignition)



Notes:

What is Gas



Boiling/condensation point for different gases:

Oxygen O_2 : -183,0°C (-297.4°F)
Methane CH_4 : -161,50°C (-258.70°F)
Nitrogen N_2 : -195,80°C (-322.44°F)

Normal air consists of the following:

20,9% O_2
78,1% N_2
1% other gases

Notes:

TOPIC 3: Physical Properties and Characteristics of Fuels

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.933	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.732	32 Ge Germanium 72.61	33 As Arsenic 74.922	34 Se Selenium 78.09	35 Br Bromine 79.904	36 Kr Krypton 84.80
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molibdenum 95.94	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.29
55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71 Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinides	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Fl Flerovium [289]	115 Uup Ununpentium unknown	116 Lv Livermorium [298]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown

57 La Lanthanum 138.906	58 Ce Cerium 140.115	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.966	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26	69 Tm Thulium 168.934	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

Notes:

Weight of Gas

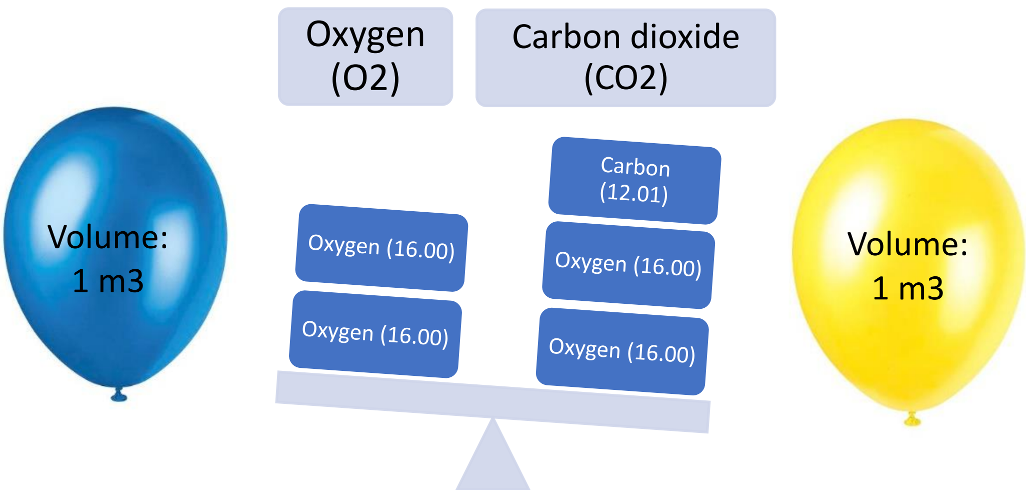
- Different gases has different weights.
- And the weights are temperature dependent
- And weights of gas is expressed by *g/mol*
- Cold gas is heavier than warm gas

Molar masse: g/mol?

Dry air = 28.96 g/mol
Carbon (C)= 12.01 g/mol
Oxygen (O2)= 32.00 g/mol
Nitrogen (N2)= 28.01 g/mol
– Carbon dioxide (CO2)= 44.01 g/mol
– Helium (He)= 4.003 g/mol
– Methane (CH4)= 16.04 g/mol
– Propane (C3H8)= 44.09 g/mol

Density of Gas:

Air is defined as 1 in density
CO2 is 1.52



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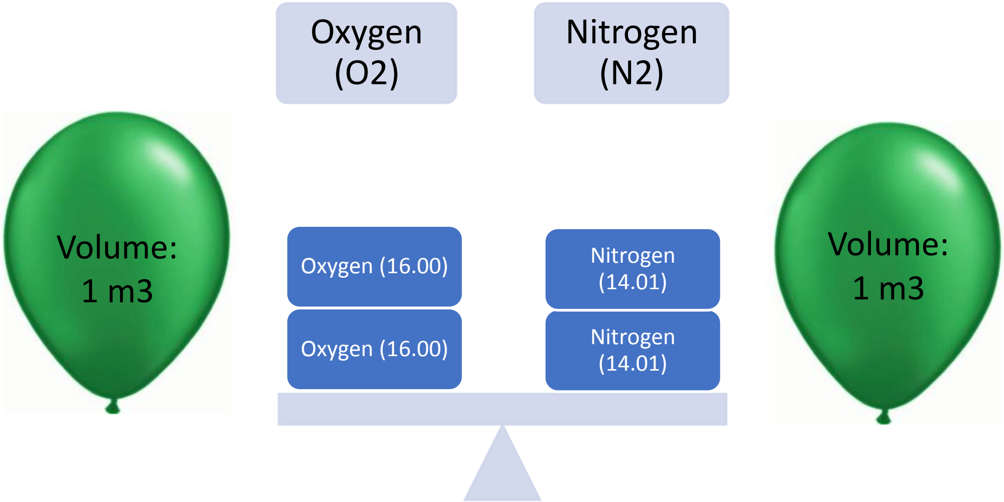
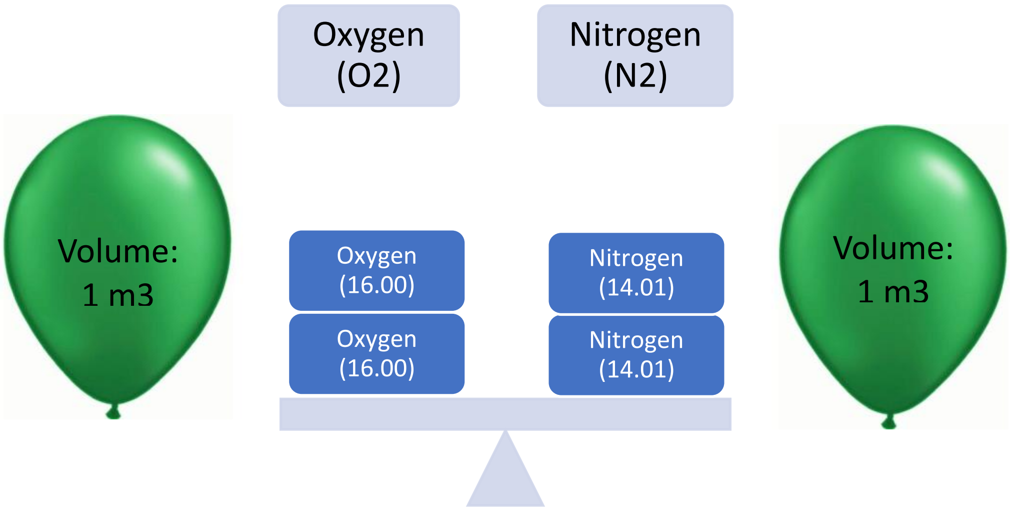
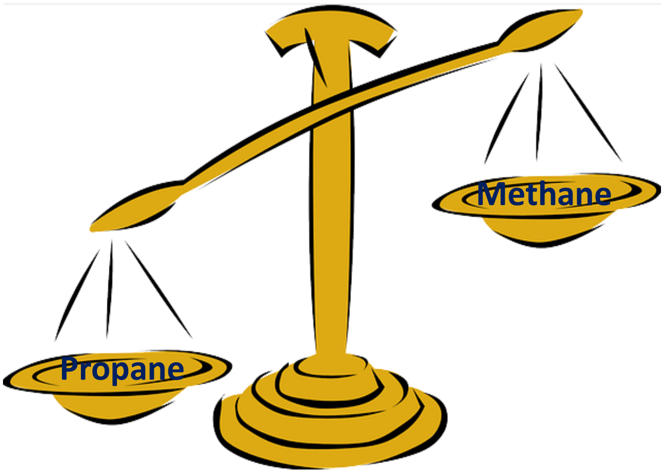
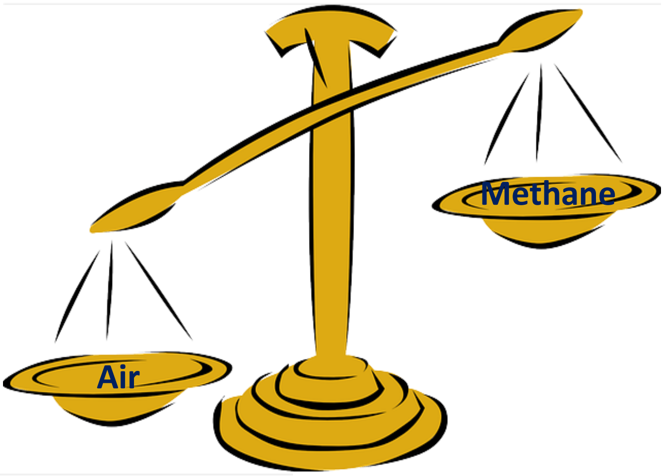

Oxygen (O2)
Nitrogen (N2)
Volume: 1 m3
Oxygen (16.00)
Oxygen (16.00)
Nitrogen (14.01)
Nitrogen (14.01)
Volume: 1 m3

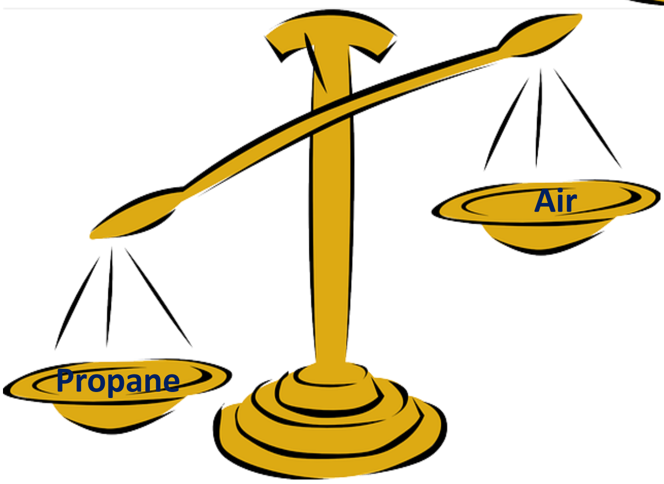

Oxygen (O2)
Nitrogen (N2)
Volume: 1 m3
Oxygen (16.00)
Oxygen (16.00)
Nitrogen (14.01)
Nitrogen (14.01)
Volume: 1 m3

Notes:

TOPIC 3: Physical Properties and Characteristics of Fuels

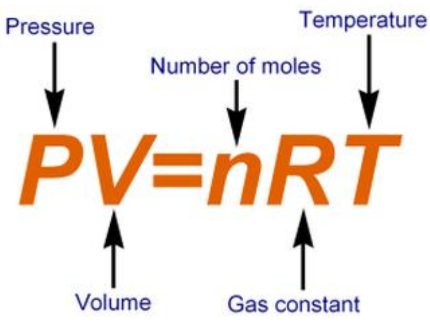






Notes:

Ideal Gas Law



Volume vs Temperature

$$P = \frac{nR}{V} T \qquad V = \frac{nR}{P} T$$

$$P = \frac{nR}{V} T \qquad V = \frac{nR}{P} T$$

Pressure vs Temperature

$$P = \frac{nR}{V} T \qquad V = \frac{nR}{P} T$$

$$P = \frac{nR}{V} T \qquad V = \frac{nR}{P} T$$

Notes:

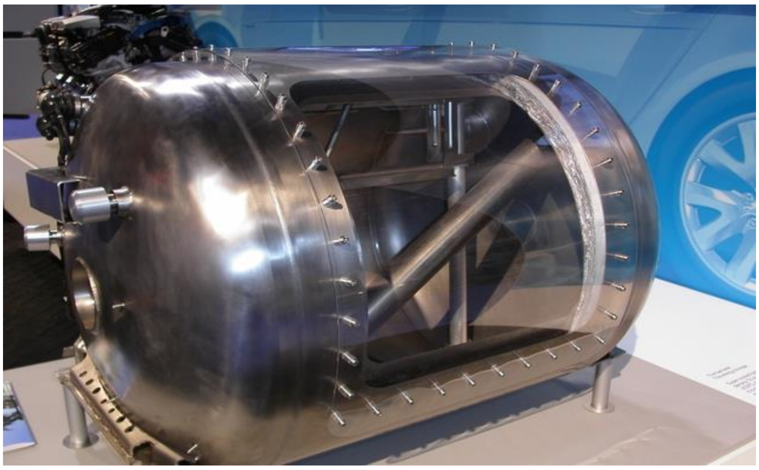
TOPIC 3: Physical Properties and Characteristics of Fuels

Natural Gas

- Most natural gas is odorless in its natural state.
- In vapor form it is almost impossible to detect without some type of gas detection equipment.
- Ignition point 480-600 °C (900 to 1200 °F).
- Explosive range of NG (methane) is 5 percent to 15 percent.
- Natural gas (methane) is lighter than air and will rise and diffuse rapidly when it escapes to an open area.
- The specific gravity of natural gas (methane) is in the range of 0.56, compared to the specific gravity of air.
- High concentrations may cause asphyxiation. Symptoms may include loss of mobility/consciousness. Symptoms may include dizziness, headache, nausea and loss of co-ordination.

Liquefied Natural Gas

- LNG is deep cooled NG, and becomes liquefied at approx..
  -160 degrC at atmospheric pressure.
- It is stored in special tanks on-board vessels, vacuum insulated.



Notes:

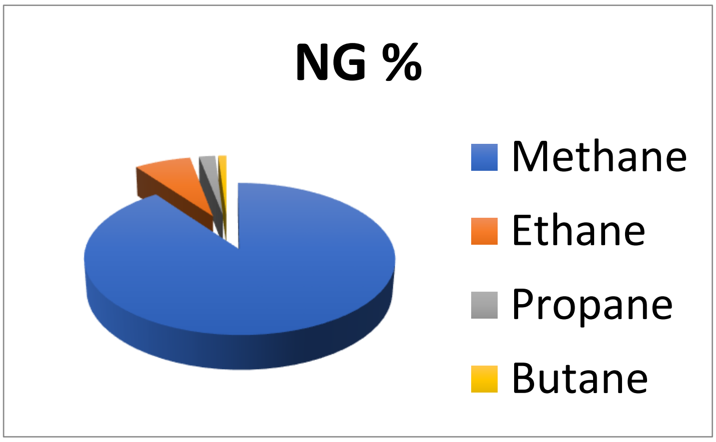
Liquefied Natural Gas (LNG)

Composition:

Mixture of hydrocarbons:

- Methane > 90%
- Ethane 5 – 10%
- Propane 1 - 2%
- Butane 0,5 - 1%

Lighter than air when same temperature as air



Different ways to storage and transport gas:

1. Compressed gas:
   Different gases stored under pressure in containers/pipe systems (CNG, air, oxygen, etc)
2. Condensed and cryogen gas:
   Gas under pressure becomes liquid in containers (CO_2, LPG, butane, etc)
   Deep cooled gas stored as liquid in special constructed containers (LNG, LIN, LOX)
3. Dissolved gas:
   Gas dissolved in another medium (acetylene dissolved in acetone stored in low pressure container)

Notes:

Safety Equipment

- Handling of LNG requires proper safety equipment.
- Why?


Cryo damage


Fire damage

Proper safety equipment would be:

Notes:

GHS – REACH – CLP

- **GHS -** Globally Harmonized System:
  UN published in 2002 a new standard for classification and labelling of dangerous substances.
- **REACH -** Registration, Evaluation, Authorisation and Restriction of Chemicals:
  Is EU's new chemical guidelines based on GHS, and entered into force May 30th 2008 in Norway.
- **CLP:** Classification, Labelling and Packaging:
  A new harmonised system for classification, labelling and packing of substances from EU.

Why Standardization?

Different signs
Standardization of signs

Physical hazards pictograms:

Physical And Health Hazard Pictograms:

Notes:

Safety Data Sheet

1. Identification of the substance/mixture and of the company/undertaking
2. Hazards identification
3. Composition/information on ingredients
4. First aid measures
5. Firefighting measures
6. Accidental release measure
7. Handling and storage
8. Exposure controls/personal protection
9. Physical and chemical properties
10. Stability and reactivity
11. Toxicological information
12. Ecological information
13. Disposal considerations
14. Transport information
15. Regulatory information
16. Other information

Kleenheat Gas — SAFETY DATA SHEET LNG — SAFE PERSON • PROCESS • PLACE

1. IDENTIFICATION: PRODUCT IDENTIFIER AND CHEMICAL IDENTITY

Product Name	LNG
Proper Shipping Name	NATURAL GAS, REFRIGERATED LIQUID with high methane content
Other Names	Liquefied Natural Gas
Recommended Use	Fuel
Supplier Name	Wesfarmers Kleenheat Gas Pty Ltd (ABN 40 008 679 543)
Address	Campus Drive (off Murdoch Drive) Murdoch, Western Australia, 6150
Telephone No.	13 21 80
Australian Emergency Contact No.	1800 093 336 (24 hours, 7 days)

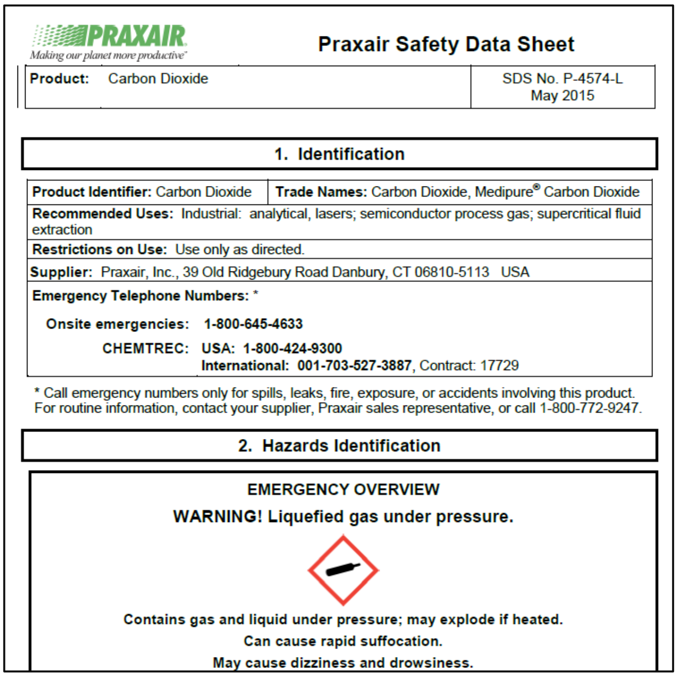
2. HAZARDS IDENTIFICATION

GHS Classification

Physical Hazards

Flammable Gas – Category 1
Refrigerated Liquefied Gas

Hazard Statements



PRAXAIR — Making our planet more productive — **Praxair Safety Data Sheet**

Product: Carbon Dioxide — SDS No. P-4574-L May 2015

1. Identification

Product Identifier: Carbon Dioxide	**Trade Names:** Carbon Dioxide, Medipure® Carbon Dioxide

Recommended Uses: Industrial: analytical, lasers; semiconductor process gas; supercritical fluid extraction

Restrictions on Use: Use only as directed.

Supplier: Praxair, Inc., 39 Old Ridgebury Road Danbury, CT 06810-5113 USA

Emergency Telephone Numbers: *

Onsite emergencies: 1-800-645-4633

CHEMTREC: USA: 1-800-424-9300
International: 001-703-527-3887, Contract: 17729

* Call emergency numbers only for spills, leaks, fire, exposure, or accidents involving this product. For routine information, contact your supplier, Praxair sales representative, or call 1-800-772-9247.

2. Hazards Identification

EMERGENCY OVERVIEW

WARNING! Liquefied gas under pressure.

Contains gas and liquid under pressure; may explode if heated.
Can cause rapid suffocation.
May cause dizziness and drowsiness.

Notes:

TOPIC 4: FIGHTING GAS FIRE

RESOLUTION MSC.391(95)
(adopted on 11 June 2015)

ADOPTION OF THE INTERNATIONAL CODE OF SAFETY FOR SHIPS USING GASES OR OTHER LOW-FLASHPOINT FUELS (IGF CODE)

FIRE SAFETY

- Goal

  The goal of this chapter is to provide for fire protection, detection and fighting for all system components related to the storage, conditioning, transfer and use of natural gas as ship fuel.

- Functional requirements
- Regulations for fire protection
- Regulations for fire main
- Regulations for water spray system
- Regulations for dry chemical powder fire-extinguishing system
- Regulations for fire detection and alarm system

EXPLOSION PREVENTION

- Goal

  The goal of this chapter is to provide for the prevention of explosions and for the limitation of effects from explosion.

- Functional requirements
- Regulations – General
- Regulations on area classification
- Hazardous area zones

Notes:

TOPIC 5: OVERVIEW OF BUNKERING OPERATION

5.1 SAFETY EQUIPMENT AND PROTECTIVE DEVICES

Safety Equipment

Proper safety equipment would be:

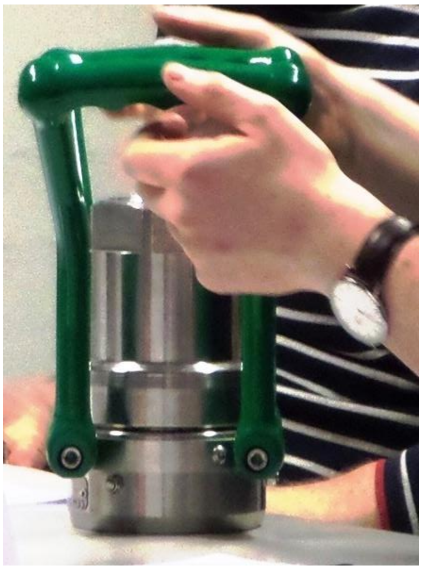
You shall also wear Gas monitor

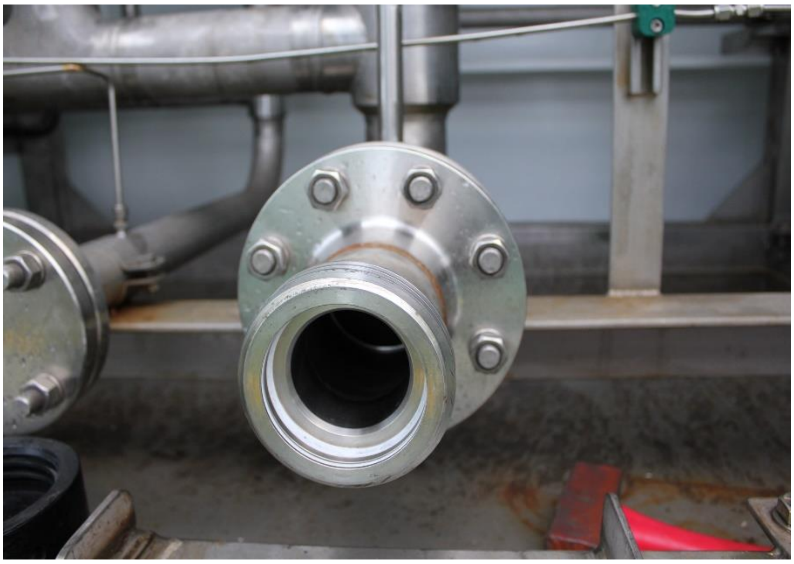
Notes:

5.2 FUELS AND FUEL STORAGE SYSTEMS OPERATIONS

Quick Closing Valves

Stainless in Material Highest Quality





Notes:

Bunkering Manifold / Water Trays

Notes:

It takes about 30 minutes to cool down pipes. Makes contingency

Prior to bunkering:

- Test the BSD function.

Notes:

TOPIC 5: OVERVIEW OF BUNKERING OPERATION

Important easures after bunkering:

- Gas freeing with Nitrogen.
- Release pressure in bunker hose before disconnection.
- Make sure that bunker hose is stored in a proper way.

  Humidity and water in bunker system will create operational problems if present.
- Seal of bunker line and clean up.
- Check safety equipment, re-order new items until next bunkering.
- Check gas meters and set them back in the charger.
- Sign and close out all permits and check lists.

Improper storage of hoses!

Notes:

TOPIC 5: OVERVIEW OF BUNKERING OPERATION

Notes:

TOPIC 6: HAZARDS, SAFETY, AND PREPAREDNESS

6.1 HAZARDS AND HAZARD CONTROL ASSOCIATED WITH OPERATIONS ON SHIPS SUBJECT TO THE IGF CODE

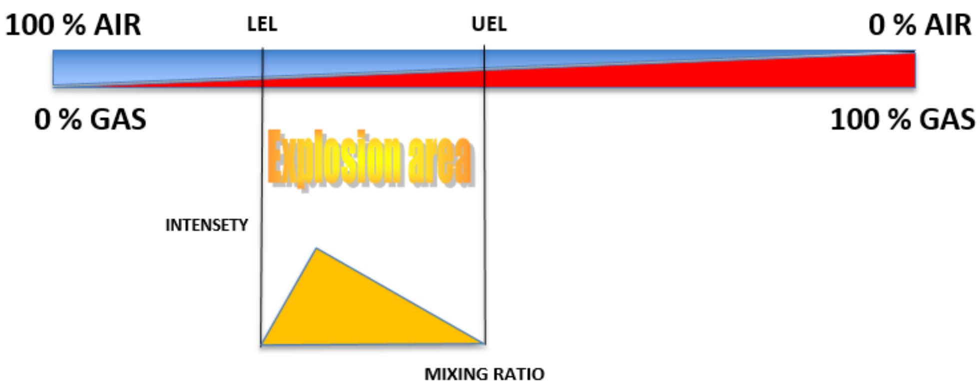
GAS FIRE / EXPLOSIONS

- How does a gas fire start?
- What is a gas fire?
- LEL/UEL
- Basic conditions for gas fire or explosions

How does a gas fire start

- First of all we need a leak of a flammable gas.
- Second we need air. (oxygen at the right concentration)
- Third will be an ignition source or sufficient heat to self-ignition.
- Will any gas mixture ignite?

Explosion Area



Notes:

6.2 GAS-MEASURING INSTRUMENTS AND SIMILAR EQUIPMENT

GAS MEASURING

- How do we detect gas or a gas leak?
- Human and mechanical:
  - Visual, sound, smell (but not for LNG, odourless)
  - Handheld measuring device
  - Fixed measuring device

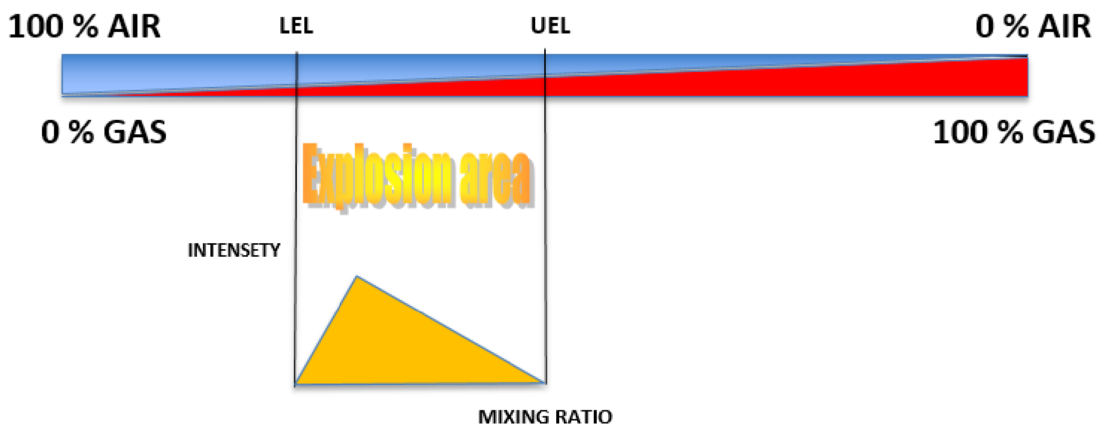
Handheld Devices

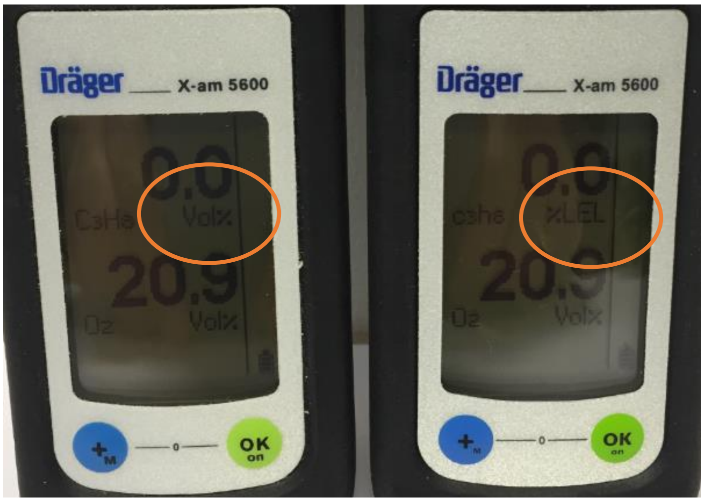
Fixed Devices


Notes:

Vol% vs %LEL

What's the difference?





Notes:

Calibration

Handheld:

- Normally once a year they should be re-certified by an approved vendor. Check your internal - and government requirements
- Can be “bump tested” with calibration gas by someone on-board (Chief Officer typically), when required
- Changing out sensors can easily be done on-board.
- Fresh air calibrated every time they are switched on for operational use.

Demonstrations

- Gas detection
- LEL/UEL
- Lean/Rich/Ideal gas mix

Notes:

6.3 SAFE WORKING PRACTICES AND PROCEDURES AND PERSONAL SHIPBOARD SAFETY INCLUDING EMERGENCY PROCEDURES

EMERGENCY PREPAREDNESS

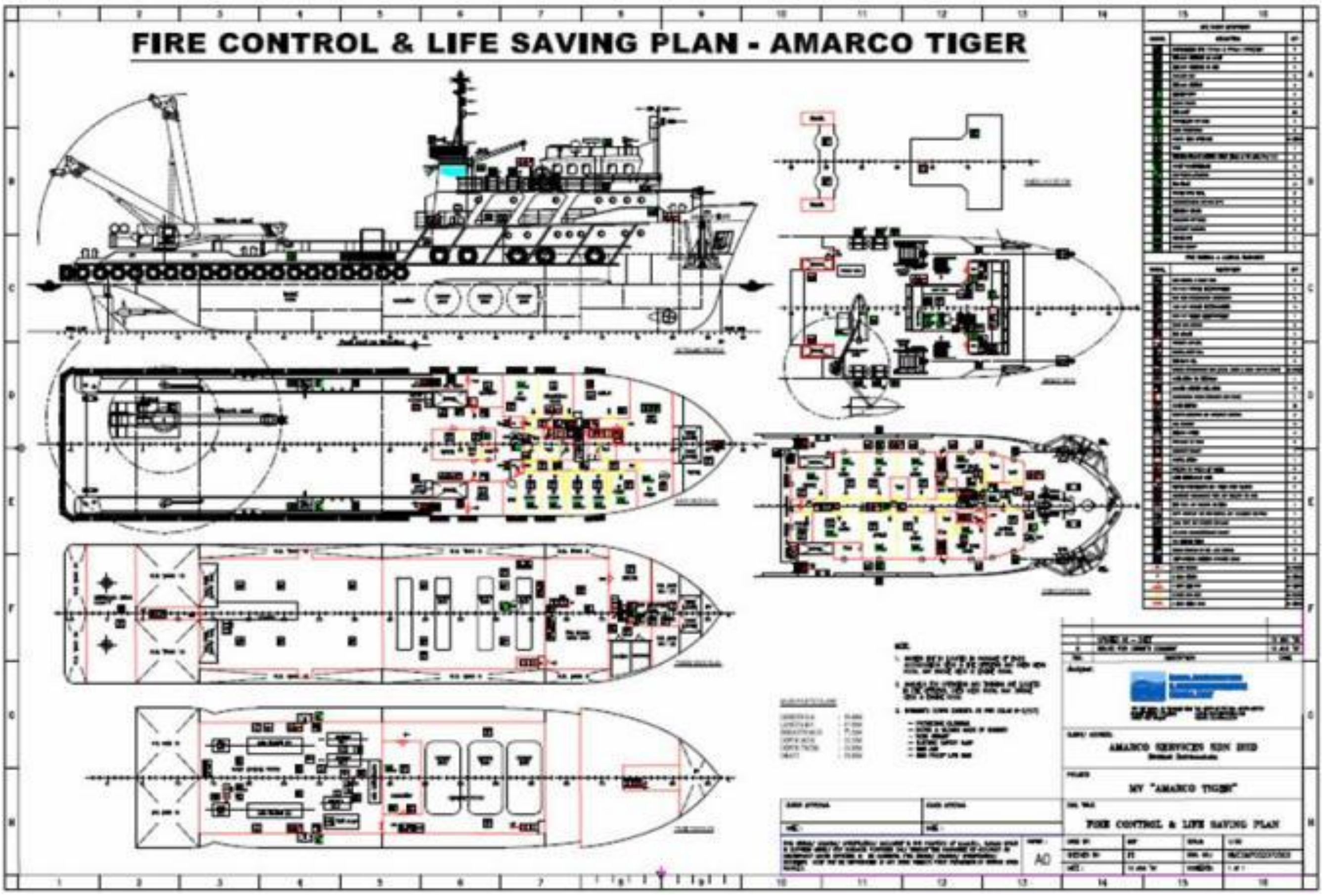
- How to prepare and what to do?
  - training and competence
  - awareness
- Who does what?
  - roles and responsibilities
  - onshore and offshore
- Communication
  - closed loop
  - correct type of communication equipment
- Exercises and drills
  - on board
  - combined onshore-offshore
  - types of drills
- Case
  - Group exercise
  - Presentations

How to prepare and what to do?

- **Knowledge, competence and training**

  What is actually LNG? How does it appears? Dangers?
  Know your own vessel. What is where and what to do.
  Awareness. Be prepared both mentally and physically.

Notes:



Who does what

- **Roles and responsibilities**

  What is your role? What is your responsibility?

  Personal responsibility – sound alarm! Where is your station?
  Team responsibility – team player

- **Onshore and offshore**

  Who is responsible for the emergency response?
  Onshore and alongside
  Offshore in operation

Notes:

Communication

- **Correct communication**

  Means of communication

  Verbal (normal/shouting), radios (UHF/VHF), telephone, PA/alarms

  Closed loop.

  Always use closed loop communication in an emergency
  Why is this important?

- **Correct type of communication equipment**

  What kind of communication equipment can we use where?

  EEX and non- EEX zones
  Associated dangers?

Exercises & Drills

- **On-board:**

  Regular drills according to the vessels plan (SMS)
  Why is this important?

- **Combined onshore – and offshore**

  Bunkering terminal and vessel
  Ship owner and vessel

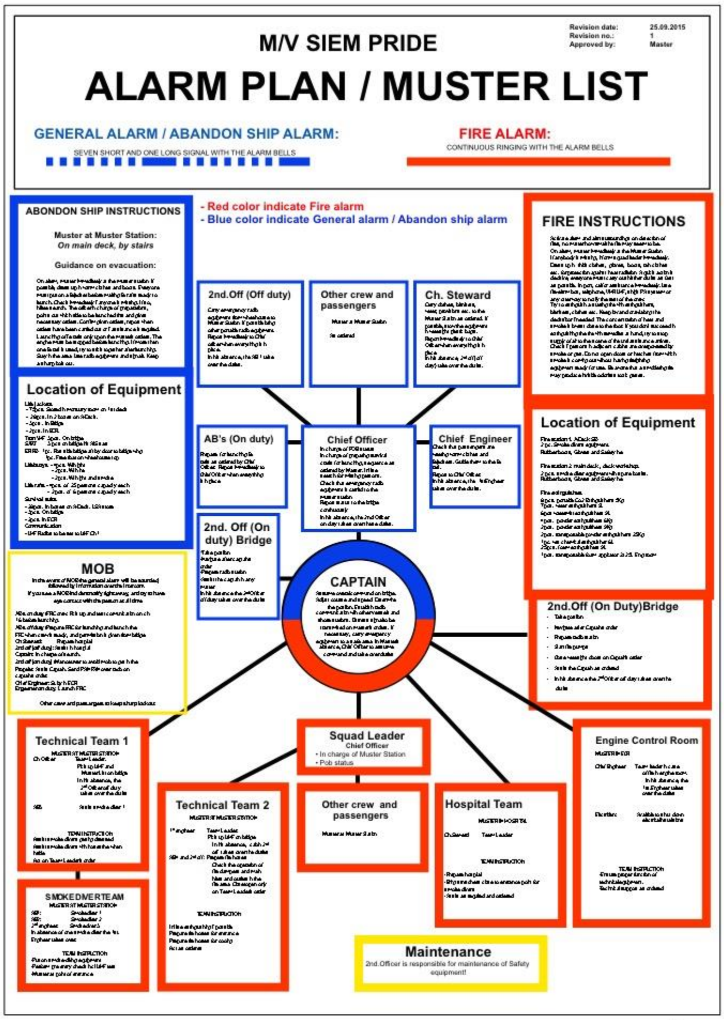
- **Types of drills and exercises**

  All vessel, GA – all involved and full muster
  Department drills and exercises – department "go through"
  Table top – preparing and how to deal with an emergency
  Equipment exercises – do you know all the equipment?

Notes:

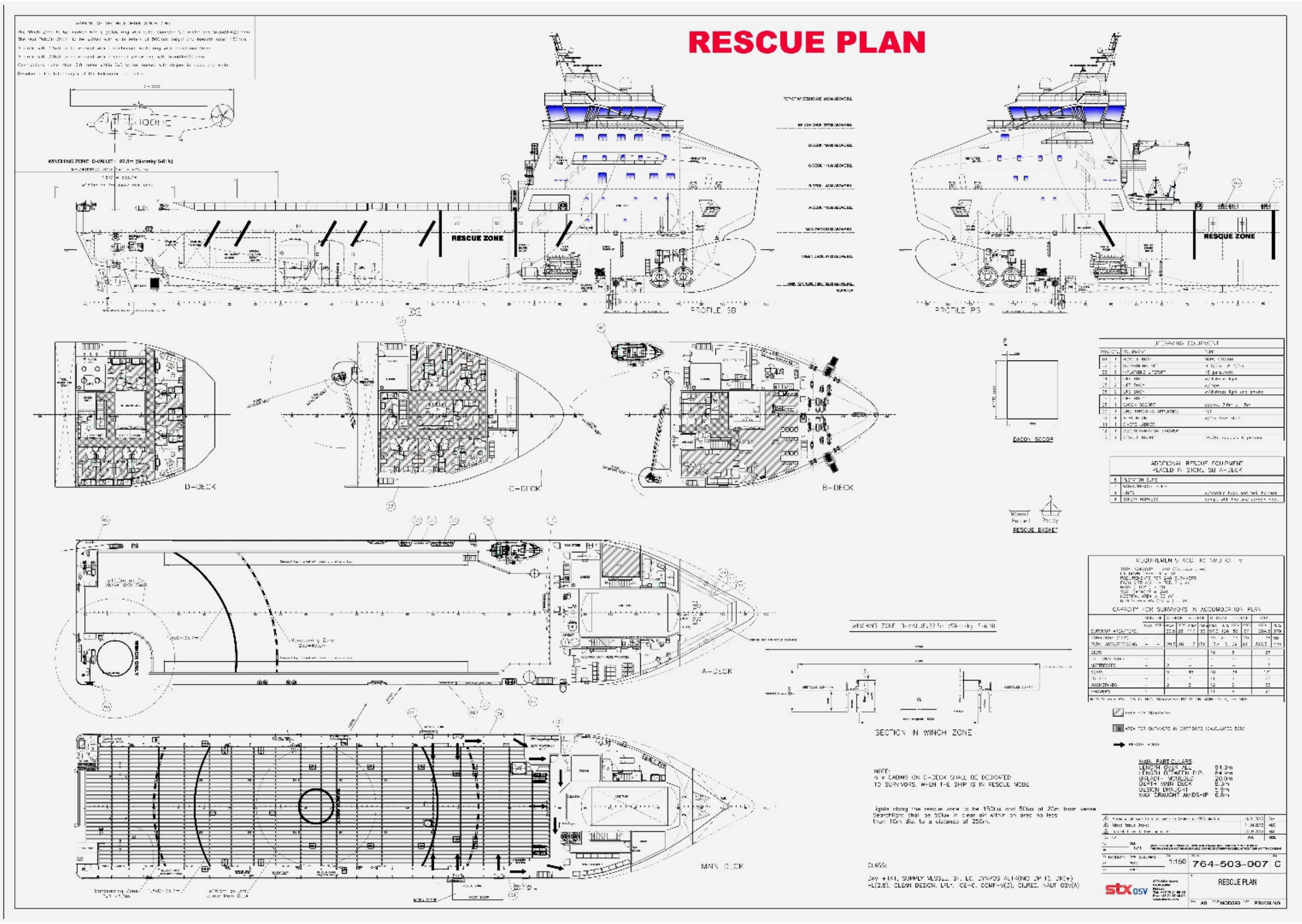
TOPIC 6: HAZARDS, SAFETY, AND PREPAREDNESS

Emergency Preparedness



Notes:

TOPIC 6: HAZARDS, SAFETY, AND PREPAREDNESS



Notes:

STCW
Convention

International Convention on Standards of Training, Certification and Watchkeeping for Seafarers

INCLUDING 2010 MANILA AMENDMENTS

Consolidated edition, 2011

Supplement

April 2017

Since the publication of the STCW Consolidated Edition 2011, the following amendments have been adopted by the Maritime Safety Committee:

Resolution	Amends	Date of entry into force	Page
MSC.396(95)	**STCW Convention** Chapter I: General provisions – *Regulations I/1 and I/11* Chapter V: Special training requirements for personnel on certain types of ships – *New Section V/3*	1 January 2017	2
MSC.397(95)	**STCW Code** Part A: Mandatory standards regarding provisions of the Annex to the STCW Convention – Chapter V: Standards regarding special training requirements for personnel on certain types of ships – *New Section A-V/3*	1 January 2017	4

Resolution MSC.396(95)
adopted on 11 June 2015

International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978

Chapter I
General provisions

Regulation I/1
Definitions and clarifications

1 *In paragraph 1, after the existing subparagraph .40, the following new definition is inserted:*

"**.41** *The IGF Code* means the *International Code of Safety for Ships using Gases or other Low-flashpoint Fuels*, as defined in SOLAS regulation II-1/2.29."

Regulation I/11
Revalidation of certificates

2 *Existing paragraph 1 is amended to read:*

"**1** Every master, officer and radio operator holding a certificate issued or recognized under any chapter of the Convention other than regulation V/3 or chapter VI, who is serving at sea or intends to return to sea after a period ashore, shall, in order to continue to qualify for seagoing service, be required, at intervals not exceeding five years, to:

.1 meet the standards of medical fitness prescribed by regulation I/9; and

.2 establish continued professional competence in accordance with section A-1/11 of the STCW Code."

Chapter V
Special training requirements
for personnel on certain types of ships

3 *The following new regulation V/3 is added after existing regulation V/2:*

"Regulation V/3
Mandatory minimum requirements for the training and qualifications of masters, officers, ratings and other personnel on ships subject to the IGF Code

1 This regulation applies to masters, officers and ratings and other personnel serving on board ships subject to the IGF Code.

2 Prior to being assigned shipboard duties on board ships subject to the IGF Code, seafarers shall have completed the training required by paragraphs 4 to 9 below in accordance with their capacity, duties and responsibilities.

3 All seafarers serving on board ships subject to the IGF Code shall, prior to being assigned shipboard duties, receive appropriate ship and equipment specific familiarization as specified in regulation I/14, paragraph 1.5.

4 Seafarers responsible for designated safety duties associated with the care, use or in emergency response to the fuel on board ships subject to the IGF Code shall hold a certificate in basic training for service on ships subject to the IGF Code.

5 Every candidate for a certificate in basic training for service on ships subject to the IGF Code shall have completed basic training in accordance with provisions of section A-V/3, paragraph 1 of the STCW Code.

6 Seafarers responsible for designated safety duties associated with the care, use or in emergency response to the fuel on board ships subject to the IGF Code who have been qualified and certified according to regulation V/1-2, paragraphs 2 and 5, or regulation V/1-2, paragraphs 4 and 5 on liquefied gas tankers, are to be considered as having met the requirements specified in section A-V/3, paragraph 1 for basic training for service on ships subject to the IGF Code.

7 Masters, engineer officers and all personnel with immediate responsibility for the care and use of fuels and fuel systems on ships subject to the IGF Code shall hold a certificate in advanced training for service on ships subject to the IGF Code.

8 Every candidate for a certificate in advanced training for service on ships subject to the IGF Code shall, while holding the Certificate of Proficiency described in paragraph 4, have:

- **.1** completed approved advanced training for service on ships subject to the IGF Code and meet the standard of competence as specified in section A-V/3, paragraph 2 of the STCW Code; and
- **.2** completed at least one month of approved seagoing service that includes a minimum of three bunkering operations on board ships subject to the IGF Code. Two of the three bunkering operations may be replaced by approved simulator training on bunkering operations as part of the training in paragraph 8.1 above.

9 Masters, engineer officers and any person with immediate responsibility for the care and use of fuels on ships subject to the IGF Code who have been qualified and certified according to the standards of competence specified in section A-V/1-2, paragraph 2 for service on liquefied gas tankers are to be considered as having met the requirements specified in section A-V/3, paragraph 2 for advanced training for ships subject to the IGF Code, provided they have also:

- **.1** met the requirements of paragraph 6; and
- **.2** met the bunkering requirements of paragraph 8.2 or have participated in conducting three cargo operations on board the liquefied gas tanker; and
- **.3** have completed sea going service of three months in the previous five years on board:
  - **.1** ships subject to the IGF Code;
  - **.2** tankers carrying as cargo, fuels covered by the IGF Code; or
  - **.3** ships using gases or low flashpoint fuel as fuel.

10 Every Party shall compare the standards of competence which it required of persons serving on gas-fuelled ships before 1 January 2017 with the standards of competence in Section A-V/3 of the STCW Code, and shall determine the need, if any, for requiring these personnel to update their qualifications.

11 Administrations shall ensure that a Certificate of Proficiency is issued to seafarers, who are qualified in accordance with paragraphs 4 or 7, as appropriate.

12 Seafarers holding Certificates of Proficiency in accordance with paragraph 4 or 7 above shall, at intervals not exceeding five years, undertake appropriate refresher training or be required to provide evidence of having achieved the required standard of competence within the previous five years."

Resolution MSC.397(95)
adopted on 11 June 2015

Seafarers' Training, Certification and Watchkeeping (STCW) Code

Part A
Mandatory standards regarding provisions of the annex to the STCW Convention

Chapter V
Standards regarding special training requirements for personnel on certain types of ships

1 *The following new section A-V/3 is added after existing section A-V/2:*

"**Section A-V/3**
Mandatory minimum requirements for the training and qualification of masters, officers, ratings and other personnel on ships subject to the IGF Code

Basic training for ships subject to the IGF Code

1 Every candidate for a certificate in basic training for service on ships subject to the IGF Code shall:

.1.1 have successfully completed the approved basic training required by regulation V/3, paragraph 5, in accordance with their capacity, duties and responsibilities as set out in table A-V/3-1; and

.1.2 be required to provide evidence that the required standard of competence has been achieved in accordance with the methods and the criteria for evaluating competence tabulated in columns 3 and 4 of table A-V/3-1; or

.2 have received appropriate training and certification according to the requirements for service on liquefied gas tankers as set out in regulation V/3, paragraph 6.

Advanced training for ships subject to the IGF Code

2 Every candidate for a certificate in advanced training for service on ships subject to the IGF Code shall:

.1.1 have successfully completed the approved advanced training required by regulation V/3, paragraph 8 in accordance with their capacity, duties and responsibilities as set out in table A-V/3-2; and

.1.2 provide evidence that the required standard of competence has been achieved in accordance with the methods and the criteria for evaluating competence tabulated in columns 3 and 4 of table A-V/3-2; or

.2 have received appropriate training and certification according to the requirements for service on liquefied gas tankers as set out in regulation V/3, paragraph 9.

Exemptions

3 The Administration may, in respect of ships of less than 500 gross tonnage, except for passenger ships, if it considers that a ship's size and the length or character of its voyage are such as to render the application of the full requirements of this section unreasonable or impracticable, exempt the seafarers on such a ship or class of ships from some of the requirements, bearing in mind the safety of people on board, the ship and property and the protection of the marine environment.

Table A-V/3-1

Specification of minimum standard of competence in basic training for ships subject to the IGF Code

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Contribute to the safe operation of a ship subject to the IGF Code	Design and operational characteristics of ships subject to the IGF Code Basic knowledge of ships subject to the IGF Code, their fuel systems and fuel storage systems: .1 fuels addressed by the IGF Code .2 types of fuel systems subject to the IGF Code .3 atmospheric, cryogenic or compressed storage of fuels on board ships subject to the IGF Code .4 general arrangement of fuel storage systems on board ships subject to the IGF Code .5 hazard zones and areas .6 typical fire safety plan .7 monitoring, control and safety systems aboard ships subject to the IGF Code Basic knowledge of fuels and fuel storage systems' operations on board ships subject to the IGF Code: .1 piping systems and valves .2 atmospheric, compressed or cryogenic storage .3 relief systems and protection screens .4 basic bunkering operations and bunkering systems .5 protection against cryogenic accidents .6 fuel leak monitoring and detection	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	Communications within the area of responsibility are clear and effective Operations related to ships subject to the IGF Code are carried out in accordance with accepted principles and procedures to ensure safety of operations

Table A-V/3-1 *(continued)*

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Contribute to the safe operation of a ship subject to the IGF Code *(continued)*	Basic knowledge of the physical properties of fuels on board ships subject to the IGF Code, including: .1 properties and characteristics .2 pressure and temperature, including vapour pressure/temperature relationship Knowledge and understanding of safety requirements and safety management on board ships subject to the IGF Code		
Take precautions to prevent hazards on a ship subject to the IGF Code	Basic knowledge of the hazards associated with operations on ships subject to the IGF Code, including: .1 health hazards .2 environmental hazards .3 reactivity hazards .4 corrosion hazards .5 ignition, explosion and flammability hazards .6 sources of ignition .7 electrostatic hazards .8 toxicity hazards .9 vapour leaks and clouds .10 extremely low temperatures .11 pressure hazards .12 fuel batch differences Basic knowledge of hazard controls: .1 emptying, inerting, drying and monitoring techniques .2 anti-static measures .3 ventilation .4 segregation .5 inhibition .6 measures to prevent ignition, fire and explosion .7 atmospheric control .8 gas testing .9 protection against cryogenic damages (LNG) Understanding of fuel characteristics on ships subject to the IGF Code as found on a Safety Data Sheet (SDS)	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	Correctly identifies, on a Safety Data Sheet (SDS), relevant hazards to the ship and to personnel, and takes the appropriate actions in accordance with established procedures Identification and actions on becoming aware of a hazardous situation conform to established procedures in line with best practice

Table A-V/3-1 *(continued)*

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Apply occupational health and safety precautions and measures	Awareness of function of gas-measuring instruments and similar equipment: .1 gas testing Proper use of specialized safety equipment and protective devices, including: .1 breathing apparatus .2 protective clothing .3 resuscitators .4 rescue and escape equipment Basic knowledge of safe working practices and procedures in accordance with legislation and industry guidelines and personal shipboard safety relevant to ships subject to the IGF Code, including: .1 precautions to be taken before entering hazardous spaces and zones .2 precautions to be taken before and during repair and maintenance work .3 safety measures for hot and cold work Basic knowledge of first aid with reference to a Safety Data Sheet (SDS)	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	Procedures and safe working practices designed to safeguard personnel and the ship are observed at all times Appropriate safety and protective equipment is correctly used First aid do's and don'ts

Table A-V/3-1 *(continued)*

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Carry out firefighting operations on a ship subject to the IGF Code	Fire organization and action to be taken on ships subject to the IGF Code Special hazards associated with fuel systems and fuel handling on ships subject to the IGF Code Firefighting agents and methods used to control and extinguish fires in conjunction with the different fuels found on board ships subject to the IGF Code Firefighting system operations	Practical exercises and instruction conducted under approved and truly realistic training conditions (e.g. Simulated shipboard conditions) and, whenever possible and practicable, in darkness	Initial actions and follow-up actions on becoming aware of an emergency conform with established practices and procedures Action taken on identifying muster signals is appropriate to the indicated emergency and complies with established procedures Clothing and equipment are appropriate to the nature of the firefighting operations The timing and sequence of individual actions are appropriate to the prevailing circumstances and conditions Extinguishment of fire is achieved using appropriate procedures techniques and firefighting agents
Respond to emergencies	Basic knowledge of emergency procedures, including emergency shutdown	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	The type and impact of the emergency is promptly identified, and the response actions conform to the emergency procedures and contingency plans
Take precautions to prevent pollution of the environment from the release of fuels found on ships subject to the IGF Code	Basic knowledge of measures to be taken in the event of leakage/spillage/venting of fuels from ships subject to the IGF Code, including the need to: .1 report relevant information to the responsible persons .2 awareness of shipboard spill/leakage/venting response procedures .3 awareness of appropriate personal protection when responding to a spill/leakage of fuels addressed by the IGF Code	Examination or assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	Procedures designed to safeguard the environment are observed at all times

Table A-V/3-2

Specification of minimum standard of competence of advanced training for ships subject to the IGF Code

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Familiarity with physical and chemical properties of fuels aboard ships subject to the IGF Code	Basic knowledge and understanding of simple chemistry and physics and the relevant definitions related to safe bunkering and use of fuels used on board ships subject to the IGF Code, including: .1 the chemical structure of different fuels used on board ships subject to the IGF Code .2 the properties and characteristics of fuels used on board ships subject to the IGF Code, including: .2.1 simple physical laws .2.2 states of matter .2.3 liquid and vapour densities .2.4 boil-off and weathering of cryogenic fuels .2.5 compression and expansion of gases .2.6 critical pressure and temperature of gases .2.7 flashpoint, upper and lower flammable limits, auto-ignition temperature .2.8 saturated vapour pressure/reference temperature .2.9 dewpoint and bubble point .2.10 hydrate formation .2.11 combustion properties: heating values .2.12 methane number/ knocking .2.13 pollutant characteristics of fuels addressed by the IGF Code .3 the properties of single liquids .4 the nature and properties of solutions	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	Effective use is made of information resources for identification of properties and characteristics of fuels addressed by the IGF Code and their impact on safety, environmental protection and ship operation

Table A-V/3-2 *(continued)*

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Familiarity with physical and chemical properties of fuels aboard ships subject to the IGF Code *(continued)*	.5 thermodynamic units .6 basic thermodynamic laws and diagrams .7 properties of materials .8 effect of low temperature, including brittle fracture, for liquid cryogenic fuels Understanding the information contained in a Safety Data Sheet (SDS) about fuels addressed by the IGF Code		
Operate controls of fuel related to propulsion plant and engineering systems and services and safety devices on ships subject to the IGF Code	Operating principles of marine power plants Ships' auxiliary machinery Knowledge of marine engineering terms	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	Plant, auxiliary machinery and equipment is operated in accordance with technical specifications and within safe operating limits at all times

Table A-V/3-2 *(continued)*

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Ability to safely perform and monitor all operations related to the fuels used on board ships subject to the IGF Code	Design and characteristics of ships subject to the IGF Code Knowledge of ship design, systems, and equipment found on ships subject to the IGF Code, including: .1 fuel systems for different propulsion engines .2 general arrangement and construction .3 fuel storage systems on board ships subject to the IGF Code, including materials of construction and insulation .4 fuel-handling equipment and instrumentations on board ships: .4.1 fuel pumps and pumping arrangements .4.2 fuel pipelines .4.3 expansion devices .4.4 flame screens .4.5 temperature monitoring systems .4.6 fuel tank level gauging systems .4.7 tank pressure monitoring and control systems .5 cryogenic fuel tanks temperature and pressure maintenance .6 fuel system atmosphere control systems (inert gas, nitrogen), including storage, generation and distribution .7 toxic and flammable gas-detecting systems .8 fuel Emergency Shut Down system (ESD)	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	Communications are clear and understood Successful ship operations using fuels addressed by the IGF Code are carried out in a safe manner, taking into account ship designs, systems and equipment Pumping operations are carried out in accordance with accepted principles and procedures and are relevant to the type of fuel Operations are planned, risk is managed and carried out in accordance with accepted principles and procedures to ensure safety of operations and to avoid pollution of the marine environment

Table A-V/3-2 *(continued)*

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Ability to safely perform and monitor all operations related to the fuels used on board ships subject to the IGF Code *(continued)*	Knowledge of fuel system theory and characteristics, including types of fuel system pumps and their safe operation on board ships subject to the IGF Code .1 low pressure pumps .2 high pressure pumps .3 vaporizers .4 heaters .5 pressure build up units Knowledge of safe procedures and checklists for taking fuel tanks in and out of service, including: .1 inerting .2 cooling down .3 initial loading .4 pressure control .5 heating of fuel .6 emptying systems		

Table A-V/3-2 *(continued)*

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Plan and monitor safe bunkering, stowage and securing of the fuel on board ships subject to the IGF Code	General knowledge of ships subject to the IGF Code Ability to use all data available on board related to bunkering, storage and securing of fuels addressed by the IGF Code Ability to establish clear and concise communications and between the ship and the terminal, truck or the bunker-supply ship Knowledge of safety and emergency procedures for operation of machinery, fuel- and control systems for ships subject to the IGF Code Proficiency in the operation of bunkering systems on board ships subject to the IGF Code including: .1 bunkering procedures .2 emergency procedures .3 ship-shore/ship-ship interface .4 prevention of rollover Proficiency to perform fuel system measurements and calculations, including: .1 maximum fill quantity .2 On Board Quantity (OBQ) .3 Minimum Remain On Board (ROB) .4 fuel consumption calculations Ability to ensure the safe management of bunkering and other IGF Code fuel related operations concurrent with other onboard operations, both in port and at sea	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved simulator training .3 approved training programme .4 approved laboratory equipment training or witnessing bunker operation	Fuel quality and quantity is determined taking into account the current conditions and necessary corrective safe measures are taken Procedures for monitoring safety systems to ensure that all alarms are detected promptly and acted upon in accordance with established procedures Operations are planned and carried out in accordance with fuel transfer manuals and procedures to ensure safety of operations and avoid spill damages and pollution of the environment Personnel are allocated duties and informed of procedures and standards of work to be followed, in a manner appropriate to the individuals concerned and in accordance with safe working procedures

Table A-V/3-2 *(continued)*

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Take precautions to prevent pollution of the environment from the release of fuels from ships subject to the IGF Code	Knowledge of the effects of pollution on human and environment Knowledge of measures to be taken in the event of spillage/ leakage/ venting	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	Procedures designed to safeguard the environment are observed at all times
Monitor and control compliance with legislative requirements	Knowledge and understanding of relevant provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL), as amended and other relevant IMO instruments, industry guidelines and port regulations as commonly applied Proficiency in the use of the IGF Code and related documents	Assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	The handling of fuels on board ships subject to the IGF Code complies with relevant IMO instruments and established industrial standards and codes of safe working practices Operations are planned and performed in conformity with approved procedures and legislative requirements

Table A-V/3-2 *(continued)*

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Take precautions to prevent hazards	Knowledge and understanding of the hazards and control measures associated with fuel system operations on board ships subject to the IGF Code, including: .1 flammability .2 explosion .3 toxicity .4 reactivity .5 corrosivity .6 health hazards .7 inert gas composition .8 electrostatic hazards .9 pressurized gases .10 low temperature Proficiency to calibrate and use monitoring and fuel detection systems, instruments and equipment on board ships subject to the IGF Code Knowledge and understanding of dangers of non-compliance with relevant rules/regulations Knowledge and understanding of risks assessment method analysis on board ships subject to the IGF Code Ability to elaborate and develop risks analysis related to risks on board ships subject to the IGF Code Ability to elaborate and develop safety plans and safety instructions for ships subject to the IGF Code Knowledge of hot work, enclosed spaces and tank entry including permitting procedures	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	Relevant hazards to the ship and to personnel associated with operations on board ships subject to the IGF Code are correctly identified and proper control measures are taken Use of flammable and toxic gas detection devices are in accordance with manuals and good practice

Table A-V/3-2 *(continued)*

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Apply occupational health and safety precautions and measures on board a ship subject to the IGF Code	Proper use of safety equipment and protective devices, including: .1 breathing apparatus and evacuating equipment .2 protective clothing and equipment .3 resuscitators .4 rescue and escape equipment Knowledge of safe working practices and procedures in accordance with legislation and industry guidelines and personal shipboard safety including: .1 precautions to be taken before, during and after repair and maintenance work on fuel systems addressed in the IGF Code .2 electrical safety (reference to IEC 60079-17) .3 ship/shore safety checklist Basic knowledge of first aid with reference to a Safety Data Sheets (SDS) for fuels addressed by the IGF Code	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	Appropriate safety and protective equipment is correctly used Procedures designed to safeguard personnel and the ship are observed at all times Working practices are in accordance with legislative requirements, codes of practice, permits to work and environmental concerns First aid do's and don'ts
Knowledge of the prevention, control and firefighting and extinguishing systems on board ships subject to the IGF Code	Knowledge of the methods and firefighting appliances to detect, control and extinguish fires of fuels addressed by the IGF Code	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training .4 approved training programme	The type and scale of the problem is promptly identified, and initial actions conform with the emergency procedures for fuels addressed by the IGF Code Evacuation, emergency shutdown and isolation procedures are appropriate to the fuels addressed by the IGF Code

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Liquefied Natural Gas

Material Safety Data Sheet

1. PRODUCT AND COMPANY IDENTIFICATION

Product Name	**Liquefied Natural Gas**
UN-Number	UN1972
Recommended Use	Industrial use.
Synonyms	LNG
Supplier Address*	Linde Gas North America LLC - Linde Merchant Production Inc. - Linde LLC 575 Mountain Ave. Murray Hill, NJ 07974 Phone: 908-464-8100 www.lindeus.com Linde Gas Puerto Rico, Inc. Las Palmas Village Road No. 869, Street No. 7 Catano, Puerto Rico 00962 Phone: 787-641-7445 www.pr.lindegas.com Linde Canada Limited 5860 Chedworth Way Mississauga, Ontario L5R 0A2 Phone: 905-501-1700 www.lindecanada.com * May include subsidiaries or affiliate companies/divisions. For additional product information contact your local customer service.
Chemical Emergency Phone Number	Chemtrec: 1-800-424-9300 for US/ 703-527-3887 outside US

2. HAZARDS IDENTIFICATION

DANGER!

Emergency Overview

Extremely flammable
Extremely cold liquid and gas under pressure.
May cause skin, eye, and respiratory tract irritation
Asphyxiant at high concentrations
May cause central nervous system depression
Contents under pressure
Keep at temperatures below 52°C / 125°F

Appearance Colorless. **Physical State** Cryogenic Liquid. **Odor** Petroleum like

OSHA Regulatory Status	This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Potential Health Effects

Principle Routes of Exposure Inhalation.

Acute Toxicity

Inhalation May cause central nervous system depression with nausea, headache, dizziness, vomiting, and incoordination. Simple asphyxiant. May cause suffocation by displacing the oxygen in the air. Exposure to oxygen-deficient atmosphere (<19.5%) may cause dizziness, drowsiness, nausea, vomiting, excess salivation, diminished mental alertness, loss of consciousness and death. Exposure to atmospheres containing 8-10% or less oxygen will bring about unconsciousness without warning and so quickly that the individuals cannot help or protect themselves. Lack of sufficient oxygen may cause serious injury or death.

Eyes Contact with product may cause frostbite.

Skin May cause frostbite.

Skin Absorption Hazard No known hazard in contact with skin.

Ingestion Not an expected route of exposure.

Chronic Effects None known.

Aggravated Medical Conditions Respiratory disorders.

Environmental Hazard See Section 12 for additional Ecological Information.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Name	CAS-No	Volume %	Chemical Formula
Methane	74-82-8	62-93	CH_4
Nitrogen	7727-37-9	1-9	N_2
Propane	74-98-6	1-7	C_3H_8
Ethane	74-84-0	3-11	C_2H_6
N-Butane	106-97-8	1-3	C_4H_{10}
Isobutane	75-28-5	1-3	C_4H_{10}
Helium	7440-59-7	<2	He
Isopentane	78-78-4	<1	C_5H_{12}
Pentane	109-66-0	<1	C_5H_{12}
Carbon dioxide	124-38-9	<1	CO_2

4. FIRST AID MEASURES

Eye Contact In the case of contact with eyes, rinse immediately with plenty of water and seek medical advice. If frostbite is suspected, flush eyes with cool water for 15 minutes and obtain immediate medical attention.

Skin Contact Wash off immediately with plenty of water. If skin irritation persists, call a physician. For dermal contact or suspected frostbite, remove contaminated clothing and flush affected areas with lukewarm water. DO NOT USE HOT WATER. A physican should see the patient promptly if contact with the product has resulted in blistering of the dermal surface or in deep tissue freezing.

Inhalation	PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF INHALATION OVEREXPOSURE. RESCUE PERSONNEL SHOULD BE EQUIPPED WITH SELF-CONTAINED BREATHING APPARATUS. Conscious inhalation victims should be assisted to an uncontaminated area and inhale fresh air. If breathing is difficult, administer oxygen. Unconscious persons should be moved to an uncontaminated area and, as necessary, given artificial resuscitation and supplemental oxygen. Treatment should be symptomatic and supportive.
Ingestion	None under normal use. Get medical attention if symptoms occur.
Notes to Physician	Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Flammable Properties	Extremely flammable.
Suitable Extinguishing Media	Dry chemical or CO_2. Water spray or fog. DO NOT EXTINGUISH A LEAKING GAS FIRE UNLESS LEAK CAN BE STOPPED.
Hazardous Combustion Products	Carbon monoxide. Carbon dioxide (CO_2).

<u>Explosion Data</u>

Sensitivity to Mechanical Impact	None
Sensitivity to Static Discharge	Yes.
Specific Hazards Arising from the Chemical	May form explosive mixtures with air. Continue to cool fire exposed cylinders until flames are extinguished. Cylinders may rupture under extreme heat. Damaged cylinders should be handled only by specialists. Vapors from liquefied gas are initially heavier than air and spread along ground. Vapors may travel to source of ignition and flash back.
Protective Equipment and Precautions for Firefighters	If possible, stop the flow of gas. Do not extinguish the fire until supply is shut off as otherwise an explosive-ignition may occur. If the fire is extinguished and the flow of gas continues, use increased ventilation to prevent build-up of explosive atmosphere. Ventilation fans must be explosion proof. Use non-sparking tools to close container valves. Use water spray to cool surrounding containers. Be cautious of a Boiling Liquid Evaporating Vapor Explosion, BLEVE, if flame is impinging on surrounding containers. As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions	ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Wear self-contained breathing apparatus when entering area unless atmosphere is proved to be safe. Monitor oxygen level.
Environmental Precautions	Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. Prevent spreading of vapors through sewers, ventilation systems and confined areas.
Methods for Containment	Stop the flow of gas or remove cylinder to outdoor location if this can be done without risk. If leak is in container or container valve, contact the appropriate emergency telephone number in Section 1 or call your closest Linde location.
Methods for Cleaning Up	Return cylinder to Linde or an authorized distributor.

7. HANDLING AND STORAGE

Handling

Ground and bond all lines and equipment associated with product system. All equipment should be non-sparking and explosion proof. Remove all sources of ignition. Use only in ventilated areas. "NO SMOKING" signs should be posted in storage and use areas.

Never attempt to lift a cylinder by its valve protection cap. Protect cylinders from physical damage; do not drag, roll, slide or drop. When moving cylinders, even for short distance, use a cart designed to transport cylinders. Use equipment rated for cylinder pressure. Use backflow preventive device in piping.

Use an adjustable strap wrench to remove over-tight or rusted caps. Never insert an object (e.g. wrench, screwdriver, pry bar,etc.) into valve cap openings. Doing so may damage valve, causing leak to occur. If user experiences any difficulty operating cylinder valve discontinue use and contact supplier.

Never put cylinders into trunks of cars or unventilated areas of passenger vehicles. Never attempt to refill a compressed gas cylinder without the owner's written consent. Never strike an arc on a compressed gas cylinder or make a cylinder a part of an electrical circuit.

For additional recommendations, consult Compressed Gas Association Pamphlets P-1, P-14, and Safety Bulletin SB-2.

Storage

Outside or detached storage is preferred. Protect from physical damage. Cylinders should be stored upright with valve protection cap in place and firmly secured to prevent falling. Store in cool, dry, well-ventilated area of non-combustible construction away from heavily trafficked areas and emergency exits. Keep at temperatures below 52°C / 125°F. Full and empty cylinders should be segregrated. Use a "first in-first out" inventory system to prevent full cylinders from being stored for excessive periods of time. Always store and handle compressed gas cylinders in accordance with Compressed Gas Association, pamphlet CGA-P1, Safe Handling of Compressed Gases in Containers.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Guidelines

Chemical Name	ACGIH TLV	OSHA PEL	NIOSH IDLH
Isopentane 78-78-4	TWA: 600 ppm		
Carbon dioxide 124-38-9	STEL = 30000 ppm TWA: 5000 ppm	TWA: 5000 ppm TWA: 9000 mg/m^3 (vacated) TWA: 10000 ppm (vacated) TWA: 18000 mg/m^3 (vacated) STEL: 30000 ppm (vacated) STEL: 54000 mg/m^3	IDLH: 40000 ppm TWA: 5000 ppm TWA: 9000 mg/m^3 STEL: 30000 ppm STEL: 54000 mg/m^3
N-Butane 106-97-8	TWA: 1000 ppm	(vacated) TWA: 800 ppm (vacated) TWA: 1900 mg/m^3	TWA: 800 ppm TWA: 1900 mg/m^3
Pentane 109-66-0	TWA: 600 ppm	TWA: 1000 ppm TWA: 2950 mg/m^3 (vacated) TWA: 600 ppm (vacated) TWA: 1800 mg/m^3 (vacated) STEL: 750 ppm (vacated) STEL: 2250 mg/m^3	IDLH: 1500 ppm Ceiling: 610 ppm 15 min Ceiling: 1800 mg/m^3 15 min TWA: 120 ppm TWA: 350 mg/m^3
Methane 74-82-8	TWA: 1000 ppm		
Ethane 74-84-0	TWA: 1000 ppm		
Propane 74-98-6	TWA: 1000 ppm	TWA: 1000 ppm TWA: 1800 mg/m^3	IDLH: 2100 ppm TWA: 1000 ppm TWA: 1800 mg/m^3
Isobutane 75-28-5	TWA: 1000 ppm	N/A	N/A

Immediately Dangerous to Life or Health.

Other Exposure Guidelines Vacated limits revoked by the Court of Appeals decision in AFL-CIO v. OSHA, 965 F.2d 962 (11th Cir., 1992).

Engineering Measures Showers. Eyewash stations. Explosion proof ventilation systems.

Ventilation Use ventilation adequate to keep exposures below recommended exposure limits.

Personal Protective Equipment

Eye/Face Protection Wear protective eyewear (safety glasses).

Skin and Body Protection Work gloves and safety shoes are recommended when handling cylinders. Wear cold insulating gloves when handling liquid. Cotton or Nomex® clothing is recommended to prevent static build-up.

Respiratory Protection

General Use If exposure limits are exceeded or irritation is experienced, NIOSH/MSHA approved respiratory protection should be worn. Positive-pressure supplied air respirators may be required for high airborne contaminant concentrations. Respiratory protection must be provided in accordance with current local regulations.

Emergency Use Use positive pressure airline respirator with escape cylinder or self contained breathing apparatus for oxygen-deficient atmospheres (<19.5%).

Hygiene Measures Wear suitable gloves and eye/face protection.

9. PHYSICAL AND CHEMICAL PROPERTIES

Product Information

Appearance	Colorless.	**Odor**	Petroleum like.
Odor Threshold	No information available	**Physical State**	Cryogenic Liquid
Flash Point	-306°F / -188°C	**Flashpoint Method**	Closed cup
Autoignition Temperature	580°C / 1076°F	**Flammability Limits in Air**	
		Upper	15%
		Lower	5%

The following information is for the NON-INERT components of this mixture:

Chemical Name	Boiling Point	Melting Point	Molecular Weight	Evaporation Rate	Water Solubility	Vapor Pressure	Vapor Density (Air=1)	Gas Density Kg/m^3@20°C
Isopentane	28 °C	-160 °C	72.14	-	No information available		2.5	3.212 @15°
Carbon dioxide	56 °C	-56 °C	44.00	-	0.145 g/ml @ 25°C	838 psig (5778 kPa) @ 21.1°C	1.522	1.839
Pentane	36°C	<-50 °C	72.14		No information available	1100 hPa @ 38 °C	2.5	3.228 @15°
N-Butane	-0.5 °C	-138.3 °C	58.12	-	No information available	2200 hPa @ 20 °C	2.11	2.52 @15°
Methane	-162 °C	-182.5 °C	16.04	-	No information available	46700 hPa @ -82.5 °C	0.56	0.668 @15°
Ethane	-88.7°C	-183 - -20 °C	30.06	-	No information available	600 - 39000 hPa @ 20 °C	1.05	1.282 @15°
Propane	-42.1°C	-183 - -20 °C	44.09	-	No information available	600 - 39000 hPa @ 20 °C	1.55	1.99 @15°
Isobutane	-11.7 °C	-255 °C	58.12	-	No information available	2100 hPa @ 20 °C	2.06	2.51 @15°

The following information is for the INERT components that may be part of this mixture:

Chemical Name	Boiling Point	Melting Point	Molecular Weight	Evaporation Rate	Water Solubility	Vapor Pressure	Vapor Density (Air=1)	Gas Density Kg/m^3@20°C
Helium	-268.94 °C	-272.0 °C	4.00	-	0.0089 (vol/vol @ 20°C and 1 atm)	Above critical temperature	0.138	0.166
Nitrogen	-196 °C	-210 °C	28.01	-	0.023 (vol/vol @ 20°C and 1 atm)	Above critical temperature	0.97	1.165

10. STABILITY AND REACTIVITY

Stability	Stable.
Incompatible Products	Oxidizing agents.
Conditions to Avoid	Heat, flames and sparks.
Hazardous Decomposition Products	Carbon monoxide (CO). Carbon dioxide (CO_2).
Hazardous Polymerization	Hazardous polymerization does not occur.

11. TOXICOLOGICAL INFORMATION

Acute Toxicity

Product Information

LD50 Oral: No information available.

LD50 Dermal: No information available.

LC50 Inhalation: No information available.

Repeated Dose Toxicity No information available.

Component Information No information available.

Chemical Name	LD50 Oral	LD50 Dermal	LC50 Inhalation
Propane		-	= 658 mg/L (Rat) 4 h
Ethane			= 658 mg/L (Rat) 4 h
N-Butane			658 mg/L (Rat) 4 h
Isobutane			= 658 mg/L (Rat) 4 h
Isopentane			= 280000 mg/m^3 (Rat) 4 h
Pentane	> 2000 mg/kg (Rat)	= 3000 mg/kg (Rabbit)	= 364 g/m^3 (Rat) 4 h
Carbon dioxide			470000 ppm (Rat)

Chronic Toxicity

Chronic Toxicity None known.

Carcinogenicity Contains no ingredient listed as a carcinogen.

Irritation No information available.

Sensitization No information available.

Reproductive Toxicity No information available.

Developmental Toxicity Oxygen deficiency during pregnancy has produced developmental abnormalities in humans and experimental animals.

Synergistic Materials None known.

Target Organ Effects None known.

12. ECOLOGICAL INFORMATION

Ecotoxicity

Will not bioconcentrate.

Ozone depletion potential; ODP; (R-11 = 1): Does not contain ozone depleting chemical (40 CFR Part 82).

Chemical Name	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Isopentane				EC50 48 h: = 2.3 mg/L (Daphnia magna)

Chemical Name	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Pentane		LC50 96 h: = 11.59 mg/L (Pimephales promelas) LC50 96 h: = 9.87 mg/L (Oncorhynchus mykiss) LC50 96 h: = 9.99 mg/L (Lepomis macrochirus)		EC50 48 h: = 9.74 mg/L (Daphnia magna)

Chemical Name	Log Pow
Isopentane	3.3
N-Butane	2.89
Pentane	3.39
Ethane	2.8
Propane	2.3
Isobutane	2.88

13. DISPOSAL CONSIDERATIONS

Waste Disposal Methods Do not attempt to dispose of residual waste or unused quantities. Return in the shipping container PROPERLY LABELED WITH ANY VALVE OUTLET PLUGS OR CAPS SECURED AND VALVE PROTECTION CAP IN PLACE to Linde for proper disposal. This material, as supplied, is a hazardous waste according to federal regulations (40 CFR 261).

14. TRANSPORT INFORMATION

DOT

Proper shipping name	Methane, refrigerated liquid
Hazard Class	2.1
Subsidiary Class	None
UN-Number	UN1972
Description	UN1972,Methane, refrigerated liquid,2.1
Emergency Response Guide Number	115

TDG

Proper Shipping Name	Methane, refrigerated liquid
Hazard Class	2.1
UN-Number	UN1972
Description	UN1972,METHANE, REFRIGERATED LIQUID,2.1

MEX

Proper Shipping Name	Methane, refrigerated liquid
Hazard Class	2.1
UN-Number	UN1972
Description	UN1972 Methane, refrigerated liquid,2.1

IATA

UN-Number	UN1972
Proper Shipping Name	Natural gas, refrigerated liquid
Hazard Class	2.1
ERG Code	10L

Description	UN1972,Natural gas, refrigerated liquid,2.1
Maximum Quantity for Passenger	Forbidden
Maximum Quantity for Cargo Only	Forbidden
Limited Quantity	Forbidden

IMDG/IMO

Proper Shipping Name	Methane, refrigerated liquid
Hazard Class	2.1
UN-Number	UN1972
EmS No.	F-D, S-U
Description	UN1972, Methane, refrigerated liquid,2.1, FP -188C

ADR

Proper Shipping Name	Methane, refrigerated liquid
Hazard Class	2.1
UN-Number	UN1972
Classification Code	3F
Description	UN1972 Methane, refrigerated liquid,2.1,

15. REGULATORY INFORMATION

International Inventories

TSCA	Complies
DSL	Complies
EINECS/ELINCS	Complies

Legend

TSCA - United States Toxic Substances Control Act Section 8(b) Inventory
DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List
EINECS/ELINCS - European Inventory of Existing Commercial Chemical Substances/EU List of Notified Chemical Substances

U.S. Federal Regulations

SARA 313
Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372.

SARA 311/312 Hazard Categories

Acute Health Hazard	Yes
Chronic Health Hazard	No
Fire Hazard	Yes
Sudden Release of Pressure Hazard	Yes
Reactive Hazard	No

Clean Water Act
This product does not contain any substances regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42).

Risk and Process Safety Management Programs
This material, as supplied, contains one or more regulated substances with specified thresholds under 40 CFR Part 68 or regulated as a highly hazardous chemical pursuant to the 29 CFR Part 1910.110 with specified thresholds:

Chemical Name	U.S. - CAA (Clean Air Act) - Accidental Release Prevention - Toxic Substances	U.S. - CAA (Clean Air Act) - Accidental Release Prevention - Flammable Substances	U.S. - OSHA - Process Safety Management - Highly Hazardous Chemicals
Isopentane		10000 lbs	
N-Butane		10000 lbs	
Pentane		10000 lbs	
Methane		10000 lbs	
Ethane		10000 lbs	
Propane		10000 lbs	
Isobutane		10000 lbs	

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contain any substances regulated as hazardous air pollutants (HAPS) under Section 112 of the Clean Air Act Amendments of 1990.

CERCLA/SARA
This material, as supplied, does not contain any substances regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund Amendments and Reauthorization Act (SARA) (40 CFR 355). There may be specific reporting requirements at the local, regional, or state level pertaining to releases of this material.

U.S. State Regulations

California Proposition 65
This product does not contain any Proposition 65 chemicals.

U.S. State Right-to-Know Regulations

Chemical Name	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Helium	X	X	X	-	X
Isopentane	X	X	X		
Carbon dioxide	X	X	X	-	X
N-Butane	X	X	X		X
Pentane	X	X	X		X
Methane	X	X	X		X
Ethane	X	X	X		X
Propane	X	X	X		X
Isobutane	X	X	X		
Nitrogen	X	X	X	-	X

International Regulations

Chemical Name	Carcinogen Status	Exposure Limits
Carbon dioxide	-	Mexico: TWA= 5000 ppm Mexico: TWA= 9000 mg/m^3 Mexico: STEL= 15000 ppm Mexico: STEL= 27000 mg/m^3
N-Butane		Mexico: TWA 800 ppm Mexico: TWA 1900 mg/m^3
Pentane		Mexico: TWA 600 ppm Mexico: TWA 1800 mg/m^3 Mexico: STEL 760 ppm Mexico: STEL 2250 mg/m^3

Canada

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

WHMIS Hazard Class
A Compressed gases
B1 Flammable gas

16. OTHER INFORMATION

Prepared By	Product Stewardship 23 British American Blvd. Latham, NY 12110 1-800-572-6501
Issuing Date	22-Sep-2011
Revision Date	
Revision Number	0
Revision Note	Initial Release.

NFPA	Health Hazard 3	Flammability 4	Stability 0	Physical and Chemical Hazards -
HMIS	Health Hazard 3	Flammability 4	Physical Hazard 2	Personal Protection -

Note: Ratings were assigned in accordance with Compressed Gas Association (CGA) guidelines as published in CGA Pamphlet P-19-2009, CGA Recommended Hazard Ratings for Compressed Gases, 3rd Edition.

End of Safety Data Sheet

No. 142 (cont) Chapter 3 - Functional and General Requirements for LNG Bunkering Operation

Section 1 **Pre-bunkering phase**

Section 2 **Bunkering phase**

Section 3 **Bunkering completion phase**

No. 142 (cont)

Section 1 - Pre-bunkering phase

1.1 Definition

The pre-bunkering phase starts from the first communication between receiving ship and bunkering facility for ordering a bunker of LNG, and ends with the physical connection of the bunker line to the bunker station.

1.2 Goal

The goal of the pre-bunkering phase is the preparation and the completion of a safe connection between the transfer systems of the bunkering facility and the receiving ship.

1.3 Functional requirements

The following functional requirements should be considered during the pre-bunkering phase:

- The risk assessment has been conducted and the findings have been implemented.
- An LNG Bunker Management Plan has been established and is applicable to the ship.
- A compatibility check demonstrates that the safety and bunkering systems of the bunkering facility and the ship to be bunkered match.
- The necessary authorities have been informed regarding the LNG bunkering operation.
- The permission for the transfer operation is available from the relevant authority.
- The boundary conditions such as transfer rate, boil-off handling and loading limit have been agreed between the supplier and the ship to be bunkered.
- Initial checks of the bunkering and safety system are conducted to ensure a safe transfer of LNG during the bunkering phase.

1.4 General requirements

1.4.1 Personnel on duty

During the transfer operation, personnel in the safety zone should be limited to essential staff only. All staff engaged in duties or working in the vicinity of the operations should wear appropriate personal protective equipment (PPE) and an individual portable gas detector as required by the LNG Bunker Management Plan.

1.4.2 Compatibility assessment (prior to confirming the bunkering operation)

A compatibility assessment of the bunkering facility and receiving ship should be undertaken prior to confirming the bunkering operation to identify any aspects that require particular management.

The compatibility assessment should be undertaken with the assistance of an appropriate Checklist to be completed and agreed by Master(s) and PIC prior to engaging in the bunkering operation.

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As a minimum, compatibility of the following equipment and installation should be checked prior to engaging further in any LNG bunkering operation:

- Communication system (hardware, software if any and language) between the PIC, ship's crew and BFO personnel
- ESD system
- Bunker connection
- Emergency release system (ERS) or coupling (ERC)
- Vapour return line when appropriate
- Nitrogen lines availability and connection
- Mooring equipment
- Bunker Station location
- Transfer system sizing and loading on manifold
- Location of ERS
- Closure speed of valves
- HAZOP results as applicable

1.5 Preparation for bunker transfer

1.5.1 Environmental conditions

The environmental conditions (weather (especially lightening), sea state, temperature, and visibility limitation such as fog or mist) should be acceptable in terms of safety for all the parties involved.

1.5.2 Mooring

1.5.2.1 Mooring condition of receiving ship

The ship should be securely moored to the bunker supplier to prevent excessive relative movement during the bunkering operation.

1.5.2.2 Mooring condition of bunker ship

For ship-to-ship bunkering the bunker ship should be securely moored according to the result of the compatibility check, so that excessive movements and overstressing of the bunkering connections can be avoided. Refer to 1.7.3 below. For the mooring of the bunker ship the limiting conditions should be considered such as weather, tide, strong wind and waves.

1.5.2.3 Parking condition of truck LNG tanker(s)

The truck LNG tanker(s) should be securely parked, to prevent unintended movements.

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All ignition sources linked to the truck are to be managed in accordance with the bunkering management plan/procedure taking into account Hazardous areas and Safety Zones. Any situation whereby this requirement cannot be met, special consideration must be provided (i.e. non-standard) to ensure the risk of ignition is managed to ALARP.

In any case, the truck engine should not be running during connection and disconnection of the transfer system.

1.5.3 Communication

Communication should be satisfactorily established between the bunkering facility and the receiving ship prior to any transfer operation. If they are to be used, visible signals should be agreed by and clear to all the personnel involved in the LNG bunkering operation.

In case of communication failure, bunkering operations should be stopped and not resumed until communication is re-established.

1.5.4 Agreement of the transfer conditions

The following should be agreed before commencing the bunker transfer:

- Transfer time, temperature and pressure of the delivered LNG, pressure inside the receiving ship tank, delivery line measurement, vapour return line measurement (if any) should be agreed and checked prior to engaging in any LNG Bunkering Operation.

- The maximum LNG temperature that the receiving ship can handle should be stated by the receiving ship in order to avoid excessive boil-off generation.

- Liquid levels, temperature and pressure for the LNG bunker tanks of the receiving ship should be checked and noted on the bunkering checklist.

- The maximum loading level and transfer rate, including cool down and topping up should be agreed upon. This includes the pressure capacity of pumps and relieving devices in the connected transfer system. The filling limit of the receiving tank depends on MARVS (as per IGC / IGF codes) and accounts for the possible expansion of cold LNG.

The agreed transfer conditions should be included in the LNG Bunker Management Plan.

1.5.5 Individual safety equipment in place (PPE)

All personnel involved in the LNG bunkering operation should properly wear adequate Personal Protective Equipment (PPE). It should be ensured that all the PPEs have been checked for compliance and are ready and suitable for use.

1.5.6 Protection of the hull plate, shell side and ship structure

Protection from cryogenic brittle fracture of the receiving ship deck and structure caused by leakage of LNG should be fitted as per IGF code requirements.

When appropriate one or more of the following protective measures may be utilised:

- A water curtain may be installed to protect the ship's hull.

- A cover of suitable material grade to withstand LNG temperatures may be installed underneath the transfer hose to protect deck plating.

- A drip tray of suitable material grade to withstand LNG temperatures may be fitted below the pipe coupling to collect LNG spill.

It is recommended that spill protection is also provided for the BFO equipment, this may be governed by local regulations for truck-to-ship bunkering and shore based facilities.

1.5.7 Safety zone requirements and mark out

- The boundaries of the safety zone associated with bunker station and BFO connection should be clearly marked out.

- Any non-EX equipment installed in hazardous areas and/or in safety zone, such as the bunker station, should be electrically isolated before the bunkering operation commences and throughout the bunkering process until such time as the area is free of any gas leak hazard. Any such arrangement where there is non-Ex rated equipment installed in a hazardous zone should be subject to special consideration by the classification society.

- Radio communications equipment not needed during bunkering and cell phones should be switched off as appropriate.

1.5.8 Electric isolation

A single isolation flange should be provided, in each arm or hose of the transfer system, between the receiving ship manifold and the bunker pipeline. The installation should not permit shorting out of this insulation for example by, leaving the flange resting in stainless steel drip tray. This flange prevents galvanic current flow between the receiving ship and the bunkering facility. Steel to steel contact between receiving ship and bunkering facility e.g. via mooring lines, ladders, gangways, chains for fender support etc. should be avoided through the use of insulation. Bunker hoses/pipes should be supported and isolated to prevent electrical contact with the receiving ship.

When bunkering from trucks, the truck should be grounded to an earthing point at the quay to prevent static electricity build up. Where approval has been given for the bunkering truck to be parked on the deck of the ship then the truck should be grounded to the receiving ship.

Ship-shore bonding cables/straps should not be used unless required by national or local regulations.

If national or local regulations require a bonding cable/strap to be used, the circuit continuity should be made via a ‘certified safe’ switch (e.g. one housed inside a flame proof enclosure) and the connection on board the receiving ship should be in a location remote safe area from the hazardous area. The switch should not be closed until the bonding cable/strap has been connected, and it should be opened prior to disconnection of the bonding strap.

1.5.9 ERS

Simulated testing of all types of coupling having the function of ERC within the ERS should be performed according to a recognised standard. Testing records should be retained with the bunkering operator or organisation responsible for such equipment ready for immediate inspection by authorities. Any transfer /support system should be proved operational (if necessary by inspection of marine loading arm or supported hose) and be confirmed as part of the pre-transfer checklist.

Testing of the system prior to each bunkering operation should prove all components are satisfactory, with the exception of actually releasing the ERC. The system used to link the ERS system with the ships' ESD1 trip circuit should be tested and proved operational.

1.5.10 Emergency Release Coupling (Break away coupling)

The disconnection can be triggered manually or automatically. In either case, activation of the ERS system should trigger activation of the ESD (ESD1) before release of the ERC (ESD2).

Where applicable, step-by-step operating instructions should be permanently affixed to the ERC equipment and all personnel involved in its operations should be trained and made familiar with its correct use. Additionally, clear procedures should be in place identifying the process for authorisation to remotely activate the ERC.

In the event of ESD2 activation, i.e. breakaway coupling sudden release triggered due to emergency event or overstress on the transfer line induced by ship movement, the backlashing hoses can damage hull structure and injure personnel in the absence of an appropriate supporting arrangement. This supporting arrangement, if fitted, should not prevent the correct operation of the breakaway coupling, any relative motion between the receiving ship and the bunkering facility should act directly on the ERC to ensure its correct operation if the event of vessel drift or unexpected truck movement.

Routine inspection and testing of the release equipment is required, responsibility for this testing will depend on agreements between the BFO and RSO.

1.5.11 ESD testing

The bunkering facility and receiving ship should both test their emergency shutdown systems not more than 24 hours before bunkering operations commence. The PIC should then be advised of the successful completion of these tests. These tests should be documented in accordance with the bunkering procedure.

1.5.12 Visual inspection of bunker hose or arm before physical connection

Bunker hoses and connecting systems should be visually examined for wear and tear, physical damage and cleanliness. If any defects are found during this inspection, the bunkering operation is cancelled until the transfer hose is replaced.

1.5.13 Liquid and gas leakage detection systems activated

The gas detection system as described in Chapter 1, 5.4 should be activated. Temperature sensor(s) should be installed in the bunker station below the drip tray and their temperature calibration(s) should be checked. Their function should also be tested.

1.5.14 Preparation of the transfer system

The piping at the bunkering facility should be inerted and cooled down (as far as practicable) prior to the connection with the ship to be bunkered. If this operation may cause any specific hazards when connecting to the transfer line it should be carried out after the connection has been carried out. The specific cooling down procedure for the transfer system in terms of cooling down rate should be observed with special care regarding the potential for induced thermal stresses and damage and leaks that may occur. Connections to the bunkering facility and the receiving ship should be visually checked and if necessary retightened. During this operation there should be no release of any LNG or natural gas.

1.6 Pre-bunkering checklist

The LNG Bunker Management Plan should include a checklist to be used during LNG bunkering operation by all involved personnel. This checklist should be elaborated once the full agreement on: procedures to apply, equipment to be used, quantity and quality of LNG to bunker, and training is obtained by all involved parties.

At the time of writing this guideline a LNG bunkering operation checklist is under development within ISO and IMO. In the meantime the LNG Bunkering operation specific checklist should be therefore adapted from the examples checklists for truck-to-ship, shore-to-ship and ship-to-ship LNG bunkering that have been elaborated by WPCI and IAPH. These can be downloaded from: www.lngbunkering.org.

1.7 Connection of the transfer system

1.7.1 Connecting

Equipment utilised with the transfer system such as couplings and hoses should be approved and tested both before and after installation. For emergency release coupling requirements (ERC), see Chapter 1, 5.6.

The transfer system should be connected such that all the forces acting during the transfer operation are within the operating range.

1.7.2 Condition of flange and sealing surfaces prior to connection

During connecting of the transfer system, humidity at the flange mating surfaces should be avoided and it should be ensured that all mating surfaces are clean. When necessary, compressed air should be used for cleaning the contact surface of flanges and seals before physical connection and clamping of the couplings. Heating of the connections to dry them prior to connecting may be considered in some circumstances.

1.7.3 Minimum bending radius of the hose

Hoses should be suitably supported in a manner that the minimum acceptable bending radius according to the qualification standard of the hose is not exceeded. Equipment utilised with the transfer system such as hose rests, saddles, and guidance systems (as applicable) should be approved and tested.
A LNG transfer hose should normally not lie directly on the deck plate and should be isolated thermally from the deck. As a minimum, suitable protection such as wooden boards should also be provided to avoid damage from friction on the quay.

The hose arrangement should be so designed with enough slack to allow for all possible movements between the receiving ship and the bunkering facility.

1.7.4 Transfer line purging

After connection of the transfer system it should be purged to ensure that no oxygen or humidity remains in the transfer system. Nitrogen should be used for purging of any parts of the system that will be cooled to cryogenic temperatures during the bunkering operation.

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Attention is drawn to quantity of the inert gas used for purging / inerting, which may result in high inert gas content in the LNG tank of the receiving ship, which may affect the proper operation of engines. A typical purging sequence of the transfer line involves the injection of five (5) times the volume of the bunker line. The volume of inert gas required may be minimised by the design of the transfer system (i.e. using shorter lengths of hose).

1.7.5 Transfer line pressure testing

During inerting of the transfer system the leak test according to the bunkering procedure should be carried out. As a minimum, a leak test of the connection points and flanges in the system from the bunkering facility up to the ESD valve on the receiving ship should be performed prior to any transfer operation.

No. 142 (cont)

Section 2 - Bunkering phase

2.1 Definition

The bunkering phase begins after the physical connection between the bunkering facility and the receiving ship's bunker station has been safely completed with the opening of the LNG transfer valve from the bunker ship, the truck tanker or the onshore bunkering facility.

It continues with the cooling down of the transfer line followed by the LNG bunker transfer and ends at the end of the topping up phase and the closure of the LNG valve from the bunkering facility.

2.2 Goal

Transfer of the required quantity of LNG without release of LNG and/or natural gas to the surrounding environment in a safe and efficient operation.

2.3 Functional requirements

- During the whole transfer process a suitable ESD and ERS system should be provided for the transfer system.

- After connection of the transfer system a suitable cooling down procedure should be carried out in accordance with the specification of the transfer system and the receiving tank supplier requirements.

- Flash gas or boil-off gas will not be released to atmosphere during normal transfer operations.

- Bunker lines, transfer system and tank condition should be continuously monitored for the duration of the transfer operation.

2.4 General requirements

2.4.1 ERS

The ERS control signals and actuators should be checked and tested and should be ready for use.

The mechanical release mechanism of the ERS system should be proven operational and ready for use before fuel bunkering operation commences.

2.4.2 ESD connection testing

It should be ensured that a linked ESD system connected, tested and ready for use is available. There are two phases of testing Warm ESD testing and Cold ESD testing.

2.4.2.1 Warm ESD Testing

The ESD system should be tested following completion of manifold connection & ESD link. The testing should take place between the receiving ship and the bunkering facility prior to commencement of operation (warm ESD1) to confirm that the systems are compatible and correctly connected. The initiation of the warm ESD1 signal should be done from either one of the receiving ship or the bunkering facility.

2.4.3 Cool down of transfer system

As far as practicable, cooling down of the transfer lines should be carried out according to the requirements of the transfer system and according to the bunkering procedure with special care regarding the potential leaks that may occur as components shrink as they are cooled. Connections to the bunkering facility and the receiving ship should be monitored and, if necessary, tightened.

If a pump is used to deliver the required pressure for the tank to be filled, it is necessary to cool it to operating temperature before starting. This is done by filling the pump circuit with liquid from the tank.

2.4.3.1 Cold ESD Testing

Following the successful completion of cool down operation the cold test should be carried out as far as practicable to ensure that the ESD valves operate correctly in cold conditions before initiating the main LNG bunker transfer.

2.4.4 Main bunker transfer

After proper cooling down of the transfer system and a stable condition of the system the transfer rate can be increased to the agreed amount according to the bunkering procedure. The transfer process should be continuously monitored with regard to the operating limits of the system.

If there are any deviations from the operation limits of the system the transfer of LNG should be immediately stopped.

2.4.5 Monitoring pressure and temperature

Receiving tank pressure and temperature should be monitored and controlled during the bunkering process to prevent over pressurisation and subsequent release of natural gas or liquid natural gas through the tank pressure relief valve and the vent mast.

2.4.6 Vapour management

The vapour management methodology will vary depending on tank type, system type and system condition, but should be agreed on during the compatibility check.
For atmospheric tanks a vapour return line may be used but also other systems like reliquefaction units or pressurised auxiliary systems can also be used to regulate the pressure of the return vapour.

If the receiving tank is a Type C tank, the above remains valid. An alternative practise of LNG bunkering widely used, especially in a truck-to-ship bunkering situation or when no vapour return line is available, is to spray LNG into the top of the receiving tank through diffusers in order to cool the vapour space. As a result the tank pressure will be reduced and therefore the pressure increase due to flash gas can be contained and managed for the duration of the LNG bunkering.

2.4.7 Topping up of the tank

The topping up of the tank should be carefully surveyed by the Person in Charge and/or the Chief Engineer surveying the filling up of the LNG tank(s). The LNG fuel transfer flow rate should be slowed with an appropriate declining value when the receiving tank LNG level approaches the agreed loading limit. The loading limit of the tank and the tank pressure should be paid special attention by the PIC during this operational step. The opening of the tank's Pressure Relief Valve (PRV) due to overpressure in tank, for example following overfilling, should be avoided.

2.4.8 Selection of measurement equipment

The impact on the safety of the transfer system by any equipment used for the measurement of LNG quantity during the bunkering operation should be considered. The measurement method selected, and the equipment used (flow meters, etc.), should minimise disruption to the flow of LNG to prevent pressure surge, excess flash gas generation, or pressure losses in the transfer system.

No. 142 (cont)

Section 3 - Bunkering completion phase

3.1 Definition

The post bunkering phase begins once the bunker transfer (final topping up phase) has been completed and the bunkering facility LNG delivering valve has been closed. It ends once the receiving ship and bunkering facility have safely separated and all required documentation has been completed.

3.2 Goal

This phase should secure a safe separation of the transfer systems of the receiving ship and bunkering facility without release of LNG or excess vapour to the surrounding environment.

3.3 Functional requirements

The following functional requirements should be considered during the Post Bunkering Phase:

- The draining, purging and inerting sequences as described in 3.4 below for the different bunkering cases are fulfilled without release of excess natural gas to the atmosphere.

- The securing and safe storage of transfer system equipment is ensured.

- The unmooring operation and separation of ship(s) is completed safely.

3.4 Draining, purging and inerting sequence

This part of the process is intended to ensure that the transfer system is in a safe condition before separation, the couplings should not be separated unless there is an inert atmosphere on both sides of the coupling.

The details of this process will be design dependent but should include the following steps:

- Shut down of the supply.

- Safe isolation of the supply.

- Draining of any remaining LNG out of the transfer system.

- Purging of natural gas from the transfer system.

- Safe separation of the transfer system coupling(s).

- Safe storage of the transfer system equipment in a manner that the introduction of moisture or oxygen into the system.

3.4.1 LNG Bunkering from Truck LNG Tank

The process of purging and inerting will follow the general outline described above, all purged gasses are generally returned to the receiving ship tank.

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(cont)

3.4.2 LNG Bunkering from Bunker ship

The process of purging and inerting will follow the general outline described above, all purged gasses are generally returned to the bunker ship tank.

3.4.3 LNG Bunkering from shore based terminal

The process of purging and inerting will follow the general outline described above, all purged gasses are generally returned to the shore facility.

3.4.4 LNG Bunkering using portable tanks

The method for safe disconnection of portable tanks will vary depending on the specific design of the system. The general principles remain the same:

- All pipe connections to be isolated at the delivery and receiving ends.
- The connecting hose(s) should be purged and inerted to below the lower flammable limit to prevent risk of ignition and minimise release of natural gas during disconnection.
- Hoses and connections should be securely blanked or otherwise protected to avoid introduction of moisture and oxygen into the system.

3.5 Post-bunkering documentation

Upon completion of bunkering operations the checklist in the LNG bunkering management plan (as described in the pre-bunkering section above) should be completed to document that the operation has been concluded in accordance with the agreed safe procedure. The vessel PIC should receive and sign a Bunker Delivery Note for the fuel delivered, the details of the bunker delivery note are specified in the annex to part C-1 of IGF Code.