MB02 TAKE PRECAUTIONS TO PREVENT HAZARDS ON A SHIP SUBJECT TO IGF CODE

Interreg
Baltic Sea Region
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

MB02 TAKE PRECAUTIONS TO PREVENT HAZARDS ON A SHIP SUBJECT TO IGF CODE

- Basic knowledge to control the risks associated with use of LNG
- Description of health, ship, equipment and environmental hazards associated with LNG operations and explanation on how to control these hazards;

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BASIC KNOWLEDGE OF THE HAZARDS ASSOCIATED WITH OPERATIONS ON SHIPS SUBJECT TO THE IGF CODE

HAZARDS RELATED TO LNG CONCERN:

- HUMAN HEALTH
- SURROUNDINGS (vessel, environment)

Health hazard (cont. 1/2)

- **Methane *CH_4***
- The main hazard: **FLAMMABLE, FROSTBITE, ASPHYXIANT**

RISK	EMERGENCY PROCERURES
FIRE	Stop gas supply Extinguish with: Dry powder, Halon, CO_2 Cool surrounding area with water spray
SPILLAGE	Stop the flow Avoid contact with liquid or vapour Flood with large amounts of water to disperse spill
VAPOUR INHALED	Remove victim to fresh air If inhalation victim is not breathing, ensure that their airways are open and administer cardiopulmonary resuscitation (CPR) Render First Aid when required
LIQUID ON SKIN	Treat patient gently Remove contaminated clothing Immerse frostbitten area in warm water until thawed
LIQUID IN EYE	Flood eye gently with large amount of clean fresh water Force eye open to allow liquid to evaporate If the person cannot tolerate light, protect the eyes with a bandage or handkerchief Do not introduce ointment into the eyes without medical advice
EFFECT OF LIQUID	Not absorbed through skin Frostbite to skin or eyes
EFFECT OF VAPOUR	Possible damage to lungs, skin Headache, dizziness, vomiting, and incoordination

Health hazard (cont. 2/2)

- **Nitrogen N_2**
- The main hazard: **FROSTBITE, ASPHYXIANT**

RISK	EMERGENCY PROCERURES
FIRE	Non-flammable Cool cargo tanks surrounding area with water spray in the event of fire near to them
SPILLAGE	Stop the flow Avoid contact with liquid or vapour Flood with large amounts of water to disperse spill
VAPOUR INHALED	Remove victim to fresh air Render First Aid if required
LIQUID ON SKIN	Treat patient gently Remove contaminated clothing Immerse frostbitten area in warm water until thawed
LIQUID IN EYE	Flood eye gently with large amount of clean fresh/sea water Force eye open if required
EFFECT OF LIQUID	Frostbite to skin or eyes
EFFECT OF VAPOUR	Asphyxiation. Cold vapour could cause damage

Environmental hazard (cont. 1/2)

- LNG rapid evaporation is expected from both land and water with no residues left behind
- LNG spills on water do not harm aquatic life or damage waterways in any way
- LNG vaporizes, the vapour cloud can ignite if there is a source of ignition, but otherwise LNG dissipates completely

Environmental hazard (cont. 2/2)

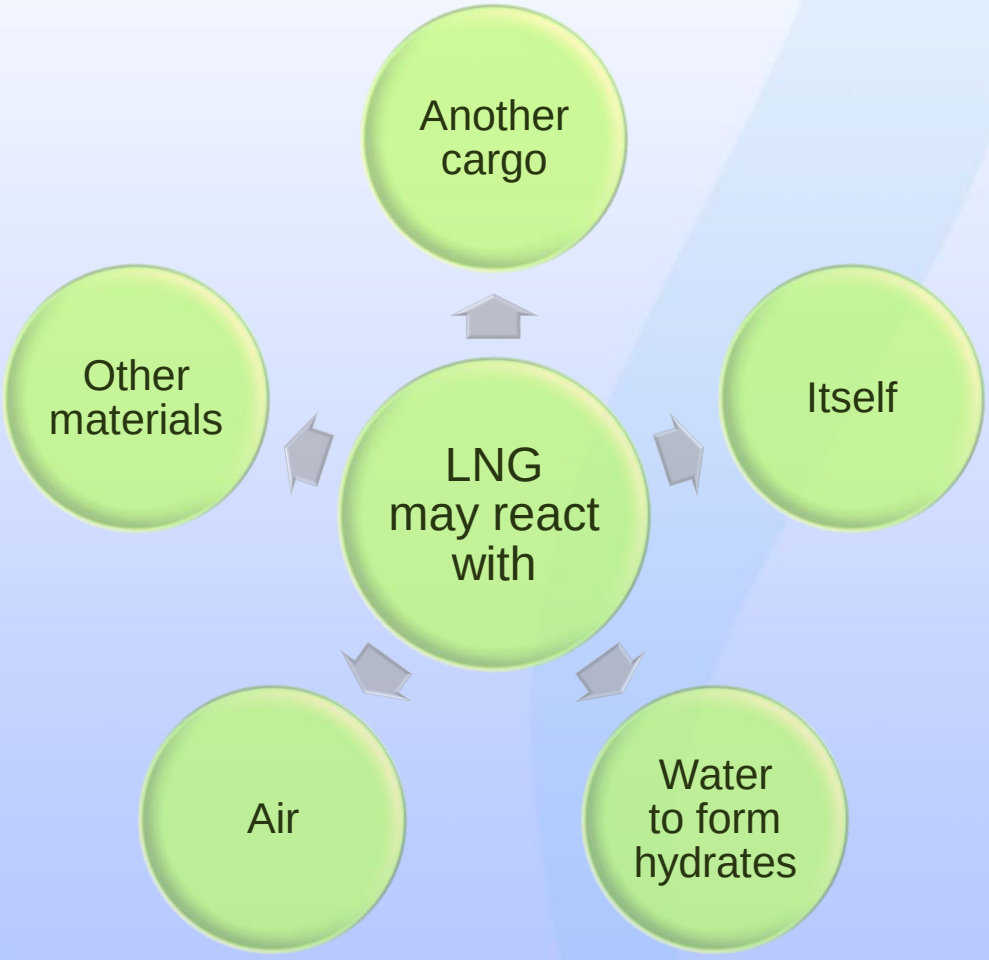
Methane:

- Not significant air pollutant
- Not considered as water pollutant
- No reactivity with water (Fresh/Salt), although may freeze to form ice or hydrates
- Dangerous reaction is possible when contacted with chlorine

Nitrogen:

- No reaction when contacted with water (Fresh/Sea).
- Insoluble
- No reaction with air or other gases/liquids

Reactivity of LNG (cont. 1/5)



1.hydrate formation. Strategic points means places when expansion occurs (lowering temperature and pressure).

Reactivity of LNG (cont. 2/5)

Reaction with water (hydrate formation)

- Water for hydrate formation can come from:
  - Purge vapors with incorrect dew point
  - Water in the cargo system
  - Sometimes: water dissolved in the cargo

Reactivity of LNG (cont. 3/5)

Self-reaction

- Some self-react cargos (like ethylene oxide), which cannot be inhibited must be carried out under inert gas
- Most common form is polymerization initiated by the presence of small quantities of other cargos or certain metals

Reactivity of LNG (cont. 4/5)

Reaction with air

- Can cause explosion by forming unstable oxygen compounds
- Cargos must be either inhibited, carried under IG or N_2

Reaction with other cargos

- Consult data sheet for each cargo
- If possible, separate reliquefaction systems to be used for each cargo
- If danger of chemical reaction exist than use of completely segregated systems is required, known as positive segregation

  (See specification of certain cargos in IMO Gas Carrier Code)
- If there is any doubt of the reactivity or compatibility of two cargos they must be treated as incompatible and ‘positive segregation’ provided

Reactivity of LNG (cont. 5/5)

Reaction with other materials

- Consult data sheet list of materials not allowed to come into contact with cargo
- ONLY compatible materials to be used in the cargo system

Corrosion (cont. 1/7)

CORROSION MITIGATION AREA

INSIDE THE PRESSURE BONDUARY EXPOSED TO PROCES CONDITIONS

MITIGATION:

CATHODIC PROTECTION

EXTERIOR EXPOSED TO WEATHER

MITIGATION :

PROTECTIVE COATING

CATHODIC PROTECTION

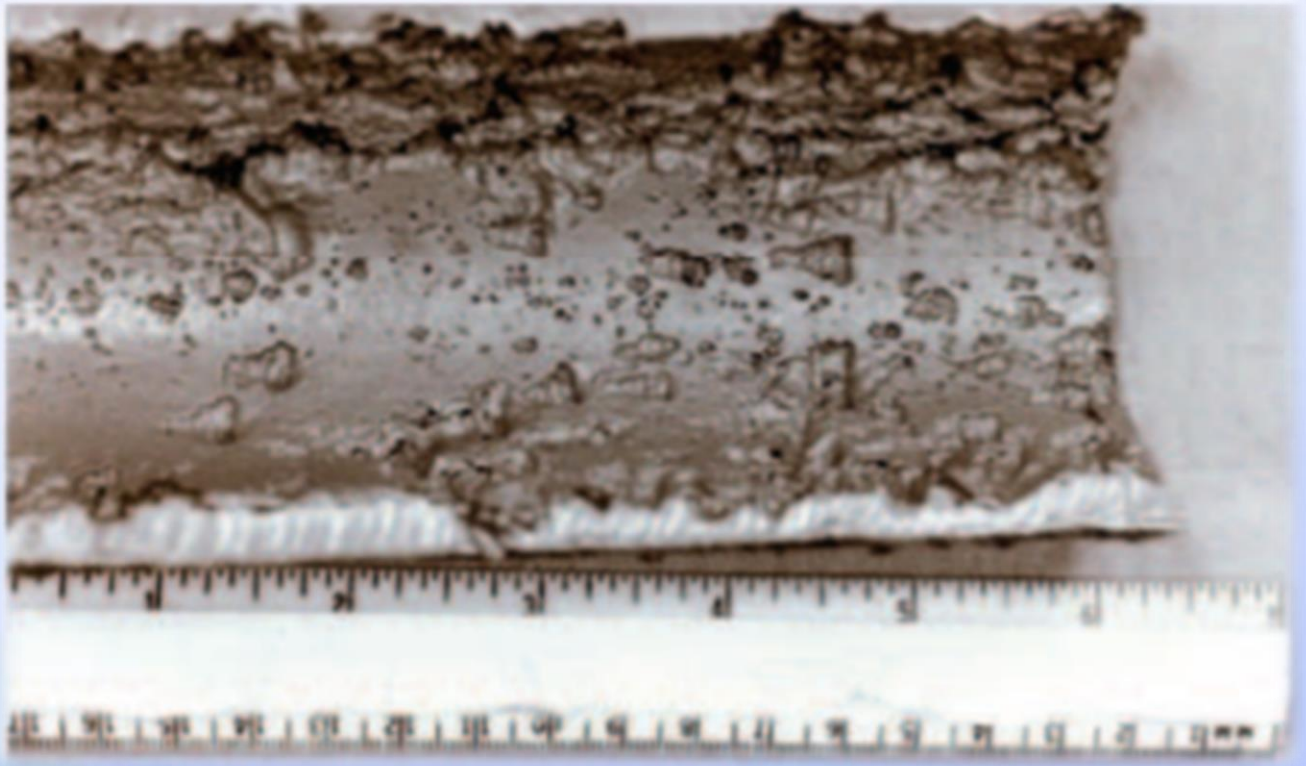
Corrosion (cont. 2/7)

PROTECTIVE COATING AND INSULATION SELECTION:

- Structural steel
  - Three coat paint system
    - Primer (inorganic zinc)
    - Epoxy intermediate coat
  - Hot tip galvanizing
- Cathodic protection
  - Storage tank bottoms and internals
  - Underground pipelines/piping
  - Existing cathodic protection systems/Grid integration
  - Marine jetty, Construction dock, pipelines

Corrosion (cont. 3/7)

Wet CO2 Corrosion
CO2 corrosion damage of the carbon steel pipe



[source: ADGAS Corrosion Booklet]

Corrosion (cont. 4/7)

Corrosion under insulation (CUI)

[source: ADGAS Corrosion Booklet]

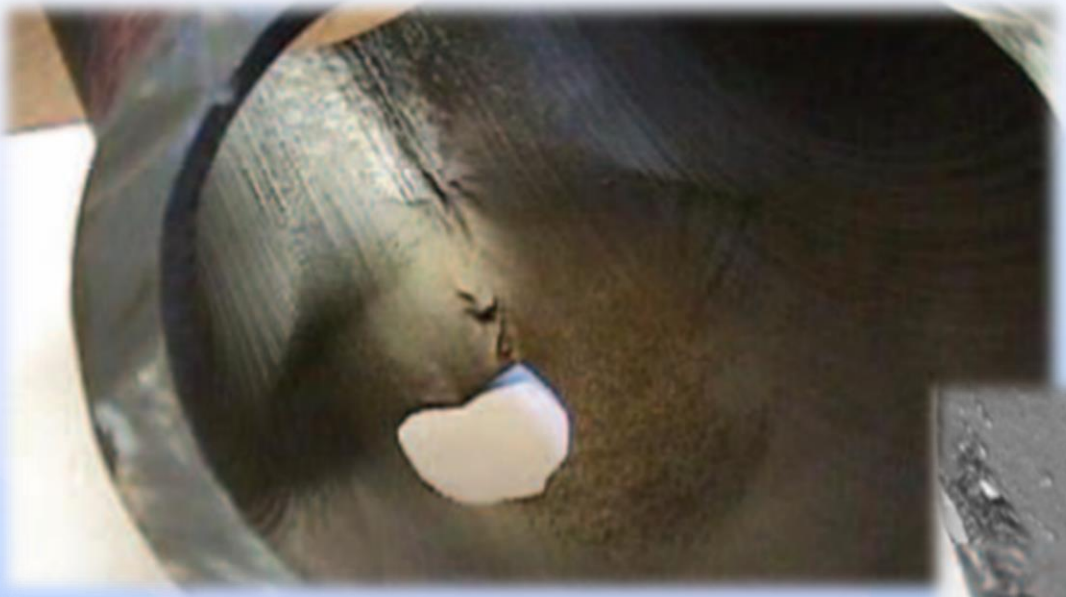
Corrosion (cont. 5/7)

Thermal fatigue

[source: ADGAS Corrosion Booklet]

Corrosion (cont. 6/7)

Erosion and corrosion

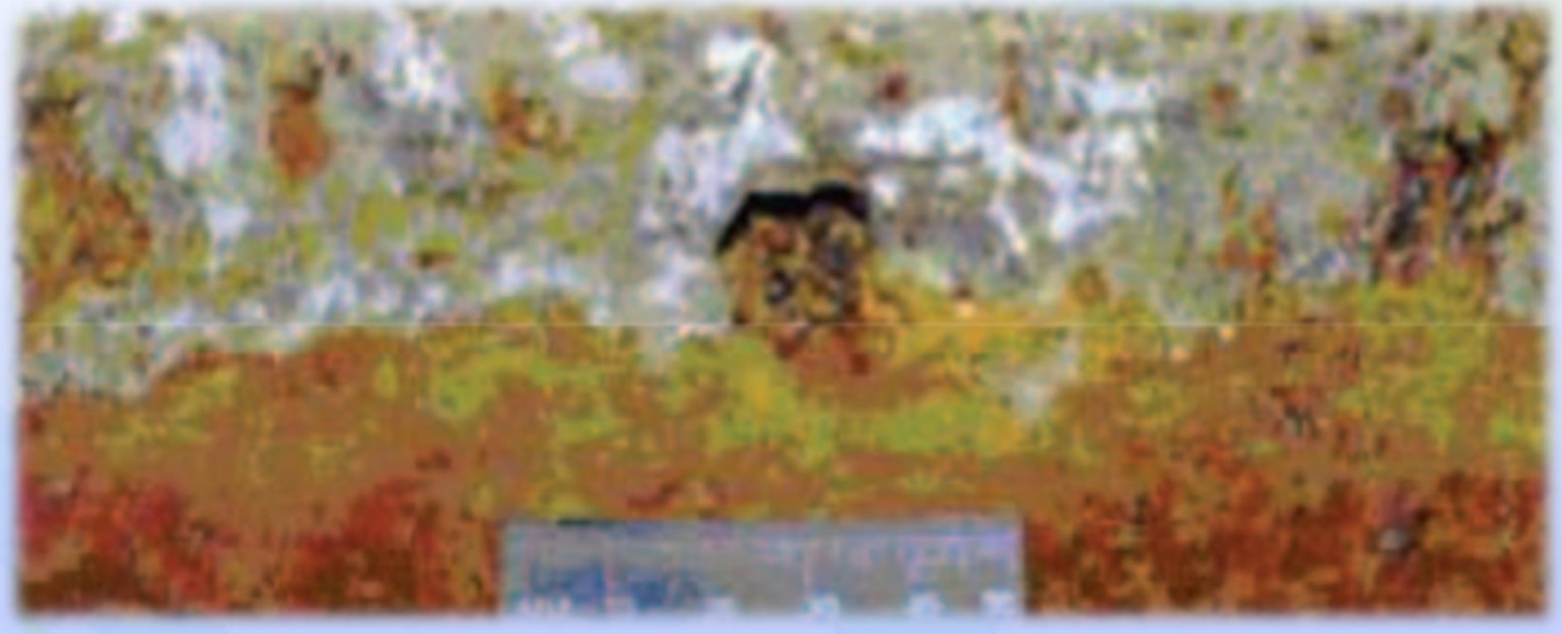


Erosion of Impeller

[source: ADGAS Corrosion Booklet]

Corrosion (cont. 7/7)

Microbiologically Induced Corrosion MIC



[source: ADGAS Corrosion Booklet]

Ignition, explosion, flammability hazards (cont. 1/3)

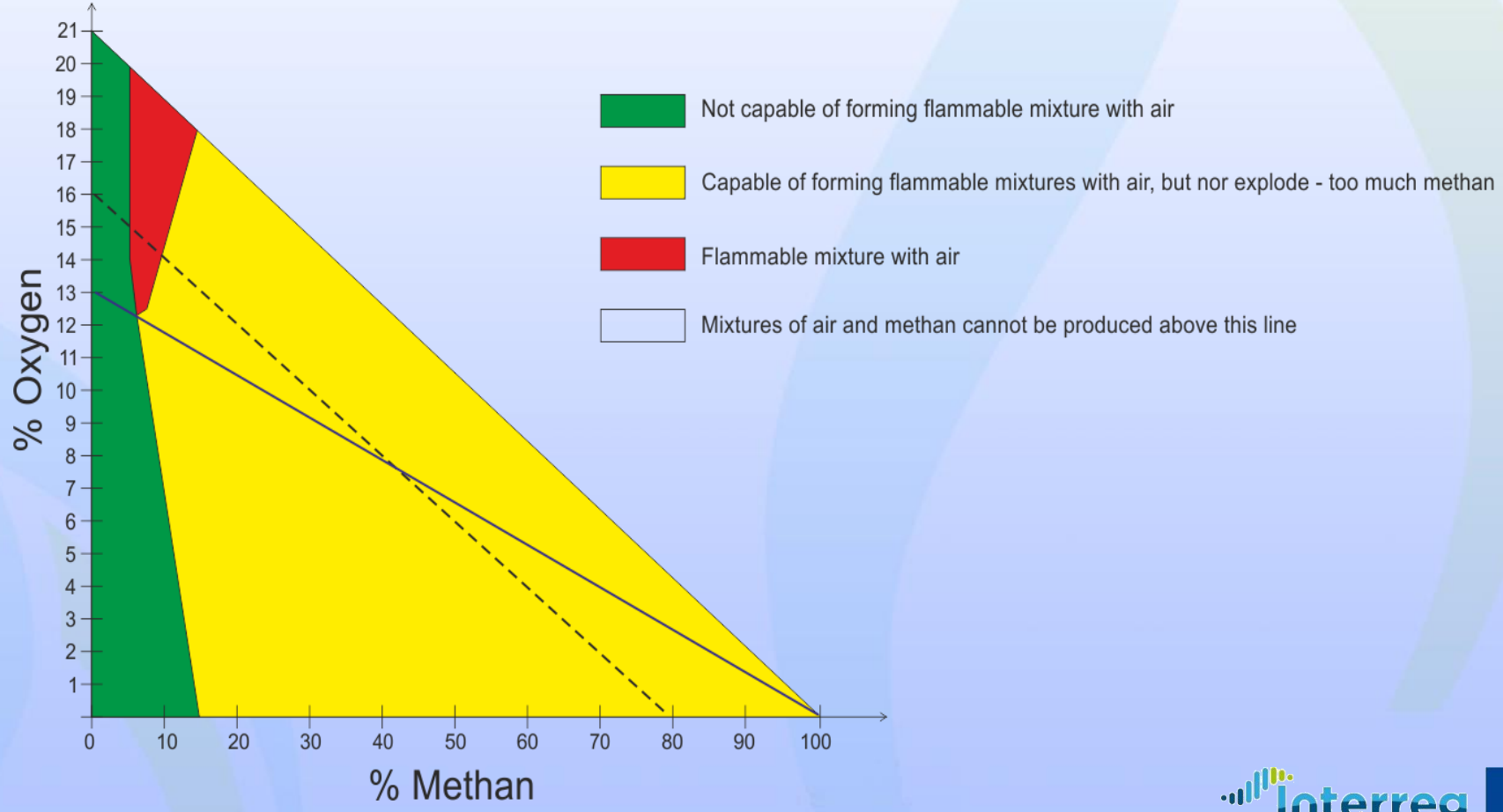
Liquefied Gas	Flash Point [°C]	Flammable range [%by vol. in air]	Auto-ignition temp [°C]
Methane	-175	5.3-14.0	595
Ethane	-125	3.0-12.5	510
Propane	-105	2.1-9.5	468
n-Butane	-60	1.5-9.0	365
i-Butane	-76	1.5-9.0	500
Ethylene	-150	3.0-34.0	453
Propylene	-108	2.0-11.1	453
α-Butylene	-80	1.6-10.0	440
β-Butylene	-72	1.6-10.0	465
Butadiene	-60	1.1-12.5	418
Isoprene	-50	1.5-9.7	220
Vinyl Chloride	78	4.0-33.0	472
Ethylene Oxide	18	3.0-100.0	429
Propylene Oxide	37	2.1-38.5	465
Ammonia	-57	14.0-28.0	615
Chlorine		Non-flammable	

Ignition, explosion, flammability hazards (cont. 2/4)

- LNG when exposed to air, it evaporates extremely rapidly, producing explosive gas vapor
- Pools of LNG can burn for burns with a visible flame
- Flammability limits are narrow
- Combusting in air-to-fuel proportions of 5-15% ONLY
- Below 5% the mix is too lean to burn and above 15% the mix is too rich to burn

Ignition, explosion, flammability hazards (cont. 4/4)

Flammability of Methane, O_2 and N_2 mixtures



Sources of ignition

Sources of ignition:

- Smoking& naked lights
- Spontaneous ignition waste
- Hot work, Cold work
- Safety tools
- Aluminum
- Portable Electrical Equipment & air driven lamps
- Mobile phones
- Radio transmitter, Radar, VHF
- Insulation flanges& ship shore bonding cables
- Cargo handling equipment such as cranes, railroad cars, trains, cryogenic tanker trucks
- Cooking stove in galley, Electric heaters in pantries, etc.

Electrostatic hazards (cont. 1/6)

- Static electricity can cause sparks capable of ignition a flammable gas
- Some routine operations can cause electrostatic charging

Electrostatic hazards (cont. 2/6)

Precautions to minimize the hazard of static electricity

- No CO_2 to be released to flammable mixture
- Metal reinforcement bounded to the cargo flanges
- No steam injection to system with flammable mixture
- Anti-electrostatic clothes and shoes
- Electrostatic discharge plate
- Grounded handle

Electrostatic hazards (cont. 3/6)

Electrostatic Generation

- Some materials (solid, liquid or vapor) can generate and retain a static charge depends on their electrical resistance. If the resistance is high, a charge can be built up
- The cargo system of a gas carrier is electrically bonded to the ship's hull via various bonding connections. This is provided to prevent charge build-up.

Cargo hoses are bonded to their **flanges by the metal reinforcement**. Thanks to this solution it provides a continuous path to earth though the ship's manifold and the hull.

Electrostatic hazards (cont. 4/6)

- If the system is un-bonded, there is a possibility of static electricity to be generated by flow of liquid, vapor or vapor containing particles (e.g. rust) through piping

- Steam and Carbon Dioxide

Both should be injected into a tank, compartment or piping system with a presence of a flammable mixture.

Electrostatic hazards (cont. 5/6)

- No liquid carbon dioxide under pressure should be released at high velocity
- Rapid evaporation causes cooling and particles of solid carbon dioxide may form
- The solid particles in the cloud of CO_2 may become electrostatically charged

Electrostatic hazards (cont. 6/6)

- Ship/Shore Insulating, Earthing and Bonding
- Connection/disconnection of cargo hose strings and metal arms requires from the terminal operator to ensure that they are fitted with an insulating flange or a single length of non-conducting hose
- It is necessary to create electrical discontinuity between the ship and shore
- A ship/shore bonding cables hall not be used because is not effective as a safety device and may even be dangerous

Toxity hazards

- The principal constituents of natural gas, methane, ethane, and propane, are not considered to be toxic
- Those gases are considered as simple asphyxiants (they are health risk as they can displace oxygen in a close environment)
- threshold limit value (TLV) for an average natural gas composition is about 10,500 ppm
- LNG become toxic by adding odour substances

Vapor leaks and clouds (cont. 1/4)

- LNG has no natural odor of its own
- Difficult for personnel to detect leaks unless the leak is sufficiently large to create a visible condensation cloud or localized frost formation
- Methane gas detectors has to be placed in any area where LNG is being transferred or stored
- LNG transfer and fuel system itself need to be closely monitored due to constant warming of the LNG

Vapor leaks and clouds (cont. 2/4)

HOW to detect gas leak in a system?

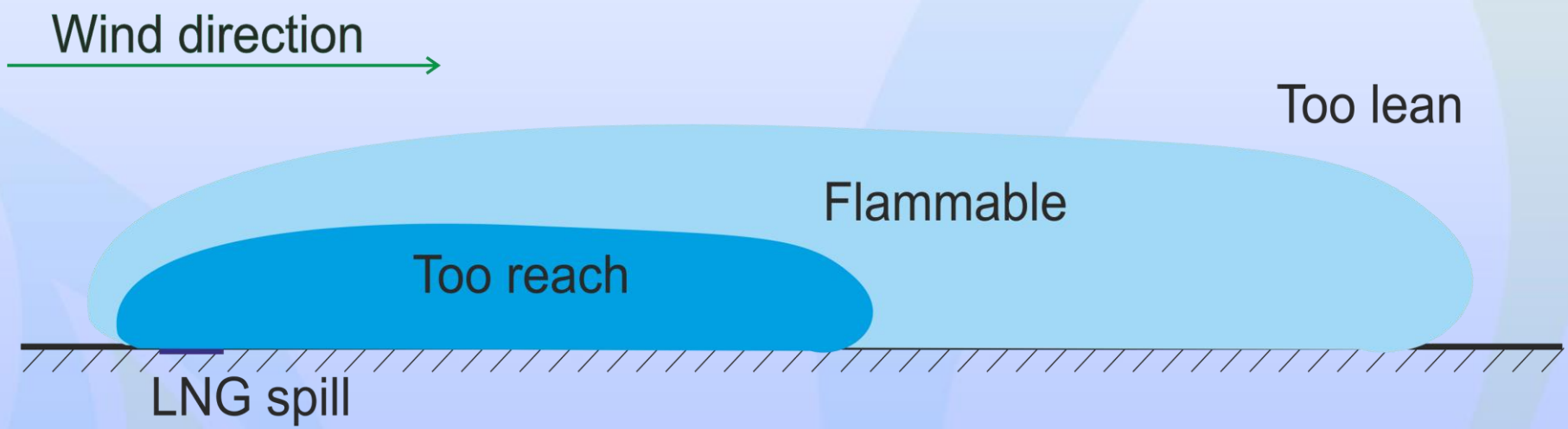
MIX couple of tablespoons of typical dish soap into container with water

When system is pressurized wet down suspected area with soap solution

IF THERE IS AN LEAK YOU WILL SEE BUBBLES FORM ON THE LEAKAGE AREA

Vapor leaks and clouds (cont. 3/4)

Situation of flammability within vapor cloud



Vapor leaks and clouds (cont. 4/4)

- VAPOR CLOUD may form when LNG spill
- Lack of breathable atmosphere
- Vapor cloud will gradually disperse downwind
- Vapor cloud is long, thin, cigar shaped
- Vapor initially ‘hugs the surface’
- The major danger from an LNG vapor cloud occurs when it is ignited

Extremely low temperatures

(cont.1/2)

- Low cargo temperatures can freeze water in the system leading to blockage of, and damage to pumps, valves, sensor lines, spray lines etc.

- All the temperature sensing equipment must be well maintained and calibrated minimum as per manufacturer requirements

Extremely low temperatures

(cont.2/2)

- LNG spillage on the vessel can result in the brittle fracture of the steel
- Stainless steel drip tray are necessary
- Water curtain must be provided
- Liquid domes must have laid down fire hoses
- Water spray ready for use

Pressure hazards

- To minimize danger of damage to the system, the pressure of the cargo should be maintained between the specified minimum and maximum

- Avoid liquid hammers (shock pressures) by SLOW opening or closing valve actions as the pressure can be sufficient to cause hose or pipeline failure

- Suitable means shall be provided to relieve the pressure

Fuel batch differences (cont. 1/6)

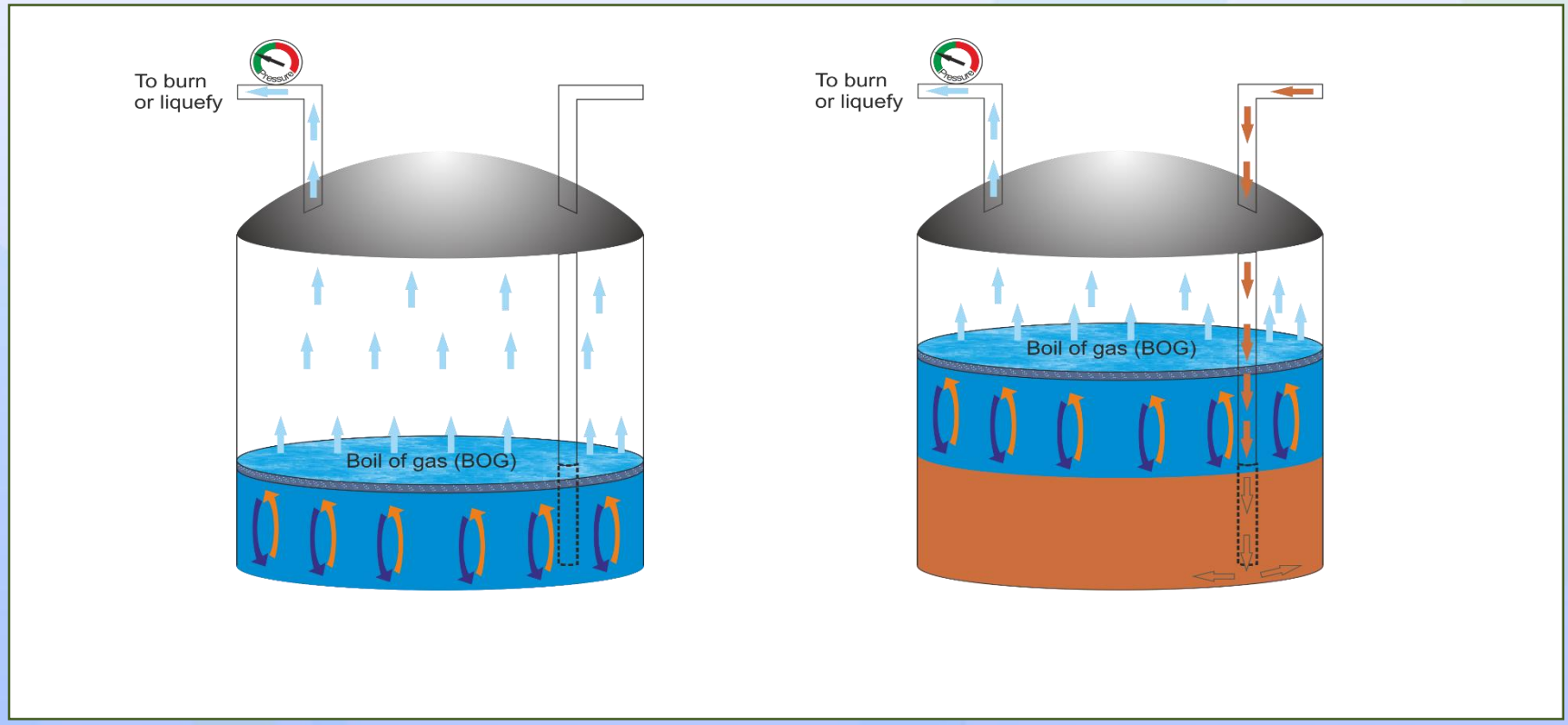
Origin	Nitrogen N_2 [%]	Methane C_1 [%]	Ethane C_2 [%]	Propane C_3 [%]	C_4 [%]	Total [%]	LNG Density [kg/m^3]	Gas Density [kg/m^3(n)]
Australia - NWS	0.0	**87.3**	8.3	3.3	1.0	100	467	0.831
Australia - Darwin	0.1	**87.6**	10.0	2.0	0.3	100	461	0.812
Algeria - Skikda	0.6	**90.4**	7.4	0.6	0.1	100	447	0.776
Algeria - Bethioua	0.6	**89.5**	8.2	1.3	0.3	100	455	0.795
Algeria - Arzew	0.7	**88.9**	8.4	1.6	0.4	100	457	0.801
Brunei	0.0	**90.1**	5.3	3.0	1.5	100	462	0.818
Egypt - Idku	0.0	**95.3**	3.6	0.7	0.3	100	437	0.756
Egypt - Damietta	0.0	**97.3**	2.5	0.1	0.1	100	429	0.737
Equatorial Guinea	0.0	**93.4**	6.5	0.1	0.0	100	440	0.760
Indonesia - Arun	0.1	**91.9**	5.7	1.6	0.8	100	451	0.789
Indonesia - Badak	0.0	**90.1**	5.5	3.0	1.4	100	461	0.816

Fuel batch differences (cont. 2/6)

Origin	Nitrogen N_2 [%]	Methane C_1 [%]	Ethane C_2 [%]	Propane C_3 [%]	C_4 [%]	Total [%]	LNG Density [kg/m^3]	Gas Density [kg/m^3(n)]
Indonesia - Tangguh	0.1	**96.9**	2.4	0.4	0.2	100	431	0.742
Libya	0.6	**82.6**	12.6	3.6	0.7	100	479	0.858
Malaysia	0.1	**91.7**	4.6	2.6	0.9	100	454	0.798
Nigeria	0.0	**91.7**	5.5	2.2	0.6	100	452	0.791
Norway	0.5	**92.0**	5.7	1.3	0.4	100	448	0.782
Oman	0.2	**90.7**	5.8	2.1	1.2	100	457	0.805
Peru	0.6	**89.1**	10.3	0.1	0.0	100	452	0.787
Qatar	0.3	**90.9**	6.4	1.7	0.7	100	453	0.795
Russia - Sakhalin	0.1	**92.5**	4.5	2.0	1.0	100	451	0.789
USA - Alaska	0.2	**99.7**	0.1	0.0	0.0	100	421	0.719
Trinidad	0.0	**96.8**	2.8	0.4	0.1	100	431	0.741
Yemen	0.0	**93.2**	5.9	0.8	0.1	100	442	0.767

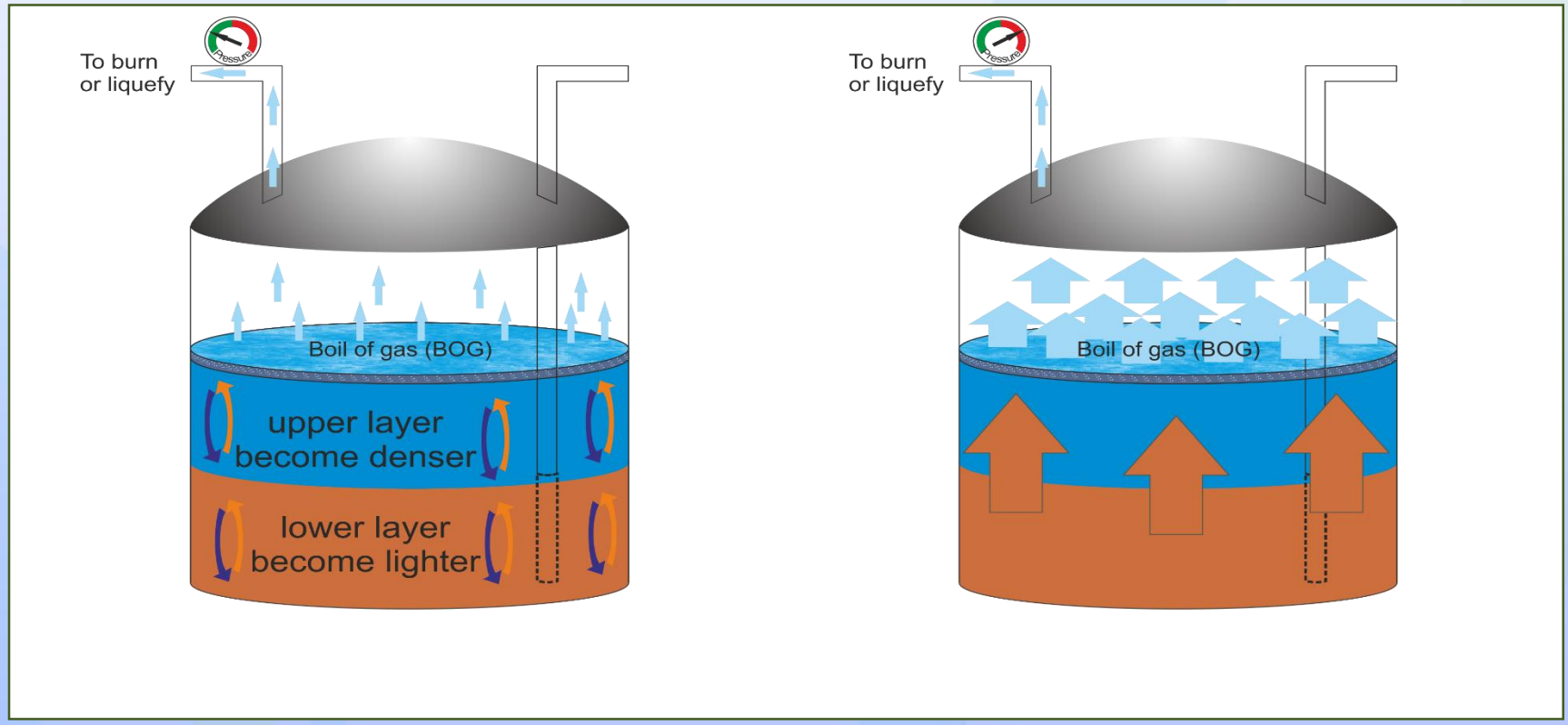
Fuel batch differences (cont. 3/6)

Rollover is a rapid transfer of heat and mass within the storage tank due to superheating of lower layers in a large storage tank



Fuel batch differences (cont. 4/6)

Rollover is a rapid transfer of heat and mass within the storage tank due to superheating of lower layers in a large storage tank



Fuel batch differences (cont. 6/6)

To help prevent rollover:

- Store liquids of differing density in separate shore tanks
- Promote mixing by filling shore tanks with liquefied gas what should be made via nozzles or jets
- Avoid prolonged stoppages during LNG transfer to ships
- Close eye shall be kept for unusual data in cargo conditions and boil-off rates
- Transfer cargo to other tanks or recirculate within the affected shore tank

Basic knowledge of hazard controls

Basic knowledge to control the risks associated with use of LNG

Emptying, inerting, drying and monitoring techniques

EMPTYING (cont. 1/3)

Regular LNG operation procedures (LNG tanker)

EMPTYING / DISCHARGE

On arrival at discharge port:

- tank pressures and temperatures should be set as per terminal requirements

Before discharge operation starts:

- the pre-operational ship/shore procedures should be carried out
- suitable cargo plan for both ship and shore side must be draw up
- safety issues connected with planned cargo discharge should be raised up

EMPTYING (cont. 2/3)

The method of discharging the ship depends on

- Cargo specification
- Terminal storage
- Type of ship

EMPTYING (cont. 3/3)

Discharge methods

- Discharge by pressurising the vapor space
- Discharge via centrifugal pumps alone or with booster pumps
- Discharge via booster pump and cargo heater

INERTING (cont. 1/2)

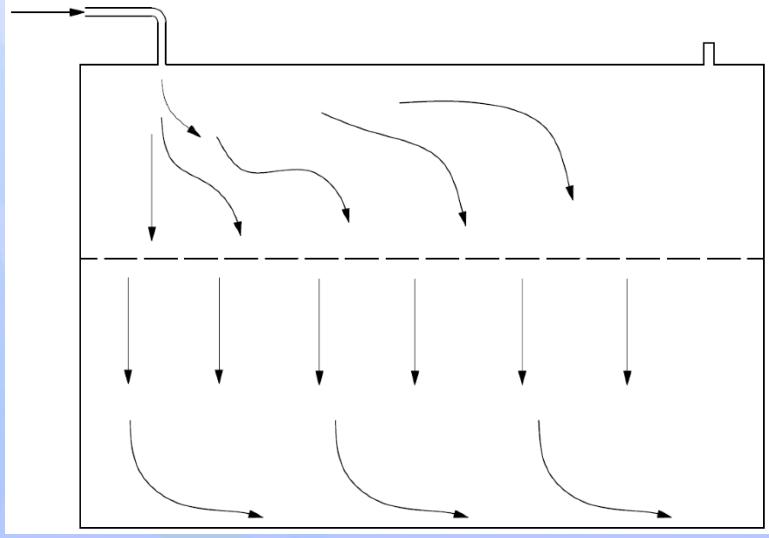
- Inerting cargo tanks, cargo machinery and pipelines is undertaken primarily to ensure a nonflammable condition during subsequent gassing-up with cargo
- To archive nonflammable conditions oxygen concentration must be reduced from 21% to a maximum of 5% by volume (lower values are preferred)
- Inert gas is supplied from the inert gas generator on board

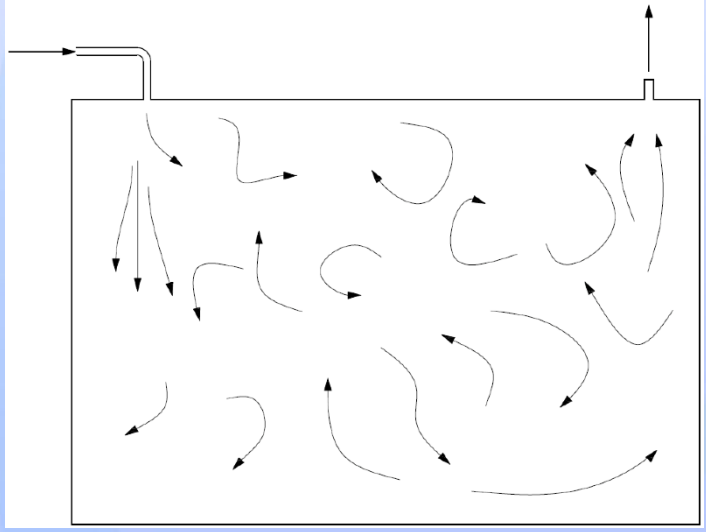
INERTING (cont. 2/2)

Procedures used
for inerting cargo tanks

Displacement

Dilution





DRYING (cont. 1/2)

- Drying means that water vapor and free water must all be removed from the system prior loading
- If this is not done, the residual moisture can cause problems with icing and hydrate formation within the cargo system

DRYING (cont. 2/2)

Tank atmosphere drying can be accomplished in several ways

- Drying using inert gas from the shore
- Drying using inert gas from ship's plant
- On board air-drying systems

MONITORING TECHNIQUES

MONITORING TECHNIQUES while EMPTYING, INERTING, DRYING operations:

1. Observing manifold pressures on liquid/vapor line
2. Observing tank pressures and levels
3. Monitoring pressures at the insulating spaces
4. Monitoring the temperatures in the tanks via temperature sensors provided at different tank levels
5. Watch for any abnormalities

Anti-static measures (cont. 1/4)

- Risk for a strong spark to occur exists because of difference of potential of static electricity accumulated in the hull of the LNG fueled ship and for example the tank truck

- For the period from the connection to the disconnection of the LNG fuel transfer hose, either the electrical insulation between the ship and the tank truck/shore tank/etc. shall be maintained, or a bonding cable shall be connected

- Insulated flanges need to be installed at the ends of all hoses associated with LNG fuel transfer

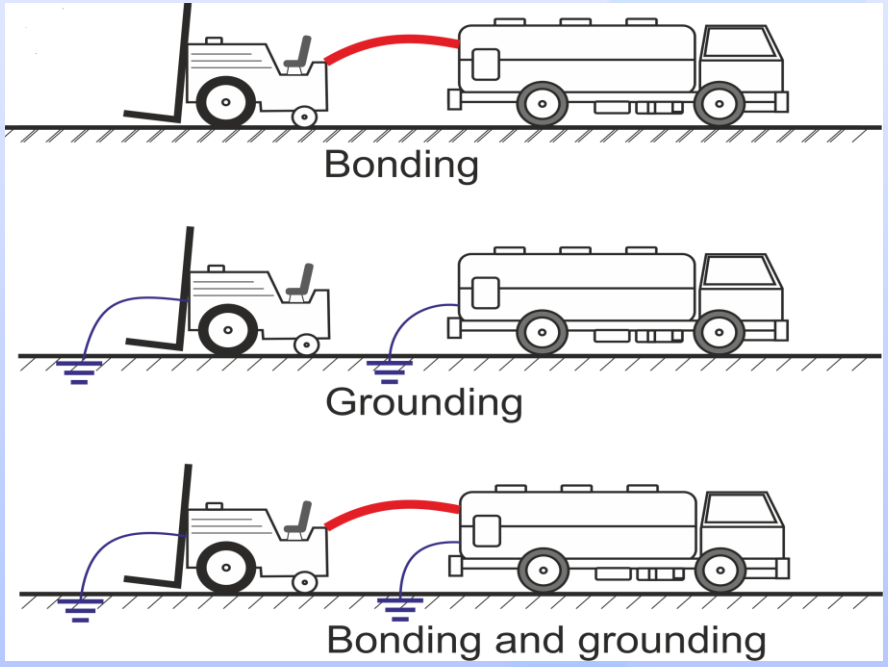
Anti-static measures (cont. 2/4)

Special precautions are needed and adequate response taken for the following:

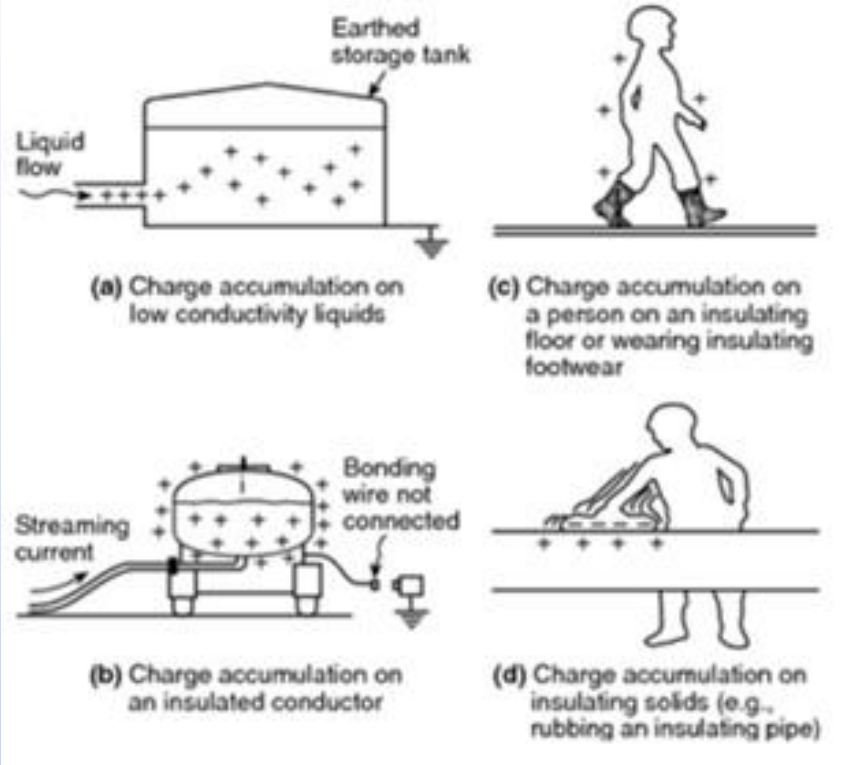
- Against high frequency induction when hose handling crane is used for handling conductive hose
- Deck, crane structure, lifting wire, shackles, and hose form an open-ended inductive loop. Thus care is necessary to guard against arc discharge between hose end and steel deck or other hull structures
- During hose handling work and LNG fuel transfer, the power supply of the main transmitter in the MF/HF radio shall be turned off and the antenna grounded.
- The hose shall be supported by hose handling crane etc., considering that the disconnected hose may touch the hull and generate sparks

Anti-static measures (cont. 3/4)

- Stuff working near the manifolds of the ship shall use long-sleeved anti-static work uniforms, helmet, leather gloves, safety boots and goggles. Also, tools to guard against static electricity shall be used for work



Anti-static measures (cont. 4/4)



Examples of charge accumulation

[source: H. L. Walmsley: Avoidance of electrostatic hazards in the petroleum industry]

Ventilation (cont. 1/2)

- Separate ducting required for the ventilation of hazardous spaces from non-hazardous spaces
- Ventilation ducting arrangements are to be of a gas tight construction
- Electric fan motors are not to be located in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone as the space served
- Any loss of the required ventilating capacity is to give an audible and visual alarm

Ventilation (cont. 2/2)

- Air inlets & outlets
  - for hazardous enclosed spaces
    - Air inlets are to be taken from non-hazardous area
    - Air outlets are to be located in an open area
  - for non-hazardous enclosed spaces
    - Air inlets are to be taken from non-hazardous areas at least 1.5 m away from the boundaries of any hazardous area
    - Air outlets are to be located outside hazardous areas
    - The required capacity of the ventilation plant is normally based on the total volume of the room
    - An increase in required ventilation capacity may be necessary for rooms having a complicated form

Segregation (cont. 1/2)

SEGREGATION

- IMO GAS CARRIER CODE IGC regulates all techniques of segregation provided for various cargo-related operations to avoid cargo contamination

Segregation for not compatible cargos

- fitting blanks and/or portable bends
- removing pipe spool pieces

Segregation (cont. 2/2)

Segregation
for compatible cargos

- Double valve segregation
- Positive visible blank

Measures to prevent ignition, fire and explosion
(cont. 1/6)

ALL SOURCES OF IGNITION SHALL BE EXCLUDED FROM SPACES WHERE FLAMMABLE VAPOR MAY BE PRESENT !!!

Three things are needed to support a fire:

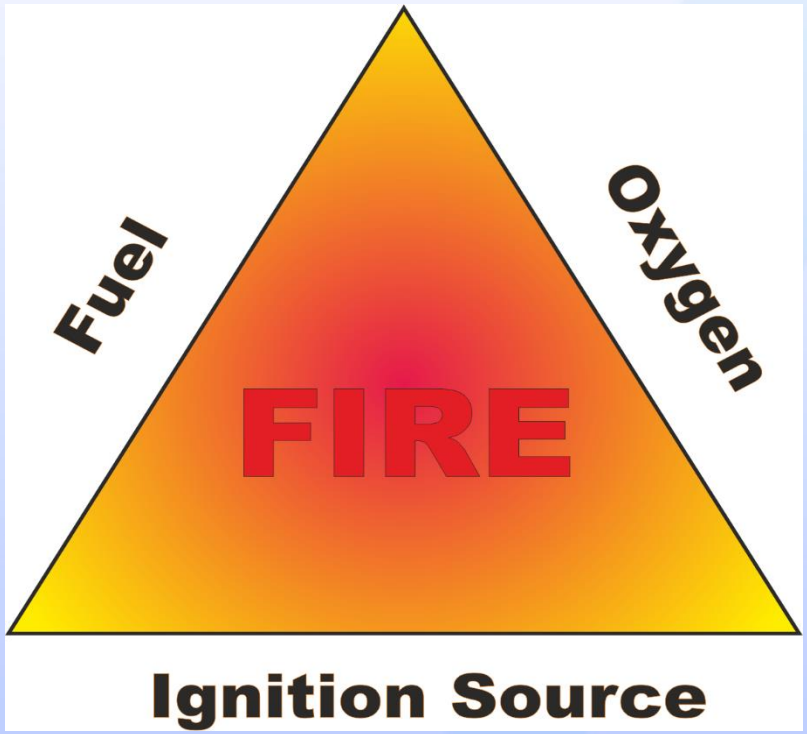
1. Source of fuel (e.g., flammable gas or vapor)

2. Air (oxygen)

3. Source of ignition (e.g., spark, open flame, or high-temperature surface)

Measures to prevent ignition, fire and explosion

(cont. 2/6)



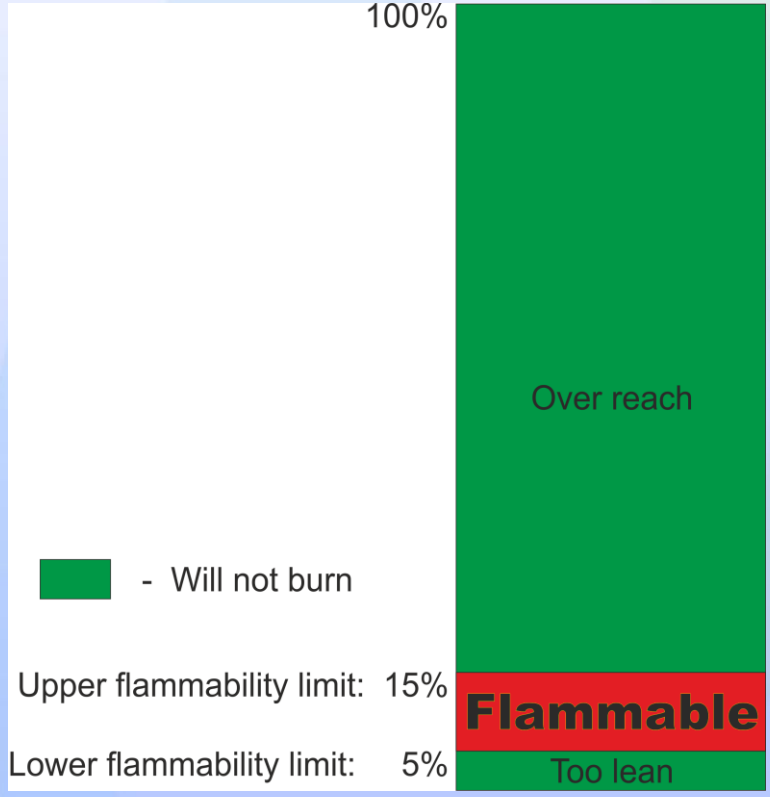
Fire Triangle

Measures to prevent ignition, fire and explosion
(cont. 3/6)

"FLAMMABLE RANGE" is the range of a concentration of a gas or vapor that will burn if an ignition source is introduced

The limits are commonly called:

- Lower Flammable Limit (LFL)
- Upper Flammable Limit (UFL)



Flammability range for methane

Measures to prevent ignition, fire and explosion

(cont. 4/6)

Fuel	LFL	UFL
Methane	5.0	15.0
Butane	1.86	7.6
Kerosene	0.7	5.0
Propane	2.1	10.1
Hydrogen	4.0	75.0
Acetylene	2.5	>82.0

Flammability limits of hydrocarbon fuels

Measures to prevent ignition, fire and explosion
(cont. 5/6)

- All LNG terminals use several types of equipment on and around the storage tanks and piping throughout the facility to detect any unlikely leakages and combustible gas mixtures

- The IGNITION TEMPERATURE, also known as auto-ignition temperature, is the lowest temperature at which a gas or vapor in air (e.g., natural gas) will ignite spontaneously without a spark or flame being present

Measures to prevent ignition, fire and explosion
(cont. 6/6)

- Temperatures higher than the auto ignition temperature will cause ignition after a shorter exposure time to the high temperature.

	Natural Gas	Diesel Oil	Gasoline
Auto-ignition temperature	599ºC	260-371ºC	226-471ºC

Auto-ignition temperature of some fuels at standard conditions

Atmospheric control (cont. 1/9)

- Automatic gas detection systems are installed in terminals, at jetties and vessels
- Their purpose is monitoring possible leakage of flammable and toxic vapors
- The number and location of detector heads is various
- Their positioning will also depend on the density of the gas being monitored and on the more likely sources of release

Atmospheric control (cont. 2/9)

- In the case of flammable products, the gas detection equipment provided for hold spaces and inter barrier spaces that are required to be inerted shall be capable of measuring as concentrations of 0% to 100% by volume

- Alarms shall be activated when the vapor concentration by volume reaches the equivalent of 30% LFL in air

- **Hold and Inter-barrier Spaces**

- These spaces may have to be filled with inert gas if the cargo is flammable

Atmospheric control (cont. 3/9)

Full secondary Barrier system:

- Filled with Dry inert gas or nitrogen
- Maintained with make-up gas provided by the shipboard inert gas generation system, or by shipboard storage which should be sufficient for at least 30 days at normal rates of consumption

Atmospheric control (cont. 4/9)

Partial secondary Barrier system:

- Same requirements as for Full secondary barrier system
- Alternatively, subject to certain conditions, the space may be filled with dry air

Atmospheric control (cont. 5/9)

No secondary Barrier system:

- Filled with Dry air or dry inert gas depending on the cargo
- Maintained either with dry air provided by suitable air drying equipment, or with make-up inert gas provided by the shipboard inert gas generation system or shipboard storage

Atmospheric control (cont. 6/9)

Cargo Tanks and Piping Systems:

- The tank atmosphere should be monitored at different levels to ensure these are no pockets of excessive concentrations of oxygen or cargo vapor, particularly in tanks with complex internal structures or bulkheads

Atmospheric control (cont. 7/9)

Gas carriers must be fitted with fixed **gas detection system with audible and visual alarms.**

These must be fitted in:

- the wheelhouse
- the cargo control room
- the gas detector readout location

Atmospheric control (cont. 8/9)

Detector heads are normally provided in the following spaces:

- Cargo compressor room
- Electric motor room
- Cargo control room (unless classified as gas-safe
- Enclosed spaces such as hold spaces and inter barrier spaces
- Airlocks
- Burner platform vent hoods and engine room gas supply pipelines

Atmospheric control (cont. 9/9)

Regular testing of the equipment is required:

- Span gas of a certified mixture for calibration purposes
- Sampling and analyzing from each detector head
- The gas detection equipment shall be capable of sampling and analyzing for each sampling head location sequentially at intervals not exceeding 30 min
- Alarms should be activated when the vapor concentration reaches 30 per cent of the lower flammable limit

Gas testing (cont. 1/10)

GAS TESTING

- Portable gas detection equipment is required for ensuring spaces are safe for entry, work or other operations
- Gas carriers must have at least two sets of portable gas detection equipment adapted to the cargoes listed in the Fitness Certificate.
- Means for measuring oxygen levels in inert atmospheres are also required

Gas testing (cont. 2/10)

Gas testing include the detection of

- Cargo vapor in air, inert gas or the vapor of another cargo
- Concentrations of gas in or near the flammable range
- Concentrations of oxygen in inert gas, cargo vapor or enclosed spaces
- Toxic gases

Gas testing (cont. 3/10)

Each vessel will however carry instruments capable of measuring Oxygen, Hydrogen Sulphide, Methane, Carbon Monoxide, Carbon Dioxide and also the lower explosive limit

Instruments carried onboard must measure:

- Oxygen
- Hydrogen Sulphide
- Methane
- Carbon Monoxide
- Carbon Dioxide
- LEL (lower explosive limit)

Gas testing (cont. 4/10)

- COMBINED FUNCTION METRES

Gas Detector Riken RX415

[source: http://www.equipcoservices.com]

Gas testing (cont. 5/10)

Portable combination gas detector Riken Reiki 515

[source: Model RX-515 operation manual]

Gas testing (cont. 6/10)

PERSONAL MONITORING METERS

- Some can be carried in a pocket
- Intended only as a personal monitor
- Used for enclosed space entry
- Audible and visual alarm if the Oxygen content falls below its preset level
- NOT designed for testing the atmosphere for oxygen or other gases

Gas testing (cont. 7/10)

- Draeger PAC5000: this instrument measures O2, CO and H2S

Personal GAS monitor Draeger PAC5000

[source: http://file.yizimg.com]

Gas testing (cont. 8/10)

- Riken GX2001: this instrument measures LEL, O2, H2S and CO

Personal GAS monitor Riken GX2001
[source: http://www.rkiinstruments.com]

Gas testing (cont. 9/10)

TOXIC GAS DETECTORS

- measure relatively low concentrations of toxic gases
- normally require a special attachment or tube which the gas is aspirated through

Dräger-Tube pump accuro
and Natural Gas Test tubes

[source: Dräger-Tubes & CMS-Handbook 16th ed.]

Gas testing (cont. 10/10)

SAMPLE LINES

1. The material and condition of sample lines can affect the accuracy of gas measurements

2. The tubing must always be checked before and during use and if necessary be cleaned or replaced

3. Realize the length of tubing and compare to the meter manufacturer's instructions as to the number of aspirations per meter length

Protection against cryogenic damages (LNG)
(cont.1/6)

Pressure Build-Up/Explosions

- Cryogenic liquids exhibit large volume exchange ratios which can cause rapid pressure changes
- This condition can result in an explosion caused by the build up of trapped vapor in the container
- As a result, it is critical to contain these liquids in insulated dewars with pressure relief valves

Protection against cryogenic damages (LNG)
(cont.2/6)

Flesh tearing and materials embrittlement

- The touching of uninsulated containers or other materials that have been cooled by cryogenic liquids can cause serious skin injuries
- The extremely cold surface of the cooled material will cause the flesh to stick fast and tear when one attempts to withdraw from it
- Even non-metallic materials are dangerous to touch at low temperatures
- In addition to the hazards of frostbite or flesh sticking to cold materials, objects that are soft and pliable at room temperature, are easily broken because they become hard and brittle at extremely low temperatures and will easily fracture

Protection against cryogenic damages (LNG)
(cont.3/6)

SAFE HANDLING PROCEDURES:

1. Preparation
2. Transfer and use
3. Storage

Protection against cryogenic damages (LNG)
(cont.4/6)

Preparation:

- Always be familiar with the hazards of the liquid in use
- Work in an open, well-ventilated location
- Ensure that safety glasses and if necessary face shields, gloves are worn
- Examine containers and pressure relief valves for signs of defect

Protection against cryogenic damages (LNG)

(cont.5/6)

Transfer and use

- Use only fitted transfer tubes designed for use with the dewar container. Damaged transfer tubes should be replaced. Do not handle transfer tubes with bare hands as the fitting is not insulated
- Do not lower experiments into storage dewars unless provisions have been made to vent the dewar and prevent freezing in the narrow neck
- Immediately re-cap any container to prevent atmospheric moisture from entering and forming an ice plug
- Provide proper venting for the dewars used in experiments

Protection against cryogenic damages (LNG)
(cont.6/6)

Storage:

- Store in a well ventilated area
- Required pressure relief valves
- No moisture with storage containers
- Keep all sources of ignition away