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

Interreg Baltic Sea Region
EUROPEAN UNION
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- Description of health, ship, equipment and environmental hazards associated with LNG operations and explanation on how to control these hazards
- Basic knowledge to control the risks associated with use of LNG

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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 a victim to fresh air If the 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)

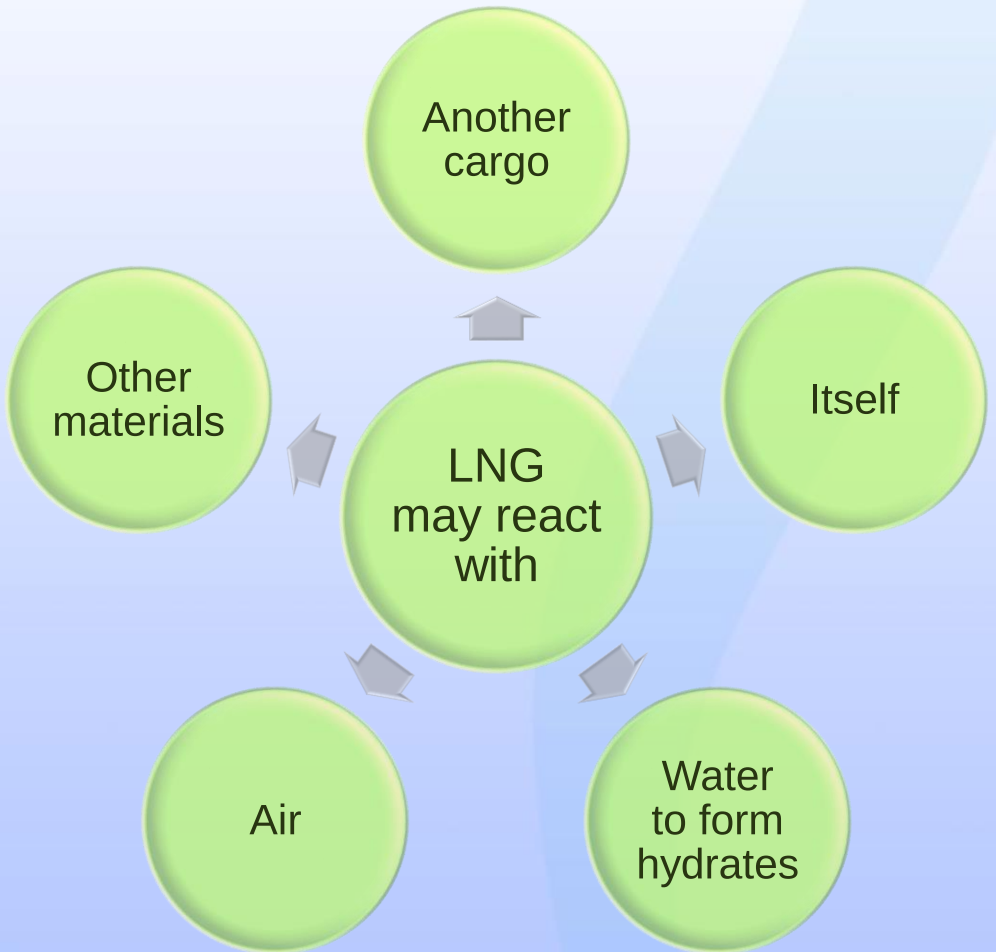
Methane:

- 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)



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

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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

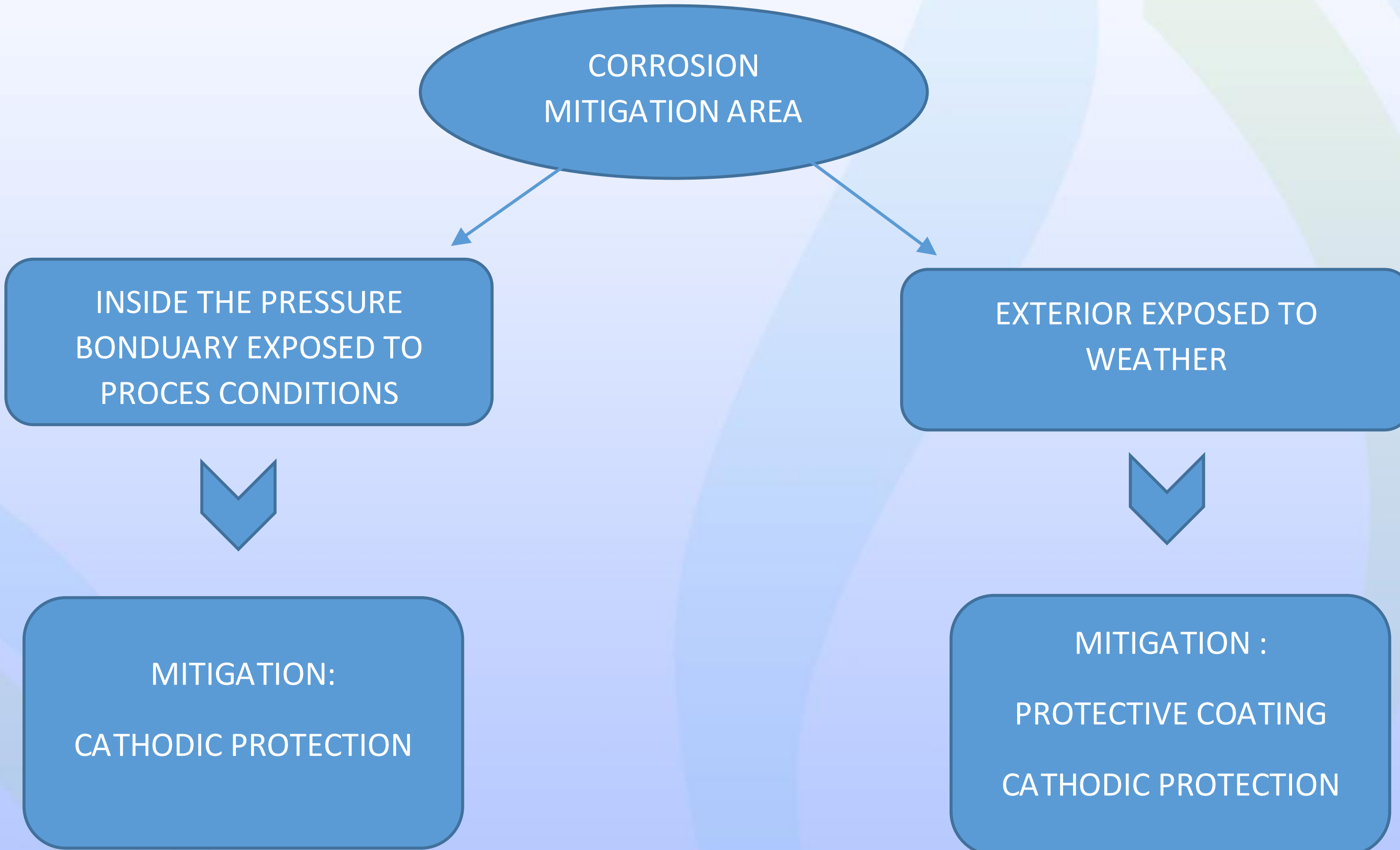
  (See specification of certain cargos in IMO Gas Carrier Code)
- If there is any doubt of the reactivity or compatibility of two cargos they must be treated as incompatible and ‘positive segregation’ provided

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

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

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

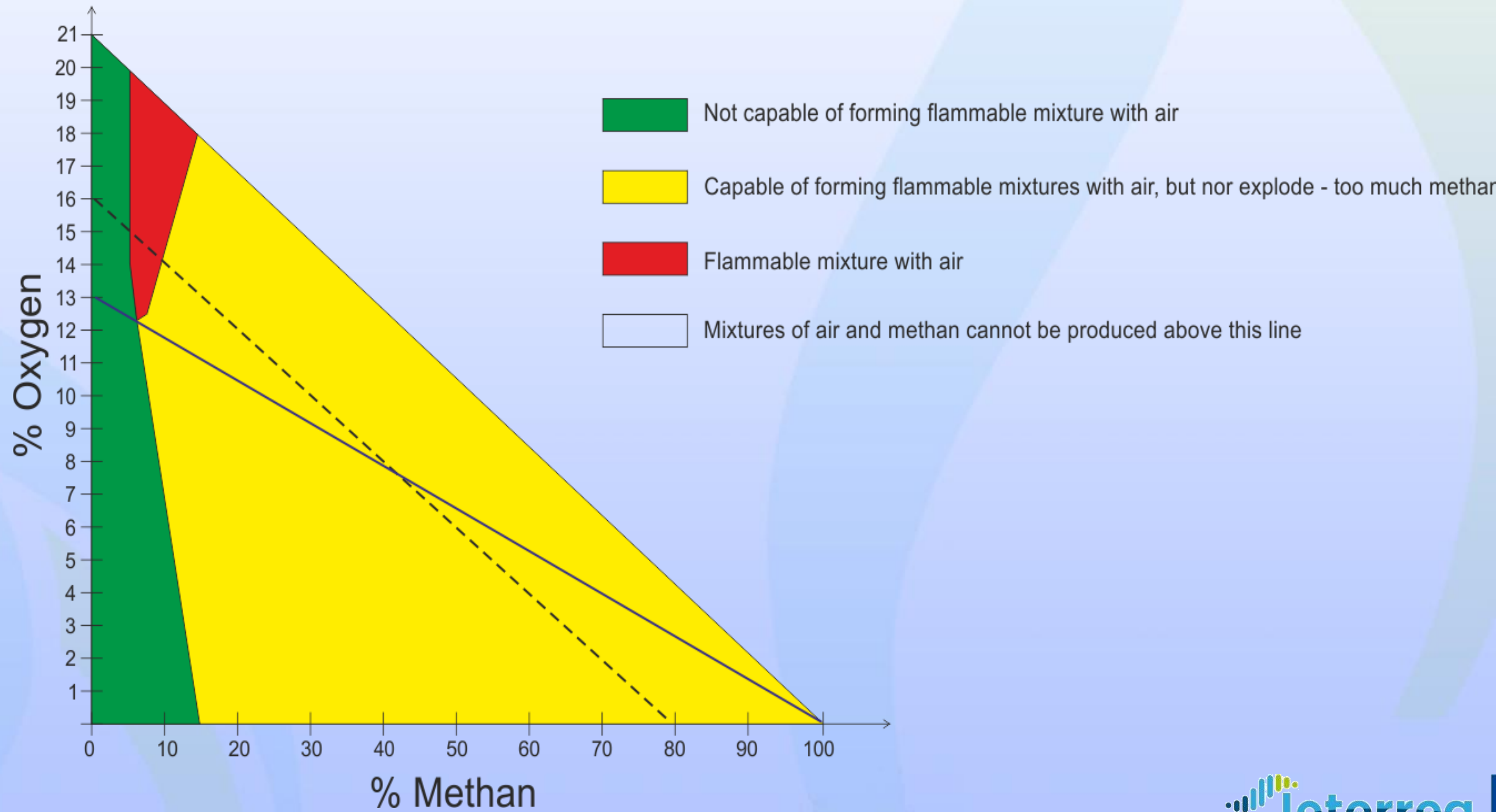
Liquefied Gas	Flash Point [°C]	Flammable range [%by vol. in air]	Auto-ignition temp [°C]
Methane	-175	5.3-14.0	595
Ethane	-125	3.0-12.5	510
Propane	-105	2.1-9.5	468
n-Butane	-60	1.5-9.0	365
i-Butane	-76	1.5-9.0	500
Ethylene	-150	3.0-34.0	453
Propylene	-108	2.0-11.1	453
α-Butylene	-80	1.6-10.0	440
β-Butylene	-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 not 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 shall 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 an odour substances i.e. tetrahydrothiophene - THT

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?

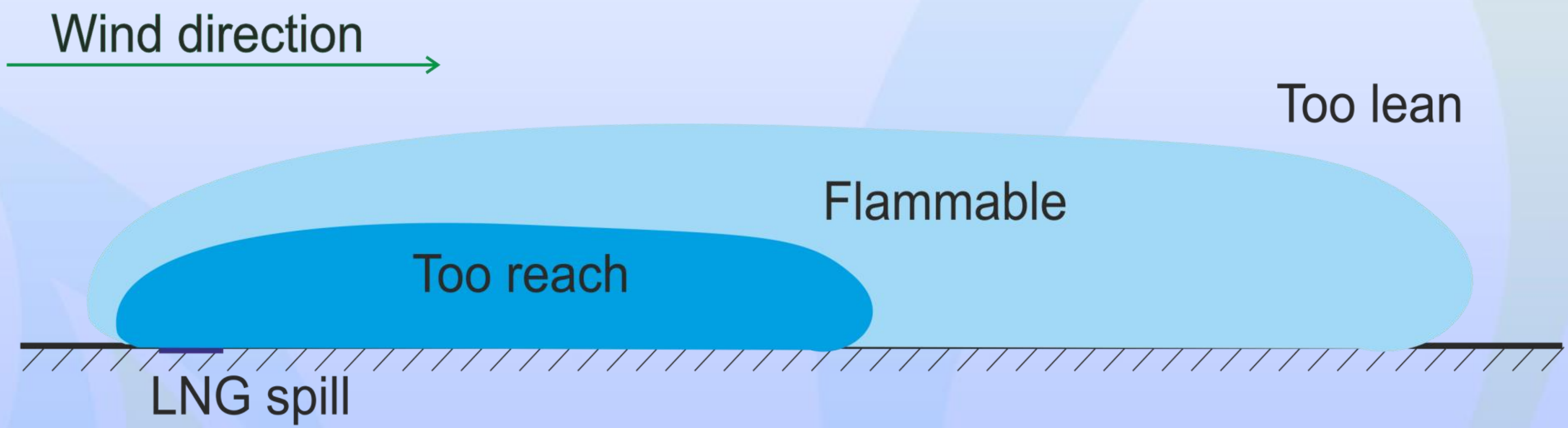
MIX couple of tablespoons of typical dish soap into container with water

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

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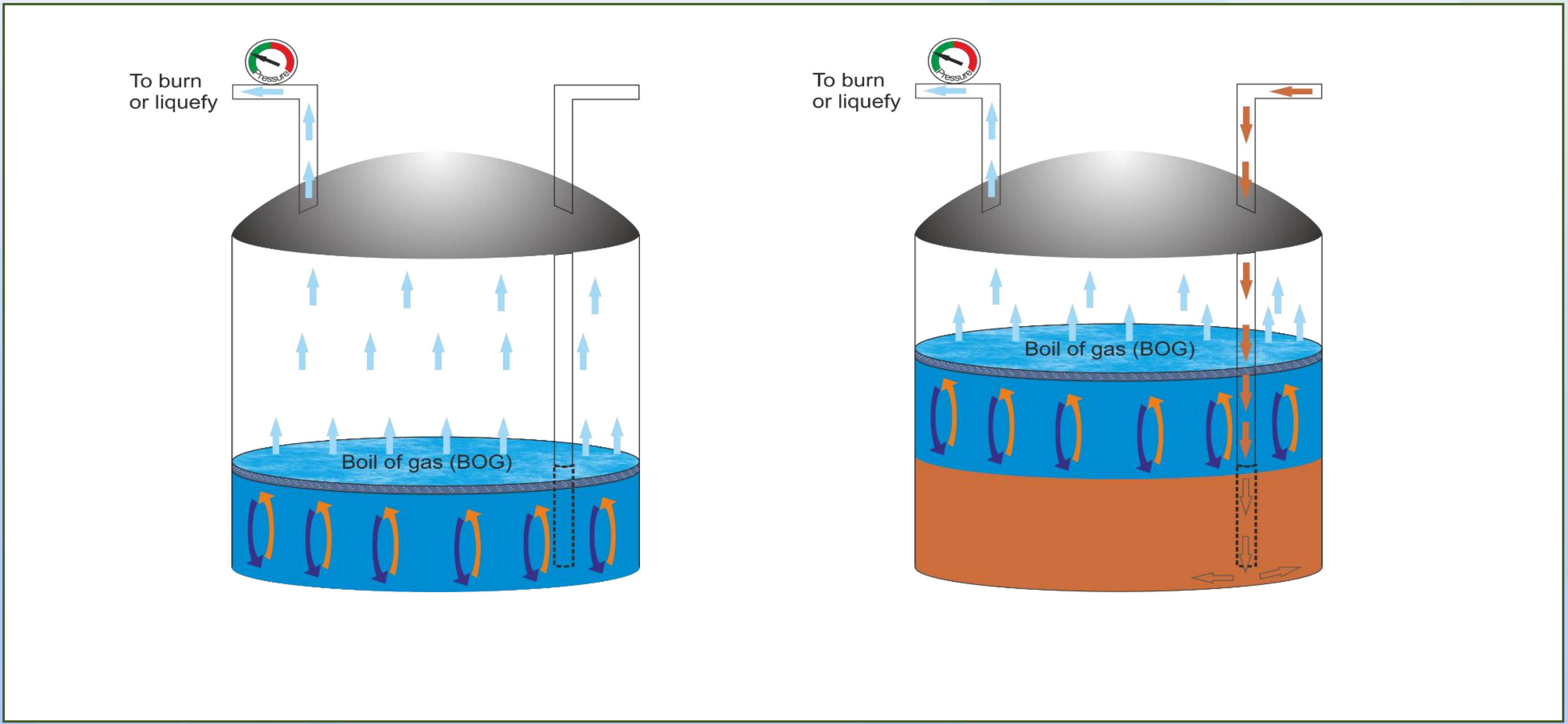
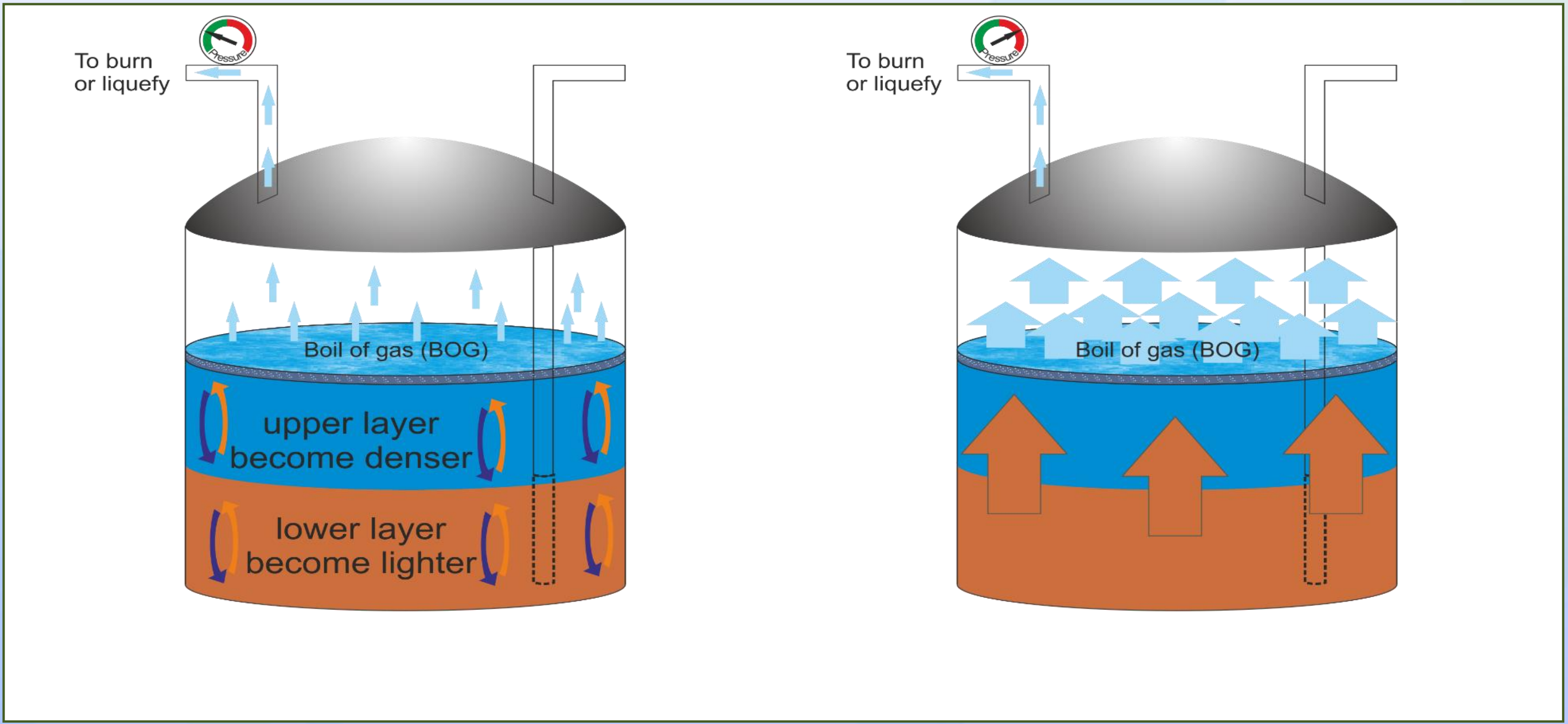
Fuel batch differences (cont. 3/6)

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

- Thank you for your attention