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)

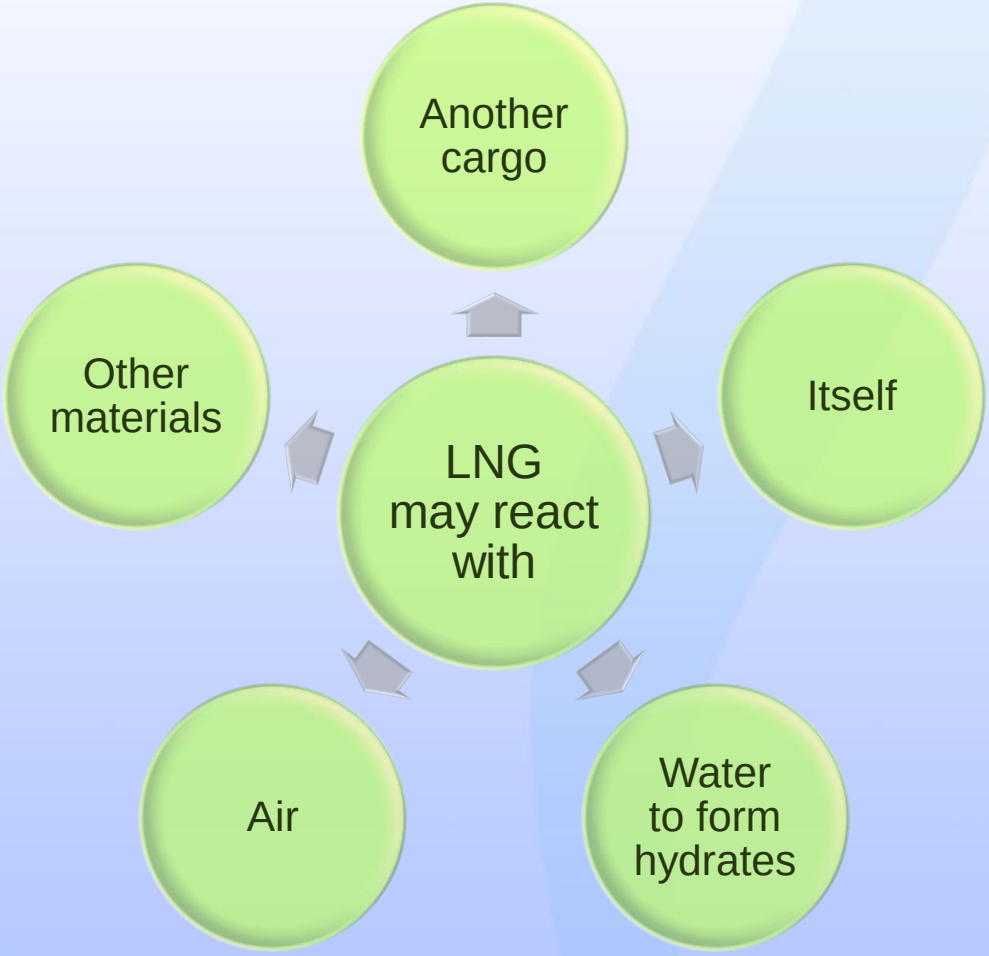
Methane:

- 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)



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

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

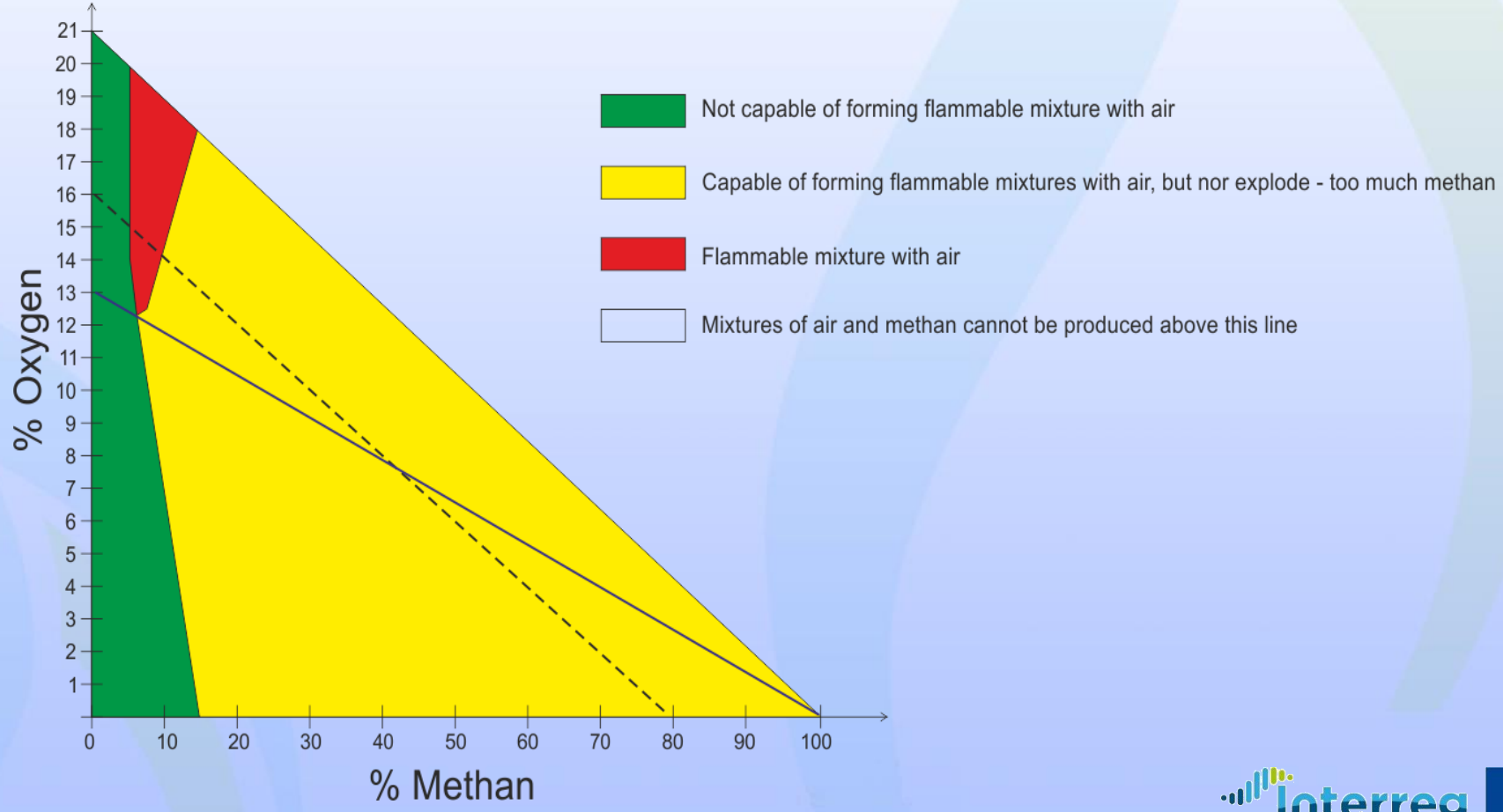
Liquefied Gas	Flash Point [°C]	Flammable range [%by vol. in air]	Auto-ignition temp [°C]
Methane	-175	5.3-14.0	595
Ethane	-125	3.0-12.5	510
Propane	-105	2.1-9.5	468
n-Butane	-60	1.5-9.0	365
i-Butane	-76	1.5-9.0	500
Ethylene	-150	3.0-34.0	453
Propylene	-108	2.0-11.1	453
α-Butylene	-80	1.6-10.0	440
β-Butylene	-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. 1/3)

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

Electrostatic hazards (cont. 2/3)

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.

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?

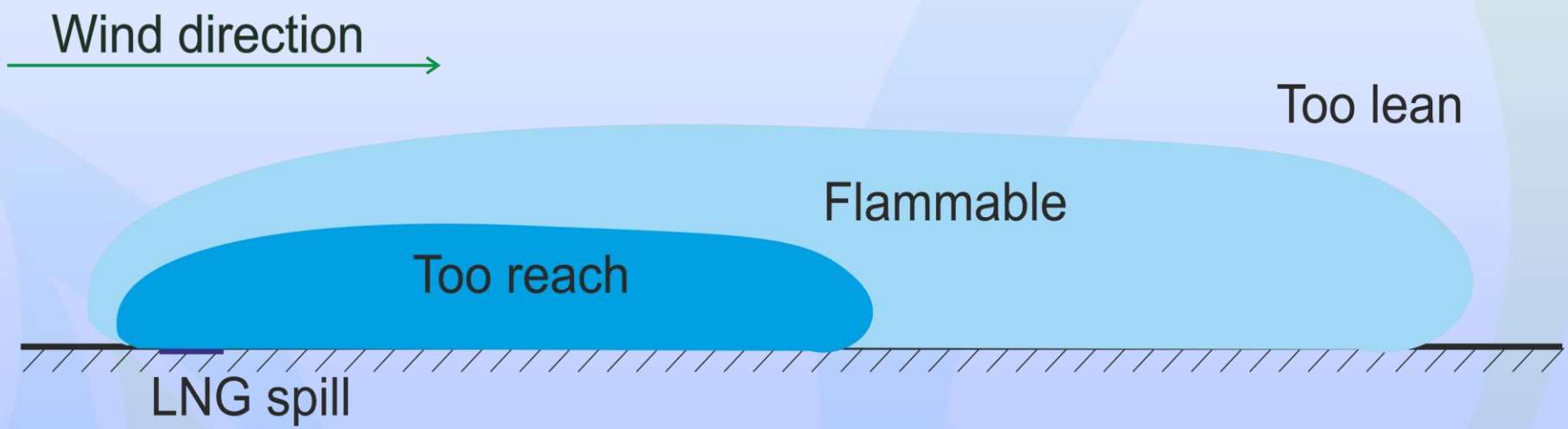
MIX couple of tablespoons of typical dish soap into container with water

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)

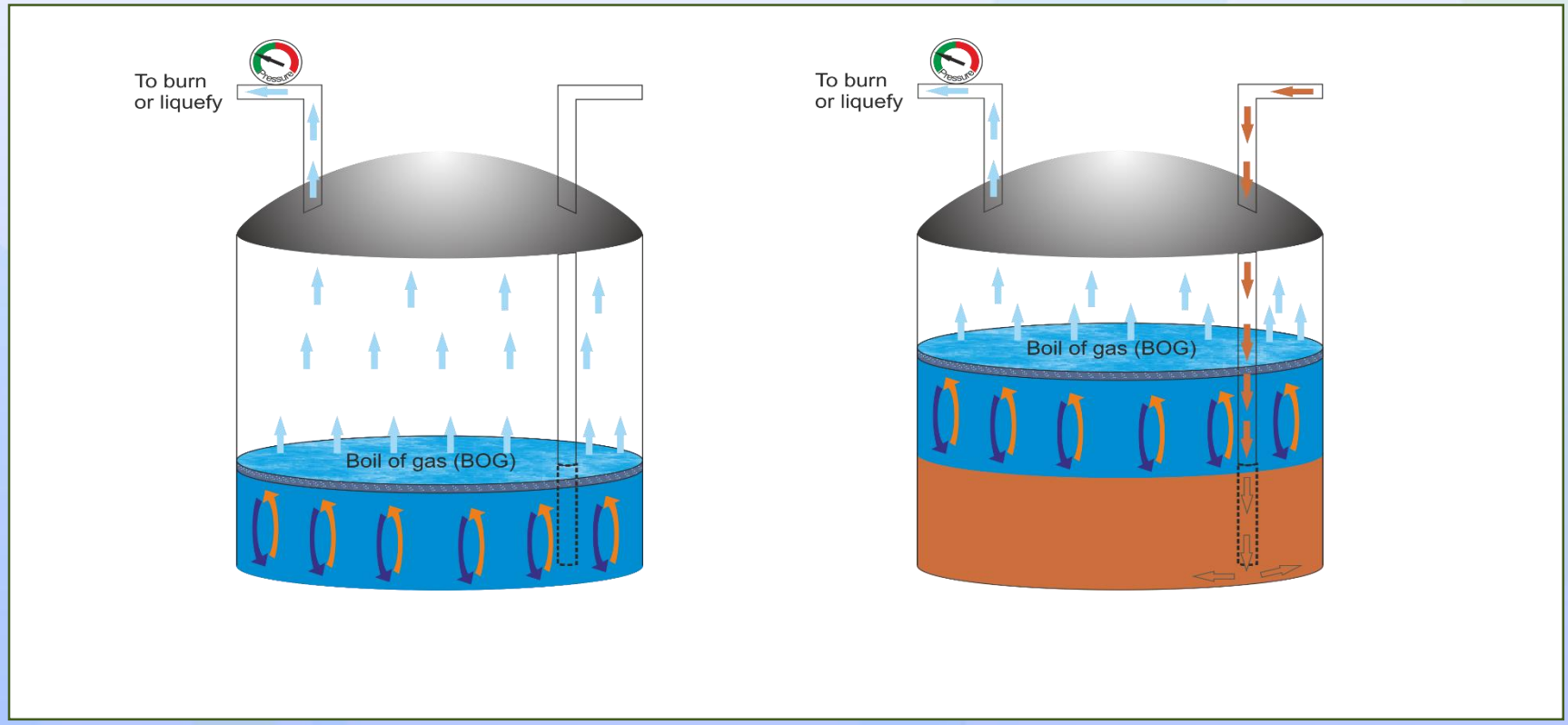
Origin	Nitrogen N_2 [%]	Methane C_1 [%]	Ethane C_2 [%]	Propane C_3 [%]	C_4 [%]	Total [%]	LNG Density [kg/m^3]	Gas Density [kg/m^3(n)]
Australia - NWS	0.0	**87.3**	8.3	3.3	1.0	100	467	0.831
Australia - Darwin	0.1	**87.6**	10.0	2.0	0.3	100	461	0.812
Algeria - Skikda	0.6	**90.4**	7.4	0.6	0.1	100	447	0.776
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

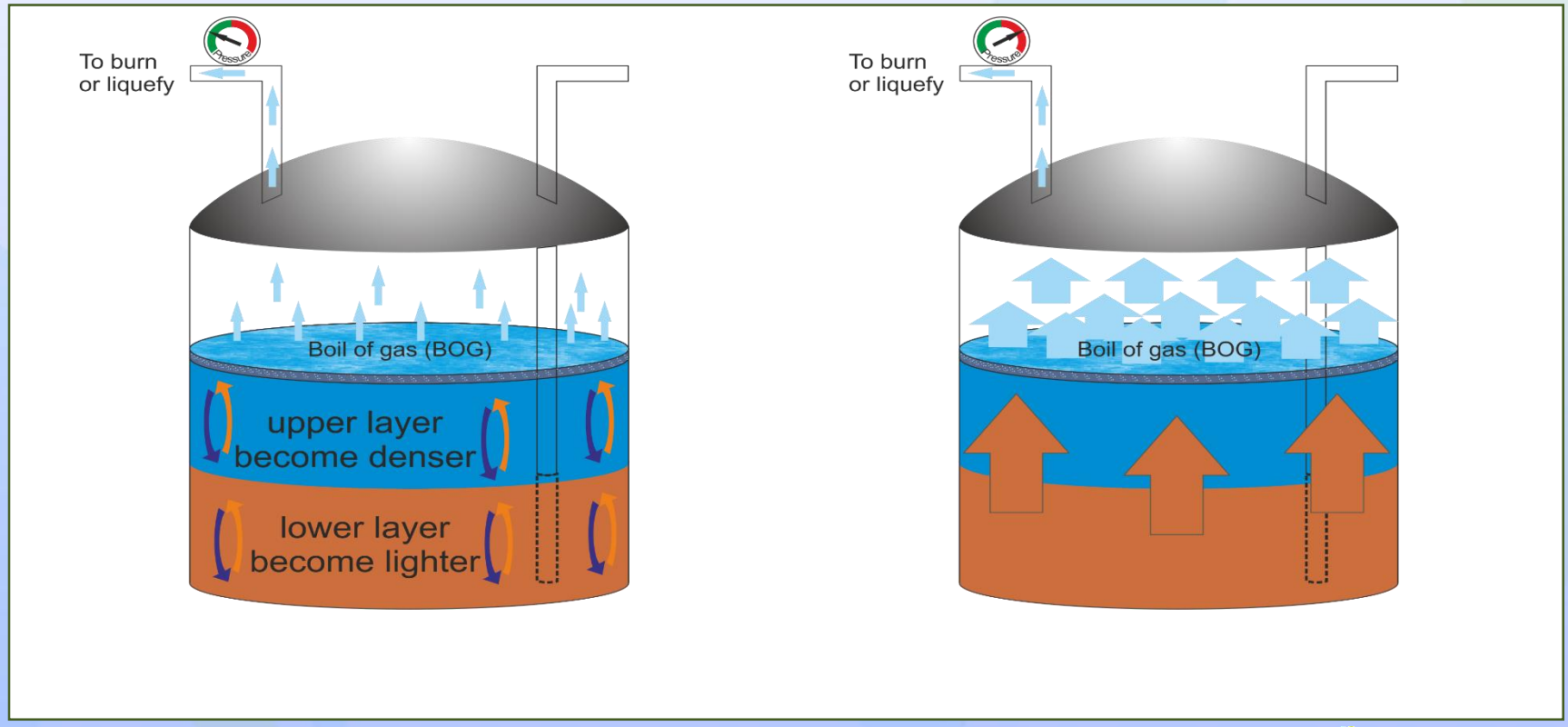
Fuel batch differences (cont. 3/6)

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

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)

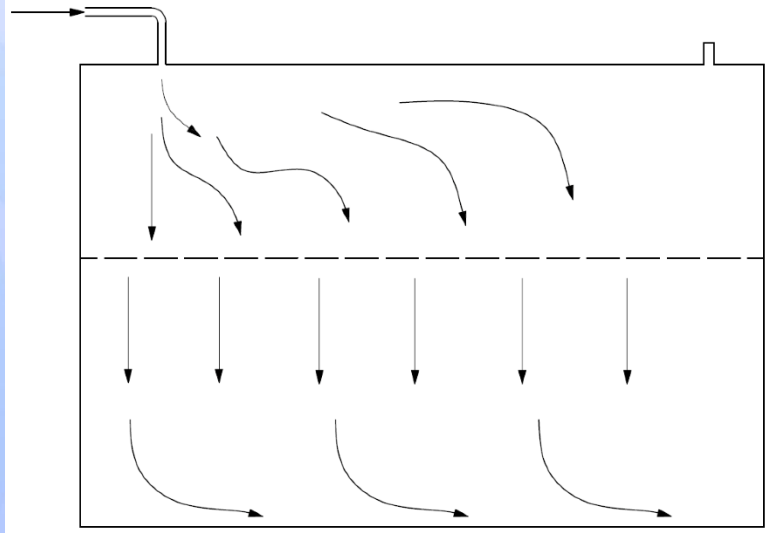
- Inerting cargo tanks, cargo machinery and pipelines is undertaken primarily to ensure a nonflammable condition during subsequent gassing-up with cargo
- To archive nonflammable conditions oxygen concentration must be reduced from 21% to a maximum of 5% by volume (lower values are preferred)
- Inert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

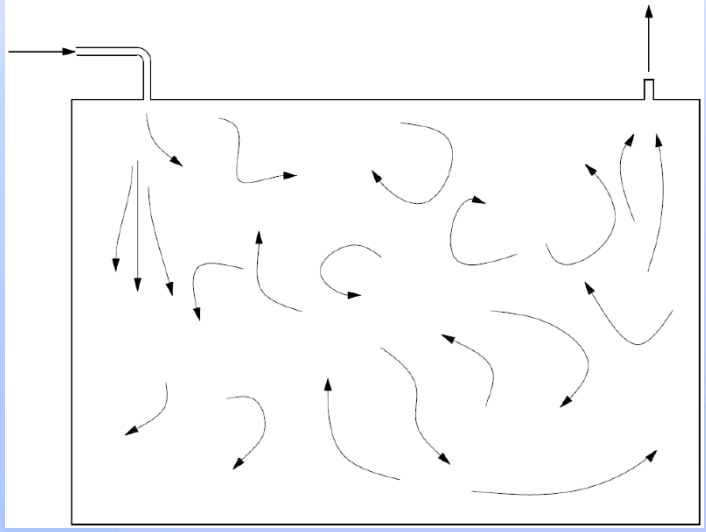
INERTING (cont. 2/2)

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

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 !!!

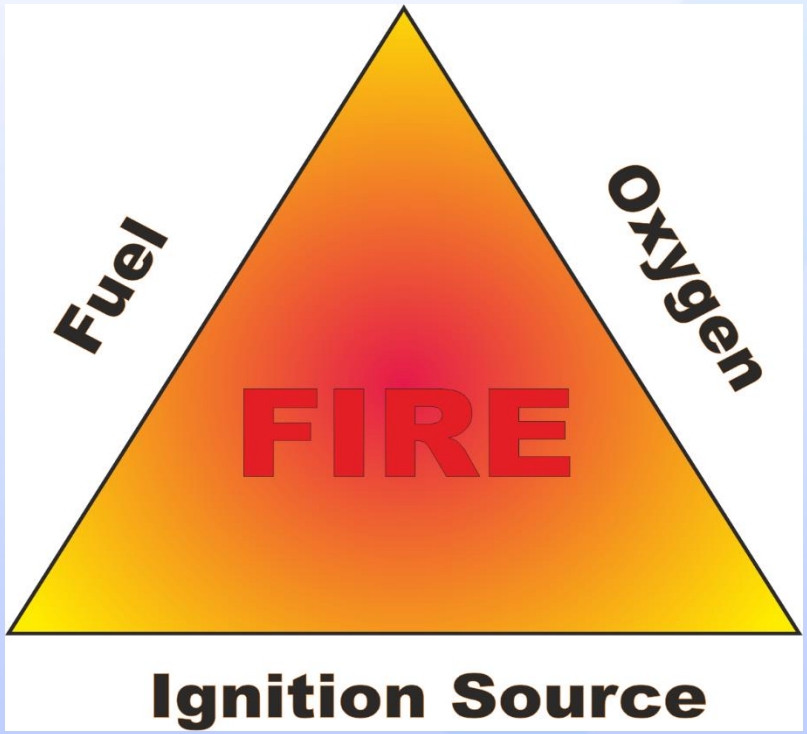
Three things are needed to support a fire:

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)



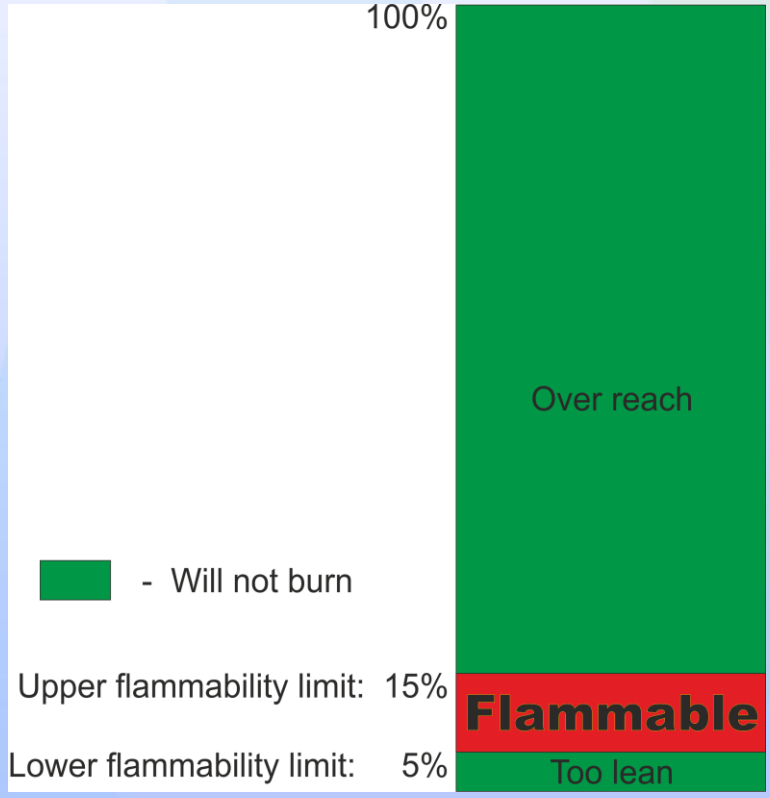
Fire Triangle

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 of 2)

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. 2 of 2)

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

Gas testing

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

- 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

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

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

Personal GAS monitor Draeger PAC5000

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

Thank you for your attention