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

- 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
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**

<table>
<thead>
<tr>
<th>RISK</th>
<th>EMERGENCY PROCEDURES</th>
</tr>
</thead>
</table>
| 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                                                                                                                       |
• **Nitrogen \( \text{N}_2 \)**
• The main hazard: **FROSTBITE, ASPHYXIANT**

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

LNG may react with:
- Another cargo
- Other materials
- Air
- Water to form hydrates
- Itself
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
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 N₂

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 BOUNDARY EXPOSED TO PROCESS CONDITIONS

MITIGATION:
CATHODIC PROTECTION

EXTERIOR EXPOSED TO WEATHER

MITIGATION:
PROTECTIVE COATING
CATHODIC PROTECTION
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)

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

- Not capable of forming flammable mixture with air
- Capable of forming flammable mixtures with air, but not explode - too much methane
- Flammable mixture with air
- Mixtures of air and methane cannot be produced above this line
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 CO₂ 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 Generation

- Some materials (solid, liquid or vapor) can generate and retain a static charge depending 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
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

Wind direction

LNG spill

Too reach

Flammable

Too lean
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)

<table>
<thead>
<tr>
<th>Origin</th>
<th>Nitrogen N₂ [%]</th>
<th>Methane C₁ [%]</th>
<th>Ethane C₂ [%]</th>
<th>Propane C₃ [%]</th>
<th>C₄ [%]</th>
<th>Total [%]</th>
<th>LNG Density [kg/m³]</th>
<th>Gas Density [kg/m³(n)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia - NWS</td>
<td>0.0</td>
<td>87.3</td>
<td>8.3</td>
<td>3.3</td>
<td>1.0</td>
<td>100</td>
<td>467</td>
<td>0.831</td>
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<td>Australia - Darwin</td>
<td>0.1</td>
<td>87.6</td>
<td>10.0</td>
<td>2.0</td>
<td>0.3</td>
<td>100</td>
<td>461</td>
<td>0.812</td>
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<td>90.4</td>
<td>7.4</td>
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<td>0.1</td>
<td>100</td>
<td>447</td>
<td>0.776</td>
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<td>89.5</td>
<td>8.2</td>
<td>1.3</td>
<td>0.3</td>
<td>100</td>
<td>455</td>
<td>0.795</td>
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<td>0.4</td>
<td>100</td>
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<td>0.801</td>
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<td>100</td>
<td>451</td>
<td>0.789</td>
</tr>
<tr>
<td>Indonesia - Badak</td>
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<td>3.0</td>
<td>1.4</td>
<td>100</td>
<td>461</td>
<td>0.816</td>
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</tbody>
</table>
## Fuel batch differences (cont. 2/6)

<table>
<thead>
<tr>
<th>Origin</th>
<th>Nitrogen $\text{N}_2$ (%)</th>
<th>Methane $\text{C}_1$ (%)</th>
<th>Ethane $\text{C}_2$ (%)</th>
<th>Propane $\text{C}_3$ (%)</th>
<th>$\text{C}_4$ (%)</th>
<th>Total (%)</th>
<th>LNG Density [kg/m$^3$]</th>
<th>Gas Density [kg/m$^3$ (n)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia - Tangguh</td>
<td>0.1</td>
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<td>0.2</td>
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</table>
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.
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