NYK-FIL MARITIME E-TRAINING, INC.

BASIC TRAINING FOR SERVICE ON SHIPS SUBJECT TO THE IGF CODE

Introduction

Course Objective:

The course intends for safe operations of ships designed according to the IGF code and designed in accordance with the requirements for seafarers on ships using gases or other low-flashpoint fuels. The course meets the requirements of the STCW Convention amendments:

- Part A, Chapter V - *Special training requirements for personnel on certain types of ships*, required by regulation V/3, paragraph 5, in accordance with their capacity, duties and responsibilities as set out in table A-V/ 3-1 — *Specification of minimum standard of competence in basic training for ships subject to the IGF Code*, and

- Part B, Section B-V/3 – *Guidance regarding the training and qualifications of masters, officers, ratings and other personnel on ships subject to the IGF Code*

Course Contents:

1. Contribute to the safe operation of a ship subject to the IGF Code
2. Contribute to the safe operation of a ship subject to the IGF Code
3. Apply occupational health and safety precautions and measures
4. Carry out fire-fighting operations on a ship subject to the IGF Code
5. Respond to emergencies
6. Take precautions to prevent pollution of the environment from the release of fuels found on ships subject to the IGF Code

WHY TRAINING

$$\textit{Risk} = \frac{\text{Consequence} * \text{Probability}}{\text{Knowledge}}$$

Technology can reduce Consequence and Probability

Adding knowledge -> Reduce Risk!

- ***Design, construction and operation:*** INTERNATIONAL CODE OF SAFETY FOR SHIPS USING GASES OR OTHER LOW-FLASHPOINT FUELS (IGF CODE)"

- ***Safety training:*** STCW Chapter V- Special training requirements for seafarers on ships using gases or other Low-flashpoint fuels

- ***Environment:*** MARPOL 73/78, Annex VI outlines international requirements for vessel air emissions and shipboard air pollution prevention measures.

Competence: Contribute to the safe operation of a ship subject to the IGF Code

1. Ship Design and Operational Characteristics of Ships Subject to the IGF Code

The goal of the IGF Code is to provide for safe and environmentally-friendly design, construction and operation of ships and in particular their installations of systems for propulsion machinery, auxiliary power generation machinery and/or other purpose machinery using gas or low-flashpoint fuel as fuel.
Main factors to be considered during design of a ship subject to the IGF code as:

- protection of the fuel storage tank and fuel pipework from damage through collisions with other vessels or by dropped objects
- redundancy of fuel systems to ensure that the vessel can continue to navigate if one system has a shutdown due to a leakage or failure
- minimization of any hazards provided by the use of gas as fuel
- safety systems that provide a safe shut-down of hazardous systems and in worst case scenarios, removal of their inventories to prevent the build-up of potentially flammable atmospheres

INTRODUCTION TO LNG

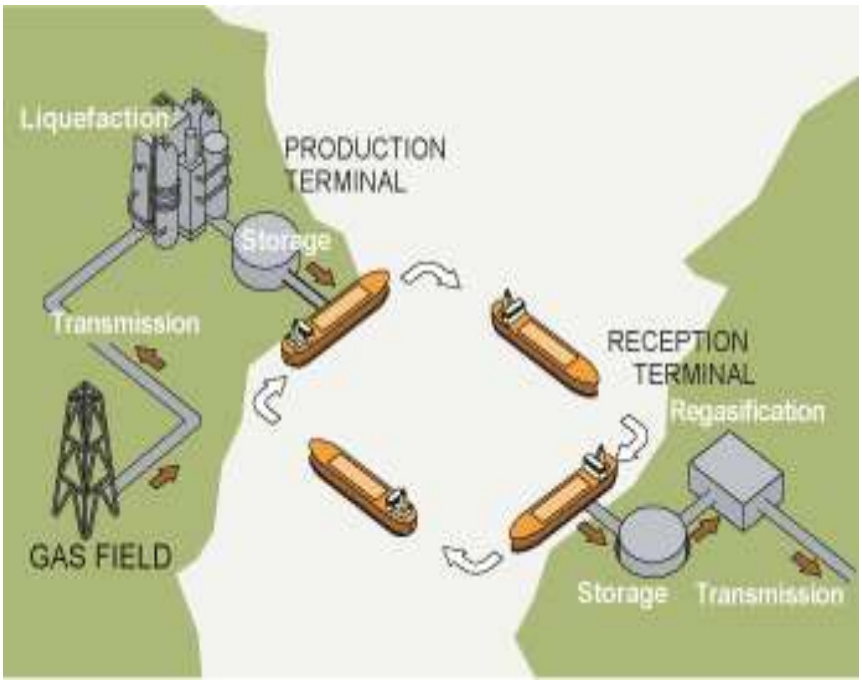
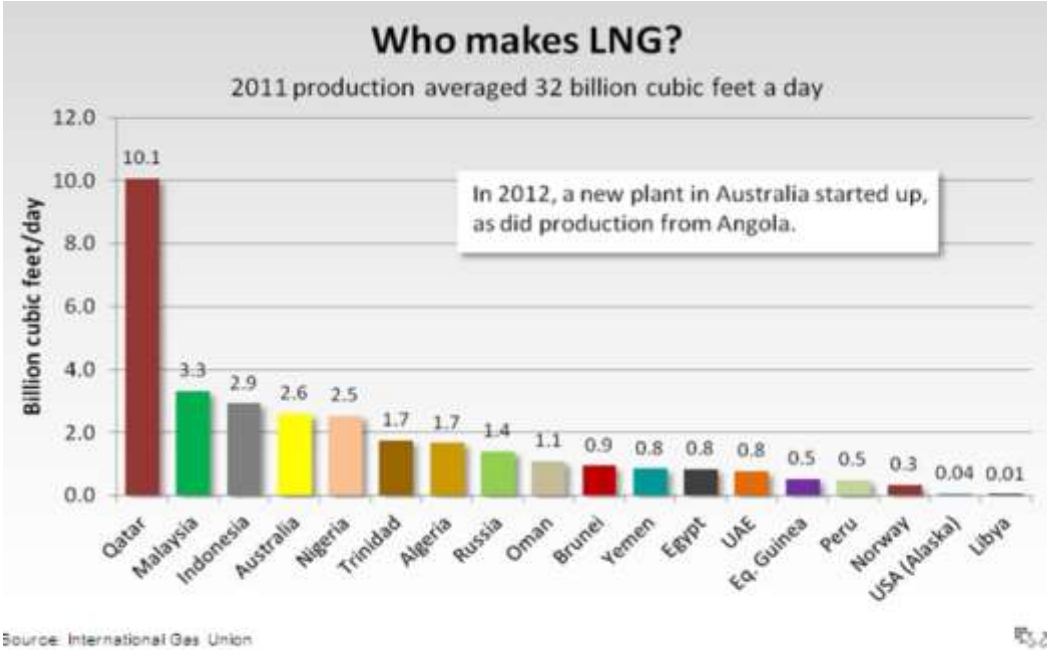


Figure 1. LNG "boiling" at atmospheric pressure and temperature (Source: Osaka Gas Co. Ltd.)

LNG FUEL – Who makes LNG?



LNG as Fuel

2. <u>Ship's Fuel Systems and Fuel Storage System</u>

2.1. Fuels addressed by the IGF Code

The flash point of a chemical substance is the lowest temperature where enough fluid can evaporate to form a combustible concentration of gas.

The flash point is an indication of how easy a chemical may burn. Materials with higher flash points are less flammable or hazardous than chemicals with lower flash points.

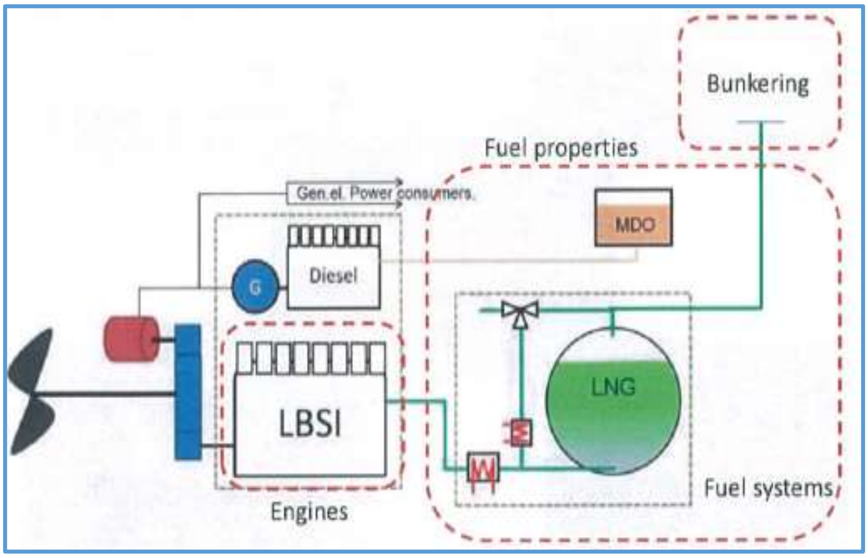
Some fuels and their flash points at atmospheric pressure:

Fuel	Flash Point (°F) (deg C)
Acetaldehyde	-36
Acetone	0
Benzene	12
Biodiesel	266
Carbon Disulfide	-22
Diesel Fuel (1-D)	100
Diesel Fuel (2-D)	126
Diesel Fuel (4-D)	130
Ethyl Alcohol, Ethanol	63
Fuels Oil No.1	100 - 162
Fuels Oil No.2	126 - 204
Fuels Oil No.4	142 - 240
Fuels Oil No.5 Lite	156 - 336
Fuels Oil No.5 Heavy	160 - 250
Fuels Oil No.6	150
Gasoline	-45
Gear oil	375 - 580
Iso-Butane	-117
Iso-Pentane	less than -60
Iso-Octane	10
Jet fuel (A/A-1)	100 - 150
Kerosene	100 - 162
Methyl Alcohol	52
Motor oil	420 - 485
n-Butane	-76
n-Pentane	less than -40
n-Hexane	-7
n-Heptane	25
n-Octane	56
Naphthalene	174
NeoHexane	-54
Propane	-156
Styrene	90
Toluene	40
Xylene	63

2.2. Types of Fuel Systems subject to the IGF Code

Hybrid

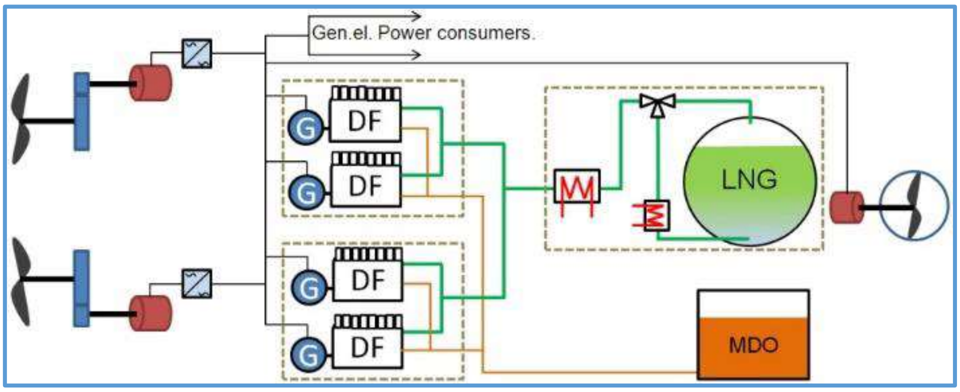
Integrated electric propulsion (IEP) or full electric propulsion (FEP) or integrated full electric propulsion (IFEP) is an arrangement of marine propulsion systems such that **gas engines** or **diesel generators** or **both generate three-phase electricity** which is then used to power electric motors turning either propellers or waterjet impellors. It is a modification of the combined diesel-electric and gas propulsion system for ships which eliminates the need for clutches and reduces or eliminates the need for gearboxes by using electrical transmission rather than mechanical transmission of energy, so it is a series hybrid electric propulsion, instead of parallel.



Dual Fuel

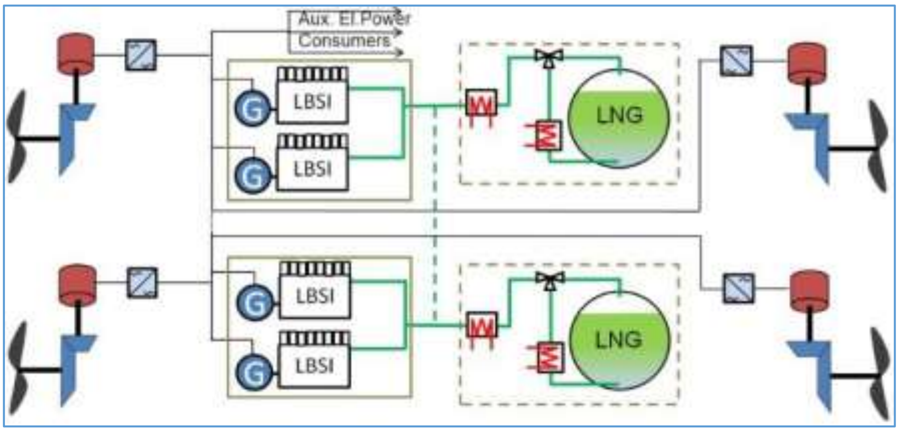
The technology of this engine implements gas injected at high pressure (about 300 bar) with "pilot fuel" (5% MCR fuel). The oil ignites first and then ignites the gas from the combustion of oil. This machine can only use fuel oil or a mixture of gas and oil

Moreover, it has the advantage of eliminating "methane slip" effects. The Diesel cycle engines require high pressure gas, and there is only one system, the direct injection.

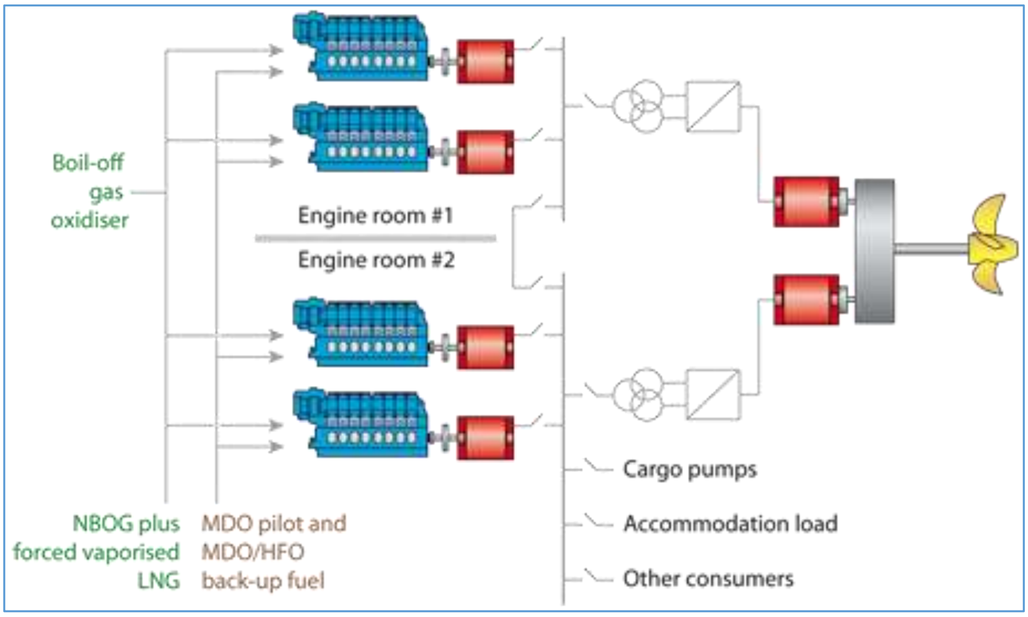


Gas Only / Fuel Gas Engine (Single Fuel Gas Engines)

The cycle Otto / Miller is the basis for the operation of this engine. Applied combustion technology lean (lean burn) in one cycle spark ignition. Instead of a pilot fuel, a rich gas / air mixture is ignited in a combustion antechamber, which forms a strong ignition source for the very lean mixture in the cylinder. This technology ensures high efficiency and low emissions (satisfies IMO Tier III regulations for nitrogen dioxide), but allows flexibility regarding use and oil.



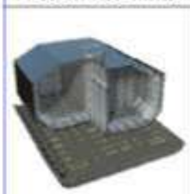
LNG Fueled Propulsion System



2.3. Fuel Containment Systems

Fuel tank technology is also available providing several options of fuel tank types. These tanks are double-wall for providing efficient insulation in different ways. The most common fuel tank is cylindrical with vacuum insulation. Today, all existing vessels use the pressurized Type C tanks.
Different Types of LNG Tanks

The

	Prismatic tank	Spherical tank	Cylindrical tank		Tank truck
Tank type					
IMO type	B	B or C	C		
Heat insulation	External		External	Vacuum	Vacuum
Max. pressure	0.7 bar	1 bar	10 Bar		10 Bar
Space efficiency	High	Low	Medium		Low/Medium
Gas delivery	Pumping Out		Pressure Built-Up Type		
Design cost	High	Medium	Low	Low	-
BOG treatment	Necessary		Not Necessary		
Suitable cap.	>5,000m^3	>5,000m^3	30-1,000m^3	30-1,000m^3	<100m^3
Cost	High	High	Medium	Medium	Low/Medium

challenges that exist in the storage of natural gas are:

- The low temperature requires:
- Specially construction materials such as stainless steel and aluminum
- Special insulation
- Provision for the contraction of the tank

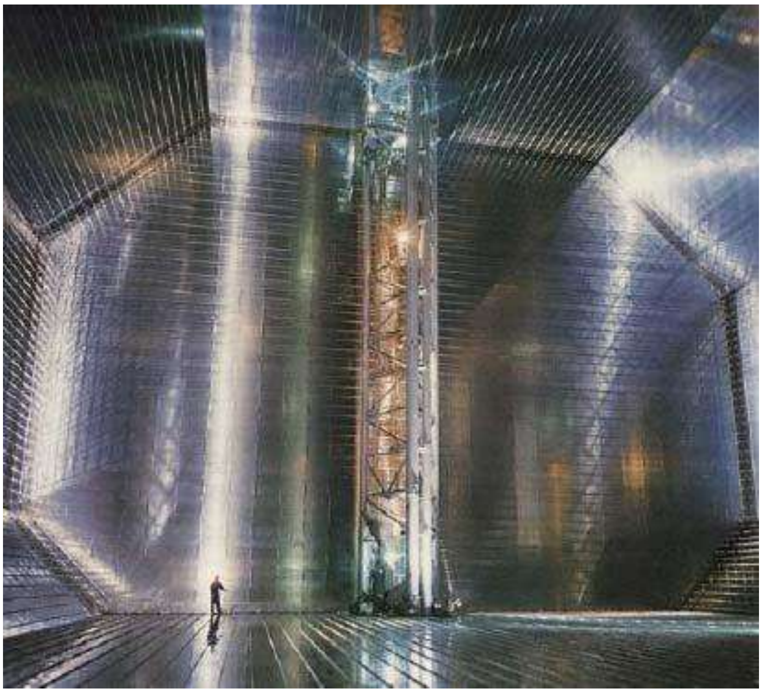
- Easy ignition and lower weight when it is warmer than the air require adequate ventilation and other safety measures
- Larger volume tanks
- Location of tanks

There are two types of gas storage tanks on the vessel:

- *The Membrane Tanks*
- *The Independent Tank*

Membrane Tanks

Membrane tanks use the available space efficiently but require a secondary barrier in the event of a gas leak. Furthermore, they are reinforced with a nitrogen system and a gas detector for each separate insulated space.



Membrane Tank

- *Advantages of the membrane tanks:*
- More LNG volume
- Proven technology
- Delivery time in line with our project schedule
- LNG as bunker fuel will be so cold as possible (more energy per m^3 LNG)

- *Disadvantages of the membrane tanks:*
- Higher BOG rate than type C vacuum insulated tanks for this range of volume
- Not (yet) known for inland waterways

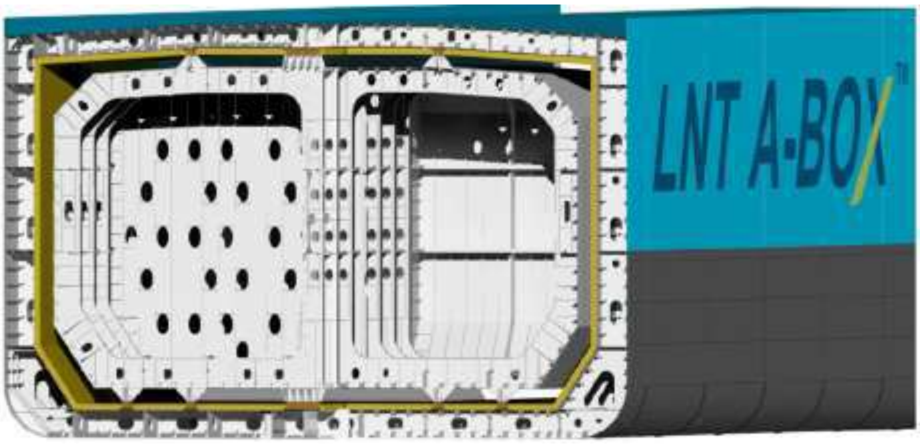
Independent Tanks

There are three types of independent tanks:

- *Type A*
- *Type B*
- *Type C (pressurized tanks)*

Type A

The usage of this type of tanks is suitable for higher volumes of LNG. It is an **atmospheric tank** which is adjustable to hull shape and it is space efficient. However, it is not common to be used by LNG fueled vessels as Type A tanks require a full secondary barrier to prevent potential release of the liquefied gas in the event of a tank failure. Another obstacle is also the price of Type A tanks that is very high.



Type A Tank

Type B

For high capacity, appropriate Type B independent tanks are required. According to the IGC Code, the tank must be arranged so that it can be possible to provide compressed inert gas to have a secondary barrier and provide adequate protection to the steel in case of gas leak. The pressurized inert gas consists of dry air and the inert gas filling.

Type C

The independent tanks type C is the most common, as mentioned earlier, because they are manufactured for low capacity. Their main characteristic is the high-pressure gas, approximately 5 bar, and a maximum allowable working pressure of 20 bar. This allows the provision of directly on machines, without having gone through pumps. There are both advantages and disadvantages of the usage of this type of tanks, as we can observe below:

- *Advantages of Type C tanks:*
- Standard tanks, long experience
- Pressure built up in case of zero consumption
- High bunkering rates
- Easy installation
- *Disadvantages of Type C tanks:*
- Space requirements (DNV-Gerd-Michael Wursig, 2013)

There are two types of tanks double skinned cylinders, capacity of 10-10.000 m3 and bilobed tanks, capacity 100-20.000 m3, placed either internally or on the deck.

2.4. General arrangement of Fuel Storage Systems on board ships subject to the IGF code

Of the two possibilities, above or below deck, the above deck location is less complex and less expensive. The below deck location requires zoned separation from other spaces, explosion proof appliance, dedicated ventilation systems and, in general, more controls. LNG tank storage cannot be placed where MDO can be stored (wing tanks, DB's) and thus the volume requirements are many times that of storing MDO. On the other hand, above deck locations, well away from the vessels roll and pitch centers, invite greater sloshing and possibly greater structural weight in the installation. The location in the length of the vessel could be impacted by cargo considerations as discussed later.

The tanks that will be installed on open deck have the following limitations.

- Have B/5 distance from the hull as mentioned earlier. In ships not carrying passengers, the tanks can be placed closer to the edge of the deck. This depends on the volume of the tank and ranged from 0.8-2.0 m but never less than 800mm.
- To be located in a place where there is adequate natural ventilation

Tank Locations

LNG Arrangement Oil Tanker

2.5. Hazard Zones and Areas

Hazardous Areas Classification

FIRST – WHAT'S THE PURPOSE OR HAZARDOUS AREA CLASSIFICATION?

Hazardous area classification in respect of selection of electrical equipment, cables and wiring and positioning of openings and air intakes.

"Hazardous areas are defined as areas in which a flammable or explosive gas and air mixtures is, or may normally be expected to be, present in quantities such as to require special precautions for the construction and use of electrical equipment and machinery." – IEC 60092-502

SECOND – WHAT'S HAZARDOUS MATERIAL/ FLASH POINT?

AS ABS RULE DEFINITION:

"Areas where flammable or explosive gases, vapors, or dust are normally present or likely to be present are known as hazardous areas. Hazardous areas are however more specifically defined for certain machinery installations, storage spaces and cargo spaces that present such hazard, e.g.:

- Helicopter refueling facilities
- Paint stores
- Cargo oil tanks and other spaces of oil carriers
- Ro-Ro cargo spaces

FLASH POINT:

FLASH POINT of a material is the Material's Temperature making it ready for Explosion by ignition.
Gasoline = – 45°C
Diesel fuel = + 55°C
* High flash point liquids are less hazardous than low flash point liquids.
* Practically liquids with flash point above 55°C are not liable to generate a hazardous area, unless they are likely to be submitted to a temperature above this flash point.

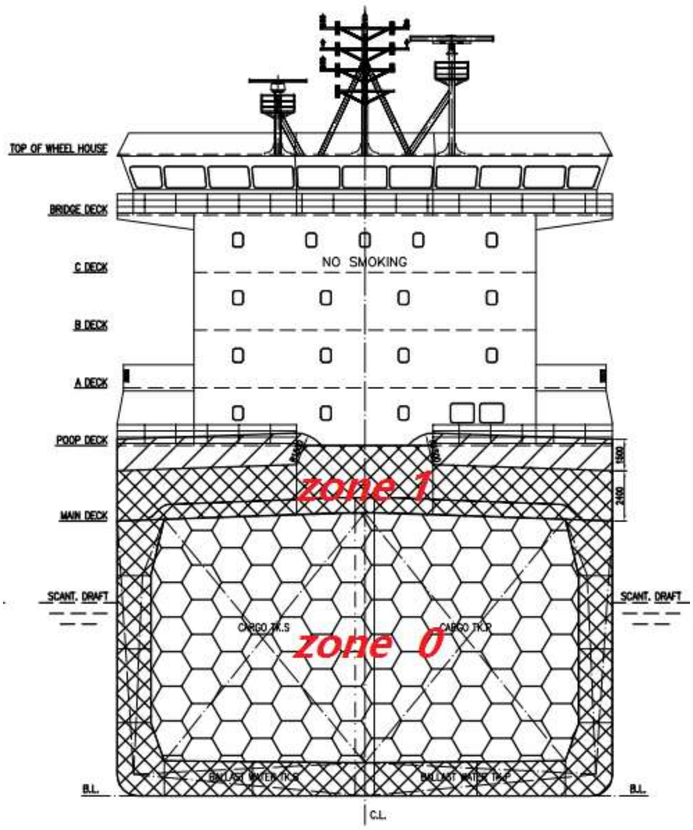
THIRD – HOW MANY TYPES OF HAZARDOUS AREA?

Hazardous areas are classified into 3 zones based upon the frequency of the occurrence and duration of an explosive gas atmosphere, as follows:

Zone 0

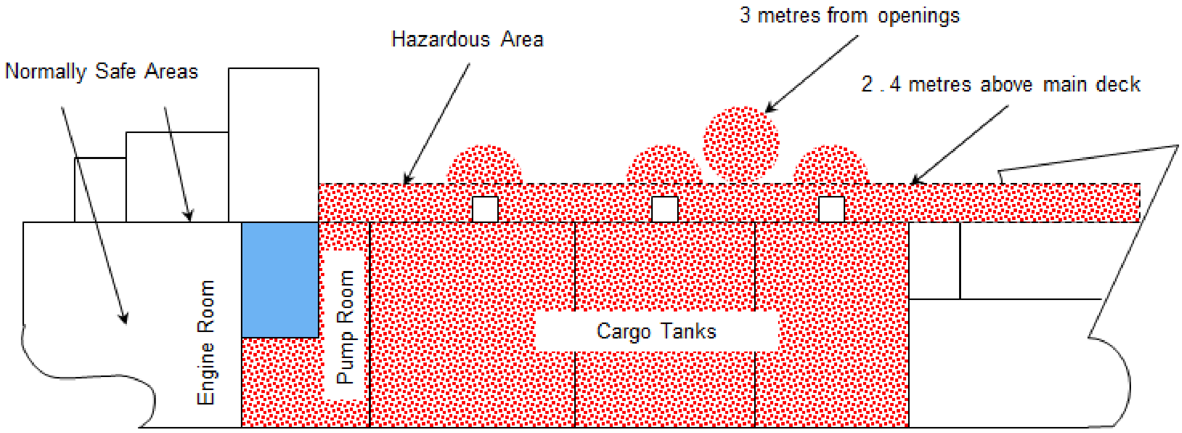
Area in which an explosive gas atmosphere is present continuously or for long periods or frequently.

Ex: The interiors of cargo tanks, slop tanks, any pipework of pressure-relief or other venting systems for cargo and slop tanks, pipes and equipment containing the cargo or developing flammable gases or vapors.

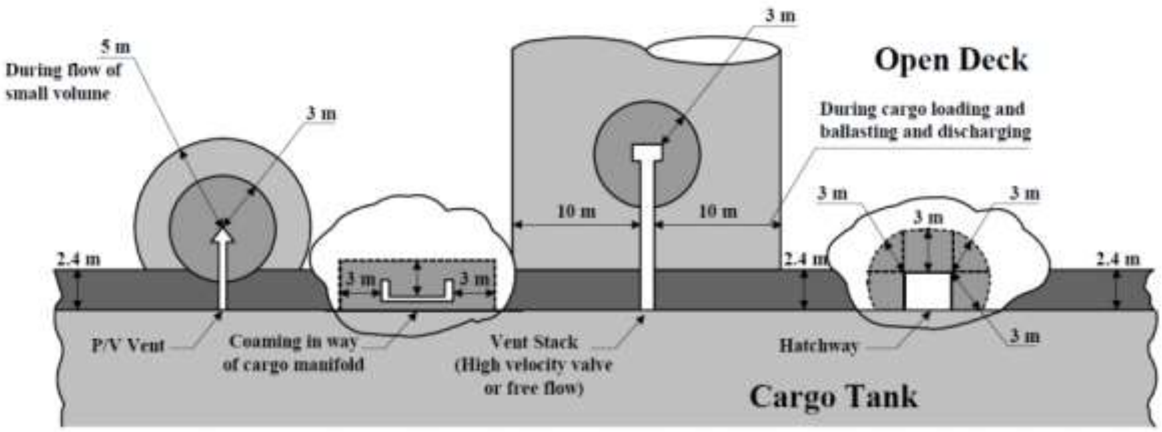


Zone 1

Area in which an explosive gas atmosphere is in which an explosive gas atmosphere is likely to occur in normal likely to occur in normal operation operation occasionally occasionally.



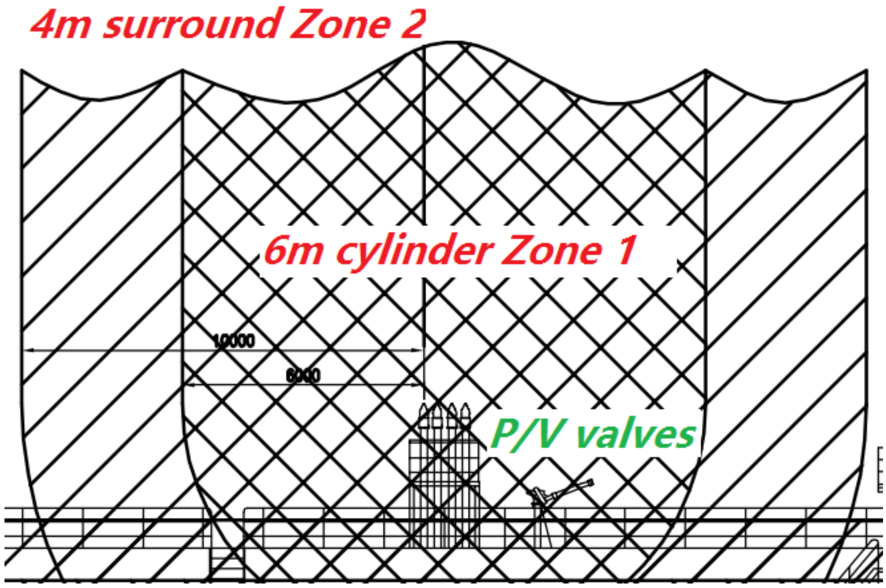
Ex: Any spaces adjacent to integral cargo tanks (void, cofferdam, pump room). Area within 3 m of any cargo tank outlet, gas or vapour outlet or within 1.5 m of cargo pump room entrances, cargo pump room ventilation inlet, openings into cofferdams or other Zone 1 spaces or up to a height of 2.4 m above the deck or 3 m beyond the manifold. Vertical cylinder of unlimited height and 6 m radius cantered upon the center of the outlet.



Zone 2

Area in which an explosive gas atmosphere is not likely to occur in normal operation but, if it does occur, will persist will persist for a short period for a short period only.

Ex: Area within 10 m horizontally from any cargo tank outlet or gas or vapour outlet. Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1. Spaces 4 m beyond the cylinder of zone 1.



<u>*Non-hazardous area (safe area)*</u>

A non-hazardous area is an area in which an explosive atmosphere is not expected to be present

FINALLY – WHAT'S THE REQUIREMENT FOR EACH ZONE BASE ON REGULATION?

Electric items:

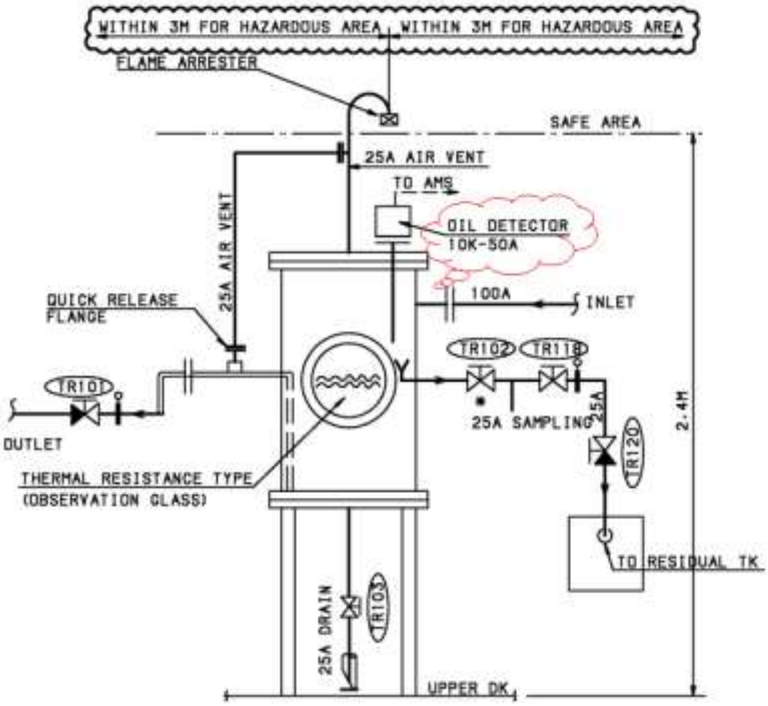
Electric equipment: To be certified intrinsically-safe Ex(ia)-Zone 0/ Ex(ib)-Zone 1

Electric cable: Electrical cables are not to be installed in hazardous areas except as specifically permitted or when associated with intrinsically safe circuits. (Mean not All cables passing through Hazardous zone to be I.S certified, but the I.S system/equipment.

Hull/Hull outfitting items:

ABS – Pt 5A: Where structural members pass through the boundary of a tank, leakage into theadjacent space could be hazardous or undesirable, and full penetration welding is to be adopted for the members for at least 150mm on each side of the boundary.

ABS – Pt 4 Cable trays and protective casings passing through hazardous areas are to be electrically conductive.



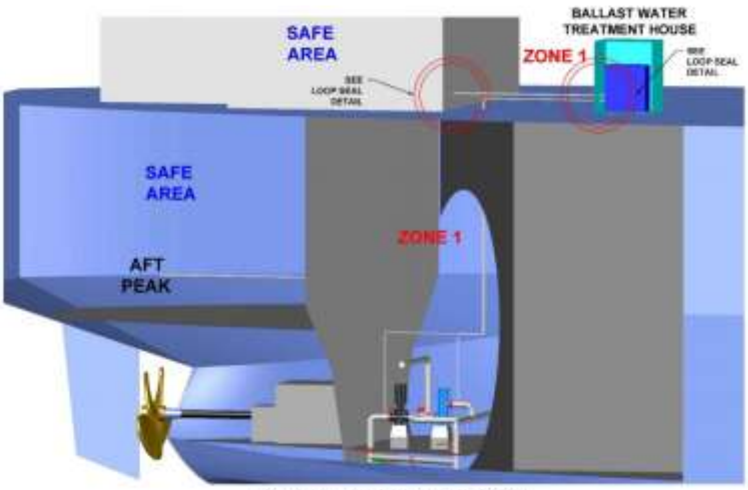
ABS -Pt 5C: An inspection tank (observation tank) is to be provided for detection of oil contamination in the condensate return. The tank is to be of the closed type, dedicated to the cargo heating system only, with no interconnection to any other system, and vented to the weather. The vent outlet is to be fitted with a corrosion resistant flame screen. The inspection tank may be located within the machinery space, in which case, the vent is to terminate outside of the cargo area and the area within 3 m (10 ft) of the outlet is to be considered hazardous.

REQUIREMENTS FOR DESIGNATING A BWTS SPACE INSTALLED WITHIN A ZONE 1 SPACE AS NON-HAZARDOUS

• The compartment arrangements shall be provided with separation from the hazardous

space by two gas tight self-closing doors without hold back arrangements forming an airlock capable of maintaining an overpressure.

• All ventilation inlets and outlets are routed such that they are located outside of the hazardous area.

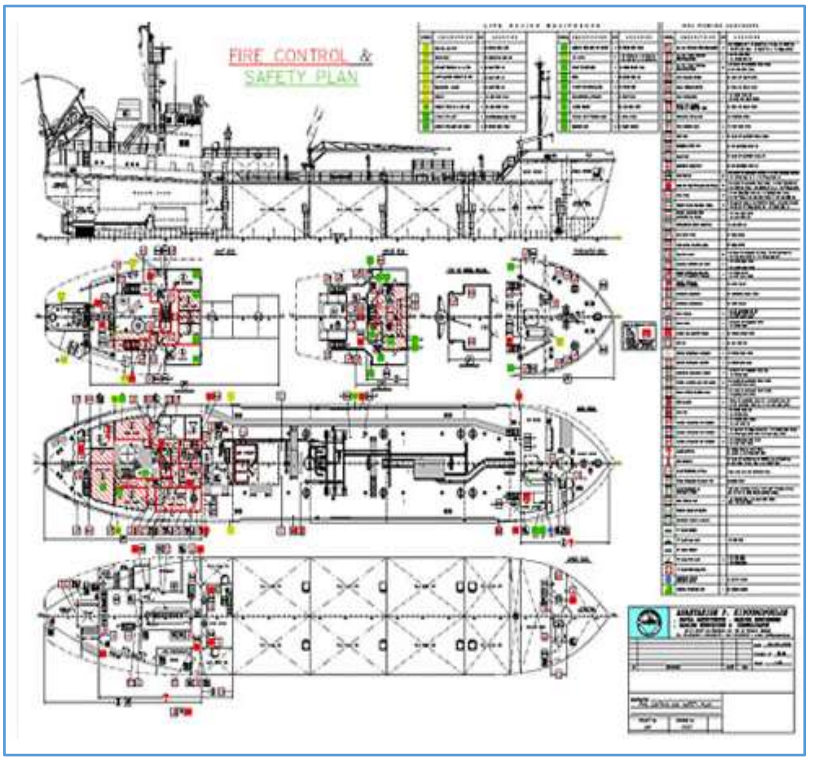


CRUDE OIL TANKER WITH PUMP ROOM

• The relative overpressure or air flow is to be continuously monitored and so arranged that in the event of a ventilation failure (loss of relative overpressure or loss of air flow) an audible and visual alarm is given at a manned control station and the electrical supply of all equipment (not necessarily of the certified safe type) is to be automatically disconnected.

• The mechanical ventilation system is to have at least twenty (20) air changes an hour or as required by the BWMS manufacturer, whichever is greater, that will maintain the separate compartment under a positive pressure relative to the external hazardous area.

2.6. Fire Safety Plan



A Brief Overview of Fire Control Plan on Ship

The Fire Control Plan is a mandatory requirement of SOLAS convention described in Regulation 15 of Chapter II. The fire control plan provides us information about fire station on each deck of the ship, on various bulkheads, and in spaces enclosed by "A" class division, "B" class divisions. It also explains us the type of fire detection system and fire fighting systems available on ship.

Important things about Fire Control Plan:

Fire alarms, appliances, escape route, Switches etc. Fire control plan tells us about various fire alarm systems, sprinkler installation, extinguishing appliances, means of escape to different compartments and decks, and ventilation system including particulars of remote operation of dampers and fans. The position of various dampers, their marking, and which fan is for particular compartment or deck is also explained so that required damper and fans can be closed in case of fire.

- The general arrangement plan should be permanently exhibited for the guidance of ship officer in conspicuous locations such as navigating bridge, engine room and accommodation.
- At least one copy of the fire control plan shall be available ashore at the offices of the Company.
- Copies of the fire control plan must be provided to each of the members of the fire patrol team in a passenger ship and also posted at each continuously manned central control station.
- A copy of Fire Control Plan should be permanently stored in prominently marked weathertight enclosures outside deckhouse for assistance of shore side firefighting system in case the ship is in port or in dry-dock.

Importance of Fire control Plan:

- The Fire control plan is not just a paper requirement for the classification society or the port state control. It is a useful document to understand:
- The location of various firefighting and safety equipment onboard for new joiners
- Location of nearest and safest firefighting equipment and escape route when fighting fire on ship
- The port firefighting station team has no clue about the ship arrangement. The fire control plan is extremely useful and easy to read document to tackle major fire on ship by port Fire fighters
- Fire control plan is an important part of safety management plan of the ship and any discrepancy may lead to non-conformities against the SMS
- Copy of Fire control plans kept the shore officer is also inspected while issuing/ re-issuing the document of compliance (DOC) and safety management certificate (SMC) to the company

Machinery spaces of category A

Those spaces and trunks to such spaces which contain either:
1. Internal combustion machinery used for the main propulsion,
2. Internal combustion machinery used for purpose other than the main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW, or
3. Any oil-fired boiler or oil fuel unit, or any oil-fired equipment other than boilers, such as inert gas generators, incinerators, etc, (SOLAS).

BULKHEAD DIVISION OF CLASS FOR FIRE

There are 3 class of division:

"A" class division: are those dicvision formed by bulkheads and decks which comply with the following:

- they shall be constructed of steel or other equivalent material.
- they shall be suitable stiffened.
- they shall be so constructed as to capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test.
- they shall be insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140 degree Celsius above the original temperature, nor will the temperature at any one point , including any joint, rise more than 180 degree Celsius above the original temperature within the time listed below:

- class" A-60" 60 minutes
- class "A-30" 30 minutes
- class "A-15" 15 minutes
- class "A-0" 0 minutes

The administration may require a test of a prototype bulkhead or deck to ensure that it meets the above requirement for integrity and temperature rise.

"B" class division: are those division formed by bulkheads, decks, ceiling or lining which comply with following:

- they shall be so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test.
- they shall have an insulation value such that the average temperature of the unexposed side will not rise more than 140 degree Celsius above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225 degree Celsius above the original temperature within the temperature within the time listed below:

- class "b-15" 15 minutes
- class "b-0" 0 minutes

- they shall be constructed of approved non-combustible materials and all materials entering into the construction and erection of "b" class divisions shall be non-combustible with the exception that combustible veneers may be permitted provided that they meet other requirements.
- the administration may require a test of a prototype bulkhead or deck to ensure that it meets the above requirement for integrity and temperature rise.

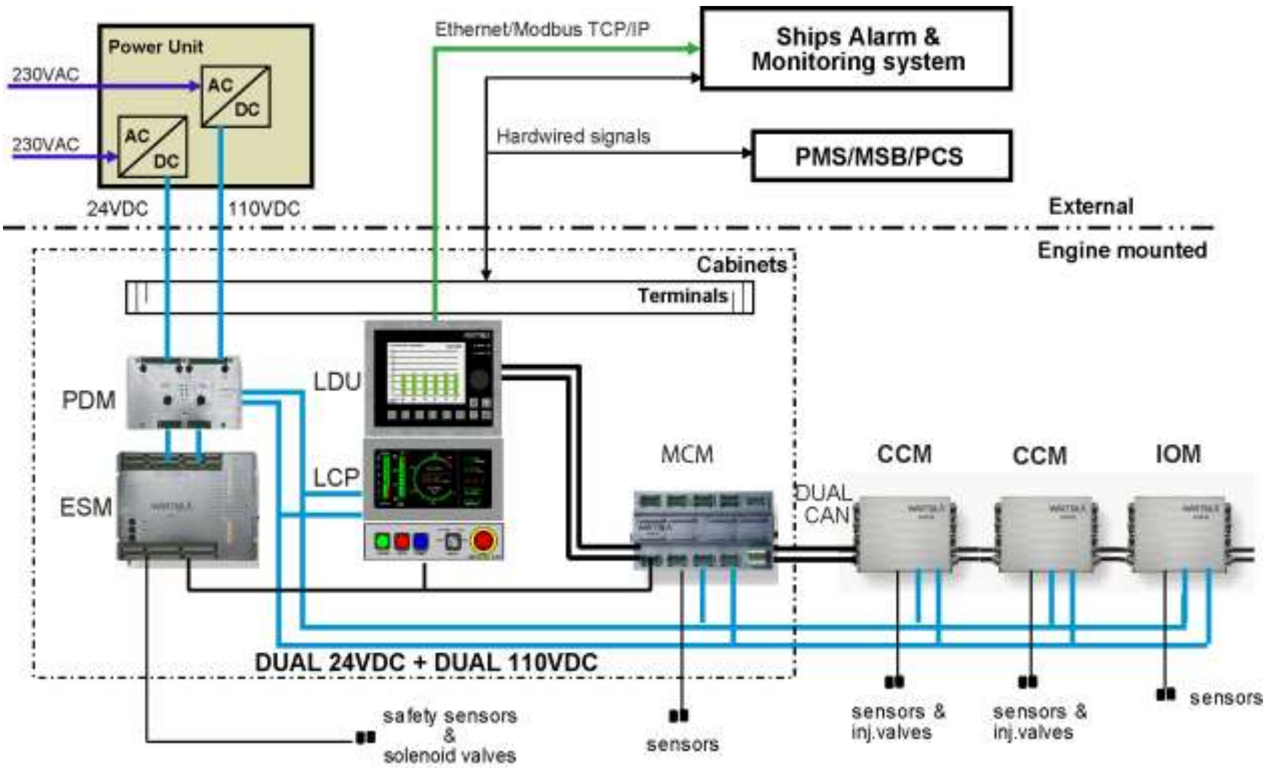
"C" class division: are the divisions constructed of approved non-combustible materials. they need meet neither requirements relative to the passage of smoke and flame or limitations relative to the temperature rise. combustible veneers are permitted provided they meet the requirement.

2.7. Monitoring, control and safety systems

Suitable instrumentation devices should be fitted to allow both local and remote reading of essential parameters to ensure the safe management of all fuel-gas equipment including bunkering.

Tanks not permanently installed in the ship should be provided with the same monitoring system as permanently installed tanks

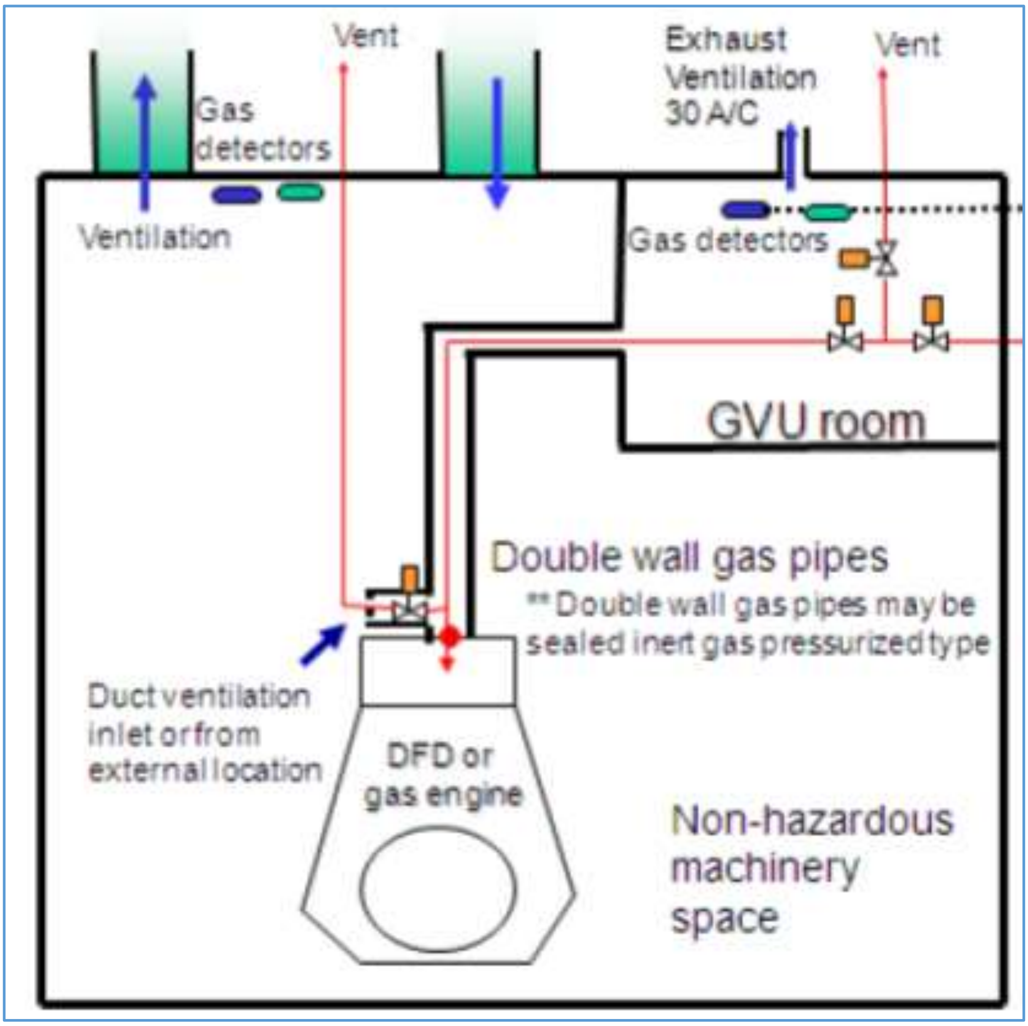
LNG Fuel Control and Safety



3. <u>Operation of Fuel and Fuel Storage System</u>

3.1. Piping Systems and Valves

Fuel tank technology is also available providing several options of fuel tank types. These tanks are double-wall for providing efficient insulation in different ways. LNG is stored in the tanks as a 'boiling cryogen' which is a very cold liquid at its boiling point. However, as efficient as the tank may be, it will not keep the LNG cold enough to remain liquid by itself. As heat is transferred, the pressure in the tank rises as LNG starts evaporating. Under this condition, the gas that boils off needs to be released from the tank in order to control the pressure rates within the tank



The figure shows the main parts of the engine room of a ship running on LNG. We can observe ventilation ducts and air flow channels in the machinery, fire and gas detectors and double walled pipes. In these tubes, there is space containing pressurized inert gas at a pressure higher than that of the gas. In case of loss of pressure of the inert gas due to leakage of gas safety systems are actuated.

Engine Room is designed and built according to inherently safe concept:

- LNG in double wall piping, ventilated with fresh air
- Inerting system for maintenance and emergency with N2
- Normal ventilation in engine room
- Normal equipment in engine room
- Exhaust piping burst discs
- Normal fire fighting

Fuel Gas Supply System:

- From Tank to tank room ('cold box') in liquid form
- LNG gasification with heat from LT-circuit
- Heat from AC-system, 'cold recovery'

- From tank room to GVUs in gaseous form
- Double walled from tank room to Gas Valve
- Units (GVU)

- Tank room controls the pressure and
- temperature according to need

- From GVUs to engines and boilers
- Gas Valve Unit can be located in a room or be built into a module
- GVU distance to engines limitation, max 10 meters
- GVU regulates the gas pressure to the engine according to engine load
- Boiler GVU regulates the gas pressure to boiler

3.2. Atmospheric, Compressed or Cryogenic Storage

Different ways of storage and transportation of gases

1. *Compressed gas:*

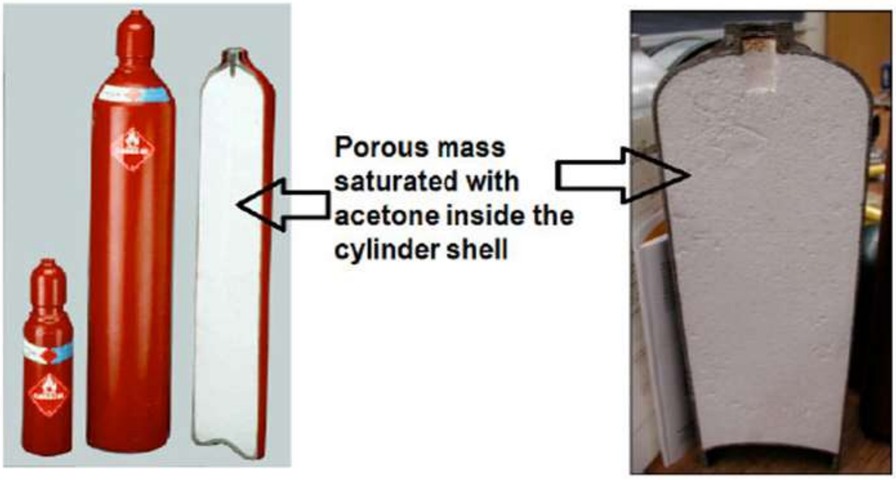
Different gases stored under pressure in containers/pipe systems. (CNG, air, oxygen, etc.)

2. *Condensed and cryogenic 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):

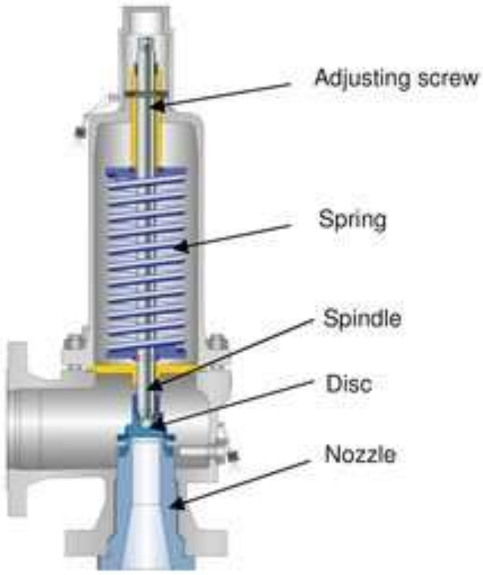
3. *Dissolved gas:*
as dissolved in another medium (acetylene dissolved in acetone stored in low pressure container)



3.3. Relief Systems and Protection Screens

What is a Relief Valve?

Relief valves, or commonly known as pressure relief valves (PRVs), belong to the family of protective devices specifically designed to protect pressure-sensitive systems and equipment from the damaging effects of overpressure conditions. A relief valve device is basically immune to the back-pressure effects of a system and is subject to periodic strip down. Pressure relief valves are one of the most critical parts of a pressure system that are set to open at a preset pressure level in order to avoid system failures. Every pressure system is set with a predetermined design limit called a setpoint, above which the valve begins to open to prevent overpressure conditions.



The interiors of cargo tanks, slop tanks, any pipework of pressure-relief or other venting systems for cargo and slop tanks, pipes and equipment containing the cargo or developing flammable gases or vapours.

Loading and discharging
The products shall be loaded and discharged in such a manner that venting of the tanks to atmosphere does not occur. If vapour return to shore is used during tank loading, the vapour return system connected to a containment system for the product shall be independent of all other containment systems.
During discharging operations, the pressure in the cargo tank shall be maintained above 0.07 bar.
The cargo shall be discharged only by deep well pumps, hydraulically operated submerged pumps, or inert gas displacement. Each cargo pump shall be arranged to ensure that the product does not heat significantly if the discharge line from the pump is shut off or otherwise blocked.
Tanks carrying these products shall be vented independently of tanks carrying other products. Facilities shall be provided for sampling the tank contents without opening the tank to atmosphere.

3.4. Basic Bunkering Operations and Bunkering Systems

LNG Bunkering Operation

There are four different LNG bunkering methods that either have been commonly used or have been idealized which are:

1. Truck-to-Ship (TTS): is the most common method used to support the LNG-fueled ship network, to date. It is the transfer of LNG from a truck’s storage tank to a vessel moored to the dock or jetty. Typically, this is undertaken by connecting a flexible hose designed for cryogenic LNG service. A typical LNG tank truck can carry 13,000 gallons of LNG and transfer a complete load in approximately one hour.

2. Shore/Pipeline-to-Ship (PTS): LNG is transferred from a fixed storage tank on land through a cryogenic pipeline with a flexible end piece or hose to a vessel moored to a nearby dock or jetty. These facilities have scalable onsite storage such that designs could be capable of performing bunkering of larger volumes than TTS or with portable tanks.

3. Ship-to-Ship (STS): It is the transfer of LNG from one vessel or barge, with LNG as cargo, to another vessel for use as fuel. STS offers a wide range of flexibility in location bunkering, and flexibility on quantity and transfer rate. There are two types of STS bunkering operations, one is performed at the port, and the other is carried out at sea. This has only been carried out at the Port of Stockholm for the new LNG-fueled ferry, Viking Grace.

4. Portable tanks: They can be used as portable fuel storage. They can be driven or lifted on and off a vessel for refueling. The quantity transferred is flexible and dependent on the number of portable tanks transferred. A 40-foot (ISO-scale) intermodal portable tank can hold approximately 13,000 gallons of LNG.

Bunker Operations

It is important to note that LNG bunker procedures may vary greatly between projects, ships, and bunker facilities. The use of standardized procedures and checklists from existing projects may be helpful as guidance. However, vessel-specific procedures for the bunkering operation should be developed to include any characteristics or features that are unique to the particular bunkering facility and receiving vessel or location.

Sequence

The following is a simplified bunker operation sequence. Actual sequences will vary depending on the supplier's and receiver's equipment and capabilities. More detailed sequences are currently available online from some ports, such as the Port of Rotterdam.

Before Transfer:

1. Notify port authorities of intent to bunker, when required to do so.
2. Compatibility confirmed between the supplier and receiver regarding equipment, procedures and protocols.
3. Receiving ship moors alongside the quay or pier, or bunker vessel moors alongside receiving ship.
4. Security and safety zones are established.

5. Any pre-bunkering checklist, procedures, and communication protocols are completed and agreed between the supplier and receiver. Persons-in-charge are designated.
6. Communications, monitoring and ESD links have been established. ESD is to be tested.
7. Supplier evaluates tank pressure and temperature (depends on tank types and bunker procedure).
8. Firefighting equipment is readied for immediate use.
9. All safety systems, such as gas detection and alarms, are operational and have been tested.
10. Sufficient lighting is established.
11. All involved personnel put on required PPE.
12. Weather and sea conditions are deemed to be within established limits.
13. Electrical isolation or bonding connections, as applicable, are confirmed.
14. Water spray curtains and drip trays, as applicable, are in place.
15. Supplier's bunker hoses or transfer arms are connected between the supplier's and receiving ship's manifolds.
16. Supplier and/or receiver should inert and then gas up and cool down all required bunker lines and equipment that will be utilized.
17. LNG transfer starts.

During Transfer:
1. Monitor tank levels.
2. Monitor tank pressures and temperatures.
3. Monitor pump transfer rates.
4. Adjust pump flow rates as necessary.
5. Adjust top spray and bottom fill rates as necessary to control tank pressure.
6. Adjust mooring lines and bunker hoses and arms as necessary.
7. Monitor that the integrity of security and safety zones is maintained. Monitor that weather and sea conditions remain within limits.

After Transfer:
1. LNG transfer stops.
2. LNG in lines is allowed to vaporize and displace the remaining liquid back to the tanks.
3. Supplier and receiver inert all bunker lines and bunker hoses utilized during the bunker operations.
4. Supplier's bunker hoses, communications, monitoring, ESD and electrical isolation or bonding connections are disconnected from the receiving ship's manifold.
5. Receiving ship unmoors from the quay or pier, or bunker vessel unmoors from the receiving ship and notifies port authority.

3.5. Protection against Cryogenic Accidents

The LNG industry has an excellent safety record. This is due in large part to the combination of industry practice and regulations that are in place to prevent incidents from occurring and to reduce or mitigate the impacts of incidents if they occur.
LNG is a clean fuel and as such is considered environmentally favorable to other fuels. The main hazards handling LNG are fire and explosion, cryogenic freeze burns, embrittlement of metals and plastics, and confined spaces hazards. These are all well understood and can be well mitigated with a careful appreciation of the hazards.

Cryogenic effects

Storage and handling of LNG may expose personnel to contact with very low temperature liquid, vapors, or solid surfaces. The viscosity of cryogenic liquids is low, meaning that they penetrate through porous materials of clothing more quickly than water. Contact with a cryogenic can cause severe damage to the skin and eyes. It can also make ordinary metals, plastics, rubber, and some clothing materials subject to embrittlement and fracture; therefore, cryogenic operations require specialized containers, materials, and protective clothing. Training should always be provided to educate workers regarding the hazards of contact with cryogenic liquid and cold surfaces and the need for personal protective equipment (e.g., gloves, insulated clothing).

LNG containers are manufactured from high quality metals intended for cryogenic storage. LNG carriers and some storage tanks are designed with an inner and outer cryogenic shell that prevents the LNG from coming into contact with the outer hull at ambient temperature. International ship design rules require that areas where cargo tank leakage or spill during unloading might be expected (e.g., ship deck and tank covers) must be designed for contact with cryogenic LNG to prevent brittle facture. Since near the beginning of the LNG trade in 1969 there have been eight marine LNG incidents resulting in spillage with some hull damage due to cold fracture (Livingston et al., 2009). In an early experience at an export terminal, a valve failed, spraying a worker with LNG.

The cold vapors from the venting of pressure relief valves on an LNG line or tank are a possible source of exposure. Careful location of relief valve vents is needed. Other normal system design practices include using remotely operated isolation valves and a reliable system for gas detection that helps to isolate the source of a release.

3.6. Fuel Leak Monitoring and Detection

How do we detect gas or gas leak?

Human and mechanical:

- Visual, sound, smell (but not for LNG, odorless)
- Handheld measuring device
- Fixed measuring device

Gas analyzing equipment on board liquefied gas carriers:

An instrument which alerts someone to the presence of gas, especially in spaces where gas is not normally expected. Gas analyzing equipment include oxygen monitors, detectors for combustible gases, compressed breathing air monitors, and systems for detection of an array of toxic gases. Available equipment ranges from single-gas and four-gas portables to multi-channel stationary gas detection systems.

Vapour detection equipment is required by IMO codes for a number of reasons.

- Cargo vapour in air, inert gas or the vapour of another cargo.
- Concentrations of gas in or near the flammable range.
- Concentrations of oxygen in inert gas, cargo vapour or enclosed spaces.

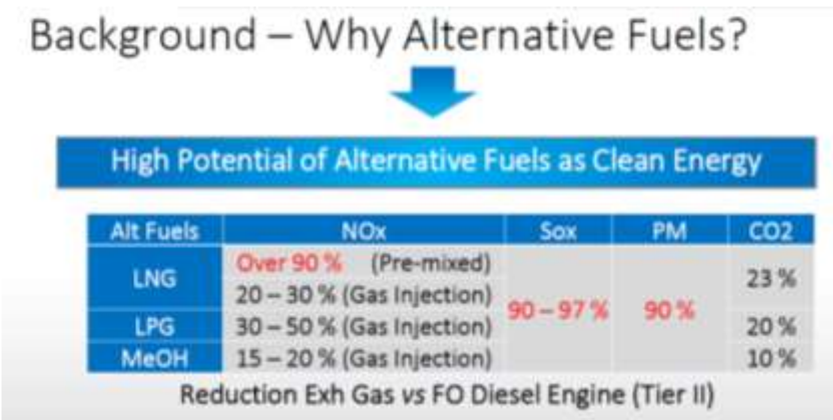
4. Physical Properties of Fuels

4.1. Properties and Characteristics

General properties and characteristics of fuels on board ships subject to the IGF Code:

Alternative Fuels in Shipping

The use of alternative fuels is regarded today as a key relevant area of technological development for sustainable transport. In shipping, like in other transport modes, there is today a consistent focus given to the potential application of different cleaner fuel solutions, with some of them posing significant challenges to ship design. The gradual adoption of these fuels, and the example set by first movers has been fundamental in paving the way to a wider use of alternative fuels for the future.



Alt Fuels	NOx	Sox	PM	CO2
LNG	Over 90 % (Pre-mixed) 20 – 30 % (Gas Injection)	90 – 97 %	90 %	23 %
LPG	30 – 50 % (Gas Injection)			20 %
MeOH	15 – 20 % (Gas Injection)			10 %

Alternative Fuel Properties

Properties	LNG	LPG	MeOH	Oil(ref)
Boiling Point (@1 atm)	-161.5 °C	-42.2 °C	65 °C	≧150 °C
SG-Liq. (@BP, 1 atm)	0.425	0.580	0.80	0.83
SG-Vap. (@0°C, 1 atm)	0.554	1.522	1.1	-
Flash Point	-188 °C	-104 °C	11 °C	60-100 °C
Auto Ignition Temp.	537 °C	470 °C	455 °C	250-380 °C
LFL-UFL (Vol. in air)	5–15 %	2.2–9.5 %	5.5–44 %	-
Min. Ignition Energy	0.28 mJ	0.25 mJ	0.14 mJ	
	✓ Cryogenic T° ✓ Lower Specific Gravity ✓ Higher Min. Ignition Energy	✓ Heavier Vapour ✓ Lower LFL ✓ High Pressure	✓ Heavier Vapour ✓ Wide Flammable Limit ✓ Lower Min. Ignition Energy ✓ Toxic ✓ Invisible Fire	

Technical and Economical Comparison

LNG	LPG	MeOH
Shale Gas Revolution	Shale Gas Revolution	Large Production (over 70MTon / year)
Effective for all IMO Environment Regulations	Liquified by pressure at ambient T° (lower cost)	Renewable Energy (Biomass Fuel)
Records on LNG fuel ships	Possibility of existing LPG infraestructure - over 1,000 LPG terminals - Over 1,000 LPGC	Records on MeOH Fuel vehicles
Expected stable and lower Price		Liquified Fuel at ambient T° and Pressure (easier handling)

Methanol is gaining some popularity as an alternative fuel. It is widely available as it is a petrochemical feedstock. It is also used in a limited way as an engine fuel ("wood alcohol"). A few ferries are trialing methanol on the Scandinavian/Baltic trades. However, it is highly toxic, is miscible with water, and has a low energy content per unit volume (energy density) of 15.6 million Joules/cubic meter [MJ/m3], so extra space is needed for fuel tanks. Methanol is only seen as interesting for bunker fuel if it is available at very low cost. Methanol presents significant structural and operational fire protection challenges when used on board a ship as a propulsion fuel.

<u>Properties and characteristics of liquefied gas fuel</u>

What is LNG?

Liquefied natural gas, or LNG, is natural gas that has been cooled sufficiently to condense into a liquid. At atmospheric pressure, this happens at a temperature of -162°C (-260ºF). As the natural gas condenses, about 600 volumes of gas become one volume of liquid. This makes it commercially feasible to transport large volumes of gas in a ship. The LNG is generally regasified by heating at its destination before being fed into a pipeline grid, power stations and/or used as transport fuel.

LNG is a mixture of hydrocarbons, predominately methane (80 – 99%). Other significant components include other alkanes – ethane, propane and butane. Nitrogen may also be present at levels up to 1%. All the more complex hydrocarbons, along with carbon dioxide and Sulphur compounds, are removed to trace levels during production.

Physical properties

LNG, a colorless and odorless liquid, burns only when in its vapour state. It's very low temperature means that at ambient temperature the liquid is always boiling and creating vapour.

The vapour is heavier than air until it warms to about -110°C. The vapour is colorless but can be seen as it mixes with air because water vapour in the air is condensed by the coldness of the warming natural gas. The result is a white cloud.

How is LNG made and where does it come from?

LNG is produced using a physical process: natural gas is compressed to 50 – 80 times atmospheric pressure and then cooled from ambient temperature until it liquefies.

The scale and cryogenic temperatures involved make LNG production much more difficult than the underlying physics would suggest.

Liquefaction plants are frequently valued in billions, or tens of billions, of US dollars, require several hundred megawatts of electricity generation capacity (a megawatt (MW) of electricity is sufficient to power 500 – 1000 European homes), and can occupy an area of up to 1.5 km2.

As of early 2019, 18 countries were producing LNG in bulk, with another 12 producing smaller quantities for domestic consumption. According to the LNG importers group GIIGNL, the biggest producers in 2017 were Qatar (77.59 million tons), Australia (55.56 million tons) and Malaysia (26.87 million tons).

What is LPG? Liquefied Petroleum Gas - Propane

LPG – Liquefied Petroleum Gas – describes flammable hydrocarbon gases including propane, butane and mixtures of these colourless, low carbon gaseous fuels.

In different countries, the LPG heating fuel gases supplied can be propane, butane or propane-butane blends.

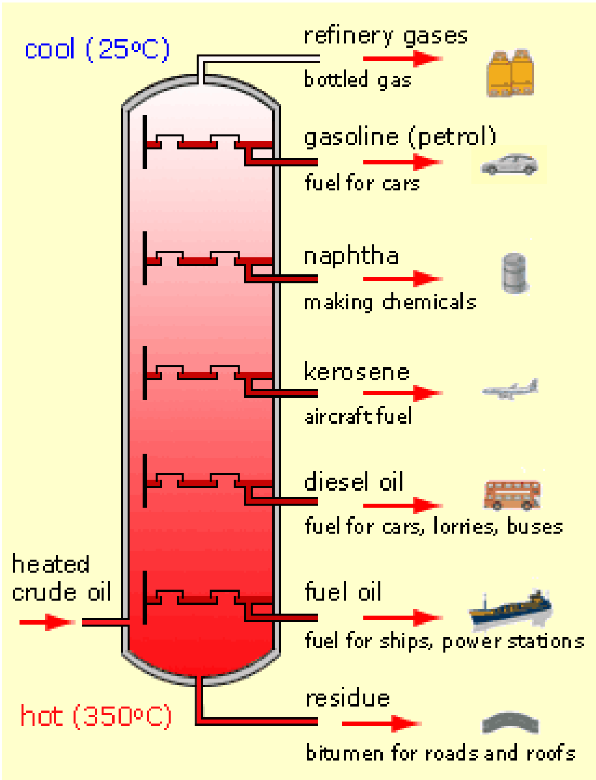
What is LPG - Summary:

1. LPG (or LP Gas) is the acronym for Liquefied Petroleum Gas or Liquid Petroleum Gas.
2. LPG is a group of flammable hydrocarbon gases that are liquefied through pressurization and commonly used as fuel.
3. LPG comes from natural gas processing and petroleum refining.
4. There are a number of fuel gases that fall under the “LPG” label, including propane, butane (n-butane) and isobutane (i-butane), as well as mixtures of these gases.
5. LPG gases can all be compressed into liquid at relatively low pressures.
6. LPG is frequently used for fuel in heating, cooking, hot water and vehicles, as well as for refrigerants, aerosol propellants and petrochemical feedstock.
7. LPG is generally stored, as a liquid, in steel vessels ranging from small BBQ gas bottles to larger gas cylinders and LPG storage tanks.

Where Does LPG Come From?

- LPG comes from drilling oil and gas wells.
- It is a fossil fuel that does not occur in isolation.
- LPG is found naturally in combination with other hydrocarbon fuels, typically crude oil and natural gas.
- LPG is produced during natural gas processing and oil refining.

- It is isolated, liquefied through pressurization and stored in pressure vessels.



How is LPG Made? What is the Production Process?

Where does LPG come from - production process

- LPG is made during natural gas processing and oil refining.
- LPG is separated from unprocessed natural gas using refrigeration.
- LPG is extracted from heated crude oil using a distillation tower.
- This LPG can be used as is or separated into its three primary parts: propane, butane and isobutane.
- It is stored pressurised, as a liquid, in cylinders or tanks.

LPG is Refined from Oil & Natural Gas

- LPG processes from oil refining - Diagram is produced during natural gas processing and petroleum refining.
- Propane does not occur naturally in isolation.
- LPG processing involves separation and collection of the gas from its petroleum base.
- LPG is isolated from the hydrocarbon mixtures by separation from natural gas or by the refining of crude oil.
- Both processes begin by drilling oil wells.
- The gas/oil mixture is piped out of the well and into a gas trap, which separates the stream into crude oil and "wet" gas, which contains LPG and natural gas.
- The heavier crude oil sinks to the bottom of the trap and is then pumped into an oil storage tank for refining.
- Crude oil undergoes a variety of refining processes, including catalytic cracking, crude distillation, and others.
- One of the refined products is LPG.
- The "wet" gas, off the top of the gas trap, is processed to separate the gasoline (petrol) from the natural gas and LPG.
- Once refined, LPG fuel is stored as a liquid under pressure in gas bottles - cylinders or tanks.
- he natural gas, which is mostly methane, is piped to towns and cities for distribution by gas utility companies.
- The petrol is shipped to service stations.
- The LPG fuel also enters the distribution network, where it eventually finds its way to end users, including Home LPG and Commercial LPG users all around Australia and the world.
- At the point of use it once again becomes a gas.

Ethylene, C_2H_4, is a highly flammable, colourless and noncorrosive gas with a sweet odour. It is easily ignited and a flame can easily flash back to the source of the leak. Under prolonged exposure to fire or heat the containers may rupture violently and rocket. Can cause explosion. Vapours arising from the boiling liquid are lighter than air. Ethylene is not toxic, but is a simple asphyxiant.

Ethylene is used as an anaesthetic, a refrigerant, and to make other chemicals as polymers and plastics.

Ethylene is produced in petrochemical processes, as ***steam cracking*** where hydrocarbons and steam are heated to 750–950 °C. This process converts large hydrocarbons into smaller ones and introduces unsaturated products.

LPG Attributes Table

LPG Attributes	Propane	Butane
Chemical Formula	C_3H_8	C_4H_{10}
Energy Content: MJ/m^3	95.8	111.4
Energy Content: MJ/kg	49.58	47.39
Energy Content: MJ/L	25.3	27.5
Boiling Temp: Cº	-42	-0.4
Pressure @ 21ºC: kPa	858.7	215.1
Flame Temp: Cº	1967	1970
Expansion: m^3/L	0.270	0.235
Gas Volume: m^3/kg	0.540	0.405
Relative Density: H_2O	0.51	0.58
Relative Density: air	1.53	2.00
L per kg	1.96	1.724
kg per L	0.51	0.58
Specific Gravity @ 25ºC	1.55	2.07
Density @ 15ºC: kg/m^3	1.899	2.544

Note: Some numbers have been rounded.

4.2. Pressure and Temperature, including Vapour Pressure/Temperature Relationship

What is a state of aggregation?

Every material in our environment is in a particular state, like liquid, solid or gaseous. Every material can be in every state. Sometimes it is quite difficult to imagine materials like iron in a gaseous state, but if a certain level of temperature is reached, also iron can be in a gaseous state.

How is the process from one state to the other state called?

The process, when a material changes its state by heating or cooling the material are differently called:

- From solid to liquid: ***melting***
- From liquid to gaseous: ***evaporation***
- From gaseous to solid: ***consolidation***
- From gaseous to liquid: ***condensation***
- From liquid to solid: ***solidification***
- From solid to gaseous: ***sublimation***

Boiling point

The boiling point is the temperature at which the vapor pressure of a liquid equals the external pressure surrounding the liquid. Therefore, the boiling point of a liquid depends on atmospheric pressure. The boiling point becomes lower as the external pressure is reduced. As an example, at sea level the boiling point of water is 100 C (212 F), but at 6,600 feet the boiling point is 93.4 C (200.1 F).

Liquid Density

DENSITY OF LIQUIDS

Liquid density data are essential in process engineering design such as sizing of storage vessels that contain the basic raw materials and products for a plant, in process piping design involving either single-phase incompressible fluids, compressible fluids or two-phase flow mixtures. In distillation, absorption, or stripping, liquid density data are required in the determination of flooding and sizing of column diameter. Additionally, liquid density usage is encountered in various heat-, mass-, and momentum-transfer operations.

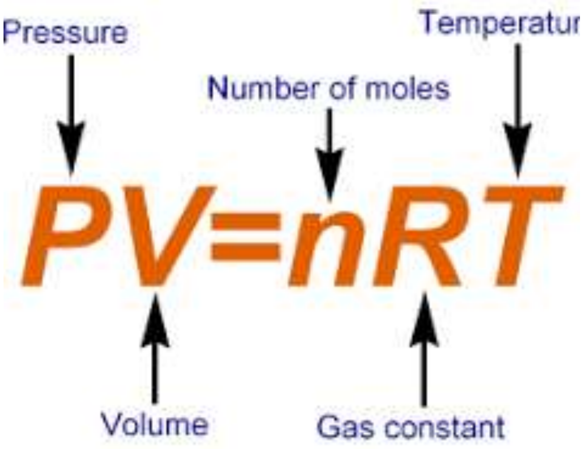
Density, mass of a unit volume of a material substance. The formula for density is d = M/V, where d is density, M is mass, and V is volume. Density is commonly expressed in units of grams per cubic centimetre

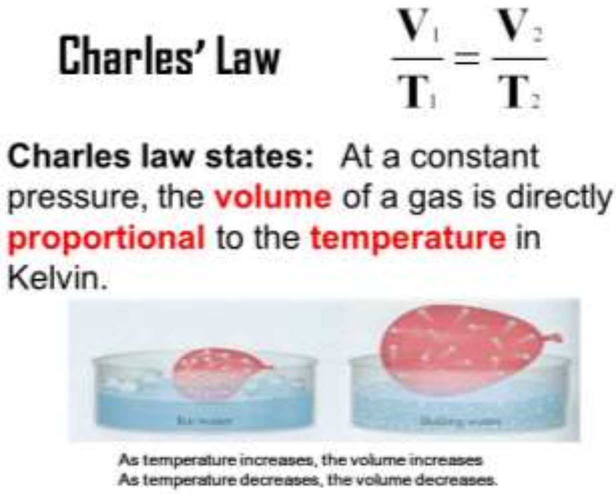
Vapour density

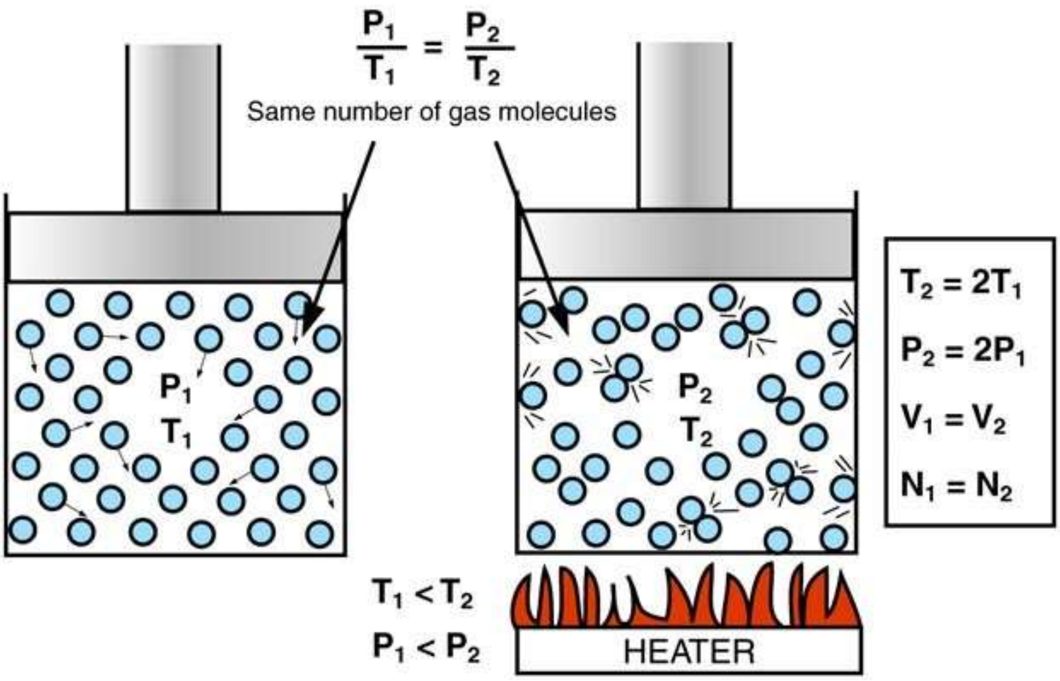
Vapour density is the density of a vapour in relation to that of hydrogen. It may be defined as mass of a certain volume of a substance divided by mass of same volume of hydrogen. Vapour density = mass of n molecules of gas / mass of n molecules of hydrogen.

Flashpoint

The flash point of a chemical substance is the lowest temperature where enough fluid can evaporate to form a combustible concentration of gas.







Boiling / condensation point for different gases:

- Oxygen O_2 : -183.0 ^{o}C
- Methane CH_4 : -161.50 ^{o}C
- Nitrogen N_2 : -195.80 ^{o}C

Refrigerated liquefied gases are normally transported in cryogenic condition at or close to their boiling point, but if type C tanks are used, the liquefied gas can be stored at pressure above ambient

Low flashpoint liquids have a boiling temperature above zero, for instance 65°C is the boiling point of methanol. They also have flashpoint below normal ambient temperatures, methanol has a flashpoint of around 12°C

Low temperatures can cause burns which may damage skin and tissue when in direct contact with cold liquid or vapour

Liquefied gases are boiling liquids and give off vapours readily, low flashpoint liquids also give off vapours due to flashing, vapour can be flammable, toxic or both, vapour in sufficient concentration will exclude oxygen and may cause asphyxiation whether the vapour is toxic or not, an explosive mixture may be produced when most vapours are mixed with air, gases are made up of molecules that are in constant motion and exert pressure when they collide with the walls of their container

5. Fuel Characteristics

Understanding of fuel characteristics on ships subject to the IGF Code as found on a Safety Data Sheet (SDS)
The vessel's operation manual for handling of the IGF fuel shall contain relevant operational instructions for safe fuel handling. Information about fuels to be handled is essential to the safety of the vessel and her crew. Information may also be found in Safety Data Sheets for each product, which includes all necessary data for the safe handling and use of the fuel. The properties of low flash point fuels used on ships subject to the IGF Code from a Safety Data Sheet (SDS)

Properties and characteristics of low flashpoint liquid fuels

Methanol and LNG are two major alternative fuels that both are inherently free from sulphur and economically viable options. These fuels both have flash points below 60°C, but have very different properties compared to HFO and MGO. The differing fuel properties make it clear that fuel handling systems and safety considerations have to be adapted to each fuel individually. In the following sections are given some typical properties of methanol and LNG in comparison with properties of HFO and MGO.

The physical data for methanol is easier to specify, as this fuel contains a single chemical substance with a low degree of contaminants. LNG varies to a limited extent in composition depending on the source of the gas, and characteristic physical properties are given here.

Parameter	Heavy Fuel Oil (HFO)	Marine Gas Oil (MGO)	Methanol	Liquid Natural Gas (LNG)[g]
Composition	Residual from distillation, chain length of 20-70	Petroleum distillate, chain length of 10-20	CH_3OH	CH_4 (88-97 %) *other major components are C_2H_6, C_3H_8 and C_4H_{10}*
Appearance	Highly viscose liquid, preheated before combustion	Liquid	Liquid	Stored as non-compressed liquid (-162 °C), gasified before combustion
Sulphur content (wt-%)	< 3.5 - < 4.5 for HFO [a]	< 1.0 - < 1.5 for MGO [a] <0.1 for LSMGO	-	<<0.1
Viscosity (mm^2/s)	30 - 700, at 50 °C [a]	1.4 - 6.0, at 40 °C [a]	0.59 - 0.74 at 20 °C [f]	-
Density (Kg/m^3)	960 - 1010 for HFO [a] (at 15 °C)	<890 for MGO [a] and LSMGO (at 15 °C)	792 [f] (at 15 °C)	431 - 464 (liquid density at boiling point)
Boiling point (°C)	150 - 600 [a], 350 - 650 [h]	149 - 366 [c], 200 - 385 [h]	65 [f]	~ -160
Vapour pressure (kPa) at 20 °C	<0.1 [a], 1×10^{-8} - 1×10^{-20} [h]	~5×10^{-2} [c]	12 - 14 [f]	-
Vapour density (air = 1)	>5 [a]	>3 [c]	1.1 [f]	~1.5 (at boiling point) ~0.6 (at 20 °C)
Water solubility (mg/L)	<1 to 6 [h]	Negligible [c]	100 v/v % soluble	No
Energy content, higher calorific value (MJ/kg)	~43 [a]	~44 [a]	23	~50
Energy density (MJ/L)	~43	~39	18	~22 (liquid)

6. Safety Requirements and Safety Management

The different safety requirements and safety barriers used in the IGF Code.

Sufficient safety barriers must be in place in order to keep the risk within acceptable limits.

Liquefied natural gas has approximately 600 times the energy density of natural gas at atmospheric conditions. LNG is typically stored at a pressure between 1 and 4 bar, whereby the equilibrium temperatures are approximately –160°C to –155°C. In order to minimize the risks related to both property and life, it is vital that the material used for the LNG system has been certified for cryogenic temperatures and that the system has built-in pressure relief functionality.

Liquefied gas fuel containment safety principles

The containment systems shall be provided with a full secondary liquid-tight barrier capable of safely containing all potential leakages through the primary barrier and, in conjunction with the thermal insulation system, of preventing lowering of the temperature of the ship structure to an unsafe level.
The size and configuration or arrangement of the secondary barrier may be reduced or omitted where an equivalent level of safety can be demonstrated. Liquefied gas fuel containment systems for which the probability for structural failures to develop into a critical state has been determined to be extremely low, but where the possibility of leakages through the primary barrier cannot be excluded, shall be equipped with a partial secondary barrier capable of safely handling and disposing of the leakages.

- The ISM Code is the only internationally accepted standard for the safe management and operation of ships and for pollution prevention.
  The Code establishes safety-management objectives and requires a safety management system (SMS) to be established by "the Company", which is defined as the owner or any other organization or person, such as the manager or bareboat charterer, who has assumed responsibility for operating the ship and who, on assuming such responsibility, has agreed to take over all duties and responsibility imposed by the Code.

- The requirement to comply with the ISM Code as per ***chapter IX of the SOLAS Convention*** in the 'Management for the safe operation of ships'.
  Regulation 2

Application

1. This chapter applies to ships, regardless of the date of construction, as follows:
- passenger ships including passenger high-speed craft, not later than 1 July 1998;
- oil tankers, chemical tankers, gas carriers, bulk carriers and cargo high-speed craft of 500 gross tonnage and upwards, not later than 1 July 1998; and
- other cargo ships and mobile offshore drilling units of 500 gross tonnage and upwards, not later than 1 July 2002.
2. This chapter does not apply to government-operated ships used for non-commercial purposes.

Regulation 3

Safety management requirements

1. The company and the ship shall comply with the requirements of the International Safety Management Code.
2. The ship shall be operated by a company holding a Document of Compliance referred to in regulation 4.

Regulation 4

Certification

1. A Document of Compliance shall be issued to every company which complies with the requirements of the International Safety Management Code. This document shall be issued by the Administration, by an organization recognized by the Administration, or at the request of the Administration by another Contracting Government.
2. A copy of the Document of Compliance shall be kept on board the ship in order that the master can produce it on request for verification.
3. A Certificate, called a Safety Management Certificate, shall be issued to every ship by the Administration or an organization recognized by the Administration. The Administration or organization recognized by it shall,

before issuing the Safety Management Certificate, verify that the company and its shipboard management operate in accordance with the approved safety-management system.

Regulation 5

Maintenance of conditions

The safety-management system shall be maintained in accordance with the provisions of the International Safety management Code.

Regulation 6

Verification and control

1. The Administration, another Contracting Government at the request of the Administration or an organization recognized by the Administration shall periodically verify the proper functioning of the ship's safety-management system.
2. Subject to the provision of paragraph 3 of this regulation, a ship required to hold a certificate issued pursuant to the provisions of regulation 4.3 shall be subject to control in accordance with the provisions of regulation XI/4. For this purpose, such certificate shall be treated as a certificate issued under regulation I/12 or I/13.
3. In cases of change of flag State or company, special transitional arrangements shall be made in accordance with the guidelines developed by the Organization.

The proper implementation of the ISM Code should result in a safety culture being developed. Following the spirit of the ISM Code involves, at least, a commitment to continuous improvement of the company's safety record. The industry provides robust guidelines and recommendations in the form of a "safety guide" and other publications.

Competence: Take precautions to prevent hazards on a ship subject to the IGF Code

7. Hazards Associated with Operations on Ships

Health hazards

Health hazards of gases and low flash point fuels

Gas / Fuel	*Hazard*
Liquefied Natural Gas / Methane	Liquefied gases may cause cryogenic burns or injury Light hydrocarbon gases are simple asphyxiants and can cause anesthetic effects at high concentrations. Gas can accumulate in confined spaces and limit oxygen available for breathing Continued exposure can lead to hypoxia (inadequate oxygen), rapid breathing, cyanosis (bluish discoloration of the skin), numbness of the extremities, unconsciousness and death.
Liquefied Petroleum Gas	Liquefied gases may cause cryogenic burns or injury Gas can accumulate in confined spaces and limit oxygen available for breathing Continued exposure can lead to hypoxia (inadequate oxygen), rapid breathing, cyanosis (bluish discoloration of the skin), numbness of the extremities, unconsciousness and death.
Liquid Nitrogen	Direct contact can freeze the skin causing frostbite and cold burns. Delicate tissue, such as eyes, can be damaged by an exposure to the cold gas alone which would be too brief to affect skin.

Propane	Contact with the liquefied or pressurized gas may cause momentary freezing followed by swelling and eye damage. Asphyxiant. High concentrations in confined spaces may limit oxygen available for breathing.
Butane	Contact with the liquefied or pressurized gas may cause frostbite. Light hydrocarbon gases are simple asphyxiants and can cause anesthetic effects at high concentrations
Ethane	Contact with the liquefied or pressurized gas may cause frostbite. Contact with the liquefied or pressurized gas may cause momentary freezing followed by swelling and eye damage. Light hydrocarbon gases are simple asphyxiants and can cause anesthetic effects at high concentrations
Methanol	Acute exposure of humans to methanol by inhalation or ingestion may result in visual disturbances, such as blurred or dimness of vision, leading to blindness. Neurological damage, specifically permanent motor dysfunction, may also result. Contact of skin with methanol can produce mild dermatitis
Carbon Dioxide	Exposure to CO2 can produce a variety of health effects. These may include headaches, dizziness, restlessness, a tingling or pins or needles feeling, difficulty breathing, sweating, tiredness, increased heart rate, elevated blood pressure, coma, asphyxia, and convulsions.

Nitrogen is a colorless, odorless gas that creates an oxygen deficient state. If the generator were to develop a leak, nitrogen gas could leak out undetected into the work environment. In a matter of minutes, nitrogen gas from a leaking tank can deplete the workspace of oxygen. To protect the health of your employees, it is necessary to only use nitrogen generators in conjunction with an oxygen monitor, which alerts staff to low levels of oxygen.

Environmental Hazard

Some gases and low flash point fuels pose a threat to the surrounding natural environment and can adversely affect people's health. Vapour, whether toxic or flammable, should be vented to atmosphere with extreme caution. Venting of any vapours should consider all local and international regulations and weather conditions. Weather conditions include wind conditions, electrical storms and cold weather

Petroleum gases will readily evaporate from the surface and would not be expected to have significant adverse effects in the aquatic environment.

Reactivity hazards

Low flashpoint fuels and liquified gases are stable under normal ambient and anticipated conditions of use. Avoid all possible sources of ignition. Heat will increase pressure in the storage tank. Avoid contact with acids, aluminum chloride, chlorine, chlorine dioxide, halogens and oxidizing agents. Liquified gases burns readily, rapidly or completely vaporizes at atmospheric pressure and normal ambient temperature.

Corrosion Hazards

Some gases and low flash point fuels are corrosive and can damage human tissue. Carriage of some corrosive fuels requires specific tank material to resistant corrosion.Some compressed gases are corrosive. They can burn and destroy body tissues on contact. Corrosive gases can also attack and corrode metals. Common corrosive gases include ammonia, hydrogen chloride, chlorine and methylamine.

Ignition, explosion and flammability hazards

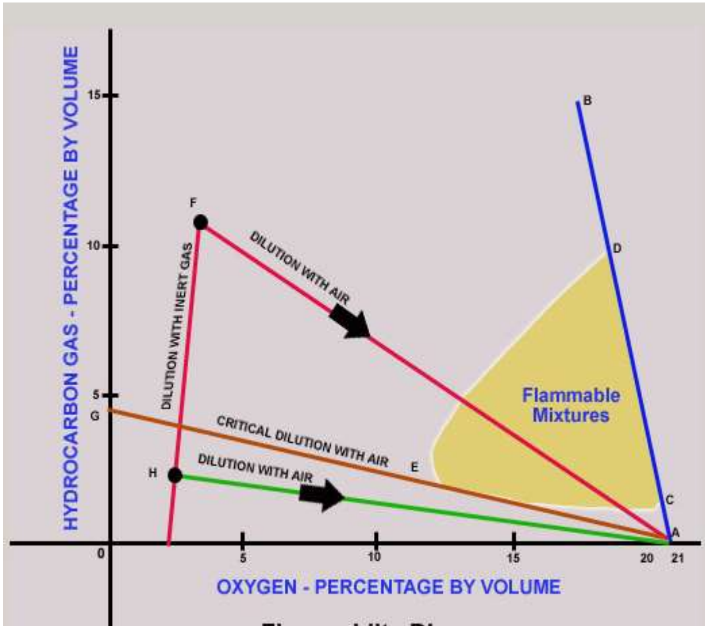
The ability of most liquefied gases and low flash point fuels to generate flammable vapour is a major factor for starting a fire.

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?

The minimum and maximum concentrations of vapour in air which form flammable (explosive) mixtures are known as the lower explosive limit (LEL) and upper explosive limit (UEL) respectively. The terms LFL (lower flammability limit) and UFL (upper flammability level) are also used

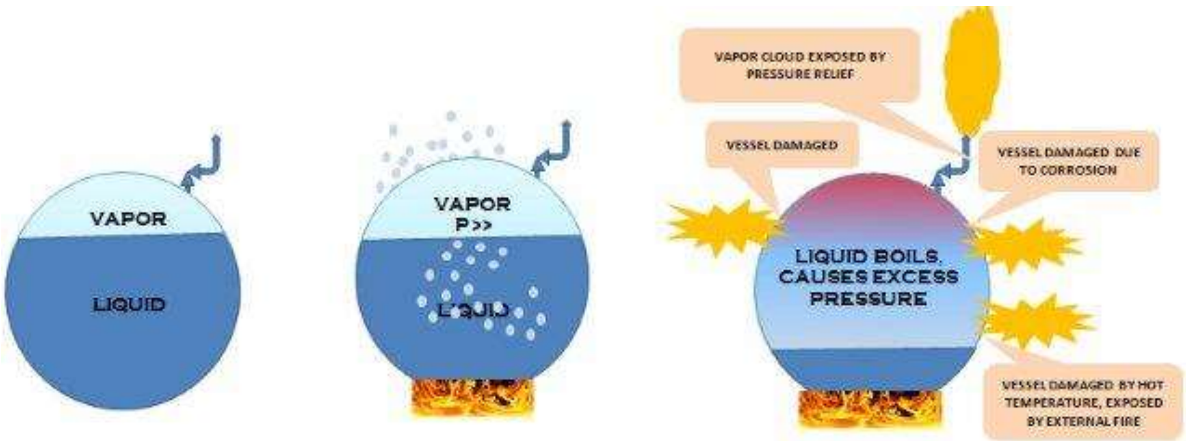
What is Boiling Liquid Expanding Vapour Explosion (BLEVE)?



Flammabilty Diagram

BLEVE is a vapour explosion which may result from catastrophic failure of a tank structure, which was containing cargo liquid above the boiling point at nominal atmospheric pressure.

The cargo in the tanks of gas carrier is partially liquid and partially vapour in normal condition. However, when the tank structure collapses, the vapour tries to escape or leak through the opening, resulting in decrease in the pressure inside the tank. These drastic lowering of pressure inside the cargo tank results in rapid boiling of liquid and increase in vapour formation.



The pressure of the escaping vapour becomes very high and leads to a shock wave or explosion in presence of a fire source, completely destroying the tanks structure and surrounding areas.

Common Causes of BLEVE:

The most common reason which leads to BLEVE is fire near tanks containing gas cargo such as propane. Because of the high temperature of the surrounding, the tank temperature starts to increase and the inside of the tanks gets over pressurized. The high pressure inside the tank will be generally released by the relief valve.

However, if the pressure builds up rapidly because of high temperature and high rate of heating in the surrounding, the tank will collapse at the weaker point, exposing pressurized and flammable vapour to the naked flame and leading to Boiling Liquid Expanding Vapour Explosion.

Sources of ignition

Sources of ignition:
The main sources of ignition most likely to occur on a ship are:

- Heat by radiation, conduction or convection.
- Electrical Spark (e.g. from faulty equipment or loose connections)
- A spark from impact (e.g. using a steel hammer in a dangerous area)
- Static Electricity (e.g. using nylon rope to sound oil tanks)
- Welding and other hot work
- Spontaneous Combustion (e.g. oil-soaked rags or lagging)
- Funnel Sparks
- SMOKING

For stowage purpose IMDG Code recommends away from “Sources of Ignition” for some classes or substances.
Sources of Ignition includes

- Open fire
- Machinery Exhausts and Galley Uptakes
- Electrical Equipment and Electrical Outlets*
- Reefers and Heated tanks#

** Certified safe type as per SOLAS II-2/19.3.2 excluded*
**Explosion proof electrical fittings excluded*

Electrostatic hazards

Static electricity is an imbalance of electric charges within or on the surface of a material. The charge remains until it is able to move away by means of an electric current or electrical discharge. Static electricity is electricity that does not flow in a current. Static electricity generated by rubbing two nonmagnetic objects together. The friction between the two objects generates attraction because the substance with an excess of electrons transfers them to the positively-charged substance. Usually, substances that don’t conduct current electricity (insulators) are good at holding a charge. These substances may include rubber, plastic, glass or pitch. The electrons that are transferred are stored on the surface of an object.

Static electricity presents fire and explosion hazards during the handling of petroleum and tanker operations. Certain operations can give rise to accumulations of electric charge which may be released suddenly in electrostatic discharges with sufficient energy to ignite flammable hydrocarbon gas/air n-fixtures; there is, of course, no risk of ignition unless a flammable mixture is present. There are three basic stages leading up to a potential static hazard:

Electro static charge separation

Whenever two dissimilar materials come into contact charge separation occurs at the interface. The interface may be between two solids, between a solid and a liquid or between two immiscible liquids. At the interface, a charge of one sign (say positive) moves from material A to material B so that materials A and B become respectively negatively and positively charged. Whilst the materials stay in contact and immobile relative to one another, the charges arc extremely close together. The voltage difference between the charges of opposite sign is then very small, and no hazard exists. The charges can be widely separated by many processes, such as:

- The flow of liquids (e.g. petroleum or mixtures of petroleum and water) through pipes or fine filters.
- The settling of a solid or an immiscible liquid through a liquid (e.g. rust or water through petroleum).
- The ejection of particles or droplets from a nozzle (e.g. steaming operations).
- The splashing or agitation of a liquid against a solid surface (e.g. water washing operations or the initial stages of filling a tank with oil).
- The vigorous rubbing together and subsequent separation of certain synthetic polymers (e.g. the sliding of a polypropylene rope through PVC gloved hands).

When the charges are separated, a large voltage difference develops between them. Also, a voltage distribution is set up throughout the neighboring space and this is known as an electrostatic field. As examples, the charge on a charged petroleum liquid in a tank produces an electrostatic field throughout the tank, both in the liquid and in the ullage space, and the charge on a water mist by tank washing produces a field throughout the tank.

Charge accumulation

Charges, which have been separated, attempt to recombine and neutralize each other. This process is known as charge relaxation. If one, or both, of the separated materials carrying a charge, is a very poor electrical conductor, recombination is impeded and the material retains or accumulates the charge upon it. The period of time for which the charge is retained is characterized by the relaxation time of the material, which is related to its conductivity; the lower the conductivity the greater is the relaxation time.

If a material has a comparatively high conductivity, the recombination of charges is very rapid and can counteract the separation process, and consequently little or no static electricity accumulates on the material. Such a highly conducting material can only retain or accumulate charge if it is insulated by means of a poor conductor, and the rate of loss of charge is then dependent upon the relaxation time of this lesser conducting material.

The important factors governing relaxation are therefore the electrical conductivities of the separated materials and of any additional materials, which may be interposed between them after their separation.

Charge discharge

Electrostatic Discharges

The electrostatic breakdown between any two points, giving rise to a discharge, is dependent upon the strength of the electrostatic field in the space between the points. This field strength, or voltage gradient, is given approximately by dividing the difference in voltage between the points by their distance apart. The field strength of about 3,000 kilovolts per meter is sufficient to cause breakdown of air or petroleum gases.

The field strength near protrusions is greater than the overall field strength in the vicinity and discharges therefore generally occur at protrusions. A discharge may occur between a protrusion and space in its vicinity without reaching another object. These single electrode discharges are rarely, if ever, the incentive in the context of normal tanker operations. The alternative is a discharge between two electrodes adjacent to each other.

Toxicity hazards

What is a toxic substance?

A toxic substance is one which is liable to cause either harm to human health, serious injury or death. Toxic means the same as poisonous. Toxicity is an intrinsic property of a chemical, which man cannot modify, and its effect is a function of exposure. In some cases, correct response to its effects after exposure can diminish its consequences.

There are three common ways that a cargo can be toxic: swallowed (oral toxicity), absorbed through the skin, eyes and mucous membranes (dermal toxicity) or inhalation as a vapour or mist (inhalation toxicity).

A chemical may be toxic by more than one of these routes: for example, toxic vapours and mists affect people most via the respiratory system but they can also be absorbed through the skin. The smaller the quantity (or dose) of the substance that is required to harm health, the more toxic a substance is. In some cases, the toxic effect of a chemical can be countered by administering antidotes, but in most cases the hazard must be avoided by correct use of protective clothing, breathing apparatus and ventilation procedures. If there is no exposure to the chemical, or if exposure is reduced to safe levels, there can be no toxic effect.

TLV (Threshold Limit Value) is defined as a concentration of a gas which a person can be exposed to without any adverse effect.

A TLV reflects the level of exposure that the typical worker can experience without an unreasonable risk of disease or injury. TLVs are not quantitative estimates of risk at different exposure levels or by different routes of exposure.

TWA (Time Weighted Average)

Time weighted average (TWA) is the average workplace exposure to any hazardous contaminant or agent using the baseline of an 8 hour per day or 40 hours per week work schedule. The TWA reflects the maximum average exposure to such hazardous contaminants to which workers may be exposed without experiencing significant adverse health effects over the standardized eight-hour work period.

The TWA is expressed in units of parts per million (ppm) or mg/m3.

STEL (Short Term Exposure Limit Value)

A Short-Term Exposure Limit (STEL) is defined by ACGIH as the concentration to which workers can be exposed continuously for a short period of time without suffering from:

- irritation
- chronic or irreversible tissue damage
- narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency.

Odor threshold value

Odor threshold is the minimum concentration of a substance at which a majority of test subjects can detect and identify the characteristic odor of a substance. While odor thresholds can serve as useful warning properties, they must be used cautiously because olfactory perception varies among individuals.

An odor threshold is used to help determine the air quality in a given work site and potential risk to an individual. Odor threshold factors will vary upon location and potential types of exposures.

Vapour leaks and clouds

Serious vapour leaks will only be caused by mechanical failure, or failure to follow correct procedures
Ignition may not take place within immediate vicinity of the leakage due to the over-rich concentration of vapour. An uncontrolled leakage could quickly envelope the deck and accommodation areas. The rate of dispersal of a vapour cloud will depend on climatic conditions
Cargo system leaks

In the event of cargo system leaks & contact with LNG chilled to its temperatures of about –160 degree C will damage living tissue. Most metals lose their ductility at these temperatures; LNG may cause the brittle fracture of many materials. In case of LNG spillage on the ship's deck, the high thermal stresses generated can result in the fracture of the steel.

Collision - Involving uncontrollable escape of LNG cargo (MEMBRANE)

The event can only be described in a hypothetical context, as no such situation has actually occurred. The following is therefore based on theoretical studies and investigations.

In the loaded condition with failure of the primary and secondary membranes, liquid cargo will pass through the primary, secondary barriers, inner hull and the ruptured ballast tank and out to the sea. As the membrane containment system is supported by the inner hull steel structure, failure of the inner hull due to the collision damage and embrittlement would lead to collapse of the membrane containment system in the damaged area. This would lead to a further major increase of the outflow of LNG.

Ignition may not take place within the vessel due to the over-rich concentration of vapours. In such cases, the attempted separation of the vessel from a colliding vessel or other structure should not be attempted, if circumstances permit, in order to avoid the risk of creating an ignition source during separation. This despite the colliding vessel probably encountering hull structure failure from both the collision damage and the embrittlement from the outflow of LNG.

The vaporization of the spillage will initially form a heavy white vapour cloud and this is likely to quickly envelope the deck and accommodation areas. Hence it is essential that all potential sources of ignition are isolated and the decks cleared of all personnel.

Extremely low temperatures

Low temperatures can cause cold burns which may damage skin and tissue when in direct contact with cold liquid or vapour

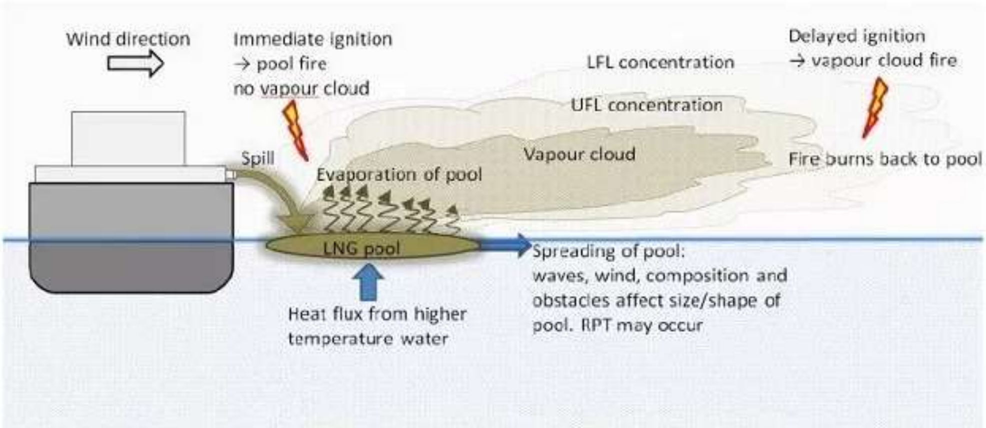
Protective clothing that should be worn when handling extremely cold fuels or working on their piping and storage systems

All personnel involved directly with LNG handling operations should wear personal protective equipment (PPE) including:
- gloves
- face protection
- other suitable clothing to protect against LNG drips, spray, spills, and leaks.

PPE is also required to protect against skin damage caused by contact with the cold pipes, hoses, or equipment.

Procedures to be used in the event of a spill of extremely cold fuels

Hazards of a large LNG spill over water includes asphyxiation, cryogenic burns and cryogenic damage to the ship from LNG, dispersion, fires, and explosions. Thermal hazards occur too from the fire that breaks out during a spill. Cryogenic and fire damage to an LNG cause further damage to LNG cargo tanks following an initial cargo tank breach, though the additional impact on public safety would be limited.



Possible outcome of LNG spill over water

In the case of a leakage or spillage of LNG, the following general procedure should be followed:

- Isolate source of LNG. If loading or discharging, the ESD system should be activated
- Summon assistance
- Protect the hull from risk of cold fracture
- Speed vaporization to minimize ignition risk

The exact procedure will depend upon the nature of the incident, inclusive of size of spill, location, ambient conditions and ignition risks.

Pressure hazards

Pressure surge or liquid hammer, as it is commonly known, is the result of a sudden change in liquid velocity. Liquid hammer usually occurs when a transfer system is quickly started, stopped or is forced to make a rapid change. Any of these events can lead to a catastrophic system component failure.

When the ESD System activates, it creates a pressure surge on the LNG Loading Lines, which may exceed the design pressure, therefore, it may lead to a failure of the Loading Lines. To overcome this pressure surge, the ESD system initiates several sequential actions to protect the line from severe surge pressure. Nevertheless, if the ESD system malfunctions, the resulting surge pressure has been found to be higher than the pipeline design pressure.

When the ESD malfunction, the loading pumps will not trip and the vent valves will not open. Therefore, the resulted surge pressure will increase quite high, exceeding the design-pressure, that may lead to the failure of the loading line.

Therefore, it was proposed to improve the existing surge protection by installing additional instrumentation as a sequential back-up when the existing protection system fails. As a result, in order to improve the reliability of the existing surge protection system, pressure switches were installed on the loading line, which function to trip the loading pumps and opens the vent valves at specified set pressure when the main surge protection fails.

Fuel batch differences

Batch is measured amount of oil in a pipeline. Batches is the homogeneous quantities of petroleum (heating oil, gasoline, diesel, kerosene, jet fuel, LP-Gas, residual fuel, natural gas and ethanol) is shipped through a pipeline usually having a specified minimum acceptable size. Batching Sequence Is the order in which product shipments are sent through a pipeline.

Methane Number (MN) can differ based on LNG composition.

Did you know that the methane number of a gas provides an indication of the knock tendency of a fuel? It is a product of the different constituent gases within the natural gas, particularly the proportions of methane, ethane, propane and butane. Understanding the knock resistance is important when selecting an engine for a gas-powered combined heat and power plant.

Methane, which has a high knock resistance, is given an index value of 100. Hydrogen, which burns quickly relative to methane, has a low knock resistance and is given the index value of 0. If a gas mixture has a methane number of 80, its knock resistance is equivalent to that of a gas comprised of 80% methane and 20% hydrogen. There are gas constituents which have a higher methane number than 100 therefore it is also possible for a gas composite to have a higher methane number than 100. Biogas often has a methane number in excess of 100.

Understanding the methane number of the natural gas fuel is an important factor when determining the appropriate engine version to select.

8. <u>Hazard Controls</u>

Emptying, inerting, drying and monitoring techniques

Liquefied natural gas (LNG) – Natural gas comes from natural sources and is composed of methane, ethane, propane and small amount of butane. It is condensed to about 1/600 of the volume by cooling it to below the -160°C, its boiling point, to produce LNG.
Liquid LNG is pumped ashore by use of two submerged pumps installed at the bottom of each tank. In the process, the cargo tank pressure shows a decreasing tendency as the LNG level drops in the tank, resulting from the discharge of LNG. Conversely, shore tank pressure shows an increasing tendency with the receipt of LNG.

Draining / purging

The procedures for draining / purging of the manifold lines and ships liquid lines are the same whether the ship has been loading or discharging. This is done by using a Nitrogen “punch” method. After completion of loading or discharging, this operation is carried out prior to disconnecting the liquid and vapour arms.

- On completion the manifold ESD valves are closed and the spray line is lined up from the manifold to all tanks via the spray return valves. The cool down valve on each manifold is kept closed. Then the terminal raises the pressure within the arms to a certain level (normally around 4 kgs/cm2). Then the spray cool down valves are opened up and LNG liquid and vapour in the liquid arm is fed to the cargo tanks through the spray line by Nitrogen (N_2) pressure.

- Vapour in the vapour arm is fed to the cargo tanks through the vapour header by N2 gas supplied from the terminal. Draining is normally carried out by pressuring the arms one by one.
- The procedure is repeated until the arm is completely free of liquid and the hydrocarbon level is below 1% by volume. Remember that the allowed hydrocarbon concentration might vary from terminal to terminal.
- Draining of the ship's liquid lines is done by opening up the spray bypass valve at the manifold. As the pressure increases in the liquid line the liquid will be led through the spray line and back to the cargo tank.

  The purpose of inerting is primarily to prevent flammable vapour/air mixtures in tanks and piping and that inerting shall be performed with an inert gas prior to venting with dry air to avoid an explosion hazardous atmosphere in tanks and fuel pipes. It shall be possible to empty, purge and vent fuel storage tanks with fuel piping systems.

Gas freeing, inerting and venting of fuel tanks:

- Fuel tanks shall be provided with an arrangement for safe inert gas purging and gas freeing.
- Fuel tanks without direct access from open deck shall have a sufficient number of ventilations inlets and outlets to ensure complete gas freeing, but no less than 2 inlets and 2 outlets per tank.
- The tanks shall have an arrangement for pressure/vacuum relief or equivalent during voyage, bunkering and fuel transfer with closed tank hatch covers.
- Individual pressure vacuum relief valves or an equivalent arrangement shall be fitted to each tank to limit the pressure or vacuum in the tank.
- The venting system shall be designed with redundancy for the relief of full flow overpressure and vacuum. Pressure sensors fitted in each fuel tank, and connected to an alarm system, may be accepted in lieu of the redundancy requirement for pressure relief.
- Pressure/vacuum safety valves shall be located on open deck and shall be of a type which allows the functioning of the valve to be easily checked.
- Intake openings of pressure/vacuum relief valves shall be located at least 1.5 m above tank deck, and shall be protected against the sea.
- The vent system shall be sized, allowing for flame screens, if fitted, to permit bunkering at a design rate without over-pressuring the tank. Specifically, under conditions in which a saturated fuel vapour is discharged through the venting system at the maximum anticipated bunkering rate, the pressure differential between the fuel tank vapour space and the atmosphere shall not exceed the design vapour pressure of the tank, or, for independent tanks, the maximum working pressure of the tank.
- The venting system shall be connected to the highest point of each fuel tank and vent lines shall be self-draining under all normal operating conditions of list and trim.
- The arrangement for gas freeing fuel tanks shall be such as to minimize the hazards due to the dispersal of flammable vapours in the atmosphere and to flammable vapour mixtures in a fuel tank. The ventilating system used for gas freeing of fuel tanks shall be used exclusively for ventilating purposes.

Primary inerting is carried out to ensure that the concentration inside the containment system is dry and non-flammable prior introducing gas.

- Aeration with dry air must be done prior purging to reduce the dew point for low boiling point fuels.
- Drying with inert gas or nitrogen may be done to reduce the dew point in the fuel tanks for some fuels.
- Inerting is done by replacing vapours with an inert-gas until the concentration of vapours is lower than the LEL. Inert gas used on ships is either nitrogen or inert gas produced in the ship's inert gas plant.
- The correct inerting procedure is ensured by regular checks of the atmosphere at different levels.
- Atmosphere checks are done by measuring the percentage of oxygen and vapours through the sampling tubes.
- Atmosphere is checked for dryness by measuring the dew point.
- Atmosphere in an inerted tank or void space is safe regarding fire hazard but dangerous regarding health

Anti-static system

Electrical bonding of isolated piping systems and tanks is important to avoid static electricity

Static Electricity

Static electricity results from the interaction of dissimilar materials. This can occur when materials are rubbed together, such as in the classic example of walking across a carpet on a dry winter day while wearing woollen socks. However, static discharges can also develop when a liquid pass through a pipe, through an opening into a tank, and/or when mixing or agitating the mixture. The liquid is moving different electrons from one to another, and the friction of electrons creates static electricity. An electrostatic discharge (also called a static spark) is a discharge of electricity across a gap between two points not in contact, resulting from a difference in electrical potential. The spark produced when the electrical charge jumps across the gap usually contains enough energy to ignite flammable vapours if they are in concentrations that will sustain combustion. The generation of static electricity cannot be totally eliminated because it is normally present at every interface. However, there are ways to reduce the potential for static charge build-up when transferring flammable liquids. The two most important ways to prevent static sparks are~ bonding and grounding.

Bonding

Bonding & Grounding – Controlling Static Electricity Bonding is done to eliminate the difference in electrical potential between two or more objects. An adequate bond between two or more conductive objects will allow the charges to flow freely between objects, resulting in no difference I n electrical potential. Bonding will not eliminate the static charge, but will equalize the potential between the objects bonded so that a spark will not occur between them. The likelihood of a spark between the objects is then essentially eliminated.

Grounding

Bonding & Grounding - Controlling Static Electricity Grounding an object serves a different purpose than bonding. Bonding eliminates the difference in electrical potential between containers that are bonded together, but it will not eliminate the potential difference between an object and the ground. To ensure that a static charge will not create a spark as a result of this difference, a conductive path must be provided to the earth. A proper ground will provide a means for continuously discharging a charged, conductive body to the earth.

Grounding may be achieved by attaching a wire conductor between the container and a water pipe or the full length of an 8-foot long copper clad steel rod embedded in the ground. Total resistance to ground should be kept below one mega-ohm. When using a buried rod, resistance is affected by soil moisture. It is important that the grounding system be checked to ensure that there is continuity and proper resistance.

Ventilation

Mechanical exhaust ventilation systems are provided to disperse any vapour that may collect in the tank connection spaces, fuel preparation rooms, secondary barriers around piping or other hazardous spaces.

- The bunkering station shall be so located that sufficient natural ventilation is provided. The bunkering station shall be separated from other areas of the ship by gas tight bulkheads, except when located in the cargo area on tankers. Closed or semi-enclosed bunkering stations will be subject to special consideration with respect to requirements for mechanical ventilation.

- Fuel tanks without direct access from open deck shall have a sufficient number of ventilation inlets and outlets to ensure complete gas freeing, but no less than 2 inlets and 2 outlets per tank.
- The arrangement for gas freeing fuel tanks shall be such as to minimize the hazards due to the dispersal of flammable vapours in the atmosphere and to flammable vapour mixtures in a fuel tank. The ventilating system used for gas freeing of fuel tanks shall be used exclusively for ventilating purposes.
- The annular space in the double walled fuel pipe shall be ventilated to open air and be equipped with vapour and liquid leakage detection. Inerting of the annular space in the double walled fuel piping may be accepted as an alternative in low pressure fuel systems. The inerted annular space shall be pessurized with inert gas at a pressure greater than the fuel pressure. Suitable alarms shall be provided to indicate a loss of inert gas pressure between the pipes.
- Where a nitrogen generator or nitrogen storage facilities are installed in a separate compartment, outside of the engine room, the separate compartment shall be fitted with an independent mechanical extraction ventilation system, providing 6 air changes per hour. A low oxygen alarm shall be fitted. Such separate compartments shall be treated as one of other machinery spaces, with respect to fire protection

Segregation

The International Maritime Dangerous Goods (IMDG) Code was developed as a uniform international code for the transport of dangerous goods by sea covering such matters as packing, container traffic and stowage, with particular reference to the segregation of incompatible substances.

Where codes and regulations call for segregation, the position of the valves, blanks, portable bends and spool pieces associated with such segregation should be carefully arranged and clearly identified.

Segregation of cargo- and fuel system:

- Measures shall be provided to prevent inadvertent transfer of incompatible or contaminating cargo to the fuel system, after the fuel storage tanks have been loaded.
- If cargo tanks located within the cargo area are used as LFL fuel storage tanks, these cargo tanks shall be dedicated as LFL fuel tanks when the ship is operating on LFL fuel.
- Any cargo liquid line for dedicated LFL fuel storage tanks shall be separated from liquid cargo piping serving other cargo tanks, including common liquid cargo piping.
- Cross-connections to cargo liquid piping serving common systems or other tanks may be accepted provided the connections are arranged with spool pieces, typically swing bends. The arrangement of spool pieces shall be such that even if a spool piece is unintentionally left in place, inadvertent transfer of incompatible or contaminating cargo from or to the dedicated LFL fuel storage tank is not possible.
- The piping and manifold serving the dedicated LFL fuel storage tanks shall be specially colour coded.
- The cargo tank venting system for the dedicated LFL fuel tanks shall be separated from venting systems from other cargo tanks when operating on LFL fuel.
- Other cargo handling systems serving other cargo tanks such as tank washing, inert gas and vapour return shall be separated when used as LFL fuel storage tanks. Inert gas systems may be accepted connected to a common system when used as LFL fuel storage tanks, provided the system is under continuous pressure.
- LFL fuel tank location shall take into account compatibility with other cargoes. When carrying LFL fuel in the storage tanks, these tanks cannot be located adjacent to cargo tanks intended for cargoes that are not compatible with the LFL fuel.

Inhibition

Inhibitor - Chemical or substance added or applied to another substance, to slowdown a reaction or to prevent an unwanted chemical change.

When a product containing an oxygen-dependent inhibitor is carried on a ship for which inerting is required, the inert gas system shall be operated as required to maintain the oxygen level in the vapour space of the tank at or above the minimum level of oxygen required

Measures to prevent ignition, fire and explosion

Probability of fire and explosions shall be reduced to a minimum

Fire safety:

- Measures shall be implemented to reduce the consequences of fire and explosions in cargo tanks and in the cargo area for the dedicated LFL fuel service tanks and LFL fuel supply systems.
- Inerting of cargo tanks during cargo tank cleaning operations and inert gas purging prior to gas freeing would be considered an acceptable measure to reduce the consequence of in-tank explosion. Such inerting should be performed for all cargo tanks and regardless of size of ship.
- LFL fuel tanks and associated tank connection spaces (if fitted) on weather deck shall be protected by a water spray system for cooling and fire prevention and to cover exposed parts of the tank located on open deck.
- This system comes in addition to the deck foam firefighting system required for chemical tankers.
- For the purpose of isolating damaged sections, manual stop valves shall be fitted or the system may be divided into two sections with control valves located in a safe and readily accessible position not likely to be cut-off in case of fire.
- The system shall be served by a separate water spray pump with capacity sufficient to deliver the required amount of water.
- A connection to the ship's fire main through a stop valve shall be provided.

Atmospheric control

Fuel tanks and piping need to have the system purged with inert gas/ nitrogen before filling with flammable fuel.

Inerting and Purging: Before bunkering, it is necessary to inert and purge the bunker hoses and other warm bunker lines. In order to prevent a flammable gas mixture, the inerting process includes displacing air from the bunker lines with inert gas, typically nitrogen, to ensure the oxygen content is less than or equal to 1 percent. Purging, also known as gassing up and gas filling, is the process of displacing the inert gas with warm natural gas. Purging can either be done with vapor purge lines, which force vapor from the tank through the bunker lines; or by slowly pumping small volumes of LNG through the bunker lines, which will quickly vaporize and purges the lines. After the bunker lines have been inerted and purged, the lines are slowly cooled to the temperature of LNG with the use of cold LNG vapor and/or LNG. This process prevents the risk of cold shock and damage that would occur if LNG was allowed to flow through the warm hoses and pipes at the normal flow rate. Once the bunker lines have been cooled, the transfer of LNG can begin.

Gas testing

Gas sampling points shall be provided for each fuel tank to monitor the progress of atmosphere change.

Bunkering and Fuel Tank Level Monitoring

Liquid level gauging:

Installed in each fuel tank and operative over the full range of fuel temperature and pressure:

- Indirect measurement devices such as weight or flow meters.
- Direct measurement closed gauging devices such as float gauges, capacitance gauges, radar, ultrasonic gauges.

Liquid level monitoring (Two systems):

- Includes high level alarm:
  - Fill valve closes.
- Each tank must have an independent high-level alarm:
  - Activates automatic shutoff of manifold valves (ESD).

Protection against cryogenic damages (LNG)

Preventive measures against spillage of low temperature cargo in gas carrier:

Liquid spills have the potential to cause damage to the ship's structure and frostbite or chemical burns to any person contacting the liquid or cold vapour. The liquid will evaporate to form a flammable or toxic cloud.

The rate at which spilled liquid vapourises and forms a gas cloud depends mainly on the properties of the liquid spilled, the air temperature, the nature of the surface it is spilled on and the area that it spreads over. Initially the cloud will be cold and low lying and drift down wind. It may be visible as a white cloud, which is condensed water vapour.

Care should be taken to prevent spillage of low temperature cargo because of the hazard to personnel and the danger of brittle fracture. Remember that a flammable or toxic cloud may not be visible. If spillage does occur, the source should first be isolated and the spilt liquid then dispersed. If these is a danger of brittle fracture, a water hose may be used both to vaporize the liquid and to keep the steel warm.

If the spillage is contained in a drip tray the contents should be covered or protected to prevent accidental contact and allowed to evaporate. Liquefied gases quickly reach equilibrium and visible boiling ceases; this quiescent liquid could be mistaken for water and carelessness could be dangerous.

Suitable drip trays are arranged beneath manifold connections to control any spillage when transferring cargo or draining lines and connections. Care should be taken to ensure that unused manifold connections are isolated and that if blanks are to be fitted the flange surface is clean and free from frost. Accidents have occurred because cargo escaped past incorrectly fitted blanks.

Liquefied gas spilt onto the sea will generate large quantities of vapour by the heating effect of the water. This vapour may create a fire or health hazard, or both. Great care should be taken to avoid such spillage, especially when disconnecting cargo hoses.

Competence: Apply occupational health and safety precautions and measures

9. Gas measuring instruments

Awareness of function of gas-measuring instruments and similar equipment

Gas testing

Gas analyzing equipment on board liquefied gas carriers - An instrument which alerts someone to the presence of gas, especially in spaces where gas is not normally expected. Gas analyzing equipment include oxygen monitors, detectors for combustible gases, compressed breathing air monitors, and systems for detection of an array of toxic gases. Available equipment ranges from single-gas and four-gas portables to multi-channel stationary gas detection systems.

Vapour detection equipment is required by IMO codes for a number of reasons.

- Cargo vapour in air, inert gas or the vapour of another cargo.
- Concentrations of gas in or near the flammable range.
- Concentrations of oxygen in inert gas, cargo vapour or enclosed spaces.

Oxygen Analyzer/ Indicators

An instrument used to measure oxygen concentrations, expressed as a percentage by volume. Peroxide A compound formed by the chemical combination of cargo liquid or vapour with atmospheric oxygen, or oxygen from another source. These compounds may in some cases be highly reactive or unstable and constitute a potential hazard.

Combustible Gas Indicators

Portable multi gas detection systems monitor a variety of different gases including, Carbon monoxide (CO), Hydrogen sulfide (H_2S), Oxygen (O_2), Carbon dioxide (CO_2), combustible gases, and other toxic gases such as Ammonia (NH_3), Chlorine (Cl_2), Sulfur dioxide (SO_2), Nitric oxide (NO), Nitrogen dioxide (NO_2).

Toxicity Detectors

Toxic gas detectors commonly operate on the principle of absorption of the toxic gas in a chemical tube which results in a colour change. A common type of toxic gas detector is illustrated. Immediately prior to use, the ends are broken from a sealed glass tube. This is inserted into the bellows unit, and a sample aspirated through it. The reaction between the gases being sampled and the chemicals contained in the tube causes a colour change.

Fixed Gas Detection System

There are two types of gas detection system commonly used on board LNG carriers, a sampling system and a gas detection system incorporating remote heads.

The sampling system draws gas samples from each monitored location into a central analyzer located in a 'safe' area. Typically, samples will be drawn from cargo areas in a pre-programmed sampling sequence and will be passed through an infrared analyzer. The system alarms if pre-set limits are exceeded.

Remote detector heads may also be used to monitor gas concentrations. The signal from flameproof infrared gas detectors will be passed to a central control unit having visual and audible alarm functions.

Demonstration/ Practical - Perform gas testing using different types of Gas Measuring Instrument

10. Specialized safety equipment and protective devices

Breathing apparatus

Compressed air breathing apparatus:

In the self-contained version (SCBA), the wearer carries his air for breathing in a compressed air cylinder at an initial pressure of between 135 and 200 bars. The pressure is reduced at the outlet from the cylinder to about 5 bars and fed to the face mask as required through a demand valve providing a slight positive pressure within the mask. Working duration depends upon the capacity of the air cylinder and the respiratory demand. Indicator and alarm features are usually provided to warn of air supply depletion.

A typical set, providing approximately 30 minutes operation with physical exertion, may weigh about 13kg and the bulk of the cylinder on the back of the wearer imposes some restriction on his maneuverability in confined spaces. Although when properly adjusted, the SCBA is simple and automatic in operation, its maintenance requires care and skill. To ensure their serviceability when required, all such breathing sets must be checked monthly and worn and operated during appropriate exercises preferably using special exercise air cylinders in order to keep the operational cylinders always fully charged.

Although modern demand valves are designed to maintain a slight positive pressure within the face mask, it must not be assumed that this feature will prevent leaks from the contaminated atmosphere into an ill-fitting face mask. While face mask materials and contours are designed to accommodate a range of typical facial shapes and sizes, it is essential that, before entry to a dangerous space, the air tightness of the mask on the wearer's face be thoroughly checked in accordance with the manufacturer's instructions. Comprehensive practical tests have shown that it is virtually impossible to ensure continued leak tightness in operational conditions on a bearded face.

Most compressed air breathing sets may be used in the air line version (ALBA) whereby the compressed air cylinder and pressure reducing valve are placed outside the contaminated atmosphere and connected to the face mask and demand valve by a trailed air hose. At the expense of decreased range ability and the need for extra care in guiding the trailing air hose, the wearer is relieved of the weight and bulk of the air cylinder and his operational duration may be extended by the use of large air cylinders of continuous supply cylinder changeover arrangements.

Protective clothing

In addition to breathing apparatus full protective clothing should be worn when entering an area where contact with cargo is a possibility. Types of protective clothing vary from those providing protection against liquid splashes to a full positive pressure gas-tight suit which will normally incorporate helmet, gloves and boots. Such clothing is also to be resistant to low temperatures and solvents.

Full protective clothing is particularly important when entering a space which has contained toxic gas such as ammonia, chlorine, ethylene oxide, VCM or butadiene.

One complete set of protective clothing is to consist of:

- One self-contained air breathing apparatus not using stored oxygen having a capacity of at least 1200L of free air.
- Protective clothing, boots, gloves and tight fitting goggles.
- Steel-covered rescue line with belt.
- Explosion proof lamp.

At least 5 suits of protective clothing, are supplied to LPG ships and these should be stowed: Emergency Headquarters 3 nos & Cargo Control Room 2 nos

When wearing protective clothing it is important to ensure that neither the sleeves are tucked into the gloves, not the trousers into the boots. This is to avoid low temperature cargo falling into the gloves and boots of personnel working in areas where splashing of cargo of spillage is possible. Sleeves are to pass over gloves and trousers over the boots of all protective clothing.

Resuscitators

A resuscitator should not be used in toxic or reduced O2 atmosphere.

Hand-operated resuscitator – Hand-operated resuscitators are used to maintain or restore respiration in an emergency situation; therefore, as a matter of principle, they must function independently of external sources of power especially in disaster situations

VORTRAN **Automatic Resuscitator (VAR)** – This is a unique single patient use, disposable resuscitator. It provides consistent, reliable, hands-free ventilator support via a mask or endotracheal tube using a continuous gas flow source. The VARs are to be used by properly trained personnel for the delivery of short term, constant flow pressure-cycled ventilator support in emergency and hospital environments. They are cost competitive and provide more consistent ventilation than manual resuscitators.

Rescue and escape equipment

Arrangements for hoisting an injured person with a rescue line must be made and kept in readiness when persons are working in congested/ enclosed spaces. stretchers and medical first-aid equipment must be provided on board

Escape Breathing Sets

One short-duration escape breathing apparatus is useful for each person on board ships. The total number of sets onboard is equal to the number of persons the ship is certified to carry.

The Master is to ensure that all personnel onboard are familiar with the operation and the limitations of these sets. In particular, newly joined personnel are to be instructed in the use of these sets when they sign on.

It is the responsibility of the Second Officer to ensure that the compressed air cylinders are full and that they are checked monthly or more frequently if required. On no account are these sets to be used for operation use, inspection, rescue or fire-fighting support. They have duration of 15 minutes and are to be used only to assist personnel escape from concentrations of toxic vapours.

Demonstration/ Practical - Proper use of Specialized Safety Equipment and Protective Devices

11. Safe Working Practices and Procedures

11.1. Precautions to be taken before entering hazardous spaces and zones

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

An enclosed space is a space which is not used for day to day activity and which has any of the following characteristics:

- *Limited opening for entry and exit*
- *Inadequate ventilation*
- *Is not designed for continuous worker occupancy*

The presence of any one of the characteristics as stated above can make space an enclosed space. A ship-specific list should be available to identify all enclosed spaces onboard and should be displayed in public spaces. The most common confined spaces onboard ships are cargo holds, chain lockers, cofferdams, water tanks, void spaces, duct keels, fuel tanks, engine crankcases, exhaust and scavenge receiver.

Any area on the ship that has been left closed for any length of time without ventilation must be considered dangerous. Changes in the environment of a space which is not labelled unsafe can also make space unsafe, for example, failure of fixed ventilation or the migration of hazardous vapours from an adjacent hazardous space.

It is best practice to not to enter a dangerous space, however onboard crew members have to enter enclosed spaces for a number of reasons including routine inspection of tanks (ballast tanks, DB tanks), checking if a tank is dry before loading, cleaning of tanks or holds, maintenance including painting, repairing, etc

No person should open or enter an enclosed space unless authorized by the master or the nominated responsible person and unless the appropriate safety procedures laid down for the particular ship including permit to work have been followed

Only a tank or space declared gas-free can be entered by personnel without breathing apparatus and protective clothing

A gas-free tank or space may not be considered to remain gas-free unless regular measurements of the atmosphere prove so

Procedure for Entering an Enclosed Space:

- The following are the points that need to be followed before entering an enclosed space:
- Risk assessment to be carried out by a competent officer as enclosed or confined space entry is deficient in oxygen, making it a potential life hazard
- A list of work to be done should be made for the ease of assessment for e.g. if welding to be carried out or some pipe replacement etc. This helps in carrying out the work quickly and easily
- Potential hazards are to be identified such as the presence of toxic gases

- Opening and securing has to be done and precaution should be taken to check if the opening of enclosed space is pressurized or not
- All fire hazard possibilities should be minimized if hot work is to be carried out. This can be done by emptying the fuel tank or chemical tank near the hot workplace
- The confined space has to be well ventilated before entering. Enough time should be allowed to establish a ventilation system to ensure that air containing enough oxygen to sustain life is introduced. Ventilation can either be natural or mechanical using blowers.
- Space has to be checked for oxygen content and other gas content with the help of oxygen analyzer and gas detector.
- Permit to work is to be valid only for a certain time period. If the time period expires then again new permit is to be issued and the checklist is to be filled out.
- Permit to work has to be checked and permitted by the Master of the ship in order to work in confined space
- Proper signs and Men at work signboards should be provided at required places so that person should not start any equipment, machinery or any operation in the confined space endangering the life of the people working
- Duty officer has to be informed before entering the enclosed space
- The checklist has to be signed by the person involved in entry and also by a competent officer
- One person always has to be kept standby to communicate with the person inside the space. Effective communication between the people inside the space and the person standing by is vitally important.
- The person should carry oxygen analyzer with him inside the enclosed space and it should be on all the time to monitor the oxygen content. As soon as level drops, the analyzer should sound alarmed and space should be evacuated quickly without any delay
- No source of ignition has to be taken inside unless the Master or competent officer is satisfied
- The number of persons entering should be constrained to the adequate number of persons who are actually needed inside for work
- The rescue and resuscitation equipment are to be present outside the confined space. Rescue equipment includes breathing air apparatus, spare charge bottles, stretchers, means of hoisting an incapacitated person from the space like a tripod, rescue harness, portable lighting, etc.
- Means of hoisting an incapacitated person should be available
- After finishing the work and when the person is out of the enclosed space, the after-work checklist has to be filled
- The permit to work has to be closed after this

11.2. Precautions to be taken Before and During Repair and Maintenance

The use of appropriate PPE is mandatory to protect the crew against the various hazards. Monitoring and evaluation of spaces adjacent to fuel tanks for vapour content should be considered carried out at regular intervals. If gas concentrations are observed, repairs and maintenance work must be stopped when working in the concerned area. Additionally, the cause of the presence of gas concentration must be investigated into and the same eliminated. Other adjoining spaces must be checked for similar defects.

11.3. Safety Measures for Hot and Cold Work

Hot work

Work involving sources of ignition or temperatures sufficiently high to cause the ignition of a flammable gas mixture is termed as Hot Work. This includes any work requiring the use of welding, burning or soldering equipment, blow torches, some power-driven tools, portable electrical equipment which is not intrinsically safe or contained within an approved explosion-proof housing, and internal combustion engines.

Hot work outside the main machinery spaces (and in the main machinery spaces when associated with fuel tanks and fuel pipelines) must take into account the possible presence of flammable vapours in the atmosphere, and the existence of potential ignition sources.

Any hot work outside the designated hot work area in machinery room should be under SMS and permit control.

Hot work outside the main machinery spaces should only be permitted in accordance with prevailing national or international regulations and/or port/terminal requirements and should be subject to the restrictions of a shipboard hot work permit procedure of company's SMS (safety management system).

Hot work in dangerous and hazardous areas should be prohibited during bunkering, tank cleaning, gas freeing, purging or inerting operations.

Checks by officer responsible for safety:

Head of Department (Chief Officer & Chief Engineer)

- Inspecting the work area and the equipment to be used for hot-work together with the person/s carrying out the job.
- Physically checking and filling-up the work permit jointly with the responsible officer and the person/s involved in the work.
- Testing the atmosphere of the work area where applicable
- Ensuring continuous effective ventilation of the work area.
- Determining that hot-work is safe to be carried out and signing the permit.
- Monitor the work is going on as per safety briefing.
- Inform the master to retract the permit if safe working conditions are breached.
- To continue monitoring the worked area for at least 30 minutes after completion of hot work or until the risk of fire no longer exists.

<u>*Cold work*</u>

Cold Work is the work which cannot create a source of ignition or generate temperature conditions likely to be of sufficient intensity to cause ignition of combustible gases, vapours or liquids in or adjacent to the area involved.

Cold work includes but not limited to:

- Opening vessels, pipes or enclosed spaces
- Where equipment requires decontamination
- Mechanical maintenance work
- Civil maintenance work
- Erection removal of scaffolding
- Insulation and painting
- Blanking/de-blanking.
- Disconnecting and connecting pipelines.
- Removing and fitting of valves, blanks, spades or blinds.
- Work on pumps

Before carrying out cold work, the following is to be taken care of:

- Determining that the area is safe for work and sign the permit.
- Complete the Cold Work Permit form, jointly with the person/s involved in the work.
- Ensure that the work is carried out as per the conditions mentioned in the Cold Work permit.
- Retract the permit if safe working conditions are breached.

Cold work permits are used in hazardous maintenance work that does not involve "hot work". Cold work permits are issued when there is no reasonable source of ignition, and when all contact with harmful substances has been eliminated or appropriate precautions taken

Control Measures:

- Proper PPE shall be donned at all times.
- All equipment and ropes to be used for the job shall be thoroughly inspected prior operation.
- Ensure area is clear of any slipping hazard.
- Safety harness shall be used where applicable.
- A tool box meeting must be conducted prior commencement of the job.
- Use right tool for the job.
- Examine each tool for damage before use.
- Operate tools according to the manufacturer's instructions.
- Disconnect tools when they are not in use and when changing accessories such as blades, bits and cutters etc.

12. First Aid with reference to SDS *(refer to provided SDS)*

Competence: Carry out firefighting operations on a ship subject to the IGF Code

13. Fire Organization

Fire organization and action to be taken on ships subject to the IGF Code

Planning and implementation of fire emergency procedure requires an emergency organization. Training and drills should prepare the fire response organization to become familiar with their duties and equipment and to respond to emergencies in a timely and correct manner.

The master must ensure that the duty officer is authorized to stop bunkering in the event of an emergency or if in the opinion of the duty officer such stoppage is necessary to prevent an emergency situation.

The duty officer must inform the master in any event of an emergency situation at the earliest opportunity.

Emergency actions to be taken by the duty officer after informing the Master.

As soon as a fire is detected, several actions should be taken to ensure the safety of the vessel and the personnel:

- The Officer of the Watch must, if the bridge is equipped with a fire control panel or fire detector indicator, mark the indicator lamp which was first activated, showing the fire zone
- General alarm should be sounded
- Bridge team should be informed
- Fire party should muster
- The fire should be isolated, by closing ventilation system, skylights, doors, boundary cooling, etc
- Before entering the fire space, crew should wear the appropriate PPE and use the proper fire extinguishing system, regarding the type of fire
- Interested parties should be notified

14. Special Hazards Associated with Fuel System & Fuel Handling

The need to be alert to the fact that toxic fumes (for toxic fuel only) may enter the accommodation and an evacuation of non-essential crew and visitors may become necessary

Most flammable vapours (not warm methane or hydrogen) are heavier than air and may travel long distances to a point of ignition and flash back.

Personnel in gas dangerous spaces involving toxic vapours must be immediately vacated from the downwind areas.

"Jet fire" should be allowed to burn till fuel is exhausted or cut off.

On any vessel, emergencies may have catastrophic consequences, unless proper action is taken. Actions therefore must be prompt, timely and adequate

15. Firefighting Agents and Methods used to Control and Extinguish Fires in Conjunction with Different Fuels

For cooling, fire prevention, and crew protection – water spray systems are fitted when tanks for the IGF Code fuel are located on open deck.

Water spray systems

It is a requirement that a series of water spray nozzles are located at each tank liquid and vapour dome, at the midships manifold, on the compressor house, on the forward bulkhead of the accommodation block and around the midships cargo control room if applicable. The water for the operation of these nozzles is fed from a pump and line system independent from, but cross connected with, the ship's fire main. In addition to the above system, the sides of the accommodation block may be protected by spray nozzles supplied with water from the fire main via isolating valves.

For LNG fuel a permanently installed dry chemical powder fire-extinguishing system will be installed in the bunkering station area to cover all possible leak points.

Dry chemical powder

Dry chemical fixed installations are provided on Gas Carriers. Manufacturer's instructions should be referred to for details of operation and maintenance procedures. Whenever a dry powder hose has been in use, it should be blown clear with nitrogen to prevent any possibility of blockage. The extinguishing power of dry chemical powders depends on the chemical reaction of the small particles when exposed to flame. They are flame inhibiting agents and have been widely proven in LNG fire tests.

The maximum possible rate of application of dry powder is desirable. As many high velocity jets as possible should be brought to bear at once, preferably in a down wind direction. Jets should be aimed with the objective of reducing boil-off rate by sweeping over the whole fire area and on no account must the surface of an LNG pool be agitated. Possible re-ignition must be guarded against.

Correct use of dry chemical powder equipment is essential if reserves are not to be wasted and the fire is to be successfully extinguished. Extinction with dry powder is obtained by maximising the rate of application and minimising any agitation of pools of LNG. This may be achieved by coordinating a simultaneous attack with all available applicators. A first-aid shot with only one hose or monitor may be warranted with small fires, but continuous individual efforts can never be as successful as a simultaneous attack with as many applicators as possible being brought to bear.

One portable dry powder extinguisher of at least 5 kg capacity shall be located near the bunkering station.

Safety and Firefighting: Sections 3/7 and 4/9 of the ABS Guide for Propulsion and Auxiliary Systems for Gas Fueled Ships (Gas Fueled Ships Guide) and SOLAS Chapter II-2 can be referenced for fire protection requirements for an LNG fueled vessel. A permanently installed fire extinguishing system will typically be fitted at the bunker station and drip trays. Manual release of the system should be easily possible from outside, but near, the bunker station. In addition, portable dry chemical fire extinguishers are typically located near the bunker station and in nearby areas with easy access by the crew. For enclosed or semi-enclosed bunker stations, a fixed fire and gas detecting system should be fitted.

A water curtain is frequently fitted wherever large quantities of cold LNG can leak and damage critical structural components, such as the ship's side shell directly below the LNG bunker station and bunker hoses and above the waterline.
For some IGF Code fuels, normal firefighting methods are ineffective or dangerous. Therefore, other fire extinguishing methods will be necessary.

Demonstration/Practical – Fire Fighting Operation

16. Fire-fighting System operations

Portable fire-fighting operations

A portable fire extinguisher by definition is an item of equipment for the purpose of extinguishing a fire. The reality is however that a portable fire extinguisher is effective only for the type and size of a fire that it is rated for.

Portable fire extinguishers are generally provided as "first attack" units in firefighting and should be used only in early stages of fire before the fire grows to a stage that is beyond the capacity of the extinguisher. There are broadly six types of fire extinguisher; Water, Foam, Wet Chemical, Dry Chemical Powder, Vaporizing Liquid and Carbon Dioxide. The selection of an extinguisher must be made with the class of fire in mind.

Fire extinguishers contain an agent that is expelled from the extinguisher help to try and extinguish a fire.

The agent in each of the extinguishers explained in this document is stored under pressure. The valve is operated when the hand-held trigger is depressed.

Some fire extinguishers are also fitted with a pressure gauge that provides a visual indication of the extinguishers pressurised state. Gauges may illustrate a numerical value or a colour coded pressure range where green illustrates the extinguisher is pressurised and is in a state of readiness.
Fixed dry chemical system operations

Deck Dry Chemical Powder Fire-extinguish System to be installed for extinguishing fire on deck including cargo manifold on liquefied gas carriers as regulated by SOLAS, IGC Code 2016, MSC.1/Circ.1315 and etc.

Dry Chemical Powder is discharged by pressure of nitrogen gas stored in bottles without other power source. The system is remotely activated from navigation bridge. Fire-fighting operation can be performed with both monitor nozzles and hand hoses concurrently. Shock-absorbers are fitted on hand hose storing boxes to prevent unnecessary load worked on hand hoses laid down during cargo operation. Dry Chemical Powder is not electrically conductive and therefore it can be used to electric equipment. Stable discharging performance even in cold ambient temperature. Mixture of particles of dry chemical powder and nitrogen gas are discharged and it gets into every opening space in the area for effective fire-extinction. Immediate fire-extinction is expected by chemical reaction in an instant.

Dry chemical powder fire extinguishers and extremely effective and versatile.

ABE Type: -

- Class A Fires - paper, cardboard, wood, fabrics, people etc.
- Class B Fires - flammable liquid fires, petrol, deisel, oil etc
- Class E Fires - electrical fires, computers, photocopiers, switchboards etc

BE Type: -

- Class B Fires - flammable liquid fires, petrol, deisel, oil etc
- Class E Fires - electrical fires, computers, photocopiers, switchboards etc
- Class F Fires - although not included in the rating the BE type is capable of extinguishing cooking oil fires

Both types of dry chemical powder fire extinguishers can be used on flammable gas fires, however evaluate the situation carefully before doing this, as burning gas eliminates the gas, whereas if the fire is extinguished, the gas can continue to leak, build up and become a potential bomb if ignition is triggered.

Basic knowledge of spill containment in relation to firefighting operations

EMERGENCY RESPONSE AND FIREFIGHTING

Emergency responses to LNG incidents generally involve a spill or fire. For spills inside LNG facilities, the product will usually be diverted to containment impounding pits. Vapors are produced and may be in their flammable range. The recommended methods for dealing with an unignited and contained LNG spill include high-expansion foam and/or water curtains. High-expansion foam reduces the vaporization, thereby reducing the vapor cloud. It cannot, however, completely prevent vaporization. Initially, it may increase the rate, since the foam adds heat to the LNG. However, once this vapor surge is dispersed, the foam reduces vaporization. Tests using high-expansion foam have shown a 60-percent vapor reduction. Using nonaspirated or low-expansion foams does not significantly reduce vaporization and should not be used; water curtains can be used to control the vapor cloud. Do not allow runoff to come in contact with the LNG pool, because it will increase the vaporization rate.

Demonstration/Practical – Fire Fighting Operation

Competence: Respond to emergencies

17. Emergency Procedures Including Emergency Shutdown

Emergency organization

On most ships the basic structure of the emergency organization consists of four elements:

- *Command Centre*
  BRIDGE TEAM
  This team is responsible for command and control of the situation and for ensuring that an efficient muster of personnel is carried out. If required, the bridge team will institute a controlled search for any person not accounted for.
  The bridge team must also establish immediate external communication, establish internal communication between the bridge, engine room, and emergency and support teams, maintain the safe navigation of the vessels and keep detailed timed record and log event.

- *Emergency Party*
  EMERGENCY TEAM 1 AND 2
  The emergency teams first muster and report to the bridge. They then make ready equipment and report their readiness to the bridge, and be ready to take action as directed by the Master or Officer in Command.

- *Back-up Emergency Party*
  SUPPORT TEAM
  The support team advises its readiness to the bridge and provides support to emergency team as and when instructed by the Master or Officer in Command. Below are some examples:

- Hospital and first aid
- Prepare lifeboats and life rafts
- Prepare to provide breathing apparatus support to emergency team
- Provide logistical support to emergency teams, such as recharging self-contained breathing apparatus cylinder
- Provide additional firefighting equipment
- Maintain security patrols
- Provide boundary cooling
- The success of this team is measured by the effective support it can provide the emergency team. To provide this service, individual team members will need similar skills and attributes so far for an emergency team.

- Technical Party
  ENGINE ROOM TEAM
  The engine room team must advise the bridge of the state of readiness of the engine room. This advice must indicate the status of plant and emergency systems, which must be placed in state of maximum readiness. The team must also establish whether the emergency had any adverse effect on the operation of the plant and then determine what actions, if any, need to be taken to remedy any deficiencies to the plant and emergency systems. The team should be able to maintain essential emergency services.

All personnel on board should know their place in the emergency organization and their duty in case the emergency procedure is being initiated

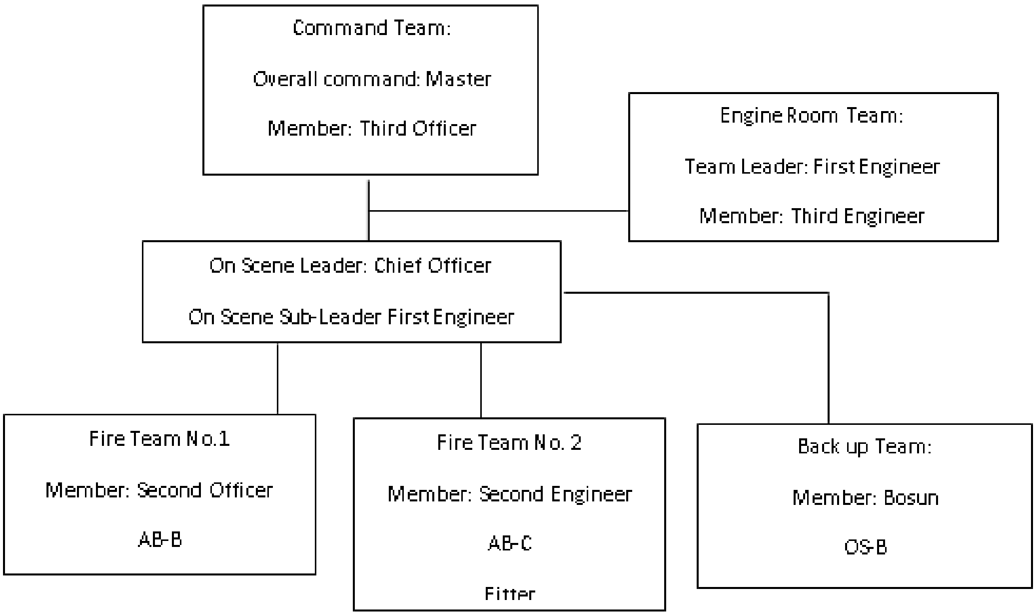
The need to identify a senior officer as being in control during the emergency, with another senior officer identified as his deputy.

TEAM LEADERS

All team leaders must be capable of carrying out tasks that would be assigned to members of their team. The team leader must never become so involved in actual operation that control of his team action is lost such that they jeopardize their lives. To be able to achieve this, a leader must ensure that his team is efficiently trained and that they have confidence in the leader and in each responsibility.

The general composition and the task of the command center, emergency party, back-up emergency party, engineers' group

Sample formation of Emergency Response Team:



Alarms

General Emergency Alarm

The signal consists of ***seven short blasts followed by one long blast*** on the ship's whistle and bells or klaxons or equivalent sounding elsewhere in the ship. There are other special alarms operated from the navigating bridge to summon the crew to fire stations. Other possible fire alarms include: CO2; pump room alarm; manually operated alarm system; UMS fire-detection system. All these alarms could sound like a siren. When the CO2 alarm sounded, leave the room quickly closing the doors behind you. Make sure all crew members are out of the area. CO2 or carbon dioxide is non-toxic however on the discharge of CO2 in fire extinguishing concentration, serious hazards such as suffocation which leads to death and reduced visibility.

All crew members should be familiar with the emergency plan and act according to the plan when the alarm is raised. Any person who discovers an emergency should raise the alarm and pass on information according to relevant procedures.

Emergency procedures

The ship's muster list and emergency instructions specify action to be taken by all crew members and officers in case of an emergency.

A ship's crew must be prepared at all times to tackle and fight any kind of emergencies which can arise due to reasons such as rough weather, machinery malfunction, pirate attack, human error etc. Such emergencies can lead to a fire, collision, flooding, grounding, environmental pollution, and loss of life.

The Muster List consists of duties and responsibilities in case of such mishaps, designated and assigned to each person on the ship; in other words, it is a list of the functions each member of a ship crew is required to perform in case of emergency.

Owing to it being a document that specifies the job that every crew member is assigned with in case of an emergency, it must be displayed at every conspicuous location onboard. Some of the important areas where the muster list is posted are- Bridge, Engine room, accommodation alleyways etc. – areas where ship's crew spends the maximum of their time.

Clear instructions are provided for every person on board in the language or languages required by the ship's flag State and also in the English language. The list shall be ready before the ship proceeds to sea. The regulatory requirements for the Muster List are specified in SOLAS Chapter III, Reg. 8 and 37. The regulation applies to all ships.

The vessel's safety plan and fire control plan specify details and location of all equipment for emergency use.

The fire control plan is posted onboard in distinct locations accessible to everyone. For the effective use of all fire technical facilities it is necessary to have knowledge of the different fire systems and how these can be used in various situations.

Information in the Fire Control Plan

The following information is mostly given by means of symbols. The meaning of each symbol is shown on the plan. All crew in a vessel should study the plan in order to become familiar with the fire-fighting installations on board (e.g. knowledge of escape routes, location of extinguishers, etc.). This is because the crew has to act quickly and accurately in case of emergency:

a) Position of water-tight door (as applicable)
   In case of fire or fire drills, water tight doors must be closed. This is of utmost importance, because a fire always needs oxygen, which can each via the accesses.
b) Exit doors and passages
c) Emergency exits
d) Emergency stops of the ventilation (engine room, accommodation, pump rooms) – ventilation, flaps and fan switches either local or remote control.
e) Fire pumps
f) Emergency fire pumps
   Fire pumps are normally located in the engine room. The number and capacity of the pumps must be as prescribe in the regulations. Emergency fire pumps must always be located far from the fire pumps.
g) Connection for fire hoses
   Number, size and length of the hoses are prescribed in the regulations. Fire hoses on the open deck have at least of 2 inches. In the accommodation smaller hoses are permitted.
h) Positions and types of fire extinguisher

i) Position of International Shore Connection
j) Location of alarm apparatus
k) Location of the release arrangements for the fixed extinguishing installations
l) Location of fireman's outfit

All personnel should know the location of emergency equipment and be familiar with its use. It is essential that personnel are property trained for emergency operations. All equipment which may be used in an emergency must be maintained in good order and be ready for use at all times.

Emergency shutdown

All crew members of the ship must be aware of locations and the methods of activating the manual emergency shut down system specific to their vessel

Emergency Shutdowns on Cargo Systems

Emergency Shutdown (ESD) systems have been a requirement of the IMO IGC Code for the carriage of liquefied gases in bulk for a long time.

An ESD system is basically a link between the ship and the terminal. It can be automatically activated either by pre-defined conditions, such as high tank levels or high pressure, or manually activated by an emergency button.

Once activated, by either party or an abnormal condition, then a series of events starts to return the cargo system to a static condition so that any remedial action can be taken in a timely and safe manner. This includes the structured closing of valves both onboard and ashore and the tripping of pumps and compressors.

Another key feature of any ESD system is the ability to stop the cargo operation safely. No party either on board or at shore, should have to shut a valve against a full flow of incoming liquid. A system that links the ship and shore can allow either party to activate a pre-defined and controlled shutdown procedure. This process aims to protect the system against unacceptable pressure surges and brings the transfer operation to a static condition safely.

Emergency shutdown on a typical ship subject to IGF Code will be initiated by one of the following:

- manual activation by personnel using the emergency shutdown pushbuttons for stop of bunkering
- manual activation by personnel using the emergency shutdown pushbuttons for stop of fuel supply to engine room
- gas detection
- loss of ventilation
- fuel tank very high-level alarm

Competence: Take precautions to prevent pollution of the environment from the release of fuels found on ships subject to the IGF Code

18. Measures to Take in the event of Leakage/ Spillage/ Venting of Fuels

Report of relevant information to the responsible persons

Procedure for spill emergencies: Seagoing chemical tanker design and operational routines all aim at reducing the risk for environmental pollution. Nevertheless: accidents can happen or be caused by improper action by anyone involved on board, ashore or by other ships. Traditional thinking rules that the vessel and her cargo should be salvaged on the basis of the values they represent. With chemical and oil cargoes this is not necessarily true. It is more a matter of containing the cargo on board or by other means until the situation can be mastered with due regard to weather, shipping etc.

Spills of any size in port, due to over-fillings, hose breakage etc, should be reported to the Port Authorities at once. Keep in mind that water supplies, other water intakes local fishing, public amenities etc can be affected with enormous human and economic consequences unless immediate counteractions can be taken.

In order to reduce the danger for minor spillages deck scuppers should be closed, drip pans arranged under hose manifold and a close watch kept when topping up the cargo tanks.

Any accidental spills in port area and how spills are to be treated must be sought from Port Authorities, who will normally take charge of a spill situation.

Awareness of shipboard spill/leakage/venting response procedures

The biggest risk of a cargo spill is during cargo handling operations, either because of equipment failure or improper handling procedures. Cargo spills are therefore most likely to happen in port. In the event of a spill, the following actions should be taken immediately:

- Activate the alarm.
- Stop all cargo operations and close valves and hatches.
- If alongside a berth, notify the terminal staff of the chemicals involved and possible risk posed to personnel.
- Notify local port authorities, usually through the terminal staff.
- Prohibit smoking and use of naked lights throughout the ship.
- Clear all non-essential personnel from the area.
- Close all accommodation access doors, and stop all non-closed-circuit ventilation.
- Arrange for main engines and steering gear to be brought to stand-by

Awareness of appropriate personal protection when responding to a spill/leakage of fuels addressed by the IGF Code

Because LNG is a cryogenic liquid, there is a risk of cold burns if it is in contact with skin. Therefore, LNG should be stored, transported and handled using cryogenic equipment compliant with applicable norms and regulations. To minimize the risks further, Personal Protective Equipment (PPE) should be worn by personnel conducting transfer activities (i.e., filling an LNG road tanker or truck). In this regard, the hazards of LNG handling are very similar to those of common industrial gasses like liquid Nitrogen (LIN), Argon (LAR) and Oxygen (LOX).

Initial procedures for the use of personal protection

Personal protective equipment

It is advised to use the following Personal Protective Equipment (PPE) when working with cryogenic gases and liquids:

- Overall with long sleeves
- Safety Goggle or Face shield
- Safety Shoes
- Cryogenic gloves
- Helmet
- Gas detector