INFORMATIVE PUBLICATION 38/I

GUIDELINES FOR THE SAFETY OF SHIPS USING METHYL OR ETHYL ALCOHOL AS FUEL

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1 GENERAL

1.1 Introduction

Methyl alcohol CH_3OH (methanol) and ethyl alcohol C_2H_5OH (ethanol) are chemical compounds that can be used as fuel in ships under the conditions specified in this *Publication*. Due to their specific properties, however, they require additional safety measures in relation to typical oil fuels. Selected properties of methanol, ethanol and diesel oil are provided below (average, approximate values are listed).

	Methanol	**Ethanol**	**Diesel oil**
Flashpoint [°C]	10	12	62
Autoignition point [°C]	450	400	230
Explosion limits [% vol.]	6 to 36	3 to 28	1 to 6
Calorific value [MJ/kg]	20	27	43
Density at 20°C [kg/m^3]	790	790	830

The low flash point of alcohols means that they pose a greater risk of fire than the oil fuels normally used on board ships. In the case of methanol, an additional risk is that it is a strong poison and its inhalation or accidental consumption may result in serious disability or even death.

From the engine point of view, the problem may be that the alcohols form mixtures with water in any proportion, while the engines require alcohol with a very low water content, much lower than the typical 4 to 5% alcohol content in potable spirit. Another problem is the corrosive properties of alcohols (e.g. to aluminium) and washing out the oil from the friction surfaces of the interacting parts. Due to the high heat of vaporization, ethanol contributes additionally to the difficult starting of a cold engine.

From the operational point of view, the disadvantage of alcohols is that their calorific value is about two times lower than that of oil fuels and the resulting higher consumption of alcohols as fuel.

The main reasons for using alcohols as fuel are ecological considerations - they are renewable fuels, and their combustion produces mainly water vapour and carbon dioxide.

1.2 Application

1.2.1 This *Publication* applies to marine and inland waterways ships and floating facilities, supervised and classed by PRS, whose main propulsion and auxiliary devices are powered by methyl/ethyl alcohol.

1.2.2 This Publication has been developed based on the *Interim Safety Guidelines for Ships Using Methyl/Ethyl Alcohol as Fuel*, contained in MSC.1/Circ.1621.

1.2.3 Principles for materials and fittings, storage, preparation and distribution of low flashpoint liquid fuel, should comply with *IGF Code*.

1.3 Definitions

For the purpose of this *Publication*, the definitions provided in this sub-chapter apply. Terms not defined have the same meaning as in *SOLAS Convention,* Chapter II-2 and the *IGF Code*.

1.3.1 ***Bunkering*** means the transfer of fuel from land-based or floating facilities into ships' permanent tanks or connection of portable tanks to the fuel supply system.

1.3.2 ***Fuel*** means methyl/ethyl alcohol fuels, containing allowable additives or impurities, suitable for the safe operation on board ships, complying with an international standard.

1.3.3 ***Fuel tank*** is any integral, independent or portable tank used for storage of fuel. The spaces around the fuel tank are defined as follows:

- **.1** ***Fuel storage hold space*** is the space enclosed by the ship~~'s~~ structure in which a fuel tank is situated. If tank connections are located in the fuel storage hold space, a fuel storage hold space should also be considered as *tank connection space*. Integral fuel tanks do not have a fuel storage hold space;
- **.2** ***Cofferdam*** is a structural space surrounding a fuel tank which provides an added layer of gas and liquid tightness protection against external fire, and toxic and flammable vapours between the fuel tank and other areas of the ship; and
- **.3** ***Tank connection space*** is a space surrounding all tank connections and tank valves that is required for tanks with such connections in enclosed spaces.

1.3.4 ***Fuel preparation space*** means any space containing equipment for fuel preparation purposes, such as fuel pumps, fuel valve train, heat exchangers and filters.

1.3.5 ***Gas freeing*** is the process carried out to achieve a safe tank atmosphere. It includes two distinct operations:

- **.1** purging the hazardous tank atmosphere with an inert gas or other suitable medium (e.g. water) to dilute the hazardous vapour to a level where air can be safely introduced; and
- **.2** replacing the diluted inert atmosphere with air.

1.3.6 ***Independent tanks*** are self-supporting, do not form part of the ship's hull and are not essential to the hull strength.

1.3.7 ***Integral tank*** means a fuel-containment envelope tank which forms part of the ship's hull and which may be stressed in the same manner and by the same loads which stress the contiguous hull structure and which is normally essential to the structural completeness of the ship's hull.

1.3.8 ***Portable tank*** means an independent tank being able to be:

- **.1** easily connected and disconnected from ship systems; and
- **.2** easily removed from ship and installed on board ship.

1.3.9 ***Single failure*** is where loss of intended function occurs through one fault or action.

1.3.10 ***Single fuel engine*** means an engine capable of operating on a fuel defined as in 1.3.2 only.

1.3.11 ***Low-flashpoint liquid*** means a liquid fuel with a flash point lower than that permitted under paragraph 2.1.1 of *SOLAS Convention*, regulation II-2/4.

1.3.12 ***Unacceptable loss of power*** is when it is not possible to sustain or restore normal operation of the propulsion machinery in the event of one of the essential auxiliaries becoming inoperative, in accordance with *SOLAS Convention*, regulation II-1/26.3.

1.4 Alternative design

1.4.1 This *Publication* contains functional recommendations for all appliances and arrangements related to the usage of methyl/ethyl alcohol fuels.

1.4.2 Appliances and arrangements of methyl/ethyl alcohol fuel systems may deviate from those set out in this *Publication*, provided such appliances and arrangements meet the intent of the goal and functional recommendations concerned and provide an equivalent level of safety to the relevant sections.

1.4.3 The equivalence of the alternative design should be demonstrated as specified in *SOLAS Convention*, regulation II-1/55 and submitted to PRS for acceptance. Operational methods or procedures should not be considered as an alternative to a particular fitting, material, appliance, apparatus, item of equipment or type thereof which is prescribed by this *Publication*.

1.5 Design documentation

Design documentation should include the following items:

1.5.1 General documentation of fuel systems, including:

- General and functional description of systems;
- Fuel systems' equipment on board layout plan;
- Plan of hazardous areas and zones;
- Risk assessment.

1.5.2 Arrangement plan of fuel tanks, including:

- Independent, integral and portable tanks;
- Fixing of independent and portable tanks;
- Fuel leakage collection systems;
- Tank venting systems;
- Relief valves, overpressure/vacuum systems;
- Tank purge and gas freeing systems.

1.5.3 Diagrams of the fuel systems, including:

- Fuel bunkering and storage system;
- Fuel preparation system;
- Fuel supply system;
- Calculations of pipeline diameters;
- Selection of equipment and fittings;
- List of materials and components;
- List of certificates and documents of compliance.

1.5.4 Documentation of the spaces where fuel systems are located, including:

- Layout of fuel devices and pipes;
- Ventilation diagram and capacity calculations (including layout of fans and ventilation ducts);
- Structural fire protection;
- Electrical installations and degree of protection of electric components;
- List of certificates for devices installed in hazardous zones.

1.5.5 Documentation of airlocks.

1.5.6 Documentation of safety systems including:

- Control and/or monitoring systems of the functioning/condition of devices, systems and tanks;
- Dangerous gas concentration detection and alarm system (including arrangement of detectors);
- Fire detection and alarm systems;
- Fixed firefighting systems and portable fire-fighting equipment;
- Inert gas system;
- Description of alarm conditions and safety actions;
- Emergency shutdown system (ESD).

1.5.7 Final acceptance and tests program for fuel systems, dangerous gas concentration detection and alarm system, fire detection and alarm systems, firefighting, ventilation, inert-gas, control and monitoring, purging and gas freeing systems.

1.6 Certificates and documents of compliance

Equipment and components of ship systems using methyl/ethyl alcohol as fuel should be provided with appropriate certificates and/ or documents of compliance. The type of required certificate/document of compliance is determined each time by PRS

1.7 Operational documentation

Documentation for the safe operation and maintenance of systems that use methyl/ethyl alcohol as fuel should be available onboard the ship, covering:

.1 design documentation listed in para 1.5;
.2 user manual of all systems and devices related to systems using methyl/ethyl alcohol as fuel, listed in para 1.8;
.3 maintenance plan, listed in para 1.9.

1.8 User manual

1.8.1 User manual referred to in 1.7.2 should contain at least:

.1 general information on the operation of a vessel that uses methanol/ethanol as a fuel;
.2 specific fuel properties and special equipment necessary for the safe handling of the fuel used;
.3 sufficiently detailed operational procedures related to the fuel used including bunkering, storage and fuel transfer together with installation diagrams;
.4 emergency procedures in the event of signalling a threat to the safe operation of the fuel system and the safety of the ship;
.5 operating procedure of the inert gas system;
.6 procedures for purging, inerting and gas freeing of fuel tanks/systems;
.7 procedures for the operation of fire-fighting systems and use of extinguishing agents;
.8 description of the operation of fixed and portable gas detection equipment and its servicing and maintenance;
.9 emergency shutdown systems (ESD), if fitted;
.10 emergency procedures in the event of leakage, fire or poisoning.

1.8.2 The fuel system diagram should be permanently displayed at the ship's bunkering control station and at the bunkering station.

1.9 Maintenance plan

The maintenance plan should include the schedule and information for periodic inspection, testing and maintenance for all systems and equipment associated with systems using methyl/ethyl alcohol as fuel.

2 GOAL AND FUNCTIONAL RECOMMENDATIONS

2.1 Goal

The goal of this *Publication* is to provide for safe and environmentally friendly design and construction of ships and in particular their installations of systems for propulsion machinery, auxiliary power generation machinery and/or other purpose machinery using methyl/ ethyl alcohol as fuel.

2.2 Functional recommendations

2.2.1 The safety, reliability and dependability of the systems should be equivalent to that achieved with new and comparable conventional oil-fuelled main and auxiliary machinery.

2.2.2 The probability and consequences of fuel-related hazards should be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of fuel leakage or failure of the risk reducing measures, necessary safety actions should be initiated.

2.2.3 The design philosophy should ensure that risk-reducing measures and safety actions for the fuel installation do not lead to an unacceptable loss of power.

2.2.4 Hazardous areas should be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the ship, persons on board and equipment.

2.2.5 Equipment installed in hazardous areas should be minimized to that necessary for operational purposes and should be suitably and appropriately certified.

2.2.6 Unintended accumulation of explosive, flammable or toxic vapour and liquid concentrations should be prevented.

2.2.7 System components should be protected against external damage.

2.2.8 Sources of ignition in hazardous areas should be minimized to reduce the probability of fire and explosions.

2.2.9 Safe and suitable fuel supply, storage and bunkering arrangements should be provided, capable of receiving and containing the fuel in the required state without leakage.

2.2.10 Piping systems, containment and overpressure relief arrangements that are of suitable design, material, construction and installation for their intended application should be provided.

2.2.11 Machinery, systems and components should be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.

2.2.12 Suitable control, alarm, monitoring and shutdown systems should be provided to ensure safe and reliable operation.

2.2.13 Fixed fuel vapour and/or leakage detection suitable for all spaces and areas concerned should be arranged.

2.2.14 Fire detection, protection and extinction measures appropriate to the hazards concerned should be provided.

2.2.15 Commissioning, trials and maintenance of fuel systems and fuel utilization machinery should satisfy the goal in terms of safety, availability and reliability.

2.2.16 The technical documentation should permit an assessment of the compliance of the system and its components with this *Publication*, design standards used, and the principles related to safety, availability, maintainability and reliability.

2.2.17 A single failure in a technical system or component should not lead to an unsafe or unreliable situation.

3 GENERAL RECOMMENDATIONS

3.1 Goal

The goal of this section is to ensure that the necessary assessments of the risks involved are carried out in order to eliminate or mitigate any adverse effect on the persons on board, the environment or the ship.

3.2 Risk assessment

3.2.1 A risk assessment should be conducted to ensure that risks arising from the use of methyl/ethyl alcohol fuels affecting persons on board, the environment, the structural strength, or the integrity of the ship are addressed. Consideration should be given to the hazards associated with physical layout, operation and maintenance, following any reasonably foreseeable failure.

3.2.2 The risks should be analysed using acceptable and recognized risk analysis techniques*. Loss of function, component damage, fire, explosion, toxicity and electric shock should, as a minimum, be considered. The analysis should ensure that risks are eliminated wherever possible. Risks which cannot be eliminated should be mitigated as necessary. Details of risks, and the means by which they are mitigated, should be documented to the satisfaction of PRS.

* See IACS Rec. No. 146 *Risk Assessment as required by the IGF Code.*

3.3 Limitation of explosion consequences

An explosion in any space containing any potential sources of release* and potential ignition sources should not:

.1 cause damage to or disrupt the proper functioning of equipment/systems located in any space other than that in which the incident occurs;
.2 damage the ship in such a way that flooding of water below the main deck or any progressive flooding occur;
.3 damage work areas or accommodation in such a way that persons who stay in such areas under normal operating conditions are injured;
.4 disrupt the proper functioning of control stations and switchboard rooms necessary for power distribution;
.5 damage life-saving equipment or associated launching arrangements;
.6 disrupt the proper functioning of fire-fighting equipment located outside the explosion-damaged space;
.7 affect other areas of the vessel in such a way that chain reactions involving, inter alia, cargo, gas and bunker oil may arise; or
.8 prevent persons' access to life-saving appliances (LSA) or impede escape routes.

* Double wall fuel pipes are not considered as potential sources of release.

4 SHIP DESIGN AND ARRANGEMENT

4.1 Goal

The goal of this section is to provide for safe location, space arrangements and mechanical protection of power generation equipment, fuel storage system, fuel supply equipment and refuelling systems.

4.2 Functional recommendations

This section is related to functional recommendations 2.2.1 to 2.2.7 and 2.2.12, 2.2.14 and 2.2.16. In particular, the following applies:

.1 the fuel tank(s) should be located in such a way that the probability of the tank(s) being damaged following a collision or grounding is reduced to a minimum taking into account the safe operation of the ship and other hazards that may be relevant to the ship;
.2 fuel containment systems, fuel piping and other fuel release sources should be located and arranged such that released fuel, either as vapour or liquid, is led to safe locations;
.3 the access or other openings to spaces containing potential sources of fuel release should be arranged such that flammable, asphyxiating or toxic vapours or liquids cannot escape to spaces that are not designed for the presence of such substances;
.4 fuel piping should be protected against mechanical damage;
.5 the propulsion and fuel supply system should be designed such that safety actions after any fuel leakage do not lead to an unacceptable loss of power; and
.6 the probability of a fire or explosion in a machinery space as a result of a fuel release should be minimized in the design, with special attention to the risk of leakage from pumps, valves and connections.

4.3 General

4.3.1 Tanks containing fuel should not be located within accommodation spaces or machinery spaces of category A.

4.3.2 Integral fuel tanks should be surrounded by protective cofferdams, except on those surfaces bound by shell plating below the lowest possible waterline, other fuel tanks containing methyl/ethyl alcohol, or fuel preparation space.

4.3.3 The fuel containment system should be abaft of the collision bulkhead and forward of the aft peak bulkhead.

4.3.4 Fuel tanks located on open decks should be protected against mechanical damage.

4.3.5 Fuel tanks on open decks should be surrounded by coamings and spills should be collected in a dedicated holding tank.

4.3.6 Special consideration should be given to chemical tankers using methyl/ethyl alcohol cargoes as fuel.

4.4 Independent fuel tanks

4.4.1 Independent tanks may be accepted on open decks or in a fuel storage hold space.

4.4.2 Independent tanks should be fitted with:

.1 mechanical protection of the tanks depending on location and cargo operations;
.2 if located on an open deck, drip tray arrangements for leak containment and water spray systems for emergency cooling; and

.3 if located in a fuel storage hold space, the space should meet the recommendations of sections 10 and 12.

4.4.3 Independent fuel tanks should be secured to the ship's structure. The arrangement for supporting and fixing the tanks should be designed for the maximum expected static, dynamic inclinations and accidental loads as well as the maximum expected values of acceleration, taking into account the ship characteristics and the position of the tanks.

4.5 Portable tanks

4.5.1 Portable fuel tanks should be located in dedicated areas fitted with:

.1 mechanical protection of the tanks depending on location and cargo operations;
.2 if located on an open deck, drip tray arrangements for leak containment and water spray systems for emergency cooling; and
.3 if located in a fuel storage hold space, the space should meet the recommendations of sections 11 and 13 (inne numery rozdziałów w wersji polskiej).

4.5.2 Portable fuel tanks should be secured to the deck while connected to the ship systems. The arrangement for supporting and fixing the tanks should be designed for the maximum expected static and dynamic inclinations, as well as the maximum expected values of acceleration, taking into account the ship characteristics and the position of the tanks.

4.5.3 Consideration should be given to the ship's strength and the effect of the portable fuel tanks on the ship's stability.

4.5.4 Connections to the ship's fuel piping systems should be made by means of approved flexible hoses suitable for methyl/ethyl alcohol or other suitable means designed to provide sufficient flexibility.

4.5.5 Arrangements should be provided to limit the quantity of fuel spilled in case of inadvertent disconnection or rupture of the non-permanent connections.

4.5.6 The pressure relief system of portable tanks should be connected to a fixed venting system.

4.5.7 Control and monitoring systems for portable fuel tanks should be integrated in the ship's control and monitoring system. A safety system for portable fuel tanks should be integrated in the ship's safety system (e.g. shutdown systems for tank valves, leak/vapour detection systems).

4.5.8 Safe access to tank connections for the purpose of inspection and maintenance should be ensured.

4.5.9 When connected to the ship's fuel piping system:

.1 each portable tank should be capable of being isolated at any time;
.2 isolation of one tank should not impair the availability of the remaining portable tanks; and
.3 the liquid level in the tank should not exceed its filling limit.

4.6 Fuel piping in machinery space

4.6.1 A single failure within the fuel system should not lead to a release of fuel into the machinery space.

1.1.1 All fuel piping within machinery space boundaries should be enclosed in gas and liquid tight enclosures in accordance with 8.4.

4.7 Location and protection of fuel piping

4.7.1 Fuel pipes should not be located less than 800 mm from the ship's side.

4.7.2 Fuel piping should not be led directly through accommodation spaces, service spaces, electrical equipment rooms or control stations as defined in the *SOLAS Convention*.

4.7.3 Fuel pipes led through ro-ro spaces, special category spaces and on open decks should be protected against mechanical damage.

4.7.4 Fuel piping should comply with the following:

.1 fuel piping that passes through enclosed spaces in the ship should be enclosed in a pipe or duct that is gas and liquid tight towards the surrounding spaces with the fuel contained in the inner pipe. Such double walled piping is not required in cofferdams surrounding fuel tanks, fuel preparation spaces or spaces containing independent fuel tanks as the boundaries for these spaces will serve as a second barrier;

.2 all fuel pipes should be self-draining to suitable fuel or collecting tanks in normal condition of trim and list of the ship. PRS may accept alternative arrangements for draining the pipes.

4.8 Location of fuel preparation spaces

Fuel preparation spaces should be located outside machinery spaces of category A.

4.9 Bilge systems

4.9.1 Bilge systems installed in areas where methyl/ ethyl alcohol can be present should be segregated from the bilge system of spaces where methyl alcohol or ethyl alcohol cannot be present.

4.9.2 One or more holding tanks for collecting drainage and any possible leakage of methyl/ethyl alcohol from fuel pumps, valves or from double walled inner pipes located in enclosed spaces should be provided. Means should be provided for safely transferring contaminated liquids to onshore reception facilities.

4.9.3 The bilge system serving the fuel preparation space should be operable from outside the fuel preparation space.

4.10 Drip trays

4.10.1 Drip trays should be fitted where leakage and spill may occur, in particular, in way of single wall pipe connections.

4.10.2 Each tray should have a sufficient capacity to ensure that the maximum amount of spill according to the risk assessment can be handled.

4.10.3 Each drip tray should be provided with means to safely drain spills or transfer spills to a dedicated holding tank. Means for preventing backflow from the tank should be provided.

4.10.4 Drip trays for leakage of less than 10 litres may be provided with means for manual emptying.

4.10.5 The holding tank should be equipped with a level indicator and alarm, and should be inerted at all times during normal operation.

4.11 Arrangement of entrances and other openings in enclosed spaces

4.11.1 Direct access should not be permitted from a non-hazardous area to a hazardous area. Where such openings are necessary for operational reasons, an airlock which complies with the recommendations of section 4.12 should be provided.

4.11.2 Fuel preparation spaces should have independent access direct from open deck. Where a separate access from open deck is not practicable, an airlock complying with section 4.12 should be provided.

4.11.3 Fuel tanks and surrounding cofferdams should have suitable access from the open deck, where practicable, for gas freeing, cleaning, maintenance and inspection.

4.11.4 Without direct access to open deck, an entry space to fuel tanks or surrounding cofferdams should be provided and comply with the following:

.1 be fitted with an independent mechanical extraction ventilation system, providing a minimum of six air changes per hour; a low oxygen alarm and a gas detection alarm should be fitted;
.2 have sufficient open area around the fuel tank hatch for efficient evacuation and rescue operation;
.3 not be an accommodation space, service space, control station or machinery space of category A; and
.4 a cargo space may be accepted as an entry space, depending upon the type of cargo, if the area is cleared of cargo and no cargo operation is undertaken during entry to the space.

4.11.5 The area around independent fuel tanks should be sufficient to carry out evacuation and rescue operations.

4.11.6 For safe access, horizontal hatches or openings to or within fuel tanks or surrounding cofferdams should have a minimum clear opening of 600 mm x 600 mm that also facilitates the hoisting of an injured person from the bottom of the tank/cofferdam. For access through vertical openings providing main passage through the length and breadth within fuel tanks and cofferdams, the minimum clear opening should not be less than 600 mm x 800 mm at a height of not more than 600 mm from bottom plating unless gratings or footholds are provided. Smaller openings may be accepted provided evacuation of an injured person from the bottom of the tank/cofferdam can be demonstrated.

4.12 Airlocks

4.12.1 An airlock is a space enclosed by gastight bulkheads with two gastight doors spaced at least 1.5 m and not more than 2.5 m apart. Unless subject to the requirements of the International Convention on Load Lines, the door sill should not be less than 300 mm in height. The doors should be self-closing without any hold-back arrangements.

4.12.2 Airlocks should be mechanically ventilated at an overpressure relative to the adjacent hazardous area or space.

4.12.3 Airlocks should have a simple geometrical form. They should provide for free and easy passage and should have a deck area not less than 1.5 m^2. Airlocks should not be used for other purposes, for instance as storerooms.

4.12.4 An audible and visual alarm system to give a warning on both sides of the airlock should be provided to indicate if more than one door is moved from the closed position.

4.12.5 For non-hazardous spaces with access from hazardous spaces below deck where the access is protected by an airlock, upon loss of underpressure in the hazardous space access to the space should be restricted until the ventilation has been reinstated. Audible and visual alarms should be given at a manned location to indicate both loss of pressure and opening of the airlock doors when pressure is lost.

4.12.6 Essential equipment necessary for safety should not be de-energized and should be of a certified safe type. This may include lighting, fire detection, gas detection, public address and general alarms systems.

4.12.7 Electrical equipment which is not of the certified safe type for propulsion, power generation, manoeuvring, anchoring and mooring equipment as well as the emergency fire pumps should not be located in spaces to be protected by airlocks.

5 FUEL CONTAINMENT SYSTEM

5.1 Goal

The goal of this section is to provide for a fuel containment system where the risk to the ship, its crew and to the environment is minimized to a level that is at least equivalent to a conventional oil-fuelled ship.

5.2 Functional recommendations

5.2.1 This section refers to functional recommendations 2.2.1, 2.2.2, 2.2.5 and 2.2.8 to 2.2.16 of this *Publication*.

5.2.2 The fuel tanks should be designed such that a leakage from the fuel tank or its connections does not endanger the ship, persons on board or the environment. Potential dangers to be avoided include:

- **.1** flammable fuels spreading to locations with ignition sources;
- **.2** toxicity potential and risk of oxygen deficiency or other negative impacts on crew health due to fuels and inert gases;
- **.3** restriction of access to muster stations, escape routes or LSAs (life-saving appliances); and
- **.4** reduction in availability of LSAs.

5.2.3 The fuel containment system and the fuel supply system should be designed such that safety actions after any leakage, irrespective of in liquid or vapour phase, do not lead to an unacceptable loss of power.

5.2.4 If portable tanks are used for fuel storage, the design of the fuel containment system should be equivalent to permanent installed tanks as described in this section.

5.3 Fuel tanks venting and gas freeing system

5.3.1 The fuel tanks should be fitted with a controlled tank venting system.

5.3.2 A fixed piping system should be arranged to enable each fuel tank to be safely gas freed, and to be safely filled with fuel from a gas-free condition.

5.3.3 The formation of gas pockets during the gas freeing operation should be avoided by considering the arrangement of internal tank structure and location of gas freeing inlets and outlets.

5.3.4 Pressure and vacuum relief valves should be fitted to each fuel tank to limit the pressure or vacuum in the fuel tank. The tank venting system may consist of individual vents from each fuel tank or the vents from each individual fuel tank may be connected to a common header. Design and arrangement should prevent flame propagation into the fuel containment system. If pressure relief valves (PRVs) of the high velocity type are fitted to the end of the vent pipes, they should be certified for endurance burning in accordance with MSC/Circ.677. If PRVs are fitted in the vent line, the vent outlet should be fitted with a flame arrestor certified for endurance burning in accordance with MSC/Circ.677.

5.3.5 Shut-off valves should not be arranged either upstream or downstream of the PRVs. Bypass valves may be provided. For temporary tank segregation purposes (maintenance) shut-off valves in common vent lines may be accepted if a secondary independent over/underpressure protection is provided to all tanks as per 5.3.6.

5.3.6 The fuel tank-controlled venting system should be designed with redundancy for the relief of full flow overpressure and/or vacuum. Pressure sensors fitted in each fuel tank, and connected to an alarm system, may be accepted in lieu of the secondary redundancy requirement for pressure relief. The opening pressure of the PRVs should not be lower than 0.007 MPa below atmospheric pressure.

5.3.7 PRVs should vent to a safe location on open deck and should be of a type which allows the functioning of the valve to be easily checked.

5.3.8 The fuel tank vent system should be sized to permit bunkering at a design loading rate without over-pressurizing the fuel tank.

5.3.9 The fuel tank vent system should be connected to the highest point of each tank and vent lines should be self-draining under all normal operating conditions.

5.4 Inerting and atmospheric control within the fuel storage system

5.4.1 All fuel tanks should be inerted at all times during normal operation.

5.4.2 Cofferdams should be arranged either for purging or filling with water through a non-permanent connection. Emptying the cofferdams should be done by a separate drainage system, e.g. bilge ejector.

5.4.3 The system should be designed to eliminate the possibility of a flammable mixture atmosphere existing in the fuel tank during any part of the atmosphere change operation, gas freeing or inerting by utilizing an inerting medium.

5.4.4 To prevent the return of flammable liquid and vapour to the inert gas system, the inert gas supply line should be fitted with two shutoff valves in series with a venting valve in between (double block and bleed valves). In addition, a closable non-return valve should be installed between the double block and bleed arrangement and the fuel system. These valves should be located inside hazardous spaces.

5.4.5 Where the connections to the inert gas piping systems are non-permanent, two non-return valves may substitute the valves required in 5.4.4.

5.4.6 Blanking arrangements should be fitted in the inert gas supply line to individual tanks. The position of the blanking arrangements (pipe open/blanked) should be immediately obvious to personnel entering the tank. Blanking should be via removable spool piece.

5.4.7 Fuel tank vent outlets should be situated normally not less than 3 m above the deck or gangway if located within 4 m from such gangways. The vent outlets are also to be arranged at a distance of at least 10 m from the nearest air intake or opening to accommodation and service spaces and ignition sources. The vapour discharge should be directed upwards in the form of unimpeded jets.

5.4.8 Vapour outlets from fuel tanks should be provided with devices tested and type approved to prevent the passage of flame into the tank. Due attention should be paid in the design and position of the PRVs with respect to blocking and due to ice during adverse weather conditions. Recommendations for inspection and cleaning should be arranged.

5.4.9 The arrangements for gas freeing and ventilation of fuel tanks should be such as to minimize the hazards due to the dispersal of flammable vapours to the atmosphere and to flammable gas mixture in the tanks. The ventilation system for fuel tanks should be exclusively for ventilating and gas freeing purposes. Connection between fuel tank and fuel preparation space ventilation will not be accepted.

5.4.10 Gas freeing operations should be carried out such that vapour is initially discharged in one of the following ways:

- **.1** through outlets at least 3 m above the deck level with a vertical efflux velocity of at least 30 m/s maintained during the gas freeing operation;
- **.2** through outlets at least 3 m above the deck level with a vertical efflux velocity of at least 20 m/s which are protected by suitable devices to prevent the passage of flame; or
- **.3** through outlets underwater.

5.4.11 In designing a gas freeing system in conformity with 5.3.2 due consideration should be given to the following:

- **.1** materials of construction of system;
- **.2** time to gas free;
- **.3** flow characteristics of fans to be used;
- **.4** the pressure losses created by ducting, piping, fuel tank inlets and outlets;
- **.5** the pressure achievable in the fan driving medium (e.g. water or compressed air); and
- **.6** the densities of the fuel vapour/air mixture.

5.5 Inert gas availability on board

5.5.1 Inert gas should be available permanently on board in order to achieve at least one trip from port to port considering maximum consumption of fuel expected and maximum length of trip expected, and to keep tanks inerted during 2 weeks in harbour with minimum port consumption.

5.5.2 A production plant and/or adequate storage capacities might be used to achieve the availability target defined in 5.5.1.

5.5.3 Fluid used for inerting should not modify the characteristics of the fuel.

5.5.4 The production plant, if fitted, should be capable of producing inert gas with oxygen content at no time greater than 5% by volume. A continuous-reading oxygen content meter should be fitted to the inert gas supply from the equipment and should be fitted with an alarm set at a maximum of 5% oxygen content by volume. The system should be designed to ensure that if the oxygen content exceeds 5% by volume, the inert gas should be automatically vented to atmosphere.

5.5.5 The system should be able to maintain an atmosphere with an oxygen content not exceeding 8% by volume in any part of any fuel tank.

5.5.6 An inert gas system should have pressure controls and monitoring arrangements appropriate to the fuel containment system.

5.5.7 Where a nitrogen generator or nitrogen storage facilities are installed in a separate compartment outside of the engine-room, the separate compartment should be fitted with an independent mechanical extraction ventilation system, providing a minimum of six air changes per hour. If the oxygen content is below 19% in the separate compartment, an alarm should be given. A minimum of two oxygen sensors should be provided in each space. Visual and audible alarms should be placed at each entrance to the inert gas room.

5.5.8 Nitrogen pipes should only be led through well ventilated spaces. Nitrogen pipes in enclosed spaces should:

- **.1** have only a minimum of flange connections as needed for fitting of valves and be fully welded; and
- **.2** be as short as possible.

5.5.9 Notwithstanding the recommendations of section 5.5, inert gas utilized for gas freeing of tanks may be provided externally to the ship.

6 MATERIAL AND GENERAL PIPE DESIGN

6.1 Goal

The goal of this section is to ensure the safe handling of fuel, under all operating conditions, to minimize the risk to the ship, personnel and to the environment, having regard to the nature of the products involved.

6.2 Functional recommendations

This section relates to functional recommendations 2.2.1, 2.2.6, 2.2.8, 2.2.9 and 2.2.10 of this *Publication*. In particular, all materials used should be suitable for the fuel under the maximum working pressure and temperature.

6.3 General pipe design

6.3.1 The design pressure for any section of the fuel piping system is the maximum gauge pressure to which the system may be subjected in service, taking into account the highest set pressure on any relief valve on the system.

6.3.2 The wall thickness t of pipes made of steel should not be less than:

$$t = (t_0 + b + c) / (1 - a/100) \quad \text{[mm]}$$

where:

t_0 = theoretical thickness, [mm]

$t_0 = PD/(2Ke + P)$, [mm]

P = system design pressure, but not less than the design pressure given in 6.3.1, [MPa]

D = outside pipe diameter

K = allowable stress, [N/mm^2] (see 6.3.3)

e = efficiency factor equal to 1.0 for seamless pipes and for longitudinally or spirally welded pipes, delivered by approved manufacturers of welded pipes, which are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with recognized standards. In other cases, an efficiency factor less than 1.0, in accordance with recognized standards, may be required depending upon the manufacturing process

b = allowance for bending, [mm]. The value for b should be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b should not be less than: $b = Dt_0/2.5r$ where: r = mean radius of the bend, [mm]

c = corrosion allowance, [mm]. If corrosion or erosion is expected, the wall thickness of piping should be increased over that required by the other design recommendations

a = negative manufacturing tolerance for thickness, [%]

6.3.3 For pipes made of steel the allowable stress K to be considered in the formula for t_0 in 6.3.2 is the lower of the following values:

$$R_\mathrm{m}/\mathrm{A} \text{ or } R_\mathrm{e}/\mathrm{B}$$

where:

R_m = specified minimum tensile strength at ambient temperature (N/mm^2)

R_e = specified minimum yield stress at ambient temperature (N/mm^2). If stress-strain curve does not show a defined yield stress, the 0.2% proof stress applies

The values of A and B should be at least A = 2.7 and B = 1.8

6.3.4 Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to superimposed loads, the wall thickness should be increased over that required by 6.3.2 or, if this is impracticable or would cause excessive local stresses, these loads should be reduced, protected against or eliminated by other design methods. Such superimposed loads may be due to supports, ship deflections, liquid pressure surge during transfer operations, the weight of suspended valves, reaction to loading arm connections or otherwise.

6.3.5 For pipes made of materials other than steel, the allowable stress should be accepted by PRS.

6.3.6 High pressure fuel piping systems* should have sufficient constructive and fatigue strength. This should be confirmed by carrying out stress analysis and taking into account:

.1 stresses due to the weight of the piping system;
.2 acceleration loads when significant; and
.3 internal pressure and loads induced by hog and sag of the ship.

* Whether a fuel system should be considered as a high-pressure system for the purpose of this *Publication* depends on the design and arrangement of the specific system. Accordingly, the stress analysis should be waived or done to the satisfaction of the Administration.

6.3.7 Fuel pipes and all the other piping needed for safe and reliable operation and maintenance should be colour marked in accordance with a standard at least equivalent to those acceptable to PRS.

6.3.8 All fuel piping and independent fuel tanks should be electrically bonded to the ship's hull. Electrical conductivity should be maintained across all joints and fittings. Electrical resistance between piping and the hull should be maximum 10^6 Ohm.

6.3.9 Piping other than fuel supply piping and cabling may be arranged in the double wall piping or duct provided that it does not create a source of ignition or compromise the integrity of the double pipe or duct. The double wall piping or duct should only contain piping or cabling necessary for operational purposes.

6.3.10 Filling lines to fuel tanks should be arranged to minimize the possibility for static electricity, e.g. by reducing the free fall into the fuel tank to a minimum.

6.3.11 The arrangement and installation of fuel piping should provide the necessary flexibility to maintain the integrity of the piping system in the actual service situations, taking potential for fatigue into account. Expansion bellows should not be used.

6.3.12 Piping fabrication and joining details

6.3.12.1 The inner piping, where a protective duct is required, is to be full penetration butt-welded and fully radiographed. Flange connections in this piping are to only be permitted within the tank connection space and fuel preparation space or similar.

6.3.12.2 Piping for fuel should be joined by welding except:

.1 for approved connections to shut-off valve and expansion joints, if fitted; and
.2 for other exceptional cases specifically accepted by PRS.

6.3.12.3 The following direct connections of pipe length without flanges may be considered:

.1 butt-welded joints with complete penetrations at the root;
.2 slip-on welded joints with sleeves and related welding having dimensions in accordance with recognized standards should only be used in pipes having an external diameter of 50 mm or less; the possibility for corrosion is to be considered; and
.3 screwed connections, in accordance with recognized standards, should only be used for piping with an external diameter of 25 mm or less.

6.3.12.4 Welding, post-weld heat treatment, radiographic testing, dye penetrating testing, pressure testing, leakage testing and non-destructive testing should be performed in accordance with recognized standards. Butt welding should be subject to 100% non-destructive testing, while sleeve welds should be subject to at least 10% liquid penetrant testing (PT) or magnetic particle testing (MT).

6.3.12.5 Where flanges are used, they should be of the welded-neck or slip-on type. Socket welds are not to be used in nominal sizes above 50 mm.

6.3.12.6 Expansion of piping should normally be allowed for by the provision of expansion loops or bends in the fuel piping system. Use of expansion joints used in high pressure* fuel systems should be accepted by PRS. Slip joints should not be used.

* Whether a fuel system should be considered as a high-pressure system for the purpose of this *Publication* depends on the design and arrangement of the specific system.

6.3.12.7 Other pipes connections should be in accordance with 6.3.12.2, but for exceptional cases PRS may consider alternative arrangements.

6.4 Selection of materials

Due consideration should be taken with respect to the corrosive nature of fuel when selecting materials.

7 BUNKERING

7.1 Goal

The goal of this section is to provide for suitable systems on board the ship to ensure that bunkering can be conducted without causing danger to persons, the environment or the ship.

7.2 Functional recommendations

7.2.1 This section relates to functional recommendations 2.2.1 to 2.2.11 and 2.2.13 to 2.2.16 of this *Publication*. In particular, the following applies.

7.2.1.1 The piping system for transfer of fuel to the fuel tank should be designed such that any leakage from the piping system cannot cause danger to the persons on board, the environment or the ship.

7.3 Bunkering station

7.3.1 General

7.3.1.1 The bunkering station should be located on open deck so that sufficient natural ventilation is provided. Closed or semi-enclosed bunkering stations should be subject to special consideration with respect to recommendations for mechanical ventilation. PRS may expect special risk assessment to be submitted.

7.3.1.2 Entrances, air inlets and openings to accommodation, service and machinery spaces and control stations should not face the bunkering station.

7.3.1.3 Closed or semi-enclosed bunkering stations should be surrounded by gas and liquid-tight boundaries against enclosed spaces.

7.3.1.4 Bunkering lines should not be led directly through accommodation, control stations or service spaces. Bunkering lines passing through non-hazardous areas in enclosed spaces should be double walled or located in gastight ducts.

7.3.1.5 Arrangements should be made for safe management of fuel spills. Coamings and/or drip trays should be provided below the bunkering connections together with a means of safely collecting and storing spills. This could be a drain to a dedicated holding tank equipped with a level indicator and alarm. Where coamings or drip trays are subject to rainwater, provision should be made to drain rainwater overboard.

7.3.1.6 Showers and eye wash stations for emergency usage are to be located in close proximity to areas where the possibility for accidental contact with fuel exists. The emergency showers and eye wash stations are to be operable under all ambient conditions.

7.3.2 Ships' bunker hoses

7.3.2.1 Bunker hoses carried on board are to be suitable for methyl/ethyl alcohol. Each type of bunker hose, complete with end-fittings, should be prototype-tested at a normal ambient temperature, with 200 pressure cycles from zero to at least twice the specified maximum working pressure. After this cycle pressure test has been carried out, the prototype test should demonstrate a bursting pressure of at least 5 times its specified maximum working pressure at the upper and lower extreme service temperature. Hoses used for prototype testing should not be used for bunker service.

7.3.2.2 Before being placed in service, each new length of bunker hose produced should be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure, but not more than two fifths of its bursting pressure. The hose should be stencilled, or otherwise marked, with the date of testing, its specified maximum working pressure and, if used in services other than ambient temperature services, its maximum and minimum service temperature, as applicable. The specified maximum working pressure should not be less than 1 MPa gauge.

7.3.2.3 Means should be provided for draining any fuel from the bunkering hoses upon completion of operation.

7.3.2.4 Where fuel hoses are carried on board, arrangements should be made for safe storage of the hoses. Hoses should be stored on the open deck or in a storage room with an independent mechanical extraction ventilation system, providing a minimum of six air changes per hour.

7.4 Bunkering manifold

The bunkering manifold should be designed to withstand the external loads during bunkering. The connections at the bunkering station should be of dry-disconnect type equipped with additional safety dry break-away coupling/self-sealing quick release. The couplings should be of a standard type.

7.5 Bunkering system

7.5.1 Means should be provided for draining any fuel from the bunkering lines upon completion of operation.

7.5.2 Bunkering lines should be arranged for inerting and gas freeing. When not engaged in bunkering, the bunkering lines should be free of gas, unless the consequences of not gas freeing is evaluated and approved.

7.5.3 A ship-shore link (SSL) or an equivalent means for automatic and manual ESD communication to the bunkering source should be fitted.

7.5.4 In the bunkering line, as close to the connection point as possible, there should be a manually operated stop valve and a remotely operated shutdown valve arranged in series. Alternatively, a combined manually operated and remote shutdown valve may be provided. It should be possible to operate this remotely operated valve from the bunkering control station.

7.5.5 Where bunkering lines are arranged with a cross-over, suitable isolation arrangements should be provided to ensure that fuel cannot be transferred inadvertently to the ship side not in use for bunkering.

8 FUEL SUPPLY TO CONSUMERS

8.1 Goal

The goal of this section is to ensure safe and reliable distribution of fuel to the consumers.

8.2 Functional recommendations

This section is related to functional recommendations 2.2.1 to 2.2.6, 2.2.8 to 2.2.11 and 2.2.13 to 2.2.17 of this *Publication*.

8.3 Fuel supply system – general

8.3.1 The fuel piping system should be separate from all other piping systems.

8.3.2 The fuel supply system should be arranged such that the consequences of any release of fuel will be minimized, while providing safe access for operation and inspection. The causes and consequences of release of fuel should be subject to special consideration within the risk assessment in 3.2.

8.3.3 The piping system for fuel transfer to the consumers should be designed in a way that a failure of one barrier cannot lead to a leak from the piping system into the surrounding area causing danger to the persons on board, the environment or the ship.

8.3.4 Fuel lines should be installed and protected so as to minimize the risk of injury to persons on board in case of leakage.

8.4 Fuel distribution piping

8.4.1 The outer pipe or duct should be gas and liquid tight.

8.4.2 The annular space between inner and outer pipe should have mechanical ventilation of underpressure type with a capacity of minimum 30 air changes per hour and be ventilated to open air. Appropriate means for detecting leakage into the annular space should be provided. The double wall enclosure should be connected to a suitable draining tank allowing the collection and the detection of any possible leakage.

8.4.3 Inerting of the annular space might be accepted as an alternative to ventilation. Appropriate means of detecting leakage into the annular space should be provided. Suitable alarms should be provided to indicate a loss of inert gas pressure between the pipes.

8.4.4 The outer pipe in the double walled fuel pipes should be dimensioned for a design pressure not less than the maximum working pressure of the fuel pipes. As an alternative the calculated maximum built-up pressure in the duct in the case of an inner pipe rupture may be used for dimensioning of the duct.

8.5 Redundancy of fuel supply

Propulsion and power generation arrangements, together with fuel supply systems, should be arranged so that a failure in fuel supply does not lead to an unacceptable loss of power.

8.6 Safety functions of the fuel supply system

8.6.1 All fuel piping should be arranged for gas freeing and inerting.

8.6.2 Fuel tank inlet and outlet valves should be as close to the tank as possible. Valves required to be operated under normal operation, such as when fuel is supplied to consumers or during bunkering, should be remotely operated if not easily accessible.

8.6.3 The main fuel supply line to each consumer or set of consumers should be equipped with an automatically operated master fuel valve. The master fuel valve(s) should be situated in the part of the piping that is outside the machinery space containing methyl/ethyl alcohol-fuelled consumer(s). The master fuel valve(s) should automatically shut off the fuel supply in accordance with section 14.2.2 and Table 14.1 in section 14.

8.6.4 Means of manual emergency shutdown of fuel supply to the consumers or set of consumers should be provided on the primary and secondary escape routes from the consumer compartment, at a location outside consumer space, outside the fuel preparation space and at the bridge. The activation device should be arranged as a physical button, duly marked and protected against inadvertent operation and operable under emergency lighting.

8.6.5 The fuel supply line to each consumer should be provided with a remotely operated shut-off valve.

8.6.6 There should be one manually operated shutdown valve in the fuel line to each consumer to ensure safe isolation during maintenance.

8.6.7 Valves should be of the fail-safe type.

8.6.8 When pipes penetrate the fuel tank below the top of the tank a remotely operated shut-off valve should be fitted to the fuel tank bulkhead. When the fuel tank is adjacent to a fuel preparation space, the valve may be fitted on the tank bulkhead on the fuel preparation space side.

8.7 Fuel preparation spaces and pumps

8.7.1 Any fuel preparation space should not be located within a machinery space of category A, should be gas and liquid tight to surrounding enclosed spaces and vented to open air.

8.7.2 Hydraulically powered pumps that are submerged in fuel tanks should be arranged with double barriers preventing the hydraulic system serving the pumps from being directly exposed to methyl/ethyl alcohol. The double barrier should be arranged for detection and drainage of eventual methyl/ethyl alcohol leakage.

8.7.3 All pumps in the fuel system should be protected against running dry (i.e. protected against operation in the absence of fuel or service fluid). All pumps which are capable of developing a pressure exceeding the design pressure of the system should be provided with relief valves. Each relief valve should be in closed circuit, i.e. arranged to discharge back to the piping upstream of the suction side of the pump and to effectively limit the pump discharge pressure to the design pressure of the system.

9 POWER GENERATION INCLUDING PROPULSION AND OTHER ENERGY CONVERTERS

9.1 Goal

The goal of this section is to provide safe and reliable delivery of mechanical, electrical or thermal energy.

9.2 Functional recommendations

9.2.1 This section is related to functional recommendations 2.2.1, 2.2.11, 2.2.13 to 2.2.17 of this *Publication*. In particular, the following applies:

.1 the exhaust system should be designed to prevent any accumulation of unburnt fuel; and
.2 each fuel consumer should have a separate exhaust system.

9.2.2 One single failure in the fuel system should not lead to an unacceptable loss of power.

9.3 General

9.3.1 All engine components and engine-related systems should be designed in such a way that fire and explosion risks are minimized.

9.3.2 Engine components containing methyl/ethyl alcohol fuel should be effectively sealed to prevent leakage of fuel into the machinery space.

9.3.3 For engines where the space below the piston is in direct communication with the crankcase, a detailed evaluation regarding the hazard potential of fuel gas accumulation in the crankcase should be carried out and reflected in the safety concept of the engine.

9.3.4 A means should be provided to monitor and detect poor combustion or misfiring. In the event that it is detected, continued operation may be allowed, provided that the fuel supply to the concerned cylinder is shut off and provided that the operation of the engine with one cylinder cut-off is acceptable with respect to torsional vibrations.

9.4 Dual-fuel engines

9.4.1 In case of shut-off of the methyl/ethyl alcohol supply, the engines should be capable of continuous operation by oil fuel only without interruption.

9.4.2 An automatic system should be fitted to change over from methyl/ethyl alcohol fuel operation to oil fuel operation with minimum fluctuation of the engine power. Acceptable reliability should be demonstrated through testing. In the case of unstable operation on engines when methyl/ethyl alcohol firing, the engine should automatically change to oil fuel mode. There should also be the possibility for manual changeover.

9.4.3 In case of an emergency stop or a normal stop, the methyl/ethyl alcohol fuel should be automatically shut off not later than the pilot oil fuel. It should not be possible to shut off the pilot oil fuel without first or simultaneously closing the fuel supply to each cylinder or to the complete engine.

9.5 Single fuel engines

In case of a normal stop or an emergency shutdown, the methyl/ethyl alcohol fuel supply should be shut off not later than the ignition source. It should not be possible to shut off the ignition source without first or simultaneously closing the fuel supply to each cylinder or to the complete engine.

10 FIRE SAFETY

10.1 Goal

The goal of this section is to provide fire protection, detection and fighting for all systems related to storing, handling, transfer and use of methyl/ethyl alcohol as fuel.

10.2 Functional recommendations

This section is related to functional recommendations 2.2.1, 2.2.2, 2.2.4, 2.2.5, 2.2.12, 2.2.14 and 2.2.16 of this *Publication*.

10.3 General

The recommendations in this section are additional to provisions given in *SOLAS Convention,* chapter II-2.

10.4 Structural fire protection

10.4.1 For the purposes of fire protection, fuel preparation spaces should be regarded as machinery space of category A. Should the space have boundaries towards other machinery spaces of category A, accommodation, control station or cargo areas, these boundaries should not be less than A-60.

10.4.2 Any boundary of accommodation up to navigation bridge windows, service spaces, control stations, machinery spaces and escape routes, facing fuel tanks on open deck should have A-60 fire integrity.

10.4.3 For fire integrity, the fuel tank boundaries should be separated from the machinery spaces of category A and other rooms with high fire risks by a cofferdam of at least 600 mm, with insulation of not less than A-60 class.

10.4.4 The bunkering station should be separated by A-60 class divisions towards machinery spaces of category A, accommodation, control stations and high fire risk spaces, except for spaces such as tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and similar spaces where the insulation standard may be reduced to class A-0.

10.5 Water fire main

When the fuel storage tank is located on the open deck, isolating valves should be fitted in the fire main in order to isolate damaged sections of the fire main. Isolation of a section of fire main should not deprive the fire line ahead of the isolated section from the supply of water.

10.6 Fire detection and fire fighting

10.6.1 Where fuel tanks are located on open deck, there should be a fixed fire-fighting system of alcohol-resistant foam type, as set out in chapter 17 of the *IBC Code* and, where appropriate, chapter 14 of the *FSS Code*.

10.6.2 The alcohol-resistant foam type fire-fighting system should cover the area below the fuel tank where a spill of fuel could be expected to spread.

10.6.3 The bunker station should have a fixed fire-extinguishing system of alcohol resistant foam type and a portable dry chemical powder extinguisher or an equivalent extinguisher, located near the entrance of the bunkering station.

10.6.4 Where fuel tanks are located on open deck, there should be a fixed water spray system for diluting eventual spills, cooling and fire prevention. The system should cover exposed parts of the fuel tank.

10.6.5 A fixed fire detection and fire alarm system complying with *FSS Code* should be provided for all compartments containing the methyl/ethyl alcohol fuel system.

10.6.6 Suitable detectors should be selected based on the fire characteristics of the fuel. Smoke detectors should be used in combination with detectors which can more effectively detect methyl/ethyl alcohol fires.

10.6.7 Means to ease detection and recognition of methyl/ethyl alcohol fires in machinery spaces should be provided for fire patrols and for fire-fighting purposes, such as portable heat-detection devices.

10.7 Fire extinguishing of engine-room and fuel preparation space

10.7.1 Machinery space and fuel preparation space where methyl/ethyl alcohol-fuelled engines or fuel pumps are arranged should be protected by an approved fixed fire-extinguishing system in accordance with *SOLAS Convention,* regulation II-2/10 and the *FSS Code*. In addition, the fire-extinguishing medium used should be suitable for the extinguishing of methyl/ethyl alcohol fires.

10.7.2 An approved alcohol-resistant foam system covering the tank top and bilge area under the floor plates should be arranged for machinery space category A and fuel preparation space containing methyl/ethyl alcohol.

10.8 Portable fire-fighting equipment and fire-fighter's outfits

10.8.1 A ship fitted with engines using methyl/ethyl alcohol as fuel, should be equipped with at least 4 portable foam applicator units, complying with the *FSS Code*, located in appropriate places for the purpose of extinguishing fuel fires.

10.8.2 The ship should have at least two additional fire-fighter's outfits (in addition to those required by *SOLAS Convention,* regulations II-2/10 and 18), stored in two separate places.

10.8.3 A portable fire extinguisher, suitable for extinguishing an alcohol fire, located in a weatherproof enclosure, should be provided on the open deck, at the fuel bunkering station and at the entrance to the engine room.

11 EXPLOSION PREVENTION AND AREA CLASSIFICATION

11.1 Goal

The goal of this section is to provide recommendations for the prevention of explosions and for the limitation of effects of a fire and explosion.

11.2 Functional recommendations

This section is related to functional recommendations 2.2.1 to 2.2.6, 2.2.8 and 2.2.11 to 2.2.17 of this *Publication*. The probability of explosions should be reduced to a minimum by:

- **.1** reducing the number of sources of ignition;
- **.2** reducing the probability of formation of ignitable mixtures; and
- **.3** using certified safe type electrical equipment suitable for the hazardous zone where the use of electrical equipment in hazardous areas is unavoidable.

11.3 General

11.3.1 Hazardous areas on open deck and other spaces not addressed in this section should be analysed and classified based on a recognized standard.* The electrical equipment fitted within hazardous areas should be according to the same standard.

[4)] Refer to *IEC 60092-502:1999, part 4.4: Tankers carrying flammable liquefied gases*, as applicable.

11.3.2 All hazardous areas should be inaccessible to passengers and unauthorized crew at all times.

11.4 Area classification

11.4.1 Area classification is a method of analysing and classifying the areas where explosive gas atmospheres may occur. The object of the classification is to allow the selection of electrical apparatus able to be operated safely in these areas.

11.4.2 In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2, according to 12.5. In cases where the prescriptive recommendations in 12.5 are deemed to be inappropriate, area classification according to IEC 60079-10-1:2015 should be applied with special consideration by the Administration.

11.4.3 Ventilation ducts should have the same area classification as the ventilated space.

11.5 Hazardous area zones

11.5.1 Hazardous area zone 0

This zone includes, but is not limited to, the interiors of methyl/ethyl fuel tanks, any pipework for pressure-relief or other venting systems for fuel tanks, pipes and equipment containing methyl/ethyl fuel.

11.5.2 Hazardous area zone 1

This zone includes, but is not limited to:

.1 cofferdams and other protective spaces surrounding the fuel tanks;
.2 fuel preparation spaces;
.3 areas on open deck, or semi-enclosed spaces on deck, within 3 m of any methyl/ethyl fuel tank outlet, gas or vapour outlet, bunker manifold valve, other methyl/ethyl fuel valve, methyl/ethyl fuel pipe flange, methyl/ethyl fuel preparation space ventilation outlets;
.4 areas on open deck or semi-enclosed spaces on deck in the vicinity of the fuel tank P/V outlets, within a vertical cylinder of unlimited height and 6 m radius centred upon the centre of the outlet and within a hemisphere of 6 m radius below the outlet;
.5 areas on open deck or semi-enclosed spaces on deck, within 1.5 m of fuel preparation space entrances, fuel preparation space ventilation inlets and other openings into zone 1 spaces;
.6 areas on the open deck within spillage coamings surrounding methyl/ethyl fuel bunker manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck;
.7 enclosed or semi-enclosed spaces in which pipes containing methyl/ethyl fuel are located, e.g. ducts around methyl/ethyl fuel pipes, semi-enclosed bunkering stations; and
.8 a space protected by an airlock is considered as a non-hazardous area during normal operation, but will require equipment to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone 1.

11.5.3 Hazardous area zone 2

This zone includes, but is not limited to:

.1 areas 4 m beyond the cylinder and 4 m beyond the sphere defined in 11.5.2.4;
.2 areas within 1.5 m surrounding other open or semi-enclosed spaces of zone 1 defined in 11.5.2.1; and
.3 airlocks.

12 VENTILATION

12.1 Goal

The goal of this section is to provide for the ventilation necessary for safe working conditions for personnel and the safe operation of machinery and equipment where methyl/ethyl alcohol is used as fuel.

12.2 Functional recommendations

This section is related to functional recommendations 2.2.1, 2.2.2, 2.2.4, 2.2.6 and 2.2.11 to 2.2.17 of this *Publication*.

12.3 General

12.3.1 Ventilation inlets and outlets for spaces required to be fitted with mechanical ventilation should be located such that according to the *International Convention on Load Lines* they will not be required to have closing appliances.

12.3.2 Any ducting used for the ventilation of hazardous spaces should be separate from that used for the ventilation of non-hazardous spaces. The ventilation should function at all temperatures and environmental conditions the ship will be operating in.

12.3.3 Electric motors for ventilation fans should not be located in ventilation ducts for hazardous spaces unless the motors are certified for the same hazard zone as the space served.

12.3.4 Design of ventilation fans serving spaces where vapours from fuels may be present should fulfil the following:

- **.1** ventilation fans should not produce a source of vapour ignition in either the ventilated space or the ventilation system associated with the space; ventilation fans and fan ducts, in way of fans only, should be of non-sparking construction defined as:
  - **.1** impellers or housings of non-metallic material, due regard being paid to the elimination of static electricity;
  - **.2** impellers and housings of non-ferrous metals;
  - **.3** impellers and housings of austenitic stainless steel;
  - **.4** impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller, due regard being paid to static electricity and corrosion between ring and housing; or
  - **.5** any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm tip design clearance;
- **.2** in no case should the radial air gap between the impeller and the casing be less than 0.1 of the diameter of the impeller shaft in way of the bearing but not less than 2 mm; the gap need not be more than 13 mm; and
- **.3** any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and should not be used in these places.

12.3.5 Ventilation systems necessary to avoid any vapour accumulation should consist of independent fans, each of sufficient capacity, unless otherwise specified in this *Publication*. The ventilation system should be of a mechanical exhaust type, with extraction inlets located such as to avoid accumulation of vapour from leaked methyl/ethyl alcohol in the space.

12.3.6 Air inlets for hazardous enclosed spaces should be taken from areas that, in the absence of the considered inlet, would be non-hazardous. Air inlets for non-hazardous enclosed spaces should be taken from non-hazardous areas at least 1.5 m away from the boundaries of any hazardous area. Where the inlet duct passes through a more hazardous space, the duct should be gastight and have over-pressure relative to this space.

12.3.7 Air outlets from non-hazardous spaces should be located outside hazardous areas.

12.3.8 Air outlets from hazardous enclosed spaces should be located in an open area that, in the absence of the considered outlet, would be of the same or lesser hazard than the ventilated space.

12.3.9 The required capacity of the ventilation plant is normally based on the total volume of the room. An increase in required ventilation capacity may be necessary for rooms having a complicated form.

12.3.10 Non-hazardous spaces with entry openings to a hazardous area should be arranged with an airlock and be maintained at overpressure relative to the external hazardous area. The overpressure ventilation should be arranged according to the following:

.1 during initial start-up or after loss of overpressure ventilation, before energizing any electrical installations not certified safe for the space in the absence of pressurization, it should be required to:
  - **.1** proceed with purging (at least five air changes) or confirm by measurements that the space is non-hazardous; and
  - **.2** pressurize the space;

.2 operation of the overpressure ventilation should be monitored and in the event of failure of the overpressure ventilation:
  - **.1** an audible and visual alarm should be given at a manned location; and
  - **.2** if overpressure cannot be immediately restored, automatic or programmed, disconnection of electrical installations according to a recognized standard* should be required.

* Refer to *IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features, table 5.*

12.3.11 Non-hazardous spaces with entry openings to a hazardous enclosed space should be arranged with an airlock and the hazardous space should be maintained at underpressure relative to the non-hazardous space. Operation of the extraction ventilation in the hazardous space should be monitored and in the event of failure of the extraction ventilation:

.1 an audible and visual alarm should be given at a manned location; and

.2 if underpressure cannot be immediately restored, automatic or programmed, disconnection of electrical installations according to recognized standards in the non-hazardous space should be required.

12.3.12 Double bottoms, cofferdams, duct keels, pipe tunnels, hold spaces and other spaces where methyl/ethyl fuel may accumulate should be capable of being ventilated to ensure a safe environment when entry into the spaces is necessary.

12.4 Ventilation of fuel preparation spaces

12.4.1 Fuel preparation spaces should be provided with an effective mechanical forced ventilation system of extraction type. During normal operation the ventilation should be at least 30 air changes per hour.

12.4.2 The number and power of the ventilation fans should be such that the capacity is not reduced by more than 50% if a fan with a separate circuit from the main switchboard or emergency switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard is inoperable.

12.4.3 Ventilation systems for fuel preparation spaces and other fuel handling spaces should be in operation when pumps or other fuel treatment equipment are working.

12.5 Ventilation of bunkering station

Bunkering stations that are not located on open deck should be suitably ventilated to ensure that any vapour being released during bunkering operations will be removed outside. If the natural ventilation is not sufficient, the bunkering stations should be subject to special consideration with respect to recommendations for mechanical ventilation. The Administration may require special risk assessment.

12.6 Ventilation of ducts and double wall pipes

12.6.1 Ducts and double wall pipes containing fuel piping fitted with a mechanical ventilation system of the extraction type should be provided with a ventilation capacity of at least 30 air changes per hour.

12.6.2 The ventilation system for double wall piping and ducts should be independent of all other ventilation systems.

12.6.3 The ventilation inlet for the double wall piping or duct should always be located in a non-hazardous area, in open air, away from ignition sources. The inlet opening should be fitted with a suitable wire mesh guard and protected from ingress of water.

13 ELECTRICAL INSTALLATIONS

13.1 Goal

The goal of this section is to provide for electrical installations that minimize the risk of ignition in the presence of a flammable atmosphere.

13.2 Functional recommendations

This section is related to functional recommendations 2.2.1 to 2.2.3, 2.2.5, 2.2.8, 2.2.11, 2.2.13, 2.2.15 to 2.2.17 of this *Publication*.

13.3 General

13.3.1 Electrical installations should comply with a recognized standard* at least equivalent to those acceptable to the IMO.

* Refer to *IEC 60092:2018* series standards, as applicable.

13.3.2 Electrical equipment or wiring should not be installed in hazardous areas unless essential for operational purposes or safety enhancement.

13.3.3 Where electrical equipment is installed in hazardous areas as provided in 13.3.2, it should be selected, installed and maintained in accordance with IEC standards or other standards at least equivalent to those acceptable to the IMO.

13.3.4 The lighting system in hazardous areas should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and should be located in a non-hazardous area.

13.3.5 The onboard installation of the electrical equipment units should be such as to ensure the safe bonding to the hull of the units themselves.

14 CONTROL, MONITORING AND SAFETY SYSTEMS

14.1 Goal

The goal of this section is to provide for the arrangement of control, monitoring and safety systems that support an efficient and safe operation of the fuel installations as covered in the other sections of this *Publication*.

14.2 Functional recommendations

This section is related to functional recommendations in 2.2.1 to 2.2.3, 2.2.9 to 2.2.11, 2.2.13, 2.2.14 and 2.2.17 of this *Publication*. In particular, the following applies:

.1 the control, monitoring and safety systems of the methyl/ethyl alcohol installations should be arranged such that there is not an unacceptable loss of power in the event of a single failure;

.2 a fuel safety system should be arranged to close down the fuel supply system automatically, upon failure in systems as described in Table 14.1 and upon other fault conditions which may develop too fast for manual intervention;

.3 the safety functions should be arranged in a dedicated fuel safety system that is independent of the fuel control system in order to avoid possible common cause failures; this includes power supplies and input and output signal;

.4 the safety systems including the field instrumentation should be arranged to avoid spurious shutdown, e.g. as a result of a faulty vapour detector or a wire break in a sensor loop; and

.5 where two fuel supply systems are required to meet the recommendations, each system should be fitted with its own set of independent fuel control and safety systems.

14.3 General

14.3.1 Suitable instrumentation devices should be fitted to allow a local and a remote reading of essential parameters to ensure safe management of the whole fuel equipment including bunkering.

14.3.2 Liquid leakage detection should be installed in the protective cofferdams surrounding the fuel tanks, in all ducts around fuel pipes, in fuel preparation spaces, and in other enclosed spaces containing single walled fuel piping or other fuel equipment.

14.3.3 The annular space in a double walled piping system should be monitored for leakages and the monitoring system should be connected to an alarm system. Any leakage detected should lead to shutdown of the affected fuel supply line in accordance with Table 14.1.

14.3.4 At least one bilge well with a level indicator should be provided for each enclosed space, where an independent storage tank without a protective cofferdam is located. A high-level bilge alarm should be provided. The leakage detection system should trigger an alarm and the safety functions in accordance with Table 14.1.

14.3.5 For tanks not permanently installed in the vessel, a monitoring system equivalent to that provided for permanent installed tanks should be provided.

14.4 Bunkering and fuel tank monitoring

14.4.1 Fuel tanks level indicators

Each fuel tank should be fitted with closed level gauging devices, arranged to ensure a level reading is always obtainable and unless any necessary maintenance can be carried out while the fuel tank is in service, two devices should be installed.

14.4.2 Overflow control

14.4.2.1 Each fuel tank should be fitted with a visual and audible high-level alarm. This should be able to be function tested from the outside of the tank and can be common with the level gauging system (configured as an alarm on the gauging transmitter), but should be independent of the high-high-level alarm.

14.4.2.2 An additional sensor (high-high-level) operating independently of the high liquid level alarm should automatically actuate a shut-off valve to avoid excessive liquid pressure in the bunkering line and prevent the tank from becoming liquid full.

14.4.2.3 The high and high-high-level alarm for the fuel tanks should be visual and audible at the location at which gas freeing by water filling of the fuel tanks is controlled, given that water filling is the preferred method for gas freeing.

14.5 Bunkering control

14.5.1 Bunkering control should be from a safe remote location. At this safe remote location:

- **.1** tank level should be capable of being monitored;
- **.2** the remote-control valves required by 8.5.4 should be capable of being operated from this location; closing of the bunkering shutdown valve should be possible from the control location for bunkering and from another safe location; and
- **.3** overfill alarms and automatic shutdown should also be indicated at this location.

14.5.2 If the ventilation in the ducting enclosure or annular spaces of the double walled bunkering lines stops, an audible and visual alarm should be activated at the bunkering control location.

14.5.3 If fuel leakage is detected in ducting enclosure or the annular spaces of the double walled bunkering lines, an audible and visual alarm and emergency shutdown of the bunkering valve should automatically be activated.

14.6 Monitoring of engine operation

In addition to the instrumentation provided in accordance with *SOLAS Convention,* chapter II-1, part C, indicators should be fitted on the navigation bridge, the engine control room and the manoeuvring platform for:

- **.1** operation of methyl/ethyl alcohol fuel engines; and
- **.2** operation and mode of operation of the engine in the case of dual fuel engines.

14.7 Hazardous gas detection

14.7.1 Permanently installed gas detectors should be fitted in:

- **.1** all ventilated annular spaces of the double walled fuel pipes;
- **.2** machinery spaces containing fuel equipment or consumers;
- **.3** fuel preparation spaces;
- **.4** other enclosed spaces containing fuel piping or other fuel equipment without ducting;
- **.5** other enclosed or semi-enclosed spaces where fuel vapours may accumulate;
- **.6** cofferdams and fuel storage hold spaces surrounding fuel tanks;
- **.7** airlocks; and
- **.8** ventilation inlets to accommodation and machinery spaces, if required, based on the risk assessment required in 3.2.

14.7.2 The number and placement of detectors in each space should be considered taking into account the size, layout and ventilation of the space. Gas dispersal analysis or a physical smoke test should be used to find the best arrangement.

14.7.3 Fuel vapour detection equipment should be designed, installed and tested in accordance with a recognized standard.*

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* Refer to *IEC 60079-29-1:2016 – Explosive atmospheres – Gas detectors – Performance requirements of detectors for flammable gases.*

14.7.4 An audible and visible alarm should be activated at a fuel vapour concentration of 20% of the lower explosion limit (LEL). The safety system should be activated at 40% of LEL at two detectors. Special consideration should be given to toxicity in the design process of the detection system.

14.7.5 For ventilated ducts and annular spaces around fuel pipes in the machinery spaces containing methyl/ethyl alcohol-fuelled engines, the alarm limit should be set to 20% of LEL. The safety system should be activated at 40% of LEL at two detectors.

14.7.6 Audible and visible alarms from the fuel vapour detection equipment should be located on the navigation bridge, in the continuously manned central control station, safety centre and at the control location for bunkering as well as locally.

14.7.7 Fuel vapour detection required by this section should be continuous without delay.

14.8 Fire detection

Fire detection in machinery space containing methyl/ethyl alcohol engines and fuel storage hold spaces should give audible and visual alarms on the navigation bridge and in a continuously manned central control station or safety centre as well as locally.

14.9 Loss of ventilation

Any loss of the required ventilating capacity should give an audible and visual alarm on the navigation bridge, and in a continuously manned central control station or safety centre as well as locally.

14.10 Safety functions of fuel supply systems

14.10.1 If the fuel supply is shut off due to activation of an automatic valve, the fuel supply should not be opened until the reason for the disconnection is ascertained and the necessary precautions taken. A readily visible notice giving instruction to this effect should be placed at the operating station for the shut-off valves in the fuel supply lines.

14.10.2 If a fuel leak leading to a fuel supply shutdown occurs, the fuel supply should not be operated until the leak has been found and dealt with. Instructions to this effect should be placed in a prominent position in the machinery space.

14.10.3 A caution placard or signboard should be permanently fitted in the machinery space containing methyl/ethyl-fuelled engines stating that heavy lifting, implying danger of damage to the fuel pipes, should not be done when the engine(s) is running on methyl/ethyl.

14.10.4 Pumps and fuel supply should be arranged for manual remote emergency stop from the following locations as applicable:

- **.1** navigation bridge;
- **.2** cargo control room;
- **.3** onboard safety centre;
- **.4** engine control room;
- **.5** fire control station; and
- **.6** adjacent to the exit of fuel preparation spaces.

Table 14.1
Monitoring of methyl/ethyl alcohol supply system to engines

Parametr	Alarm	Automatic shutdown of tank valve (valve(s) referred to in 8.6.2)	Automatic shutdown of master fuel valve (valve(s) referred to in 8.6.3)	Automatic shutdown of bunkering valve	Comments
High-level fuel tank	X			X	See 14.4.2.1
High-high-level fuel tank	X			X	See 14.4.2.2 and 14.5.1
Loss of ventilation in the annular space in the bunkering line	X			X	See 14.5.2
Gas detection in the annular space in the bunkering line	X			X	See 14.5.3
Loss of ventilation in ventilated areas	X				See 14.9
Manual shutdown	X			X	See 14.5.1
Liquid methyl/ethyl alcohol detection in the annular space of the double walled bunkering line	X			X	See 14.5.3
Vapour detection in ducts around fuel pipes	X				See 14.7.1.1
Vapour detection in cofferdams surrounding fuel tanks. One detector giving 20% of LEL	X				See 14.7.5
Vapour detection in airlocks	X				See 14.7.1.7
Vapour detection in cofferdams surrounding fuel tanks. Two detectors giving 40% of LEL	X	X		X	See 14.7.1.6
Vapour detection in ducts around double walled pipes, 20% of LEL	X				See 14.7.7
Vapour detection in ducts around double walled pipes, 40% of LEL	X	X	X		See 14.7.7. Two gas detectors to give min. 40% of LEL before shutdown
Liquid leak detection in annular space of double walled pipes	X	X	X		See 14.3.3
Liquid leak detection in engine-room	X	X			See 14.3.2
Liquid leak detection in fuel preparation space	X	X			See 14.3.2
Liquid leakage detection in protective cofferdams surrounding fuel tanks	X				See 14.3.2

15 TESTS ON BOARD

15.1 Fuel piping systems

15.1.1 All pressure pipes of fuel systems should be subject to a tightness test with a test pressure of 1.25 times the working pressure.

15.1.2 Operation of pressure relief valves in fuel lines should be tested within the prescribed pressure settings.

15.2 Tests of complete systems related to the fuel installation

15.2.1 After installation on board the ship, all systems related to fuel installation, as well as control, monitoring and safety systems should be subject to functional tests in accordance with the final acceptance and testing program.

15.2.2 All safety functions of methyl/ethyl alcohol supply system to engines, specified in Table 14.1 in sub-chapter 14.10, should be tested to confirm their correct operation.