



GUIDELINES FOR SHIPS USING LPG AS FUEL

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Chapter 1 Preamble

1.1 Purpose of the Guidelines

The Guidelines provide requirements for the arrangement, installation, control and monitoring of machinery, equipment and systems using liquefied petroleum gas (LPG) as fuel to minimize the risk to the ship, its crew and the environment. Currently, ships using low flash point fuel must be designed, constructed and operated in accordance with the IGF Code, but there are no specific requirements for the use of LPG as fuel. Therefore, the International Maritime Organization (IMO) has developed interim guidelines for ships using LPG as fuel in the form of MSC.1/Circular 1666, interim guidelines for ships using LPG cargo as fuel in the form of MSC.1/Circular 1679 and recommends that flag States that are members of the IMO should follow these guidelines.

1.2 Structure of the Guidelines

1.2.1 Chapter 2 to 16 of these guidelines apply to ships to which the IGF Code applies.

1.2.2 Chapter 17 of these guidelines applies to ships to which the IGC Code applies.

1.2.3 Application

In the case of a liquefied gas carrier to which the IGC Code applies and equipped with facilities for LPG fuel (fuel storage facilities, fuel supply facilities, fuel consumption equipment) that are completely separated from the cargo system, 1.2.1 above despite 1.2.2 above may apply to ships provided that the Society considers the IGF Code may be applied separately to the facilities for LPG fuel.

Chapter 2 General

2.1 Application

2.1.1 Chapter 2 to 16 of these Guidelines apply to ships using LPG as fuel, except for liquefied gas carriers.

2.1.2 The requirements in these Guidelines are specified on the premise of application to the ships to which SOLAS Convention applies. However, if it is difficult to comply with the requirements of these Guidelines due to the size of the ships, etc., special considerations may be given to the conditions provided that these meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety of the relevant chapters.

2.2 Definitions

Unless otherwise stated below, definitions are as defined in SOLAS chapter II-2 and 2.2 of the Guidelines for Ships Using Gases or Other Low-Flashpoint Fuels (hereinafter referred to as "the LFFS Guidelines").

2.2.1 LPG means liquefied petroleum gas. It is mainly composed of a mixture of propane (C_3H_8) and butane (C_4H_{10}) and may contain small amounts of other hydrocarbons and impurities. In these Guidelines, petroleum gas either in its liquefied or gaseous state is referred to as LPG. When it is necessary to distinguish between the liquefied state and the gas state, LPG in the liquefied state is referred to as LPG liquid, and LPG in the gaseous state is referred to as LPG gas.

2.2.2 Fuel in these Guidelines means LPG.

2.2.3 Auto-ignition temperature means the lowest temperature at which the fuel spontaneously ignites in normal atmosphere without an external source of ignition, such as a flame or spark.

2.2.4 Gas dispersion analysis means the analysis of the dispersion behaviour of gases using appropriate modelling techniques such as computational fluid dynamics (CFD) analysis.

2.2.5 Ventilation analysis means the analysis of the ventilation efficiency of a space using appropriate modelling techniques such as CFD analysis.

2.2.6 Effectiveness of ventilation refers to the effect of ventilation to control the diffusion and persistence of an explosive gas atmosphere due to gas leakage, depending on the degree and efficiency of ventilation (refer to IEC 60079-10-1).

2.2.7 Degree of dilution means a measure of the ability of ventilation or atmospheric conditions to dilute a release to a safe level. The degree of dilution is defined as high, medium and low (refer to IEC 60079-10-1, 6.5.4).

2.3 Alternative Design

2.3.1 These Guidelines contain functional requirements for all appliances and arrangements related to the usage of LPG fuels.

2.3.2 Appliances and arrangements of LPG fuel systems may deviate from those set out in these Guidelines, provided such appliances and arrangements meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety to the relevant chapters.

2.3.3 The equivalence of the alternative design is to be demonstrated as specified in SOLAS regulation II-1/55 and approved by the Society. However, the Society should not allow operational methods or procedures to be applied as an alternative to a particular fitting, material, appliance, apparatus, item of equipment or type thereof which is prescribed by these Guidelines.

Chapter 3 Goal and Functional Requirements

3.1 Goal

The goal of these Guidelines 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 LPG as fuel.

3.2 Functional Requirements

3.2.1 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.

3.2.2 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.

3.2.3 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.

3.2.4 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.

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

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

3.2.7 System components should be protected against external damage.

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

3.2.9 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. Other than when necessary for safety reasons, the system should be designed to prevent venting under all normal operating conditions including idle periods.

3.2.10 Piping systems, containment and over-pressure relief arrangements that are of suitable design, material, construction and installation for their intended application should be provided.

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

3.2.12 Fuel containment system and machinery spaces containing source that might release gas into the space should be arranged and located such that a fire or explosion in either will not lead to an unacceptable loss of power or render equipment in other compartments inoperable.

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

3.2.14 Fixed gas detection including liquid leakage detection system suitable for all spaces and areas concerned should be arranged.

3.2.15 Fire detection, protection and extinguishing measures appropriate to the hazards concerned should be provided.

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

3.2.17 The technical documentation should permit an assessment of the compliance of the system and its components with the applicable rules, guidelines, design standards used and the principles related to safety, availability, maintainability and reliability.

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

Chapter 4 General Requirements

4.1 Goal

The goal of this chapter 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.

4.2 Risk Assessment

4.2.1 Unless expressly provided otherwise, the requirements of 4.2 of the LFFS Guidelines apply.

4.2.2 In addition to the requirements listed in 4.2.2 of the LFFS Guidelines, risk assessment is to also address paragraphs 5.3.6, 6.3.3, 10.3.2, 13.3.4 and 15.2.2 of these Guidelines.

4.3 Limitation of Explosion Consequences

4.3.1 An explosion in any space containing any potential sources of release¹ and potential ignition sources should not:

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

Note 1: Double wall fuel pipes are not considered as potential sources of release.

Chapter 5 Ship Design and Arrangement

5.1 Goal

5.1.1 General

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

5.2 Functional Requirements

5.2.1 General

This chapter is related to functional requirements 3.2.1 to 3.2.3, 3.2.5, 3.2.6, 3.2.8, 3.2.12 to 3.2.15 and 3.2.17. In addition, additional functional requirements stated in 5.2.2 apply to ships.

5.2.2 Additional Functional Requirements

- (a) The fuel tank(s) is to 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.
- (b) Fuel containment systems, fuel piping and other fuel sources of release are to be so located and arranged that released gas is led to a safe location in the open air. Locations of the release should be determined taking into consideration the surrounding arrangement so as to minimize the possibility of accumulation of the gas released on the open space and to facilitate dispersion into the atmosphere.
- (c) The access or other openings to spaces containing fuel sources of release are to be so arranged that flammable, asphyxiating or toxic gas cannot escape to spaces that are not designed for the presence of such gases taking into account the specific gravity and dispersion characteristics of LPG gas.
- (d) Fuel piping should be protected against mechanical damage.
- (e) The propulsion and fuel supply system are to be so designed that safety actions after any LPG leakage do not lead to an unacceptable loss of power.
- (f) The probability of a gas explosion in a machinery space with gas or low-flashpoint fuelled machinery should be minimized.

5.3 General Provisions

5.3.1 Application

Unless expressly provided otherwise, the requirements of chapter 5 of the LFFS Guidelines apply.

5.3.2 Arrangement of Machinery Spaces

In addition to 5.4 of the LFFS Guidelines, a single failure of fuel systems is not to be led to a gas release in the machinery space, i.e. only gas-safe machinery space concept in accordance with the LFFS Guidelines is to be accepted.

5.3.3 Emergency shutdown (ESD) protected Machinery Spaces

The requirements of 5.6 of the LFFS Guidelines do not apply to ships using LPG as fuel. ESD-protected machinery spaces may be permitted, provided that the requirements of alternative design (SOLAS II-1/55) are met to the satisfaction of the Society.

5.3.4 Location and Protection of Fuel Piping

In addition to the requirements in 5.7 of the LFFS Guidelines, double barrier around fuel piping systems is to be continuous and not have openings in machinery spaces. (Refer to 5.5 of the LFFS Guidelines)

5.3.5 Bilge System

In addition to the requirements in 5.9 of the LFFS Guidelines, the bilge systems in the hazardous area are to be arranged separately for each space and discharged overboard or to an enclosed tank fitted with a gas detector. Where bilge piping of two or more hazardous areas is connected, means is to be provided to prevent the gas in one area from entering into other areas through the connected bilge pipes.

5.3.6 Drip Tray

In addition to the requirements in 5.10.1 of the LFFS Guidelines, drip trays identified by the risk assessment in accordance with 4.2 are to be equipped with means to detect leakage and shut off the fuel if required. However, 5.10.3 of the LFFS Guidelines does not apply to ships using LPG as fuel.

5.3.7 Tank Vents and Pressure Relief Valves

In addition to the requirements of chapter 5 of the LFFS Guidelines, the following provisions on pipe vents and pressure relief devices apply:

- (a) LPG gas line from the following is to be led to a vent mast:
 - (i) the pressure relief valve of the tank; and
 - (ii) vent lines and bleed lines for gas fuel systems; and
- (b) LPG liquid line from the following is to be led to a fuel tank. Where it is not practicable, the line may be led to a vent mast but liquid release from the outlet of vent is not acceptable:
 - (i) the pressure relief valve of the liquid fuel supply pipe;
 - (ii) vent line and bleed line of liquid fuel supply piping; and
 - (iii) pressure relief valve in bunkering line.

Chapter 6 Fuel Containment System

6.1 Goal

6.1.1 General

The goal of this chapter is to provide that LPG storage is adequate so as to minimize the risk to personnel, the ship and the environment to a level that is equivalent to a conventional oil-fuelled ship.

6.2 Functional Requirements

6.2.1 General

This chapter is related to functional requirements 3.2.1, 3.2.2, 3.2.5 and 3.2.8 to 3.2.17. In addition, additional functional requirements stated in 6.2.2 apply to ships.

6.2.2 Additional Functional Requirements

- (a) The fuel containment system is to be so designed that a leak from the tank or its connections does not endanger the ship, persons on board or the environment. Potential dangers to be avoided include:
 - (i) exposure of ship materials to temperatures below acceptable limits;
 - (ii) flammable fuels spreading to locations with ignition sources;
 - (iii) toxicity potential and risk of oxygen deficiency due to fuels and inert gases;
 - (iv) restriction of access to muster stations, escape routes and life-saving appliances (LSA); and
 - (v) reduction in availability of LSA.
- (b) The pressure and temperature in the fuel tank are to be kept within the design limits of the containment system and possible carriage requirements of the fuel.
- (c) The fuel containment arrangement is to be so designed that safety actions after any LPG leakage do not lead to an unacceptable loss of power.
- (d) If portable tanks are used for fuel storage, the design of the fuel containment system is to be equivalent to permanent installed tanks as described in this chapter.
- (e) The fuel containment system is to be designed considering various characteristics of all possible compositions of the LPG.

6.3 General Requirements

6.3.1 Application

Unless expressly provided otherwise, the requirements of chapter 6 of the LFFS Guidelines apply.

6.3.2 Limitation of maximum allowable relief valve setting (MARVS)

The requirement of 6.3.1 of the LFFS Guidelines does not apply to ships using LPG as fuel.

6.3.3 Tank Connection Spaces

In addition to 6.3.4 of the LFFS Guidelines, the following applies: For the fuel tank located in enclosed space, a tank connection space is to be provided separately from fuel storage hold space. For the fuel tank located on an open deck, a tank connection space is also to be provided where escaped gas may accumulate on the open deck or enter non-hazardous space such as accommodation space and machinery space based on the risk assessment.

6.3.4 Secondary Barrier

In addition to 6.4.2.1 of the LFFS Guidelines, no secondary barrier is to be required where the fuel temperature at atmospheric pressure is at or above -10°C. Where the fuel temperature at atmospheric pressure is not below -55°C, the hull structure may act as a secondary barrier.

6.3.5 CNG(Compressed Natural Gas) Containment System

The requirements of 6.6 of the LFFS Guidelines does not apply to ships using LPG as fuel.

6.3.6 Tank Vent Outlets

In addition to 6.7.2.7 of the LFFS Guidelines, vent exits are to be located to ensure the following:

- (a) escaped LPG gas does not escape to non-hazardous areas through the opening around the vent exit;
- (b) escaped LPG gas is not trapped by any structure on an open deck; and
- (c) escaped LPG gas does not form a flammable atmosphere in the way of exhaust gas outlets and other ignition sources.

Note: The study for 6.3.6(a) to (c) above should be verified by gas dispersion analysis, if required by the risk assessment.

6.3.7 Vent Piping System

In addition to 6.7.2 of the LFFS Guidelines, the vent piping system should be fitted with an inert gas purging interface.

Chapter 7 Material and General Pipe Design

7.1 General

7.1.1 Application

The requirements of chapter 7 of the LFFS Guidelines apply.

Chapter 8 Bunkering

8.1 Goal

8.1.1 General

The goal of this chapter 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.

8.2 Functional Requirements

8.2.1 General

This chapter is related to functional requirements 3.2.1 to 3.2.11 and 3.2.13 to 3.2.17. In addition, additional functional requirements stated in 8.2.2 apply to ships.

8.2.2 Additional Functional Requirements

- (a) The piping system for transfer of fuel to the storage tank is to be designed such that any leakage from the piping system cannot cause danger to personnel, the environment or the ship.
- (b) Bunkering systems are to be suitable for temperature, pressure and all compositions of LPG used on board.
- (c) Means is to be provided to manage vapour generated in the tank during bunker transfer. Where means of vapour managements are not provided on ship, vapour return connection should be fitted at bunkering manifold.

8.3 General Requirements

8.3.1 Application

- (a) Unless expressly provided otherwise, the requirements of chapter 8 of the LFFS Guidelines apply.
- (b) For ships using LPG as fuel, 8.3.1.6 of the LFFS Guidelines is not applicable.

Chapter 9 Fuel Supply to Consumers

9.1 Goal

9.1.1 General

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

9.2 Functional Requirements

9.2.1 General

This chapter is related to functional requirements 3.2.1 to 3.2.6, 3.2.8 to 3.2.11 and 3.2.13 to 3.2.17. In addition, additional functional requirements stated in 8.2.2 apply to ships.

9.2.2 Additional Functional Requirements

- (a) The fuel supply system is to be so arranged that the consequences of any release of fuel will be minimized, while providing safe access for operation and inspection.
- (b) The piping system for fuel transfer to the consumers is to 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.
- (c) Fuel lines outside the machinery spaces are to be installed and protected so as to minimize the risk of injury to personnel and damage to the ship in case of leakage.
- (d) Fuel supply systems are to be able to supply fuel at the required pressure, temperature and flow rate.
- (e) Where fuel supply systems supply LPG in the liquid state, purging, drain, vent and leakage is to be subject to special consideration to provide an equivalent level of safety of fuel in the gas state.

9.3 General Requirements

9.3.1 Application

Unless expressly provided otherwise, the requirements of chapter 9 of the LFFS Guidelines apply.

9.3.2 Arrangements of Double Block and Bleed Valves

Notwithstanding 9.4.4 of the LFFS Guidelines, where fuel supply systems supply LPG in the liquid state, relevant bleed lines are to be led to the fuel tank or gas-liquid separator or similar device to prevent LPG liquid from being released to the atmosphere.

9.3.3 Ventilation of Gas Supply Branch Downstream of the Double Block and Bleed Valves

In addition to 9.4.7 of the LFFS Guidelines, where fuel supply systems supply LPG in the liquid state, vent lines are to be led to the fuel tank or gas-liquid separator or similar device.

9.3.4 Protection Against Rupture

The requirements of 9.4.10 of the LFFS Guidelines does not apply to ships using LPG as fuel.

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9.3.5 Gas Fuel Supply to Consumers in ESD-protected Machinery Spaces

The requirements of 9.7 of the LFFS Guidelines does not apply to ships using LPG as fuel.

9.3.6 Verification of the Strength

In addition to 9.8.2 of the LFFS Guidelines, the most conservative value of k should be selected for considering expected composition of fuel (propane: 1.13, butane: 1.096)

Chapter 10 Power Generation Including Propulsion and Other Gas Consumers

10.1 Goal

10.1.1 General

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

10.2 Functional Requirements

10.2.1 General

This chapter is related to functional requirements 3.2.1, 3.2.11, 3.2.13, 3.2.16 and 3.2.17. In addition, additional functional requirements stated in 10.2.2 apply to ships.

10.2.2 Additional Functional requirements

- (a) The exhaust systems are to be configured to prevent any accumulation of unburnt gaseous fuel.
- (b) Unless designed with the strength to withstand the worst case over pressure due to ignited gas leaks, engine components or systems containing or likely to contain an ignitable gas and air mixture are to be fitted with suitable pressure relief systems. Dependent on the particular engine design, this may include the air inlet manifolds and scavenge spaces.
- (c) The explosion venting is to be led away from where personnel may normally be present.
- (d) All gas consumers are to have a separate exhaust system.
- (e) Fuel consumers are to be suitably designed for operation with possible compositions of LPG fuel.

10.3 General Requirements

10.3.1 Application

Unless expressly provided otherwise, the requirements of chapter 10 of the LFFS Guidelines apply.

10.3.2 Gas Turbines

Notwithstanding 10.5.2 of the LFFS Guidelines, the gas turbine is to be fitted in a gastight enclosure arranged in accordance with 10.5.3 of the LFFS Guidelines. Gas leakage in the gastight enclosure and the consequence are to be evaluated based on the risk assessment in accordance with 4.2 and to the satisfaction of the Society.

10.3.3 Internal Combustion Engines of Piston Type

Notwithstanding 10.3.1.7 of the LFFS Guidelines, if combustion has not been detected by the engine monitoring system within an engine-specific time after the opening of the fuel supply valve, the fuel supply valve is to be automatically shut off. Means to ensure that any unburnt fuel mixture is purged away from the exhaust system is to be provided.

Chapter 11 Fire Safety

11.1 Goal

11.1.1 General

The goal of this chapter is to provide for fire protection, detection, and fighting for all system components related to the storage, conditioning, transfer and use of LPG as ship fuel.

11.2 Functional requirements

11.2.1 General

This chapter is related to functional requirements 3.2.2, 3.2.4, 3.2.5, 3.2.7, 3.2.12, 3.2.14, 3.2.15 and 3.2.17.

11.3 General Requirements

11.3.1 Application

Unless expressly provided otherwise, the requirements of chapter 11 of the LFFS Guidelines apply.

11.3.2 Fire Protection

In addition to 11.3.1 of the LFFS Guidelines, the fuel preparation room is to be separated from a machinery space of category A and rooms with high fire risks. The separation is to be done by a cofferdam of at least 900 mm with insulation of A-60 class.

11.3.3 Fire-extinguishing System for Fuel Preparation Room

In addition to the requirements of chapter 11 of the LFFS Guidelines, a fuel preparation room is to be provided with a fixed fire-extinguishing system complying with any of the requirements of International Code for Fire Safety Systems (FSS code) and taking into account the necessary concentrations/application rate required for extinguishing LPG gas fires.

Chapter 12 Explosion Prevention

12.1 Goal

12.1.1 General

The goal of this chapter is to provide the prevention of explosions and for the limitation of effects from explosion.

12.2 Functional Requirements

12.2.1 General

This chapter is related to functional requirements 3.2.2 to 3.2.5, 3.2.7, 3.2.8, 3.2.12 to 3.2.14 and 3.2.17. In addition, additional functional requirements stated in 12.2.2 apply to ships.

12.2.2 Additional Functional Requirements

The probability of explosions is to be reduced to a minimum by the following:

- (a) reducing number of sources of ignition; and
- (b) reducing the probability of formation of ignitable mixtures.

12.3 General Requirements

12.3.1 Application

Unless expressly provided otherwise, the requirements of chapter 12 of the LFFS Guidelines apply.

12.3.2 Classification of Hazardous Areas

The classification of a hazardous area is to be subject to special consideration to characteristics of LPG (e.g. density, lower explosive limit). IEC 60079-10-1 may be referred, if necessary, to determine hazardous areas.

Chapter 13 Ventilation

13.1 Goal

13.1.1 General

The goal of this chapter is to provide for the ventilation required for safe operation of LPG-fuelled machinery and equipment.

13.2 Functional Requirements

13.2.1 General

This chapter is related to functional requirements 3.2.2, 3.2.5, 3.2.8, 3.2.10, 3.2.12 to 3.2.14 and 3.2.17. In particular, the capacity and layout of ventilation system are to be so designed that efficiency of ventilation is ensured considering the density of LPG gas.

13.3 General Requirements

13.3.1 Application

Unless expressly provided otherwise, the requirements of chapter 13 of the LFFS Guidelines apply.

13.3.2 Air Inlets for Hazardous Enclosed Spaces

In addition to 13.3.5 of the LFFS Guidelines, air outlets and air inlets for hazardous enclosed spaces are to be arranged to prevent exhausted gas from re-entering the space through air inlets, based on the risk assessment in accordance with 4.2 and to the satisfaction of the Society.

13.3.3 Required Capacity of the Ventilation Plant

In addition to 13.3.8 of the LFFS Guidelines, when determining the required ventilation capacity, special consideration should be given to the density and lower explosion limit (LEL) of LPG gas, which should be supported by numerical calculations such as CFD analysis.

13.3.4 Ventilation Trunks

- (a) In addition to 13.4.2 of the LFFS Guidelines, approved automatic fail-safe fire dampers are to be fitted in the ventilation trunk for the tank connection space, fuel preparation room or any other space as deemed necessary by a risk assessment in accordance with 4.2 and to the satisfaction of the Society.
- (b) The number and location of the extraction points of the ventilation in each space is to be considered taking into account the size and layout of the space. Where bottom arrangements are complicated, it is to be demonstrated based on ventilation analysis that capacity and duct arrangements of ventilation are adequate for the space.

13.3.5 Machinery Spaces

The requirements in 13.5.2, 13.5.3 and 13.5.4 of the LFFS Guidelines do not apply to ships using LPG as fuel.

13.3.6 Ventilation Inlets

Notwithstanding 13.8.3 of the LFFS Guidelines, the ventilation inlet for the double wall piping or duct is to always be located in an open area away from ignition sources. The inlet opening is to be fitted with a suitable wire mesh guard and protected from ingress of water.

Chapter 14 Electrical Installations

14.1 Goal

14.1.1 General

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

14.2 Functional Requirements

14.2.1 General

This chapter is related to functional requirements 3.2.1, 3.2.2, 3.2.4, 3.2.7, 3.2.8, 3.2.11, 3.2.13 to 3.2.16 and 3.2.18. In addition, additional functional requirements stated in 14.2.2 apply to ships.

14.2.2 Additional Functional Requirements

Electrical generation and distribution systems, and associated control systems, are to be designed such that a single fault will not result in the loss of ability to maintain fuel tank pressures and hull structure temperature within normal operating limits.

14.3 General Requirements

14.3.1 Application

Unless expressly provided otherwise, the requirements of chapter 14 of the LFFS Guidelines apply.

14.3.2 Installation Requirements of Electrical Equipment in Hazardous Areas

In addition to 14.3.3 of the LFFS Guidelines, equipment for hazardous areas is to be of a certified safe type appropriate for compositions of LPG in accordance with IEC 60079-20. IEC 60079-20 classifies the temperature class and equipment groups for propane and butane as the following:

Table 14-1 Temperature Class and Equipment Groups

	Temperature class	Equipment group
Propane	T2	IIA
Butane	T2	IIA
Equipment is to be certified to IEC temperature class T2 and equipment group IIA.		

Chapter 15 Control, Monitoring and Safety Systems

15.1 Goal

15.1.1 General

The goal of this chapter is to provide for the arrangement of control, monitoring and safety systems that support an efficient and safe operation of the LPG-fuelled installation as covered in the other chapters of this Part.

15.2 Functional Requirements

15.2.1 General

This chapter is related to functional requirements 3.2.1, 3.2.2, 3.2.11, 3.2.13 to 3.2.15, 3.2.17 and 3.2.18. In addition, additional functional requirements stated in 15.2.2 apply to ships.

15.2.2 Additional Functional Requirements

- (a) The control, monitoring and safety systems of the LPG-fuelled installation are to be so arranged that the remaining power for propulsion and power generation is in accordance with 9.3.1 of the LFFS Guidelines in the event of single failure;
- (b) A safety system is to be arranged to close down the fuel supply system automatically, upon failure in systems as described in Table 15-1 of the LFFS Guidelines and upon other fault conditions which may develop too fast for manual intervention;
- (c) For ESD protected machinery configurations, where allowed by alternative design, the safety system is to shut down LPG supply upon LPG leakage and, in addition, disconnect all non-certified safe type electrical equipment in the machinery space;
- (d) The safety functions should be arranged in a dedicated gas safety system that is independent of the control system in order to avoid possible common cause failures. This includes power supply and input and output signal;
- (e) The safety systems including the field instrumentation are to be arranged to avoid spurious shutdown, e.g. as a result of a faulty gas detector or a wire break in a sensor loop;
- (f) Where two or more fuel supply systems are required to meet the requirements, each system is to be fitted with its own set of independent gas control and gas safety systems.

15.3 General Requirements

15.3.1 Application

Unless expressly provided otherwise, the requirements of chapter 15 of the LFFS Guidelines apply.

15.3.2 Arrangements of Gas Detectors

In addition to 15.8.1 of the LFFS Guidelines, permanently installed gas detectors are to be fitted at ventilation inlets of accommodation and machinery spaces and other rooms with high fire risk, unless the Society deems it unnecessary based on a risk assessment in accordance with section 4.2, and at the bunkering station as required in chapter 8 of these Guidelines.

Note : "other rooms with high fire risk" as defined in section 2 of the annex to MSC.1/Circ.1591.

15.3.3 Monitoring of Bunkering Station

In addition to 8.3.1 of the LFFS Guidelines, bunkering manifolds are to be continuously monitored by the ship's crew from a safe area in direct line of sight of the manifold or by closed-circuit television (CCTV) during bunker transfer.

Chapter 16 Additional Requirement

16.1 General

16.1.1 Application

Unless expressly provided otherwise, the requirements of chapter 16, 17, 18 and 19 of the LFFS Guidelines apply.

Chapter 17 Use of LPG Cargo as Fuel

17.1 General

17.1.1 This chapter apply to gas carriers complying with the requirements of CR Guidelines for Ships Carrying Liquefied Gases in Bulk (hereinafter referred to as "the LGC Guidelines") using LPG cargoes as fuel, as a supplement to the existing requirements of chapter 16 of the LGC Guidelines.

17.1.2 LPG as provided in chapter 16 of the LGC Guidelines, is composed of propane (C_3H_8), butane (C_4H_{10}), or a propane-butane mixture as listed in chapter 19 of the LGC Guidelines and may contain small amounts of other hydrocarbons and impurities. It can be in either a liquefied or gaseous state. LPG in the liquefied state is referred to as LPG liquid, and LPG in the gaseous state is referred to as LPG gas.

17.2 Goal

The goal of this chapter is to ensure safe and reliable operation of fuel supply systems and consumers for use of LPG cargo as fuel.

17.3 Functional Requirements

17.3.1 Functional requirements

- (a) Single failure is not to cause leakage of fuel into the space where fuel consumers are installed.
- (b) Effectiveness of the ventilation and detection for LPG leakage are to be ensured taking into account characteristics of LPG.
- (c) Since LPG has different properties depending on the composition ratio of propane and butane, the composition ratio of fuel is to be suitable for normal operation of the fuel consumer.
- (d) Fuel supply systems are to be designed to prevent fuel from unintended phase changes in processing of fuel supply to consumers considering vapour pressure at the working temperature, as follows:
 - (i) where fuel is supplied in the gaseous state, measures is to be taken so that the temperature of fuel is not lowered to the dew point at the working pressure; and
 - (ii) where fuel is supplied in the liquid state, measures is to be taken so that the pressure of fuel is not lowered to the vapour pressure at the working temperature.
- (e) Vent, purging and bleed lines of fuel supply systems are to be designed to prevent LPG liquid from being released to the atmosphere.

17.4 General Requirements

17.4.1 Supplementary guidance to the requirements of chapter 16 of the LGC Guidelines
Gas carriers using LPG cargo as fuel are to comply with the following requirements.

- (a) In accordance with the principles of 16.9 of the LGC Guidelines, liquefied petroleum gas (LPG) cargoes may be utilized in machinery spaces of category A. In these spaces, it may be utilized only in systems such as boilers, inert gas generators, internal combustion engines, gas combustion units and gas turbines.
- (b) The LPG fuel supply systems and LPG fuel consumers are to be designed for operation with the possible range of composition of the intended fuel. Information about the range of acceptable compositions is to be provided on board.
- (c) The fuel supply system should comply with the requirements of 16.4.1, 16.4.2, 16.4.3 and 16.5 of the LGC Guidelines.
- (d) LPG fuel consumers are to exhibit no external visible flame and are to maintain the uptake exhaust temperature sufficiently below the auto-ignition temperature of the fuel. In a mixture of gases, the component with the lowest auto-ignition temperature is to be the appropriate reference.
- (e) LPG gas or liquid, may be used as fuel in systems referenced in 17.4.1(a) above.
- (f) Provision is to be made for inerting and venting to a safe location the gas fuel piping systems located in the machinery space. For permanent installations, the inert gas piping connected to the fuel piping is to be fitted with double block and bleed valves. In addition, a non-return valve is to be installed in the inert gas piping upstream of the double block and bleed valves. For liquid fuel supply systems, consideration is to be given to draining the piping without release of liquid to the atmosphere.
- (g) The supply and return piping of each gas consumer unit are to be provided with fuel isolation by automatic double block and bleed, vented to a safe location, under both normal and emergency operation. The automatic valves are to be arranged to fail to the closed position on loss of actuating power. In a space containing multiple consumers, the shutdown of one is not to affect the gas fuel supply to the others. For liquid fuel supply systems, the piping is to be drained without release of liquid to the atmosphere.
- (h) Gas nozzles and the burner control system are to be configured such that gas fuel can only be ignited by an established oil fuel flame, unless the boiler and combustion equipment is designed and approved by the Society acting on their behalf, to ignite on gas fuel.

17.5 Additional Requirements

17.5.1 Risk Assessment

- (a) A risk assessment is to be conducted of the LPG fuel arrangements to document an equivalent level of safety to utilizing LNG as fuel. Consideration is to be given to the hazards associated with the arrangement, operation, and maintenance of the fuel system, considering reasonably foreseeable failures.
- (b) The risk assessment is to address the consequences of fuel leakage, considering the properties of LPG gas and its accumulation or escape into another space.

17.5.2 Arrangements of spaces containing gas fuel consumers

- (a) A single failure of fuel systems in the machinery space is not to lead to a gas release in the machinery space. Fuel piping is to be of double wall design or ducted and the outer boundary should be continuous in the space. Non-continuous double barriers are not to be used under the circumstances described in 16.4.6.2 of the LGC Guidelines.
- (b) The air inlet of the annular space is not to be in the machinery space. In addition, the air inlet of the annular space is to be in a location which would be safe in the absence of the air inlet. Consideration is to be given to the risk of liquid carry over resulting from a liquid leak.

17.5.3 Fuel Supply

- (a) Where fuel supply systems supply LPG liquid, vent and purging are to lead to a fuel tank, gas-liquid separator, or similar device. Heating of the gas-liquid separator may be required for ships operating in cold areas.
- (b) Fuel supply systems referenced in 17.5.3(a) above and vent masts, are to be fitted with an inert gas purging interface and are to include a means for preventing condensation of vapour in the system.
- (c) In application of 16.4.3.2 of the LGC Guidelines, the ventilation inlets for the double wall piping and ducts are to be in a non-hazardous area, away from ignition sources. Ventilation outlets for the double wall piping and ducts are to be in the cargo area.

17.5.4 Fuel plant ventilation and gas detection

- (a) In addition to the requirements of 16.3.1 and 16.5.1 of the LGC Guidelines, special consideration is to be given to the density and lower explosion limit (LEL) of LPG gas. Ventilation capacity, including ventilation inlet and outlet location, is to be supported by numerical calculations, such as a computational fluid dynamics (CFD) analysis. Notwithstanding, for spaces within the cargo area, on the open deck and containing LPG fuel conditioning equipment, the requirements of 12.1.3 of the LGC Guidelines, are to apply.
- (b) In addition to the requirements of 13.6.12 of the LGC Guidelines, gas detection heads are to be fitted in spaces where LPG gas may accumulate particularly where air circulation is reduced or near the bottom of the space. The suitability of their location is to be supported by numerical calculations, such as a CFD analysis or physical smoke test.

17.5.5 Combustion Equipment

- (a) Gas fuel consumer exhaust gas temperature is to be continuously monitored.
- (b) Gas turbines are to be fitted with a gas-tight enclosure unless fuel supply piping meets the requirements of 16.4.3 of the LGC Guidelines. The consequences of gas leakage are to be evaluated based on the risk assessment in 17.5.1.