

RULES FOR CLASSIFICATION

Ships

Edition July 2016

Part 6 Additional class notations

Chapter 2 Propulsion, power generation and auxiliary systems

The content of this service document is the subject of intellectual property rights reserved by DNV GL AS ("DNV GL"). The user accepts that it is prohibited by anyone else but DNV GL and/or its licensees to offer and/or perform classification, certification and/or verification services, including the issuance of certificates and/or declarations of conformity, wholly or partly, on the basis of and/or pursuant to this document whether free of charge or chargeable, without DNV GL's prior written consent. DNV GL is not responsible for the consequences arising from any use of this document by others.

**The electronic pdf version of this document, available free of charge
from <http://www.dnvgl.com>, is the officially binding version.**



FOREWORD

DNV GL rules for classification contain procedural and technical requirements related to obtaining and retaining a class certificate. The rules represent all requirements adopted by the Society as basis for classification.

© DNV GL AS July 2016

Any comments may be sent by e-mail to *rules@dnvgl.com*

If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of DNV GL, then DNV GL shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 2 million.

In this provision "DNV GL" shall mean DNV GL AS, its direct and indirect owners as well as all its affiliates, subsidiaries, directors, officers, employees, agents and any other acting on behalf of DNV GL.

CHANGES – CURRENT

This document supersedes the January 2016 edition.

Changes in this document are highlighted in red colour. However, if the changes involve a whole chapter, section or sub-section, normally only the title will be in red colour.

Main changes July 2016, entering into force 1 January 2017

- **Sec.6 Low flashpoint liquid fuelled engines - LFL Fuelled**
 - **Sec.6 [3.2.1][2]:** The minimum distance from fuel tank and piping to ship's shell has been amended according to distance used in IGF code.
 - **Sec.6 [3.2.2][1]:** Requirement regarding cofferdam around LFL tank towards bottom plating has been relaxed in line with IGF code.
 - **Sec.6 [3.3.4][3]:** The paragraph has been amended for clarification, to allow for expansion bellows in the outer piping.
 - **Sec.6 [8.2.1][1]:** The paragraph has been updated with reference to Pt.5 Ch.7 Sec.22 for testing of tanks defined as pressure vessels.
 - **Sec.6 [8.3][1]:** The sub-section has been updated with new paragraphs [8.3.1.5] to [8.3.1.8] containing additional requirements to testing and inspection according to applicable requirements in Pt.4 Ch.6 and based on experience from projects.
- **Sec.9 Scrubber ready**
 - **Sec.9 [1.3.5][1]:** Requirement for a plan for how to preserve installed systems and equipment has been included.
 - **Sec.9 [2.2.7][2]:** The paragraph has been amended to include an exemption related to required arrangement of watertight division penetrations.
 - **Sec.9 [2.2.7][3]:** A Guidance note has been added to the paragraph regarding documentation for minor and major modification.
 - **Sec.9 [2.3.1][2] d):** The paragraph has been amended with reference to statutory requirements.

Editorial corrections

In addition to the above stated changes, editorial corrections may have been made.

CONTENTS

Changes – current.....	3
Section 1 Battery power.....	12
1 General.....	12
1.1 Introduction.....	12
1.2 Scope.....	12
1.3 Application.....	12
1.4 Terminology and definitions.....	13
1.5 Procedural requirements.....	13
2 Design principles for Battery(Safety) notation.....	16
2.1 General.....	16
2.2 Arrangement.....	16
2.3 Operational environment control.....	17
2.4 Fire safety for battery spaces.....	18
2.5 Safety assessment.....	19
2.6 System design.....	19
2.7 Testing.....	20
2.8 Operation and maintenance.....	20
3 Design principles for Battery(Power) notation.....	21
3.1 General.....	21
3.2 System design.....	21
3.3 Testing.....	22
3.4 Operation and maintenance.....	22
4 Battery system.....	22
4.1 Battery system design.....	22
4.2 Testing.....	25
Section 2 Periodically unattended machinery space - E0 and ECO.....	27
1 General.....	27
1.1 Introduction.....	27
1.2 Scope.....	27
1.3 Application.....	27
1.4 Definitions.....	27
1.5 Documentation.....	28
1.6 Periodical test.....	29
2 System arrangement.....	30
2.1 General.....	30

2.2 Automatic control system.....	31
2.3 Alarm system.....	31
2.4 Safety system.....	32
2.5 Fire safety and fire detection and alarm system.....	34
3 Class notation E0.....	35
3.1 Extent of monitoring.....	35
3.2 Arrangement on the bridge.....	51
3.3 Arrangement in the engine room.....	51
3.4 Control of propulsion machinery from the navigation bridge (SOLAS Ch. II-1/49).....	51
3.5 Electric power supply.....	52
3.6 Fire safety.....	53
3.7 Special requirements for ships less than 300 gross tonnage with propulsive output less than 1000 kW per engine.....	53
4 Class notation ECO.....	54
4.1 General requirements.....	54
4.2 Control station.....	54
4.3 System arrangement.....	54
4.4 Extent of monitoring.....	55
5 Survey.....	55
5.1 General.....	55
Section 3 Fuel Cell installations - FC.....	59
1 General.....	59
1.1 Introduction.....	59
1.2 Scope.....	59
1.3 Application.....	59
1.4 Classification.....	59
1.5 Definitions.....	60
1.6 Documentation.....	61
1.7 Certification.....	66
1.8 Operation and maintenance manuals.....	66
2 Design principles for FC(Power) notation.....	67
2.1 Design principles.....	67
3 Materials.....	67
3.1 General.....	67
3.2 Special requirements for different fuels.....	68
4 Arrangement and system design.....	68
4.1 Location and separation of spaces.....	68
4.2 Arrangement of entrances and other openings.....	69

4.3 General pipe design.....	69
4.4 System configuration.....	70
4.5 FC fuel supply system in fuel cell spaces.....	70
4.6 FC fuel storage.....	72
4.7 FC Fuel tank design.....	72
4.8 Fuel bunkering system and distribution system outside machinery spaces.....	72
4.9 Ventilation system.....	73
4.10 Exhaust systems.....	76
5 Fire safety.....	76
5.1 General.....	76
5.2 Fire protection.....	76
5.3 Fire extinction.....	76
5.4 Fire detection and alarm systems.....	77
6 Electrical systems.....	78
6.1 General.....	78
6.2 Area classification.....	78
6.3 Inspection and testing of electrical equipment in hazardous area.....	79
6.4 Maintenance of electrical equipment in hazardous area.....	80
7 Control, monitoring and safety systems.....	80
7.1 General.....	80
7.2 Monitoring.....	81
7.3 Gas detection.....	82
7.4 Safety functions of gas supply systems.....	83
8 Compressors.....	85
8.1 FC fuel compressors.....	85
9 Manufacture, workmanship and testing.....	86
9.1 Liquefied gas tank.....	86
9.2 FC Fuel piping systems.....	86
9.3 On-board testing of FC plant.....	86
Section 4 Fuel treatment and conditioning systems - Fuel.....	88
1 General.....	88
1.1 Introduction.....	88
1.2 Scope.....	88
1.3 Application.....	88
1.4 Environmental conditions.....	88
1.5 Definitions.....	88
1.6 Certification.....	89

1.7 Documentation.....	89
1.8 General requirements.....	90
2 System arrangements and components.....	90
2.1 System for storage and transfer of fuel.....	90
2.2 Fuel oil settling and daily service tanks.....	91
2.3 Fuel treatment system.....	92
Section 5 Gas fuelled ship installations - Gas fuelled.....	94
1 General.....	94
1.1 Introduction.....	94
1.2 Scope.....	94
1.3 Application.....	94
1.4 Classification.....	94
1.5 Definitions.....	95
1.6 Documentation requirements.....	98
1.7 Certification requirements for manufacturers.....	102
1.8 Onboard documentation.....	103
1.9 Signboards.....	104
2 Materials.....	104
2.1 General.....	104
3 Ship arrangement.....	106
3.1 Ship arrangement principles.....	106
3.2 Arrangement of machinery spaces.....	106
3.3 Arrangement of other spaces containing fuel systems.....	108
3.4 Arrangement of air locks.....	111
4 Fuel containment systems.....	111
4.1 General.....	111
4.2 Liquefied gas fuel tanks.....	112
4.3 Compressed gas fuel tanks.....	118
4.4 Portable liquefied gas fuel tanks.....	118
4.5 Loading limit for liquefied gas fuel tanks.....	119
4.6 Maintenance of fuel storage condition.....	120
4.7 Requirements depending on fuel tank location.....	120
5 Piping systems.....	121
5.1 General.....	121
5.2 Pressure relief systems.....	126
5.3 Fuel bunkering system.....	127
5.4 Nitrogen installations.....	128
5.5 Exhaust system.....	129

5.6 Other ship systems.....	130
6 Ventilation systems.....	130
6.1 Ventilation of spaces.....	130
7 Fire safety.....	132
7.1 General.....	132
7.2 Fire protection.....	132
7.3 Fire extinction.....	133
7.4 Fire detection and alarm systems.....	134
8 Electrical systems.....	134
8.1 General.....	134
8.2 Area classification.....	135
8.3 Inspection and testing.....	136
8.4 Maintenance.....	137
9 Control, monitoring and safety systems.....	137
9.1 General.....	137
9.2 Fuel installation control and monitoring.....	139
9.3 Fuel installation safety.....	143
10 Gas turbines and boilers.....	148
10.1 Gas fuelled boiler installations.....	148
10.2 Gas fuelled turbines.....	149
11 Manufacture, workmanship and testing.....	149
11.1 Fuel containment system.....	149
11.2 Fuel piping systems.....	149
11.3 Valves.....	151
11.4 Expansion bellows.....	151
11.5 Pumps.....	151
11.6 Shutdown valves in liquefied gas fuel piping systems.....	152
Section 6 Low flashpoint liquid fuelled engines - LFL fuelled.....	153
1 General.....	153
1.1 Introduction.....	153
1.2 Scope.....	153
1.3 Application.....	153
1.4 References.....	153
1.5 Procedural requirements.....	155
2 Materials.....	159
2.1 General.....	159
3 Arrangement and design.....	160
3.1 General.....	160

3.2 Fuel storage.....	160
3.3 Fuel transfer and supply.....	163
3.4 Access.....	165
3.5 Ventilation of hazardous spaces containing LFL fuel installations.....	166
3.6 Fuel bunkering in ships other than tankers.....	166
3.7 Inert gas/nitrogen installations.....	167
4 Fire safety.....	168
4.1 General.....	168
4.2 Containment of fire.....	168
4.3 Fire fighting.....	168
5 Electrical systems.....	169
5.1 General.....	169
5.2 Area classification.....	169
5.3 Inspection and testing.....	170
5.4 Maintenance.....	170
6 Control, monitoring and safety systems.....	171
6.1 General.....	171
6.2 Control system.....	171
6.3 Safety system.....	172
6.4 Engine monitoring.....	175
7 Engines and pumps.....	176
7.1 Pumps.....	176
7.2 Engines.....	177
8 Manufacture, workmanship and testing.....	178
8.1 General.....	178
8.2 Fuel tanks.....	178
8.3 Piping system.....	178
8.4 Onboard testing.....	179
9 Operation manual.....	179
9.1 General.....	179
10 Personnel protection.....	180
10.1 General.....	180
11 Ship type considerations.....	180
11.1 Chemical tankers.....	180
11.2 Passenger vessels.....	182
11.3 Offshore supply vessels.....	182
Section 7 Redundant propulsion - RP.....	183
1 General.....	183

1.1 Introduction.....	183
1.2 Scope.....	183
1.3 Application.....	183
1.4 References.....	185
1.5 Procedural Requirements.....	186
2 Technical requirements for RP(1, x).....	190
2.1 General.....	190
2.2 System configuration.....	190
2.3 Auxiliary systems.....	191
2.4 Propulsion and steering control systems.....	191
3 Technical requirements for RP(2, x) and RP(3, x).....	192
3.1 System design.....	192
3.2 System configuration.....	195
3.3 Auxiliary systems.....	197
3.4 Propulsion, steering and auxiliary control system.....	199
3.5 Separation requirements for RP(3, x)	201
Section 8 Tentative rules for gas ready ships - Gas ready.....	202
1 General.....	202
1.1 Introduction.....	202
1.2 Scope.....	202
1.3 Application.....	202
1.4 Definitions.....	202
1.5 Class notation - Gas ready.....	202
1.6 Documentation.....	203
2 Ship installations preparing for later liquefied natural gas fuel conversion.....	206
2.1 Gas ready with qualifier S included.....	206
2.2 Gas ready with qualifier T included.....	206
2.3 Gas ready with qualifier P included.....	206
2.4 Gas ready with qualifiers MEc or AEc included.....	206
2.5 Gas ready with qualifiers MEi, AEi or B included.....	206
2.6 Gas ready with qualifier Misc included.....	207
3 Manufacture, workmanship and testing.....	207
3.1 General.....	207
Section 9 Scrubber ready.....	208
1 General.....	208
1.1 Introduction.....	208
1.2 Class notation – Scrubber ready	209

1.3 Documentation.....	210
2 Ship arrangement and installation.....	213
2.1 Scrubber ready with qualifier <i>D</i>	213
2.2 Scrubber ready with qualifier <i>C</i>	214
2.3 Scrubber ready with qualifiers <i>H</i> or <i>O</i>	216
2.4 Scrubber ready with qualifier <i>HS</i>	217
2.5 Scrubber ready with qualifier <i>R</i>	217
2.6 Scrubber ready with qualifier <i>S</i>	218
2.7 Scrubber ready with qualifier Misc.....	218
3 Manufacture, workmanship and testing.....	218
3.1 General.....	218
Changes – historic.....	219

SECTION 1 BATTERY POWER

1 General

1.1 Introduction

The additional class notation **Battery(Power)** applies to battery installations in battery powered vessels, vessels with redundant propulsion (RP), or DP vessels where the batteries are included in the redundancy for dynamic positioning. Whereas, additional class notation **Battery (Safety)** applies to battery-hybrid vessels.

1.2 Scope

The scope for additional class notations **Battery(Power)** and **Battery (Safety)** add an increased level of safety related to battery installations in vessels. The rules in this section are considered to satisfy the requirements for specific types of battery installation and certification, in accordance with the following list:

- battery systems used as main source of power
- battery systems used as additional source of power
- battery systems used for miscellaneous services
- safety requirements for batteries other than Lead Acid and NiCd. For Lead Acid and NiCd batteries see [Pt.4 Ch.8](#)
- requirements for certification of the batteries.

1.2.1 Since commercial battery technology will be under constant development, the requirements of this section may need to be supported by additional information and requirements, on a case by case basis. Designs that are not in compliance with this section may be approved after evaluation by the Society, provided that it can be demonstrated that the design represents an equal or better level of safety.

1.3 Application

1.3.1 Battery(Power)

The additional class notation **Battery(Power)** is mandatory for vessels where the battery power is used as propulsion power during normal operation, or when the battery is used as a redundant source of power for main and/or additional class notations. The additional class notation **Battery(Power)** will be assigned when all the requirements in this chapter have been satisfied.

1.3.2 Battery(Safety)

The additional class notation **Battery(Safety)** is mandatory for vessels where the battery installation is used as an additional source of power and has an aggregate rated capacity exceeding 50kWh (excluding Lead Acid and NiCd batteries). The class notation **Battery(Safety)** is applicable for battery-hybrid vessels when the batteries are used as an additional source of power or for improving the dynamic power performance. The additional class notation **Battery(Safety)** will be given when the safety requirements in this section have been met.

1.3.3 Battery systems used for other miscellaneous services not covered by the mandatory class notations or for batteries with capacity up to 50kWh and built in compliance with the safety requirements in this section may be given the class notation **Battery(Safety)**.

1.3.4 Fire safety, SOLAS/HSC code safety certificates

SOLAS or the HSC do not include regulations regarding fire safety measures suitable for these types of battery installation. The requirements in this section shall be complied with in addition to the general fire safety measures in SOLAS Reg.II-2 / HSC Code Ch.7.

1.3.5 Relation to other parts of the rules

- electrical installation is in general described in [Pt.4 Ch.8](#)
- control and monitoring systems is in general described in [Pt.4 Ch.9](#)
- use of batteries as a part of the Dynamic Positioning Systems is described in [Ch.3 Sec.1](#) and [Ch.3 Sec.2](#).

1.4 Terminology and definitions

Definitions are given in [Table 1](#).

Table 1 Definitions

<i>Term</i>	<i>Definition</i>
<i>BMS</i>	Battery Management System, a collective terminology comprising control, monitoring and protective functions of the battery system.
<i>EMS</i>	Energy Management System, a system providing monitoring and control of the energy capacities.
<i>battery cell</i>	The smallest building block in a battery, a chemical unit.
<i>battery module</i>	Assembly of cells including electronic control.
<i>battery sub-pack</i>	Same as Battery module.
<i>battery pack</i>	One or more modules including complete BMS and can be used as a standalone unit.
<i>battery string</i>	A battery string comprises a number of cells or modules connected in series with the same voltage level as the battery system.
<i>battery space</i>	The space enclosed by structural separation in which the batteries are located.
<i>battery system</i>	The whole battery installation including battery modules, electrical interconnections, BMS and other safety features.
<i>C-Rate</i>	The current necessary to completely charge/recharge the battery divided by the rated Amper-hours (Ah).
<i>HVIL:</i>	High Voltage Interlock Loop.
<i>LEL</i>	Lower Explosion Limit
Sealed Battery	A battery that remains closed and does not release either gas or liquid when operated within the limits specified by the manufacturer.
<i>SOC</i>	The available capacity expressed as percentage of the rated capacity(0-100%).
<i>SOH</i>	The State of Health reflects the general condition of a battery and its ability to deliver the specified performance compared with a new battery (0-100%).

1.5 Procedural requirements

1.5.1 Certification requirements

Products shall be certified as required by [Table 2](#).

Table 2 Certification required for the notations, Battery(Power) and Battery(Safety).

<i>Object</i>	<i>Certificate type</i>	<i>Issued by</i>	<i>Certification standard</i>	<i>Additional description</i>
Battery System	PC	Society	Pt.6 Ch.2 Sec.1	The Battery Management System (BMS) shall be certified as a part of the battery system.
Battery Charger	PC	Society	Pt.4 Ch.8	The battery charger shall be certified as outlined in Pt.4 Ch.8 Sec.1 Table 3
Energy management system	PC	Society	Pt.6 Ch.2 Sec.1	Only applicable for the Battery(Power) notation. If the Energy Management System (EMS) is a part of the Power Management System (PMS) then they should be certified together.

1.5.2 Documentation requirements

1.5.2.1 General

General requirements for documentation can be found in [Pt.1 Ch.3 Sec.2](#). Refer to [Pt.1 Ch.3 Sec.3](#) for definition of the documentation types.

1.5.2.2 System design

Documentation related to system design shall be submitted as required by [Table 3](#) for the **Battery(Safety)** notation and with additional documentation required by [Table 4](#) for the **Battery(Power)** notation.

Table 3 System design, documentation requirements for Battery(Safety)

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Battery spaces	Z030 – Arrangement plan	Internal arrangement showing battery system and other equipment inside the battery space including fire detection, ventilation and possible gas detection.	FI
	Z010 - Vessel arrangement	Position of battery space towards other spaces/ items	FI
	G010 – Risk analysis	Safety assessment including internal and external safety risks (see [2]).	AP
	G060 – Fire Integrity arrangement	Arrangement of the structural protection of battery space and propulsion machinery	AP
	G061 – Fire Integrity penetrations	Penetration drawing	AP
	G040 – Fire Control plan	Plan for firefighting appliances and escape	AP
	G200 – Fixed fire extinguishing system documentation	Water-based protection of battery spaces	AP
	Z030 – Fire detection arrangement	Arrangement of the fire detection in the battery space	AP
	I200 - Fire detection system	Fire detection system in battery space	AP
	S012 – Ducting diagram for the ventilation system	Detailed arrangements of the ventilation ducts for battery spaces	AP
	S014 – Duct routing sketch for the ventilation system	Overview of the ventilation ducts for battery spaces	AP

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
	Z140 – Test procedures for quay and sea trial	Test plan for the battery installation on-board	AP
	I200 - Gas detection system	If applicable	AP
	G080 – Hazardous area classification drawing	If applicable	AP
	E090 - Table of Ex installation	If applicable	AP
Main battery power system	E170 – Electrical schematic drawing	Schematic drawing of the battery system showing the internal arrangement of the battery packs, strings and modules, including switchgear and control gear	AP
	I030 – Block diagram	Only applicable for Lithium Batteries Interfaces with chargers, power and energy management systems and alarms	FI
	Z160 - Operation manual		L
	Z163 - Maintenance manual		L
Electric power system	E170 – Electrical Schematic drawing	Emergency disconnection of the battery system, including location of emergency disconnection button.	AP
AP = For Approval; FI = For Information; L = Local Handling			

Table 4 System design, additional documentation requirements for class notation Battery(Power)

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Electric power system	E220 – System philosophy	An overall description of the propulsion and power installation for all relevant operating modes, including charging.	FI
	E040 – Electrical load balance	Load balance (energy and power) including size of batteries, charger capacity and discharge/recharge capacity. The load balance shall reflect the operational mode stated in the system philosophy. Minimum available energy for the planned operation/voyage shall be calculated.	AP
AP = For Approval; FI = For Information			

1.5.2.3 Component certification

The Battery system required to be delivered with the Society's Product Certificate shall be documented as described in [Table 5](#).

Table 5 Component certification, documentation requirements

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Battery System	Z072 – Safety description	Ref- [4]	FI
	E120 – Specification	Including ratings and environmental data.	AP

Object	Documentation type	Additional description	Info
	Z252 – Test procedure at manufacturer	Ref. [4]	AP
	I020 Functional description	Battery management system (BMS)	AP
	I030 Block Diagram	Battery management system (BMS)	AP
	I050 Power supply arrangement	Battery management system (BMS)	AP
	I110 List of controlled and monitored points	Battery management system (BMS)	AP
	I150 Circuit diagram	Battery management system (BMS)	AP
	Z265 – Calculation report	Documentation of the SOH and SOC calculation	FI
	Z160 - Operation manual		FI
	Z163 - Maintenance manual		FI
Energy Management System	I200 – Control and monitoring system documentation	Ref. [3] and Pt.4 Ch.9 Sec.1	AP
Battery Charger	See Pt.4 Ch.8 Sec.1 Table 2.		
AP = For Approval; FI = For Information			

1.5.3 Survey and testing requirements

1.5.3.1 Requirements for new-building survey can be found in [2] and [3].

1.5.3.2 Requirements for survey of the batteries at manufacturers can be found in [4].

1.5.3.3 Survey requirements for vessels in operation with class notation **Battery(Power)** and **Battery(Safety)** can be found in Pt.7 Ch.1 Sec.2 and Pt.7 Ch.1 Sec.4.

2 Design principles for Battery(Safety) notation

2.1 General

2.1.1 The requirements in [2.2], [2.3] and [2.4] in this section are applicable for Lithium Ion batteries. The safety assessment required in [2.5] is applicable for all batteries, except Lead Acid and NiCd batteries, where the requirements in Pt.4 Ch.8 Sec.2 apply.

Guidance note:

For Lithium Ion batteries the requirements in [2.5] may override the requirements given in [2.2], [2.3] and [2.4] depending on the lithium chemistry and the identified hazards.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.2 The design shall ensure that any single failure in the battery system shall not render any main functions unavailable for more than the maximum restoration time specified in Pt.4 Ch.1.

Guidance note:

Main functions are defined in Pt.1 Ch.1 Sec.1.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.2 Arrangement

2.2.1 Battery spaces shall be positioned aft of collision bulkhead. Boundaries of battery spaces shall be part of vessels structure or enclosures with equivalent structural integrity.

2.2.2 The battery space shall not contain other systems supporting essential vessel services, including pipes and cables serving such systems, in order to prevent loss of propulsion or steering upon possible incidents (e.g. thermal runaway) in the battery system, unless the potential loss of essential services is within the acceptance criteria stated in [Pt.4 Ch.1 Sec.3 \[2.3.4\]](#).

2.2.3 The battery space shall not contain heat sources or high fire risk objects.

Guidance note:

High fire risk objects are objects similar to those listed in SOLAS Reg. II – 2/3.31. Heat sources are sources with temperature higher than 220°C as used in SOLAS Reg. II-2/4.2.2.6.1.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.3 Operational environment control

2.3.1 Temperature control

2.3.1.1 Battery systems shall be arranged within a space with ventilation that can provide air with temperature control of the ambient temperature. The temperature control (max/min temperature) shall follow recommendations given by the battery maker. For liquid cooled battery system, such ventilation system is not required.

Guidance note:

The lifetime of the batteries is temperature dependent.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.3.1.2 The following shall give an alarm at a manned control station:

- high ambient temperature in battery space
- failure of ventilation.

2.3.1.3 The following shall be monitored and presented at a manned control station:

- ambient temperature of battery space
- indication of ventilation running.

2.3.1.4 The ventilation system for battery spaces shall be independent ducting system from any other heat and air condition system (HVAC) serving other spaces and arranged with mechanical air supply.

2.3.1.5 The ventilation systems shall be arranged with automatic stop upon confirmed fire within the battery space.

Fail-safe arrangement of the automatic stop shall be provided.

Guidance note:

The safe state is considered as fans running.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.3.1.6 Local operation of ventilation shall be possible upon any failure in the remote or automatic control system.

2.3.1.7 If liquid cooled batteries are used, independent mechanical exhaust ventilation system is required for extracting possible battery vapour in an abnormal situation.

2.3.2 Hazardous area

2.3.2.1 Depending on the chemistry of the batteries as defined by the safety description given in [4.1.2] it may be needed to classify the battery space, where flammable gas may arise, according to the zones definitions given in IEC 60079-10-1. This classification shall be used as a basis to support the proper selection and installation of equipment for use in the hazardous area. The hazardous area plan for the battery space, shall be a part of the complete hazardous area plan for the vessel.

2.3.2.2 If explosion protected equipment (Ex equipment) is needed then the equipment selection shall comply with the zone requirements given in Pt.4 Ch.8 Sec.11.

2.3.2.3 If a failure/damage of the batteries can lead to release of flammable gases, then gas detection shall be arranged.

The air at the exhaust outlet shall be monitored and give an alarm at 30% LEL and interlocked to ensure automatic disconnection of the batteries. It shall de-energise any electrical circuit within the space upon detection exceeding 60% LEL (lower explosion limit) These LEL conditions shall give alarm at bridge.

A fail-safe arrangement of the 60% LEL trip shall be provided.

Guidance note:

A failure in the gas detection system should not lead to disconnection or de-energising of the batteries.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.3.2.4 In cases where batteries will cause flammable atmosphere upon leakage/damage, an additional emergency mechanical exhaust fan and emergency inlet direct from open air shall also be arranged. The exhaust fan shall be of non-sparking type and have capacity of not less than 6 air changes per hour. The emergency fan shall be manually operated and possible to operate even when a fire is detected in the battery space.

2.4 Fire safety for battery spaces

2.4.1 Fire integrity

2.4.1.1 Battery spaces shall with reference to SOLAS Reg. II-2/3.30 be defined as a machinery space. With respect to structural fire protection as given in SOLAS Reg. II-2/9.2.2.4 and 2.2.3 the battery room shall be defined as other machinery spaces with the additional requirements given in sub-sections [2.4.1.2] and [2.4.1.3]. Battery spaces are considered as not normally manned.

For High Speed Light Crafts (HSLC) a fire safety assessment, to ensure levels of safety which are equivalent to the conventional SOLAS regulations / definitions used in this sub-section, shall be presented to the Society with respect to Fire Safety in HSC Code Chapter 7.

2.4.1.2 Fire integrity of battery spaces for class notation **Battery(Power)** shall be enclosed by A-0 fire integrity and have A-60 fire integrity towards:

- machinery spaces of category A as defined in SOLAS Reg. II-2/3
- enclosed cargo areas for carriage of dangerous goods.

2.4.1.3 Fire integrity of battery spaces for class notation **Battery(Safety)** shall be enclosed by A-0 fire integrity with additional A60 insulation towards muster stations and evacuation stations.

2.4.1.4 Battery systems within the battery space shall be arranged with sufficient protection (partition plates or sufficient distance in accordance with maker recommendation) to prevent escalation between battery modules in case of a thermal runaway.

2.4.1.5 Access to the space shall be through normally closed doors with alarm or self-closing doors.

2.4.2 Fire detection

2.4.2.1 Battery spaces shall be monitored by conventional smoke detection within the spaces. Smoke detection shall comply with the international code for Fire Safety Systems (FSS Code).

Guidance note:

The thermal management by the BMS, for the battery cells, is the primary indicator of incidents which may lead to possible overheating and fire.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.4.2.2 Battery space fire alarm shall be given at the bridge. The alarm shall comply with the FSS Code.

2.4.3 Fire extinguishing

2.4.3.1 Battery spaces shall be protected by a water-based fixed fire extinguishing system approved for use in machinery spaces of category A as given in SOLAS Reg. II-2/10 and the FSS Code.

Guidance note:

As there are no established test criteria or approved fire extinguishing systems for battery spaces/protection of battery installation in accordance with SOLAS or the FSS Code, an alternative fire extinguish system could be considered.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.4.3.2 If automatic release of fire extinguishing media is designed, the activation shall be based on a voting principle (e.g. 2 out of N).

2.5 Safety assessment

The arrangement of the battery spaces shall be such that the safety of passengers, crew and vessel is ensured. This shall be documented by a safety assessment with the following steps:

- identification of hazards (a list of all relevant accident scenarios with potential causes and outcomes)
- assessment of risks (evaluation of risk factors)
- risk control options (devising measures to control and reduce the identified risks)
- actions to be implemented.

Conformance and non-conformance with the requirements in [2.2], [2.3] and [2.4] shall also be included in the safety assessment.

Guidance note:

The safety assessment should cover all potential hazards represented by the type (chemistry) of battery and cover at least:

- gas development risk (toxic, flammable, corrosive)
- fire risk
- explosion risk
- necessary detection and alarm systems (gas detection, fire detection etc.) and ventilation
- external risks (fire, water ingress etc.)
- loss of propulsion or auxiliary power for essential or important services.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

The safety assessment shall be based on the actual battery that is going to be used. The safety description for the battery, as required in [4.1.2.1], shall be used as a basis.

For High Speed Light Crafts (HSLC) the safety assessment shall be a part of the fire safety assessment of the vessel.

2.6 System design

2.6.1 General

2.6.1.1 The outgoing circuits on a battery system shall, in addition to short circuit and over current protection, be provided with switchgear for isolating purposes so that isolating for maintenance is possible.

2.6.1.2 Emergency disconnection of the battery system (as required in [4.1.2.4]) shall be arranged at the following locations:

- adjacent to (outside of) the battery space
- navigation bridge (for **Battery(Power)** class notation).

2.6.1.3 Emergency disconnection shall be arranged as hardwired circuit and separated from cables used for control, monitoring and alarm functions.

Guidance note:

Requirements in Pt.4 Ch.8 Sec.2 are applicable.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.6.2 Battery charger

2.6.2.1 The charger shall communicate with and operate within the limits given by the battery management system.

2.6.2.2 The charger shall be designed with the needed capacity specified by the battery application.

2.6.2.3 The charger shall be designed to prevent exceedance of the specified current level (C-rates) and voltage level.

Guidance note:

The limitation of current and voltage levels from the charger is in addition to the BMS limitations.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.6.2.4 Charging failure shall give alarm at a manned control station.

2.7 Testing

2.7.1 Testing

A test plan for the installation on-board the vessel shall be submitted for approval. This plan shall include:

- test of correct interface between the charger and the battery system
- test of alarms and safety functions
- test of functions in the battery space (e.g. possible ventilation, liquid cooling, gas detection, fire detection, leakage detection) as installed.

2.8 Operation and maintenance

2.8.1 Operation

Instructions for emergency operation shall be kept on-board.

The emergency operation procedures shall include actions for handling the batteries in case of an external fire and the event of an internal thermal incident in one battery module.

2.8.2 Maintenance

A plan for systematic maintenance and function testing shall be kept on-board showing in detail how components and systems shall be tested and what shall be observed during the tests.

3 Design principles for Battery(Power) notation

3.1 General

The requirements given for **Battery(Safety)** in [2] shall be fulfilled.

3.2 System design

3.2.1 Battery system

3.2.1.1 When the main source of power is based on batteries only, the main source of power shall consist of at least two independent battery systems located in two separate battery spaces.

3.2.1.2 The cables from the battery system to the main switchboard shall follow the routing requirements as given in **Pt.4 Ch.8 Sec.2 [9.5]**.

3.2.1.3 A battery system shall be able to supply the short circuit current necessary to obtain selective tripping of downstream circuit breakers and fuses.

3.2.1.4 It shall be possible to operate the battery system locally. This local operation shall be independent from any remote control systems.

3.2.2 Battery capacity

3.2.2.1 When a battery system is regarded as main source of power (replaces one of the required main source of power in **Pt.4 Ch.8 Sec.2 [2.1.1] b)**, then the capacity of the battery shall be sufficient for the intended operation of the vessel. The design capacity shall be stated in the appendix to the class certificate as an operational limitation.

3.2.2.2 When battery systems are used as redundant power sources for dynamic positioning, the capacity (available power and available energy) of the battery systems shall be sufficient for the planned operation.

3.2.2.3 The SOC and SOH of the battery systems shall be monitored and available for the operator.

3.2.2.4 In case of over-temperature in a battery system, a request for manual load reduction shall be issued both visually and acoustically on the bridge. Alternatively an automatic load reduction can be arranged.

3.2.3 Energy Management System, EMS

3.2.3.1 Energy Management System (EMS) shall be installed.

3.2.3.2 For battery systems providing power to main and/or redundant propulsion or dynamic positioning, the energy management system shall provide a reliable measure of the available energy and power, taking into consideration the batteries SOH and SOC.

3.2.3.3 The EMS system shall be designed in such a way that the battery temperatures are kept within specified limits. This shall be done by limiting the:

- maximum charge and discharge current rates (C-rates)
- maximum and minimum battery voltages, i.e. over charging and excessive discharge.

3.2.3.4 The following parameters shall be provided with remote monitoring at the navigating bridge:

- available energy of the batteries
- available power of the batteries
- remaining time or range that the battery can supply energy for the planned operation/voyage

3.2.3.5 An individual alarm shall be given at the navigating bridge when the battery reaches minimum capacity as required for intended operation or voyage of the vessel.

3.3 Testing

3.3.1 Testing

The following additional tests, supplementary to the tests stated in [2], shall be included in the test plan:

- verification of SOH. This shall be performed by a complete charge/discharge cycle or other method as documented by the manufacturer
- charging and discharging capacities to verify maximum C-rates as specified for the intended operation of the vessel.

3.4 Operation and maintenance

3.4.1 Operation

Operating instruction shall be kept on-board and shall include the following in addition to the emergency procedures stated in [2]:

- charging procedure
- normal operation procedures of the battery system
- local operation procedure.

3.4.2 Maintenance

A maintenance plan for the battery system shall be kept on-board and shall include verification procedures for SOH in addition, to the elements stated in [2]

4 Battery system

4.1 Battery system design

4.1.1 General

The requirements given in this section are related to lithium battery systems.

Guidance note:

Battery systems with other chemistries will be considered on a case by case basis. The main principles in this section will be applied.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.1.2 Safety

4.1.2.1 All hazards shall be described in a safety description. Safety precautions mitigating the identified risks shall be included.

The safety description shall cover all potential hazards represented by the type (chemistry) of battery and at least cover:

- potential gas development (toxic, flammable, corrosive)

- fire risk
- submersion risk
- explosion risk
- necessary detection and alarm systems (gas detection, fire detection etc.) and ventilation for the battery space
- a suitable fire extinguish method must be given
- internal cell failure/thermal runaway
- internal and external short circuit
- external heating/fire
- safe charging/discharging characteristics.

4.1.2.2 The battery system shall have an integrated Battery Management System (BMS). (See [4.1.3] for details).

4.1.2.3 The battery charging equipment shall interface with and operate within the limits given by the BMS.

4.1.2.4 Battery systems larger than 50 kWh shall be equipped with an independent emergency shutdown for disconnection of the battery system.

4.1.2.5 For sealed batteries, a safety pressure valve or other means of explosion protection (weak point) shall be included in the battery design.

4.1.2.6 A possible cell thermal runaway shall be confined at lowest level possible.

Guidance note:

The design of a module should inhibit thermal propagation from cell to cell or at least be confined within the module.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.1.2.7 The main power connectors shall have integrated "High Voltage Interlock Loop" (HVIL) contact (last make/first break) which open the power contactor.

4.1.3 Battery Management System

4.1.3.1 The Battery Management System (BMS) shall :

- provide limits for charging and discharging to the charger
- protect against overcurrent, over-voltage and under-voltage)
- protect against over-temperature
- control cell balancing.

4.1.3.2 The following parameters shall be measured:

- cell voltage
- cell temperature
- battery string current.

4.1.3.3 The following parameters shall be indicated at local control panels or in remote workstations:

- system voltage
- max, min and average cell voltage
- max, min and average cell temperature

Guidance note:

The values may be calculated in an external system.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.1.3.4 The following parameters shall be calculated and be available for the Energy Management System (EMS):

- state of charge of the batteries (SOC)
- state of health of the batteries (SOH).

Guidance note:

Methods for estimating SOC and SOH should be based on best industry practice for the relevant battery technology. Such methods may use a combination of measurements, electrochemical models and prediction algorithms, and take factors such as battery characteristics, operating temperature, charge rates, cell aging and self-discharge into account.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.1.4 Battery alarms

4.1.4.1 Any abnormal condition in the battery system shall initiate an alarm in the vessel's main alarm system with individual or group-wise indication. For vessels without a centralised main alarm system, battery alarms shall be presented at the bridge.

4.1.4.2 Abnormal conditions that can develop into safety hazards shall be alarmed before reaching the hazardous level. Sensors and other components used for such alarms shall be separate from emergency shutdown or other protective safety functions.

4.1.4.3 The following battery failures shall give an alarm:

- high cell temperature
- over and under voltage
- battery shutdown
- unbalanced cell voltage
- tripping of battery breakers/contactors
- other safety protection functions.

4.1.5 Safety functions

4.1.5.1 Activation of protective safety functions shall give alarm.

Failures in the protective safety system rendering the safety function out of operation shall be detected and give alarm.

For batteries providing power to essential vessel services, failures in the protective safety system shall be detected, alarmed, but not cause shutdown of the battery system.

For batteries used on vessels with class notation **Battery(Safety)**, failures in the protective safety system shall be detected, alarmed and cause shutdown of the battery system.

4.1.5.2 Battery protection shall be arranged for excessive temperatures in the batteries.

This protection shall be arranged with components independent from those used for the required temperature indication, alarm and control functions.

If temperature sensors are arranged in close vicinity within the battery module so that loss of functionality of a broken sensor element or circuitry will be mitigated by a neighbouring sensor, the sensor element/circuitry can be common for indication, alarm, control and safety functions. Such arrangements shall still be designed with single fault tolerance in CPUs and other electronic parts of the system. The objective is that no single failure shall cause loss of both safety and alarm functions at the same time.

4.1.5.3 Other fail-safe and independent protective functions shall be implemented if the battery type or design used comprises additional hazards.

4.1.6 Materials

The battery casing, covering modules and cells, shall be made of a flame-retardant material.

4.1.7 Ingress protection

The requirements for IP rating of the batteries depends on the location. As a minimum, IP 44 is required.

Guidance note:

IP 44 is required as a minimum based on the use of water-based fire extinguishing system in the battery space. If other extinguish system is used then the minimum IP rate can be reduce but not lower than IP2X for low voltage (< 1500 Vdc) installations or IP32 for high voltage (> 1500 Vdc) installations.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.1.8 Signboards

Relevant parts of [Pt.4 Ch.8 Sec.10 \[2.3.2\]](#) and [Pt.4 Ch.8 Sec.10 \[2.3.3\]](#) apply.

4.2 Testing

4.2.1 General

A test program for functional and safety tests at manufacturer shall be submitted for approval before testing.

Guidance note:

Lead Acid: The IEC 60896-11 and IEC 60896-21 standards are relevant for respectively vented and valve regulated batteries.

NiCd: The IEC 60623 and IEC 62259 standards are relevant for respectively vented and valve regulated batteries.

Lithium: The IEC 62620 and IEC 62619 standards are relevant for respectively functional tests and safety tests.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.2.2 Lithium cell tests

The cells shall be type tested accordingly to [Table 6](#).

Table 6 Type tests of battery cells.

Item	Test	Comments
1	External Short Circuit	IEC 62619 8.2.1 (alternatively IEC 62281 T-5 or UN38.3 T-5)
2	Impact	IEC 62619 8.2.2 (alternatively IEC 62281 T-6 or UN38.3 T-6)
3	Thermal abuse	IEC 62619 8.2.4 (alternatively IEC 62281 T-2 or UN38.3 T-2)
4	Overcharge	IEC 62619 8.2.5 (alternatively IEC 62281 T-7 or UN38.3 T-7)
5	Forced Discharge	IEC 62619 8.2.6 (alternatively IEC 62281 T-8 or UN38.3 T-8)

Guidance note:

If similar tests to the IEC 62619 (published 2016) have been performed according to other standards, these tests may be acceptable.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

The type tests for the cells shall be performed at a recognized laboratory. The type test report shall be available for the surveyor.

4.2.3 Lithium battery system tests

The battery system shall be tested in accordance with [Table 7](#).

The type tests (TT) shall be carried out on the first certification and the type test report shall be available for the surveyor for later product certification of identical battery systems.

The routine tests (RT) shall be performed for each product certification.

Table 7 Tests of battery systems.

Item	Test	Comments	
1	Propagation/Internal Thermal Event	IEC 62619 8.3.3	TT
2	Overcharge with Voltage	IEC 62619 9.2.2	TT
3	Overcharge with Current	IEC 62619 9.2.3	TT
4	Overheating Control	IEC 62619 9.2.4	TT
5	Sensor failures	Detection of all failure modes of the sensors	TT
6	Cell balancing	According to specification	TT
7	SOC validation	According to specification	TT
8	Capacity Validation	IEC 62620 6.3.1	TT
9	Safety function test	— Emergency stop function — Alarms and shutdowns — HVIL — Temperature protection BMS — Overvoltage protection BMS — Undervoltage protection BMS — Communication Failure — Additional tests based on the implemented safety function of the BMS (May be a type test)	RT
10	Dielectrical strength (High Voltage test)	The rules Pt.4 Ch.8 Sec.3 [4.6] Battery cells that might be damaged by the test can be disconnected to ensure that the test voltage can be applied without damaging the battery cells. The dielectrical routine test can be omitted if all subassemblies have been routine tested and the fully-assembled battery system has been type tested.	RT
11	Insulation resistance	The rules Pt.4 Ch.8 Sec.10 Table 5	RT

Guidance note:

If similar tests to the IEC 62619 (published 2016) have been performed , these tests may be considered for acceptance.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

SECTION 2 PERIODICALLY UNATTENDED MACHINERY SPACE - E0 AND ECO

1 General

1.1 Introduction

The additional class notations **E0** and **ECO** apply to periodically unattended machinery spaces, where machinery, alarm and automation arrangements provide for the safety of the ship in all sailing conditions, including manoeuvring, and when alongside, which are equivalent to that of a ship having machinery spaces attended. Cargo handling is not included.

1.2 Scope

When all machinery and auxiliary systems in the engine room necessary for the performance of the main functions, are fitted with instrumentation and automation equipment in compliance with the requirements of [Pt.4 Ch.9](#), and the relevant parts of this section, then class notations **E0** or **ECO** may be granted.

1.3 Application

The additional class notation **E0** is considered to meet the regulations of SOLAS/II-1/E, for periodically unattended machinery spaces, when alarms, required for **E0** in this section, are relayed to the bridge and the engineers' accommodation. Additionally, a bridge control system for the main propulsion machinery, arranged as specified in [Pt.4 Ch.1](#), and a watch responsibility transfer system are also required to be installed.

The additional class notation **ECO** is considered to meet the regulations of SOLAS/II-1/C/31.3 for continuous supervision from a control station when alarms, required for **ECO** in this section, are initiated in an attended centralised control station, and a remote control system for the main propulsion machinery is installed at this station.

For the additional class notation **ECO**, it is not required to have remote control from the bridge, of main propulsion machinery, or any safety functions installed in the engine room other than those required by main class.

The assignment of class notations **E0** and **ECO** is based on the assumptions that:

- engineering staff can attend the machinery space at short notice,
- periodical test of all field instruments, required by these rules, is performed according to an approved plan,

The plan shall be kept on board and presented at annual and complete periodical surveys, as specified in [Pt.7 Ch.1 Sec.6](#). For the format and the contents of the plan, refer to [\[1.6.1\]](#).

1.4 Definitions

1.4.1 General

1.4.1.1

Table 1 Definitions

<i>Term</i>	<i>Definition</i>
Main alarm system	System performing signal handling and initiation of an alarm, and communicates with the bridge alarm system, the engineers' alarm and the engineers' watch call system.

<i>Term</i>	<i>Definition</i>
Local (sub) alarm systems	System performing signal handling and initiates the local alarm, and communicates with the main alarm system. Guidance note: The local alarm system may only give visual signal when the audible signal is handled by the main alarm system. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
Extension alarm system	Main alarm system extended to the engineers' cabins, public spaces and the navigation bridge and will be in operation when the engine room is unattended.
Engineers' alarm	An alarm system, which shall be provided to operate from the engine control room or the manoeuvring platform, as appropriate, and shall be clearly audible in the engineers' accommodation. (SOLAS Ch. II-1/38) Guidance note: The engineers' alarm is normally an integral part of the extension alarm system, but may be a separate system. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.5 Documentation

1.5.1 Documentation requirements

1.5.1.1 The basic documentation requirements for control and monitoring systems are given in [Pt.4 Ch.9 Sec.1](#). The additional documentation required for **E0** and **ECO** shall be submitted as required by [Table 2](#) and [Table 3](#).

Table 2 Documentation requirements for E0

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>For approval (AP) or For information (FI)</i>
Extension alarm and watch responsibility system	I200 Control and monitoring system documentation		AP
Vessel control and monitoring systems	I110 - List of controlled and monitored points	All alarms required for the equipment in the machinery spaces by Pt.4 and the alarms for E0 notation according to Table 4 - Table 13 in [3], including alarm groups and cross reference to P&IDs.	AP
	I260 - Field instruments periodic test plan	See [1.6]	AP
Fire detection and alarm system	I200 Control and monitoring system documentation		AP
AP=For approval; FI=For information			

For class notation **ECO**, see [\[4\]](#):

Table 3 Documentation requirements for ECO

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>For approval (AP) or For information (FI)</i>
Vessel control and monitoring systems	I110 - List of controlled and monitored points	All alarms required for the equipment in the machinery spaces by Pt.4 and the alarms for ECO notation according to Table 4 - Table 13 in [3] , including alarm groups and cross reference to P&IDs.	AP
	I260 - Field instruments periodic test plan	See [1.6]	AP
Fire detection and alarm system in machinery spaces	I200 - Control and monitoring system documentation		AP
AP=For approval; FI=For information			

1.5.1.2 For control and monitoring systems installed to meet the requirements of this section, an operation manual (Z161) and a maintenance manual (Z163) shall be kept on-board

1.5.1.3 For general requirements to documentation, including definition of the Info codes, see [Pt.1 Ch.3 Sec.2](#).

1.5.1.4 For a full definition of the documentation types, see [Pt.1 Ch.3 Sec.3](#).

1.5.2 Operation instructions

1.5.2.1 On the bridge and at the control stand in the engine room, instructions shall be fitted, stating routines to be followed in connection with transfer of control to and or from the engine room, and precautions to be taken at alarm conditions.

1.6 Periodical test

1.6.1 General

1.6.1.1 All field instruments required by these rules shall be tested regularly according to the plan for periodical test.

1.6.1.2 The plan for periodical test shall identify all field instruments required by these rules. The plan shall in addition describe how each instrument shall be tested, describe the expected result and also identify the test intervals according to [\[1.6.3\]](#).

Guidance note 1:

The plan for periodical test should contain the following information:

- only the field instruments as required by these rules, alternatively, a clear identification of these field instruments and eventual instruments recommended by the manufacturer of the machinery.
- unique instrument identification (tag number)
- service description
- measuring range and unit
- limits for alarm, slowdown and shutdown
- test interval

- test method (may be a reference to a detailed description also describing necessary test equipment)
- expected result (e.g. shutdown)
- record / log of performed tests.

The Society may upon request provide a sample plan.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

The plan for periodical test may be in printed or electronic version, but it must be evident that the contents are approved. If the ship is under PMS (planned maintenance system) survey arrangement [Pt.7 Ch.1 Sec.7](#), the complete content of the plan for periodical test is assumed to be incorporated in the planned maintenance system.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.6.2 Testing

1.6.2.1 Testing of field instruments shall, if not otherwise agreed, include the physical sensor and the whole signal loop, and verify correct functionality, indication and alarming.

Guidance note:

Different ways of testing the field instruments may be applied, according to manufacturers' recommendations and as described in the plan for periodical test. The installation of the field instrument should allow for easy hook-up to a test kit (e.g. via a 3-way valve, thermo-well etc). Where this is not feasible e.g. due to access limitations, alternative test methods may be acceptable, e.g. by comparing two or more sensors measuring the same process parameter, hooking up a temporary reference test sensor, etc. Analogue sensors should be tested by varying the process parameter over the operating range.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.6.3 Test intervals

1.6.3.1 All field instruments for critical alarms shall be tested every 6 months, unless more frequent testing is specified by the maker of the machinery or system. This applies to shut down alarms for main- and auxiliary engines and boilers. The test intervals for all other field instruments as required by these rules shall not exceed 12 months.

Guidance note:

The critical alarms for rotating machinery are typically low lub oil pressure, overspeed and crankcase explosive conditions; and for boilers low water level.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2 System arrangement

2.1 General

2.1.1 Extent of automation

2.1.1.1 The extent of automation shall be sufficient to permit unattended engine room operation for 24 hours, or for the maximum continuous operation time when less than 24 hours. Normal service at sea and normal manoeuvres is presumed. Normal manoeuvres do not include emergency manoeuvres, where alarm and safety limits may be exceeded.

2.1.1.2 Starting of engine plant and transfer to various operating modes may be accepted as manual operations, if the need for such actions will not arise at short notice.

2.2 Automatic control system

2.2.1 Special requirements

2.2.1.1 Where the bilge pumps are arranged for automatic starting, alarms shall be initiated if the influx of liquid is greater than the pump capacity and when the pump is operating more frequently than what would normally be expected.

2.2.1.2 Starting air receivers shall be automatically charged.

2.3 Alarm system

2.3.1 General

2.3.1.1 A main alarm system shall be installed at the machinery control station in the engine room or in the engine control room, if provided.

2.3.1.2 Local (sub) alarm systems are permitted provided there is one common alarm to the main alarm system from each local alarm system. When local alarm systems are permitted to include a safety system, there shall be at least two separate alarms to the main alarm system from the local alarm system.

The common alarm to the main alarm system shall not be inhibited by acknowledged alarms in the local alarm system, but shall be activated by any new detected alarm by the local alarm system.

2.3.1.3 The alarm system including the extension alarm system shall be continuously powered. In case of loss of the normal power supply, an automatic change over to a continuously available power supply with a capacity for at least 30 minutes is required.

2.3.2 Alarm system on the bridge

2.3.2.1 When machinery spaces are attended, the engine room alarms and indicators on the bridge shall be minimized. When the propulsion machinery is remote controlled from the navigation bridge, only engine room alarms and indicators which requires the attention of the navigation officers shall be activated on the navigation bridge.

2.3.2.2 When machinery spaces are unattended, any alarm condition from machinery and systems installed in the engine room shall initiate an alarm on the bridge with individual or group wise indication. The visual alarm signal shall remain present until acknowledged in the engine room.

2.3.2.3 Alarm conditions within one group shall not prevent the initiation of alarms in other groups. New alarms within a group shall not be inhibited by acknowledged existing alarms.

2.3.2.4 The extension alarm system on the bridge and in the accommodation shall be so designed that failures such as loss of power supply or broken cable connection to the main alarm system in the engine room, initiate an alarm.

2.3.2.5 It shall not be possible to reduce the light intensity of alarm indicators on the bridge below the intensity necessary in normal daylight. Automatic adjustment of light intensity based on ambient light conditions is accepted.

2.3.2.6 Power failure to the extension alarm system shall initiate an audible alarm with visual indication on the bridge.

2.3.3 Alarm systems in the engineers' accommodation

2.3.3.1 An extension alarm system shall be installed in the watch-keeping engineer's cabin, on the navigation bridge and in all public spaces where watch-keeping engineer is intended to be located, for example day room, gymnasium and such like. Any alarm condition from machinery and systems installed in the engine room shall initiate an alarm on the responsible watch-keeping engineer's alarm system installation and public space installations (i.e. bridge extension alarm systems) during engine unattended periods.

Local silencing of the audible alarm on the bridge or in the accommodation spaces shall not acknowledge the alarm in the engine room.

It shall be indicated on the bridge when the audible alarm has been silenced in the watch-keeping engineer's cabin.

2.3.3.2 The extension alarm system shall be activated by the watch responsibility transfer system.

2.3.3.3 When the engine room is unattended, the engineers alarm shall be activated if an alarm has not received attention locally, within a limited time.

(SOLAS Ch. II-1/51.1.3)

Guidance note:

Limited time should normally be understood to be between 1 to 3 minutes.

---e-n-d---o-f---g-u-i-d-a-n-c-e---o-t-e---

2.3.4 Watch responsibility transfer system

2.3.4.1 A system for activating and deactivating the extension alarm system to the navigation bridge shall be provided.

2.3.4.2 The system shall initiate audible and optical (flashing light) warning at both control positions when watch transfer is requested, and the warning shall remain in operation until acknowledged.

2.3.4.3 The responsibility shall not be transferred before acknowledgement at the receiving end.

2.3.4.4 Indication shall be provided showing which control station has the watch responsibility.

2.3.4.5 Transfer of watch keeping responsibility to the navigation bridge shall not be possible before the extension alarm system has been set to a duty engineer's cabin. The watch keeping responsibility panel shall indicate which engineer is on duty.

2.4 Safety system

2.4.1 General

2.4.1.1 The safety system shall cover fault conditions which could lead to complete breakdown, serious damage or explosion.

2.4.1.2 When two or more safety actions are initiated by one failure condition (e.g. start of standby pump and stop of engine at low lubricating oil pressure), these actions shall be activated at different levels. The least drastic action shall be activated first.

2.4.1.3 Power failure in the safety system shall not cause loss of propulsion nor steering functions.

2.4.1.4 Whenever the safety system is activated, alarm shall be initiated.

2.4.2 Automatic start of pumps

2.4.2.1 Faults in the mechanical or electrical system of the running pump are not to inhibit automatic start of the standby pump.

2.4.2.2 Automatic start of the standby pump shall be initiated by the process parameter which is being monitored, e.g. low pressure signal, and shall be arranged so that the standby pump does not stop automatically when first started («locking circuit»).

2.4.2.3 Manual start and stop of the pumps shall be possible without initiating an alarm for the automatic start of the standby pump.

2.4.2.4 Operating circuits for pump units shall be arranged according to [Pt.4 Ch.8](#).

2.4.2.5 When a pump is standby, this shall be clearly indicated on the operator panel.

2.4.3 Automatic stop of auxiliary engines and propulsion machinery

2.4.3.1 External circuitry for safety and alarm shall be arranged such that a failure to any one system or function cannot spread to another system or function. An alarm shall be initiated for voltage failure.

Guidance note:

The systems for safety and alarm should be separately fused. Similarly, automatic stop circuits for individual units should be separately fused.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.4.3.2 The safety system shall be arranged so that a single open circuit in wiring between sensors and control unit, or between control unit and actuators, including external stop circuit, does not cause unintentional stop. This requirement can be waived if the manoeuvrability is maintained after shutdown of one unit, see [Pt.4 Ch.9 Sec.3 \[1\]](#)

Guidance note:

A single system based on normally open contacts can be accepted; alternatively, a system with normally closed contacts where discrimination between loop failure and stop signals is provided.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.4.3.3 In case of an automatic stop of one engine in a multi-engine plant, measures shall be taken to avoid overload of the running engine.

2.4.3.4 All parameters which may cause automatic stop shall initiate an alarm prior to stop.

Guidance note:

Propulsion machinery is defined as all machinery which will cause loss of the propulsion function if stopped, with exception of main boilers.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.4.4 Automatic stop of oil fired auxiliary boilers

2.4.4.1 Connections between sensors and control unit shall be based upon normally closed contacts, so that an open circuit will lead to shutoff of the oil supply.

2.4.4.2 The parameter causing an automatic stop shall be identified on the control panel.

2.4.5 Internal communication

2.4.5.1 The two-way voice communication system, according to SOLAS Reg. II-I/50, shall be supplied by a battery or an uninterruptible power supply as a stand-by power supply sufficient to operate the system for at least 30 minutes.

2.5 Fire safety and fire detection and alarm system

2.5.1 General

2.5.1.1 A fixed fire detection and fire alarm system shall be installed in accordance with the relevant provisions of SOLAS, II-2, Part C, Reg.7 (Pt.4 Ch.11) in periodically unattended machinery spaces. (SOLAS Ch. II-2, Part C, 7.4.1)

2.5.1.2 This fire detection system shall be so designed and the detectors so positioned as to detect rapidly the onset of fire in any part of those spaces, and under any normal conditions of operation of the machinery and variations of ventilation, as required by the possible range of ambient temperatures.

Except in spaces of restricted height and where their use is especially appropriate, detection systems using only thermal detectors shall not be permitted.

2.5.1.3 The detection system shall initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating fire.

The audible and visual alarms shall be located in different places, sufficient to ensure that the alarms are heard and observed on the navigation bridge and by a responsible engineer officer. When the navigation bridge is unmanned, the alarm shall sound in a place where a responsible member of the crew is on duty. (SOLAS Ch. II-2, Part C, 4.2)

Guidance note:

Thermal detectors only may be used in workshops adjacent to machinery spaces when the nature of the work being carried out will cause erroneous alarms. This guidance note only applies if the compartments themselves do not contain fuel oil installations.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.5.1.4 Fire detectors shall be type approved.

Guidance note:

Where fire detectors are provided with timers (in workshops) for inhibiting the alarm, these should be arranged to automatically reset the alarm upon completion of timer and should not be possible to negate for period exceeding 15 minutes.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.5.1.5 Manually operated call points shall be located at the following positions:

- passageways and stairways, including emergency exits, having nearby entrance to engine and boiler rooms
- navigation bridge
- control station in engine room.

Guidance note:

Manual call points should be located as required by SOLAS Ch. II-2.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.5.1.6 Start of fire pumps shall be arranged according to the requirements in SOLAS Ch. II-2, Part C, 10.2.1.2.2.2.

3 Class notation E0

3.1 Extent of monitoring

3.1.1 General

3.1.1.1 The control and monitoring systems shall cover machinery and auxiliary systems in the engine room, necessary for the performance of the main functions, as specified in [Pt.1 Ch.1 Sec.1 \[1.2\]](#).

3.1.1.2 The parameters to be monitored will depend upon output and type of engine as well as arrangement of machinery plant. The parameters listed in [Table 4](#) to [Table 13](#) are in general corresponding to those specified in [Pt.4](#), but some additional parameters are required to comply with **E0** rules. Other combinations than those listed may be accepted, when the chosen monitoring can detect fault conditions in an equivalent satisfactory manner.

For propulsion engines, see [Pt.4 Ch.3 Sec.1 Table 9](#).

For propulsion turbines, see [Pt.4 Ch.3 Sec.3 Table 6](#).

For shafting, propeller, gear, clutch and elastic couplings, see [Pt.4 Ch.4](#).

For auxiliary engines, see [Pt.4 Ch.3 Sec.1 Table 10](#).

For auxiliary turbines, see [Pt.4 Ch.3 Sec.3 Table 7](#).

For auxiliary boiler, see [Pt.4 Ch.7 Sec.6 Table 2](#) and [Pt.4 Ch.7 Sec.6 Table 6](#).

3.1.2 Safety actions

3.1.2.1 The required safety shutdowns for propulsion systems in [Pt.4](#) shall be automatically executed. Manual activation from the bridge of safety actions for propulsion machinery may be accepted if running of the machinery does not jeopardize the safety. Manual activation will not be permitted for:

- overspeed protection
- lubricating oil pressure
- crankcase explosive conditions (for trunk piston engines)
- short circuit in electrical propulsion plants.

The alarm for manual activation of shut down shall be independent from the main alarm system.

3.1.2.2 For automatic shutdowns that do not protect a propulsion engine from immediate break down an emergency device shall be arranged to override these safety actions.

The override facility shall be arranged such that unintentional operation is prevented and initiate a visual and audible indication when operated. Refer to [Pt.4 Ch.1 Sec.4 \[1.4.8\]](#).

3.1.2.3 For multi-engine propulsion plants, overriding of safety shutdowns and slowdowns, as required by [Pt.4 Ch.1 Sec.4 \[1.4.8\]](#) is not required if manoeuvrability of the vessel is maintained after activation of shutdown or slowdown on one of the engines.

Table 4 Control and monitoring of propulsion engines

<i>System</i>	<i>Item</i>	<i>Valid for engine type ¹⁾</i>	<i>Gr 1 Indication alarm load reduction</i>	<i>Gr 2 Automatic start of stand-by pump with alarm ²⁾</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comments</i>
1.0 Fuel oil system	Leakage from jacketed high pressure pipes	C, T	A			Level monitoring of leakage tank or equivalent
	Fuel oil pressure after filter (engine inlet)		IR, LA	AS		
	Fuel oil temperature or viscosity of heavy fuel		A			
	Common rail fuel oil pressure	C, T	LA			
2.0 Lubricating oil system	Lubrication oil to all bearings, inlet pressure ³⁾	C, T	IR, IL, LA, LR	AS	SH	
	Lubrication oil to all bearings, inlet temperature		IR, IL, HA			
	Thrust bearing metal temperature	C	IR, HA, LR		SH	Shall be activated automatically
	Cylinder lubricating flow	C, T	LA, LR			At least one measuring point for each lubricator unit if applicable.
	Common rail servo oil pressure	C, T	LA			
3.0 Turbocharger system	Turbocharger lubrication oil inlet pressure	C, T	IR, IL, LA			Applicable if separately forced lubrication or if turbocharger lubrication is part of engine main lubrication system but separated by pump, throttle or pressure reduction valve

<i>System</i>	<i>Item</i>	<i>Valid for engine type ¹⁾</i>	<i>Gr 1 Indication alarm load reduction</i>	<i>Gr 2 Automatic start of stand-by pump with alarm ²⁾</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comments</i>
	Turbocharger lubrication oil outlet temperature		IR, HA			Applicable only when the T/C is served by group of cylinders > 2500 kW
	Speed of turbocharger		IR, HA			Applicable only when the T/C is served by group of cylinders > 1000 kW
4.0 Piston cooling system	Piston coolant inlet pressure (common)	C	IR or IL, LA, LR	AS		Load reduction and automatic start of stand-by pump is not required if the coolant is oil taken from the main lubrication oil system of the engine
	Piston coolant outlet flow each cylinder		LR			
5.0 Cylinder cooling medium	Cylinder cooling inlet pressure or flow	C, T	IR or IL, LA, LR	AS		Monitoring of expansion tank level, with alarm at low level, is an acceptable alternative for engines with cylinder power < 130 kW
	Cylinder cooling outlet temperature		IR or IL, HA, LR			Temperature to be monitored for each cylinder if individual stop valves are fitted for the cylinder jackets, otherwise main outlet. Sensor location so as to enable alarm in event of closed valve For trunk engines, two independent sensors are required for alarm and load reduction
6.0 Starting and control air systems	Control air reservoir pressure (if arranged)	C, T	IR or IL, LA			

<i>System</i>	<i>Item</i>	<i>Valid for engine type ¹⁾</i>	<i>Gr 1 Indication alarm load reduction</i>	<i>Gr 2 Automatic start of stand-by pump with alarm ²⁾</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comments</i>
	Starting air pressure		IR, IL, LA			Before starting valve and after the last downstream valve of the pressure producing equipment
6.1 Pneumatic return of exhaust valve	Exhaust gas valve air spring pressure	C	IR or IL, LA			Pressure readings shall be taken at the supply line locally on the engine
7.0 Charge air system	Charge air pressure	C, T	IR			
	Charge air temperature, under each piston (fire detection)	C	HA, LR			
	Charge air temperature at charge air cooler outlet	C,T	IR,HA			
8.0 Exhaust gas system	Exhaust gas temp after each cylinder ⁴⁾	C, T	IR, HA, LR ⁵⁾			
	Exhaust gas temp before T/C ^{6), 7)}		IR, HA, LR			LR is only required when the T/C is served by group of cylinders > 2500 kW
9.0 Hydraulic oil system	Leakage from jacketed high pressure pipes for hydraulic operation of valves	C, T	A			Level monitoring of leakage tank or equivalent
10.0/11.0 Engine speed/ direction of rotation	Engine speed/ direction of rotation	C, T	IL, IR			
	Over speed protection		LR		SH	SH or LR. Shall be activated - automatically
	Excessive time within barred speed range ⁸⁾	C	A			

<i>System</i>	<i>Item</i>	<i>Valid for engine type ¹⁾</i>	<i>Gr 1 Indication alarm load reduction</i>	<i>Gr 2 Automatic start of stand-by pump with alarm ²⁾</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comments</i>
	Engine direction of rotation - wrong way	C	A			
12.0 Chain tension	Position feeler "sensor"	C	IL			Where applicable
13.0 Crankcase explosive condition ⁹⁾ ¹⁰⁾	Oil mist detection ¹¹⁾	C	HA, LR			
		T	HA		SH	Shall be activated automatically One oil mist detector having two independent outputs for detecting alarm and shut-down is acceptable.
	Other systems than oil mist detection	T	IL, IR, HA, LR		SH	For trunk engines, shut down of engine and declutching of gear in a multi engine system is required. Request for manual SH is also accepted
14.0 Sea cooling water	Cooling water pressure	C, T	LA	AS		
15.0 Fuel valve cooling medium	Pressure	C, T	LA	AS		If installed
	Temperature	C, T	HA			
16.0 Misfire ⁴⁾	Detection of misfire	C, T	A, LR			Chosen LR depends on permissible misfire

<i>System</i>	<i>Item</i>	<i>Valid for engine type ¹⁾</i>	<i>Gr 1 Indication alarm load reduction</i>	<i>Gr 2 Automatic start of stand-by pump with alarm ²⁾</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comments</i>
<i>Gr 1</i> = Sensor(s) for indication, alarm, load reduction (common sensor permitted but with different set points and alarm shall be activated before any load reduction) if no other requirement is stated above <i>Gr 2</i> = Sensor for automatic start of standby pump <i>Gr 3</i> = Sensor for shut down <i>IL</i> = Local indication (presentation of values), in vicinity of the monitored engine component or system <i>IR</i> = Remote indication (presentation of values), in engine control room or another centralized control station such as the local platform/manoeuvring console <i>A</i> = Alarm activated for logical value <i>LA</i> = Alarm for low value <i>HA</i> = Alarm for high value <i>AS</i> = Automatic start of standby pump with corresponding alarm <i>LR</i> = Load reduction, either manual or automatic, with corresponding alarm, either slow down (r.p.m. reduction) or alternative means of load reduction (e. g. pitch reduction), whichever is relevant. <i>SH</i> = Shut down with corresponding alarm. For definitions of Load reduction (LR) and Shut down (SH), see Pt.4 Ch.1. 1) C = Crosshead engine, T = Trunk engine. 2) To be provided when stand-by pump is required. 3) Pressure to be monitored for all inlets to main bearings, crosshead bearings, torsional vibration dampers and camshaft bearings where pressure may differ due to presence of pumps, throttles, rotor seals or pressure reduction valves. 4) Diesel engines with cylinder output of 130 kW and above shall have means to detect misfire. Example: Exhaust gas after each cylinder, deviation from average. 5) Alarm with request for load reduction to be given in case of excessive average exhaust gas temperature. This applies when there is no separate sensor before T/C, and the T/C is served by a group of cylinders > 1000 kW. The alarm level shall be set with due considerations to safe operation of T/C. 6) Applicable only when the T/C is served by a group of cylinders > 1000 kW and if no individual exhaust gas temperature for each cylinder. 7) Temperature measurement after turbine is accepted for T/C served by a group of cylinders < 2500 kW, provided that the alarm levels are set to safeguard the T/C. The alarm level shall be substantiated by the T/C manufacturer. 8) When driving in barred speed range in excess of approved maximum duration set by torsional vibration level in the shafting (where deemed necessary, limitations in duration will be given in connection with approval of torsional vibration analysis). This safety device will only be required when so stated in connection with approval of torsional vibration analysis. 9) For trunk engines: Either a) 'Oil mist concentration' or b) 'Temperature monitoring of main- and crank bearings combined with crank case pressure monitoring'. Other methods, like e.g. 'crank case pressure monitoring' combined with either 'Oil splash temperature deviation' or 'Metal particle detection' (shunt to filter), may be approved provided their capability with regard to risk of false alarms and speed of detection is proven. 10) For crosshead engines: Oil mist concentration or temperature monitoring of main-, crank- and crosshead bearings together with other relevant positions, or other methods may be applied as additional measures of preventing crankcase explosions. These additional measures are optional. device 11) Applicable to engines of 2250 kW and above, or with cylinder diameter > 300 mm. 12) Oil mist detectors shall be type tested in accordance with IACS UR M67.						

Table 5 Control and monitoring of propulsion turbines

<i>System</i>	<i>Item</i>	<i>Gr 1 Indication alarm load reduction</i>	<i>Gr 2 Automatic start of stand- by pump with alarm</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comment</i>
1.0 Lubricating oil	<i>Inlet pressure (after filter)</i>	<i>IR, IL, LA</i>	<i>AS</i>	<i>SH¹⁾</i>	
	<i>Inlet temperature</i>	<i>IR, HA</i>			
	<i>Filter differential pressure</i>	<i>IR, HA</i>			
	<i>Level in system tank</i>	<i>LA</i>			
2.0 Bearings	<i>Bearing temperature</i>	<i>IR, HA</i>			
3.0 Turbine speed	<i>Overspeed</i>	<i>LR</i>		<i>SH</i>	<i>LR or SH, if applicable, to be activated automatically</i>
4.0 Condenser system	<i>Vacuum</i>	<i>IR, LA</i>		<i>SH</i>	
	<i>Vacuum pump stopped</i>		<i>AS</i>		
	<i>Level</i>	<i>IR, HA</i>	<i>AS</i>	<i>SH</i>	
	<i>Level</i>	<i>IR, LA</i>			<i>If non-cavitating condensate pump</i>
	<i>Salinity</i>	<i>HA</i>			
5.0 Cooling water (main condenser)	<i>Inlet/outlet differential pressure</i>	<i>IR, LA</i>	<i>AS</i>		
6.0 Slow turning arrangement	<i>Overspeed</i>			<i>SH</i>	
7.0 Gland steam	<i>Inlet pressure to turbine</i>	<i>IR, LA, HA</i>			
	<i>Exhaust fan stopped</i>	<i>A</i>			
8.0 Hydraulic system	<i>Pressure</i>	<i>IR, LA</i>	<i>AS</i>		
9.0 Vibration	<i>Level</i>	<i>HA</i>		<i>SH</i>	
10.0 Rotor	<i>Axial displacement</i>	<i>IR, HA</i>		<i>SH</i>	

<i>System</i>	<i>Item</i>	<i>Gr 1 Indication alarm load reduction</i>	<i>Gr 2 Automatic start of stand- by pump with alarm</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comment</i>
<i>Gr 1</i> = Sensor(s) for indication, alarm, load reduction (common sensor permitted but with different set points and alarm shall be activated before any load reduction) <i>Gr 2</i> = Sensor for automatic start of standby pump <i>Gr 3</i> = Sensor for shut down. <i>IL</i> = Local indication – (presentation of values) in vicinity of the monitored component <i>IR</i> = Remote indication – (presentation of values) in engine control room or another centralized control station such as the local platform/manoeuvring console <i>A</i> = Alarm activated for logical value <i>LA</i> = Alarm for low value <i>HA</i> = Alarm for high value <i>AS</i> = Automatic start of standby pump with corresponding alarm <i>LR</i> = Load reduction, either manual or automatic, with corresponding alarm <i>SH</i> = Shut down with corresponding alarm. For definitions of Load reduction (LR) and Shut down (SH), see Pt.4 Ch.1. 1) The shut down shall be so arranged as not to prevent admission of steam to the astern turbine for braking. Italic text in table is equivalent to Pt.4 Ch.3 Sec.3 Table 6					

Table 6 Control and monitoring of main steam and feed water installation

	<i>Gr 1 Alarm Load reduction</i>	<i>Gr 2 Automatic start of stand-by pump with alarm ¹⁾</i>	<i>Gr 3 Shut down of boiler with alarm</i>
<i>Water system</i>			
Water level, high	HA		
Water level, high	HA		SH ⁵⁾
Water level, low	LA		
Water level, low			SH
Water circulation ²⁾			SH
<i>Steam system</i>			
Steam pressure,	LA, HA, LR		
Steam temperature ³⁾	HA		
<i>Feed water system</i>			
Atmospheric drain tank, level	LA, HA		
Deaerator, level	LA, HA		

	<i>Gr 1</i> <i>Alarm</i> <i>Load reduction</i>	<i>Gr 2</i> <i>Automatic start</i> <i>of stand-by pump</i> <i>with alarm</i> ¹⁾	<i>Gr 3</i> <i>Shut down of</i> <i>boiler with</i> <i>alarm</i>
Deaerator, pressure	LA, HA		
<i>Feed water</i>			
Temperature ⁶⁾	HA		
Pressure	LA	AS	
Feed water temperature	HA		
<i>High pressure feed water</i>			
Level	HA		
<i>Fresh water generator</i>			
Fresh water outlet, salinity	HA ⁴⁾		
<i>Uptake gas</i>			
Gas temperature ⁷⁾	HA		
<i>Oil burner</i>	Monitoring of the burner shall be arranged according to Pt.4 Ch.7 Sec.6 Table 6		
<i>Gr 1</i> = Common sensor for alarm and load reduction, alarm shall be activated prior to load reduction <i>Gr 2</i> = Sensor for automatic start of standby pump <i>Gr 3</i> = Sensor for shut down <i>LA</i> = Alarm for low value <i>HA</i> = Alarm for high value <i>A</i> = Alarm activated <i>AS</i> = Automatic start of standby pump with alarm <i>LR</i> = Load reduction, turbine slow down <i>SH</i> = Shut down 1) To be provided when standby pump is required. 2) To be provided for forced circulation boilers 3) For superheated and de superheated steam outlet (external de super heaters) 4) Automatic stop of generator or by-passing of consumers 5) Turbine shut down 6) Outlet of ejector cooler/gland condenser 7) To be provided for fire detection For definitions of Load reduction (LR) and Shut down (SH), see Pt.4 Ch.1 Sec.1 Table 1 .			

Table 7 Control and monitoring of shafting, propeller, gear, clutch and elastic couplings

	<i>Gr 1 Indication alarm load reduction</i>	<i>Gr 2 Automatic start of stand- by pump with alarm ¹⁾</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comment</i>
1.0 Shafting				
<i>Separate thrust bearings, temperature</i>	<i>IL or IR, HA</i>			<i>To be provided for shaft power > 5000 kW. Sensor to be placed in the bearing metal or for pads, in the oil outlet. Maximum permissible temperature to be marked on the indicators.</i>
<i>Oil lubricated fluid film bearings, temperature</i>	<i>IL or IR, HA</i>			<i>To be provided for shaft power > 5000 kW. Sensors to be located near the bearing surface at the area of highest load. Maximum permissible temperature to be marked on the indicators.</i>
<i>Stern tube lubricating oil tank, level</i>	<i>LA</i>			
<i>Stern tube lubricating oil, pressure or flow</i>	<i>LA</i>			<i>Applicable to forced lubrication.</i>
2.0 Additional requirements for TMON				
<i>Aft stern tube bearing, temperature</i>	<i>HA</i>			
3.0 Servo oil for CP-propeller				
<i>Pressure</i>	<i>IL, IR, LA</i>	<i>AS</i>		<i>The indicators shall be able to show sudden peaks in servo pressure.</i>
<i>Level</i>	<i>IL, LA</i>			
<i>Differential pressure over filter</i>	<i>HA</i>			
4.0 Gear bearing and lubricating oil				
<i>Oil lubricated fluid film bearings (axial and radial) temperature</i>	<i>IR, HA</i>			<i>Applicable for gears with a total transmitted power of 5 MW or more.</i>
<i>Thrust bearing, temperature</i>	<i>IR, HA, LR</i>			<i>Applicable for gears with a total transmitted power of 5 MW or more. Sensor to be placed in the bearing metal or for pads in the oil outlet.</i>
<i>Lubricating oil, pressure</i>	<i>IL, IR, LA</i>	<i>AS</i>	<i>SH</i>	<i>At bearings and spray if applicable. Shut down or clutch disengagement.</i>
<i>Differential pressure over filter</i>	<i>IL, HA</i>			<i>Alarm in case of clogged filter</i>
<i>Lubricating oil, temperature</i>	<i>IL or IR, HA</i>			<i>At inlet to bearings, i.e. after cooler.</i>
<i>Lubricating oil, temperature</i>	<i>IL or IR</i>			<i>In sump, or before cooler</i>
<i>Sump level ²⁾</i>	<i>IL or IR</i>			<i>For splash lubricated gears.</i>

	<i>Gr 1 Indication alarm load reduction</i>	<i>Gr 2 Automatic start of stand- by pump with alarm ¹⁾</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comment</i>
5.0 Integrated clutch activating media				
<i>Hydraulic oil pressure</i>	<i>IL, IR, LA, LR</i>	<i>AS</i>	<i>SH</i>	<i>SH means either declutching or engine stop</i>
6.0 Twist of elastic couplings				
<i>Angular twist amplitudes</i>	<i>IR, HA</i>		<i>SH</i>	<i>Applicable when failure of the elastic element leads to loss of torque transmission. ³⁾</i>
<i>Mean twist angle</i>	<i>IR, HA</i>			
<i>Gr 1</i> = Common sensor for indication, alarm, load reduction (common sensor permitted but with different set points and alarm shall be activated before any load reduction) <i>Gr 2</i> = Sensor for automatic start of standby pump <i>Gr 3</i> = Sensor for shut down. <i>IL</i> = Local indication (presentation of values), in vicinity of the monitored component <i>IR</i> = Remote indication (presentation of values), in engine control room or another centralized control station such as the local platform/manoeuvring console <i>A</i> = Alarm activated for logical value <i>LA</i> = Alarm for low value <i>HA</i> = Alarm for high value <i>AS</i> = Automatic start of standby pump with corresponding alarm <i>LR</i> = Load reduction, either manual or automatic, with corresponding alarm, either slow down (r.p.m. reduction) or alternative means of load reduction (e. g. pitch reduction), whichever is relevant. <i>SH</i> = Shut down with corresponding alarm. May be manually (request for shut down) or automatically executed if not explicitly stated above.				
For definitions of Load reduction (LR) and Shut down (SH), see Pt.4 Ch.1 .				
1) To be provided when standby pump is required. 2) For gears with totally transmitted power of 500 kW or less, dipstick inspection is considered adequate. 3) May be omitted if the vessel is equipped with a “take me home” device, e.g. a electric motor connected to the gearbox (so-called PTH or PTI). Exemption may also be accepted for couplings that are of a design that enables the full torque to be transmitted in the event of failure of the elastic elements. Such emergency claw devices are not “getting home” devices, but only meant for temporary emergency in order to prevent loss of manoeuvrability in harbours, rivers, etc				
Italic text in table is equivalent to Pt.4 Ch.4				

Table 8 Control and monitoring of auxiliary engines

<i>System</i>	<i>Item</i>	<i>Gr 1 Indication alarm load reduction</i>	<i>Gr 2 Automatic start of stand-by pump with alarm ¹⁾</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comment</i>
1.0 Fuel oil system	<i>Leakage from jacketed high pressure pipes</i>	A			Level monitoring of leakage tank or equivalent
	<i>Fuel oil pressure</i>	LA	AS		When fuel oil treatment system is provided
	<i>High/Low temperature or viscosity of heavy fuel oil</i>	A			
	<i>Common rail fuel oil pressure</i>	LA			
2.0 Lubricating oil system	<i>Lubrication oil to main bearings, inlet pressure</i>	IR or IL, LA, LR	AS	SH	Automatic shut down for electric power generating engines LR is accepted as alternative to SH for auxiliary engines other than driving generators
	<i>Lubrication oil to main bearings, inlet temperature</i>	IR or IL, HA			
	<i>Common rail servo oil pressure</i>	LA			
3.0 Turbocharger system	<i>Speed of turbocharger</i>	IR or IL, HA			Applicable only when the T/C is served by group of cylinders > 1000 kW
4.0 Cylinder cooling medium	<i>Cylinder cooling inlet pressure or flow</i>	IR or IL, LA	AS		Monitoring of expansion tank level, with alarm at low level, is an acceptable alternative for engines with cylinder power < 130 kW
	<i>Cylinder cooling outlet temperature</i>	IR or IL, HA, LR		SH	Automatic shut down for electric power generating engines LR is accepted as alternative to SH for auxiliary engines other than driving generators
5.0 Starting air system	<i>Start air pressure</i>	LA			
6.0 Exhaust gas system	<i>Exhaust gas temp after each cylinder ²⁾</i>	IR or IL, HA, LR ³⁾			SH may replace LR for electric power generating engines

<i>System</i>	<i>Item</i>	<i>Gr 1 Indication alarm load reduction</i>	<i>Gr 2 Automatic start of stand-by pump with alarm ¹⁾</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comment</i>
	<i>Exhaust gas temp before T/C ^{4) 5)}</i>	<i>IR or IL, HA, LR</i>			<i>The LR is only required when the T/C is served by group of cylinders > 2500 kW. SH may replace LR for electric power generating engines</i>
7.0 Hydraulic oil system	<i>Leakage from jacketed high pressure pipes for hydraulic operation of valves</i>	<i>A</i>			<i>Level monitoring of leakage tank or equivalent</i>
8.0/9.0 engine speed/direction of rotation	<i>Engine speed</i>	<i>IR</i>			<i>For engines other than for electric power generation, local indication is an acceptable alternative</i>
	<i>Over speed protection</i>			<i>SH</i>	
10.0 Crankcase explosive condition ⁶⁾⁷⁾	<i>Oil mist detection ⁸⁾</i>	<i>HA</i>		<i>SH</i>	<i>One oil mist detector having two independent outputs for detecting alarm and shut- down is acceptable.</i>
	<i>Other systems than oil mist detection</i>	<i>LR</i>		<i>SH</i>	<i>LR is accepted as alternative to SH for auxiliary engines other than driving generators</i>
11. Misfire ⁹⁾	<i>Detection of misfire</i>	<i>A, LR</i>		<i>SH¹⁰⁾</i>	

<i>System</i>	<i>Item</i>	<i>Gr 1 Indication alarm load reduction</i>	<i>Gr 2 Automatic start of stand-by pump with alarm ¹⁾</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comment</i>
<i>Gr 1</i> = Sensor(s) for indication, alarm, load reduction (common sensor permitted but with different set points and alarm shall be activated before any load reduction) <i>Gr 2</i> = Sensor for automatic start of standby pump <i>Gr 3</i> = Sensor for shut down. <i>IL</i> = Local indication (presentation of values), in vicinity of the monitored engine component or system <i>IR</i> = Remote indication (presentation of values), in engine control room or another centralized control station such as the local platform/manoeuvring console <i>A</i> = Alarm activated for logical value <i>LA</i> = Alarm for low value <i>HA</i> = Alarm for high value <i>AS</i> = Automatic start of standby pump with corresponding alarm <i>LR</i> = Load reduction, either manual or automatic, with corresponding alarm <i>SH</i> = Automatic shut down with corresponding alarm. For definitions of Load reduction (LR) and Shut down (SH), see Pt.4 Ch.1. 1) To be provided when stand-by pump is required. 2) Individual exhaust temperature when cylinder power > 130 kW. 3) Alarm with request for load reduction to be given in case of excessive average exhaust gas temperature. This applies when there is no separate sensor before T/C, and the T/C is served by a group of cylinders > 1000 kW. The alarm level shall be set with due considerations to safe operation of T/C. 4) Applicable only when the T/C is served by a group of cylinders > 1000 kW and if no individual exhaust gas temperature for each cylinder. The alarm level shall be set with due considerations to safe operation of T/C. 5) Temperature measurement after turbine is accepted for T/C served by a group of cylinders < 2500 kW, provided that the alarm levels are set to safeguard the T/C. The alarm level shall be substantiated by the T/C manufacturer. 6) Either a) 'Oil mist concentration' or b) 'Temperature monitoring of main- and crank bearings combined with crank case pressure monitoring'. Other methods, like e.g. 'crank case pressure monitoring' combined with either 'Oil splash temperature deviation' or 'Metal particle detection' (shunt to filter), may be approved provided their capability with regard to risk of false alarms and speed of detection is proven. 7) Applicable to engines of 2250 kW and above, or with cylinder diameter > 300 mm. 8) Oil mist detectors shall be type tested in accordance with IACS UR M67. 9) Example: Exhaust gas temp after each cylinder, deviation from average 10) One device detecting alarm and shut-down is acceptable. Failure of the device shall be monitored and alarmed. <i>Italic text in table is equivalent to Pt.4 Ch.3 Sec.1 Table 10</i>					

Table 9 Control and monitoring of auxiliary turbines

<i>System</i>	<i>Item</i>	<i>Gr 1 Indication Alarm</i>	<i>Gr 2 Automatic start of stand-by pump with alarm</i>	<i>Gr 3 Shut down with alarm</i>	<i>Comment</i>
1.0 Lubricating oil	<i>Inlet pressure (after filter)</i>	<i>IR or IL, LA</i>		<i>SH</i>	

System	Item	Gr 1 Indication Alarm	Gr 2 Automatic start of stand-by pump with alarm	Gr 3 Shut down with alarm	Comment
	Inlet temperature	IR, HA			
	Level in system tank	LA			
2.0 Turbine speed	Overspeed			SH	SH, if applicable, to be activated automatically, see Pt.4 Ch.3 Sec.3 [5.2]
3.0 Condenser system	Pressure	IR, HA,		SH	
	Level	HA	AS		If vacuum condenser.
4.0 Steam inlet	Pressure	IR or IL, LA ¹⁾			
5.0 Rotor	Axial displacement	IR, HA		SH	When driving electric generator.
Gr 1 = Sensor(s) for indication and alarm Gr 2 = Sensor for automatic start of standby pump Gr 3 = Sensor for shut down IL = Local indication – (presentation of values) in vicinity of the monitored component IR = Remote indication – (presentation of values) in engine control room or another centralized control station such as the local platform/manoeuvring console A = Alarm activated for logical value LA = Alarm for low value HA = Alarm for high value AS = Automatic start of standby pump with corresponding alarm SH = Shut down with corresponding alarm. For definitions of Load reduction (LR) and Shut down (SH), see Pt.4 Ch.1. 1) Only for turbines driving generators, may be omitted if LA for boiler steam pressure is provided. <i>Italic text in table is equivalent to Pt.4 Ch.3 Sec.3 Table 7</i>					

Table 10 Control and monitoring of auxiliary boiler

	Alarm
1.0 Condenser	
Condenser pressure	HA
2.0 Uptake	
Uptake temperature ¹⁾	HA
1) When heat exchangers are integral with the boiler. For fire detection.	

Note: In addition to the monitoring requirements in Pt.4 Ch.7 Sec.6 Table 2 and Pt.4 Ch.7 Sec.6 Table 6, auxiliary boilers shall be provided with monitoring according to Table 10 above.

Table 11 Control and monitoring for electrical power plant

	<i>Gr 1</i> <i>Alarm</i>
1.0 Generator	
Lubricating oil, pressure ¹⁾	LA
Voltage	LA, HA
Frequency	LA
Disconnection of nonessential consumers	A
<i>Gr1</i> = Sensor for alarm <i>LA</i> = Alarm for low value <i>HA</i> = Alarm for high value <i>A</i> = Alarm activated 1) To be provided if separate system.	

Table 12 Monitoring of miscellaneous objects

<i>Item</i>	<i>Alarm</i>	<i>Comments</i>
Bilges and bilge wells		2 independent alarm circuits. Minimum 2 detectors.
Level, engine room, high	x	
Purifiers		For heavy fuel oil.
Temperature, oil inlet, high	x	
Temperature, oil inlet, low	x	
Waterseal, loss	x	
Soot-blowers, sequence stopped	x	
Automatic control system, power failure	x	Electric, pneumatic, hydraulic.
Alarm and safety system, power failure	x	
Remote control system, power failure	x	
Fire alarm systems, failure	x	

Table 13 Monitoring of tanks

<i>Item</i>	<i>Alarm</i>	<i>Comments</i>
Sludge and drain tanks, level, high	x	When automatic pumping up of tanks is arranged, alarm shall be released if the level exceeds safe level.
Service tanks, level, low	x	
Expansion tanks, level, low	x	
Circulating tanks, level, low	x	

Item	Alarm	Comments
Fuel oil drain collecting tank, level, high	x	

3.2 Arrangement on the bridge

3.2.1 General

3.2.1.1 Individual alarms are required for:

- automatic shutdown of main boiler
- automatic shutdown and/or slowdown of propulsion machinery
- request for manual shutdown and/or slowdown of propulsion machinery
- power failure bridge alarm system
- failure in the remote control systems with respect to propulsion machinery, including controllable pitch propeller if arranged
- failure in the remote control systems with respect to steering
- low starting air pressure for reversible propulsion engines.

3.2.1.2 The propulsion plant shall be restarted after a blackout, either manually from the navigation bridge or automatically. When manual starting from the navigation bridge is arranged, an indication shall be provided when the propulsion can be restarted, i.e., when all systems are in normal operating condition.

The starting arrangement shall be simple to operate.

Guidance note:

Steam propulsion plants are exempted from these requirements.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.2.1.3 Resetting of the propulsion machinery safety system shall be arranged when it is activated at black out. The reset action may either be automatic, or manually activated from the bridge, e.g. by bringing the manoeuvring lever to stop position. The reset shall only be possible when all the applicable parameters are in normal condition.

3.3 Arrangement in the engine room

3.3.1 General

3.3.1.1 Indicating instruments, alarm displays and manoeuvring devices shall be centralised in a convenient position, in or adjacent to the engine room.

Guidance note:

The layout of instruments in the control desk should comply with generally accepted ergonomical principles. Red lamps should be used only as alarm lamps.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.4 Control of propulsion machinery from the navigation bridge (SOLAS Ch. II-1/49)

3.4.1 General

3.4.1.1 In addition to the general requirements in [Pt.4 Ch.1](#) the following shall be complied with.

3.4.1.2 Under all sailing conditions, including manoeuvring, the speed, direction of thrust and, if applicable the pitch of the propeller shall be fully controllable from the navigation bridge.

3.4.1.3 Such remote control shall be performed by a single control device for each independent propeller, with automatic performance of all associated services, including where necessary, means of preventing overload of the propulsion machinery.

3.4.1.4 The main propulsion machinery shall be provided with an emergency stopping device on the navigation bridge independent of the navigation bridge control system.

3.4.1.5 Propulsion machinery orders from the navigation bridge shall be indicated in the main machinery control room or at the propulsion machinery control position as appropriate.

3.4.1.6 Remote control of the propulsion machinery shall be possible only from one location at a time; at such locations interconnected control positions are permitted. At each location there shall be an indicator showing which location is in control of the propulsion machinery. The transfer of control between the navigation bridge and machinery space shall be possible only in the main machinery space or in the main machinery control room. The system shall include means to prevent the propelling thrust from altering significantly when transferring control from one location to another.

3.4.1.7 It shall be possible for all machinery essential for the safe operation of the ship to be controlled from a local position, even in the case of failure in any part of the automatic or remote control systems.

3.4.1.8 The design of the remote automatic control system shall be such that in case of its failure an alarm will be given, and the present speed and direction of thrust of the propeller is maintained until local control is in operation.

3.4.1.9 Indicators shall be fitted on the navigation bridge for:

- a) propeller speed and direction of rotation in the case of fixed pitch propellers, or
- b) propeller speed and pitch position in the case of controllable pitch propellers.

3.4.1.10 The number of consecutive automatic attempts which fail to produce a start shall be limited to safeguard sufficient starting air pressure. An alarm shall be provided indicating low starting air pressure set at a level which still permits starting operations of the propulsion machinery.

Guidance note:

Air should be understood as any stored energy.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.5 Electric power supply

3.5.1 General

3.5.1.1 Arrangements shall be provided to prevent overloading of the generating sets.

Guidance note:

A generating set consists of one electrical generator and its prime mover.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.5.1.2 Standby generating sets shall to have separate cooling water and lubricating oil pumps. Alternatively, automatic start of standby pumps shall be arranged when they also serve other generating sets.

3.5.2 Secondary distribution systems

3.5.2.1 For essential consumers with power supply from secondary distribution systems, precautions against power failure shall be similar to those taken for units having power supply from the main system. E.g., the following means may be applied:

- adequate automatic emergency lighting for access to standby transformer for the lighting system and operating gear for manual connection
- automatic connection of standby transformer
- parallel connection of a sufficient number of transformers and arrangement for selective disconnection
- automatic connection of emergency source of power
- dividing the system in two or more circuits with automatic switchover.

In this context, essential consumers are units and equipment necessary for manoeuvring of the ship, including navigation lights and sufficient lighting (either as part of the normal lighting or as separate emergency lighting) in the engine room, on the bridge, in the chart room, in all passageways and stairways of the accommodation.

3.6 Fire safety

3.6.1 General

3.6.1.1 Where the Society finds it necessary, oil fuel and lubricating oil pressure pipelines shall be shielded or otherwise suitably protected to avoid as far as practicable oil spray or leakages on to hot surfaces or into machinery air intakes. Fuel oil injection pipes on all engines, irrespective of cylinder bore, shall be effectively shielded and secured. The number of joints in such piping systems shall be kept to a minimum and, where practicable, leakages from high pressure oil fuel pipes shall be collected, and safe drainage to a collecting tank shall be provided (see [Pt.4 Ch.3 Sec.1 Table 9](#) and [Pt.4 Ch.3 Sec.1 Table 10](#)).

3.7 Special requirements for ships less than 300 gross tonnage with propulsive output less than 1000 kW per engine

3.7.1 General

3.7.1.1 The requirements in [\[3.1\]](#), [\[3.2\]](#), [\[3.3\]](#), [\[3.5\]](#) and [\[3.6\]](#) do not apply.

3.7.2 Extent of monitoring

3.7.2.1 An alarm shall be initiated for the following conditions:

- fire in engine room
- bilge level, high
- power failure, alarm and remote control system
- for drivers, power transmissions and driven units according to [Pt.4 Ch.3](#), [Pt.4 Ch.4](#) and [Pt.4 Ch.5](#).

Main and auxiliary engines: See [Pt.4 Ch.3](#).

3.7.3 Arrangement on the bridge and engineers' accommodation

3.7.3.1 All alarms in the engine room shall initiate an alarm on the navigation bridge, and engineers' accommodation individual or collective.

3.7.4 Fire safety

3.7.4.1 Fuel oil injection pipes on all engines, irrespective of cylinder bore, shall be effectively shielded and clamped.

3.7.5 Fire alarm system

3.7.5.1 The ship shall have a fire alarm system that shall be initiated in the event of fire in the engine room and or boiler room.

Guidance note:

The fire detectors may be arranged as a single loop provided it is normally closed.

The fire detectors loop(s) may be connected to the machinery alarm system provided separate indication on the navigation bridge is arranged.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4 Class notation ECO

4.1 General requirements

4.1.1 Application

4.1.1.1 This section applies to machinery operation with continuous supervision from a centralised control station. The control station shall provide control and monitoring devices necessary to make the machinery operation as safe and effective as it would be under direct supervision.

4.2 Control station

4.2.1 Arrangement

4.2.1.1 The arrangement shall be such that all supervision and manual operations which are necessary for safe operation of the machinery plant can be carried out at the control station. This will imply that stopping of machinery, starting of stand-by units etc. in case of machinery faults shall be possible from the control station if not automatically carried out.

4.2.1.2 The control station shall be located in the engine room or in its close proximity. The control station may be arranged on or adjacent to navigation bridge provided it does not interfere with the navigation bridge control positions, and an additional centralised control position is arranged in or adjacent to the engine room. This control position shall permit some machinery control and monitoring facilities as required in [4.1.1].

4.3 System arrangement

4.3.1 General

4.3.1.1 The requirements of [2] shall be complied with to the extent applicable.

4.3.2 Alarm system

4.3.2.1 A system of alarm displays shall be provided in the centralised control station for easy identification of machinery faults.

4.3.2.2 An extension alarm system and a watch responsibility transfer system to the navigation bridge and the engineers' accommodation is not required.

4.3.3 Safety system

4.3.3.1 The safety systems specified in [2.4] can be omitted with the exception of the safety functions required in Pt.4. Corrective actions at machinery faults are presumed to be carried out manually.

4.3.4 Remote control system

4.3.4.1 Propulsion machinery shall be arranged for remote control from the centralised control station. The requirements given in [2] and Pt.4 Ch.1 Sec.4 shall be complied with to the extent applicable.

4.3.5 Fire alarm system

4.3.5.1 The fire alarm system shall satisfy the requirement of [2.5].

4.4 Extent of monitoring

4.4.1 General

4.4.1.1 Monitoring of machinery shall comply with the requirements in [3] and Pt.4 Ch.3, Pt.4 Ch.4 and Pt.4 Ch.5.

5 Survey

5.1 General

5.1.1 Trials

5.1.1.1 Upon completion of the installation, trials shall be carried out alongside quay and at sea in the presence of the surveyor for **E0** and **ECO** notations. The test in [5.1.8] for the extension alarm system is not applicable for the **ECO** notation.

5.1.1.2 The sea trials should be reserved solely for testing of the automatic and the remote control systems, and the fire alarm system. Other tests should be completed alongside quay.

5.1.1.3 The sea trials shall include a four hours continuous operation with unattended machinery spaces. Agreement shall be made in advance in each case for personnel that will be present in the control room.

Guidance note:

The four hour test may be combined with the endurance test of the engines.

Personnel for ordinary upkeep and control of the machinery are not to be present in the engine room. Special measurements can be carried out according to agreement, e.g. noise measurements.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.1.1.4 A detailed test programme, including expected test results, shall be prepared and submitted for approval prior to the trials. The programme shall be kept on board, all filled in and signed by the surveyor upon completion of the trials.

5.1.1.5 Recording of important automatically controlled parameters may be required as part of the testing.

5.1.2 Monitoring system

5.1.2.1 Alarms and safety actions as required by these rules shall be tested. Failure conditions shall be simulated as realistically as possible, preferably by letting the monitored parameters exceed the alarm and safety limits.

5.1.3 Black out recovery

5.1.3.1 It shall be tested that, after a black-out and subsequent automatic restoration of power, the propulsion and steering function can be restored from the bridge without manual intervention in the engine room.

5.1.4 Fire detection- and alarm system

5.1.4.1 After installation, the fire detection and fire alarm system shall be tested under varying conditions of engine operation and ventilation.

(SOLAS Ch. II-2/14.3).

Guidance note:

The test should be performed with all machinery and ventilation running in normal sea going conditions during the sea trial by means of smoke released in positions of high fire risk.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.1.5 Remote propulsion control systems

5.1.5.1 Testing of the remote control system for the propulsion machinery shall be carried out at sea. Prior to testing, the propulsion machinery shall run for at least 1 hour.

5.1.5.2 All tests included in the test programme for the remote control system shall be carried out without manual assistance from the engine room, and all systems shall be in operation as normal for unattended machinery space.

5.1.5.3 The remote control system shall be tested at sea to demonstrate stable control and operation of the propulsion system with its necessary auxiliaries over the full operating range, and regardless of the type of propulsion. It shall be demonstrated that necessary ramping / controller functions are implemented to ensure that any operation of the manoeuvring levers do not cause shutdown, instability or damage to the propulsion machinery or power generating units.

The different tests described below may be seen as the expected functional test scope for certain propulsion remote control systems, but other equivalent tests may be more appropriate depending on the actual installation on board.

Guidance note:

- 1) Ships with fixed pitch propeller
 - a) The test programme should as a minimum include the following manoeuvres:
 - i) from stop to dead slow ahead. Proceed stepwise to full ahead. Before each step increase, the r.p.m. of the previous setting shall have reached its steady state condition
 - ii) from approximately 2/3 of full speed ahead, go quickly to slow astern. Proceed stepwise to full astern
 - iii) stop
 - iv) after approximately 5 minutes stop, start ahead
 - v) when the ship has reached approximately 2/3 of full speed ahead, go quickly to half astern
 - vi) when the ship has reached approximately 2/3 of full speed ahead, go quickly to dead slow ahead
 - vii) when the r.p.m. is nearly stabilized, go quickly to full ahead
 - viii) when the ship has reached approximately half speed ahead, go to stop and back to dead slow ahead within 1 second.

- b) With air compressors stopped, make 12 starts with the remote control system, alternating between ahead and astern. This applies to reversible engines using starting air for re-start.
 - c) Testing of possible automatic restarts. Go to ahead and let the engine repeat the predetermined starting attempts. Go to stop. Return to ahead and check that an additional starting attempt is affected. This applies to diesel engines only.
 - d) Simulate failures causing automatic load reduction or stop of the engine. Cancel if possible this safety action and show that the engine is again controllable from the bridge.
 - e) During bridge control at half speed ahead, cut out power supply to the remote control system. No immediate critical situation shall arise. Switch over to standby manual control in the engine room, and show that this control system functions satisfactorily.
 - f) At approximately 2/3 of full speed ahead, test the emergency stop system.
- 2) Ships with controllable pitch propeller
- a) The tests specified below apply to remote control systems with a single manoeuvring lever on the bridge. For plants with dual lever control, one for r.p.m. and one for pitch, the tests to be carried out will be considered in each case.
 - i) start the engine, from the bridge if possible, and go to dead slow ahead. Proceed stepwise to full ahead. Before each step increase, the r.p.m. of the previous setting shall have reached its steady state condition
 - ii) from approximately 2/3 of full speed ahead, go quickly to dead slow astern. Proceed stepwise to full astern
 - iii) go to neutral position
 - iv) after approximately 5 minutes in neutral position, go to ahead
 - v) when the ship has reached approximately 2/3 of full speed ahead, go quickly to 2/3 of full astern
 - vi) when the ship is «dead in the water», go quickly to half ahead.
 - b) Simulate failures causing automatic load reduction or stop of the engine. Cancel if possible this safety action and show that the engine is again controllable from the bridge.
 - c) During bridge control at half speed ahead, cut out power supply to the remote control system. No immediate critical situation shall arise. Switch over to standby manual control in the engine room, and show that this control system functions satisfactorily.
 - d) At approximately 2/3 of full speed ahead, test the emergency stop system
- 3) Steam turbine ships
- a) The test programme should as a minimum include:
 - i) from stop to dead slow ahead. Proceed stepwise to full ahead. Before each step increase, the r.p.m. of the previous setting shall have reached its steady state condition
 - ii) from full speed ahead, reduce stepwise to stop with the same intervals
 - iii) from stop, increase stepwise to full astern. Run until the ship has reached a fair speed astern
 - iv) from full astern, reduce stepwise to stop
 - v) show that the automatic turning arrangement operates satisfactorily during the stop period. Go to full ahead
 - vi) after approximately 10 minutes full ahead, go quickly to stop
 - vii) after approximately 5 minutes stop, go quickly to 2/3 of full astern
 - viii) when the ship is «dead in the water», go quickly to full ahead
 - ix) when the ship has reached approximately 2/3 of full speed ahead, go quickly to 2/3 of full astern and run until the ship is «dead in the water»
 - x) go to full ahead. When the ship has reached approximately 2/3 of full speed ahead, go to stop and back to dead slow ahead within 1 second. Transfer control to the engine room.
 - b) Repeat the first four manoeuvres using the manoeuvring system in the engine room. Transfer control to the bridge.
 - c) During bridge control at half speed ahead, cut out power supply to the remote control system. No immediate critical situation shall arise. Switch over to standby manual control in the engine room, and show that this control system functions satisfactorily.
 - d) Simulate failures causing automatic load reduction or stop of turbines. Cancel, if possible, this safety action and show that the turbines are again controllable from the bridge.

- e) At approximately 2/3 of full speed ahead, test the emergency stop system.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.1.6 Main alarm system

5.1.6.1 All functions of the main alarm system shall be tested.

5.1.7 Watch responsibility transfer system

5.1.7.1 All functions of the watch responsibility transfer system shall be tested

5.1.8 Extension alarm system

5.1.8.1 For **E0** notation, all functions of the extension alarm system shall be tested

SECTION 3 FUEL CELL INSTALLATIONS - FC

1 General

1.1 Introduction

The additional class notations **FC(Power)** and **FC(Safety)** apply to fuel cell installations on-board ships, thus contributing to a global reduction in known air pollutants, whilst adding support to environmental specific pollution reduction methods such as hydrodynamic, wind and geothermal. Fuel cells do not need an environment specific location to work well, are highly efficient, and produce much less harmful air pollutants. Typical fuels that may be relevant are natural gas, methanol, propane, hydrogen or diesel fuels. Bio- fuels will be subject to special consideration. In this section, only the gaseous fuels as well as liquid fuels with flashpoint below 60 degrees C are regarded as "FC fuel". Liquid fuels with flashpoint above 60 degrees should follow requirements for normal fuel in [Pt.4 Ch.6](#).

1.2 Scope

The scope of additional class notations **FC(Power)** and **FC(Safety)** is to add an additional level of safety, related to air pollutants. These rules are applicable for installations with a variety of gaseous and liquid fuels, such as natural gas and diesel fuels, respectively. Since the fuel cell technology is still under development, the requirements of this section may have to be supported by alternative additional requirements, considered on case by case basis. See [Pt.4 Ch.1 Sec.1 \[1.1.3\]](#). Survey requirements for ships with class notation **FC(Power)** and **FC(Safety)** can be found in [Pt.7 Ch.1 Sec.2](#) and [Pt.7 Ch.1 Sec.3](#).

1.3 Application

Ships that satisfy the design requirements given in this section, where the fuel cell power is used for essential, important or emergency services, may be assigned the additional class notation **FC(Power)**.

Ships that satisfy the design requirements given in this section, where the fuel cell power is not used for essential, important or emergency services, shall satisfy the safety and environmental requirements. Installations complying with the requirements in this section, except [\[3.2\]](#) may be assigned class notation **FC(Safety)**.

1.4 Classification

1.4.1 Class notation

1.4.1.1 Ships where the fuel cell power is used for essential, important or emergency services shall satisfy the requirements in this rule section and will be given class notation **FC(Power)**.

1.4.1.2 Ships where the fuel cell power is not used for essential, important or emergency services shall satisfy the safety and environmental requirements. Installations complying with the requirements in this section, except [Sec.2](#) will be given class notation **FC(Safety)**.

1.4.2 Survey extent

1.4.2.1 Survey requirements for ships with class notation **FC(Power)** and **FC(Safety)** can be found in [Pt.7 Ch.1 Sec.2](#) and [Pt.7 Ch.1 Sec.3](#).

1.5 Definitions

1.5.1

Table 1 Definitions

<i>Term</i>	<i>Definition</i>
<i>Accommodation spaces</i>	See SOLAS Ch.II-2 Reg.3.
<i>Active components</i>	Defined in Pt.4 Ch.1.
<i>Control stations</i>	See SOLAS Ch.II-2 Reg.3.
<i>Double block and bleed valve</i>	A set of three automatic valves located at the FC fuel supply to each of the fuel cells. Two of these valves shall be in series in the FC fuel pipe to the consuming equipment. The third valve shall vent that portion of the FC fuel piping that is between the two valves in series to a safe location. Alternatively, the function of one of the valves in series and the vent valve can be incorporated into one valve body, so arranged that the flow to the FC fuel consuming unit will be blocked and the vent opened.
<i>Emergency service</i>	Defined in Pt.4 Ch.8 Sec.13.
<i>Enclosed spaces</i>	Spaces bounded by bulkheads and decks which may have doors, windows or other similar openings.
<i>ESD</i>	Emergency shutdown.
<i>Essential service is</i>	Defined in Pt.4 Ch.8 Sec.13.
<i>FC fuel</i>	Can be gases or liquids, for instance methane or natural gas, methanol, propane or hydrogen. In this context only the fuels which are gases or have low flash point are covered by the special requirements for FC fuel. Requirements to regular fuel oil and other support system are covered by the requirements in Pt.4 Ch.6.
<i>FC means fuel cell.</i>	A fuel cell is a source of electrical power in which the chemical energy of a fuel is converted directly into electrical energy by electrochemical oxidation.
<i>FC system</i>	The complete installation of FC fuel containment, FC fuel piping and the fuel cell itself with surrounding machinery, electrical and automation systems, i.e. the complete system required to transfer the energy of the fuel to electric power. A fuel cell installation may consist of one or more FC systems.
<i>Fuel cell space</i>	In this section used for machinery spaces containing fuel cell installations.
<i>Gas</i>	Defined as a fluid having a vapour pressure exceeding 2.8 bar absolute at a temperature of 37.8°C.
<i>Gas safe spaces</i>	Spaces with arrangements such that the spaces are considered gas safe under all conditions, normal as well as abnormal conditions, i.e. inherently gas safe. In a gas safe space a single failure cannot lead to release of fuel gas into the space.
<i>Hazardous area</i>	Area in which an explosive gas atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of apparatus. Guidance note: The definition of hazardous area is only related to the risk of explosion. In this context, health, safety and environmental issues, i.e. toxicity, are not considered. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

<i>Term</i>	<i>Definition</i>
<i>High pressure piping</i>	In this context piping with maximum working pressure above 10 bar.
<i>Important service</i>	Defined in Pt.4 Ch.8 Sec.13 .
<i>LEL</i>	Lower explosion limit.
<i>Low flashpoint liquids</i>	Liquids with a flashpoint below 60°C.
<i>Main tank valve</i>	A remote operated valve on the FC fuel outlet from a FC fuel storage tank, located as close to the tank outlet point as possible.
<i>Master fuel valve</i>	An automatic valve in the FC fuel supply line to each fuel cell located outside the FC space and as close to the fuel storage as possible.
<i>Non-hazardous area</i>	Area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of apparatus
<i>Safe location</i>	Location on open deck remote from any source of ignition where flammable gas, vapour or liquid can be released to the atmosphere and are expected to be diluted by natural ventilation. Safe locations shall be arranged in such a manner that released flammable gas, vapour or liquid are not ventilated in other areas where potential sources of ignitions are present.
<i>Semi-enclosed spaces</i>	Locations where natural conditions of ventilation are notably different from those on open decks due to the presence of structures such as roofs, wind breakers and bulkheads and which are so arranged that dispersion of gas may not occur.
<i>Service spaces</i>	Spaces outside the cargo area used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store rooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.
<i>Sources of release</i>	Valves or detachable pipe joints in the FC fuel system. Also compressors and seals of pumps in the FC fuel system are regarded as sources of release.
<i>Zones</i>	Hazardous areas are classified into zones based upon the frequency of the occurrence and duration of an explosive gas atmosphere, as follows:
<i>Zone 0</i>	Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.
<i>Zone 1</i>	Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.
<i>Zone 2</i>	Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

1.6 Documentation

1.6.1 Plans and particulars

1.6.1.1 Special components, equipment or systems not covered in the different parts of the existing rules may be required to be documented. Documentation requirements for such components and equipment will be subject to special consideration.

1.6.1.2 Documentation shall be submitted as required by [Table 2](#).

Table 2 Documentation requirements for class notation FC(Power) and FC(Safety)

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Fuel cell installation	Z030 – Arrangement plan	Giving location of: — machinery and boiler spaces, accommodation, service and control station spaces — FC fuel tanks and FC fuel containment systems — FC fuel pump and compressor rooms — FC fuel piping with shore connections — tank hatches, ventilation pipes and any other openings to the FC fuel tanks — ventilating pipes, doors and openings to FC fuel pump rooms, compressor rooms and other hazardous areas — entrances, air inlets and openings to accommodation, service and control station spaces — purge lines and safety blow-off lines of gaseous fuels	FI
	G080 – Hazardous area classification drawing		AP
	H030 - Tank and capacity plan	Including FC fuel containment systems.	AP
	S010 – Piping diagram (PD)	FC fuel, including shore connections	AP
	G060 - Structural fire protection drawing		AP
	Z072 – Safety description	The safety aspects in this connection are for instance explosion hazards, fire effects from the fuel cell itself or from the fuel cell support systems. If a fuel cell is connected to the grid any potential hazards affecting the ship's total power system should be included	AP
	Z030 – Arrangement plan	arrangement drawings of the fuel cell including dimensions, materials, operating temperatures, pressures, weights	FI
Fuel cell	Z060 – Functional description	including — fuel cell principles — specification of FC module outer surface temperature. — voltage and current levels in different parts of the cell type of fuels — maintenance plan (replacement of stack etc.) earthing principles — short circuit contribution capability — documentation of life time and availability, e.g. deterioration rate curve or similar.	FI

Object	Documentation type	Additional description	Info
	Z071 – Failure mode and effect analysis (FMEA)	A failure mode and effect analysis (FMEA) examining all possible faults affecting the processes in the fuel cells shall be submitted for approval, together with a test program for verification of the main conclusions from the FMEA. – The power deterioration rate for the fuel cell shall be documented through analysis or test results, and shall consider different power levels and different modes of operation.	AP
	Z252 – Test procedure at manufacturer	The test programme can be based on the IEC standard 62282-3-1 "Stationary fuel cell power systems- Safety", but shall also have to take the environmental and operating conditions in a ship into account.	AP
	Z253 – Test procedure for quay and sea trial		
	C010 – Design criteria	– design pressure – design temperature – volume(s) – fluid(s) – additional loads, if applicable – proposed set pressure of safety valve – pressure vessel class	FI
Fuel cell - pressure containing components	C020 – Assembly or arrangement drawing	Including valves and fittings.	FI
	C030 – Detailed drawing	Including attachments and supports.	AP
	C040 – Design analysis		AP
	C050 – Non-destructive testing (NDT) plan		AP
	S010 – Piping diagram (PD)	Plans of the following piping systems shall be submitted for approval: – FC fuel piping – vent lines of safety relief valves or similar piping – cooling/ heating water system in connection with FC fuel system if fitted – drawings and specifications of insulation where such insulation is installed – specification of electrical bonding of piping – specification of heat tracing arrangements if fitted.	AP
Fuel cell - piping	S090 – Specification of piping, valves, flanges and fittings		AP
	Z162 – Installation manual	program for functional tests of all piping systems including valves, fittings and associated equipment for handling FC fuel (liquid or vapour)	AP
	P020 – Sizing calculations	for safety relief valves and pressure/vacuum relief valves	AP

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
	S012 – Ducting diagram (DD)	Plans of the following equipment and systems with particulars shall be submitted: – arrangements and specifications of mechanical ventilation systems in spaces covering FC fuel systems, giving capacity and location of fans and their motors. For fans and ventilators; drawings and material specifications of rotating parts and casings – arrangement and specifications of piping systems for gas freeing and purging of FC and piping – for fixed gas detection and alarm systems: specification and location of detectors, alarm devices and call points, and cable routing layout drawing – bilge and drainage arrangements in FC module, if applicable – air inlet arrangement including filters – exhaust arrangement	AP
Fuel Cell spaces – ventilation	S030 – Capacity analysis		AP
	C030 – Detailed drawing	Rotating parts and casing of fans.	AP
	I200 – Control and monitoring system documentation		AP
Fuel Cell spaces – gas detection and alarm system, fixed	Z030 – Arrangement plan	Detectors, call points and alarm devices.	AP
	G060 – Structural fire protection drawing		AP
Fuel Cell spaces – fire protection	G200 – Fixed fire extinguishing system documentation		AP
	I200 – Control and monitoring system documentation		AP
Fuel Cell spaces – fire detection and alarm system	Z030 – Arrangement plan	Detectors, call points and alarm devices.	AP
	G080 – Hazardous area classification drawing	location of electric equipment in hazardous area shall be shown with cross reference to E090	AP
Fuel Cell – electrical installation	E090 – Table of Ex-installation		AP
	Z163 – Maintenance manual	for electrical installations in hazardous areas	FI
	E130 – Electrical datasheet,	Semiconductor assemblies, A typeapproval certificate from the Society is accepted as an alternative to the datasheet.	FI
	E110 – Cable data sheet and design drawing	If not type approved by the Society	AP

Object	Documentation type	Additional description	Info
	E220 – Electrical system philosophy	Ships with notation FC(Power) documentation showing that the electrical power system's overall properties are in compliance with Pt.4 Ch.8 shall be submitted. Such documentation may be in the form of system descriptions, system analysis and/or test programs/reports, covering: – voltage and frequency variations during steady state and transient modes – description of current DC components generated by the FC – black out and dead ship recovery required in [2.1.1] – active and reactive load capacities – configuration of the system in all operating modes and subsequent power distribution philosophy for different vessel systems or services (essential, important and emergency services) – system behaviour in relevant failure modes. – the reliability and availability shall be documented through analysis, complemented with results from development testing, as well as full scale testing.	FI
	Z071 – Failure mode and effect analysis (FMEA)	Ships with notation FC(Power) a failure mode and effect analysis for the control, monitoring and safety systems for the whole installation including the support and supply systems shall be submitted for approval, together with a test program for verification of the main conclusions from the FMEA.	AP
Fuel Cell – control and monitoring	I010 – Control system philosophy		FI
	I020 – Control system functional description		FI
	I030 – System block diagram (topology)		AP
	I050 – Power supply arrangement		AP
	I070 – Instrument and equipment list	safety devices with set points	FI
	I080 – Data sheet with environmental specifications	documentation of compliance with environmental conditions as outlined in Pt.4 Ch.1 , including calculations or test reports	AP
	I260 – Field instruments periodic test plan		AP
	I140 – Software quality plan		FI
	I090 – Schematic description of input and output circuits		AP
	S011 – Piping and instrumentation diagram (P & ID)		AP

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
	Z252 - Test procedure at manufacturer		AP
	Z163 - Maintenance manual		FI
Fuel Cell - Manuals	Z161 - Operation manual	— bunkering procedure — gas freeing and inerting procedures — normal operation procedures of the FC system — emergency operation procedures of the FC system — FC deterioration rate curves.	FI
	Z253 - Test procedure for quay and sea trial		AP
Fuel Cell - testing	Z253 - Test procedure for quay and sea trial		AP
AP = For approval; FI = For information			

1.6.1.3 For general requirements to documentation, including definition of the info codes, see [Pt.1 Ch.3 Sec.2](#).

1.6.1.4 For a full definition of the documentation types, see [Pt.1 Ch.3 Sec.3](#).

1.7 Certification

Equipment shall be certified as listed in [Table 3](#).

Table 3 Certification requirements

<i>Object</i>	<i>Certificate type</i>	<i>Issued by</i>	<i>Certification standard*</i>	<i>Additional description</i>
Fuel cells system	PC	Society		When < 300 kW and Type Approved by the Society, work certificate (W) will be accepted
Pressure equipment	PC	Society		In accordance with Pt.4 Ch.7
Valves	PC	Society		In accordance with Pt.4 Ch.6 . Hydrogen valves in spaces made gas safe as outlined in [4.4.1] shall be leakage tested with hydrogen.
Pumps and compressors	PC	Society		Ships with FC(Power) notation
Electrical equipment	PC	Society		In accordance with Pt.4 Ch.8 .
Fuel Cell Control and monitoring system	PC	Society		
Flammable Gas detection system	PC	Society		Fixed installations
*Unless otherwise specified the certification standard is Society's rules.				

1.8 Operation and maintenance manuals

1.8.1 Contents

1.8.1.1 An operation manual containing procedures as required in [Table 2](#) shall be kept onboard.

1.8.1.2 A plan for systematic maintenance and function testing shall be kept on-board showing in detail how components and systems shall be tested and what shall be observed during the tests. Columns showing test dates and verification of tests carried out shall be included. The plan shall include:

- all instrumentation, automation and control systems affecting the FC system
- test intervals to reflect the consequences of failure involving a particular system. Functional testing of critical alarms should not exceed 3 month intervals. For non-critical alarms, the longest intervals are not to surpass 12 months.

The plan shall be included in the ship's maintenance system. See [Pt.7 Ch.1 Sec.1 \[3.1.1\]](#).

2 Design principles for FC(Power) notation

2.1 Design principles

2.1.1 General

2.1.1.1 The design shall ensure that any single failure in active components of the FC system shall not lead to loss of propulsion or auxiliary power for essential or important services.

Guidance note:

The fuel cell is defined as an active component.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.1.2 The arrangement of the fuel cell spaces shall be so that a shut down due to a FC fuel leakage cannot lead to loss of propulsion or auxiliary power for essential or important services.

2.1.1.3 If the power from the fuel cell is needed for restoration of power in a black out or dead ship situation, the recovery arrangements have to be documented and approved in each case.

3 Materials

3.1 General

3.1.1 General

3.1.1.1 Materials are in general to be in accordance with the requirements in [Pt.2](#) of the rules.

The materials shall be suitable for the intended application

Use of flammable materials in the FC shall be minimized as far as practicable. The use of flammable materials inside the FC stack requires the approval of the Society. All use of flammable materials outside the FC stack shall be specially justified and accepted by the Society.

3.2 Special requirements for different fuels

3.2.1 Material requirements for hydrocarbon gas

3.2.1.1 Materials used for gas tanks, gas piping, process pressure vessels and other components in contact with hydrocarbon gas shall be in accordance with [Sec.5 \[2\]](#).

3.2.2 Material requirements for hydrogen gas

3.2.2.1 Austenitic stainless steel (e.g. 304, 316, 304L and 316L) shall be used for materials in contact with hydrogen. Other materials compatible for storage and transport of hydrogen may be approved after special consideration.

3.2.2.2 The materials used in hydrogen piping systems shall be furnished with documentation in accordance with [Sec.5 Table 4](#). For testing of tank materials relevant parts of [Pt.5 Ch.7 Sec.6 \[3\]](#) shall be used, and where this is not sufficient special considerations will have to be done.

4 Arrangement and system design

4.1 Location and separation of spaces

4.1.1 Fuel cell spaces

4.1.1.1 Fuel cell spaces shall have as simple geometrical shape as possible. Fuel cell spaces where hydrogen may be present shall have no obstructing structures in the upper part and shall be arranged with a smooth ceiling sloping up towards the ventilation outlet. Support structure like girders and stiffeners shall be facing outwards. Thin plate ceiling to cover support structure under the deck plating is not acceptable.

Guidance note:

Refer to sub-section [\[4.9\]](#) for requirements for the ventilation in fuel cell spaces.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.1.1.2 Location

FC systems shall be located in separate spaces. Installation in conventional machinery spaces is not permitted.

The requirement for a separate space can also be met by a suitable form of enclosure for the components containing or transferring fuel. In such a case, installation in conventional machinery spaces is admissible.

The installation spaces of FC stacks and directly associated components shall be arranged outside of accommodation, service and machinery spaces and control rooms, and shall be separated from such spaces by means of a cofferdam or an A-60 bulkhead.

4.1.2 Tank rooms

4.1.2.1 Tank room boundaries shall be gas tight.

The tank room is not to be located adjacent to machinery spaces of category A. If the separation is by means of a cofferdam then additional insulation to class A-60 standard shall be fitted.

4.1.3 FC fuel compressor room

4.1.3.1 Compressor rooms, if arranged, shall be located above weather deck level, unless especially approved by the Society.

4.1.3.2 Where compressors are driven by shafting passing through a bulkhead or deck, the bulkhead penetration shall be of gas tight type.

4.2 Arrangement of entrances and other openings

4.2.1 General

4.2.1.1 If the compressor room is approved located below deck the room shall have a separate access from deck, not shared with any other spaces.

4.2.1.2 The tank room entrance shall be arranged with a sill height of at least 300 mm.

4.2.1.3 Access to the tank room is as far as practicable to be through a separate access from the deck, not shared with any other spaces. If the tank room is only partially covering the tank, this requirement shall be applied to the room surrounding the tank, and where the opening to the tank room is located. The access trunk shall be fitted with separate ventilation.

If the access to the tank room is from another space in the ship, due consideration shall be made to prevent the possibility of a gas release escaping to non-hazardous areas.

The tank room shall not be open for entrance during normal operation of the FC fuel system

4.2.1.4 Entrances between hazardous and safe spaces in the ship shall be arranged with air locks, see [4.9.2].

4.3 General pipe design

4.3.1 General

4.3.1.1 FC fuel pipes are in general to comply with the applicable parts of Pt.5 Ch.7 Sec.5.

Guidance note:

Applicable parts of Pt.5 Ch.5 Sec.5 are mainly [4], [7.1.1], [8] and [9] for pipe design. The requirement for electrical bonding in Pt.5 Ch.7 Sec.5 [7.2] is applicable for gas pipes.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.3.1.2 FC fuel pipes in spaces made gas safe as outlined in [4.4.1.1] 2) shall not include expansion elements, bellows or other pipe components with poorer strength, fatigue or leakage properties than the fully welded pipe.

4.3.1.3 FC fuel pipes are not to be located less than 760 mm from the ship's side.

4.3.1.4 An arrangement for purging FC fuel bunkering lines and supply lines with nitrogen shall be provided.

4.3.1.5 The FC fuel piping system shall be installed with sufficient flexibility. Bellows will not be accepted in enclosed spaces.

4.3.1.6 The possibility for fatigue problem of the high-pressure FC fuel piping due to vibration caused by the high-pressure FC fuel compressor shall be considered. Such vibrations may be caused by unbalanced forces in the compressor itself, by resonant vibrations in the piping system or by resonance in the FC fuel column of the FC fuel discharge lines. Calculations may be required to verify that resonance problems will not occur.

4.3.1.7 A system for colour marking of all FC fuel pipes shall be used.

4.3.1.8 If a fuel gas contains heavier components that may condensate in the system, knock out drums or equivalent means for collecting the liquid shall be fitted.

4.3.1.9 Pipes shall be connected by butt welding with full penetration.

4.3.1.10 For pipes with external diameters of 25 mm or less screw fittings according to standards which are approved by the Society can be used for this application.

4.3.2 Compressors

4.3.2.1 It shall be possible to switch off the compressors from a permanently accessible point outside the installation space. In addition, the compressor shall be stopped automatically if the outlet pressure is too high or the suction pressure is too low. The compressor shall not be restarted automatically before a manual reset has been carried out.

4.3.2.2 Positive displacement compressors shall be fitted with relief valves routed into the suction line of the compressors. The relief valves shall be so dimensioned that, with the discharge of the compressor in the closed position, the maximum allowable working pressure is not exceeded by more than 10%.

4.3.2.3 Pressure reduction devices shall be so designed that failure of a pressure reduction valve cannot endanger the downstream components. In particular, the pipes downstream of the pressure reducer shall be protected by safety valves or shall be designed to a pressure rating corresponding to the maximum allowable working pressure that is permissible upstream the pressure reducer.

4.4 System configuration

4.4.1 General

4.4.1.1 The presence of FC fuel release sources in a fuel cell space will decide if it is regarded as a hazardous or non-hazardous space. There are two ways to make a fuel cell space with FC fuel piping inside non-hazardous:

- 1) All FC fuel pipes are enclosed in a gas tight double enclosure (duct or pipe) fulfilling the requirements in [4.5.2]. For Hydrogen pipes see [4.5.1].
- 2) All FC fuel pipes that are not inside a double enclosure are fully welded and the ventilation rate in the fuel cell space is sufficient to avoid gas concentration in the flammable range in all leakage scenarios, including pipe rupture. Valves in the FC piping shall be leakage tested for the FC fuel used. In addition the FC space is fitted with gas detection and an automatic shutdown system of the fuel supply, see Sec.7.

Guidance note 1:

If hydrogen valves are located in a space kept non-hazardous in the above manner 2), the valves should be leakage tested with hydrogen. For other FC fuels normal hydrostatic pressure testing with water together with a tightness test with an inert gas as part of the product certification will be sufficient.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

Compensators or other pipe components with poorer strength, fatigue or leakage properties than the fully welded pipe are not accepted in FC fuel piping in a space kept gas safe in the above manner 2).

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.5 FC fuel supply system in fuel cell spaces

4.5.1 General

4.5.1.1 In general the temperature of installations in the fuel cell space shall never be above the self- ignition temperature for the fuel used.

4.5.1.2 Hydrogen pipes are in general to be located in well ventilated spaces, and shall as far as practicable be fully welded. For hydrogen pipes, the double wall principle used to make a surrounding space non-hazardous, is only acceptable pending special consideration from the Society.

4.5.1.3 Heating media for liquefied-gas evaporators or gas preheaters that are routed back into spaces located outside the area of the gas treatment plant shall be passed through degassing containers which are located within the hazardous area.

4.5.2 FC fuel supply systems for gas safe FC spaces with FC fuel piping with double enclosure

4.5.2.1 If double enclosures of FC fuel pipes are used to make a surrounding space non-hazardous the outer pipe or duct shall fulfil one of the following:

- The space between the FC fuel piping and the wall of the outer pipe shall be pressurised with inert gas at a pressure greater than the FC fuel pressure. Suitable alarms shall be provided to indicate a loss of inert gas pressure between the pipes; or
- The air space between the FC fuel piping and the wall of the outer duct shall be equipped with mechanical under-pressure ventilation having a capacity of at least 30 air changes per hour. This ventilation capacity can be reduced to 10 air changes per hour provided automatic filling of the duct with nitrogen upon detection of gas is arranged for. The fan motors shall be placed outside the ventilated pipe or duct. The ventilation outlet shall be covered by a protection screen and placed in a position where no flammable gas-air mixture may be ignited.

4.5.2.2 The complete FC fuel piping in the space shall be covered by the outer pipe or ducting. The arrangement shall facilitate replacement and or overhaul of valves and other components.

4.5.2.3 For high pressure piping the design pressure of the outer pipe ducting shall be taken as the higher of the following:

- the maximum built up pressure: static pressure in way of the rupture resulting from the gas flowing in the annular space, or
- local instantaneous peak pressure in way of the rupture p^* : this pressure shall be taken as the critical pressure and is given by the following expression:

$$p^* = p_0 \left(\frac{2}{k+1} \right)^{\frac{k}{k-1}}$$

p_0 = maximum working pressure of the inner pipe

k = C_p/C_v constant pressure specific heat divided by the specific volume specific heat

k = 1.31 for methane

The tangential membrane stress of a straight pipe is not to exceed the tensile strength divided by 1.5 ($R_m/1.5$) when subjected to the above pressure.

The pressure ratings of all other piping components shall reflect the same level of strength as straight pipes.

As an alternative to using the peak pressure from the above formula, the peak pressure found from representative tests can be used. Test reports shall then be submitted.

4.5.2.4 For low pressure piping the outer pipe or duct shall be dimensioned for a design pressure not less than the maximum working pressure of the FC fuel pipes. The outer pipe or duct is also to be tightness tested.

4.6 FC fuel storage

4.6.1 Location of gas tanks

4.6.1.1 For requirements to gas storage tanks location, [Sec.5](#) applies

4.6.1.2 Hydrogen is not to be stored in enclosed spaces, unless the tank room is arranged with ventilation as given in [\[4.9.5\]](#), electrical equipment certified safe for hydrogen atmosphere, and arrangement of the space and ventilation outlets as given in [\[4.1.1\]](#).

4.6.2 Low flashpoint fuel storage

4.6.2.1 The storage tank for low flashpoint liquids shall be arranged as outlined in [Sec.6](#).

4.7 FC Fuel tank design

4.7.1

For requirements to gas tank design, [Sec.5](#) applies,

4.8 Fuel bunkering system and distribution system outside machinery spaces

4.8.1 Fuel bunkering station

4.8.1.1 The FC fuel bunkering station shall be so located that sufficient natural ventilation is provided. Closed/semi-enclosed bunkering stations will be subject to special consideration.

4.8.1.2 For liquid gas drip trays shall be fitted below the bunkering connections and where leakage may occur. The drip trays shall be made of austenitic stainless steel, and should be drained over the ship's side by a pipe that preferably leads down into the sea. This pipe could be temporarily fitted for bunkering operations. The surrounding hull or deck structures are not to be exposed to unacceptable cooling, in case of leakage of liquid gas.

4.8.1.3 Control of the bunkering shall be possible from a safe location in regard to bunkering operations. At this location tank pressure and tank level shall be monitored. Overfill alarm and automatic shutdown are also to be indicated at this location.

4.8.2 Bunkering system

4.8.2.1 The bunkering system shall be so arranged that no gas is discharged to air during filling of storage tanks.

4.8.2.2 A manually operated stop valve and a remote operated shut down valve in series, or a combined manually operated and remote valve shall be fitted in every bunkering line close to the shore connecting point. The position of this valve shall be monitored at the bunkering station, as well as in the control room on board. It shall be possible to release the remote operated valve in the control location for bunkering operations and or another safe location.

4.8.2.3 If the ventilation in the ducting around the FC fuel bunkering lines stop, an alarm shall sound at the bunkering control location.

4.8.2.4 If gas is detected in the ducting around the bunkering lines an alarm shall sound at the bunkering control location.

4.8.2.5 Means shall be provided for draining the liquid from the bunkering pipes at bunkering completion.

4.8.2.6 Bunkering lines shall be arranged for inerting and gas freeing. During operation of the vessel the bunkering pipes shall be gas free.

4.8.3 Distribution outside of machinery spaces

4.8.3.1 FC fuel piping is not to be led through accommodation spaces, service spaces or control stations. Hydrogen pipes are not to be led through enclosed spaces in the ship apart from the FC spaces.

Guidance note:

Hydrogen pipes may be considered accepted led through other spaces if these spaces are defined as gas hazardous, e.g. all equipment inside are spark proof and certified safe for hydrogen atmosphere. Such spaces will have to be arranged with a ventilation system and rate as required for FC fuel spaces with open hydrogen pipes, and the space should have a simple geometrical shape.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.8.3.2 Where gas pipes except hydrogen pipes pass through enclosed spaces in the ship, they shall be enclosed in a duct. This duct shall be mechanically under-pressure ventilated with 30 air changes per hour, and gas detection as required in [7] shall be provided.

4.8.3.3 The duct shall be dimensioned according to [4.5.2.3]-[4.5.2.4].

4.8.3.4 Gas pipes located in open air shall be so located or protected that they are not likely to be damaged by accidental mechanical impact.

4.8.3.5 High pressure gas lines outside the FC spaces should be installed and protected so as to minimise the risk of injury to personnel in case of rupture.

4.9 Ventilation system

4.9.1 General

4.9.1.1 Spaces in which components of the FC system are installed shall be equipped with a mechanical ventilation system or other suitable ventilation devices of the extraction type. The spaces shall be monitored by gas detection systems. Special attention shall be paid to areas with a low rate of air circulation. In order to support areas within hazardous spaces containing flanges, valves etc., suction hoods or trunks can be used.

For spaces containing hydrogen release sources also refer to [4.9.5.3] for space and ventilation system design.

4.9.1.2 Air inlets for hazardous enclosed spaces shall be taken from areas which, in the absence of the considered inlet, would be non-hazardous. Air inlets for non-hazardous enclosed spaces shall 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 shall have over-pressure relative to this space, unless mechanical integrity and gas-tightness of the duct will ensure that gases will not leak into it.

4.9.1.3 Any ducting used for the ventilation of hazardous spaces caused by the FC installation shall not serve any other spaces and be separate from that used for the ventilation of non-hazardous spaces. Electric fan motors shall not be located in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone as the space served. Electric fan motors shall not be located in ventilation ducts for spaces containing hydrogen installations.

4.9.1.4 It shall be possible to control the ventilation systems from a point outside the ventilated spaces. Arrangement shall allow spaces to be ventilated before access and before taking the equipment into operation. Notices shall be provided outside the spaces, with the warning that the ventilation system shall be switched on before entering the spaces.

The extracted air shall be monitored for fuel constituents.

4.9.1.5 Air inlet and outlet openings shall be provided with fire dampers, which shall be operable from outside the spaces. Protective screens with a mesh spacing of not more than 13 mm shall be mounted at the outer openings of ventilation ducts.

4.9.1.6 For design of ventilation fans serving spaces containing sources of release of flammable gases see requirements in [Pt.5 Ch.7 Sec.12 \[3\]](#). Fans serving spaces containing sources of release of flammable gases will have to be certified as explosion protected.

4.9.1.7 Ventilation systems in spaces with release sources from piping systems with FC fuel that is heavier than air (propane, butane or similar) have to be designed with special focus on the heavy gases, to avoid any accumulation of released gas. Ventilation suction in such spaces shall be from the lowest points of the space.

4.9.1.8 Means should be provided to indicate in the engine control station any loss of the required ventilating capacity.

4.9.1.9 Air outlets from non-hazardous spaces shall be located outside hazardous areas.

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

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

4.9.2 Non-hazardous spaces

4.9.2.1 Spaces with opening to a hazardous area, shall be arranged with an air-lock, and be maintained at overpressure, relative to the external hazardous area.

The overpressure ventilation shall be arranged according to the following requirements:

- 1) During initial start-up or after loss of overpressure ventilation, it is required before energising any electrical installations not certified safe for the space in the absence of pressurisation, to:
 - proceed with purging (at least 5 air changes) or confirm by measurements that the space is gas free; and
 - pressurise the space.
- 2) Operation of the overpressure ventilation shall be monitored.
- 3) In the event of failure of the overpressure ventilation:
 - an audible and visual alarm shall be given at a manned location.
 - if overpressure cannot be immediately restored, automatic or programmed disconnection of electrical installations is required according to IEC 60092-502.

4.9.3 Gas tank room

4.9.3.1 The tank room for gas storage tank located below deck shall be provided with an effective mechanical ventilation system of the under-pressure type, providing a ventilation capacity of at least 30 air changes per hour. Tank rooms for hydrogen tanks shall have a ventilation rate and arrangement as given in [\[4.9.5\]](#).

4.9.3.2 Approved automatic fail-safe fire dampers shall be fitted in the ventilation trunk for tank room.

4.9.3.3 The number and power of the ventilation fans shall be such that the capacity is not reduced by more than 50% of the required ventilation rate, 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 out of action. Tank rooms for hydrogen tanks shall follow [4.9.5].

4.9.4 Pump and compressor rooms for hydrocarbon gas

4.9.4.1 Pump and compressor rooms shall be fitted with effective mechanical ventilation system of the under-pressure type, providing a ventilation capacity of at least 30 air changes per hour.

4.9.4.2 Ventilation systems for pump and compressor rooms shall be in operation when pumps or compressors are working. Signboards to this effect shall be placed in an easily visible position near the control stand.

4.9.4.3 When the space is dependent on ventilation for its area classification, the following requirements apply:

- 1) During initial start-up, and after loss of ventilation, the space shall be purged (at least 5 air changes), before connecting electrical installations which are not certified for the area classification in absence of ventilation.
- 2) Operation of the ventilation shall be monitored.
- 3) In the event of failure of ventilation, the following requirements apply:
 - an audible and visual alarm shall be given at a manned location
 - immediate action shall be taken to restore ventilation
 - electrical installations shall be disconnected if ventilation cannot be restored for an extended period. The disconnection shall be made outside the hazardous areas, and be protected against unauthorised re-connection, e.g. by lockable switches.
 - a shut-off of the gas supply shall be initiated automatically.

Guidance note:

Intrinsically safe equipment suitable for Zone 0, is not required to be switched off. Certified flameproof lighting, may have a separate switch-off circuit.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.9.5 Spaces containing hydrogen piping

4.9.5.1 For spaces containing hydrogen release sources the ventilation rate shall be sufficient to avoid gas concentration in the flammable range in all leakage scenarios, including pipe rupture. This is also applicable for spaces containing fully welded hydrogen pipes.

4.9.5.2 The number and power of the ventilation fans shall be such that the capacity is still 100% 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 out of action.

Guidance note:

The ventilation fans should be operated in an alternating cycle to test that all fans are operable at all times.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.9.5.3 Ventilation ducts from spaces containing hydrogen piping or release sources shall be vertical or steadily ascending and without sharp bends to avoid any possibility for gas to accumulate.

4.10 Exhaust systems

4.10.1 The exhaust gases arising during the reforming process and the fuel cell operation shall be discharged safely to the open air at an adequate distance from openings to accommodation, machinery and service spaces.

5 Fire safety

5.1 General

5.1.1 General

5.1.1.1 The requirements in this section are additional to those given in SOLAS Ch.II-2.

5.1.1.2 For the purpose of fire protection gas compressor rooms shall be treated as cargo compressor rooms in accordance with [Pt.5 Ch.7 Sec.11](#).

5.1.1.3 The arrangement of fire extinguishing systems in fuel cells spaces, and the need for water spray for cooling of fuel cells or other components shall be evaluated and approved by the Society for each installation.

5.2 Fire protection

5.2.1 Construction

5.2.1.1 Gas tanks / tank batteries located above deck shall be shielded with class A-60 insulation towards accommodation, service stations, cargo spaces and machinery spaces.

5.2.1.2 The tank room and ventilation trunks to such spaces below the bulkhead deck shall be fire insulated to class A-60 standard. However, where the room is adjacent to tanks, voids, auxiliary machinery spaces of no fire risk, sanitary and similar spaces, the insulation may be reduced to class A-0.

5.2.1.3 The bunkering station shall be shielded with class A-60 insulation towards other spaces, except for spaces such as tanks, voids, auxiliary machinery spaces of no fire risk, sanitary and similar spaces where the insulation may be reduced to A-0 class.

5.2.1.4 A FC space shall as a minimum have gas tight steel bulkheads. The categorisation of the FC space as a category (6) or (7) space, see SOLAS Ch. II-2/ Table 9.5 and 6, is depending on the amount of combustible material or fuel available in the space. The categories for the FC spaces have to be decided for each installation.

5.3 Fire extinction

5.3.1 Fire main

5.3.1.1 The water spray system required below may be part of the fire main system provided that the required fire pump capacity and pressure is sufficient to operation of both the required numbers of hydrants and hoses and the water spray system simultaneously.

5.3.1.2 When the storage tank is located above the bulkhead deck, isolating valves shall be fitted in the fire main in order to isolate sections *if and when* the fire main may be damaged in any sections.

5.3.2 Water spray systems

5.3.2.1 A water spray system shall be fitted for cooling and fire prevention and to cover exposed parts of the fuel storage tank located above deck.

5.3.2.2 The system shall be designed to cover all areas as specified above with an application rate of 10 l/min/m² for horizontal projected surfaces and 4 l/min/m² for vertical surfaces.

5.3.2.3 For the purpose of isolating damage sections, stop valves shall be fitted or the system may be divided into two sections with control valves located in a safe and readily accessible position not likely to be cut-off in case of fire.

5.3.2.4 The capacity of the water spray pump shall be sufficient to deliver the required amount of water to the hydraulically most demanding area as specified above.

5.3.2.5 A connection to the ships fire main through a stop valve shall be provided.

5.3.2.6 Remote start of pumps supplying the water spray system and remote operation of any normally closed valves to the system should be located in a readily accessible position which is not likely to be cut off in case of fire in the areas protected.

5.3.2.7 The nozzles to be of an approved full bore type and they shall be arranged to ensure an effective distribution of water of the space being protected.

5.3.3 Dry chemical powder fire extinguishing system

5.3.3.1 One portable dry powder extinguisher of 50 kg shall be located near the bunkering station.

5.4 Fire detection and alarm systems

5.4.1 Detection

5.4.1.1 An approved fixed fire detection system shall be provided for the tank room and the ventilation trunk for tank room below deck, and also for the FC spaces.

Guidance note:

The type of fire detection system shall be decided on basis of the actual fuels and combustible gases that may be present in the spaces. Hydrogen should be given special attention as a hydrogen fire is difficult to detect. It creates no smoke, very little heat radiation and burns with a flame that is almost invisible to the eye in daylight.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.4.1.2 Smoke detectors only are not considered sufficient for rapid fire detection when gaseous fuel is used.

5.4.1.3 Where the fire detection system does not include means of remotely identifying each detector individually, the detectors shall be arranged on separate loops.

5.4.2 Alarms and safety actions

5.4.2.1 Required safety actions at fire detection in the FC space and tank room are given in [Table 5](#). In addition the ventilation shall stop automatically and fire dampers shall close.

6 Electrical systems

6.1 General

6.1.1 General

6.1.1.1 The requirements in this section are additional to those given in [Pt.4 Ch.8](#).

6.1.1.2 Electrical equipment and wiring shall in general not to be installed in hazardous areas unless essential for operational purposes. The type of equipment and installation requirements shall comply with [Pt.4 Ch.8 Sec.11](#) according to the area classification as specified in [\[6.2\]](#).

6.1.1.3 Protection against excess power shall be provided, either as an integral part of the equipment or as a part of the ships system. It shall be ensured that the fuel cell can be disconnected from the electrical load at any load condition.

6.1.1.4 The inverter shall be so designed that reverse power, such as breaking power, cannot pass into the fuel cell.

6.1.1.5 The outgoing circuits on a fuel cell arrangement shall be provided with a switch disconnecter for isolating purposes so that isolating for maintenance is possible. Contactors are not accepted as isolating devices.

Guidance note:

For definition of "switch disconnecter" refer to IEC60947-3.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

6.1.1.6 Electric cables in Zone 0 shall have armoring or shielding, or shall be laid in a metallic tube.

6.2 Area classification

6.2.1 General

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

6.2.1.2 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 the principles of the standards IEC 60079-10 and guidance and informative examples given in IEC 60092-502 for tankers. Main features of the guidance are given in [\[6.2.2\]](#).

6.2.1.3 Areas and spaces other than those classified in [\[6.2.2\]](#) shall be subject to special consideration. The principles of the IEC standards shall be applied.

6.2.1.4 Area classification of a space may be dependent of ventilation as specified in IEC 60092-502, Table 1. Requirements for such ventilation are given in [\[4.9.4\]](#).

6.2.1.5 A space with opening to an adjacent hazardous area on open deck, may be made into a less hazardous or non-hazardous space, by means of overpressure. Requirements for such pressurisation are given in [\[4.9.2\]](#).

6.2.1.6 Ventilation ducts shall have the same area classification as the ventilated space.

6.2.2 Definition of Zones

6.2.2.1 Hazardous areas Zone 0

The interiors of gas tanks, pipes and equipment containing gas, any pipework of pressure-relief or other venting systems for gas tanks.

Guidance note:

Instrumentation and electrical apparatus in contact with the gas or liquid should be of a type suitable for Zone 0. Temperature sensors installed in thermo wells, and pressure sensors without additional separating chamber should be of intrinsically safe type Ex-ia.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

6.2.2.2 Hazardous areas Zone 1

- 1) Tank room, as defined in [4.6.1.6].
- 2) Gas compressor room arranged with ventilation according to [4.9.4.3].
- 3) Areas on open deck, or semi- enclosed spaces on deck, within 3 m of any gas tank outlet, gas or vapour outlet (see note), bunker manifold valve, other gas valve, gas pipe flange, gas pump-room ventilation outlets and gas tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation.

Guidance note 1:

Such areas are, for example, all areas within 3 m of gas tank hatches, ullage openings or sounding pipes for gas tanks located on open deck and gas vapour outlets

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

- 4) Areas on open deck or semi-enclosed spaces on deck, within 1.5 m of gas compressor and pump room entrances, gas pump and compressor room ventilation inlets and other openings into Zone 1 spaces.
- 5) Areas on the open deck within spillage coamings surrounding FC fuel bunker manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck.
- 6) Enclosed or semi-enclosed spaces in which sources of release are located, e.g. ducts around FC fuel pipes, semi-enclosed bunkering stations.

Guidance note 2:

Open ended ventilation pipes from FC fuel piping systems will not create a hazardous zone in a surrounding well ventilated space.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

6.2.2.3 Hazardous areas zone 2

Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 as specified in [6.2.2.2], if not otherwise specified in this standard.

Guidance note:

A space containing FC fuel pipes can be regarded as non-hazardous if the pipes are fully welded and the ventilation rate is sufficient to avoid gas concentration in the flammable range in all leakage scenarios, including pipe rupture, refer to [4.4].

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

6.3 Inspection and testing of electrical equipment in hazardous area

6.3.1 General

6.3.1.1 Before the electrical installations in hazardous areas are put into service or considered ready for use, they shall be inspected and tested. All equipment, including cables, shall be verified as having been installed in accordance with installation procedures and guidelines issued by the manufacturer of the equipment and cables, and that the installations have been carried out in accordance to Pt.4 Ch.8 Sec.11.

6.3.1.2 For spaces protected by pressurisation it shall be examined and tested that purging can be fully accomplished. Purge time at minimum flow rate shall be documented. Required shutdowns and / or alarms upon ventilation overpressure falling below prescribed values shall be tested.

For other spaces where area classification depends on mechanical ventilation it shall be tested that ventilation flow rate is sufficient, and that required ventilation failure alarm operates correctly.

6.3.1.3 For equipment for which safety in hazardous areas depends upon correct operation of protective devices (for example overload protection relays) and / or operation of an alarm (for example loss of pressurisation for an Ex(p) control panel) it shall be verified that the devices have correct settings and/or correct operation of alarms.

6.3.1.4 Intrinsically safe circuits shall be verified to ensure that the equipment and wiring are correctly installed.

6.3.1.5 Verification of the physical installation shall be documented by the yard. Verification documentation shall be available for the Society's surveyor at the site.

6.4 Maintenance of electrical equipment in hazardous area

6.4.1 General

6.4.1.1 The maintenance manual referred to in [Table 2](#), shall be in accordance with the recommendations in IEC 60079-17 and 60092-502 and shall contain necessary information on:

- overview of classification of hazardous areas, with information about gas groups and temperature class
- list of equipment sufficient to enable the certified safe equipment to be maintained in accordance with its type of protection (list and location of equipment, technical information, manufacturer's instructions, spares etc.)
- inspection routines with information about level of detail and time intervals between the inspections, acceptance/rejection criteria
- records of inspections, with information about date of inspections and name(s) of person(s) who carried out the inspection and maintenance work.

6.4.1.2 Updated documentation and maintenance manual shall be kept on-board, with records of date and names of companies and persons who have carried out inspections and maintenance.

Inspection and maintenance of installations shall be carried out only by experienced personnel whose training has included instruction on the various types of protection of apparatus and installation practices to be found on the vessel.

7 Control, monitoring and safety systems

7.1 General

7.1.1 General

7.1.1.1 For instrumentation and automation, including computer based control and monitoring, the requirements in this section are additional to those given in [Pt.4 Ch.9](#).

The control and monitoring systems shall be certified according to [Pt.4 Ch.9](#) for the following, if installed:

- FC fuel tank level measurement system
- FC fuel tank overflow protection system
- FC fuel supply control and monitoring system
- flammable gas detection system (permanent system only)

- inert gas control and monitoring system
- oxygen indication equipment (permanent system only)
- FC power management systems (for **FC(Power)** notation only)
- FC safety system.

7.1.1.2 A local reading pressure gauge shall be fitted between the stop valve and the connection to shore at each bunker pipe.

7.1.1.3 Pressure gauges shall be fitted to FC fuel pump discharge lines and to the bunkering lines.

7.1.1.4 A bilge well in each tank room surrounding an independent FC fuel tank shall be provided with both a level indicator and a temperature sensor. Alarm shall be given at high level in bilge well. Temperature sensor low temperature indication shall lead to automatic closing of main tank valve.

7.1.1.5 The fuel cell and the FC fuel supply system shall be arranged for manual remote emergency stop from the following locations:

- the cargo control room (relevant for cargo ships only)
- navigation bridge
- engine control room
- fire control station.

7.2 Monitoring

7.2.1 FC fuel tank monitoring

7.2.1.1 FC fuel tanks shall be monitored and protected against overfilling as required in [Pt.5 Ch.7 Sec.13](#).

7.2.1.2 Each tank shall be monitored with at least one local indicating instrument for pressure and remote pressure indication at the control position. The manometers and indicators shall be clearly marked with the highest and lowest pressure permitted in the tank. In addition high pressure alarm, and if vacuum protection is required, low pressure alarm shall be provided on the bridge. The alarms shall be activated before the set pressures of the safety valves are reached.

7.2.2 FC fuel compressor monitoring

7.2.2.1 The monitoring system should include items shown in [Table 4](#):

Table 4 Monitoring system requirements

	<i>Alarm</i>	<i>Automatic stop</i>
FC fuel heater outlet, temperature high	X	
FC fuel heater outlet, temperature low	X	
FC fuel compressor outlet, temperature, high	X	X
FC fuel compressor inlet, pressure, low	X	
FC fuel compressor outlet, pressure, high	X	
FC fuel compressor outlet, pressure, low	X	
Control system failure	X	
Sealing pressure, low	X	

	<i>Alarm</i>	<i>Automatic stop</i>
Lubrication oil pressure, low	X	X
Lubrication oil temperature, high	X	
Master fuel valve close	X	

In addition high pressure FC fuel compressors shall stop automatically in the event of:

- control air pressure loss
- high gas concentration in the compressor room (Table 5)
- automatic stop or emergency stop of FC fuel supply to fuel cell.

7.2.3 Fuel cell monitoring

7.2.3.1 The fuel cell shall be monitored to the extent necessary to avoid that the safety is impaired. For installation with notation **FC(Power)** also monitoring affecting the availability or life time shall be considered. This should be seen in connection with the overall installation redundancy, see [2].

7.2.3.2 A failure mode and effect analysis examining all possible faults affecting the fuel cell operation and safety shall be carried out. Based on the outcome of the analysis the extent of the monitoring and control shall be decided. As a minimum the following items shall typically be monitored:

- cell voltage
- cell voltage deviations
- temperature exhaust gas
- temperature in FC
- electric current.

Other typical monitoring that should be considered:

- air flow
- air pressure
- cooling medium flow, pressure, temperature (if used)
- fuel flow
- fuel temperature
- fuel pressure
- gas detection in exhaust gas
- water system level
- water system pressure
- water system purity
- parameters necessary to monitor lifetime/ deterioration.

7.3 Gas detection

7.3.1 Locations

7.3.1.1 Permanently installed gas detectors shall be fitted in the tank room, in all ducts around gas pipes, in fuel cell spaces, compressor rooms, and other enclosed spaces containing FC fuel piping or other FC fuel equipment, but not including spaces where only completely ducted FC fuel pipes are present. Gas detection systems shall be installed for all types of flammable gases that may occur in the space.

7.3.1.2 The number of detectors in each space shall be considered taking size, layout, fuel density in air and ventilation of the space into account.

7.3.1.3 The detection equipment shall be located where gas may accumulate and or in the ventilation outlets. Gas dispersal analysis or a physical smoke test shall be used to find the best arrangement.

7.3.1.4 An audible and visible alarm shall be activated before the vapour concentration reaches 20% of the lower flammable limit (LEL). For ventilated ducts around FC fuel pipes the alarm limit can be set to 30% LEL.

Guidance note:

LEL is at 4% in air for hydrogen, at 5.3% in air for methane and at 1.7% in air for propane.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

7.3.1.5 Audible and visible alarms from the gas detection equipment shall be located on the bridge and in the engine control room.

7.3.1.6 Continuous detection is required for FC fuel pipe ducts and fuel cell spaces kept gas safe by ventilation and fully welded fuel pipes.

7.4 Safety functions of gas supply systems

7.4.1 General

7.4.1.1 The main supply lines for FC fuel shall be equipped with a manually operated stop valve and a remote controlled "master fuel valve" installed in series or a combined manually and remote controlled operated stop valve. The valves shall be situated in the part of the piping that is outside the FC space. The master fuel valve is automatically to cut off the FC fuel supply as given in [Table 5](#).

The automatic master fuel valve shall be operable from a reasonable number of places in the FC space, from a room outside the FC space and from the bridge.

7.4.1.2 Each fuel cell unit shall be provided with a set of "double block and bleed" valves. These valves shall be arranged so that when automatic shutdown is initiated as given in [Table 5](#), this will cause the two FC fuel valves which are in series to close automatically and the vent valve to open automatically. The two block valves shall be of fail-to-close type, while the vent valve shall be fail-to-open.

The double block and bleed valves are also to be used for normal stop of the fuel cell.

7.4.1.3 There shall be one manually operated shut down valve in the FC fuel supply line to each FC to assure safe isolation during maintenance on the fuel cell installation.

7.4.1.4 In the main supply FC fuel line to each FC space where fuel piping is not in a double duct an automatic excess flow shut off valve shall be fitted. The valve shall be adjusted to shut off FC fuel supply in the event of rupture of the FC fuel line. The valve shall be located as close as possible to the point of entry of the FC fuel supply line into the FC space.

Guidance note 1:

The shutdown should be time delayed to prevent shutdown due to transient load variations.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

This requirement may be waived if the FC fuel pipes are located in protected locations, for instance very high in the space or mechanically shielded.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

7.4.1.5 If the FC fuel supply is shut off due to activation of a remote controlled valve, the FC fuel supply is not to be opened until the reason for the closure of the valve is ascertained and the necessary precautions taken. A readily visible signboard giving instruction to this effect shall be placed at the operating station for the shut-off valves in the FC fuel supply lines.

7.4.1.6 If a FC fuel leak leading to a FC fuel supply shut down occurs, the FC fuel supply is not to be operated until the leak has been found and dealt with. Signboards to this effect shall be placed in a prominent position in the machinery space.

7.4.1.7 A signboard shall be fitted in the FC space stating that heavy lifting, maintenance or other activities capable of potentially causing damage to the FC fuel pipes and components are not to be done when the fuel cell is running.

Table 5 Monitoring of FC fuel supply system to fuel cells

<i>Parameter</i>	<i>Alarm</i>	<i>Automatic shut-down of main tank valve</i>	<i>Automatic shut-down of FC fuel supply to FC space</i>	<i>Comment</i>
Gas detection in tank room above 20% LEL	X			
Gas detection on second detector in tank room above 20% LEL	X	X		
Fire detection in tank room	X	X		
Bilge well high level tank room	X			
Bilge well low temperature in tank room	X	X		
Gas detection in duct between tank and FC space above 20% LEL	X			
Gas detection on second detector in duct between tank and FC space above 20% LEL*or above 40% LEL of one sensor	X	X ¹⁾		
Gas detection in compressor room above 20% LEL	X			
Gas detection on second detector in compressor room above 20% LEL or above 40% LEL of one sensor	X	X ¹⁾		
Gas detection in duct inside FC space above 30% LEL	X			If double pipe fitted in FC space
Gas detection on detector in duct inside FC space above 60% LEL	X		X	If double pipe fitted in FC space.
Gas detection in FC space above 20% LEL	X			Gas detection not required if all FC pipes are in complete double ducts
Gas detection on second detector in FC space above 20% LEL or above 40% LEL of one sensor	X		X	Gas detection not required if all FC pipes are in complete double ducts. Is also to lead to disconnection of not certified safe electrical equipment in FC space.
Loss of ventilation in duct between tank and FC space ³⁾	X		X ⁴⁾	
Loss of ventilation in duct inside FC space ³⁾	X		X ⁴⁾	If double pipe fitted in FC space.

<i>Parameter</i>	<i>Alarm</i>	<i>Automatic shut-down of main tank valve</i>	<i>Automatic shut-down of FC fuel supply to FC space</i>	<i>Comment</i>
Loss of some ventilation in FC space	X			Not for FC spaces with only completely ducted FC fuel pipes
Loss of all ventilation in FC space	X		X	Not for FC spaces with only completely ducted FC fuel pipes
Fire detection in FC space	X		X	Also to lead to stop of ventilation in FC space.
Failure of valve control actuating medium	X		X ²⁾	Time delayed as found necessary
Automatic shut down of fuel cell (fuel cell failure)	X		X ²⁾	
Emergency shut-down of fuel cell manually released	X		X	
1) If the tank is supplying FC fuel to more than one fuel cell and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct, only the master valve on the supply pipe leading into to the duct where gas is detected shall close. 2) Only double block and bleed valves to close. 3) If the duct is protected by inert gas as outlined in [4.5.2.1], loss of inert gas overpressure shall lead to the same actions as given here. 4) This parameter is not necessarily to lead to automatic shut down of FC fuel supply, manual options may be considered. Shut down is only needed for the FC fuel leading to the duct that has lost the ventilation.				

8 Compressors

8.1 FC fuel compressors

8.1.1 General

8.1.1.1 The FC fuel compressor shall be fitted with accessories and instrumentation necessary for efficient and reliable function.

8.1.1.2 The FC fuel compressor and FC fuel supply shall be arranged for manual remote emergency stop from the following locations:

- the cargo control room (relevant for cargo ships only)
- navigation bridge
- engine control room
- fire control station.

9 Manufacture, workmanship and testing

9.1 Liquefied gas tank

9.1.1 Manufacture and testing

9.1.1.1 Tests related to welding and tank testing shall be in accordance with Pt.5 Ch.7 Sec.6 [5], Pt.5 Ch.7 Sec.6 [6], Pt.5 Ch.7 Sec.4 [5.2.3] and Pt.5 Ch.7 Sec.4 [5.2.4].

9.2 FC Fuel piping systems

9.2.1 FC fuel pipes and ducting

9.2.1.1 The FC fuel pipes and ducting shall be tested as given in Sec.5 [11.2]. Butt welded joints of hydrogen supply pipes shall be subjected to 100% radiographic testing.

9.2.2 Valves

9.2.2.1 Each type of valve to be used at working temperatures below minus 55°C shall be prototype tested as given in Pt.5 Ch.7 Sec.5 [13.1].

9.2.2.2 Valves for use in hydrogen pipes located in ventilated spaces with fully welded hydrogen pipes, as specified in [4.4.1.1] 2), shall be tightness tested with hydrogen to show that there is no leakage of hydrogen from the valve.

9.2.3 Expansion bellows

9.2.3.1 Expansion bellows intended for use in FC fuel systems shall be prototype tested as given in Pt.5 Ch.7 Sec.5 [13.2].

9.3 On-board testing of FC plant

9.3.1 General

9.3.1.1 Testing after installation on-board of the whole system shall be performed in different relevant load conditions (typically: "start up", "normal running", "full load") and shall as a minimum always verify that, in the event of the following faults, the FC system is automatically transferred into a safe condition:

- alarm of the fire detection devices
- alarm of the gas detection system
- failure of the power supply
- failure of the programmable logic controllers (PLCs)
- triggering of the protective devices
- faults in the protective devices
- faults in the protective system

Further tests may be required based on the approved FMEAs and related test programs.

9.3.1.2 For notation **FC(Power)**, the interaction of the FC system with the ship systems shall be tested as follows:

- power generation by the FC system alone
- FC system together with conventional shipboard generation of electrical power

- FC system together with batteries
- change-over to the emergency source of electrical power
- switching the FC system online or offline
- testing of sudden load variations and load rejection

If the FC system constitutes the main propulsion system of the ship, it shall be verified that the ship has adequate propulsion power in all maneuvering situations

SECTION 4 FUEL TREATMENT AND CONDITIONING SYSTEMS - FUEL

1 General

1.1 Introduction

The additional class notation **Fuel** applies to systems and equipment utilised for the treatment of residual fuel for use in diesel engines. Residual fuel oil is so viscous that it has to be handled by a special fuel treatment system before use, and it may contain relatively high amounts of pollutants, particularly sulphur, which forms sulphur dioxide upon combustion.

1.2 Scope

The scope of additional class notation **Fuel** ensures that the fuel treatment system will reduce the content of undesired impurities to a level safe for diesel engine use, and that the fuel is delivered to the engine with the correct viscosity and pressure throughout the full operating range of engine power.

1.3 Application

Vessels with fuel systems and equipment complying with the rules in this section may be assigned the additional class notation **Fuel** (- cSt, - kg/m³, -°C). The numbers in brackets indicate the maximum viscosity in cSt at 50°C, the maximum density in kg/m³ at 15°C of the fuel oil and the minimum outside air temperature for which the installations are approved. Redundancy requirements are included in this section of the rules, as is the possibility of having two different bunker batches that may be stored and handled without need for mixing.

1.4 Environmental conditions

1.4.1 For determining heating capacity the following minimum temperatures apply:

- Sea: 0°C
- Outside air temperature: 0°C, if a lower temperature is not defined in the class notation.

1.5 Definitions

1.5.1 Definitions

Table 1 Definitions

<i>Term</i>	<i>Definition</i>
<i>Booster system</i>	is the pressurised system of pumps, heaters, valves, filters and other equipment permanently installed to provide the transfer of fuel from the day tank to the engine high pressure fuel pumps.
<i>Fuel</i>	as used in this context is an organic liquid hydrocarbon oil derived from petroleum refining. This does not preclude the incorporation of small amounts of additives intended to improve some aspects of performance.
<i>Fuel additives</i>	are chemical substances used to improve the fuel treatment efficiency and or fuel performance in diesel engines as well as minimising harmful effects.

<i>Term</i>	<i>Definition</i>
<i>Fuel quality</i>	is determined with reference to values of parameters describing chemical and physical properties. It is assumed that fuels containing contamination in excess of that specified in ISO 8217/latest version/ Grade RMH55 are not bunkered.
<i>Fuel storage system</i>	incorporates tanks for fuel storage which are not intended to influence the cleaning process (settling and drainage of contaminants).
<i>Separator</i>	is a permanently fitted centrifuge for fuel cleaning.
<i>Transfer system</i>	incorporate the system of pipes, valves, filters and pumps intended for the transfer of fuel between storage tanks and from storage tanks to the treatment system.
<i>Treatment system</i>	incorporates the system of tanks, pipes, valves heaters, filters, pumps, separators and other permanently installed components intended for cleaning and conditioning of the fuel. It also comprises arrangements for chemical treatment of the fuel by the use of fuel additives.

1.6 Certification

Table 2 Certification required

<i>Object</i>	<i>Certificate type</i>	<i>Issued by</i>	<i>Certification standard*</i>	<i>Additional description</i>
Separators	TA	Society		Fuel Oil
*Unless otherwise specified the certification standard is DNV GL Rules.				

1.7 Documentation

1.7.1 Plans and particulars

Additional to the documentation required by other relevant rules, the plans and particulars listed in [Table 3](#) shall be submitted for approval:

Table 3 Documentation requirements class notation Fuel

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Fuel oil system	S010 – Piping diagram (PD)	Fuel oil transfer pipes with heat tracing (including any low sulphur fuel change over system for SOx Emission Control area -SECA)	AP
	Z100 – Specification	Pipes with heat tracing and heated tanks with insulation	AP
	Z030 – Arrangement plan	Heating coils in fuel tank	AP
	S120 – Heat balance calculation	Comprising heated fuel tanks, fuel pre-heaters and heat losses, throughout the system	AP
	Z253 - Test procedure for quay and sea trial	Including log of temperatures, viscosity, alarms, etc.	FI
	Z161 – Operation manual	Including bunkering procedures	AP
	Z250 – Procedure	Fuel oil samples handling and records in connection with MARPOL Annex VI.	FI

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Fuel oil control and monitoring system	I200 – Control and monitoring system documentation	Fuel pre-treatment system	AP
AP=For approval; FI=For information			

1.7.2

For general requirements for documentation, including definition of the info codes, see [Pt.1 Ch.3 Sec.2](#).

1.7.3

For a full definition of the documentation types, see [Pt.1 Ch.3 Sec.3](#).

1.8 General requirements

1.8.1 System design principles

1.8.1.1 The fuel treatment plant shall be designed and installed in accordance with relevant parts of the rules unless otherwise stated in this section.

1.8.1.2 The fuel system shall ensure that:

- the content of undesired impurities is reduced to a level safe for diesel engine use.
- the fuel is delivered to the engine with the correct viscosity and pressure throughout the full operating range of engine power.
- the system provides redundancy as required in relevant rules.
- two different bunker batches may be stored and handled without need for mixing.

1.8.2 Fuel operation manual

1.8.2.1 A manual describing systems, equipment and guidance for bunkering, handling of fuel and operation of systems shall be provided.

The fuel operation manual shall emphasize measures and procedures in order to minimize the mixing of old and or new or incompatible fuel oils during bunkering and change over operations.

2 System arrangements and components

2.1 System for storage and transfer of fuel

2.1.1 Bunker manifolds

2.1.1.1 An adequate bunker manifold shall be provided on each side equipped with spill tray with a volume of at least 160 litre capacity to prevent oil pollution during bunkering operations.

2.1.1.2 An approved arrangement for sampling of fuel shall be provided at each of the bunker manifolds or in the fuel bunkering line.

2.1.2 Fuel storage tanks

2.1.2.1 At least two storage tanks shall be provided. If only two tanks are installed, the smallest tank shall not to be less than one third of the total tank capacity.

2.1.2.2 Arrangement enabling representative fuel sampling shall be provided.

2.1.2.3 All tanks shall be provided with sufficient heating capacity to keep the bulk temperature of the oil on at least 45°C.

2.1.2.4 Isolating valves for heating coils in each tank shall be provided. Sampling cocks in condensate return lines to be provided.

2.1.2.5 The storage tanks shall be provided with monitoring equipment for temperature and level.

2.1.3 Fuel transfer system

2.1.3.1 The transfer pumps shall be located as low as possible.

2.1.3.2 As far as practical, long suction lines shall be avoided.

2.1.3.3 Transfer lines shall be provided with heat tracing and insulation.

2.2 Fuel oil settling and daily service tanks

2.2.1 Tank arrangement

2.2.1.1 At least two settling and two daily service tanks shall be provided.

2.2.1.2 Settling and daily service tanks shall not be located adjacent to the ship's side.

Guidance note:

Minimum distance between hull and tank bulkhead should be 760 mm for inspection access.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.2.2 Settling tanks

2.2.2.1 The usable capacity of each settling tank shall be sufficient for 24 hours operation at maximum fuel consumption.

2.2.2.2 Heating capacity, sufficient to increase the temperature of the oil from 45°C to at least 70°C within 12 hours, shall be provided.

2.2.2.3 The tanks shall be provided with suitable openings for access and ventilation to allow effective tank cleaning.

2.2.2.4 The tank bottom shall be so designed that precipitated material may be drained to the sludge tank by opening an easily accessible drain valve. Tank bottom shall be sloped towards the drain outlet.

2.2.2.5 Suction outlets for separators shall be placed above bottom to avoid precipitated material to escape. Minimum distance from the bottom to the suction shall be 500 mm.

2.2.2.6 For sludge removal by use of separator, a bottom suction is required.

2.2.3 Daily service tanks

2.2.3.1 The usable capacity of each daily service tank shall be sufficient for 12 hours operation at maximum fuel consumption.

2.2.3.2 Heating capacity, sufficient to increase the temperature of the oil from 70°C to at least 90°C within 6 hours, shall be provided.

2.2.3.3 The tanks shall be provided with suitable openings for access and ventilation to allow effective tank cleaning

2.2.3.4 The tank bottom shall be constructed with smooth bottom and with slope towards the drain outlet.

2.2.3.5 The suction to the booster system shall be placed minimum 500 mm above bottom to avoid precipitated material to escape.

2.2.3.6 The arrangement of the tanks and interconnected piping shall be such that unintentional ingress of fuel from one tank to another is avoided.

2.2.3.7 Overflow pipe to run from the bottom of the service tank to the top of the settling tank (above the overflow discharge from the settling tank).

2.3 Fuel treatment system

2.3.1 General

2.3.1.1 The fuel treatment system shall at least consist of:

- centrifugal separators
- fuel heaters
- automatic filters
- booster system including pressurised mixing tank
- automatic viscosity control equipment
- automatic temperature control.

2.3.2 Centrifugal separators

2.3.2.1 The capacity of separators, their number and configuration shall be such that with any unit out of operation, the system shall maintain an adequate performance at the maximum fuel consumption.

Guidance note:

Capacity of separators will be considered equal to Certified Flow Rate (for the viscosity class in question) as determined by the Type Approval Programme for Fuel Oil Separators.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.3.2.2 Heaters, control systems, pumps and other auxiliary equipment for the cleaning process shall be so designed that the fuel is kept at the condition necessary for the separators to function as required.

2.3.2.3 Fuel feed rate to separators shall be controlled by means of rpm (frequency) of feed pump. (Or other equal means to control flow rate approved by the Society in each case).

2.3.2.4 Fuel heaters for separators shall have automatic temperature control. Controller shall have proportional and integral function (PI-controller). Possibility for manual control shall be arranged.

2.3.2.5 For steam heating arrangements condensate drain from heaters shall be controlled by float operated drain traps (or other equal means approved by the Society in each case). Drain traps discharge shall be by gravity.

Guidance note:

If the pressure of the heating medium inside the heater is sufficient to displace the condensate to the condensate tank located at a higher level, this is considered equivalent to gravity drain.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.3.2.6 The discharge pipe to the sludge tank shall be made as short and vertical as possible. The pipe diameter shall not be less than the separator sludge outlet stud.

2.3.2.7 Centrifugal separators shall preferably be positioned on top of the sludge tank.

2.3.2.8 A fixed arrangement for sampling fuel before and after the separator(s) shall be provided.

2.3.3 Fuel heaters and viscosity control equipment

2.3.3.1 The system of fuel heaters shall be designed with built in redundancy.

2.3.3.2 With any one heater out of service, the remaining heaters shall have the capacity of raising the fuel temperature sufficiently to achieve a viscosity required for the correct injection of fuel into the diesel engine at a flow rate corresponding to 120% of the maximum fuel consumption.

2.3.3.3 Heaters shall be designed with a maximum surface temperature of the heating elements of 170°C for steam and 200°C for thermal oil heating systems.

Guidance note:

170°C surface temperature normally corresponds to a heat load of 10 kW/m².

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.3.3.4 Fuel heaters in the booster system shall be provided with control equipment maintaining the desired viscosity.

2.3.3.5 The viscosity controller shall have proportional and integral action (PI controller).

2.3.3.6 Means for manual temperature control of the heaters shall be arranged.

2.3.3.7 For steam heating arrangements condensate drains from heaters to be controlled by float operated drain traps (or other equal means approved by the Society in each case). Drain trap discharge shall be by gravity.

SECTION 5 GAS FUELLED SHIP INSTALLATIONS - GAS FUELLED

1 General

1.1 Introduction

The additional class notation **Gas fuelled** provides criteria for the safe and environmentally friendly arrangement and installation of machinery for propulsion and auxiliary purposes, using gas as fuel.

1.2 Scope

The scope for additional class notation **Gas fuelled** includes requirements for the ship's gas fuel system, covering all aspects of the installation, from the ship's gas fuel bunkering connection up to and including the gas consumers. This section has requirements for arrangement and location of gas fuel tanks and all spaces with fuel gas piping and installations, including requirements for the entrances to such spaces. Hazardous areas and spaces, due to the fuel gas installations, are defined. Requirements for control, monitoring and safety systems for the fuel gas installations are included. For tank design and gas piping detail design, see also [Pt.5 Ch.7](#). Requirements for manufacture, workmanship and testing are included, also referring to details given in [Pt.5 Ch.7](#). Bunkering procedures are required for approval as part of the Operation Manual. The bunkering processes and crew training are not part of the scope for this section of the rules.

1.3 Application

The additional class notation **Gas fuelled** applies to installations using gas as fuel in ships. This includes internal combustion engines, boilers and gas turbines. The installations may run on gas only or be dual fuel installations. Gas may be stored in a gaseous or liquefied state. The use of gas as fuel in ships, other than LNG carriers, is not yet covered by international conventions, and such installations will need additional acceptance by flag authorities. The International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code) is adopted by IMO by resolution MSC.391(95). The IGF Code will take effect on 1 January 2017. IMO resolution MSC.285(86) 'Interim Guidelines on Safety for Gas Fuelled Engine Installations in Ships' provides international guidelines. Until the IGF Code enters into force, either IMO resolution MSC.285(86) or the IGF Code may be enforced by the flag state. Collision and grounding protection for fuel tanks are covered by statutory requirements. The rules are applicable for installations where natural gas is used as fuel. If other gases are used as fuel, then special consideration will need to be taken, and additional requirements may be relevant. These rules are not applicable to gas carriers. Ships built with machinery satisfying the requirements of the rules in this section, may be assigned the additional class notation **Gas fuelled**.

1.4 Classification

1.4.1 Survey extent

1.4.1.1 Survey requirements for ships with the class notation **Gas fuelled** are given in the Rules for Classification of Ships, [Pt.7 Ch.1 Sec.2 \[1\]](#) and [Pt.7 Ch.1 Sec.2 \[3\]](#), [Pt.7 Ch.1 Sec.3 \[3\]](#) and [Pt.7 Ch.1 Sec.4 \[3\]](#).

1.5 Definitions

1.5.1 Terms

1.5.1.1

Table 1 Terms

<i>Terms</i>	<i>Definition</i>
accommodation spaces	those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, game and hobby rooms barber shops, pantries containing no cooking appliances and similar spaces
breadth (B)	the greatest moulded breadth of the ship at or below the deepest draught (summer load line draught). See SOLAS regulation II-1/2.8
bunkering	the transfer of liquefied or gaseous fuel from land based or floating facilities into a ships' permanent tanks or connection of portable tanks to the fuel supply system.
CNG	compressed natural gas.
certified safe type	electrical equipment that is certified safe by the relevant authorities recognized by the Administration or its recognized organization acting on its behalf for operation in a flammable atmosphere based on a recognized standard.
control station	those spaces defined in SOLAS chapter II-2 and in the context of these rules, also the engine control room
design temperature	for selection of materials, the minimum temperature at which liquefied gas fuel may be loaded or transported in the liquefied gas fuel tanks
design vapour pressure "P0"	the maximum gauge pressure, at the top of the tank, used as a parameter for the design of the tank.
Double block and bleed valve	a set of two valves in series in a pipe, and a third valve enabling the pressure release from the pipe between those two valves. The arrangement may also consist of a two-way valve and a closing valve instead of three separate valves
dual fuel engines	in this context engines that can burn gaseous and liquefied fuel simultaneously and in a wide variety of proportions, or can operate successively on oil fuel and gas
ESD	emergency shutdown
enclosed space	any space which, in the absence of artificial ventilation, the ventilation will be limited and any explosive atmosphere will not be dispersed naturally Guidance note: See also definition in IEC 60092-502:1999 ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
explosion	a deflagration event of uncontrolled combustion
explosion pressure relief	measures provided to prevent the explosion pressure in a container or an enclosed space exceeding the maximum overpressure the container or space is designed for, by releasing the overpressure through designated openings
filling limit (FL)	the maximum liquid volume in a fuel tank relative to the total tank volume when the liquid fuel has reached the reference temperature.

<i>Terms</i>	<i>Definition</i>
fuel	natural gas, either in its liquefied or gaseous state.
fuel containment system	the arrangement for the storage of fuel including tank connections. It includes where fitted, a primary and secondary barrier, associated insulation and any intervening spaces, and adjacent structure if necessary for the support of these elements. If the secondary barrier is part of the hull structure it may be a boundary of the fuel storage hold space
fuel preparation room	any space containing pumps, compressors and/or vaporizers for fuel preparation purposes
fuel storage hold space	the space enclosed by the ship's structure in which a fuel containment system is situated. If tank connections are located in the fuel storage hold space, it will also be a tank connection space, and will have to fulfil the requirements for both spaces
gas	defined as a fluid having a vapour pressure exceeding 2.8 bar absolute at a temperature of 37.8°C
gas consumer	any unit within the ship using gas as a fuel.
gas control systems	providing control and monitoring for bunkering, gas storage and gas supply to machinery
gas only engine	an engine capable of operating on gas only, and not able to switch over to operation on any other type of fuel
gas safety systems	the safety systems for bunkering, gas storage and gas supply to machinery
gas valve unit spaces	spaces or boxes containing valves for control and regulation of gas supply before the consumer Guidance note: The gas valve unit is by different suppliers also called for instance GVV, gas regulating unit, GRU or gas train. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
hazardous area	an area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment. <i>Hazardous areas</i> are divided into zone 0, 1 and 2 as defined below and according to the area classification specified in [8] <i>zone 0</i> Area in which an explosive gas atmosphere is present continuously or is present for long periods. <i>zone 1</i> Area in which an explosive gas atmosphere is likely to occur in normal operations. <i>zone 2</i> Area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only. Guidance note: The definition of hazardous area is only related to the risk of explosion. In this context, health, safety and environmental issues, i.e. toxicity, is not considered. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
high pressure	a maximum working pressure greater than 10 bar
independent tanks	self-supporting, do not form part of the ship's hull and are not essential to the hull strength
interbarrier space	the space between a primary and a secondary barrier, whether or not completely or partially occupied by insulation or other material

<i>Terms</i>	<i>Definition</i>
LEL	lower explosion limit
LNG	liquefied natural gas
length (L)	the length as defined in the International Convention on Load Lines in force
loading limit (LL)	the maximum allowable liquid volume relative to the tank volume to which the tank may be loaded.
MARVS	the maximum allowable relief valves setting
master gas fuel valve	an automatic valve in the gas supply line to each engine located outside the machinery space
membrane tanks	non-self-supporting tanks that consist of a thin liquid and gas tight layer (membrane) supported through insulation by the adjacent hull structure
non-hazardous area	an area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment
north Atlantic environment	shall be in accordance with the definitions specified in IACS Recommendation 034
open deck	a deck that is open at one or both ends and equipped with adequate natural ventilation that is effective over the entire length of the deck through permanent openings distributed in the side panels or in the deck above
reference temperature	the temperature corresponding to the vapour pressure of the fuel in a fuel tank at the set pressure of the PRVs.
secondary barrier	the outer element of a fuel containment system, designed to afford temporary containment of any envisaged leakage of liquefied fuel through the primary barrier, and to prevent that the temperature of the ship's structure is lowered to an unsafe level
secondary enclosure	the enclosure around fuel piping designed to prevent liquefied and/or gaseous fuel leaking from the fuel piping system
semi-enclosed space	a space where the natural conditions of ventilation are notably different from those on open deck, due to the presence of structures such as roofs, windbreaks and bulkheads, and which are so arranged that dispersion of gas may not occur
service spaces	spaces outside the cargo area used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store rooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces
source of release	a point or location from which a gas, vapour, mist or liquid may be released into the atmosphere so that an explosive atmosphere could be formed.
tank connection space	the gastight space surrounding the bunker tank connections and tank valves
unacceptable loss of power	that 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 regulation II-1/26.3
vapour pressure	the equilibrium pressure of the saturated vapour above the liquid, expressed in bar absolute at a specified temperature

1.6 Documentation requirements

1.6.1 Plans and particulars

1.6.1.1 Documentation shall be submitted as required by [Table 2](#)

Table 2 Documentation requirements

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Propulsion and steering arrangements, general	Z050 – Design philosophy	Including information on the machinery configuration, machinery space arrangements, shut down philosophy, redundancy considerations etc. Shall be submitted before other documentation, to give support for approval of these.	FI
	Z071 – Failure mode and effect analysis (FMEA)	For non-conventional gas fuelled propulsion machinery arrangements, covering single failure in active components or systems. See [5.1.2.4] .	AP
	Z253 - Test procedure for quay and sea trial	Redundancy and failure modes based on FMEA	AP
Fuel gas system	Z030 – Arrangement plan	Including: — machinery and boiler spaces, accommodation, service and control station spaces — fuel containment systems — fuel preparation rooms — fuel bunkering pipes with shore connections — tank hatches, vent pipes and any other openings to the fuel tanks — ventilating pipes, doors and openings to fuel preparation rooms, and other hazardous areas — entrances, air inlets and openings to accommodation, service and control station spaces.	AP
	Z253 - Test procedure for quay and sea trial	Including testing of safety shut downs in accordance with the documentation type "G130 - Cause and effect diagram"	AP
	Z160 - Operation manual	[1.8.1.1]	AP
	Z240 – Calculation report	Explosion analysis (ESD protected machinery spaces)	FI
	C030 – Detailed drawing	Gastight bulkhead penetrations.	AP
Fuel gas tanks	C030 – Detailed drawing	— tanks — supports and stays — secondary barriers — insulation — marking plates — tank connection space — tank hatches, pipes and any openings to the gas tanks.	AP

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
	C040 – Design analysis	— design loads and structural analysis of fuel tanks — complete stress analysis for independent tanks type B and type C. — membrane tanks	FI
	H130 – Fabrication specification	Building tolerances	AP
	S070 – Pipe strength analysis	Strength analysis of piping inside outer tank (vacuum insulated tank.)	FI
	S080 – Thermal stress analysis	When design temperature is below -110°C.	FI
	C050 – Non-destructive testing (NDT) plan	Including — NDT procedures — information about strength and tightness testing	AP
	Z265 - Calculation report	Holding time calculation when pressure accumulation is used as boil off gas handling method.	FI
	Z265 - Calculation report	Filling limit curve	FI
	M060 – Welding procedures (WPS)		AP
	M010 – Material specifications, metals	Including connected pipes — forming procedure of dished ends — specification of stress relieving procedures for independent tanks type C (thermal or mechanical).	FI
	Z030 – Arrangement plan	Overview of tanks with all tank connections and tank connection space	FI
	Z250 – Procedure	Cooling down.	AP
	C030 – Detailed drawing	Safety relief valves and associated vent piping.	AP
	S030 – Capacity analysis	Safety relief valves and associated vent piping. Including back pressure.	AP
	Z100 – Specification	Safety relief valves and associated vent piping.	AP
	S010 – Piping diagram (PD)	Gas freeing and purging system. Including vent lines for safety relief valves or similar piping, and ducts for gas pipes.	AP
Fuel gas control and monitoring system	I200 – Control and monitoring system documentation	— functionality as required by [9]	AP
	I260 – Field instruments periodic test plan	See [1.8.1.2]	AP

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Fuel gas safety system	I200 – Control and monitoring system documentation	— functionality as required by Table 7	AP
	G130 – Cause and effect diagram	— shall cover the safety functions as required by Table 7 — interfaces to other safety and control systems shall be included	AP
Fuel gas piping system	C030 – Detailed drawing	Insulation of low temperature piping.	FI
	S010 – Piping diagram (PD)	Including vent lines for safety relief valves or similar piping, and ducts for gas pipes	AP
	S060 – Pipe routing sketch		FI
	S080 – Thermal stress analysis	When design temperature is below -110°C	FI
	S090 – Specification of valves, flanges and fittings	Including offsets, loops, bends, expansion elements such as bellows and slip joints (only inside tanks). For valves intended for service with a design temperature below -55°C, documentation of leak test and functional test at design temperature (type test) shall be included.	FI
	Z253 – Test procedure for quay and sea trial	Functional tests of all piping systems including valves, fittings and associated equipment for handling fuel (liquefied or gaseous)	AP
	Z100 – Specification	Closing time of shutdown valves in liquefied gas fuel lines operated by the safety system	FI
	Z100 – Specification	Insulation of low temperature piping.	FI
	Z030 – Arrangement plan	Vent masts, including location and details of outlets from fuel tanks safety relief valves.	AP
Fuel gas drip trays	Z030 – Arrangement plan	Hull protection beneath piping for liquefied fuel where leakages may be anticipated, such as at shore connections and at pump seals. Including specification.	AP
Fuel gas cooling system	S010 – Piping diagram (PD)		AP
Fuel gas heating system	S010 – Piping diagram (PD)		AP
Exhaust gas system	S010 – Piping diagram (PD)	Including arrangement of explosion relief or verification of strength of piping system, ref. [5.5]	AP
Hazardous area classification	G080 – Hazardous area classification drawing		AP
Air lock arrangements	Z030 – Arrangement plan	Location and construction details, including alarm equipment.	AP

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Ventilation systems for gas fuel system spaces	S012 – Ducting diagram (DD)	Including capacity and location of fans and their motors.	AP
	C030 – Detailed drawing	Rotating parts and casings for fans and portable ventilators for gas fuel system spaces.	AP
Ventilation control and monitoring system	I200 – Control and monitoring system documentation	Including detection of ventilation function, safety actions and sequences, arrangement of powering of fans etc.	AP
Explosion (Ex) protection	Z030 – Arrangement plan	Where relevant, based on an approved 'hazardous area classification drawing' where location of electric equipment in hazardous area is added (except battery room, paint stores and gas bottle store).	FI
	E170 – Electrical schematic drawing	Single line diagrams for all intrinsically safe circuits, for each circuit including data for verification of the compatibility between the barrier and the field components.	AP
	Z100 – Specification	List of "non-certified safe" electrical equipment that shall be disconnected (ESD protected machinery spaces, spaces protected by air lock)	FI
	Z071 – Failure mode and effect analysis (FMEA)	If required by [8.1.1]	AP
	Z163 – Maintenance manual	Electrical equipment in hazardous areas.	FI
Hydrocarbon gas detection and alarm system, fixed	I200 – Control and monitoring system documentation		AP
	Z030 – Arrangement plan		AP
Structural fire protection arrangements	G060 – Structural fire protection drawing		AP
External surface protection water spraying system	G200 – Fixed fire extinguishing system documentation		AP
Bunkering station fire extinguishing system	G200 – Fixed fire extinguishing system documentation		AP
Fire detection and alarm system	I200 – Control and monitoring system documentation		AP
	Z030 – Arrangement plan		AP
Fire extinguishing equipment, mobile	Z030 – Arrangement plan		AP
AP = For approval; FI = For information			

1.6.1.2 For general requirements for documentation, including definition of the Info codes, see [Pt.1 Ch.3 Sec.2](#)

1.6.1.3 For a full definition of the documentation types, see [Pt.1 Ch.3 Sec.3](#).

1.7 Certification requirements for manufacturers

1.7.1 Certification requirements

1.7.1.1 Products shall be certified as required by [Table 3](#).

Table 3 Certification required

<i>Object</i>	<i>Certificate type</i>	<i>Issued by</i>	<i>Certification standard*</i>	<i>Additional description</i>
Gas/Dual Fuel Engines	PC	Society		In accordance with Pt.4 Ch.3
Process pressure vessels	PC	Society		Shall be certified as Class I pressure vessels in accordance with Pt.4 Ch.7
Pumps	PC	Society		In accordance with Pt.5 Ch.7
Compressors	PC	Society		In accordance with Pt.4 Ch.5
Valves in fuel system	PC	Society		For valves with design temperature below 0°C In accordance with Pt.5 Ch.7 Sec.5 (irrespective of size)
Valves in fuel system	PC	Society		For valves with design pressure above 10 bar In accordance with Pt.5 Ch.7 Sec.5 (irrespective of size)
Valves in fuel system	MC	Manufacturer		For valves with design pressure equal to or lower than 10 bar, and design temperature equal to or above 0°C
Expansion bellows	PC	Society		In accordance with Pt.5 Ch.7
Fuel gas control and monitoring systems	PC	Society		Shall be certified in accordance with Pt.4 Ch.9
Fuel gas safety system	PC	Society		Shall be certified in accordance with Pt.4 Ch.9
Hydrocarbon gas detection and alarm system, fixed	PC	Society		Shall be certified in accordance with Pt.4 Ch.9
Electric motors	PC	Society		Shall be certified in accordance with Pt.4 Ch.8 when used in gas supply systems and ventilation systems
Electric motor starters	PC	Society		Shall be certified in accordance with Pt.4 Ch.8 when used in gas supply systems and ventilation systems
*Unless otherwise specified the certification standard is DNV GL Rules.				

1.7.1.2

For general certification requirements, see [Pt.1 Ch.3 Sec.4.](#)

1.7.1.3

For a definition of the certification types, see [Pt.1 Ch.3 Sec.5](#)

1.8 Onboard documentation

1.8.1 Contents

1.8.1.1 An operational manual as described in [Table 2](#) shall be kept on-board. The operation manual is in general to give information regarding the following:

- 1) Arrangement and lay-out of the gas fuel supply system, including:
 - Description of main components in the gas fuel supply system
 - A general description of how the fuel system is intended to work
- 2) Description of the safety shutdown system for the gas fuel supply system, including:
 - How to respond to gas leakages in
 - the fuel system
 - tank connection spaces
 - ESD protected machinery spaces
 - fuel preparation rooms
 - How to respond to cryogenic leakages in
 - the fuel system
 - tank connection spaces
 - fuel preparation rooms
 - How to respond to loss of ventilation in
 - the secondary enclosures in the gas fuel system
 - tank connection spaces
 - ESD protected machinery spaces
 - fuel preparation rooms
 - How to respond to fire in
 - the machinery space
 - on deck
 - fuel preparation room
- 3) Description of hazards in connection with inerted spaces and use of inert gas
- 4) Description of bunkering operations, including:
 - how to prevent overfilling of tanks
 - how to control the tank pressure when bunkering
 - how to prevent release of fuel gases to atmosphere
 - how to gas free the bunkering system at termination of bunkering operation
 - safety precautions
- 5) Description of entry procedures for
 - tank connection spaces
 - fuel preparation rooms
 - GUV enclosures

- hold spaces
 - other spaces where entry may constitute a hazard to the ship or personnel
- 6) Procedure for emptying and gas freeing of fuel gas tanks
- 7) Relevant drawings of the gas fuel installation, including:
- Fuel gas piping diagram
 - Fuel gas system arrangement plan
 - Ventilation systems

1.8.1.2 A plan for periodic test of all field instruments specified in these rules shall be kept onboard. The plan shall include test intervals, description of how to perform the tests and description of what to observe during the tests.

Test intervals for shutdown inputs and outputs (as required by [Table 7](#)) shall not exceed 6 months. For other signals the test intervals shall not exceed 12 months.

The plan may be included in the plan required for the class notation **E0**.

Guidance note:

See [Sec.2 \[1.4\]](#) for information about plan for periodic test.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.9 Signboards

1.9.1 General

1.9.1.1 If the gas supply is shut off due to activation of an automatic valve, the gas supply shall 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 shall be placed at the operating station for the shut-off valves in the gas supply lines.

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

1.9.1.3 A caution placard or signboard shall be permanently fitted in the machinery space stating that heavy lifting, implying danger of damage to the gas pipes, shall not be done when the engine(s) is running on gas.

1.9.1.4 A signboard shall be permanently fitted on hatches to gas valve unit spaces in machinery spaces stating that the hatch shall only be opened after the gas supply system is shut down and gas free.

1.9.1.5 A signboard shall be permanently fitted on access openings to inerted spaces, warning of hazards related to entry.

2 Materials

2.1 General

2.1.1 Material requirements

2.1.1.1 Materials shall be in accordance with the requirements in [Pt.2](#), unless otherwise stated.

2.1.1.2 Materials used in fuel containment and fuel piping systems shall comply with the requirements in [Pt.5 Ch.7 Sec.6 \[1\]](#), [Pt.5 Ch.7 Sec.6 \[2\]](#), [Pt.5 Ch.7 Sec.6 \[3\]](#) and [Pt.5 Ch.7 Sec.6 \[4\]](#).

For tanks containing compressed natural gas (CNG), the use of materials other than those covered by [Pt.5 Ch.7 Sec.6](#) may be specially considered and approved by the Society.

[2.1.1.3](#) High pressure gaseous fuel pipes shall as a minimum fulfil the requirements for pipe materials with design temperature down to minus 55°C in [Pt.5 Ch.7 Sec.6 Table 4](#).

[2.1.1.4](#) The secondary enclosure around high pressure gaseous fuel pipes shall as a minimum fulfil the material requirements for pipe materials with design temperature down to minus 55°C [Pt.5 Ch.7 Sec.6 Table 4](#).

[2.1.1.5](#) The secondary enclosure around liquefied fuel pipes shall as a minimum fulfil the material requirements for pipe materials with design temperature down to minus 165°C in [Pt.5 Ch.7 Sec.6 Table 4](#).

[2.1.1.6](#) The materials used in fuel gas piping systems shall be furnished with documentation in accordance with [Table 4](#).

For the definition of material documentation see the Rules for Classification of Ships, [Pt.1 Ch.3 Sec.5](#).

Table 4 Certification of material quality and testing

Object	Certificate type ^{1) 2)}	Issued by	Cert. standard ³⁾	Additional description				
				Material	Piping system	Nom. Dia	Design pressure (bar)	Design temp. (°C)
Pipes (including secondary enclosures)	MC	Society			Pressure	> 25	> 10	or < 0
	MC	Manufacturer			Pressure	≤ 25		
	MC	Manufacturer			Open ended			< 0
	MC	Manufacturer			Pressure		≤ 10	and ≥ 0
	TR	Manufacturer			Open ended			≥ 0
Flanges	MC	Manufacturer			Pressure			
	TR	Manufacturer			Open ended			
Bodies of valves and fittings ⁴⁾ , pump housings, other pressure containing components not considered as pressure vessels	MC	Society		Steel				< 0
	MC	Manufacturer						
	MC	Manufacturer		Copper alloys				
Nuts and bolts	TR	Manufacturer		Steel				

Object	Certificate type ^{1) 2)}	Issued by	Cert. standard ³⁾	Additional description				
				Material	Piping system	Nom. Dia	Design pressure (bar)	Design temp. (°C)
Notes								
1) MC Material certificate								
2) TR Test Report								
3) Unless otherwise specified, the certification standard is the rules								
4) When fittings are made from plates or pipes, the certification requirements for pipes shall be applied also for the pipe fittings.								

3 Ship arrangement

3.1 Ship arrangement principles

3.1.1 General principles

3.1.1.1 The fuel containment system installed in the ship shall be able to contain cryogenic leakages without damaging other structures due to the low temperature, and to prevent gas spreading to non-hazardous spaces.

3.1.1.2 Areas with piping systems for liquefied gas fuel shall be arranged to contain leakages without damaging other structures due to the low temperature, and to prevent gas spreading to non-hazardous spaces with the assumption that the piping system may leak anywhere in the system.

3.1.1.3 Areas with piping systems for gaseous fuel shall be arranged to prevent gas spreading to non-hazardous spaces, with the assumption that the piping system may leak anywhere in the system.

3.1.2 Location and separation of spaces, arrangement of entrances and other openings

3.1.2.1 Direct access shall not be permitted from a non-hazardous area to a hazardous area. Where such access is necessary, an air lock shall be provided.

3.1.2.2 Mustering stations and lifesaving equipment shall not be located in hazardous areas.

3.2 Arrangement of machinery spaces

3.2.1 General

3.2.1.1 A machinery space containing gas engines shall have at least two completely independent exits. This requirement may be waived after special consideration by the Society if the machinery space is very small.

3.2.1.2 Access to machinery spaces shall not be arranged from hazardous spaces.

3.2.2 ESD protected machinery spaces

3.2.2.1 In machinery spaces protected by emergency shutdown systems (ESD-protected machinery spaces), a single failure may result in a gas release into the space. These machinery spaces are considered non-hazardous under normal conditions, but shall have safety measures to prevent ignition if a failure in the gas supply line leads to release of gas.

In the event of conditions involving gas hazards, the gas supply shall be automatically shut down. Shutdown of non-safe equipment and machinery shall be automatically executed while equipment or machinery in use or active during these conditions shall be of a certified safe type.

The ventilation of the space is designed to dilute a probable maximum gas leakage to concentrations below the lower explosion limit of the gas and to rapidly ventilate any leaked gas out of the machinery space.

3.2.2.2 ESD protected machinery spaces shall be designed to provide a geometrical shape that will minimize the accumulation of gases or formation of gas pockets.

3.2.2.3 Engines used for generation of propulsion power and electric power shall be distributed in two or more machinery spaces.

3.2.2.4 An explosion in an ESD protected machinery space shall not:

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

Unless calculations show that the strength of the room is sufficient to withstand a worst case explosion, explosion pressure relief devices shall be arranged.

3.2.2.5 When a single bulkhead separates ESD protected machinery spaces, the bulkhead shall have sufficient strength to withstand a gas explosion in one of the rooms. A strength standard of the bulkhead corresponding to that of a watertight bulkhead is considered adequate.

3.2.2.6 Distribution of engines between the different machinery spaces shall be such that shutdown of fuel supply to any one machinery space does not lead to an unacceptable loss of power.

3.2.2.7 Incinerators, inert gas generators or oil fired boilers shall not be located within the ESD protected machinery space. This space shall only contain a minimum of equipment and systems required to ensure that the gas machinery maintains its function.

3.2.2.8 Gas detection systems shall be arranged in ESD protected machinery spaces. Upon gas detection the safety system shall automatically shut down the gas supply (and the oil fuel supply in case of dual fuel engines) and de-energize all non-explosion protected equipment or installations in the machinery space.

3.2.2.9 Unless the access to a machinery space of ESD protected type is from open deck, the entrances shall be arranged with air lock access. Disconnection of electrical equipment upon loss of ventilation in the ESD protected machinery space need not be arranged in the space where the access to the ESD protected machinery space is located.

3.2.2.10 ESD-protected machinery spaces shall not contain gas supply systems where the design pressure exceeds 10 bar.

3.2.2.11 ESD-protected machinery spaces shall be designed for periodically unattended operation.

3.2.3 Gas safe machinery spaces

3.2.3.1 Arrangements in gas safe machinery spaces are such that the spaces are considered gas safe under all conditions. In a gas safe machinery space a single failure will not lead to release of fuel gas into the machinery space because all leakage sources are protected by a secondary enclosure. A gas safe machinery space can be arranged as a conventional machinery space.

3.3 Arrangement of other spaces containing fuel systems

3.3.1 Fuel preparation rooms - General

3.3.1.1 Fuel preparation rooms shall in general be located on open deck. When an open deck location is difficult to arrange, a location below deck may be accepted.

3.3.1.2 Where fuel preparation rooms are accepted below deck, their access shall be independent and direct from the open deck. Where a separate access from deck is not possible, access shall be provided through an air lock which complies with [3.4].

3.3.1.3 Fuel preparation rooms shall not be located directly above or adjacent to machinery spaces of category A or other high fire risk areas. If cofferdams are used to obtain segregation between fuel preparation rooms and high fire risk spaces, they shall have a minimum distance of 900 mm between bulkheads or decks. Common boundaries of protective cofferdams with such spaces shall be kept to a minimum.

3.3.1.4 The fuel preparation room boundaries shall be gas tight towards other enclosed spaces in the ship.

3.3.1.5 Where pumps or compressors are driven by shafting passing through a bulkhead or deck for separation purposes, gastight seals with efficient lubrication or other means of ensuring the permanence of the gas seal shall be fitted in way of the bulkhead or deck.

3.3.2 Fuel preparation rooms containing liquefied gas

3.3.2.1 Fuel preparation rooms containing liquefied gas shall be designed to safely contain leakages of cryogenic liquids.

3.3.2.2 The amount of cryogenic liquid that the fuel preparation room shall be able to contain shall be estimated assuming a failure corresponding to full pipe rupture in the fuel supply system. The leakage time shall correspond to the time the safety system needs to detect the leakage and isolate it from the source.

3.3.2.3 The fuel preparation room shall be fitted with ventilation arrangements or pressure relief devices ensuring that the space can withstand any pressure build up caused by vaporization of the liquefied gas fuel. These pressure relief systems shall be constructed with materials suitable for the lowest temperatures that may arise.

3.3.2.4 The fuel preparation room shall be arranged to prevent surrounding hull structure from being exposed to unacceptable cooling, in case of leakage of cryogenic liquids.

3.3.2.5 The fuel preparation room entrance shall be arranged with a sill height exceeding the liquid level resulting from a calculated maximum leakage, but in no case lower than 300 mm.

3.3.2.6 A cryogenic leakage in the fuel preparation room shall not render necessary safety functions out of order due to low temperatures.

3.3.3 Fuel preparation rooms not containing liquefied gas

3.3.3.1 Structure and supports shall be suitably shielded from leakage from flanges and valves and other possible leakage sources in high pressure gas systems, unless the cool down effect can be shown to be negligible.

3.3.3.2 Fuel preparation rooms for high pressure systems shall be provided with overpressure protection to account for high pressure leakages, unless it can be demonstrated that the integrity of the space can be maintained without such protection.

3.3.4 Tank connection spaces

3.3.4.1 Tank connection spaces shall not be located directly adjacent to machinery spaces of category A or other rooms with high fire risk. If cofferdams are used to obtain segregation between tank connection spaces and high fire risk spaces, they shall have a minimum distance of 900 mm between bulkheads or decks. Common boundaries of protective cofferdams with such spaces shall be kept to a minimum.

3.3.4.2 Tank connection spaces shall be able to safely contain leakages of cryogenic liquids, and arranged to prevent the surrounding hull structure from being exposed to unacceptable cooling.

3.3.4.3 The amount of cryogenic liquid that the tank connection space shall be able to contain shall be estimated, assuming a failure corresponding to a full pipe rupture in the fuel supply system. The leakage time shall correspond to the time the safety system needs to detect the leakage and isolate it from the source.

3.3.4.4 The tank connection space shall be fitted with ventilation arrangements or pressure relief arrangements ensuring that the space can withstand any pressure build up caused by vaporization of the liquefied gas fuel. These pressure relief systems shall be constructed with materials suitable for the lowest temperatures that may arise.

3.3.4.5 Tank connection space boundaries shall be gas tight towards other enclosed spaces in the ship.

3.3.4.6 The tank connection space entrance shall be arranged with a sill height exceeding the liquid level resulting from a calculated maximum leakage, but in no case lower than 300 mm.

3.3.4.7 Unless the access to the tank connection space is independent and direct from open deck, it shall be arranged as a bolted hatch.

3.3.4.8 A cryogenic leakage in the tank connection space shall not render necessary safety functions out of order due to low temperatures.

3.3.5 Fuel storage hold spaces

3.3.5.1 Interbarrier spaces and fuel storage hold spaces associated with fuel containment systems, requiring full or partial secondary barriers, shall be inerted with a suitable dry inert gas and kept inerted with make-up gas provided by a shipboard inert gas generation system, or by shipboard storage, which shall be sufficient for normal consumption for at least 30 days. Shorter periods may be considered, depending on the ship's service.

3.3.5.2 Alternatively, the spaces referred to in [3.3.5.1] requiring only a partial secondary barrier may be filled with dry air provided that the ship maintains a stored charge of inert gas or is fitted with an inert gas generation system sufficient to inert the largest of these spaces, and provided that the configuration of the spaces and the relevant gas detection systems, together with the capability of the inerting arrangements, ensures that any leakage from the fuel tanks will be rapidly detected and inerting effected before a dangerous condition can develop. Equipment for the provision of sufficient dry air of suitable quality to satisfy the expected demand shall be provided.

3.3.5.3 Spaces surrounding type C independent fuel tanks shall be filled with suitable dry air and be maintained in this condition with dry air provided by suitable air drying equipment. This is only applicable for fuel tanks where condensation and icing due to cold surfaces is an issue.

3.3.5.4 Unless the access to interbarrier spaces and hold spaces, associated with fuel containment systems requiring full or partial secondary barriers is independent and direct from open deck, it shall be arranged as a bolted hatch. The access shall be from the top of the tank hold space.

3.3.5.5 Access to inerted spaces shall be through a bolted hatch. Alternative arrangements giving equivalent protection against unintended entry by personnel may be accepted. It shall be ensured that leakages of inert gas to adjacent spaces from access openings, bulkhead penetrations or other potential leakage sources are prevented.

3.3.5.6 Fuel storage hold spaces shall not be used for other purposes.

3.3.6 Fuel bunkering stations

3.3.6.1 The bunkering station shall be so located that sufficient natural ventilation is provided. Closed or semi-enclosed bunkering stations will be subject to additional requirements. Depending on the arrangement this may include:

- Segregation towards other areas
- Requirements for forced ventilation
- Requirements for leakage detection (gas detection, low temperature detection).
- Access to bunkering station through air locks
- Monitoring of bunkering station by Closed Circuit Television (CCTV)

3.3.6.2 Drip trays shall be fitted below bunkering connections and where leakage may occur which can cause damage to the ship structure or where limitation of the area which is effected from a spill is necessary. Each drip tray shall be:

- made of suitable material to hold spills (e.g. stainless steel)
- thermally insulated from the ship's structure
- fitted with a drain valve to enable rain water to be drained over the ship's side
- of sufficient capacity to handle reasonably foreseeable spills.

3.3.6.3 For CNG bunkering stations, low temperature steel shielding shall be provided to prevent the possible escape of cold jets impinging on surrounding hull structure.

3.3.7 Gas valve unit spaces

3.3.7.1 A gas valve unit space located in the machinery space is considered to be part of the secondary enclosure for gas supply pipes. When such a space is arranged as a room, the access shall be via a bolted manhole.

3.3.7.2 The gas valve unit space shall only be entered after the gas supply system is shut down and gas free. The hatch shall be fitted with a signboard to this effect.

3.3.7.3 Gas valve unit spaces for high pressure systems shall be provided with overpressure protection to account for high pressure leakages, unless it can be demonstrated that the integrity of the space can be maintained without such protection.

3.4 Arrangement of air locks

3.4.1 General

3.4.1.1 An air lock is a space enclosed by gastight bulkheads with two substantially gastight doors spaced at least 1.5 m and not more than 2.5 m apart. The doors shall be self-closing without any holding back arrangements.

3.4.1.2 Air locks shall be mechanically ventilated at an overpressure relative to the adjacent hazardous area or space. The ventilation inlets and outlets for air locks shall be located in open air.

3.4.1.3 Air locks shall have a simple geometrical form. They shall provide free and easy passage, and shall have a deck area not less than about 1.5 m². Air locks shall not be used for other purposes, for instance as store rooms.

3.4.2 Air lock monitoring and safety action

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

3.4.2.2 The air lock space shall be monitored for flammable gas.

3.4.2.3 For non-hazardous spaces with access from hazardous open deck where the access is protected by an air lock, electrical equipment which is not of the certified safe type shall be de-energized upon loss of overpressure in the space.

3.4.2.4 For non-hazardous spaces with access from hazardous spaces, where the access is protected by an air lock, electrical equipment which is not of the certified safe type shall be de-energized upon loss of underpressure in the hazardous space.

3.4.2.5 Access to the hazardous space shall be restricted until the ventilation has been reinstated. Audible and visual alarms shall be given at a manned location to indicate both, loss of pressure and opening of the air lock doors when pressure is lost.

3.4.2.6 Electrical equipment of the certified safe type need not to be de-energized.

3.4.2.7 Electrical equipment needed for maintaining ship main functions or safety functions shall not be located in spaces protected by air locks, unless the equipment is of certified safe type.

4 Fuel containment systems

4.1 General

4.1.1 Design principles

4.1.1.1 Fuel containment systems shall be located in such a way that the risk of excessive heat input from a fire is minimized.

4.1.1.2 Fuel containment systems shall be located and arranged in such a way that the risk of mechanical damage from ship operations, cargo operations and green seas is minimized, either by locating the fuel tanks away from such hazards, or by providing mechanical protection.

4.1.1.3 Fuel containment systems shall be located in such a way that the risk of mechanical damage from explosions is minimized, either by locating the fuel tanks away from areas of explosion risks by providing mechanical protection, or by reducing the risk of explosions.

4.1.1.4 Fuel containment systems shall be designed and arranged not to cause damage to other structures due to low temperature leakages.

4.1.1.5 Fuel containment systems on open deck shall be designed and arranged to minimize, as far as practicable, the extent of hazardous areas and potential sources of release.

4.1.1.6 When fuel is carried in a fuel containment system requiring a complete or partial secondary barrier:

- fuel storage hold spaces shall be segregated from the sea by a double bottom; and
- the ship shall also have a longitudinal bulkhead forming side tanks.

4.1.2 Tank access

4.1.2.1 It shall be possible to empty, inert and gas free fuel tanks and associated fuel piping systems. Procedures shall be developed in accordance with [Pt.5 Ch.7 Sec.9](#).

4.1.2.2 Access for external inspection of fuel tanks shall be provided in accordance with [Pt.5 Ch.7 Sec.3 \[5\]](#).

4.1.2.3 Access for internal inspection of fuel tanks shall be provided, except for vacuum insulated type C tanks which may be accepted without access openings.

4.2 Liquefied gas fuel tanks

4.2.1 General

4.2.1.1 Fuel tanks for liquefied gas shall be fitted with efficient insulation.

4.2.1.2 Natural gas in a liquefied state may be stored with a maximum allowable relief valve setting (MARVS) of up to 10 bar g. The maximum allowable working pressure (MAWP) of the gas tank shall not exceed 90 per cent of the MARVS.

4.2.1.3 Fuel tanks for liquefied gas shall be independent tanks or membrane tanks designed in accordance with applicable parts of [Pt.5 Ch.7 Sec.4](#), [Pt.5 Ch.7 Sec.20](#) to [Pt.5 Ch.7 Sec.24](#), unless covered by this section.

Guidance note:

References given to the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk in [Pt.5 Ch.7](#) are not applicable for fuel containment systems

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.2.1.4 The design life of fixed liquefied gas fuel containment systems shall not be less than the design life of the ship or 25 years, whichever is greater.

4.2.1.5 Liquefied gas fuel containment systems shall be designed in accordance with North Atlantic environmental conditions and relevant long-term sea state scatter diagrams for unrestricted navigation. Less demanding environmental conditions, consistent with the expected usage, may be accepted by the Society for liquefied gas fuel containment systems used exclusively for restricted navigation. More demanding environmental conditions may be required for liquefied gas fuel containment systems operated in conditions more severe than the North Atlantic environment.

4.2.1.6 The liquefied gas fuel containment system structural strength shall be assessed against failure modes, including but not limited to plastic deformation, buckling and fatigue. The specific design conditions

that shall be considered for the design of each liquefied gas fuel containment system are given in [Pt.5 Ch.7 Sec.20](#) to [Pt.5 Ch.7 Sec.24](#).

4.2.1.7 There are three main categories of design conditions:

- a) *Ultimate design conditions* – The liquefied gas fuel containment system structure and its structural components shall withstand loads liable to occur during its construction, testing and anticipated use in service, without loss of structural integrity. The design shall take into account proper combinations of the following loads:
 - internal pressure;
 - external pressure;
 - dynamic loads due to the motion of the ship in all loading conditions;
 - thermal loads;
 - sloshing loads;
 - loads corresponding to ship deflections;
 - tank and liquefied gas fuel weight with the corresponding reaction in way of supports;
 - insulation weight;
 - loads in way of towers and other attachments; and
 - test loads.
- b) *Fatigue design conditions* – The liquefied gas fuel containment system structure and its structural components shall not fail under accumulated cyclic loading.
- c) *Accidental design conditions* – The liquefied gas fuel containment system shall meet each of the following accident design conditions (accidental or abnormal events), addressed in these rules:
 - Collision – The liquefied gas fuel containment system shall withstand the collision loads specified in [\[4.2.9.3\]](#) without deformation of the supports, or the tank structure in way of the supports likely to endanger the tank and its supporting structure.
 - Fire – The liquefied gas fuel containment systems shall sustain without rupture the rise in internal pressure specified in [\[5.2.3\]](#) under the fire scenarios envisaged therein.
 - Flooded compartment causing buoyancy on tank – the anti-flotation arrangements shall sustain the upward force, specified in [\[4.2.9.3\]](#) and there shall be no endangering plastic deformation to the hull. Plastic deformation may occur in the fuel containment system provided it does not endanger the safe evacuation of the ship.

4.2.1.8 Measures shall be applied to ensure that scantlings required meet the structural strength provisions and are maintained throughout the design life. Measures may include, but are not limited to, material selection, coatings, corrosion additions, cathodic protection and inerting.

4.2.1.9 An inspection/survey plan for the liquefied gas fuel containment system shall be developed and approved by the Society. The inspection/survey plan shall identify aspects to be examined and/or validated during surveys throughout the liquefied gas fuel containment system's life and, in particular, any necessary in-service survey, maintenance and testing that was assumed when selecting liquefied gas fuel containment system design parameters. The inspection/survey plan may include specific critical locations as per [Pt.5 Ch.7 Sec.4 \[4.3.3.8\]](#).

4.2.1.10 Liquefied gas fuel containment systems shall be designed, constructed and equipped to provide adequate means of access to areas that need inspection as specified in the inspection/survey plan. Liquefied gas fuel containment systems, including all associated internal equipment shall be designed and built to ensure safety during operations, inspection and maintenance.

4.2.2 Liquefied gas fuel containment safety principles

4.2.2.1 The containment systems shall be provided with a complete secondary liquid-tight barrier capable of safely containing all potential leakages through the primary barrier and, in conjunction with the thermal insulation system, also capable of preventing lowering of the temperature of the ship structure to an unsafe level.

4.2.2.2 The size and configuration or arrangement of the secondary barrier may be reduced or omitted where an equivalent level of safety can be demonstrated in accordance with [4.2.2.3] and [4.2.2.4], as applicable.

4.2.2.3 Liquefied gas fuel containment systems, for which the probability for structural failures to develop into a critical state has been determined to be extremely low, but where the possibility of leakages through the primary barrier cannot be excluded, shall be equipped with a partial secondary barrier and small leak protection system capable of safely handling and disposing of the leakages (a critical state means that the crack develops into unstable condition).

The arrangements shall comply with the following:

- 1) failure developments that can be reliably detected before reaching a critical state (e.g. by gas detection or inspection) shall have a sufficiently long development time for remedial actions to be taken; and
- 2) failure developments that cannot be safely detected before reaching a critical state shall have a predicted development time that is much longer than the expected lifetime of the tank.

4.2.2.4 No secondary barrier is required for liquefied gas fuel containment systems, e.g. type C independent tanks, where the probability for structural failures and leakages through the primary barrier is extremely low and can be neglected.

4.2.2.5 For independent tanks requiring full or partial secondary barrier, means for safely disposing of leakages from the tank shall be arranged

4.2.3 Secondary barriers in relation to tank types

4.2.3.1 Secondary barriers in relation to the tank types defined in Pt.5 Ch.7 Sec.20 to Pt.5 Ch.7 Sec.23 shall be provided in accordance with the following table.

<i>Basic tank type</i>	<i>Secondary barrier requirements</i>
Membrane tank	Complete secondary barrier
Type A	Complete secondary barrier
Type B	Partial secondary barrier
Type C	No secondary barrier required

4.2.4 Design of secondary barriers

4.2.4.1 The location of a containment system using hull structure as secondary barrier shall be specially considered in conjunction with surrounding spaces.

4.2.4.2 The design of the secondary barrier, including spray shield if fitted, shall be such that:

- 1) it is capable of containing any envisaged leakage of liquefied gas fuel for a period of 15 days unless different criteria apply for particular voyages, taking into account the load spectrum referred to in Pt.5 Ch.7 Sec. 4 [4.3.3.6]
- 2) physical, mechanical or operational events within the liquefied gas fuel tank that could cause failure of the primary barrier shall not impair the due function of the secondary barrier, or vice versa
- 3) failure of a support or an attachment to the hull structure will not lead to loss of liquid tightness of both the primary and secondary barriers

- 4) it is capable of being periodically checked for its effectiveness by means of a visual inspection or other suitable means acceptable to the Society
- 5) the methods required in [4.2.4.2] 4) shall be approved by the Society and shall include, as a minimum:
 - details on the size of defect acceptable and the location within the secondary barrier, before its liquid tight effectiveness is compromised
 - accuracy and range of values of the proposed method for detecting defects in .1 above
 - scaling factors to be used in determining the acceptance criteria if full scale model testing is not undertaken
 - effects of thermal and mechanical cyclic loading on the effectiveness of the proposed test
- 6) the secondary barrier shall fulfil its functional requirements at a static angle of heel of 30°.

4.2.5 Partial secondary barriers and primary barrier small leak protection system

4.2.5.1 Partial secondary barriers as permitted in [4.2.2.3] shall be used with a small leak protection system and meet all the regulations in [4.2.4].

The small leak protection system shall include means to detect a leak in the primary barrier, provision such as a spray shield to deflect any liquefied gas fuel down into the partial secondary barrier, and means to dispose of the liquid, which may be by natural evaporation.

4.2.5.2 The capacity of the partial secondary barrier shall be determined, based on the liquefied gas fuel leakage corresponding to the extent of failure resulting from the load spectrum referred to in Pt.5 Ch.7 Sec.4 [4.3.3.6], after the initial detection of a primary leak. Due account may be taken of Liquid evaporation, rate of leakage, pumping capacity and other relevant factors.

4.2.5.3 The required liquid leakage detection shall be by means of liquid sensors, or by an effective use of pressure, temperature or gas detection systems, or any combination thereof.

4.2.5.4 For independent tanks for which the geometry does not present obvious locations for leakage to collect, the partial secondary barrier shall also fulfil its functional requirements at a nominal static angle of trim.

4.2.6 Supporting arrangements

4.2.6.1 Supporting arrangements are defined in Pt.5 Ch.7 Sec.4 [2.6].

4.2.7 Associated structure and equipment

4.2.7.1 Associated structure and equipment are defined in Pt.5 Ch.7 Sec.4 [2.7].

4.2.8 Thermal insulation

4.2.8.1 Thermal insulation is defined in Pt.5 Ch.7 Sec.4 [2.8].

4.2.9 Design loads

4.2.9.1 Design loads are defined in Pt.5 Ch.7 Sec.4 [3.1] to Pt.5 Ch.7 Sec.4 [3.5], except as indicated in [4.2.9.2] and [4.2.9.3] below:

4.2.9.2 Environmental loads are defined in Pt.5 Ch.7 Sec.4 [3.4]; in addition the following loads shall be considered:

- Green sea loading - Account shall be taken to loads due to water on deck.
- Wind loads - Account shall be taken to wind generated loads as relevant.

4.2.9.3 Accidental loads are defined as loads that are imposed on a liquefied gas fuel containment system and its supporting arrangements under abnormal and unplanned conditions.

a) Collision loads

The collision load shall be determined based on the fuel containment system under fully loaded condition with an inertial force corresponding to "a" in the table below in forward direction and "a/2" in the aft direction, where "g" is gravitational acceleration.

Ship length (L)	Design acceleration (a)
L > 100 m	0.5 g
60 < L ≤ 100 m	$\left\{ 2 - \frac{a(L - 60)}{80} \right\}_g$
L ≤ 60 m	2g

Special consideration should be given to ships with Froude number (Fn) > 0,4.

b) Loads due to flooding on ship

For independent tanks, loads caused by the buoyancy of a fully submerged empty tank shall be considered in the design of anti-flotation chocks and the supporting hull structure in both the adjacent hull and tank structure.

4.2.10 Structural integrity

4.2.10.1 Structural integrity is defined in [Pt.5 Ch.7 Sec.4 \[4.1\]](#).

4.2.11 Structural analyses

4.2.11.1 Structural analyses are defined in [Pt.5 Ch.7 Sec.4 \[4.2\]](#).

4.2.12 Design conditions

4.2.12.1 Design conditions are defined in [Pt.5 Ch.7 Sec.4 \[4.3\]](#).

4.2.13 Materials and construction

4.2.13.1 To determine the grade of plate and sections used in the hull structure, a temperature calculation shall be performed for all tank types. The following assumptions shall be made in this calculation:

- The primary barrier of all tanks shall be assumed to be at the liquefied gas fuel temperature.
- In addition to 1 above, where a complete or partial secondary barrier is required it shall be assumed to be at the liquefied gas fuel temperature at atmospheric pressure for any one tank only.
- For worldwide service, ambient temperatures shall be taken as 5°C for air and 0°C for seawater. Higher values may be accepted for ships operating in restricted areas and conversely, lower values may be imposed by the Society for ships trading to areas where lower temperatures are expected during the winter months.
- Still air and sea water conditions shall be assumed, i.e. no adjustment for forced convection.
- Degradation of the thermal insulation properties over the life of the ship due to factors such as thermal and mechanical ageing, compaction, ship motions and tank vibrations as defined in [Pt.5 Ch.7 Sec.4 \[5.1.3.6\]](#) and [\[5.1.3.7\]](#) shall be assumed.
- The cooling effect of the rising boil-off vapour from the leaked liquefied gas fuel shall be taken into account where applicable.
- No credit shall be given for any means of heating, unless specially considered by the Society.
- For members connecting inner and outer hulls, the mean temperature may be taken for determining the steel grade.

- Vacuum insulated tanks and their supporting structures shall be designed to withstand the temperatures that may arise as a result of loss of insulating vacuum between the inner and outer tank.

4.2.13.2 The materials of all hull structures for which the calculated temperature in the design condition is below 0°C, due to the influence of liquefied gas fuel temperature and that do not form the secondary barrier, shall be in accordance with [Pt.5 Ch.7 Sec.6 Table 5](#). This includes hull structure supporting the liquefied gas fuel tanks, inner bottom plating, longitudinal bulkhead plating, transverse bulkhead plating, floors, webs, stringers and all attached stiffening members.

4.2.13.3 The hull material forming the secondary barrier shall be in accordance with [Pt.5 Ch.7 Sec.6 Table 2](#). Where the secondary barrier is formed by the deck or side shell plating, the material grade required by [Pt.5 Ch.7 Sec.6 Table 2](#) shall be carried into the adjacent deck or side shell plating, where applicable, to a suitable extent

4.2.13.4 Materials of primary and secondary barriers are defined in [Pt.5 Ch.7 Sec.4 \[5.1.2\]](#).

4.2.13.5 Thermal insulation and other materials used in liquefied gas fuel containment systems are defined in [Pt.5 Ch.7 Sec.4 \[5.1.3\]](#).

4.2.14 Construction processes

4.2.14.1 Construction processes are defined in [Pt.5 Ch.7 Sec.4 \[5.2\]](#).

4.2.15 Tank types

4.2.15.1 Type A independent tanks are defined in [Pt.5 Ch.7 Sec.20](#).

4.2.15.2 Type B independent tanks are defined in [Pt.5 Ch.7 Sec.20](#) and [Pt.5 Ch.7 Sec.21](#).

4.2.15.3 Type C independent tanks are defined in [Pt.5 Ch.7 Sec.22](#).

In addition, requirements below for fatigue design condition apply:

- For type C independent tanks where the liquefied gas fuel at atmospheric pressure is below minus 55°C, the Society may require additional verification to check compliance with design basis for C type tanks as defined in [Pt.5 Ch.7 Sec.22 \[1.1.1\]](#), regarding static and dynamic stress depending on the configuration of the tank and arrangement of its supports and attachments.
- For vacuum insulated tanks special attention shall be made to the fatigue strength of the support design and special considerations shall also be made to the limited inspection possibilities between the inside and outer shell.

The fatigue strength assessment to be carried out in accordance with DNV Classification Notes No. 30.7 and/or Recommended Practice DNVGL-RP-C203.

4.2.15.4 Membrane tanks are defined in [Pt.5 Ch.7 Sec.23](#).

4.2.16 Additional requirements for vacuum insulated tanks

4.2.16.1 Vacuum insulated type C independent tanks shall have an outer shell that is able to function as a secondary barrier against pipe leakages, to compensate for not having closable tank valves at the tank boundary. The outer shell shall be able to withstand cryogenic temperatures and the pressure build-up due to evaporating liquids. A pipe stress analysis is required for the piping in the vacuum space. The piping in the vacuum space shall have no branch connections.

4.2.16.2 Vacuum insulated type C independent tanks shall have their vacuum space protected by a pressure relief device connected to a vent system discharging to a safe location in open air. For tanks on open deck, a direct release into the atmosphere may be accepted.

4.2.16.3 Alternatives to having an outer shell secondary barrier as required by [4.2.16.1] might be considered on a case-by-case basis. Alternative solutions shall as a minimum provide the following:

- Secondary barriers shall be provided for every pipe in the vacuum space. The secondary barriers shall be able to safely contain leakages of liquefied and gaseous fuel, taking into account cryogenic temperatures, pressure build-up, relative movements between inner and outer tank and expansion/contractions due to temperature differences.
- The outer shell and the support structure shall be made from material with a design temperature corresponding to the equilibrium temperature resulting from a loss of vacuum between inner and outer tank.
- Any part of the outer tank shell having common boundaries with a tank connection space shall be made of material resistant to cryogenic temperatures.
- All pipes and secondary enclosures in the vacuum space shall be fully welded. Pipe routing shall compensate for expansion and contractions due to changes in temperature. The use of expansion elements is not accepted for this purpose.

4.2.17 Limit state design for novel concepts

4.2.17.1 Limit state design for novel concepts is defined in Pt.5 Ch.7 Sec.24.

4.3 Compressed gas fuel tanks

4.3.1 General

4.3.1.1 Tanks for compressed natural gas (CNG) shall be certified as class I pressure vessels in accordance with Pt.4 Ch.7. Alternatively, they may be certified based on relevant requirements in Pt.5 Ch.8.

4.3.1.2 Tanks for CNG shall be fitted with pressure relief valves with a set point below the design pressure of the tank and with outlet located as required in [5.2].

4.3.1.3 Adequate means shall be provided to depressurize the tank in case of a fire which can affect the tank.

4.4 Portable liquefied gas fuel tanks

4.4.1 General

4.4.1.1 Portable fuel tanks shall be certified by the Society and comply with the requirements for type C tanks in Pt.5 Ch.7 Sec.22. The tank support (container frame or truck chassis) shall be designed for the intended purpose.

4.4.1.2 The design life of portable fuel tanks shall not be less than 20 years.

4.4.1.3 Fuel systems utilising portable fuel tanks shall have equivalent safety compared to permanent fuel tanks.

4.4.1.4 Portable fuel tanks shall be located in dedicated areas fitted with:

- mechanical protection of the tanks depending on location and cargo operations
- spill protection and water spray systems for cooling if located on open deck

If the tanks are located in an enclosed space, the space shall be considered as a tank connection space.

4.4.1.5 Portable fuel tanks shall be secured to the deck while connected to the ship systems. The arrangement for supporting and fixing the tanks shall 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.

4.4.1.6 Connections to the ship piping systems shall be made by means of approved flexible hoses or other suitable means designed to provide sufficient flexibility.

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

4.4.1.8 The pressure relief system of portable tanks for liquefied gas shall be connected to a fixed venting system.

4.4.1.9 Control and monitoring systems for portable gas fuel tanks shall be integrated in the ship's gas control and monitoring system. Safety system for portable gas fuel tanks shall be integrated in the ship's gas safety system (e.g. shutdown systems for tank valves, leak/gas detection systems).

4.4.1.10 Safe access to tank connections for the purpose of inspection and maintenance shall be ensured.

4.4.1.11 After connection to the ship's fuel piping system;

- each portable tank shall be capable of being isolated at any time, with the exception of the pressure relief system
- isolation of one tank shall not impair the availability of the remaining portable tanks
- the tank shall not exceed its maximum filling limits.
- the tank shall not exceed its maximum filling limits.

4.5 Loading limit for liquefied gas fuel tanks

4.5.1 Loading limit curve

4.5.1.1 Fuel tanks for liquefied gas shall not be filled to more than a volume equivalent to 98% full at the reference temperature as defined in [1.5.1].

A loading limit curve for actual fuel loading temperatures shall be prepared from the following formula:

$$LL = FL \rho_R / \rho_L$$

where:

- LL = loading limit as defined in [1.5.1], expressed in per cent;
- FL = filling limit as defined in [1.5.1] expressed in per cent, here 98%;
- ρ_R = relative density of fuel at the reference temperature; and
- ρ_L = relative density of fuel at the loading temperature.

4.5.1.2 In cases where the tank insulation and tank location make the probability very small for the tank contents to be heated up, due to an external fire, special considerations may be made to allow a higher loading limit than calculated using the reference temperature, but never above 95%. This also applies in cases where a second system for pressure maintenance is installed. However, if the pressure can only be maintained/controlled by fuel consumers, the loading limit as calculated in [4.5.1.1] shall be used.

4.6 Maintenance of fuel storage condition

4.6.1 Control of tank pressure and temperature

4.6.1.1 Means shall be provided to keep the fuel tank pressure and temperature within their design range at all times. Systems and arrangements to be used for this purpose may include one, or a combination of, the following:

- Energy consumption by the ship (engines, gas turbines, boilers etc.)
- Re-liquefaction
- Thermal oxidation of vapours (gas combustion unit)
- Pressure accumulation

4.6.1.2 The method chosen shall be capable of maintaining tank pressure below the set pressure of the tank for a period of 15 days, assuming full tank at normal service pressure and the ship in idle condition, i.e. only power for domestic load is generated.

4.6.1.3 The overall capacity of the system shall be such that it can control the pressure within the design conditions without venting to atmosphere. Venting of fuel vapour for control of the tank pressure is not acceptable, except in emergency situations.

4.6.1.4 If a re-liquefaction system produces a waste stream containing methane during pressure control operations within the design conditions, these waste gases shall, as far as reasonably practicable, be disposed of without venting to atmosphere.

4.6.1.5 Refrigerants or auxiliary agents used for refrigeration or cooling of fuel shall be compatible with the fuel they may come in contact with (not causing any hazardous reaction or excessively corrosive products) In addition, when several refrigerants or agents are used, these shall be compatible with each other.

4.6.1.6 The availability of the system and its supporting auxiliary services shall be such that in case of a single failure, the fuel tank pressure and temperature can be maintained within the design range.

4.6.1.7 Heat exchangers that are solely necessary for maintaining the pressure and temperature of the gas fuel tanks, within their design ranges, shall have a standby heat exchanger, unless the installed heat exchangers have a capacity in excess of 25% of the largest required capacity for pressure control, and they can be repaired onboard without external resources.

4.7 Requirements depending on fuel tank location

4.7.1 Fuel tanks located in enclosed spaces

4.7.1.1 Tanks for liquefied fuel with a design pressure of 10 bar or less may be stored in enclosed spaces in accordance with these rules. Compressed gas shall not be stored below deck, but this may be accepted on case-by case basis.

4.7.1.2 A fuel gas containment system located in enclosed spaces shall be gas tight towards adjacent spaces. For fuel gas containment systems where leakage through the primary barrier is part of the design assumptions, the gas tight barrier will be the secondary barrier, or in case of partial secondary barriers, be the fuel storage hold space.

4.7.1.3 Fuel tank connections, flanges and tank valves shall be located in a tank connection space designed to safely contain leakages of cryogenic liquids.

4.7.1.4 The space containing fuel containment systems shall be separated from the machinery spaces of category A or other rooms with high fire risks. The separation shall be done by a cofferdam of at least 900 mm with fire insulation as required in [7].

4.7.1.5 For type C fuel tanks, the fuel storage hold space may act as the protective cofferdam if the bulkhead is at least 900 mm from the outer shell of the tank. This can however not be applied to tanks located directly above machinery spaces of category A or other high fire risk areas.

4.7.1.6 Common boundaries of protective cofferdams with engine rooms or high fire risk areas shall kept to a minimum.

4.7.2 Fuel tanks not located in enclosed spaces

4.7.2.1 For fuel tanks not located in enclosed spaces, tank connection spaces need not be arranged if other measures are in place to fulfil the functional requirements in [4.1.1] and [5.1.1].

4.7.2.2 If drip trays are used to protect the ship structure from leakages at the tank connections, the material of drip trays shall have a design temperature corresponding to the temperature of the fuel carried at atmospheric pressure. Drip trays shall be thermally insulated from the ship's structure to prevent unacceptable cooling in case of leakage of liquefied gas.

4.7.2.3 Fuel tanks not located in enclosed spaces shall not be located directly above or adjacent to machinery spaces of category A or other high fire risk areas. If cofferdams are used to obtain segregation between fuel tanks and high fire risk spaces, they shall have a minimum distance of 900 mm between bulkheads or decks.

5 Piping systems

5.1 General

5.1.1 Design principles

5.1.1.1 Fuel piping systems shall be located in such a way that the risk of mechanical damage from ship operations, cargo operations and green seas is minimized, either by locating the fuel piping systems away from such hazards, or by providing mechanical protection.

5.1.1.2 Leakages in the fuel piping system shall not cause damage to other structures due to the low temperature, and the design shall prevent gas spreading to non-hazardous spaces.

5.1.1.3 Fuel piping systems shall be designed and arranged to minimize as far as practicable the extent of hazardous areas and potential sources of release.

5.1.1.4 It shall be possible to detect leakages in a fuel piping system, and to automatically isolate the leakage from the source.

5.1.1.5 It shall be possible to automatically isolate the piping systems for liquefied gas fuel at the tank boundary.

5.1.2 Fuel piping system configuration

5.1.2.1 The propulsion and fuel supply system shall be so designed that any safety actions required by these Rules do not lead to an unacceptable loss of power.

5.1.2.2 For engines using gas as the only fuel, the fuel supply system shall be arranged with redundancy and segregation all the way from the gas tank to the consumer. A leakage in the fuel supply system with following necessary safety actions shall not lead to an unacceptable loss of power.

5.1.2.3 For engines using gas as the only fuel, the fuel storage shall be divided between two or more tanks, including separate secondary barriers when required. If fuel tanks of type C are used, one tank may be accepted if two completely separate tank connection spaces are installed for the one tank.

5.1.2.4 For non-conventional gas fuelled propulsion machinery arrangements, an FMEA shall be made covering any single failure in active components or systems (see [Pt.4 Ch.1 Sec.3 \[3.2\]](#)).

Guidance note:

Non-conventional in this respect implies machinery arrangement where the propulsion machinery is based on other redundancy principles than duplication of the propulsion line with separate gas supply systems.

The requirement does in general not apply to dual-fuel engines.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.1.3 Piping design and arrangement

5.1.3.1 Piping in the fuel system shall comply with the applicable parts of [Pt.5 Ch.7 Sec.5 \[11\]](#) unless covered by this section.

5.1.3.2 Gas supply systems shall have a design pressure not less than 10 bar.

5.1.3.3 Tank connections shall be located above the highest liquid level in the tank. Connections below the highest liquid level may be accepted for fuel tanks of Type C.

5.1.3.4 Low temperature piping shall be thermally insulated from the adjacent hull structure, where necessary, to prevent the temperature of the hull from falling below the design temperature of the hull material.

5.1.3.5 Piping in the fuel system shall not be located less than 800 mm from the ship's side.

5.1.3.6 Fuel piping including vent lines shall not be routed through tanks.

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

5.1.3.8 Gas fuel piping in ESD protected machinery spaces shall be located as far as practicable from the electrical installations and tanks containing flammable liquids.

5.1.3.9 Gas fuel piping in ESD protected machinery spaces shall be protected against mechanical damage.

5.1.3.10 Fuel piping shall be capable of absorbing thermal expansion or contraction caused by extreme temperatures of the fuel without developing substantial stresses.

5.1.3.11 Provision shall be made to protect the piping, piping system and components and fuel tanks from excessive stresses due to thermal movement and from movements of the tank and hull structure.

5.1.3.12 The arrangement and installation of fuel piping shall provide the necessary flexibility to maintain the integrity of the piping system in the actual service situations, taking potential for fatigue into account.

5.1.3.13 If the fuel gas contains heavier constituents that may condense in the system, means for safely removing the liquid shall be fitted.

5.1.3.14 High pressure gas piping systems shall have sufficient constructive strength. This shall be confirmed by carrying out stress analysis and taking into account:

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

Guidance note:

Significant acceleration loads is in this context acceleration loads that give a stress equal to more than 20% of the stress from the internal pressure in the pipe.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.1.3.15 High-pressure gas lines shall be installed and protected so as to minimise the risk of injury to personnel in case of rupture.

5.1.3.16 Where tanks or piping are separated from the ship's structure by thermal insulation, provision shall be made for electrically bonding to the ship's structure both the piping and the tanks. All gasketed pipe joints and hose connections shall be electrically bonded.

5.1.3.17 Fuel pipes and all the other piping needed for a safe and reliable operation and maintenance shall be colour marked in accordance with a recognized standard.

Guidance note:

See EN ISO 14726:2008 Ships and marine technology – Identification colours for the content of piping systems.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.1.3.18 Components in the fuel containment systems and piping systems with low surface temperatures shall be so installed and protected as to reduce to a minimum any danger to persons onboard, and to prevent operational problems due to icing.

5.1.4 Fuel piping systems containing cryogenic liquids

5.1.4.1 Piping systems for liquefied gas fuel shall be protected by a secondary enclosure able to contain leakages. If the piping system is located in a space that is able to contain leakages of cryogenic liquids, this requirement can be waived.

5.1.4.2 The requirement in [5.1.4.1] need not be applied for bunkering lines on open deck.

5.1.4.3 The piping systems and corresponding secondary enclosures shall be able to withstand the maximum pressure that may build up in the system. For this purpose, the secondary enclosure may need to be arranged with a pressure relief system that prevents the enclosure from being subjected to pressures above their design pressures.

5.1.4.4 The secondary enclosure shall be made of a material that can withstand cryogenic temperatures.

5.1.5 Fuel piping systems containing gaseous fuels

5.1.5.1 Piping systems containing natural gas in enclosed spaces shall be arranged with a secondary enclosure able to contain gas leakages. If the piping system is located in a space that is arranged to contain leakages of gas, or arranged in an ESD protected machinery space, this requirement can be waived.

5.1.5.2

The requirement in [5.1.5.1] need not be applied for fully welded fuel gas vent pipes led through mechanically ventilated spaces.

5.1.5.3 The secondary enclosures shall be designed with segregations in order to prevent a gas leakage outside the machinery space from reaching the machinery space.

5.1.5.4 The secondary enclosure shall be provided with a ventilation arrangement providing at least 30 air changes per hour. Other solutions providing an equivalent safety level will be evaluated on a case-by-case basis.

5.1.5.5 For fuel gas systems where the design pressure exceeds 10 bar, the design pressure of the secondary enclosure shall be taken as the higher of the following:

- the maximum built up pressure: static pressure in way of the rupture resulting from the gas flowing in the annular space
- local instantaneous peak pressure in way of the rupture p^* : this pressure shall be taken as the critical pressure and is given by the following expression:

$$p^* = p_0 \left(\frac{2}{k+1} \right)^{\frac{k}{k+1}}$$

p_0 = maximum working pressure of the inner pipe

k = C_p/C_v - constant pressure specific heat divided by constant volume specific heat

k = 1.31 for methane

The tangential membrane stress of a straight pipe shall not exceed the tensile strength divided by 1.5 ($R_m/1.5$) when subjected to the above pressure. The pressure ratings of all other piping components shall reflect the same level of strength as straight pipes.

As an alternative to using the peak pressure from the above formula, the peak pressure found from representative tests can be used. Test reports shall then be submitted.

5.1.5.6 For fuel systems where the design pressure does not exceed 10 bar, the secondary enclosure shall be dimensioned for a design pressure not less than the maximum working pressure of the gas pipes.

5.1.5.7 The requirements in [5.1.5.5] and [5.1.5.6] are also applicable for parts of the secondary enclosure extending to air inlets and outlets on open deck.

5.1.6 Valve arrangements

5.1.6.1 Fuel tank inlets and outlets shall be provided with valves located as close to the tank as possible.

5.1.6.2 Valves that are not easily accessible shall be remotely operated. This requirement does not apply to normally closed valves not operated during normal service.

5.1.6.3 Tank valves shall be automatically operated when the safety system required in Table 7 is activated.

5.1.6.4 All automatic and remotely operated valves shall be provided with indications for open and closed valve positions at the location where the valves are remotely operated.

5.1.6.5 Remotely operated valves shall fail to a safe position upon loss of actuation power or control signals.

Guidance note:

"Fail to close" is generally considered to be the safe mode. For Double-Block-and-Bleed arrangements, the bleed valve shall fail to open position.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.1.6.6 Pipe segments and components that may be isolated in a liquid full condition shall be provided with pressure relief valves. Pressure relief valves shall discharge to the vent mast.

5.1.6.7 The liquefied gas fuel supply lines to fuel preparation rooms shall be equipped with automatically operated shut-off valves situated at the bulkhead inside the fuel preparation room.

5.1.6.8 The main gas supply line to each gas consumer or set of consumers shall be equipped with a manually operated stop valve and an automatically operated "master gas fuel valve" coupled in series or a combined manually and automatically operated valve. The valves shall be situated in the part of the piping that is outside the machinery space containing gas consumers, and placed as near as possible to the installation for heating the gas, if fitted. The master gas fuel valve shall automatically cut off the gas supply when activated by the safety system required in Table 7. For high pressure gas supply lines, the master gas fuel valve shall be arranged as two shutoff valves in series with a venting valve in between.

5.1.6.9 The gas supply line to each consumer shall be provided with double-block-and-bleed valves. These valves shall be arranged for automatic shutdown as given in Table 7, and for normal stop and shutdown of the engine. For high pressure gas supply lines, the master gas fuel valve may perform this function. An alarm for faulty operation of the valves shall be provided.

Guidance note:

Block valves open and bleed valve open is an alarm condition. Similarly engine stopped and block valves open is an alarm condition.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.1.6.10 An arrangement that automatically ventilates the pipe between the master gas valve and the double block and bleed valve when these are closed, shall be fitted. The pipe between the double block and bleed valve and the gas injection valves, shall also be automatically vented.

5.1.6.11 Each gas supply line entering an ESD protected machinery space, and each gas supply line to high-pressure installations, shall be provided with means for rapid detection of a rupture in the piping system inside the machinery space.

5.1.6.12 Each gas supply line entering an ESD protected machinery space, and each gas supply line to high-pressure installations, shall be provided with a valve that will automatically close upon detection of a gas pipe rupture in the machinery space. This valve shall be located outside the machinery space, or at the machinery space bulkhead at the point of entry inside the machinery space. It can be a separate valve or combined with other functions, e.g. the master valve.

Guidance note:

If a differential pressure measurement is used to detect a pipe rupture, the shutdown should be time delayed to prevent shutdown due to transient load variations.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.1.6.13 There shall be one manually operated shutdown valve in the gas supply line to each engine upstream of the double block and bleed valves to assure safe isolation during maintenance on the engine.

5.1.6.14 Shutdown valves in liquefied gas fuel piping systems operated by the safety system shall close fully and smoothly within 30 s of actuation. Information about the closure time of the valves and their operating characteristics shall be available onboard, and the closing time shall be verifiable and repeatable.

5.1.7 Bellows

5.1.7.1 Bellows shall not be installed in enclosed spaces.

5.1.7.2 Bellows shall only be installed where they are readily accessible for inspection.

5.1.7.3 Slip joints shall not be used, except within the liquefied gas fuel storage tanks.

5.1.7.4 If accepted, bellows in systems for cryogenic liquids shall only be installed in spaces designed to withstand cryogenic leakages.

5.1.7.5 Bellows shall be protected against icing where necessary

5.2 Pressure relief systems

5.2.1 General

5.2.1.1 All fuel tanks shall be provided with a pressure relief system appropriate to the design of the fuel containment system and the fuel being carried. Fuel storage hold spaces, interbarrier spaces, tank connection spaces and tank cofferdams, which may be subject to pressures beyond their design capabilities, shall also be provided with a suitable pressure relief system. Pressure control systems specified in [4.6.1] shall be independent of the pressure relief systems.

5.2.1.2 Fuel tanks which may be subject to external pressures above their design pressure shall be fitted with vacuum protection systems in accordance with Pt.5 Ch.7 Sec.8 [3].

5.2.1.3 All vent piping shall be designed and arranged not to be damaged by the temperature variations to which it may be exposed, or forces due to flow or the ship's motions.

5.2.2 Pressure relief valves

5.2.2.1 Fuel tanks shall have at least two completely independent pressure relief valves.

5.2.2.2 Pressure relief valves shall comply with Pt.5 Ch.7 Sec.8 [2.1] and be tested in accordance with applicable parts of Pt.5 Ch.7 Sec.8 [2.2].

5.2.2.3 Stop valves shall be fitted before and after the pressure relief valves. This shall enable in-service maintenance, to stop gas from escaping in case of a leaking pressure relief valve and to be able to maintain tank pressure in cases where this is used to drive gas supply to the engine.

5.2.2.4 The stop valves shall be arranged to minimize the possibility that all pressure relief valves for one tank are isolated simultaneously. Physical interlocks shall be included to this effect.

5.2.2.5 The remaining in-service pressure relief valves shall have the combined relieving capacity required by [5.2.3.1] when one valve is isolated from the tank. However, this capacity may be provided by all valves if a suitably maintained spare valve is carried onboard.

5.2.2.6 The outlet from the pressure relief valves shall be located at least B/3 or 6 m, whichever is greater, above the weather deck and 6 m above the working area and gangways, where B is the greatest moulded breadth of the ship in meters. The outlets shall be located at least 10 m from the nearest:

- air intake, air outlet or opening to accommodation, service and control spaces, or other non-hazardous area
- exhaust outlet from machinery or from furnace installation.

For small ships and ship types where the operation limits the possible location of the outlet, lesser heights than given above may be accepted.

5.2.2.7 The outlet from the pressure relief valves shall be so constructed that the discharge will be unimpeded and be directed vertically upwards at the exit. The outlets shall also be arranged to minimize the possibility of water or snow entering the vent system.

5.2.2.8 All other fuel gas vent outlets shall be arranged in accordance with [5.2.2.6] and [5.2.2.7]. Means shall be provided to prevent liquid overflow from gas vent outlets, due to hydrostatic pressure from spaces to which they are connected.

5.2.2.9 In the vent piping system, means for draining water from places where it may accumulate shall be provided. The PRVs and piping shall be arranged so that water under no circumstances can accumulate in or near the PRVs.

5.2.2.10 Suitable protection screens of not more than 13 mm square mesh shall be fitted on vent outlets to prevent the ingress of foreign objects without adversely affecting the flow.

5.2.2.11 PRVs shall be connected to the highest part of the liquefied fuel tank. PRVs shall be positioned on the liquefied fuel tank so that they will remain in the vapour phase at the filling limit (FL) under conditions of 15° list and 0.015L trim.

5.2.3 Sizing of pressure relieving system

5.2.3.1 The sizing of pressure relief valves shall comply with Pt.5 Ch.7 Sec.8 [4.1].

5.2.3.2 For vacuum insulated tanks in fuel storage hold spaces and for tanks in fuel storage hold spaces separated from potential fire loads by cofferdams or surrounded by spaces with no fire load, the fire factors may be reduced to the following values:

$F=0.5$ to $F=0.25$

$F=0.2$ to $F=0.1$

The minimum fire factor is $F=0.1$

5.2.4 Sizing of vent pipe system

5.2.4.1 The sizing of the vent pipe system shall comply with Pt.5 Ch.7 Sec.8 [4.2].

5.3 Fuel bunkering system

5.3.1 General

5.3.1.1 The bunkering system shall be so arranged that no gas will be discharged to air during filling of the fuel tanks.

5.3.1.2 A water distribution system shall be fitted in way of the hull under the shore connections to provide a low-pressure water curtain for additional protection of the hull steel and the ship's side structure. This system shall be operated when fuel transfer is in progress. Alternative means, providing equivalent protection, will be considered on a case-by-case basis.

5.3.2 Arrangement of bunkering lines

5.3.2.1 Bunkering lines shall in general be arranged as self-draining towards the tank. If the bunkering station need to be located lower than the fuel tanks, and bunkering lines cannot be made self-draining towards the tank, other suitable means should be provided to relieve the pressure and remove liquid contents from the bunker lines.

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

5.3.2.3 In cases where it is possible to bunker the ship from two sides through a common bunkering line, suitable isolation arrangements shall be arranged to prevent fuel being inadvertently transferred to the side not in use for bunkering.

5.3.2.4 Bunkering connections and bunkering lines shall be supported and arranged in such a way that in case of mechanical damage to the piping on open deck, the risk of damage to the ship's fuel containment system and tank valves are minimized.

5.3.2.5 The bunkering manifold shall be designed to withstand the external loads it is subjected to during bunkering. This shall include the forces on the manifold in a scenario where the bunkering line is released by a breakaway coupling.

5.3.3 Bunkering valve arrangements

5.3.3.1 A manually operated stop valve and a remote operated shutdown valve in series, or a combined manually operated and remote valve shall be fitted in every bunkering line close to the shore connecting point.

5.3.3.2 The closing time of the shutdown valve shall not be more than 5 seconds from the trigger of the alarm to full closure of the valve, unless pressure surge considerations makes a longer closing time necessary. The closing time of the shutdown valve shall also be sufficient to prevent overfilling of the tank when automatic shutdown is initiated by high tank level.

5.3.3.3 The requirement in [5.3.3.2] also applies to tank filling valves if automatic operation is initiated by high tank level.

5.3.3.4 The connections at the bunkering station shall be of dry-disconnect type equipped with additional safety dry breakaway coupling/self-sealing quick release. The couplings shall be of a standard type.

5.4 Nitrogen installations

5.4.1 Nitrogen piping systems

5.4.1.1 An arrangement for purging fuel bunkering lines and supply lines with nitrogen shall be provided.

5.4.1.2 Where the inert gas supply line is connected to the fuel system, it shall be fitted with a double-block-and-bleed valve arrangement to prevent the return of flammable gas to any non-hazardous spaces. In addition, a closable non-return valve shall be installed between the double block and bleed arrangement and the fuel system.

5.4.1.3 The double block and bleed valves shall be located outside non-hazardous spaces and comply with the following requirements:

- The operation of the valves shall be automatically executed. Signals for opening and closing shall be taken from the process directly, e.g. differential pressure.
- An alarm for faulty operation of the valves shall be provided.

5.4.1.4 Where connections to the gas piping systems are non-permanent, two non-return valves in series may substitute the non-return devices required in [5.4.1.2].

5.4.1.5 Where insulation spaces are continually supplied with an inert gas as part of a leak detection system, means shall be provided to monitor the quantity of gas being supplied to individual spaces.

5.4.1.6 The inert gas system shall be such that each space being inerted can be isolated and the necessary arrangements shall be provided for controlling pressure in these spaces.

5.4.2 Spaces containing nitrogen installation

5.4.2.1 Where a nitrogen generator or nitrogen storage facilities are installed in a separate compartment outside of the machinery space, the separate compartment shall be fitted with an independent mechanical

extraction ventilation system, providing 6 air changes per hour. A low oxygen alarm shall be fitted. Such separate compartments shall be treated as one of other machinery spaces, with respect to fire protection.

5.4.2.2 Nitrogen pipes shall only be led through well-ventilated spaces. Nitrogen pipes in enclosed spaces shall:

- be fully welded
- have only a minimum of flange connections as needed for fitting of valves
- be as short as possible.

The need for other precautions to prevent suffocation of personnel in case of leakage should be considered in each case.

5.4.3 Atmospheric control within the fuel containment system

5.4.3.1 A piping system shall be arranged to enable each fuel tank to be safely gas-freed, and to be safely filled with fuel from a gas-free condition. The system shall be arranged to minimize the possibility of pockets of gas or air remaining after changing the atmosphere.

5.4.3.2 The system shall be designed to eliminate the possibility of a flammable mixture existing in the fuel tank during any part of the atmosphere change operation, by utilizing an inerting medium as an intermediate step.

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

5.4.3.4 Inert gas utilized for gas freeing of tanks may be provided externally to the ship.

5.4.4 Inert gas production and storage on board

5.4.4.1 If inert gas generators are provided, they shall be capable of producing inert gas with oxygen content less than 5 per cent by volume. A continuous-reading oxygen content meter shall be fitted to the inert gas supply from the equipment and shall be fitted with an alarm set at a maximum of 5 per cent oxygen content by volume.

5.4.4.2 Inert gas system shall have pressure controls and monitoring arrangements appropriate to the fuel containment system. Inert gas systems shall comply with the requirements in [Pt.5 Ch.7](#).

5.5 Exhaust system

5.5.1 General

5.5.1.1 Unless exhaust systems are designed with the strength to withstand the worst case over pressure due to ignited gas leaks, explosion relief systems shall be suitably designed and fitted.

5.5.1.2 The explosion venting shall be led away from where personnel may be present.

Guidance note:

Both explosion impact and amount of potentially suffocating combustion gases shall be taken into account when deciding where explosion relief valves can be located. The distance from a relief valve to gangways and working areas should generally be at least 3 meters, unless efficient shielding is provided. Bursting discs may not open into machinery spaces, but may be located inside the casing.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.5.1.3 Bursting discs shall only be used as a means for explosion relief ventilation where any event, where a bursting disc has compromised the exhaust system, does not lead to an unacceptable loss of power.

5.5.1.4 Exhaust gas piping shall be arranged to avoid possibility for accumulation of unburned gas.

5.5.1.5 Machinery using gas as fuel shall have separate exhaust systems.

5.6 Other ship systems

5.6.1 Gas heating systems

5.6.1.1 Circulation pumps for the heating fluid shall be arranged with redundancy. If circulation is necessary to prevent freezing in the heating circuit, power supply shall then be from an UPS, or alternative means for maintaining circulation for a sufficiently long period in case of loss of electric power supply.

5.6.1.2 The heating circuit expansion tank shall be fitted with a gas detector, and shall be vented to open air.

5.6.1.3 To prevent freezing of the heating medium, the following arrangement shall be provided:

- Alarm for low temperature at heating medium outlet
- Automatic stop of liquefied gas feed pump (if fitted) and closing of tank valve at stop of circulation of heating fluid.

5.6.2 Drainage systems

5.6.2.1 Bilge systems serving hazardous spaces shall be segregated from other bilge systems.

5.6.2.2 Where fuel is carried in a fuel containment system requiring a secondary barrier, suitable drainage arrangements for dealing with any leakage into the hold or insulation spaces through the adjacent ship structure shall be provided. The bilge system shall not lead to pumps in safe spaces. Means of detecting such leakage shall be provided.

5.6.2.3 The hold or interbarrier spaces of Type A independent tanks for liquefied gas shall be provided with a drainage system suitable for handling liquefied fuel in the event of fuel tank leakage or rupture.

6 Ventilation systems

6.1 Ventilation of spaces

6.1.1 General

6.1.1.1 Any ducting used for the ventilation of hazardous spaces shall be separate from that used for the ventilation of non-hazardous spaces.

6.1.1.2 Ventilation fans serving hazardous spaces shall comply with requirements in [Pt.5 Ch.7 Sec.12 \[1.1.7\]](#).

6.1.1.3 Where a ventilation duct passes through a space with a different hazardous zone classification, possible leakages to the less hazardous zone shall be prevented. This shall be obtained by ensuring that the less hazardous space or duct has an over-pressure relative to the more hazardous space or duct. Such ventilation ducts shall have a mechanical integrity equivalent to that required for general piping systems in [Pt.4 Ch.6 Sec.9 Table 3](#).

6.1.1.4 Air inlets for hazardous enclosed spaces shall be taken from areas, which in the absence of the considered inlet would be non-hazardous.

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

6.1.1.5 Air inlets for non-hazardous enclosed spaces shall be taken from non-hazardous areas at least 1.5 m away from the boundaries of any hazardous area.

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

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

6.1.1.7 Hazardous spaces shall be continuously ventilated. Consequently, ventilation inlets and outlets for such spaces shall be located sufficiently high above deck to not require closing appliances according to the International Load Line Convention.

6.1.1.8 Ventilation ducts from spaces containing liquefied gas fuel leakage sources shall be constructed of materials having a design temperature corresponding to the minimum temperature that may arise when cold gas is ventilated out through the ducts.

6.1.1.9 The number and capacity of the ventilation fans serving:

- tank connection spaces
- ESD protected machinery spaces
- secondary enclosure ventilation systems
- fuel preparation rooms

shall be such that the capacity is not reduced by more than 50%, after a failure of an active component or a failure in the power supply system to the fans.

6.1.2 Tank connection spaces

6.1.2.1 Tank connection spaces shall be provided with an effective mechanical ventilation system of the extraction type, providing a ventilation capacity of at least 30 air changes per hour. The ventilation system shall be arranged to maintain a pressure less than the atmospheric pressure. Other solutions, providing an equivalent level of safety, may be considered on a case-by-case basis.

6.1.2.2 Spaces containing access openings for tank connection spaces shall be arranged with separate ventilation, providing at least 8 air changes per hour.

6.1.3 Fuel preparation rooms

6.1.3.1 Fuel preparation rooms shall be fitted with effective mechanical ventilation system of the extraction type, providing a ventilation capacity of at least 30 air changes per hour. The ventilation system shall be arranged to maintain a pressure less than the atmospheric pressure. For spaces where the ventilation may cause condensation and icing due to cold surfaces, other solutions providing an equivalent level of safety, may be considered on a case-by-case basis.

6.1.4 Secondary enclosures for gas pipes

6.1.4.1 Secondary enclosures containing gas piping shall be fitted with effective mechanical ventilation system of the extraction type, providing a ventilation capacity of at least 30 air changes per hour. The ventilation system shall be arranged to maintain a pressure less than the atmospheric pressure. Other solutions providing an equivalent safety level will be evaluated on a case-by-case basis.

6.1.4.2 The ventilation system for the secondary enclosure of the gas supply system shall be independent of ventilation systems in tank connection spaces and other spaces where there is a potential for liquefied gas fuel leakages.

6.1.4.3 When located in gas safe machinery spaces, the ventilation system for the secondary enclosure of the gas supply system and the ventilation of the gas valve unit spaces shall be independent of all other ventilation systems.

6.1.4.4 Ventilation openings for the secondary enclosures shall be located in open air, away from ignition sources. The inlet opening shall be fitted with a suitable wire mesh guard and protected from ingress of water.

6.1.5 Machinery spaces

6.1.5.1 The ventilation system for machinery spaces containing gas-fuelled consumers shall be independent of all other ventilation systems.

6.1.5.2 ESD protected machinery spaces shall be ventilated with at least 30 air changes per hour. The ventilation system shall ensure a good air circulation in all parts of the machinery space, and prevent any formation of gas pockets.

Arrangements where the ventilation system provides at least 15 air changes per hour in normal operation, but automatically increases the ventilation rate to 30 air changes per hour upon gas detection may also be accepted.

The power supply to fans serving an ESD protected machinery space shall be so arranged that ventilation can be maintained independent of the power generating machinery in the space.

6.1.6 Spaces protected by air locks

6.1.6.1 Non-hazardous spaces with access to a hazardous enclosed space shall be arranged with an air-lock and the hazardous space shall be maintained at under-pressure relative to the non- hazardous space.

6.1.6.2 Non-hazardous spaces with access to hazardous open deck shall be arranged with an air-lock and be maintained at overpressure relative to the external hazardous area.

7 Fire safety

7.1 General

7.1.1 General

7.1.1.1 The requirements in this section are additional to those given in SOLAS Ch.II-2.

7.2 Fire protection

7.2.1 General

7.2.1.1 A fuel preparation room shall be regarded as a machinery space of category A for fire protection purposes.

7.2.2 Construction

7.2.2.1 Any boundary of accommodation spaces, service spaces, control stations, escape routes and machinery spaces, facing fuel tanks on open deck, shall be shielded by A-60 class divisions. The A-60 class divisions shall extend up to the underside of the deck of the navigation bridge, and any boundaries above that, including navigation bridge windows, shall have A-0 class divisions. In addition, fuel tanks shall be segregated from cargo in accordance with the requirements of the International Maritime Dangerous Goods (IMDG) Code where the tanks are regarded as bulk packaging. For the purposes of the stowage and

segregation requirements of the IMDG Code, a gas fuel tank on the open deck shall be considered a class 2.1 package.

7.2.2.2 The space containing fuel containment system and fuel preparation rooms shall be separated from the machinery spaces of category A or other rooms with high fire risks. The separation shall be done by a cofferdam of at least 900 mm with insulation of A-60 class. When determining the insulation of the space containing fuel containment system from other spaces with lower fire risks, the fuel containment system shall be considered as a machinery space of category A, in accordance with SOLAS regulation II-2/9. The boundary between spaces containing fuel containment systems shall be either a cofferdam of at least 900 mm or A-60 class division. For type C tanks, the fuel storage hold space may be considered as a cofferdam.

7.2.2.3 The fire protection of fuel pipes led through ro-ro spaces shall be subject to special consideration by the Society depending on the use and expected pressure in the pipes.

7.2.2.4 The bunkering station shall 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.

7.2.2.5 When one single bulkhead separates ESD protected machinery spaces, the bulkhead shall be fire insulated to class A-60 standard.

7.3 Fire extinction

7.3.1 Fire main

7.3.1.1 The water spray system required below may be part of the fire main system provided that the required fire pump capacity and working pressure are sufficient for the operation of both the required numbers of hydrants and hoses and the water spray system simultaneously.

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

7.3.2 Water spray systems

7.3.2.1 A water spray system shall be installed for cooling and fire prevention to cover exposed parts of fuel tanks located on open deck.

7.3.2.2 The water spray system shall also provide coverage for boundaries of the superstructures, compressor rooms, pump rooms, cargo control rooms, bunkering control stations, bunkering stations and any other normally occupied deck houses that face fuel tanks on open deck, unless tanks are located 10 metres or more from the boundaries.

7.3.2.3 The system shall be designed to cover all areas as specified above with an application rate of 10 l/min/m² for horizontal projected surfaces and 4 l/min/m² for vertical surfaces.

7.3.2.4 Stop valves shall be fitted in the spray water application main supply line(s), at intervals not exceeding 40 metres, for the purpose of isolating damaged sections. Alternatively, the system may be divided into two or more sections that may be operated independently, provided the necessary controls are located together in a readily accessible position, not likely to be inaccessible in case of fire in the areas protected.

7.3.2.5 The capacity of the water spray pump shall be sufficient to deliver the required amount of water to the hydraulically most demanding area as specified above in the areas protected.

7.3.2.6 If the water spray system is not part of the fire main system, a connection to the ships fire main through a stop valve shall be provided.

7.3.2.7 Remote start of pumps supplying the water spray system and remote operation of any normally closed valves to the system shall be located in a readily accessible position, which is not likely to be inaccessible in case of fire in the areas protected. Remote operation of valves shall be possible from the control location for bunkering.

7.3.2.8 The nozzles shall be of an approved full bore type and they shall be arranged to ensure an effective distribution of water throughout the space being protected.

Guidance note:

Alternatives to full bore may be accepted if data sheets for nozzles confirm correct application rate at the working pressure and area coverage.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

7.3.2.9 An equivalent system to the water spray system may be fitted provided it has been tested for its on-deck cooling capability to the satisfaction of the Society.

7.3.3 Dry chemical powder fire extinguishing system

7.3.3.1 In the bunkering station area a permanently installed dry chemical powder extinguishing system shall cover all possible leak points. The capacity shall be at least 3.5 kg/s for a minimum of 45 s discharge. The system shall be arranged for easy manual release from a safe location outside the protected area.

7.3.3.2 In addition to any other portable fire extinguishers that may be required, one portable dry powder extinguisher of at least 5 kg capacity shall be located near the bunkering station.

7.3.4 Fire dampers

7.3.4.1 Approved automatic fail-safe fire dampers shall be fitted in the ventilation trunk for tank connection spaces and fuel preparation rooms.

7.4 Fire detection and alarm systems

7.4.1 Detection

7.4.1.1 A fixed fire detection and fire alarm system complying with the Fire Safety Systems Code shall be provided for the fuel storage hold spaces and the ventilation trunk for fuel containment system below deck, and for all other rooms of the fuel gas system where fire cannot be excluded.

7.4.1.2 Smoke detectors alone shall not be considered sufficient for rapid detection of a fire.

8 Electrical systems

8.1 General

8.1.1 General

8.1.1.1 The requirements in this section are additional to those given in [Pt.4 Ch.8](#).

8.1.1.2 Electrical generation and distribution systems, and associated control systems, shall 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.

8.1.1.3 Failure modes and effects of single failure for electrical generation and distribution systems in [8.1.1.2] shall be analysed and documented.

Guidance note:

See IEC 60812.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

8.1.1.4 Electrical equipment and wiring shall in general not to be installed in hazardous areas unless essential for operational purposes. The type of equipment and installation requirements shall comply with Pt.4 Ch.8 Sec.11 according to the area classification as specified in [8.2].

8.1.1.5 With reference to IEC 60079-20, the following temperature class and equipment groups can be used for potential ship fuels:

	<i>Temperature class</i>	<i>Equipment group</i>
Natural gas	T1	IIA
LPG (propane, butane)	T2	IIA
DME (dimethylether)	T3	IIB

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

8.1.1.7 Electrical equipment fitted in an ESD protected machinery space shall fulfill the following:

- In addition to fire and hydrocarbon detectors and fire and gas alarms, lighting and ventilation fans shall be certified safe for hazardous area zone 1.
- all electrical equipment in the machinery space, not certified for zone 1, shall be automatically disconnected if gas concentrations above 40% LEL is detected on two detectors in the machinery space.

8.1.1.8 Submerged fuel pump motors and their supply cables may be fitted in fuel containment systems. Fuel pump motors shall be capable of being isolated from their electrical supply during gas-freeing operations.

8.1.1.9 Instrumentation and electrical apparatus in contact with the fuel should be of a type suitable for zone 0. Temperature sensors shall be installed in thermo wells, and pressure sensors without additional separating chamber should be suitable for installation in Zone 0.

8.2 Area classification

8.2.1 General

8.2.1.1 In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas shall be divided into zones 0, 1 and 2 according to the principles of the standards IEC 60079-10-1; 2008 Explosive atmospheres Part 10-1: Classification of areas – Explosive gas atmospheres and guidance and informative examples given in IEC 60092-502:1999, Electrical Installations in Ships – Tankers – Special features for tankers. Main features of the guidance are given in [8.2.2].

8.2.1.2 Areas and spaces other than those classified in [8.2.2] shall be subject to special consideration. The principles of the IEC standards shall be applied.

8.2.1.3 Ventilation ducts shall have the same area classification as the ventilated space.

8.2.2 Definition of zones

8.2.2.1 Hazardous areas zone 0 includes, but is not limited to:

- 1) The interiors of fuel tanks, pipes and equipment containing fuel, any pipework of pressure-relief or other venting systems for fuel tanks.

8.2.2.2 Hazardous areas zone 1 includes, but is not limited to:

- 1) Tank connection spaces, fuel preparation rooms arranged with ventilation according to [6.1.3.1], fuel storage hold spaces and interbarrier spaces.

Guidance note:

Fuel storage hold spaces for type C tanks without any leakage sources in the hold space are not considered as zone 1.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

- 2) Areas on open deck, or semi- enclosed spaces on deck, within 3 m of any fuel tank outlet, gas or vapour outlet, bunker manifold valve, fuel tank hatches, other gas valve, gas pipe flange, ventilation outlets from zone 1 hazardous spaces and gas tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation.
- 3) Areas on open deck or semi-enclosed spaces on deck, within 1.5 m of fuel preparation room entrances, fuel preparation room ventilation inlets and other openings into zone 1 spaces.
- 4) Areas on the open deck within spillage coamings surrounding gas bunker manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck.
- 5) Enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. secondary enclosures around fuel pipes, semi-enclosed bunkering stations.
- 6) The ESD-protected machinery space is considered as non-hazardous area during normal operation, but will require equipment required to operate following detection of gas leakage to be certified as suitable for zone 1.
- 7) A space protected by an airlock is considered as non-hazardous area during normal operation, but will require equipment required to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone 1.
- 8) Except for Type C tanks, an area within 2.4 m of the outer surface of a fuel containment system where such surface is exposed to the weather.

8.2.2.3 Hazardous areas zone 2 includes, but is not limited to:

- 1) Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 as specified in [8.2.2.2], if not otherwise specified in this standard.
- 2) Air locks.
- 3) Space containing bolted hatch to tank connection space

8.3 Inspection and testing

8.3.1 General

8.3.1.1 Verification of the physical installation shall be documented by the yard. Verification documentation shall be available for the Society's surveyor at the site.

8.3.1.2 Before the electrical installations in hazardous areas are put into service or considered ready for use, they shall be inspected and tested. All equipment, including cables, shall be verified as having been installed in accordance with installation procedures and guidelines issued by the manufacturer of the equipment and cables, and that the installations have been carried out in accordance to Pt.4 Ch.8 Sec.11.

8.3.1.3 For spaces protected by pressurisation, it shall be examined and tested that purging can be fully accomplished. Purge time at minimum flow rate shall be documented. Required shutdowns and / or alarms upon ventilation overpressure falling below prescribed values shall be tested.

For other spaces where area classification depends on mechanical ventilation, it shall be tested that ventilation flow rate is sufficient, and that required ventilation failure alarm operates correctly.

8.3.1.4 For equipment for which safety in hazardous areas depends upon correct operation of protective devices (for example overload protection relays) and / or operation of an alarm (for example loss of pressurisation for an Ex(p) control panel), it shall be verified that the devices have correct settings and / or correct operation of alarms.

8.3.1.5 Intrinsically safe circuits shall be verified to ensure that the equipment and wiring are correctly installed.

8.4 Maintenance

8.4.1 General

8.4.1.1 The maintenance manual referred to in [Table 2](#), shall be in accordance with the recommendations in IEC 60079-17 and 60092-502 and shall contain necessary information on:

- overview of classification of hazardous areas, with information about gas groups and temperature class
- records sufficient to enable the certified safe equipment to be maintained in accordance with its type of protection (list and location of equipment, technical information, manufacturer's instructions, spares etc.)
- inspection routines with information about level of detail and time intervals between the inspections, acceptance/rejection criteria
- register of inspections, with information about date of inspections and name(s) of person(s) who carried out the inspection and maintenance work.

8.4.1.2 Updated documentation and maintenance manual shall be kept on-board, with records of date and names of companies and persons who have carried out inspections and maintenance. Inspection and maintenance of installations shall be carried out only by experienced personnel whose training has included instruction on the various types of protection of apparatus and installation practices to be found on the ship. Appropriate refresher training shall be given to such personnel on a regular basis.

9 Control, monitoring and safety systems

9.1 General

9.1.1 Functional requirement

9.1.1.1 The control, monitoring and safety systems applied to a fuel installation shall be arranged to fulfil the functional requirements stated below:

- Control, monitoring and safety systems shall be arranged to ensure safe and reliable operation of the fuel installation.
- Leakages of cryogenic and gaseous fuel shall be detected and alarmed.
- A fuel safety system shall be arranged to automatically close down the fuel supply system and isolate ignition sources, upon fault conditions which may develop too fast for manual intervention and upon system failures in accordance with these rules and the installations safety philosophy.
- Propulsion shall be maintained upon single failure in control, monitoring or safety system, and the remaining propulsion power shall be in accordance with [\[5.1.2\]](#).

- Propulsion shall be restored within 30 seconds (redundancy type 1) upon a fuel safety action and the restored propulsion power shall be in accordance with [5.1.2].
- Control, monitoring and safety systems shall be arranged to avoid spurious shutdowns of the fuel supply system.
- Information and means for manual intervention shall be available for the operator.

9.1.2 Arrangement of gas control, monitoring and safety systems

9.1.2.1 Each fuel supply installation shall be fitted with dedicated controllers for gas detection, fuel safety functions and fuel control and monitoring functions. Gas detection system and fuel safety system are considered to be protective safety systems, see Pt.4 Ch.9 Sec.3 [1.4].

Guidance note:

The controllers may be part of the same redundant network if arranged in accordance with Pt.4 Ch.9. Note that the protective safety systems shall, if part of an integrated network, be arranged in a separate network segment in accordance with Pt.4 Ch.9 Sec.2 [1.4.2] and Pt.4 Ch.9 Sec.4 [3].

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

9.1.2.2 Monitoring requirements for the fuel installation are given in Table 5, Table 6 and Table 7. Table 5 gives alarm requirements for gas detection, Table 6 gives alarm and indication requirements to be handled by the gas control and monitoring system. Table 7 and [9.3.1] to [9.3.7] give requirements to protective safety functions with alarm to be handled by the fuel safety system. For alarm conditions found in both Table 6 and Table 7, separate sensors shall be arranged for the gas control and monitoring system and for the fuel safety system.

9.1.2.3 For alarm handling the fuel installation shall follow the principles as for machinery space equipment.

9.1.2.4 Gas detection alarms as required by [9.2.4] shall be given both at the bridge, at the control location for bunkering and locally. If alarming depends on network communication, the functionality shall be handled by the separate network segment arranged for the fuel installation safety functions.

9.1.2.5 Fuel gas safety alarms as specified in Table 7 shall be given at the bridge. If alarming depends on network communication, the functionality shall be handled by the separate network segment arranged for the fuel installation safety functions.

9.1.2.6 For ESD protected machinery spaces, a gas detector system of redundant design shall be arranged for each machinery space.

9.1.2.7 Gas detection functionality and fuel safety functionality for a fuel supply system can be implemented in a common system unit if the system is redundant.

9.1.2.8 For each fuel supply system independent power supplies shall be arranged for the controllers of [9.1.2.1], in accordance with Pt.4 Ch.8 Sec.2 [6.3.3]. In addition each fuel safety system and each fuel control system shall be arranged with uninterruptible power supply (UPS) in accordance with Pt.4 Ch.8 Sec.2 [6.3.5].

9.1.2.9 The signals required to support the safety functions given in Table 7 shall be hardwired, and arranged with loop monitoring unless they are inherently fail safe.

Guidance note:

The requirement for hardwired signals is not applicable for signals sent to other systems for additional safety actions as specified in Table 7.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

9.1.2.10 The output signals required to perform the safety actions specified in Table 7 shall be electrically independent of the gas control system.

Guidance note:

This implies that the output signal should be separate from any control loop, and connected to e.g. separate solenoids and breaker terminals/coils.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

9.1.2.11 Where gas detection shall cause shutdown in accordance with [Table 7](#), detector voting shall be applied. A failed detector shall be considered as an active detection.

Guidance note:

A common voting principle is 2oo2 (meaning two out of two) where both units should detect gas to activate shutdown.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

9.1.3 Emergency stop

9.1.3.1 Compressors and pumps shall be arranged for manual remote emergency stop from the following locations as applicable:

- navigation bridge;
- onboard safety centre;
- engine control room;
- fire control station; and
- adjacent to the exit of fuel preparation rooms.

9.2 Fuel installation control and monitoring

9.2.1 Bunkering and tank monitoring

9.2.1.1 Each fuel tank shall be fitted with at least one liquid level gauging device, designed to operate within the allowable tank pressure and temperature range. Where only one liquid level gauge is fitted, it shall be arranged so that any necessary maintenance can be carried out while the cargo tank is in service.

9.2.1.2 Each fuel tank shall be equipped with high-level alarm, which is released when the tank is filled up to about 95% of the tank volume.

Guidance note:

Sensors for gauging and for high alarm can be handled by a common control system. For requirement to tank overflow protection see [\[9.3.1.1\]](#).

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

9.2.1.3 Each fuel tank shall be monitored for pressure and also fitted with local indicating instrument. The indicators shall be clearly marked with the highest and lowest pressure permitted in the tank. High-pressure alarm and, if vacuum protection is required, low pressure alarm shall be provided. Pressure indication and alarms shall also be indicated on the bridge. The alarms shall be activated before the set pressures of the safety valves are reached.

9.2.1.4 A local reading pressure gauge shall be fitted between the stop valve and the connection to shore at each bunker pipe.

9.2.1.5 Pressure gauges shall be fitted to fuel pump discharge lines and to the bunkering and vapour return lines.

9.2.1.6 Each fuel pump discharge shall be monitored for pressure.

9.2.1.7 Control of bunkering shall be possible from a safe location in regard to bunkering operations. At this location tank pressure, tank temperature if required by [9.2.1.10](#), and tank level shall be available.

Overfill alarm shall also to be indicated at this location, as well as leakage detection alarms for the secondary enclosure for the bunkering pipes.

9.2.1.8 For tanks where submerged fuel pump motors are installed, arrangements shall be made to alarm at low liquid level.

9.2.1.9 Fuel storage hold spaces and inter-barrier spaces without open connection to the atmosphere shall be provided with pressure indication.

9.2.1.10 Except for independent tanks of type C supplied with vacuum insulation system and pressure build-up fuel discharge unit, each fuel tank shall be provided with devices to measure and indicate the temperature of the fuel in at least three locations; at the bottom and middle of the tank as well as the top of the tank below the highest allowable liquid level.

9.2.2 Bilge wells

9.2.2.1 Bilge wells in tank connection spaces, fuel preparation rooms or other spaces containing cryogenic systems without secondary enclosures shall be provided with level sensors. Alarm shall be given at high level in bilge well.

9.2.3 Fuel heating

9.2.3.1 The heating medium for the liquefied gas vaporizer shall be provided with temperature monitoring at the heat exchanger outlet. Alarm shall be given at low temperature.

9.2.3.2 The heated fuel in supply lines to consumers shall be provided with temperature monitoring at the heat exchanger outlet. Alarm shall be given at low temperature.

9.2.4 Gas detection

9.2.4.1 A permanently installed gas detection system shall be provided for:

- tank connection spaces
- fuel preparation rooms
- motor rooms for machinery in fuel preparation rooms
- secondary enclosures around pipes containing gaseous fuels
- ESD protected machinery spaces
- gas safe machinery spaces above engine
- in way of boiler fan supply inlets in machinery spaces
- air locks
- expansion tanks in systems for heating of fuel gas
- other enclosed spaces where fuel vapour may accumulate

9.2.4.2 Where fuel gas containment systems other than Type C tanks are used, hold spaces and/or interbarrier spaces shall be provided with a permanently installed system of gas detection capable of measuring gas concentrations of 0 to 100% by volume. Alarms shall be activated before the gas concentration reaches the equivalent of 30% of the lower explosion limit (LEL) in air.

9.2.4.3 Gas detection systems shall continuously monitor for gas

9.2.4.4 Except for spaces as specified in [\[9.2.4.2\]](#), gas detection instruments for flammable products capable of measuring gas concentrations below the lower flammable limit may be accepted.

9.2.4.5 The number of detectors in each space shall be considered taking size, layout and ventilation of the space into account, and each space shall be covered by sufficient number of detectors to allow for voting in accordance with Table 7.

9.2.4.6 The detectors shall be located where gas may accumulate and/or in the ventilation outlets. Gas dispersal analysis or a physical smoke test shall be used to find the best arrangement.

Table 5 Gas detection alarms

<i>Alarm conditions</i>	
Gas detection	
Interbarrier space of fuel tank, 30% LEL	HA
Fuel tank hold space, 30% LEL	HA
Tank connection space, 20% LEL	HA
Fuel preparation room, 20% LEL	HA
Secondary enclosure of pipes for gaseous fuel outside the machinery space, 20% LEL	HA
Secondary enclosure of pipes for gaseous fuel in the machinery space, 30% LEL	HA
ESD Protected machinery spaces 20% LEL	HA
Expansion tanks in systems for heating of fuel gas	HA
Air locks	HA
Above engine in gas safe machinery spaces	HA
In way of boiler fan supply inlets in machinery spaces	HA
Motor rooms for machinery in fuel preparation rooms	HA
Other enclosed spaces where fuel vapour may accumulate	HA
Bunkering station if required	HA
<i>HA</i> = Alarm for high value	

9.2.5 Ventilation

9.2.5.1 Reduced ventilation below required capacity shall be alarmed. In order to verify the performance of ventilation systems, a flow detection system or a pressure monitoring system is required. A running signal from the ventilation fan motor is not sufficient to verify performance.

9.2.6 Gas compressors

9.2.6.1 Gas compressors shall be fitted with audible and visual alarms both on the navigation bridge and in the engine-room. As a minimum the alarms shall include low gas input pressure, low gas output pressure, high gas output pressure and compressor operation.

9.2.7 Shafts passing through bulkheads

9.2.7.1 Where bulkhead penetrations are used to separate the drive from a hazardous space, temperature monitoring for bulkhead shaft glands and bearings shall be provided. An alarm shall be initiated at high temperature.

Table 6 Monitoring of fuel installations

<i>Alarm conditions</i>		<i>Comment</i>
Fuel containment system		
Level in tank	IL, IR, HA	alarm at 95% of tank volume
Tank pressure	IL, IR*, HA*	alarm level below opening pressure of relief devices
	LA*	if vacuum protection is required
Submerged fuel pump, low level in tank	LA	dry running protection
Hold spaces and interbarrier spaces, pressure	IR	without open connection to the atmosphere
Fuel supply system		
Fuel pump discharge lines, pressure	IL, IR	
Bunkering and vapour return lines, pressure	IL	
Gas compressor		
Fuel gas inlet pressure	LA*	
Fuel gas outlet pressure	LA*	
Fuel gas outlet pressure	HA*	
Compressor operation	A*	
Bilge		
Tank connection space, level in bilge well	HA	
Fuel preparation room, level in bilge well	HA	
Other spaces containing cryogenic systems, level in bilge well	HA	systems without secondary enclosures
Fuel heating		
Heating medium temperature, at vaporizer outlet	IR, LA	
Loss of heating medium circulation	A	
Fuel supply, temperature	IR, LA	at the heat exchanger outlet
Ventilation		
Reduced ventilation in ESD protected machinery space	LA	
Reduced ventilation in tank connection space	LA	
Reduced ventilation in fuel preparation room	LA	
Reduced ventilation in secondary enclosure of pipes for gaseous fuel	LA	
Other alarm conditions		
Air lock, more than one door moved from closed position	A	local alarm on both sides of air lock, [3.4.2.1]

Alarm conditions		Comment
Air lock, door open at loss of ventilation	A	[3 4.2.5]
Malfunction of double-block-and-bleed valves	A	[5.1.6.9] and [5.4.1.3]
Temperature monitoring bulkhead shaft glands and bearings	IR, HA	
Low oxygen alarm in N2 spaces	A	local alarm, [5.4.2.1]
* also to be indicated on bridge <i>IL</i> = Local indication (presentation of values) <i>IR</i> = Remote indication (presentation of values) in engine control room or control location for bunkering when specified <i>A</i> = Alarm activated for logical value <i>LA</i> = Alarm for low value <i>HA</i> = Alarm for high value		

9.3 Fuel installation safety

9.3.1 Tank overflow protection

9.3.1.1 A level sensing device shall be provided which automatically actuates the shut-off of the flow of fuel to the tank in a manner which will both, avoid excessive liquid pressure in the loading line and prevent the tank from becoming liquid full. This level sensing device shall be independent of the level sensing devices required by [9.2.1.1] and [9.2.1.2].

9.3.1.2 For tanks where submerged fuel pump motors are installed, arrangements shall be made to automatically shut down the motors in the event of low-low liquid level. The automatic shutdown may be accomplished by sensing low pump discharge pressure, low motor current, or low liquid level. This shutdown shall be alarmed.

9.3.2 Safety upon gas detection

9.3.2.1 Gas detection in a tank connection space when two detectors indicate a vapour concentration of 40% LEL shall result in automatic closing of all valves required to isolate the leakage. This will in most cases require that all tank valves shall close automatically. Depending on the system arrangement, it may also be necessary to close other valves. Any pump for cryogenic liquids located in the tank connection space shall also be automatically shut down.

9.3.2.2 Gas detection in a fuel preparation room when two detectors indicate a vapour concentration of 40% LEL shall result in automatic closing of all valves required to isolate the leakage. This will require that valves in the fuel system supplying liquefied or gaseous fuel to the fuel preparation room shall close automatically. Depending on the system arrangement, it may also be necessary to close other valves. All machinery in the space, such as compressors and pumps, shall be automatically shut down.

9.3.2.3 Gas detection in the secondary enclosure of pipes for gaseous fuel outside the machinery space, when two detectors indicate a vapour concentration of 40% LEL, shall result in automatic closing of all valves required to isolate the leakage. Depending on the system arrangement, this may require automatic closing of the tank valve, fuel preparation room valves and the master gas fuel valve.

9.3.2.4 Gas detection in the secondary enclosure of pipes for gaseous fuel in a gas safe machinery space, when two detectors indicate a vapour concentration of 60% LEL, shall result in automatic closing of all valves required to isolate the leakage. This will require automatic closing of the master gas fuel valve and the double-block-and-bleed valves, and automatic opening of vent valve in fuel supply system between

these valves. The pipe between the double block and bleed valve and the gas injection valves shall also be automatically vented.

9.3.2.5 Gas detection in ESD protected machinery spaces, when two detectors indicate a vapour concentration of 40% LEL, shall result in automatic closing of all valves required to isolate the leakage without delay. This will require automatic closing of the master gas fuel valve and the double-block-and-bleed valves, and automatic opening of vent valve in fuel supply system between these valves. In addition, the safety system shall automatically shut down the oil fuel supply for dual fuel engines and de-energize all non-explosion protected equipment or installations in the machinery spaces.

The isolation of ignition sources shall be performed by the gas safety system via dedicated signals to the relevant electrical circuit breakers.

9.3.3 Safety upon cryogenic leakage detection

9.3.3.1 Low temperature detection in bilge wells of tank connection spaces, fuel preparation rooms or other spaces containing cryogenic systems without secondary enclosures shall result in automatic closing of all valves necessary to isolate the leakage.

9.3.3.2 Piping in the fuel system containing cryogenic liquids shall be provided with means for detection of leakages into the secondary enclosure. Detection of leakages shall result in automatic closing of all valves required to isolate the leakage. Leakage detection in the bunkering line shall immediately result in automatic closing of the bunkering valve.

9.3.4 Safety fuel heating

9.3.4.1 Loss of heating medium circulation in the fuel vaporizer shall lead to automatic isolation of supply of cryogenic fuel to the vaporiser, to prevent freezing of the heating medium. This implies that automatic closing of tank valves in fuel systems connected to the vaporizer, and automatic stop of liquefied gas pumps is required.

9.3.4.2 The heated fuel in supply lines to consumers shall be provided with temperature sensors at the heat exchanger outlet. Detection of low-low temperature shall result in automatic closing of all valves required to stop the fuel supply to the vaporizer.

9.3.5 Safety upon loss of ventilation

9.3.5.1 Loss of ventilation in ESD protected machinery spaces shall result in isolation of all fuel supply to the machinery space. This will require automatic closing of the master gas fuel valve and the double-block-and-bleed valves, and automatic opening of vent valve in fuel supply system between these valves.

9.3.5.2 Loss of ventilation in tank connection spaces shall result in automatic closing of all valves required to isolate the fuel system from the tank. This will require that all tank valves shall close automatically, and automatic stop of liquefied gas pumps.

9.3.5.3 Loss of ventilation in a fuel preparation room shall result in automatic closing of all valves required to isolate the fuel system from the fuel preparation room. This will require that valves in the fuel system, supplying liquefied or gaseous fuel to the fuel preparation room, shall close automatically. All machinery in the space, like compressors and pumps, shall be automatically shut down.

9.3.5.4 Loss of ventilation in secondary enclosure of pipes for gaseous fuel in the machinery space shall result in automatic closing of all valves required to isolate the affected fuel system from the fuel source. This will require automatic closing of the master gas fuel valve and the double-block-and-bleed valves, and automatic opening of vent valve in fuel supply system between these valves.

9.3.5.5 Loss of ventilation in the secondary enclosure of pipes for gaseous fuel outside the machinery space shall result in automatic closing of all valves required to isolate the affected fuel system from the fuel source.

Depending on the system arrangement, this may require automatic closing of the tank valve, fuel preparation room valves and the master gas fuel valve.

9.3.5.6 Loss of ventilation in a non-hazardous space with air lock entrance from hazardous area on open deck, or loss of ventilation in hazardous space with air lock entrance from a safe space, shall lead to automatic shutdown of electrical equipment not certified for operation in zone 1 in the non-hazardous space.

9.3.6 Safety upon rupture detection

9.3.6.1 Each gas supply line entering an ESD protected machinery space, and each gas supply line to high-pressure installations, shall be provided with means for rapid detection of a rupture in the gas line in the machinery space. When a pipe rupture is detected, the gas supply shall be isolated from the machinery space by automatically closing the shut-off valve located outside the machinery space.

9.3.7 Manual shutdown push buttons

9.3.7.1 Means of manual emergency shutdown of fuel supply to the engine room shall be provided at safe locations on escape routes inside a machinery space containing a gas consumer, in the engine control room, outside the machinery space, and from the navigation bridge. The activation device shall be arranged as a physical button, duly marked and protected against inadvertent operation. The manual shutdown shall be handled by the gas safety system, and be arranged with loop monitoring.

9.3.7.2 Closing of the bunkering shutdown valve shall be possible from the control location for bunkering.

9.3.8 Safety actions

9.3.8.1 The requirements in [9.3.1] to [9.3.7] and Table 7 specify fuel installation safety actions required to limit the consequences of system failures.

9.3.8.2 Safety actions additional to the ones required by Table 7 may be required for unconventional or complex fuel installations.

Table 7 Gas safety functions

Conditions		Automatic safety action with corresponding alarm					Signal to other control/safety systems for additional action
		Alarm	Shutdown of Tank valves	Shutdown of fuel preparation room valves	Shutdown of Master gas fuel valve ¹⁾	Shutdown of Bunker connection valve	Isolate ignition sources in the space
Tank safety							
Level in tank, overfill	bunkering	HA				X	
	transfer	HA	X				
Submerged fuel pump, low-level in tank		LA					Stop fuel pumps
Gas detection							
Tank connection space, 2 x 40% LEL		HA	X				Stop machinery in the space
Fuel preparation room, 2 x 40% LEL		HA		X			Stop machinery in the space

Conditions	Automatic safety action with corresponding alarm						Signal to other control/safety systems for additional action
	Alarm	Shutdown of Tank valves	Shutdown of fuel preparation room valves	Shutdown of Master gas fuel valve ¹⁾	Shutdown of Bunker connection valve	Isolate ignition sources in the space	
Secondary enclosure of pipes for gaseous fuel outside the machinery space, 2x 40% LEL	HA	X	X	X			Open vent valve between master gas valve and DDB valves.
Secondary enclosure of pipes for gaseous fuel in the machinery space, 2x 60% LEL	HA			X			Open vent valve between master gas valve and DDB valves.
ESD Protected machinery spaces 2 x 40% LEL	HA			X		X	Open vent valve between master gas valve and DDB valves.
Cryogenic liquid leakage detection							
Tank connection space, temperature in bilge well	LA	X					
Fuel preparation room, temperature in bilge well	LA		X				
Leakage detection in secondary enclosure of pipes for cryogenic liquids ²⁾	A	X	X				
Leakage detection bunkering line	A ³⁾				X		
Fuel heating							
Loss of heating medium circulation	A	X	X				Stop fuel pumps
Fuel supply, temperature	LA	X	X	X			Stop fuel pumps Open vent valve between master gas valve and DDB valves.
Ventilation							
ESD protected machinery, loss of ventilation	A			X			Open vent valve between master gas valve and DDB valves.
Tank connection space, loss of ventilation	A	X					Stop fuel pumps in the space

Conditions	Automatic safety action with corresponding alarm						Signal to other control/safety systems for additional action
	Alarm	Shutdown of Tank valves	Shutdown of fuel preparation room valves	Shutdown of Master gas fuel valve ¹⁾	Shutdown of Bunker connection valve	Isolate ignition sources in the space	
Fuel preparation room, loss of ventilation	A		X				Stop machinery in the space
Secondary enclosure of pipes for gaseous fuel outside the machinery space, loss of ventilation	A	X	X	X			Open vent valve between master gas valve and DDB valves.
Secondary enclosure of pipes for gaseous fuel in the machinery space, loss of ventilation	A			X			Open vent valve between master gas valve and DDB valves.
Loss of ventilation in hazardous space with air lock entrance from a safe space	A					X	
Loss of ventilation in non-hazardous space with air lock entrance from hazardous area on open deck	A					X	
Rupture detection of gas pipe							
Pipe in ESD protected machinery space	A			X			Open vent valve between master gas valve and DDB valves.
High pressure pipe in gas safe machinery space	A			X			Open vent valve between master gas valve and DDB valves.
Manual shutdown buttons							
Emergency shutdown of supply to the machinery space				X			Open vent valve between master gas valve and DDB valves.
Emergency shutdown of bunkering					X		

Conditions	Automatic safety action with corresponding alarm						Signal to other control/safety systems for additional action
	Alarm	Shutdown of Tank valves	Shutdown of fuel preparation room valves	Shutdown of Master gas fuel valve ¹⁾	Shutdown of Bunker connection valve	Isolate ignition sources in the space	
1) upon closure of master gas fuel valve, a signal shall be sent to the gas consumers safety system to shut down the double block and bleed valves. 2) all valves required to isolate the leakage shall close 3) alarm also to be indicated in the bunkering control location A = Alarm activated for logical value LA = Alarm for low value HA = Alarm for high value							

10 Gas turbines and boilers

10.1 Gas fuelled boiler installations

10.1.1 General

10.1.1.1 Boiler plants built for gas operation shall satisfy the requirements as given in [Pt.4 Ch.7](#) and shall in addition satisfy the requirements in this section.

10.1.1.2 Alarm and safety systems shall comply with the requirements in [Pt.4 Ch.9](#) and shall in addition satisfy the requirements in this section.

10.1.2 Gas fuelled boilers

10.1.2.1 Each boiler shall have a dedicated forced draught system. A crossover between boiler force draught systems may be fitted for emergency use, providing that any relevant safety functions are maintained.

10.1.2.2 Combustion chambers and uptakes of boilers shall be designed to prevent any accumulation of gaseous fuel.

10.1.2.3 Burners shall be designed to maintain stable combustion under all firing conditions.

10.1.2.4 On main/propulsion boilers an automatic system shall be provided to change from gas fuel operation to oil fuel operation without interruption of boiler firing.

10.1.2.5 Gas nozzles and the burner control system shall 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 to light on gas fuel.

10.1.2.6 There shall be arrangements to ensure that gas fuel flow to the burner is automatically cut off unless satisfactory ignition has been established and maintained.

10.1.2.7 On the pipe of each gas burner, a manually operated shut-off valve shall be fitted.

10.1.2.8 Provisions shall be made for automatically purging the gas supply piping to the burners, by means of an inert gas, after the extinguishing of these burners.

10.1.2.9 The automatic fuel changeover system required by [10.1.2.4] shall be monitored with alarms to ensure continuous availability.

10.1.2.10 Arrangements shall be made that, in case of flame failure of all operating burners, the combustion chambers of the boilers are automatically purged before relighting.

10.1.2.11 Arrangements shall be made to enable the boilers purging sequence to be manually activated.

10.2 Gas fuelled turbines

10.2.1 General

Gas turbines shall comply with the requirements in Pt.4 Ch.3 Sec.2.

10.2.2 Gas turbine arrangement

10.2.2.1 Gas turbines shall be fitted in gas-tight enclosures which are arranged in accordance with the requirements for ESD protected machinery spaces.

10.2.2.2 For gas turbines requiring a supply of gas with pressures above 10 bar, gas piping shall be protected with a secondary enclosure in accordance with the requirements in [5.1.5] to the extent possible.

10.2.2.3 Ventilation for the enclosure shall be as outlined in in these Rules for ESD protected machinery spaces, but shall in addition be arranged with 2 x 100% capacity fans from different electrical circuits.

10.2.2.4 Gas detection systems, disconnection and shut down functions shall be as outlined for ESD protected machinery spaces.

10.2.2.5 For other than single fuel gas turbines, an automatic system shall be fitted to change over easily and quickly from fuel gas operation to fuel oil operation and vice-versa with minimum fluctuation of the engine power.

10.2.2.6 Means shall be provided to monitor and detect poor combustion that may lead to unburnt fuel gas in the exhaust system during operation. In the event that it is detected, the fuel gas supply shall be shut down.

10.2.2.7 Unless designed with the strength to withstand the worst case over-pressure due to ignited gas leaks, pressure relief systems shall be suitably designed and fitted to the exhaust system. Pressure relief systems within the exhaust uptakes shall be lead to a safe location, away from personnel.

10.2.2.8 Each turbine shall be fitted with an automatic shutdown device for high exhaust temperatures.

11 Manufacture, workmanship and testing

11.1 Fuel containment system

11.1.1 Welding, post-weld heat treatment and NDT

Welding, post-weld heat treatment and non-destructive testing shall be in accordance with the rules in Pt.5 Ch.7 Sec.6 [5] and Pt.5 Ch.7 Sec.6 [6].

11.1.2 Testing

Fuel containment system testing shall be in accordance with Pt.5 Ch.7 Sec.4 [5.2.3] and Pt.5 Ch.7 Sec.4 [5.2.4].

11.2 Fuel piping systems

11.2.1 Piping fabrication and joining details

The requirements apply to piping that contains fuel in gaseous and liquefied state.

The piping system shall be joined by welding with a minimum of flange connections. Gaskets shall be of a type designed to prevent blow-out.

11.2.1.1 The following types of connections may be considered for direct connection of pipe lengths (without flanges):

- 1) Butt-welded joints with complete penetration at the root may be used in all applications. For design temperatures colder than -10°C , butt welds shall be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert or inert gas back-up on the first pass. For design pressures in excess of 10 bar and design temperatures of minus 10°C or colder, backing rings shall be removed.
- 2) Slip-on welded joints with sleeves and related welding, having dimensions in accordance with recognized standards, shall only be used for instrument lines and open-ended lines with an external diameter of 50 mm or less and design temperatures not colder than minus 55°C .
- 3) Screwed couplings complying with recognized standards shall only be used for accessory lines and instrumentation lines with external diameters of 25 mm or less.

11.2.1.2 Flanges in fuel piping shall be of the welding neck, slip-on or socket welding type. For all piping (except open ended lines), the following restrictions apply:

- 1) For design temperatures $< -55^{\circ}\text{C}$ only welding neck flanges shall be used.
- 2) For design pressure above 10 bar, only welding neck flanges shall be used.
- 3) For design temperatures $< -10^{\circ}\text{C}$ slip-on flanges shall not be used in nominal sizes above 100 mm and socket welding flanges shall not be used in nominal sizes above 50 mm.

11.2.1.3 Flanges in secondary enclosures for fuel piping shall be of the welding neck, slip-on or socket welding type.

11.2.2 Welding, post-weld heat treatment and NDT

11.2.2.1 Welding of fuel piping shall be carried out in accordance with [Pt.5 Ch.7 Sec.6 \[5\]](#).

11.2.2.2 Post-weld heat treatment shall be required for all butt welds of pipes made with carbon, carbon-manganese and low alloy steels. The Society may waive the regulations for thermal stress relieving of pipes with wall thickness less than 10 mm in relation to the design temperature and pressure of the piping system concerned.

11.2.2.3 In addition to normal controls before and during the welding, and to the visual inspection of the finished welds, as necessary for proving that the welding has been carried out correctly and according to the regulations in this paragraph, the following tests shall be required:

- 1) 100% radiographic or ultrasonic inspection of butt-welded joints for piping systems with;
 - design temperatures colder than -10°C ; or
 - design pressure greater than 10 bar; or
 - gas supply pipes in ESD protected machinery spaces; or
 - inside diameters of more than 75 mm; or
 - wall thicknesses greater than 10 mm.
- 2) When such butt welded joints of piping sections are made by automatic welding procedures approved by the Society, then a progressive reduction in the extent of radiographic or ultrasonic inspection can be agreed, but in no case to less than 10% of each joint. If defects are revealed, the extent of examination shall be increased to 100% and shall include inspection of previously accepted welds. This approval can

only be granted if well-documented quality assurance procedures and records are available to assess the ability of the manufacturer to produce satisfactory welds consistently.

- 3) The radiographic or ultrasonic inspection regulation may be reduced to 10% for butt-welded joints in the outer pipe of double-walled fuel piping.
- 4) For other butt-welded joints of pipes, spot radiographic or ultrasonic inspection or other non-destructive tests shall be carried out, depending upon service, position and materials. In general, at least 10% of butt-welded joints of pipes shall be subjected to radiographic or ultrasonic inspection.

11.2.2.4 The radiographs shall be assessed according to ISO 10675 and shall at least meet the criteria for level 2 on general areas and level 1 on critical areas, as given in [Pt.2 Ch.4 Sec.7 \[5.1\]](#).

11.2.3 Testing

11.2.3.1 The requirements for testing in this section apply to gas piping inside and outside the gas tanks. However, relaxation from these requirements for piping inside gas tanks and open ended piping may be accepted by the Society.

11.2.3.2 After assembly, all fuel gas piping shall be subjected to a hydrostatic test to at least 1.5 times the design pressure. However, when piping systems or parts of systems are completely manufactured and equipped with all fittings, the hydrostatic test may be conducted prior to installation onboard the ship. Joints welded onboard shall be hydrostatically tested to at least 1.5 times the design pressure

11.2.3.3 After assembly on board, the fuel piping system shall be subjected to a leak test using air, or other suitable medium to a pressure depending on the leak detection method applied.

11.2.3.4 If the secondary enclosure of the gas piping contains high-pressure pipes the secondary enclosure shall be pressure tested to the expected maximum pressure at pipe rupture, but minimum 10 bar. Secondary enclosures for low pressure gas piping shall be tightness tested.

11.2.3.5 All piping systems, including valves, fittings and associated equipment for handling fuel or vapours, shall be function tested under normal operating conditions.

11.3 Valves

11.3.1 Testing

11.3.1.1 Each type of valve shall be tested as given in [Pt.5 Ch.7 Sec.5 \[13.1\]](#).

11.4 Expansion bellows

11.4.1 Testing

11.4.1.1 Expansion bellows intended for use in fuel systems shall be prototype tested as given in [Pt.5 Ch.7 Sec.5 \[13.2\]](#).

11.5 Pumps

11.5.1 Testing

11.5.1.1 Pumps shall be tested in accordance with [Pt.5 Ch.7 Sec.5 \[13.5\]](#)

11.6 Shutdown valves in liquefied gas fuel piping systems

11.6.1 Testing

11.6.1.1 The closing characteristics of shutdown valves in liquefied gas fuel piping systems operated by the safety system shall be tested to demonstrate compliance with [5.1.6.14]. The shutdown valves with actuators shall be function tested when the valve is subjected to full working pressure. The testing may be carried out onboard after installation.

SECTION 6 LOW FLASHPOINT LIQUID FUELLED ENGINES - LFL FUELLED

1 General

1.1 Introduction

The additional class notation **LFL fuelled** provides criteria for the arrangement and installation of machinery for propulsion and auxiliary purposes, using low flash point liquids (LFLs) as fuel, which will have an equivalent level of integrity in terms of safety and availability as that which can be achieved with new and comparable conventional oil-fuelled main and auxiliary machinery.

1.2 Scope

The scope for additional class notation **LFL fuelled** includes requirements from the vessel's LFL fuel bunkering connection up to and including the consumers. The rules in this section have requirements for arrangement and location of fuel tanks and all spaces with fuel piping and installations, including requirements for entrances to such spaces. Hazardous areas and spaces due to the fuel installations are defined. Requirements for control, monitoring and safety systems for the fuel installations are included, also additional monitoring requirements for engines and pumps. For tank design and piping detail, design reference is in general made to [Pt.5 Ch.6](#). Requirements for manufacture, workmanship and testing are included, mainly referring to details given in [Pt.5 Ch.6](#). Bunkering procedures are required to be approved, however, bunkering processes are not part of the scope for this section of the rules.

1.3 Application

The additional class notation **LFL fuelled** is applicable for installations where methyl alcohol or ethyl alcohol is used as fuel. Other liquid fuels with low flash point may be accepted for use after special considerations. The use of low flash point liquid fuel is not currently covered by international conventions, and such installations will need additional acceptance by flag authorities. Methyl alcohol is a chemical within the formula CH_3OH , also known as methanol. Ethyl alcohol is a chemical within the formula $\text{C}_2\text{H}_5\text{OH}$, also known as ethanol. If other low flash point fuel types are used, then special consideration will need to be taken, and additional requirements may be relevant. Special applications depending on ship type are covered in [\[11\]](#). Vessels built in accordance with the requirements in this section may be assigned the class notation **LFL fuelled**.

1.4 References

1.4.1 Terminology and definitions

1.4.1.1

Table 1 Definitions – general terms

Term	Definition
accommodation spaces	are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, game and hobby rooms, barber shops, pantries containing no cooking appliances and similar spaces

Term	Definition
control stations	are those spaces in which the ship's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralized. Spaces where the fire recording or fire control equipment is centralized are also considered to be a fire control station. Guidance note: This does not include special fire control equipment that can be most practically located in the cargo area (if the vessel is a cargo ship). ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
control systems	are those systems providing control and monitoring for bunkering, LFL storage and LFL supply to machinery
dual fuel engines	are in this context engines that can burn LFL fuel and fuel oil simultaneously and in a wide variety of proportions, or can operate either on oil fuel or LFL
enclosed hazardous space	means any space within which, in the absence of artificial ventilation, the ventilation will be limited and any explosive atmosphere will not be dispersed naturally Guidance note: See also definition in IEC 60092-502:1999. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
engine room	means any machinery spaces containing LFL fuelled engines
fuel	can in this section be read as LFL fuel
fuel containment system	is the arrangement for the storage of fuel, including cofferdams around storage tanks.
hazardous area	is an area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of electrical apparatus. Hazardous areas are divided into Zone 0, 1 and 2 as defined below and according to the area classification specified in [5.2]. <i>Zone 0</i> = Area in which an explosive gas atmosphere is present continuously or is present for long periods. <i>Zone 1</i> = Area in which an explosive gas atmosphere is likely to occur in normal operation. <i>Zone 2</i> = Area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only. Guidance note: The definition of hazardous area is only related to the risk of explosion. In this context, health, safety and environmental issues, i.e. toxicity, is not considered. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
high risk fire areas	high risk fire areas are cargo areas for carriage of dangerous goods and cargo decks for cars with fuel in the tanks.
machinery spaces	are machinery spaces of category A and other spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces
non-hazardous area	is an area not considered to be hazardous, i.e. gas safe, provided certain conditions are being met

<i>Term</i>	<i>Definition</i>
open deck	means a weather deck or a deck that is open at one or both ends and equipped with adequate natural ventilation that is effective over the entire length of the deck through permanent openings distributed in the side panels or in the deck above
pump room	is in this section defined as any space outside the fuel tank that contains LFL fuel pumps, both transfer pumps and booster pumps
safety systems	are the safety systems for bunkering, LFL storage and LFL supply to machinery
service spaces	are spaces outside the cargo area used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store rooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces
low flashpoint liquid (LFL)	is a liquid with a vapour pressure of less than 2.8 bar absolute at a temperature of 38.7°C and having a flashpoint less than 60°C

1.4.2 Abbreviations and symbols

LEL = Lower explosion limit

LFL = Low flashpoint liquid. Low flashpoint liquid is a liquid with a flashpoint below 60°C.

1.5 Procedural requirements

1.5.1 Documentation requirements

1.5.1.1 Documentation shall be submitted as required by [Table 2](#).

Table 2 Documentation required

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Propulsion and steering arrangements, general	Z050 – Design philosophy	Including information on the machinery configuration, engine room arrangements, fuel arrangements, shut down philosophy, redundancy considerations etc.	FI
LFL system	Z030 – Arrangement plan	Arrangement plan to be in profile and plan views including: — machinery and boiler spaces, accommodation, service and control station spaces — fuel tanks and containment systems — fuel pump rooms — fuel bunkering pipes with shore connections — tank hatches, ventilation pipes and any other openings to the fuel tanks — ventilating pipes, door and opening to fuel pump rooms, double walled piping and other hazardous areas — entrances, air inlets and openings to accommodation, service and control station spaces — WT divisions.	AP
	Z253 - Test procedure for quay and sea trial	Including testing of safety shutdowns in accordance with the cause and effect diagram	AP
	Z161 – Operation manual	See [9]	AP

Object	Documentation type	Additional description	Info
LFL tanks	C030 - Detailed drawing	Including: — tanks — supports and stays — insulation — tank hatches, pipes and any opening to the tanks. — secondary barriers.	AP
	C040 - Design analysis	Independent tanks: — specification of design loads and structural analysis of fuel tanks. Integral tanks: — covered by hull structures analyses.	AP
	S010 - Piping Diagram (PD)	Purging and gas freeing system including safety relief valves and associated piping	AP
	Z030 - Arrangement plan	Overview of tanks with all tank connections and tank connection space	FI
	Z110 - Data sheet	Pressure/vacuum relief valves and associated piping	FI
LFL control and monitoring system	I200 - Control and monitoring system documentation	Control and monitoring of fuel system, including: — tank level monitoring — tank system control and monitoring — bunkering control — fuel supply control and monitoring.	AP
	I200 - Control and monitoring system documentation	Safety system covering the requirements given Table 4 .	AP
	I260 - Field instruments periodic test plan		AP
	G130 - Cause and effect diagram	Covering the safety function given by Table 4 . Including interfaces to other safety and control systems.	AP
LFL piping system	S010 - Piping diagram	Including ventilation lines for pressure/vacuum relief valves or similar piping, and ducts for fuel pipes.	AP
	S060 - Pipe routing sketch		FI
	S090 - Specification of pipes, valves, flanges and fittings	Including expansion elements.	FI
	Z100 - Specification	Electrical bonding of piping	AP
LFL drip trays	Z030 - Arrangement plan	Fuel system drip trays and coamings where leakages may be anticipated	AP
LFL Cooling system	S010 - Piping diagram		AP

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
LFL Heating system	S010 - Piping diagram		AP
Hazardous areas classification	G080 - Hazardous area classification drawing		AP
Air lock arrangement	Z030 - Arrangement plan	Location and construction details, including alarm equipment	AP
Ventilation systems for gas fuel system spaces	S012 - Ducting diagram	For spaces containing LFL installations, like LFL pipe ducts and pump rooms. Including capacity and location of fans and their motors.	AP
	C030 - Detailed drawing	Rotating parts and casings for fans and portable ventilators.	AP
Ventilation control and monitoring system	I200 - Control and monitoring	Including detection of ventilation function, safety actions and sequences, arrangement of powering of fans etc.	AP
Explosion (Ex) protection	Z030 - Arrangement plan	An approved hazardous area classification drawing where location of electric equipment is added (except battery room, paint stores and gas bottle store)	FI
	E090 - Table of Ex-installation	Based on approved area classification	AP
	Z163 - Maintenance manual	Electrical equipment in hazardous areas	FI
Hydrocarbon gas detection and alarm system, fixed	I200 - Control and monitoring system documentation	Including fixed liquid leakage detection system	AP
	Z030 - Arrangement plan	Detectors, call points and alarm devices. Including fixed liquid leakage detection	AP
Structural fire protection arrangements	G060 - Structural fire protection drawing		AP
Bunkering station fire extinguishing system	G200 - Fixed fire extinguishing system documentation	Not applicable for tankers	AP
Fire detection and alarm system	I200 - Control and monitoring system documentation		AP
	Z030 - Arrangement plan		AP
Fire extinguishing equipment, mobile	Z030 - Arrangement plan	At bunkering stations and entrance to engine rooms	AP

Object	Documentation type	Additional description	Info
Inert gas/nitrogen system	S010 - Piping diagram (PD)		AP
Inert gas control and monitoring system	I200 - Control and monitoring system documentation		AP
<i>AP</i> = For approval <i>FI</i> = For information <i>ACO</i> = As carried out <i>L</i> = Local handling <i>R</i> = On request <i>TA</i> = Covered by type approval <i>VS</i> = Vessel specific			

1.5.1.2 For general requirements to documentation, including definition of the Info codes, see [Pt.1 Ch.3 Sec.2](#).

1.5.1.3 For a full definition of the documentation types, see [Pt.1 Ch.3 Sec.3](#).

1.5.1.4 An operation manual as described in [9] shall be kept on board.

1.5.1.5 A plan for periodic test of all field instruments specified in these rules shall be kept onboard. The plan shall include test intervals, description of how to perform the tests and description of what to observe during the tests. Test intervals for shutdown inputs and outputs (as required by [Table 4](#)) shall not exceed 6 months. For other signals the test intervals shall not exceed 12 months. The plan shall be included in the vessel's maintenance plan required by [Pt.7](#).

Guidance note:

See [Sec.2 \[1.4\]](#) for information about plan for periodic test.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.5.2 Certification requirements

1.5.2.1 Components in the LFL fuel system shall be certified according to [Pt.4 Ch.6](#) as applicable for fuel oil systems. Components in the nitrogen system shall be certified as specified in [Pt.5 Ch.6 Sec.16](#). Engines shall be certified according to [Pt.4 Ch.3](#). For other items, see [Table 3](#)

1.5.2.2 For a definition of the certificate types, see [Pt.1 Ch.3 Sec.5](#).

Table 3 Certification required

Object	Certificate type	Issued by	Certification standard*	Additional description
Combustion control system for LFL burning engines	PC	Society		
	TA	Society		

Object	Certificate type	Issued by	Certification standard*	Additional description
LFL control, monitoring and safety system	PC	Society		Major units of equipment associated with essential and important control and monitoring systems, shall be provided with a product certificate unless exemption is given in a Type Approval Certificate issued by the Society or the logic is simple and the failure mechanisms are easily understood. Ref. Pt.4 Ch.9 .
Electric motors and motor starters	PC	Society		Electric motors and motor-starters for the LFL supply system and ventilation system are considered to be important consumers, and shall be certified in accordance with Pt.4 Ch.8 Sec.1 .
	TA			
Piping system	MC	Society		As required in Pt.5 Ch.6 for cargo piping.
	PC	Manufacturer		
	TR	Society		
PC = Product certificate TA = Type approval certificate TR = Test report *Unless specified otherwise the certification standard is the rules				

2 Materials

2.1 General

2.1.1 General

2.1.1.1 Metallic materials are in general to be in accordance with the requirements in [Pt.2](#).

2.1.1.2 Materials other than those covered by [Pt.2](#) may be accepted subject to approval in each separate case.

2.1.1.3 When selecting construction materials in detachable equipment units in tanks and cofferdams, due consideration should be paid to the contact spark-producing properties.

2.1.2 Fuel tanks

2.1.2.1 Materials for integral tanks and independent tanks shall be selected in accordance with ordinary practice as given in [Pt.3 Ch.3 Sec.1](#) for hull materials.

2.1.2.2 Materials for pressure vessels containing LFL shall be as given in [Pt.2 Ch.2 Sec.3](#).

2.1.3 Fuel piping

2.1.3.1 Materials for fuel pipes shall be as given in [Pt.2 Ch.2 Sec.5](#).

2.1.3.2 Materials in LFL piping systems shall be provided with documentation as required for cargo piping in accordance with Pt.5 Ch.6.

3 Arrangement and design

3.1 General

3.1.1 General

3.1.1.1 The propulsion and fuel supply system shall be so designed that the remaining power after any safety actions required by Table 4 shall be sufficient to maintain propulsion, power generation and other main functions as defined in Pt.1 Ch.1 Sec.1 [1.2].

3.1.1.2 Except for cargo area of tankers, all parts of the LFL fuel system shall be located in enclosures for physically limiting the extent of gas hazardous areas. The enclosures shall be provided with means for automatic leakage detection.

3.1.1.3 Drip trays shall be installed below all possible leakage points in the fuel system.

3.1.1.4 All fuel piping and tanks shall be electrically bonded to the ship's hull. Bonding straps across stainless steel flanges with bolts and nuts of stainless steel are not required. If carbon-manganese steel is not fitted with bonding straps across the flanges, it shall be checked for electric bonding. The electrical bonding is sufficient, when the electrical resistance between piping and the hull does not exceed 10^6 Ohm. LFL piping components which are not permanently connected to the hull by permanent piping connections, shall be electrically bonded to the hull by special bonding straps.

Guidance note:

The value of resistance 10^6 Ohm may be achieved without the use of bonding straps where LFL piping systems and equipment are directly, or via their supports, either welded or bolted to the hull of the ship. It will be generally necessary initially to achieve a resistance value below 10^6 Ohm, to allow for deterioration in service.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.1.1.5 Bilge systems installed in areas with LFL fuel installations shall be segregated from other bilge systems.

3.1.1.6

Redundancy requirements apply as follows:

- In case of dual fuel concept: Redundancy for active components as given in Pt.4 Ch.1 Sec.3 [2.3] applies for both oil fuel and LFL fuel systems. For the LFL fuel system redundancy type 3 (see definition in Pt.4 Ch.1 Sec.1 Table 1) may be considered if it can be demonstrated that activation time for R3 is achievable.
- In case of single fuel concept: Redundancy for active components as given in Pt.4 Ch.1 Sec.3 [2.3] applies. In addition all of the LFL fuel supply system including service tank shall be arranged with redundancy.

3.2 Fuel storage

3.2.1 Location of fuel tanks

3.2.1.1 Fuel tanks shall not be located within machinery spaces or within accommodation spaces.

3.2.1.2 Minimum distance between the fuel tank and fuel pipes and the ship's shell shall be at least 800 mm.

3.2.1.3 The spaces forward of the collision bulkhead (forepeak) and aft of the aftermost bulkhead (afterpeak) shall not be used as fuel tanks.

3.2.1.4 Each fuel service tank shall have a capacity sufficient for continuous rating of the propulsion plant and normal operating load at sea of the generator plant for a period of not less than 8 hours.

3.2.2 Segregation of fuel tanks

3.2.2.1 In ships other than tankers, integral fuel tanks for LFL shall be surrounded by protective cofferdams, except on those surfaces bound by bottom shell plating or the fuel pump room.

3.2.2.2 The cofferdams shall be arranged with vapour and liquid leakage detection and possibility for water filling upon detection of leakage. The water filling shall be through a system without permanent connections to water systems in non-hazardous areas. Emptying shall be done with a separate system. Bilge ejectors serving hazardous spaces shall not be permanently connected to the drive water system.

3.2.3 Gas freeing, inerting and venting of fuel tanks

3.2.3.1 Fuel tanks shall be provided with an arrangement for inert gas purging and gas freeing.

3.2.3.2 Fuel tanks shall have a sufficient number of ventilation inlets and outlets to ensure complete gas-freeing. Outlets for ventilation and purging shall be fitted with flame screens of approved type, ref IMO MSC/Circ.677

3.2.3.3 The tanks shall have controlled venting, i.e. be fitted with pressure/vacuum relief valves. If p/v valves are fitted to the end of the vent pipes they shall be of the high velocity type certified for endurance burning in accordance with IMO MSC/Circ.677. If p/v valves are fitted in the ventline, the vent outlet shall be fitted with a flame arrestor certified for endurance burning in accordance with IMO MSC/Circ.677.

3.2.3.4 Vent outlets from p/v valves and outlets for purging shall be led to open air and located so that the hazardous zone associated with the outlets does not conflict with ventilation inlets or outlets for gas safe spaces or equipment representing sources of ignition.

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

3.2.3.5 Shut-off valves shall not be fitted above or below pressure/vacuum safety valves, but by-pass valves may be provided.

3.2.3.6 The venting system shall be designed with redundancy for the relief of full flow overpressure and vacuum. In lieu of duplicating p/v valves, pressure sensors fitted in each fuel tank, and connected to an alarm system, may be accepted. The opening pressure of the vacuum relief valves is not to be lower than 0.07 bar below atmospheric pressure.

3.2.3.7 Pressure/vacuum safety valves shall be located on open deck and shall be of a type which allows the functioning of the valve to be easily checked.

3.2.3.8 Intake openings of pressure/vacuum relief valves shall be located at least 1.5 m above weather deck, and shall be protected against the sea.

3.2.3.9 Fuel tank vent outlets shall be situated not less than 3 m above the deck or gangway if located within 4 m from such gangways. The fuel tank 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 shall be directed upwards in the form of unimpeded jets.

3.2.3.10 The vent system shall be sized, allowing for flame arrestors, if fitted, to permit filling at 125% of the design rate without overpressurizing the tank.

3.2.3.11 The arrangement for gas freeing fuel tanks shall be such as to minimize the hazards due to the dispersal of flammable vapours in the atmosphere and to flammable vapour mixtures in a fuel tank. The ventilating system used for gas freeing of fuel tanks shall be used exclusively for ventilating purposes. Connection between fuel tank and pump room ventilation will not be accepted. Ventilation fans may be fixed or portable.

3.2.3.12 Gas freeing of fuel tanks shall be carried out in a way that flammable atmosphere in the tank is avoided, i.e. by purging tank with inert gas until gas content is below 2% before ventilation with air is started.

Purging and gas freeing operations shall be carried out such that vapour is initially discharged through outlets at least 2 m above the deck level with a vertical efflux velocity of at least 20 m/s.

Guidance note:

When the flammable vapour concentration at the outlets has been reduced to 30% of the lower flammable limit, gas freeing may thereafter be continued at deck level.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.2.4 Fuel tanks on weather deck of tankers

3.2.4.1 LFL fuel tanks on open deck shall be protected against mechanical damage.

3.2.4.2 LFL deck tanks on open deck shall be surrounded by coamings.

3.2.4.3 Special considerations shall be taken to minimize any fire hazards adjacent to the fuel tanks on weather deck. Protection of the LFL fuel tanks from possible fires onboard may be subject to a fire safety assessment in each particular case.

3.2.5 Portable fuel tanks

3.2.5.1 Fuel systems utilising portable storage tanks will be specially considered, and shall have equivalent safety as permanent fuel tanks.

3.2.5.2 Portable fuel tanks shall be certified by the Society.

3.2.5.3 The tank support (container frame or truck chassis) shall be designed for the intended purpose.

3.2.5.4 Except for location on the tank deck of tankers, portable fuel tanks shall be located in a dedicated space.

3.2.5.5 The tank hold space shall be arranged in accordance with requirements for fuel pump rooms.

3.2.5.6 Portable fuel tanks shall be secured to the deck while connected to the ship systems. The arrangement for supporting and fixing the tanks shall 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.

3.2.5.7 Connections to the ship piping systems shall be made by means of approved flexible hoses or other suitable means designed to provide sufficient flexibility.

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

3.2.5.9 The pressure/vacuum relief system of portable tanks shall be connected to a fixed venting system.

3.2.5.10 Control and monitoring systems for portable fuel tanks shall be integrated in the ship's control and monitoring system. Safety system for portable fuel tanks shall be integrated in the ship's gas safety system (e.g. shutdown systems for tank valves, leak/gas detection systems).

3.2.5.11 Safe access to tank connections for the purpose of inspection and maintenance shall be ensured.

3.3 Fuel transfer and supply

3.3.1 Piping systems

3.3.1.1 The fuel system shall be entirely separate from all other piping systems on board.

3.3.1.2 The piping shall be located no less than 800 mm from the ship side.

3.3.1.3 All piping containing LFL shall be arranged for gas-freeing and inerting.

3.3.1.4 The fuel piping system shall be dimensioned as given in Pt.4 Ch.6 Sec.8. The design pressure p is the maximum working pressure to which the system may be subjected. The design pressure for fuel piping is as a minimum to be taken as 10 bar.

3.3.1.5 Filling lines to fuel tanks shall be so arranged that the generation of static electricity is reduced, e.g. by reducing the free fall into the tank to a minimum.

3.3.1.6 Fuel pipes shall be colour marked based on a recognized standard.

Guidance note:

See EN ISO 14726:2008 Ships and marine technology - Identification colours for the content of piping systems.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.2 Protection of fuel transfer system

3.3.2.1 Fuel piping shall be protected against mechanical damage.

Fuel pipes lead through ro-ro spaces on open deck shall be provided with guards or bollards to prevent vehicle collision damage. Fuel pipes in other types of cargo areas with risk of damage from cargo operations shall be similarly protected. Fuel pipes in double ducts in other areas are regarded as sufficiently protected.

3.3.2.2 All piping containing LFL that pass through enclosed spaces in the ship shall be enclosed in a pipe that is gas tight and water tight towards the surrounding spaces with the LFL contained in the inner pipe. Such double walled piping is not required in cofferdams surrounding fuel tanks, fuel pump rooms, fuel tank hold spaces or other hazardous fuel treatment spaces as the boundaries for these spaces will serve as a second barrier.

3.3.2.3 Fuel piping shall not be lead through accommodation spaces, service spaces or control stations. In cases where fuel piping shall be led through accommodation spaces, the double walled fuel piping shall be led through a dedicated duct. The duct shall be of substantial construction and be gas tight and water tight.

3.3.2.4 The annular space in the double walled fuel pipe shall have mechanical ventilation of underpressure type with a capacity of minimum 30 air changes per hour. Ventilation inlets and outlets shall be located in open air. The annular space shall be equipped with vapour and liquid leakage detection.

3.3.2.5 The outer pipe in the double walled fuel pipes shall 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 a pipe rupture may be used for dimensioning of the duct.

3.3.2.6 The annular space in the double walled fuel piping shall be segregated at the engine room bulkhead. This means that there shall be no common ducting between the engine room and other spaces.

3.3.2.7 There shall be no openings between the annular space in the double walled fuel piping and enclosed spaces in the ship.

Guidance note:

Fuel valves in such spaces may be accessible through a bolted opening that is both gas tight and water tight when sealed.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.2.8 The annular space in the double walled fuel piping shall be equipped with means for safe drainage.

3.3.3 Valves

3.3.3.1 LFL service tank inlets and outlets and storage tanks with outlets under static pressure shall be provided with remotely operated shut-off valves located as close to the tank as possible. The tank valve shall automatically cut off the LFL supply as given in [Table 4](#).

3.3.3.2 Valves that are required to be operated during normal operation and which are not readily accessible shall be remotely operated. Regarding automatic operation of tank valves, see [Table 4](#).

3.3.3.3 The main supply lines for fuel to each engine room shall be equipped with automatically operated master LFL fuel valves. The shut-off valve shall be situated outside the engine room. The master LFL fuel valve is automatically to cut off the LFL supply to the engine room as given in [Table 4](#).

3.3.3.4 The LFL fuel supply to each consumer shall be provided with a remote shut-off valve.

3.3.3.5 There shall be one manually operated shutdown valve in the LFL supply line to each engine to assure safe isolation during maintenance on the engine.

3.3.3.6 All automatic and remotely operated valves shall be provided with indications for open and closed valve positions at the location where the valves are remotely operated.

3.3.3.7 Valves shall fail to a safe position.

Guidance note:

"Fail to close" is generally considered to be the safe mode.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.4 Pipe connections

3.3.4.1 Piping systems in fuel tanks and their cofferdams shall have no connections with piping systems in the rest of the ship, apart from fuel pipes which shall be arranged as specified in other parts of this section.

3.3.4.2 Fuel piping shall not penetrate fuel tank boundaries below the top of the tank. However, penetrations below the top of the tank may be accepted provided that a remotely operated shut-off valve is fitted within the fuel tank served. Where a fuel tank is adjacent to a pump room, the remotely operated stop valve may be fitted on the fuel tank bulkhead on the pump room side.

3.3.4.3 Fuel piping system shall be installed with sufficient flexibility. Expansion bellows shall not be used in the inner pipe.

3.3.5 LFL fuel pump rooms

3.3.5.1 Any pump room shall be located outside the engine room, be gas tight and water tight to surrounding enclosed spaces and vented to open air.

3.3.5.2

The pump room shall have separate mechanical ventilation of underpressure type with capacity of minimum 30 air changes per hour.

3.3.5.3

The pump room shall be provided with leakage detection, both for gases and liquids.

3.3.5.4 LFL pump rooms shall be provided with a dedicated bilge system, operable from outside the pump room. Bilge ejectors serving hazardous spaces shall not be permanently connected to the drive water system. The bilge system may have possibilities for discharge to a suitable cargo tank, slop tank or similar, however taking into account hazards related to incompatibility.

3.3.6 LFL fuel heating or cooling

3.3.6.1 The heating or cooling medium shall be compatible with the fuel and the temperature of the heating medium shall not exceed 220°C.

3.3.6.2 The heating or cooling system shall be arranged as a secondary system independent of other ship's services.

3.3.6.3 The heating or cooling system expansion tank shall be fitted with a gas detector and low level alarm and be vented to open air.

3.4 Access

3.4.1 Access to fuel tanks and cofferdams

3.4.1.1 For safe access, horizontal hatches or openings to or within fuel tanks or cofferdams shall have a minimum clear opening of 600 × 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 cargo tanks and cofferdams, the minimum clear opening shall not be less than 600 × 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.

3.4.1.2 Tanks shall be arranged for closed portable gas detection prior to opening.

3.4.1.3 Fuel tanks and surrounding cofferdams shall have suitable access from open deck for cleaning and gas-freeing, except as given in [3.4.1.4] and [3.4.1.5] below.

3.4.1.4 For fuel tanks without direct access from open deck, the arrangement shall be such that before opening any tank access located in enclosed spaces, the tanks shall be completely free of flammable gas or other gases that represent a hazard to the crew.

3.4.1.5 For fuel tanks without direct access from open deck, the entry space shall comply with the following:

- The entry space shall be well ventilated.
- The entry space shall have sufficient open area around the fuel tank hatch for efficient evacuation and rescue operations.
- Entry from accommodation spaces, service spaces, control stations and machinery spaces will not be accepted.
- Entry from cargo areas may be accepted if the area is cleared for cargo and no cargo operations are on-going during tank entry.

3.4.2 Access to pump room

3.4.2.1 Entrance to the pump room shall be from open deck. Access from an enclosed space through an air lock may be accepted upon special considerations. If accepted, airlocks shall comply with the requirements as given in [Sec.5 \[3.4\]](#).

3.5 Ventilation of hazardous spaces containing LFL fuel installations

3.5.1 General

3.5.1.1 Any ducting used for the ventilation of hazardous spaces shall be separate from that used for the ventilation of non-hazardous spaces. Electric fan motors shall not be located in ventilation ducts for hazardous spaces unless the motor is certified for the same hazardous zone as the space served.

3.5.1.2 Design of ventilation fans shall be according the requirements given in [Pt.5 Ch.6 Sec.10 \[1.2\]](#).

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

3.5.1.4 Ventilation inlets and outlets for spaces required to be fitted with mechanical ventilation in this rule section shall be so located that ingress of seawater is avoided. A location of minimum 4.5 m above the freeboard deck is regarded acceptable.

3.5.2 Hazardous spaces

3.5.2.1 Air inlets for hazardous enclosed spaces shall be taken from areas which, in the absence of the considered inlet, would be non-hazardous. Air inlets for non-hazardous enclosed spaces shall 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 shall have over-pressure relative to this space, unless mechanical integrity and gas-tightness of the duct will ensure that gases will not leak into it.

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

3.5.2.3 Fuel pump rooms and hold spaces for fuel tanks shall be provided with an effective mechanical ventilation system of the extraction type, providing a ventilation capacity of at least 30 air changes per hour.

3.5.2.4 The number and power of the ventilation fans in hazardous spaces shall be such that the capacity is not reduced by more than 50% if a fan is out of action.

3.5.2.5

Ventilation systems for pump rooms and other fuel handling spaces shall be in operation when pumps or other fuel treatment equipment are working. Warning notices to this effect shall be placed in an easily visible position near the control stand.

3.6 Fuel bunkering in ships other than tankers

3.6.1 Fuel bunkering station

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

3.6.1.2 Coamings shall be fitted below the bunkering connections.

3.6.1.3 Control of the bunkering shall be possible from a safe location in regard to bunkering operations. At this location the tank level shall be monitored. Overfill alarm and automatic shutdown is also to be indicated at this location.

3.6.2 Fuel bunkering system

3.6.2.1 A manually operated stop valve and a remote operated shutdown valve in series, or a combined manually operated and remote valve shall be fitted in every bunkering line close to the shore connecting point.

3.6.2.2 Bunkering pipes shall be self-draining.

3.6.2.3 Bunkering lines shall be arranged for inerting and gas freeing.

3.6.2.4 The connecting coupling for the transfer hose shall be of a type which automatically closes at disconnection (self-sealing type).

3.7 Inert gas/nitrogen installations

3.7.1 General

3.7.1.1 All tanks containing LFL shall be inerted.

3.7.1.2 To prevent the return of fuel vapour to any gas safe spaces, the inert gas supply line shall be fitted with two shut-off valves in series with a venting valve in between (double block and bleed valves). In addition a closable non-return valve shall be installed between the double block and bleed arrangement and the fuel tank. These valves shall be located outside non-hazardous spaces and shall function under all normal conditions of trim, list and motion of the ship. The following conditions apply:

The operation of the valves shall be automatically executed. Signals for opening and closing shall be taken from the process directly, e.g. inert gas flow or differential pressure.

An alarm for faulty operation of the valves shall be provided.

3.7.1.3 Where the connections to the fuel tanks or to the fuel piping are non-permanent, two non-return valves may substitute the non-return devices required in [3.7.1.2] above.

Guidance note:

Fuel tank connections for inert gas padding are considered as permanent for the purpose of this requirement.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.7.1.4 Low-pressure alarm shall be provided in the nitrogen supply line on the fuel tank side of any double block and bleed valves and pressure reduction units. If pressure/vacuum alarms are fitted in each fuel tank as means to comply with redundant venting requirements, a separate low-pressure alarm is not required.

3.7.1.5 A high oxygen content alarm shall be provided in the engine control room. The alarm shall be activated when the oxygen content in the inert gas supply exceeds 5%.

3.7.1.6 Where a nitrogen generator or nitrogen storage facilities are installed in a separate compartment, outside of the engine room, the separate compartment shall be fitted with an independent mechanical extraction ventilation system, providing 6 air changes per hour. A low oxygen alarm shall be fitted. Such separate compartments shall be treated as one of other machinery spaces, with respect to fire protection.

4 Fire safety

4.1 General

4.1.1 General

4.1.1.1 The requirements in this section are additional to those given in SOLAS Ch.II-2.

4.2 Containment of fire

4.2.1 General

4.2.1.1 The fire integrity of LFL fuel tank cofferdam boundaries facing machinery spaces or other high fire risk spaces shall not be less than A-60. This does not apply to the top boundary of the cofferdam above the fuel tank.

Guidance note:

High fire risk spaces are for instance cargo areas for carriage of dangerous goods and cargo decks for cars with fuel in the tanks.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.2.1.2 Fire integrity of the pump room towards control stations, accommodation and cargo area for carriage of dangerous goods shall not be less than A-60 and towards other spaces not less than A-0.

4.2.1.3 Boundaries around fuel bunkering stations in ships other than tankers shall be separated by permanent steel bulkheads towards inboard ship structure/cargo area and be open towards outboard during bunkering.

4.2.1.4 Means of escape shall be shielded from possible fire hazards from the fuel arrangement.

4.3 Fire fighting

4.3.1 Fire extinguishing of the LFL pump room

4.3.1.1 Fuel pump rooms shall be protected by an approved gas extinguishing system. Fixed pressure water-spraying system may also be considered.

4.3.2 Portable fire fighting equipment and fire fighter's outfits

4.3.2.1 Any vessel with LFL fuelled engines shall be provided with not less than 4 sets of foam applicators arranged in strategic positions for coverage of any LFL leaks or fires.

4.3.2.2 Not less than two additional fire fighter's outfit (in addition to those otherwise required in SOLAS Reg. II-2/10 and 18) shall be provided and stored in two separated fire lockers/stations.

4.3.2.3 Fire extinguishers shall be arranged within weather tight enclosures adjacent to bunkering station and at entrance to engine rooms.

5 Electrical systems

5.1 General

5.1.1 General

5.1.1.1 The requirements in this section are additional to those given in [Pt.4 Ch.8](#).

5.1.1.2 Electrical equipment and wiring shall in general not to be installed in hazardous areas unless essential for operational purposes. The type of equipment and installation requirements shall comply with [Pt.4 Ch.8 Sec.11](#) according to the area classification as specified in [\[5.2\]](#).

Guidance note:

As given in IEC 60079-20, the following temperature class and equipment groups can be used for potential ship fuels:

	<i>Temperature class</i>	<i>Equipment group</i>
Methyl alcohol	T2	IIA
Ethyl alcohol	T2	IIB

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.2 Area classification

5.2.1 General

5.2.1.1 Areas and spaces other than those classified in [\[5.2.2\]](#) shall be subject to special consideration. The principles of the IEC standards shall be applied.

5.2.2 Definition of zones

5.2.2.1 Hazardous areas zone 0

The interiors of fuel tanks, pipes and equipment containing LFL, any pipework of pressure-relief or other venting systems for fuel tanks.

Guidance note:

Instrumentation and electrical apparatus in contact with the LFL or gas should be of a type suitable for zone 0. Temperature sensors installed in thermo wells, and pressure sensors without additional separating chamber should be of intrinsically safe type Ex-ia.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.2.2.2 Hazardous areas zone 1

- 1) Cofferdams and other protective spaces surrounding the LFL fuel tanks.
- 2) Fuel pump rooms.
- 3) Areas on open deck, or semi-enclosed spaces on deck, within 3 m of any fuel tank outlet, gas or vapour outlet, manifold valve, valve, pipe flange and fuel pump-room ventilation outlets.
- 4) Areas in the vicinity of fuel tank P/V vent outlets, within a vertical cylinder of unlimited height and 6 m radius centered 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 pump room entrances, fuel pump room ventilation inlets and other openings into zone 1 spaces.
- 6) Areas on the open deck within spillage coamings surrounding LFL bunker manifold valves and 3 m beyond the coamings, up to a height of 2.4 m above the deck.

- 7) Enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. ducts around fuel pipes, semi-enclosed bunkering stations.

Guidance note:

Areas on open deck within 3 m of cargo tank access openings for ships with cofferdams towards deck are not defined as hazardous zones. Safety precautions related to the use of such access openings in connection with gas freeing should be covered in the operation manual.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.2.2.3 Hazardous areas zone 2

- 1) Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 as specified in [5.2.2.2], if not otherwise specified in this standard.
- 2) Spaces 4 m beyond the cylinder and 4 m beyond the sphere defined in [5.2.2.2] 4).
- 3) Air locks.

5.3 Inspection and testing

5.3.1 General

5.3.1.1 Before the electrical installations in hazardous areas are put into service or considered ready for use, they shall be inspected and tested. All equipment, including cables, shall be verified as having been installed in accordance with installation procedures and guidelines issued by the manufacturer of the equipment and cables, and that the installations have been carried out in accordance with [Pt.4 Ch.8 Sec.11](#).

5.3.1.2 For equipment for which safety in hazardous areas depends upon correct operation of protective devices (for example overload protection relays) and/or operation of an alarm (for example loss of pressurisation for an Ex(p) control panel) it shall be verified that the devices have correct settings and/or correct operation of alarms.

5.3.1.3 Intrinsically safe circuits shall be verified to ensure that the equipment and wiring are correctly installed.

5.3.1.4 Verification of the physical installation shall be documented by the yard. Verification documentation shall be available for the Society's surveyor at the site.

5.4 Maintenance

5.4.1 General

5.4.1.1 The maintenance manual referred to in [9] shall be in accordance with the recommendations in IEC 60079-17 and 60092-502 and shall contain necessary information on:

- overview of classification of hazardous areas, with information about gas groups and temperature class
- information sufficient to enable the certified safe equipment to be maintained in accordance with its type of protection (list and location of equipment, technical information, manufacturer's instructions, spares etc.)
- inspection routines with information about level of detail and time intervals between the inspections, acceptance/rejection criteria
- records of inspections, with information about date of inspections and name(s) of person(s) who carried out the inspection and maintenance work.

5.4.1.2 Updated documentation and maintenance manual, shall be kept onboard, with records of date and names of companies and persons who have carried out inspections and maintenance. Inspection and maintenance of installations shall be carried out only by experienced personnel whose training has included

instruction on the various types of protection of apparatus and installation practices to be found on the vessel.

6 Control, monitoring and safety systems

6.1 General

6.1.1 System arrangement

6.1.1.1

For ships with class notation E0 (unmanned machinery spaces) The requirements in [Ch.6](#) apply in full also for the LFL fuel system.

[6.1.1.2](#) A dedicated safety system, independent of the control system, shall be arranged in accordance with the general principles in [Pt.4 Ch.9 Sec.3](#).

[6.1.1.3](#) The control system shall be so arranged that the remaining power after single failure shall be sufficient to maintain propulsion and other main functions defined in [Pt.1 Ch.1 Sec.1](#).

[6.1.1.4](#) The safety system shall be so arranged that the remaining power after single failure shall be sufficient to maintain propulsion and other main functions defined in [Pt.1 Ch.1 Sec.1 \[1.2\]](#).

6.1.2 Engine shutdown prevention system

[6.1.2.1](#) Measures shall be taken to prevent that shutdown of one LFL engine causes shutdown of other engines.

Guidance note:

For LFL engine driven generators operating in parallel, a control system may be installed preventing consequential trip of an engine caused by sudden overload in case one engine is shutdown.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

6.2 Control system

6.2.1 General

[6.2.1.1](#) An independent LFL control system shall be fitted for each required LFL fuel supply system. The fuel supply system shall be fitted with a control and monitoring system to assure safe operation. Special considerations will be taken for high pressure systems.

[6.2.1.2](#) Independent power supplies to LFL control systems shall be arranged as given in [Pt.4 Ch.8 Sec.2 \[6.3.3\]](#) for each required LFL system. This supply shall in addition be arranged as an uninterruptible power supply (UPS) as given in [Pt.4 Ch.8 Sec.2 \[6.3.5\]](#).

6.2.2 Field instrumentation

[6.2.2.1](#) A local reading pressure gauge shall be fitted between the stop valve and the connection to shore at each bunker pipe.

[6.2.2.2](#) Pressure gauges shall be fitted to LFL pump discharge lines and to the bunkering lines.

6.2.3 Bunkering and tank monitoring

[6.2.3.1](#) Monitoring related to bunkering shall be available at the control location for bunkering.

6.2.3.2 Each fuel tank shall be fitted with at least one closed level gauging device. Unless necessary maintenance can be carried out while the fuel tank is in service, two devices shall be installed.

6.2.3.3 The fuel tank shall be fitted with a visual and audible high level alarm. This shall 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 shall be independent of the high-high level alarm.

6.3 Safety system

6.3.1 General

6.3.1.1 An independent safety system shall be fitted for each required LFL fuel supply system.

6.3.1.2 The safety functions given in Table 4 shall be implemented in the LFL safety system.

6.3.1.3 The signals required to activate the safety functions given in Table 4 shall be hardwired.

6.3.1.4 The signals required to activate the safety functions given in Table 4 shall be arranged with loop monitoring if they are not inherently fail safe.

6.3.1.5 Independent power supplies to LFL safety systems shall be arranged as given in Pt.4 Ch.8 Sec.2 [6.3.3] for each required LFL system. This supply shall in addition be arranged as an uninterruptible power supply (UPS) as given in Pt.4 Ch.8 Sec.2 [6.3.5].

6.3.2 LFL fuel tank safety

6.3.2.1 In ships other than tankers, indications and means for safety activation related to bunkering shall be available at the control location for bunkering.

Guidance note:

Tank pressure and tank level shall be monitored. Overfill alarm and automatic shutdown should be indicated at this location, as well as monitoring of ventilation and gas/leakage detection for the duct containing bunkering pipes.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

6.3.2.2 In addition to the high level alarm, a high-high level alarm shall be fitted. The high-high level alarm shall be independent of the high level alarm and the level gauging device.

6.3.2.3 The high and high-high level alarm for the fuel tanks shall 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.

6.3.2.4 Closing of the bunkering shutdown valve shall be possible from the control location for bunkering and from another safe location.

6.3.3 Gas detection

6.3.3.1 Fixed gas detectors shall be installed in the protective cofferdams surrounding the fuel tanks or in fuel tank hold spaces. Likewise, gas detectors shall be installed in all ducts around fuel pipes, in pump rooms, and in other enclosed spaces containing fuel piping or other LFL equipment. Gas alarms are required as specified in Table 4.

6.3.3.2 Gas detectors are in general not required in spaces where fuel piping is completely ducted.

6.3.3.3 Where gas detection shall cause shutdown in accordance with Table 4, detector voting shall be applied.

Guidance note:

A common voting principle is 2oo2 (meaning two out of two) where both units should detect gas to activate shutdown. A failed detector shall be considered as being active.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

6.3.3.4 Independent gas detector systems shall be fitted for each required LFL fuel supply system.

6.3.3.5 The number of detectors in each space shall be considered taking size, layout and ventilation of the space into account.

6.3.3.6 The detectors shall be located where gas may accumulate and/or in the ventilation outlets.

Guidance note:

Vapours from Methanol (MeOH) and Ethanol (EtOH) are heavier than air.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

6.3.3.7 Gas detection shall be alarmed on the bridge, in the engine control room and at the control location for bunkering, as well as locally.

6.3.3.8 Gas detection shall be continuous.

6.3.4 Liquid leakage detection

6.3.4.1 Liquid leakage detection shall be installed in the protective cofferdams surrounding the fuel tanks, in all ducts around fuel pipes, in pump rooms, and in other enclosed spaces containing fuel piping or other LFL equipment.

6.3.4.2 The leakage detection system shall trigger the alarm in the safety system, see [Table 4](#).

6.3.5 Ventilation monitoring

6.3.5.1 Loss of ventilation shall cause shutdown as given in [Table 4](#). A running signal from the ventilation fan motor is not sufficient to verify the performance of the ventilation; a flow- or overpressure detection or an equivalent detection principle is required.

6.3.5.2 Full stop of ventilation in the double pipe supplying LFL to single fuel LFL engine(s) shall, additionally to what is given [Table 4](#), lead to one of the following actions:

If another LFL supply system is arranged, the one with defect ventilation shall shutdown as soon as the other supply system is ready to deliver.

For a LFL electric propulsion system: Another engine supplied by a different fuel system shall start. When the second engine is connected to bus-bar the first engine shall be shut down automatically.

6.3.5.3 Reduced ventilation from what is required per area in [\[3.5\]](#) shall be alarmed.

6.3.5.4 Reduced ventilation in the ducting around the LFL bunkering lines during bunkering operations shall also be alarmed at the control location for bunkering.

6.3.6 Manual shutdown buttons

6.3.6.1 Means of manual emergency shutdown of fuel supply to the engine room as given in [Table 4](#) shall be provided at a reasonable number of places in the engine room, at a location outside the engine room, outside the LFL pump room and at the bridge. The activation device shall be arranged as a physical button, duly marked and protected against inadvertent operation.

6.3.7 Alarms and safety actions

6.3.7.1 The output signals as given in Table 4 shall be electrically independent of the LFL control system.

Table 4 Safety functions

<i>Parameter</i>	<i>Alarm</i>	<i>Automatic shutdown of tank valves</i>	<i>Automatic shutdown of master fuel valve¹⁾</i>	<i>Automatic shutdown of bunkering connection valve</i>	<i>Comment</i>
Fuel storage and bunkering system					
Tank overfilling protection, high level alarm	x				See [6.2.3.3]
Tank overfilling protection, high-high level alarm	x			x	See [6.3.2.2]
Loss of ventilation in annular space in double walled bunkering lines	x				Additional alarm at the control location for bunkering.
Gas detection in annular space in double walled bunkering lines	x				Additional alarm at the control location for bunkering.
Liquid leakage detection annular space in double walled bunkering lines	x			x	Additional alarm at the control location for bunkering.
Manual shutdown				x	See [6.3.2.4]
Gas detection in protective cofferdam around fuel tank.	x				
Liquid leakage detection in protective cofferdam around fuel tank	x				
Fuel supply system between tank and engine room bulkhead					
LFL heating circuit, gas detection or high level alarm in expansion tank, if applicable	x				
Gas detection in annular space in double walled fuel pipes, outside engine room, one detector above 20% LEL	x				
Gas detection in annular space in double walled fuel pipes, outside engine room, two detectors above 40% LEL	x	x			
Gas detection in pump room, one detector above 20% LEL	x				
Gas detection in pump room, two detectors above 40% LEL	x	x			

<i>Parameter</i>	<i>Alarm</i>	<i>Automatic shutdown of tank valves</i>	<i>Automatic shutdown of master fuel valve¹⁾</i>	<i>Automatic shutdown of bunkering connection valve</i>	<i>Comment</i>
Loss of ventilation in annular space in double walled fuel pipes, outside engine room	x	x*			*See [6.3.5]
Loss of ventilation in pump room	x				
Liquid leakage detection in annular space in double walled fuel pipes, outside engine room	x	x			
Liquid leakage detection in pump room	x	x			
<i>Engine room</i>					
Gas detection in annular space in double walled fuel pipes, inside engine room, one detector above 30% LEL	x				
Gas detection in annular space in double walled fuel pipes, inside engine room, two detectors above 40% LEL	x		x		
Liquid leakage detection in annular space in double walled fuel pipes, inside engine room	x		x		
Loss of ventilation in annular space in double walled fuel pipes, inside engine room	x		x		This parameter shall only lead to LFL supply shutdown for dual fuel engines. However, see [6.3.5].
<i>General</i>					
Manual shutdown			x		See [6.3.2.4].
1) Automatic or remote closing of master valve shall also stop LFL supply pumps					

6.4 Engine monitoring

6.4.1 General

6.4.1.1 In addition to the requirements given in Pt.4 Ch.3 Sec.1 [5], control and monitoring as given in Table 5 is required for LFL engines.

Table 5 Monitoring of dual fuel diesel or LFL-only engines

<i>System</i>	<i>Item</i>	<i>Gr.1 Indication alarm load reduction</i>	<i>Gr.2 Automatic start of standby pump with alarm ¹⁾</i>	<i>Gr.3 Shutdown with alarm</i>	<i>Comments</i>
1.0 Ignition system	Ignition failure each cylinder ²⁾	A			Automatic stop of fuel supply ³⁾
2.0 Lubricating oil system	Cylinder lubrication flow ⁴⁾	LA			
3.0 Fuel injection valve cooling system	Fuel injection valve cooling medium pressure	HA	AS		Automatic start of standby pump is not required if main pump is engine driven
	Fuel injection valve cooling medium temperature	LA			
4.0 LFL injection valve sealing oil system	LFL injection valve sealing oil pressure	LA			For high-pressure injection only
5.0 Combustion	Knocking	A			Only relevant for Otto process
6.0 LFL supply	Low pressure	LA	AS		
<i>Gr 1</i> = Common sensor for indication, alarm, load reduction <i>Gr 2</i> = Sensor for automatic start of standby pump <i>Gr 3</i> = Sensor for shutdown. <i>LA</i> = Alarm for low value <i>HA</i> = Alarm for high value <i>A</i> = Alarm activated <i>SH</i> = shutdown 1) Only for propulsion engines 2) Exhaust temperature deviation may be accepted as means of detecting ignition failure, individually on each cylinder 3) Fuel shutdown to the specific cylinder or the engine can be accepted 4) At least one measuring point for each lubricator unit.					

7 Engines and pumps

7.1 Pumps

7.1.1 General

7.1.1.1 The fuel pumps shall be fitted with accessories and instrumentation necessary for efficient and reliable function.

7.1.1.2 The fuel supply pumps shall be arranged for manual remote emergency stop from the following locations:

- navigation bridge
- engine control room.

7.1.1.3 Hydraulically powered pumps that are submerged in fuel tanks (e.g. deep well pumps) shall be arranged with double barriers preventing the hydraulic system serving the pumps from being directly exposed to the fuel. The double barrier shall be arranged for detection and drainage of possible fuel leakages.

7.2 Engines

7.2.1 General

7.2.1.1 These paragraphs apply to both LFL fuel only engines and dual-fuel engines running in LFL fuel mode.

7.2.1.2 Measures shall be taken to ensure effective sealing of injection or admission equipment that could potentially leak fuel into the engine room.

7.2.1.3 Measures shall be taken to ensure that LFL fuel injection pumps and injection devices are efficiently lubricated.

7.2.1.4 The starting sequence shall be such that LFL fuel is not injected or admitted to the cylinders until ignition is activated and the engine has reached a minimum rotational speed.

7.2.2 Functional requirements for dual fuel engines

7.2.2.1 LFL dual fuel engines shall be arranged for start, normal stop and low power operation in fuel oil mode. In case of shut-off of the LFL fuel supply, the engine shall automatically transfer to operation on oil fuel only.

7.2.2.2 Changeover to and from LFL fuel operation is only to be possible at a power level where it can be done with acceptable reliability as demonstrated through testing. On completion of preparations for changeover to LFL operation including checks of all essential conditions for changeover, the changeover process itself shall be automatic.

7.2.2.3 On normal shutdown as well as emergency shutdown, LFL fuel supply shall be shut off not later than simultaneously switching to oil fuel mode.

7.2.2.4 Ignition of the LFL-air mixture in the cylinders shall be initiated by sufficient energy. It shall not be possible to shut off the ignition source without first or simultaneously closing the LFL fuel supply to each cylinder or to the complete engine.

7.2.3 Functional requirements LFL-only engines

7.2.3.1 One single failure in the LFL fuel supply system shall not lead to total loss of fuel supply.

Guidance note:

May be waived in case of multi-engine installation.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

7.2.3.2

The starting sequence shall be such that LFL fuel is not injected or admitted to the cylinders until ignition is activated and the engine has reached a minimum rotational speed.

7.2.3.3

If ignition has not been detected by the engine monitoring system within the expected time after activation of fuel admission or injection valve, the LFL fuel supply shall be automatically shut off and the starting sequence terminated.

7.2.3.4

Measures for detected knocking shall be fitted.

8 Manufacture, workmanship and testing

8.1 General

8.1.1 General

8.1.1.1 Fabrication and testing of the fuel system shall be in compliance with [Pt.2 Ch.4](#), unless more strict requirements are given in this section.

8.2 Fuel tanks

8.2.1 Manufacture and testing

8.2.1.1 Testing of welds and non-destructive testing shall be carried out as specified for cargo tanks in chemical tankers in [Pt.5 Ch.6 Sec.5 Table 1](#). For tanks defined as pressure vessels (above 0.7 bar), testing shall be carried out as specified in [Pt.5 Ch.7 Sec.22](#). Strength and tightness testing shall be carried out as specified in [Pt.2 Ch.4 Sec.8](#) as applicable for cargo tanks in chemical tankers.

8.3 Piping system

8.3.1 Manufacture and testing

8.3.1.1 The LFL piping (inner pipe) shall be joined by butt welding with a minimum of flange connections.

8.3.1.2 Flanges in secondary enclosures for fuel piping shall be of the welding neck, slip-on or socket welding type.

8.3.1.3 In addition to normal controls before and during the welding, and to the visual inspection of the finished welds, as necessary for proving that the welding has been carried out correctly, the LFL pipe shall be subject to 100% radiographic or ultrasonic inspection of butt-welded joints.

8.3.1.4 After assembly on board, the fuel piping system shall be subjected to a leak test using air, or other suitable medium to a pressure depending on the leak detection method applied. Secondary enclosures for low pressure gas piping shall be tightness tested.

8.3.1.5 In addition, the outer pipe welding connections shall be subject to at least 10% random magnetic particle testing (MT) or dye-penetrant testing (PT). The results from surface examination (e.g. MT, PT) shall satisfy the requirements of level B of ISO 5817.

8.3.1.6 If the outer pipe of the LFL-piping contains pipes with design pressure above 10 bar, it shall be tested to the expected maximum pressure at pipe rupture, but minimum 10 bar.

8.3.1.7 All piping systems, including valves, fittings and associated equipment for handling of LFL-fuel shall be function tested under normal operating conditions.

8.3.1.8 Non-destructive testing shall be performed as stated in Pt.4 Ch.6 Sec.10 [1.5]

8.4 Onboard testing

8.4.1 General

8.4.1.1 Control, monitoring and safety systems required by these rules, shall be tested onboard in accordance with Pt.4 Ch.9 Sec.1 [4.5].

8.4.1.2 The functionality of the cause and effect diagram required by Table 2 shall be tested onboard.

9 Operation manual

9.1 General

9.1.1 General

9.1.1.1 An operation manual describing all essential procedures for handling of LFL fuel shall be prepared. The manual is subject to approval and shall be kept on board.

9.1.1.2 The operation manual is in general to include the following items:

- 1) Ship particulars
- 2) Fuel system particulars:
 - fuel properties
 - fuel tank capacities
 - fuel handling system
 - inert gas N2
 - fuel tank venting
 - fuel pump room safety if applicable
 - fuel tank instrumentation
 - fire safety
 - gas detection
 - liquid leakage detection
 - emergency water filling of cofferdams.
- 3) Operations:
 - assumptions
 - bunkering
 - fuel transfer between tanks
 - normal operation of the fuel system
 - cleaning, purging and gas freeing
 - tank entry procedures
 - cofferdam safety
 - gas detection
 - fuel pump room safety
 - emergency operations related to LFL fuel hazards
 - medical treatment procedures for exposure to the LFL fuel.
- 4) Reference documents:
 - general arrangement

- LFL fuel system
- pressure/vacuum valves flow curves
- nitrogen system
- fuel tank venting
- hazardous zones
- fire extinguishing
- procedure and arrangement manual (if applicable)
- bilge system for cofferdam and pump room.

9.1.1.3 The following instructions shall be included in the operation manual as applicable:

- the fuel tanks shall be filled with inert gas and the O₂-content in the tanks shall not exceed 5% by volume
- the control and safety systems shall be function tested.

10 Personnel protection

10.1 General

10.1.1 General

10.1.1.1 Personnel protection shall be in compliance with Pt.5 Ch.6 Sec.17. It is sufficient with two complete sets of safety equipment instead of three as required in Pt.5 Ch.6 Sec.17 [2.1.1].

11 Ship type considerations

11.1 Chemical tankers

11.1.1 General

11.1.1.1 This section covers special considerations for LFL cargo used as fuel on chemical tankers certified for the carriage of the relevant LFL fuel, based on the following:

- the risk of a fire/explosion in the cargo area spreading to the fuel supply system,
- the risk of inadvertent transfer of incompatible or contaminating cargo to the fuel system
- the risk of fire/explosion associated with increased frequency of use of piping systems for transfer of LFL fuel/cargo from service tank to engine room and transfer from a cargo tank to service tank (when a cargo tank is dedicated as a LFL fuel storage tank).

11.1.2 Arrangement

11.1.2.1 A dedicated LFL fuel service tank shall be provided. The piping system serving this tank shall be separated from cargo handling piping systems, except for the fuel transfer pipes from tanks for fuel storage.

11.1.2.2 The LFL fuel service tank(s) and fuel pump room shall be located in cargo area.

11.1.3 Fire safety

11.1.3.1 Measures shall be implemented to reduce the consequences of fire and explosions in cargo tanks and in the cargo area for the dedicated LFL fuel service tanks and LFL fuel supply systems.

11.1.3.2 Inerting of cargo tanks during cargo tank cleaning operations and inert gas purging prior to gas-freeing would be considered an acceptable measure to reduce the consequence of in-tank explosion. Such inerting should be performed for all cargo tanks and LFL fuel tanks regardless of size of ship.

11.1.3.3 The LFL fuel tanks shall be covered by the cargo deck fire/foam extinguishing system. Additional foam monitors/foam sprinklers shall be fitted, if necessary.

11.1.3.4 The exterior boundaries of the LFL fuel service tank(s) and the fuel pump room shall be protected by a water spray system for cooling and fire prevention. The spraying capacity shall not be less than 10 l/min/m² for horizontal projected surfaces and 4 l/min/m² for vertical surfaces.

11.1.3.5 The system shall be served by a separate water spray pump with capacity sufficient to deliver the required amount of water as specified in [Sec.4](#).

11.1.3.6 A connection to the ships fire main through a stop valve shall be provided.

11.1.4 Segregation of cargo- and fuel system

11.1.4.1 Measures shall be provided to prevent inadvertent transfer of incompatible or contaminating cargo to the fuel system, after the fuel storage tanks have been loaded.

11.1.4.2 If cargo tanks located within the cargo area are used as LFL fuel storage tanks, these cargo tanks shall be dedicated as LFL fuel tanks when the ship is operating on LFL fuel.

11.1.4.3 Any cargo liquid line for dedicated LFL fuel storage tanks shall be separated from liquid cargo piping serving other cargo tanks, including common liquid cargo piping.

11.1.4.4 Cross-connections to cargo liquid piping serving common systems or other tanks may be accepted provided the connections are arranged with spool pieces. The arrangement of spool pieces shall be such that even if a spool piece is unintentionally left in place, inadvertent transfer of incompatible or contaminating cargo from or to the dedicated LFL fuel storage tank is not possible.

Guidance note:

An arrangement with swing bends would normally be the preferred spool piece arrangement to prevent unintentional transfer to or from LFL fuel storage tanks.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

11.1.4.5 The cargo tank venting system for the dedicated LFL fuel tanks shall be separated from venting systems from other cargo tanks when operating on LFL fuel.

11.1.4.6 Other cargo handling systems serving other cargo tanks such as tank washing, inert gas and vapour return shall be separated when used as LFL fuel storage tanks. Inert gas systems may be accepted connected to a common system when used as LFL fuel storage tanks, provided the system is under continuous pressure.

11.1.4.7 LFL fuel tank location shall take into account compatibility with other cargoes. When carrying LFL fuel in the storage tanks, these tanks cannot be located adjacent to cargo tanks intended for cargoes that are not compatible with the LFL fuel.

11.1.4.8 For tankers arranged for operation on LFL fuel only, the following additional requirements apply:

- the fuel storage tanks and piping system shall be independent of cargo handling systems serving cargo tanks.
- if the LFL service tank is located within the cargo area, in case of shutdown of LFL fuel supply, the ship shall be provided with sufficient alternative power supply for operating the safety functions onboard (e.g.

fire and foam extinguishing, fire and gas detection and alarm, ballast, bilge drainage, LFL fuel safety systems).

11.2 Passenger vessels

11.2.1 General

11.2.1.1 Areas classified as hazardous zone as given in, [5.2.2] shall be inaccessible for passengers at all times.

11.2.1.2 The aft- and forepeak in passenger vessels cannot be used as cofferdam space for a LFL fuel tank.

11.3 Offshore supply vessels

11.3.1 General

11.3.1.1 LFL fuel tanks on deck are not accepted on offshore supply vessels.

11.3.1.2 The aft- and forepeak in offshore supply vessels cannot be used as cofferdam space for a LFL fuel tank.

SECTION 7 REDUNDANT PROPULSION - RP

1 General

1.1 Introduction

The additional class notation **RP** introduces rules to ensure that the propulsion and steering systems will remain in operation, or be restored to a certain degree, after a single failure. The choice of notations determines the level of system redundancy. The suffix "**x**" indicates the remaining power capacity after failure and for qualifier "**+**" the required capacity shall be maintained without disruption.

1.2 Scope

The scope for additional class notation **RP** adds an increased level of safety as the availability of the propulsion and steering functions are increased. The design shall ensure that the propulsion and steering systems will remain in operation, or be restored to a certain degree, after a single failure. The propulsion and steering systems arrangement shall be evaluated in an FMEA. The additional class notation **RP** does not include requirements or recommendations concerning the vessel's operation or other characteristics. The requirements of the rules in this section are supplementary to the main class rules.

1.3 Application

Vessels build and tested for compliance with the requirements of the rules of this section may be assigned a variant of the additional class notation **RP**, as given in [Table 1](#). For example: **RP(1, x)** can be assigned to systems arrangement where main and alternative propulsion are provided by a common propulsion system with redundant prime movers, **RP(2, x)** can be assigned to system arrangement of two propulsion systems operating in parallel and **RP(3, x)** can be assigned to system arrangement of two propulsion systems separated by A-60 bulkheads and operating in parallel. The suffix "**x**" indicates that at least x% of the propulsion power can be restored and maintained after single failure. An additional qualifier "**+**" can be included in **RP(2, x)** and **RP(3, x)** notations when the propulsion and steering systems are of a redundant design such that the required propulsion and steering capacity are maintained without disruption upon single failure; this will require extended analysis and verification of the design.

Table 1 RP class notations

Notation	Description
RP(1, x)	Main and alternative propulsion is provided by a common propulsion system (one propeller, one shaft and one rudder/steering gear) with redundant prime movers or by separate propulsors (two or more propellers), such that at least x% of the propulsion power can be restored and maintained after single failure e.g.: — two prime movers with clutch, where one of the prime movers may be of power take in type, connected to a common gear, one shaft line and one rudder. — one prime mover, one shaft line and one rudder providing the main propulsion system and one separate alternative propulsion system, e.g. azimuth or pod thruster capable of providing manoeuvrability. See Figure 1 Guidance note: A retractable azimuth thruster can be accepted as alternative propulsion. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Notation	Description
RP(2, x)	The vessel propulsion and steering system is of a redundant design with two (or more) propellers in parallel operation such that the availability of at least x% propulsion power and associated steering system can be restored and maintained after single component failure. See Figure 2
RP(3, x)	The vessel propulsion and steering system is of a redundant design with two (or more) propellers in parallel operation and separated by watertight A-60 bulkheads such that the availability of at least x% propulsion power and associated steering system can be restored and maintained after single component failure and upon incidents of fire or flooding. See Figure 3

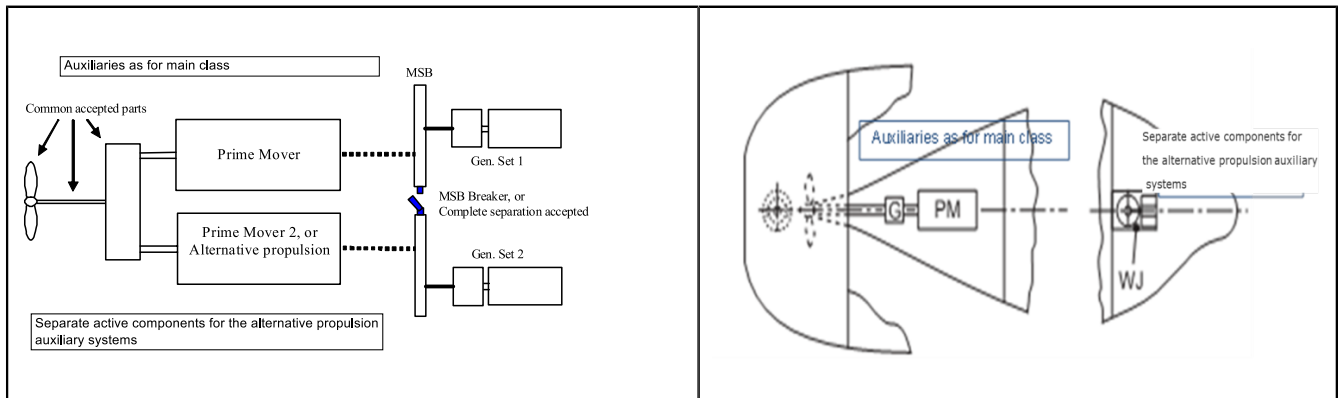


Figure 1 Examples RP(1, x)

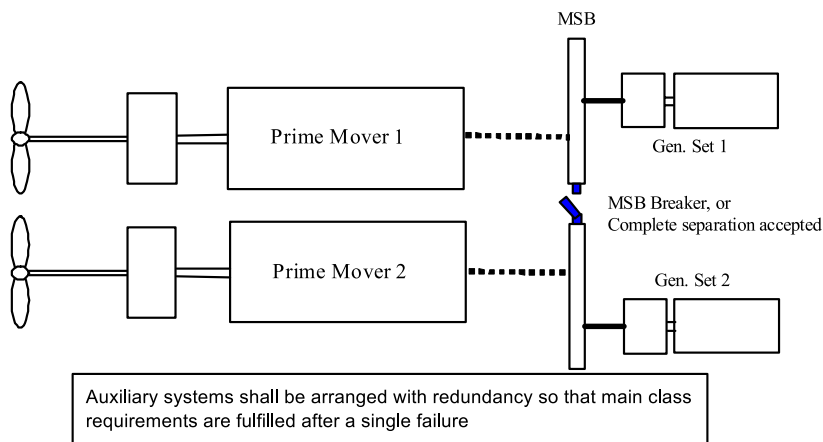


Figure 2 Examples RP(2, x)

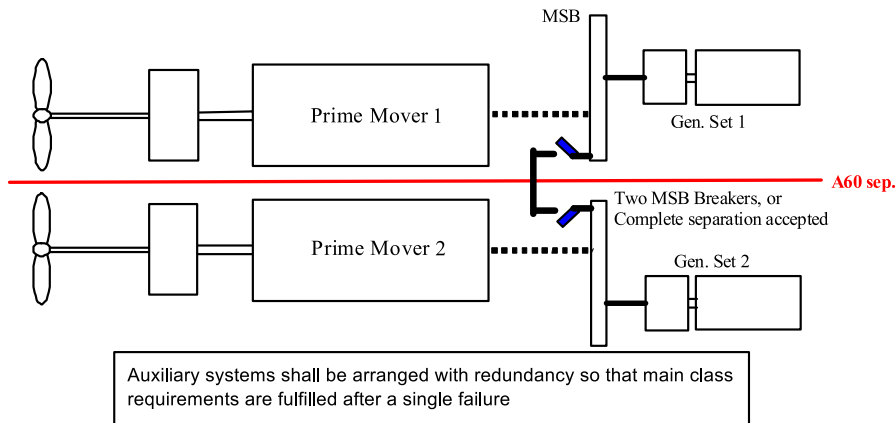


Figure 3 Examples RP(3, x)

1.4 References

1.4.1 References

1.4.1.1 For relevant international standards see [Table 2](#).

Table 2 References

Reference	Title
DNVGL-RP-D102	Recommended Practice for FMEA of Redundant Systems
IEC 60812	Analysis techniques for system reliability - Procedure for failure mode and effects analysis (FMEA)
IMO HSC Code, Annex 4	Procedures for FMEA

1.4.2 Definitions

Table 3 Definitions

Term	Definition
<i>active components</i>	are components for mechanical transfer of energy, e.g. pumps, fans, electric motors, generators, combustion engines and turbines.
<i>bulkhead deck</i>	see Pt.3 Ch.1 Sec.4 Table 7 for definition.
<i>mutually independent</i>	system B is independent of system A when any single system failure occurring in system A has no effect on the maintained operation of system B. A single system failure occurring in system B may have an effect on the maintained operation of system A. Two systems are mutually independent when a single system failure occurring in either of the systems has no consequences for the maintained operation of the other system according to above.
<i>redundancy</i>	the ability of a component or system to maintain its function when one failure has occurred. Redundancy can be achieved, for instance, by installation of multiple components, systems or alternative means of performing a function

Term	Definition
<i>redundancy group</i>	all components and systems that is subject to a single failure as specified in [2.1] for the specific notations. Guidance note: The redundancy groups will emerge as a consequence of the worst case single failure within each group. The Rules does not give requirements to the number of (beyond 2) or ratio between the defined groups. The groups are to be identified in the FMEA, verified by testing and incorporated in the consequence analysis. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
<i>remaining propulsion power</i>	is the vessels available propulsion power after the occurrence of a failure
<i>worst case failure</i>	failure modes which cause the largest reduction of the propulsion and steering capacity. This means loss of the most significant redundancy group, given the prevailing operation. Failure modes related to the different class notations are given in [2].

1.4.3 Abbreviations

1.4.3.1 Relevant abbreviations are given in Table 4.

Table 4 Abbreviations

Abbreviation	In full
FMEA	Failure Mode and Effect Analysis
UPS	Uninterruptible Power Supply
MCR	Maximum Continuous rating

1.5 Procedural Requirements

1.5.1 Document requirements

1.5.1.1 The propulsion, power generation and steering systems, with their auxiliaries and remote control shall be documented according to main class. In addition, documentation shall be submitted as required by Table 5.

Table 5 Documentation required

System	Documentation type	Additional description	Info	Notation
Propulsion and steering arrangement	Z050 – Design philosophy	The document shall identify the redundancy design intent and describe the propulsion and steering arrangement and if applicable the alternative propulsion arrangement. In order to determine the suffix (x) the main propulsion capacity MCR must be specified for each propeller, and if applicable for the alternative propulsion. For electric propulsion system the power available for propulsion or alternative propulsion after worst case failure must be specified. The document shall also specify the intended technical system configuration(s) which shall be verified against the requirements of the relevant notation.	AP	All
	Z071 - Failure mode and effect analysis (FMEA) *)	Including conclusive evidence that upon any single failure in required duplicated components or systems, and for RP(3, x) also incident of fire or flooding, x propulsion power and steering capability can be restored and maintained at least up to the degree expressed by the suffix x .	AP	All
	Z253 - Test procedure for quay and sea trial *)	An FMEA test procedure for failure testing at the sea trial to verify the conclusions in the FMEA. This shall be based upon the failure modes identified, and the vessel system setup as specified in the FMEA, see [1.3.1.11] .	AP	All
	I060 Principal cable routing sketch	All relevant cables for all systems required to restore and maintain propulsion and steering.	AP	RP(3, x)
	Z030 - Arrangement plan	Fire and flooding separation. Also indication of the different fire zones allocated to the installation of the redundant equipment.	AP	RP(3, x)
	Z265 - Calculation report	Documentation to demonstrate compliance with capacity requirements given in [2.1.1.3] and [2.1.1.4] or [3.1.1.5] and [3.1.1.10] .	FI	All
*) for a more extensive description on the requirements, see below.				

1.5.1.2 A Failure Mode and Effect Analysis, FMEA, for the complete propulsion and steering systems, with their auxiliaries, shall be submitted for approval. The FMEA shall show that redundancy requirements are fulfilled where relevant.

1.5.1.3 The purpose of the FMEA is to identify and describe the different failure modes of the equipment when referred to its functional task. Special attention shall be paid to the analysis of systems that may enter a number of failure modes and thus induce a number of different effects on the propulsion and steering performance. The FMEA shall include at least the information specified in [\[1.3.1.4\]](#) to [\[1.3.1.10\]](#).

1.5.1.4 The FMEA shall give general vessel information and clearly describe the design intent and the intended overall redundancy and acceptance criteria. The technical system configuration(s) to be verified

shall be described, and prerequisites for achieving the required failure tolerance and redundancy shall be specified.

Guidance note:

Technical system configuration(s) may be setting of any valve cross-over, power feed change-over arrangement condition etc..

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.5.1.5 A breakdown of the systems, into functional blocks shall be made. The functions of each block shall be described. The breakdown shall be performed to such a level of detail that the design intent can be documented.

1.5.1.6 A description of each functional block shall be made and all associated failure modes with their failure causes shall be identified for normal operational modes.

1.5.1.7 A description of the effects of each failure mode on the functional block, and on the propulsion and steering function shall be made.

1.5.1.8 A description of the arrangement and installation of redundant component groups in fire and flooding protected compartments shall be provided for **RP(3, x)**. This also includes cables and communication lines, and associated equipment.

1.5.1.9 Compliance statements referring to the design intent and acceptance criterion shall be made.

1.5.1.10 The FMEA shall be a self-contained document including all necessary descriptions, supporting documents and drawings in order to document the conclusions.

Guidance note 1:

Description of FMEA systematic may be found in the documents RP-D102 FMEA of Redundant Systems, IEC 60812 and IMO HSC Code, Annex 4.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

Separate FMEAs covering control systems (as supplied by manufacturer) should be incorporated in the overall system FMEA (as supplied by the yard).

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.5.1.11 A test program to support the conclusions shall be included or referred. This test program shall also be submitted for approval and shall be used for the final sea trial of the complete redundant propulsion and steering systems. The test program shall be based upon the failure modes identified in the FMEA in order to verify the conclusions. References shall be made between the FMEA and the FMEA test program.

1.5.1.12 FMEA(s) and FMEA test program(s) shall be kept on board and at all times and be kept updated to cover alterations to the propulsion and steering systems.

1.5.1.13 For vessels with qualifier **+**, the FMEA shall be extended to cover additional failure modes applicable for the technical system configuration(s) of the power generation and switchboard specified in the system design philosophy, see [3.2.4].

1.5.2 Certification required

1.5.2.1 Equipment shall be certified according to main class requirements.

1.5.3 Survey and test requirements

1.5.3.1 For initial issue of class notation upon completion, the propulsion and steering systems, with their auxiliaries, shall be subjected to final tests during sea trials, in compliance with the requirements for main class.

1.5.3.2 A selection of tests within each system analysed in the FMEA shall be carried out, including simulation of fire and flooding incidents when required. Specific conclusions of the FMEA for the different systems shall be verified by tests when redundancy or independence is required. The test program required in [1.3.1.11] shall be used for this testing.

Guidance note:

For **RP(3, x)** this implies that simultaneous loss of all systems in relevant fire zones or flooded compartments should be tested.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.5.3.3 The test procedure for redundancy shall be based on the simulation of failures and shall be performed under as realistic conditions as practicable.

Guidance note:

It is understood that not all failure modes in all systems are possible to simulate. For such failure modes the acceptance of the system will be based on the theoretical FMEA, and hence the documentation analysis of these failure modes should be emphasized in the FMEA.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.5.3.4 It is not required that the built-in endurance as required by [2.1.1.3] and [2.1.1.4] and by [3.1.1.5] and [3.1.1.10] be demonstrated. However, time-critical resources shall be substantiated by adequate tests of rate of consumption and depletion.

1.5.3.5 The capability of the of the remaining propulsion system after the worst case single failure scenarios shall be tested at sea to demonstrate that the propulsion power and steering capabilities as indicated by the notation **x** can be achieved with satisfactory thermal stability and performance of the machinery plant including necessary auxiliaries.

1.5.3.6 For **RP(2, x)** and **RP(3, x)** steering gear function and capacity test as listed by Pt.4 Ch.10 Steering Gear shall be performed for the remaining system after a worst case failure (This shall be verified after failure of any one redundancy groups).

1.5.3.7 For **RP(1, x)** notation, the time necessary to activate the alternative propulsion system after failure of the main propulsion system shall be demonstrated.

1.5.3.8 For **RP(1, x)** notation, a speed trial is to be performed with the alternative propulsion system consisting of at least two legs in opposite direction, to compensate influence of wind and current. For separate alternative propulsion units, also the steering capability of the unit shall be demonstrated and documented.

1.5.3.9 When deemed necessary by the attending surveyor, tests additional to those specified by the test program may be required.

2 Technical requirements for RP(1, x)

2.1 General

2.1.1 Basic requirements

2.1.1.1 The design shall ensure the ability of the main or alternative propulsion system to be brought to and remain in operation after the occurrence of any single failure, as specified in [2.1.2].

2.1.1.2 The alternative propulsion shall, when brought into operation, be designed for continuous operation.

Guidance note:

Generally no restrictions should be put on the starting intervals of electrical machines. If arranged, the arrangement is subject to approval in each case.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.1.3 The alternative propulsion system power capacity shall be such that it will enable the vessel to maintain a speed of not less than 7 knots.

2.1.1.4 The vessel shall be able to proceed with the propulsion power required in [2.1.1.3] for a period of at least 72 hours.

For vessels built for a specific service where the duration of a sea voyage is less than 72 hours, the built-in endurance of the alternative propulsion system may be limited to the duration of the maximum crossing time, but not less than 12 hours.

Guidance note:

In case a vessel is built to proceed with the alternative propulsion system for a period of less than 72 hours, this limitation will be stated in the appendix to the classification certificate.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.1.5 It shall be possible to activate the alternative propulsion system within maximum 30 minutes after failure of the main propulsion system, except for failures in common active and passive components where common components have been specially accepted.

Guidance note:

Activation of the alternative propulsion may involve manual mechanical work provided that procedures and equipment necessary for activation is kept on-board the vessel, and that activation of the alternative propulsion (with the required capacity) within 30 minutes can be demonstrated at sea trials.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.2 Failure modes

2.1.2.1 The defined failure modes include failure of any active component or system, except for failures in common active components specially accepted as common. This includes normally propeller, shaft and gear for the arrangement of one propeller shaft train with two driving units acting via the common gear box.

2.2 System configuration

2.2.1 General

2.2.1.1 The basic requirements for providing the alternative propulsion power are as described in [1.1.3.1].

2.2.2 Electrical power distribution

2.2.2.1 The power distribution to both the main and alternative propulsion systems and their respective auxiliary systems shall be arranged so that at least one of the propulsion systems are capable of being put into operation and operated after loss of any single switchboard section.

2.2.3 Electrical power plant control

2.2.3.1 The power plant control system shall be arranged so that a single failure shall not jeopardise both main and alternative propulsion.

2.3 Auxiliary systems

2.3.1 General

2.3.1.1 Auxiliary systems for the main propulsion system shall be arranged as required by 1A1 main class requirements. Separate active components shall be arranged for the alternative propulsion auxiliary systems. For additional requirements to specific auxiliary functions see [2.3.2] to [2.3.4].

2.3.2 Fuel oil

2.3.2.1 The transfer and fuel oil pre-treatment systems and tank arrangements shall be able to support the power capacity required by [2.1.1.3] for the period specified in [2.1.1.4] after a single failure as specified in [2.1.2.1], unless fuel which do not require pre-treatment are arranged for the period. Fuel pre-treatment shall be understood as all equipment for purification, filtering, heating, and measuring fuel oil.

2.3.3 Lubrication oil system

2.3.3.1 The main propulsion system and the alternative propulsion system shall have independent lubrication oil systems.

2.3.3.2 The lubrication oil storage and purification system shall be able to support the power capacity required by [2.1.1.3] for the period specified in [2.1.1.4] after a single failure as specified in [2.1.2.1].

2.3.4 Compressed air system

2.3.4.1 The starting air system shall comply with main class for the main propulsion, and with adequate facilities to enable three starting attempts for the alternative propulsion.

2.4 Propulsion and steering control systems

2.4.1 General

2.4.1.1 When a centralised control system is arranged, the control system arrangement shall comply with the requirements for redundancy and separation as given by these rules.

2.4.2 Propulsion control system

2.4.2.1 Independent local control for main and alternative propulsion system shall be arranged consistent with the failure concept given in [2.1.1.1]. Each system shall include a separate control panel. Such means shall be operable after any failure of the centralized control system installation on the navigating bridge.

2.4.2.2 Reliable means of communication, also operable during black-out, between the navigating bridge and the emergency/local control stations shall be arranged for main and for alternative propulsion.

2.4.2.3 Remote control of both the main and the alternative propulsion systems shall be installed at the navigating bridge. The navigating bridge main and alternative remote propulsion control systems shall be independent of each other, so that any single failure will only affect one of them.

Guidance note:

Mechanical levers are not required to be duplicated.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.4.3 Control power sources

2.4.3.1 Power supply for main and alternative propulsion and steering systems shall be distributed consistent with the redundancy requirement [2.1.1.1].

2.4.4 Steering control system

2.4.4.1 If alternative propulsion and steering is realized by a second driven unit e.g. independent steerable thruster or water jet:

- Steering systems related to main and alternative propulsion shall be independent.
- For the steering system related to alternative propulsion, strength and capacity shall be as required for main system, but at a vessel speed only corresponding to the maximum speed (minimum 7 knots) when propulsion power is provided by alternative unit only. The steering system for alternative propulsion does not need to include an auxiliary steering gear.

3 Technical requirements for RP(2, x) and RP(3, x)

3.1 System design

3.1.1 Redundancy concept

3.1.1.1 The redundancy concept shall ensure the ability of the system to be restored and/or to remain in operation in accordance with the objectives of the specific notation. This covers the following aspects:

- propulsion
- steering
- recovery time
- endurance.

3.1.1.2 The propulsion system forming the required redundancy shall be intended to provide propulsion during normal operation

3.1.1.3 Propulsion

For notation **RP(2, x)** the vessel's propulsion system shall be of a redundant design such that at least x% of the propulsion power can be restored after any single failure in the propulsion and auxiliary systems, before the vessel has lost steering speed. For definition of failure modes see [3.1.2].

Guidance note 1:

The remaining propulsion power after loss of one propulsion line may in practice be less than x% due to hydro-dynamical properties of the vessel when operating at lower speed.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

Vessels designed and built with a larger degree of separation than 2 will be subject to special evaluation.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.1.1.4 For notation **RP(3, x)**, the requirement to ensure at least x% of the propulsion power as described in [3.1.1.3], also includes single failure of one compartment caused by fire and flooding incidents. For definition of failure modes see [3.1.2].

3.1.1.5 The remaining propulsion power capacity (as described in [3.1.1.3]) shall enable the ship to maintain a speed of not less than 6 knots while heading into BF 8 weather conditions with corresponding wave conditions. The requirement shall be documented by computation where relevant wave spectrum is utilised.

Guidance note:

For vessels engaged in specialised operations, e.g. seismic, pipe layers, vessels engaged in confined waters etc, the propulsion power capacity after a failure should be sufficient to keep the vessel and equipment in a safe condition after a failure. This should be determined together with the ship owner based on the vessel operations. Written acceptance of the propulsion capabilities shall be provided from the owner.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.1.1.6 Steering

The steering arrangement shall consist of two independent steering systems, each in compliance with the main class rules.

Guidance note:

In a typically installation of two steering gear systems two pumps are fed from the emergency switchboard and two pumps are fed from each side of the main switchboard. One single failure may then initially cause loss of three pumps which is accepted.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.1.1.7 The vessel shall be fully manoeuvrable when operating one (1) propulsion and one (1) steering system.

Guidance note:

This implies that each steering system should comply with main class requirements for rudder (or equivalent means, e.g. thrusters) movement when only one propulsion and one steering system is in operation.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.1.1.8 Qualifier +:

The vessels propulsion system shall be of a redundant design such that at least x% of the propulsion power and at least one associated steering system will be maintained without disruption upon any single failure. Redundancy shall be based on running machinery. Full stop of propulsion or steering systems and subsequent start-up of available propulsion or steering is considered as a disruption, and not acceptable. In addition, any specific requirements as stated in these rules for qualifier +, shall be complied with.

Guidance note:

The redundancy requirements will not be considered as complied with if based upon manual or automatic start or restart of generators or pumps, or if based upon automatic or manual reconfiguration of auxiliary systems e.g. by use of valves. Automatic activation of equipment may be accepted as contributing to redundancy only if their reliability and simplicity of operation is satisfactory so that they can be brought into operation before propulsion power is degraded below x%. This principle is typically only accepted for transfer of control between redundant controllers and for standby start of sea water cooling pumps for RP2 (x%).

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.1.1.9 Recovery time for notations without qualifier +:

To ensure the required x% propulsion power, restoration of dedicated systems is allowed as long as the restoration process is completed before the vessel has lost steering speed

Guidance note:

The objective of the above stated link between recovery of the propulsion power and steering capability is to allow more time when the vessel is at transit speed in open waters than when the vessel is proceeding at reduced speed in congested waters, in or is in a manoeuvring situation. This implies that systems which are not continually available should be prepared for service before entering critical situations where the recovery time otherwise would be too long in view of external hazards.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.1.1.10 Endurance

After any single failure the vessel shall be able to proceed with the required remaining propulsion power for a period of at least 72 hours.

3.1.1.11 For vessels built for a specific service where the duration of a sea voyage is less than 72 hours, the built-in endurance at the required remaining propulsion power may be limited to the duration of the maximum crossing time but not less than 12 hours.

Guidance note:

The propulsion power period after failure should be determined together with the ship owner based on the vessel operation area. Written acceptance of the propulsion capabilities shall be provided from the owner.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.1.2 Failure modes

3.1.2.1 For the **RP(2, x)** notation, the defined failure modes include component breakdown and malfunctions, but exclude the effects of fire and flooding. Thus, it is acceptable that redundant components are installed in a common area or compartment.

3.1.2.2 In addition to active components, the component breakdown as stated above shall include the failure of the following components:

- coolers and heat exchangers
- filters
- motorised valves
- boilers
- transformers
- switchgear
- cables
- systematic failures or faults that can be hidden until a new fault appears.

See [3.3] for more specific requirement.

3.1.2.3 For the **RP(3, x)** notation, the failure modes include all those defined for **RP(2, x)**, in addition to any failure in the propulsion and steering systems that will result from incidents of fire and flooding. Hence, redundant components and systems shall be located in different fire sub-divisions. The sub-divisions are to be watertight below the bulkhead deck. Reference is also made to the separation requirements given in [3.5].

Guidance note:

Loss of stability (e.g. as a result of flooded compartments) is not a relevant failure mode.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.2 System configuration

3.2.1 General

3.2.1.1 The basic requirement of maintaining at least x% of propulsion MCR power shall be realised by installation of at least two mutually independent propulsion systems.

Guidance note:

The minimum of x% propulsion power is to be understood as the nominal power consumption of one propeller when operating with all propulsion systems together. I.e. the deviations in thrust output caused by changes in vessel speed and propeller r.p.m. at loss of one propulsion system need not to be considered.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.2.1.2 Typical configuration will consist of two propulsion lines, alternatively two azimuth thrusters. The normal operation mode is to run both systems in parallel, and upon a failure one system will continue in operation. Two independent engine systems geared onto one propeller are not considered equivalent.

3.2.1.3 The redundancy in steering function shall be realised by the installation of two (or more) mutually independent steering systems, e.g. two rudders or two azimuth thrusters. Each steering system, with steering controls and actuators, shall comply with the main class rules. This implies that each steering system shall be provided with a main and an auxiliary steering gear.

Guidance note:

Vessels designed and built with a larger degree of separation than 2 will be subject to special evaluation.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.2.1.4 After failure of one propulsion system, the steering capability, as required for main steering gear, shall be available at the maximum achievable speed.

3.2.2 Electrical power generation

3.2.2.1 The electrical power required for propulsion, steering and auxiliary systems shall be generated by a power plant complying with main class requirements of Pt.4 and the redundancy, capacity, separation and single failure integrity as specified for the given notation.

3.2.2.2 The vessel shall be capable of operating with the emergency switchboard out of operation.

3.2.3 Electrical power distribution

3.2.3.1 When power for propulsion, steering and their auxiliaries is supplied from one switchboard, the bus-bars of the switchboard shall be arranged for automatic separation into at least 2 sections, with the circuits for propulsion and steering units and auxiliaries distributed between the sections. Automatic separation shall take place when short circuit currents are detected on the main bus-bars. The bus-bar breaker(s) or inter-connector breaker(s), shall be capable of breaking the maximum short circuit current in the system, and shall provide discrimination towards the generator breakers for short circuit. In addition bus-bar breaker(s) or inter-connector breaker(s), shall be provided with under voltage trip. Alternatively the redundancy may be provided by two separate switchboards.

3.2.3.2 Power supply to control and auxiliary systems shall be arranged so that at least one of the propulsion and steering systems are capable of being operated after failure of any one switchboard section. The remaining capacity shall be so that the requirements in [3.1.1] are fulfilled. This applies for all electrical (AC and DC) distribution systems.

3.2.3.3 When considering single failures of switchboards, the possibility of short-circuit of the bus-bars shall be considered.

3.2.3.4 Bus-bar control and protection systems shall be designed to work with both open and closed bus-bar breakers.

3.2.3.5 For **RP(3, x)** notation, the switchboard sections as described in [3.2.3.1] shall be separated by bulkheads and decks, fire-insulated by A-60 class division, and in addition, watertight if below the bulkhead deck. These sections may be connected by 2 bus-bar breakers, which shall be installed at each side of the A-60 partition. Power distribution must also be arranged in compliance with the separation requirements given in [3.5].

3.2.3.6 The power distribution system shall be arranged so that the power supply can be automatically restored, such that the power supply to the switchboard(s) is restored within 45 s and power to the auxiliary services in compliance with [3.1.1].

3.2.3.7 For qualifier **+**: The online power reserve, i.e. the difference between online generator capacity and generated power at any time, shall be displayed at the Main navigation workstation. The indication shall be continuously available. For split bus power arrangements, indications shall be provided for individual bus sections.

3.2.4 Power management requirements for qualifier +

3.2.4.1 A power management system shall be arranged, operating with both open and closed bus-bar breakers. This system shall be capable of performing the following functions:

- load dependent starting of additional generators
- block starting of large consumers when there is not adequate running generator capacity, and to start up generators as required, and hence to permit requested consumer start to proceed
- if load dependent stop of running generators is provided, facilities for disconnection of this function shall be arranged.

Guidance note:

Exemption from the requirement for an automatic power management system (PMS) may be granted, provided that functions for blackout prevention, tripping of non-essential consumers and block starting of large consumers are taken care of by other systems. Exemptions will be given to systems where PMS will add few or no benefits.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.2.4.2 A failure in a power management system shall not cause alteration to the power generation, and shall initiate an alarm at the Main navigation workstation.

Guidance note:

Special attention should be paid to ensure redundant distribution (for **RP(3, x)** also separation) of I/O signals so that effects of single failures in the PMS system will not fail the overall redundancy philosophy..

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.2.4.3 It shall be possible to operate the switchboards in manual as required for the main class, with the power management system disconnected.

3.2.4.4 Overload, caused by the stopping of one or more generators, shall not create a black-out.

Guidance note:

Reduction in thrusters load, i.e. pitch or speed reductions, should be introduced to prevent blackout and enable standby generators to come online. If this function is taken care of by the propulsion control system, the function shall be coordinated with the power management system.

Load reductions should preferably be achieved through the tripping of unimportant consumers, and the requirement does not exempt such means. But, it is common that the relative load proportions will require thruster load reduction, in order to effectively reduce overload situations.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.2.4.5 When generators in different redundancy groups are running in parallel this will introduce the possibility that a single failure may propagate between systems. In such cases it is required that protective measures are implemented in the system in order to ensure the required integrity between the redundancy groups. Analysis of relevant failure modes shall be addressed in the FMEA.

Guidance note:

Examples of failure modes that will be relevant are given below.*) The analysis and test requirements may be part of the RP FMEA and FMEA test program or other documentation. In case such verification is documented in other documentation the FMEA should give reference to this documentation, and refer/state conclusions based on this.

<i>Failure Modes:</i>	<i>Minimum analysis and test requirement</i>
Short circuits, earth failures	Selectivity between generator breakers and bus-tie on short circuit and earth failures, in form of a discrimination analysis.
Over load	Overload required to be handled by functionality in control systems (PMS, Switchboard logic), control system documentation, FMEA and functional testing at PMS/FMEA trials. (Can I/O failure between PMS/SWB be a hidden failure?)
Governor failures	Power failure, speed pick-up failure, over-fuel, isochronous load sharing lines. Analyse and test all these.
Overvoltage and AVR, failure scenarios	Over excitation/excitation break-down/under excitation, to be analysed in the FMEA analysis. FMEA test requirement: loss of excitation (power or no output), loss of sense or over excitation (disconnect CT feedback or increase excitation).
Failures related to PMS and active load sharing	Analysis, functional testing. FMEA test: Power failure, network failure (disconnect), PMS I/O failure testing required as found necessary in FMEA analysis, load sharing line failure (disconnect).
Transient under voltage (short circuit ride through): (In electrical systems transient voltage dips may occur, e.g. due to short circuits and subsequent intended opening of feeder or bus-tie breakers for disconnection of the faulty equipment. In connection with operation with closed bus such transients will affect the whole connected distribution system.)	The FMEA must analyse the effect of transient voltage dips in the system and identify measures necessary to avoid problems with: — unintended tripping of frequency converters — unintended tripping of motors and other important components, like auxiliary system pumps (tripping of motor starters and/or contactors) — unintended activation of under voltage protection systems — DC control power systems, e.g. dual feeding through diodes or automatic change-over. — In relation with the above items, functionality must be checked in order to verify the potential effect of this failure mode. — The requirement is that the equipment not belonging to the propulsion/steering system directly affected by the failure shall ride through the transient period and be immediately available, without operator intervention, when the system voltage is re-established. It should also be evaluated if re-establishment of system voltage could cause unacceptable high voltages ("voltage over-shoot"). — Measures must be implemented as found necessary through analysis. — No "short circuit test"-requirements to verify the conclusions. (Additionally, or as an alternative, verification of the above mentioned items may also be based on testing. Such testing should be based upon non-destructive methods for simulating the transient low voltage period in the system.)

*) It must be understood that this is not an exhaustive list of failure modes relevant for closed bus-tie systems. Reference is made to document DNVGL-RP-D102 "Failure Mode and Effect Analysis (FMEA) of Redundant Systems" Appendix D, for discussion on the subject of closed bus-tie systems.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.3 Auxiliary systems

3.3.1 General

3.3.1.1 Auxiliary system shall be so arranged and separated that they after failure are able to support the required remaining propulsion and steering capacity in accordance with [3.1.1].

Guidance note:

Typical systems included:

- ventilation systems
- cooling systems
- fuel oil transfer system
- fuel pre-treatment systems, i.e. all equipment for purification, filtering, heating, and measuring fuel oil
- lubrication oil systems
- other systems when relevant.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.1.2 In addition to the redundancy and separation required by [3.3.1.1] each auxiliary systems shall be such arranged that the remaining system after failure of any active component, fulfils main class redundancy requirements and have capacity to support normal full propulsion power.

Guidance note:

The intention is to achieve a similar availability of the normal propulsion power as for a single engine propulsion plant.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.1.3 Fixed piping may be shared by redundant components for the **RP(2, x)** notation, except as given in [3.3.2.1], [3.3.4.2], [3.3.5.2] and [3.3.6].

3.3.1.4 For the **RP(3, x)** notation, separate piping systems shall be arranged for redundant systems. These systems shall be separated by A-60 class fire division as required in E. below. Cross-over pipes are accepted provided these can be closed from both sides of separating bulkheads, with one valve on each side of the bulkhead(s) fitted directly or as close as possible to it. Crossover valves shall be easy to reach and clearly marked. Ventilation ducts shall not have cross-over facilities.

3.3.1.5 If equipment is dependent upon air ventilation or another cooling media for control of ambient temperature, in order to avoid excessive heat increase, the cooling system shall be designed with redundancy.

3.3.1.6 For **RP(3, x)**, the capacity of the bilge system in each engine room shall be in accordance with the main class rules.

3.3.1.7 Main and emergency firefighting systems shall be arranged in accordance with SOLAS Ch.II-2 requirements.

3.3.2 Fuel oil

3.3.2.1 There shall be at least two service tanks, which shall serve dedicated sub-systems. Cross-over facilities may be arranged.

Guidance note:

It is generally to be understood that the intended integrity will be in place when such cross-over facilities is kept closed.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.2.2 For **RP(3, x)**, the service tanks and associated piping shall be installed one in each of the separate engine rooms.

3.3.2.3 If the fuel system requires heating, also the heating system shall comply with the redundancy requirements and in addition, the separation requirements as applicable for the **RP(3, x)** notation.

3.3.3 Lubrication oil system

3.3.3.1 Each propulsion system shall have an independent lubrication oil circulation system. The system shall comply with the redundancy requirements and in addition the separation requirements as applicable for the **RP(3, x)** notation.

3.3.4 Cooling water

3.3.4.1 Cooling water systems for **RP(2, x)** and **RP(3, x)** notations shall comply with main class rules, while also taking into consideration the requirements for component redundancy and separation as given in [3.1.2] and [3.5] below. For vessels with class notation **Passenger ship** or **Ferry** notation, sea water suction shall be arranged from separate sea chests located in the bottom of the ship, in addition to a high sea chest located at one side. The two low sea chests shall have separate ventilation arrangements.

3.3.4.2 Fresh water cooling systems shall be arranged as fully separated systems also for the **RP(2, x)** notation, in view of the risk of severe loss of water or accumulation of gas due to leakage, so that the redundancy and capacity requirements in [1.4.3] are fulfilled after failure of any one fresh water cooling system.

Guidance note:

Redundant systems for air conditioning and control of ambient temperature, e.g. air condition units, chillers and HVAC, may share common piping for notation **RP(2, x)**. See also [3.3.1.5].

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.5 Compressed air system

3.3.5.1 The starting air system shall comply with main class for **RP(2, x)**. For **RP(3, x)**, an equivalent system will be accepted when the compressors and air receivers are adequately distributed on both sides of fire and or flooding partitions.

3.3.5.2 The control air system shall be considered in view of the actual use of compressed air for control functions. If control air is found necessary for essential functions in the propulsion and steering system separated systems shall be arranged also for the **RP(2, x)** notation, so that the redundancy and capacity requirements in [1.4.2] are fulfilled after failure of any one control air system.

3.3.6 Ventilation systems

3.3.6.1 **RP(3, x)** notation: Ventilation systems shall not have any common units or cross-over pipes, when supplying different fire-division areas.

3.4 Propulsion, steering and auxiliary control system

3.4.1 Propulsion control system

3.4.1.1 Independent control systems for each propulsion line shall be arranged according to main class and consistent with the failure concept given in [3.1.2]. Each line shall include a main control station and an emergency control station.

3.4.1.2 Reliable means of communication, also operable during black-out, between the navigating bridge and the alternative or emergency control stations shall be arranged. The systems shall be so arranged that at least one means of communication is available also after any relevant single failure.

Guidance note:

For notation **RP(3, x)**: This requirement is not relevant for failure modes which makes the bridge unavailable, e.g. fire.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.4.1.3 The bridge propulsion control system shall be independent for each propulsion line; so that any single failure will only affect one of them, and that operation of the remaining system can continue on the normal means of operation (e.g. levers). Alternatively a system arranged with redundancy can be accepted if in addition independent back-up control system for each propulsion system is arranged. The redundant system must be so arranged that any single failure will not prevent continued normal control of the complete propulsion system. The independent back-up control system shall be based upon similar input devices as the normal means of operation (e.g. levers).

3.4.1.4 For both propulsion systems local control shall be available after any single failure of cabling or equipment on the bridge or between the bridge and the location where the local control is installed. For **RP(3, x)** notation this also includes incidents of fire, and associated cabling and equipment installed outside of the bridge shall follow the requirements in [3.5] below.

3.4.1.5 Both normal bridge control and back-up control if arranged according to [3.4.1.3] shall be arranged so that the operator can control the systems from (or adjacent to) the main navigation stand, in order to maintain the normal view to the outside and to the required feedback and heading indicators.

Guidance note:

Mechanical levers are not required to be duplicated.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.4.2 Control system for auxiliary services

3.4.2.1 Control systems for auxiliary systems shall be arranged in accordance with the redundancy and separation concept for the propulsion and steering, so that a single failure within any control system does not affect the required remaining propulsion and steering capabilities, as given for the specific notations.

3.4.3 Battery and UPS systems

3.4.3.1 If control systems are powered by Uninterruptible power supplies (UPSes), the UPSes shall be arranged with redundancy in technical design and physical separation in accordance with [1.4.3], and in addition, each UPS shall be arranged with a by-pass, which may be used when an UPS fails. The input power supply to the redundant UPSs serving different redundancy groups shall be derived from respective sides of the main switchboard. The battery for each UPS shall be able to provide output power at maximum load for 30 minutes.

3.4.3.2 If the control system is powered by batteries, the batteries shall be built with redundancy in technical design and physical separation in accordance with [3.1.1], and in addition, be arranged with cross-over facilities, which may be used when a battery fails. The battery installed for shall be able to provide output power at maximum load for 30 minutes.

3.4.3.3 UPS charge fail and UPS by-pass shall initiate an alarm at the navigating bridge.

3.4.3.4 Battery charging failure and UPS on bypass power shall initiate an alarm at the navigating bridge.

3.4.3.5 Power to control systems shall be arranged so that all equipment which has not lost its power due to a partial black-out can still be operated.

3.4.4 Steering control system

3.4.4.1 The requirements in [3.4.1.4] and [3.4.1.5] also apply to the bridge steering gear systems.

3.5 Separation requirements for **RP(3, x)**

3.5.1 General

3.5.1.1 Systems, including single components, cabling, and piping, that form part of the designed redundancy, shall be separated by bulkheads and decks, which shall be fire insulated with A-60 class division, and in addition shall be watertight if below the bulkhead deck. Watertight bulkheads shall be capable of withstanding one sided flooding, and if doors are fitted in such bulkheads, they shall comply with SOLAS Ch. II-1/25-9.

Guidance note 1:

If two A-0 bulkheads are arranged in areas with low fire risk, this may be accepted based on case-by-case approval.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

When it is practically unfeasible to comply with the above requirement, cables running together within an A-60 cable duct or equivalent fire-protection can be accepted. This alternative is not accepted in high fire risk areas, e.g. engine rooms and fuel treatment rooms. Cable connection boxes are not allowed in such ducts. If cables are located in A-60 cable ducts, means should be provided to keep the temperature inside the duct within the specified temperature for the cables.

This, as far as practicable, also applies to piping.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 3:

Definition of high fire risk areas: Reference to be made to SOLAS Chapter II-2 Reg. 3.31 Machinery spaces of category A.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.5.1.2 The remote control panels and cabling on the bridge area are accepted as a non-separable and does not need to be separated by A-60 partitions provided alternative control stands are arranged.

SECTION 8 TENTATIVE RULES FOR GAS READY SHIPS - GAS READY

1 General

1.1 Introduction

The rules in this section apply to ships, which during the newbuilding phase are planned for, and partly prepared for, later conversion to liquefied natural gas (LNG) fuel.

1.2 Scope

The additional class notation **Gas Ready** has supplementary levels and corresponding requirements. The minimum mandatory levels include:

- verification of compliance with **Gas fuelled** rules for a future LNG fuelled ship design
- the main engine(s) installed can be converted to dual fuel operation (or are of dual fuel type from newbuilding stage).

In addition optional levels may be included, i.e. it can be chosen to include different preparations of the ship for a later conversion, and include certification and installation of parts of the LNG fuel systems in the newbuilding.

1.3 Application

The additional class notation **Gas ready** provides the basis for compliance with the rules in force at the time of contract for construction for the newbuilding. The rules in force at the time of a later ship conversion to LNG fuel shall be complied with regardless of the **Gas ready** notation. At time of conversion, documentation should be submitted for approval. The design verification from the newbuilding stage will be used to support the approval. The **Gas ready** class notation does not include survey requirements for follow up of the ship when in operation. At time of conversion a survey and evaluation of the condition of the equipment or systems installed from newbuilding stage will be done. The test scope will depend on time elapsed from newbuilding, and in what way the systems and components have been preserved/ maintained. The rules are applicable for installations where natural gas, stored as LNG, is intended to be used as fuel. If the rules are applied to designs with other gas fuels, special considerations will have to be done.

1.4 Definitions

Definitions for terms used in this section are found in [Sec.5 \[1.5\]](#).

1.5 Class notation - Gas ready

A ship complying with the relevant parts of this section may be given a the additional class notation, **Gas ready**, with qualifiers as outlined in [Table 1](#).

Table 1 Class notation Gas ready with relevant qualifiers

	<i>Qualifiers</i>	<i>Purpose</i>	<i>Application</i>
Gas ready	D	The design for the ship with LNG as fuel is found to be in compliance with the Gas fuelled notation rules applicable for the newbuilding, ref. Pt.1 Ch.1 Sec.2 [1.3] .	Mandatory for Gas ready .

	<i>Qualifiers</i>	<i>Purpose</i>	<i>Application</i>
	S	Structural reinforcements to support the fuel containment system (LNG fuel tank(s)) are installed, and materials to support the relevant temperatures are used.	
	T	Fuel containment system (LNG fuel tank(s)) is installed.	
	P	The ship is prepared for future gas fuel system installations: Pipe routing, structural arrangements for bunkering station, and gas valve unit space.	
	MEc	Main engine(s) installed can be converted to dual fuel.	Mandatory for Gas ready . MEi can be used as an alternative.
	MEi	Main engine(s) installed can be operated on gas fuel.	
	AEc	Auxiliary engines installed can be converted to dual fuel.	The auxiliary engine capacity after conversion shall be sufficient for the ship power balance.
	AEi	Auxiliary engines installed can be operated on gas fuel.	
	B	Boilers installed are capable of burning gas fuel.	
	Misc	Additional systems and equipment are installed on board from newbuilding stage.	Based on agreement between owner and yard, and detailed list provided to Society for acceptance.

Guidance note:

Examples of notation:

Gas ready (D, MEc) means that the future LNG fuelled design is examined and found to be in compliance with rules in force at time of newbuilding, and the ship main engine is of a type that can be converted to dual fuel operation.

Gas ready (D, S, MEc, AEc) means that the future LNG fuelled design is examined and found to be in compliance with rules in force at time of new building, the ship is constructed with the necessary structural reinforcement and low temperature materials around the LNG fuel tank(s), and the main and auxiliary engines are of types that can be converted to dual fuel engines.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.6 Documentation

1.6.1 Documentation requirements for qualifier D

1.6.1.1 Documentation for design verification shall be submitted as required in [Table 2](#).

1.6.1.2 The following is required to separate the design verification documentation in [Table 2](#) from the normal newbuilding documentation:

- The documentation shall be marked “Gas ready” at the beginning of drawing title as indicated in [Table 2](#).
- The documentation will be given status examined (EX) instead of approved.

Table 2 Documentation requirements for Gas ready qualifier D

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Propulsion and steering arrangements, general	Z050 - Design Philosophy	Including information on the machinery configuration, engine room arrangements, fuel arrangements, shut down philosophy, redundancy considerations etc.	EX
Fuel gas system	Z030 - Arrangement plan	General arrangement drawing including LNG tank location with distance from ship side, adjacent spaces, bunkering station location, pipe routing, engine room arrangement and location of any other spaces containing gas equipment. Location of entrances (air locks as relevant) for spaces with gas equipment shall also be shown.	EX
	Z030 - Arrangement plan	Engine room arrangement, only if not included in general arrangement.	EX
Hazardous area classification	G080 - Hazardous area classification drawing		EX
Ventilation systems for gas fuel system spaces	S012 - Ducting diagram (DD)	For gas equipment spaces including ventilation capacity, location of inlets and outlets, segregation from other ventilation systems.	EX
Fuel gas tanks	Z030 - Arrangement plan	Including arrangement of tank connection space and pump rooms/compressor rooms if relevant. The LNG tank design drawings shall preferably contain sufficient detail to allow for structural strength and thermal exposure calculations for surrounding structure.	EX
	Z265 - Calculation report	Impact evaluations for structural strength for the tank location. If details of the LNG tank system are unknown, estimates should be made. See [2.1].	EX
	Z265 - Calculation report	Temperature calculations around LNG fuel tanks. If details of the LNG tank system are unknown, estimates should be made. See [2.1].	EX
Fuel gas piping system	S010 - Piping diagram (PD)	Including details for double piping/ducts and arrangement/location of vent mast/vent outlet(s) for pressure relief valves and purging. If piping details are not available, as a minimum the main components in the system shall be shown.	EX
	Z265 - Calculation report	Boil off gas capacity estimates and system description.	EX

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Inert gas system	S010 - Piping diagram (PD)	Amount of inert gas and type of system needed will among other things depend on type of tank to be used.	EX
Structural fire protection arrangements	G060 - Structural fire protection drawing	Structural/passive fire protection in relation to LNG tank/other spaces with gas equipment.	EX
External surface protection, water spraying system	G200 - Fixed fire extinguishing system documentation		EX
Bunkering station fire extinguishing system	G200 - Fixed fire extinguishing system documentation		EX
Bilge system	S010 - Piping diagram (PD)	(if fitted in spaces containing gas equipment)	EX
Stability calculations	Z265 - Calculation report	Gas Ready stability impact estimates with LNG tank(s) included	EX

1.6.2 Documentation requirements for qualifier S

Calculations for structural strength for the tank location and temperature calculations around LNG fuel tanks shall be submitted for approval for every vessel with **S** included as a qualifier. If the details of the fuel containment system (LNG tanks) and its supports are not clear at new building stage, see minimum scope to be documented in [2.1].

With the qualifier **S** included in the notation, the “**Gas ready** calculations for structural strength for the tank location” and “**Gas ready** temperature calculations around LNG fuel tanks” need not be included in documentation for the **D** qualifier.

1.6.3 Documentation requirements for additional qualifiers

1.6.3.1 When qualifiers in addition to **D** and **S** are included in the class notation, documentation for the relevant parts that shall be installed on board is subject to normal class approval as part of the newbuilding documentation. Details of documentation requirements are found in Sec.5 [1]. When physical installations are included, the normal ship documentation (general arrangement, structural drawings, stability documentation etc.) shall also reflect these installations as relevant. The documentation for the actual ship installations shall not have the “gas ready” wording in the start of the drawing title, and will be given normal approval/ for information status as outlined in relevant parts of the rules (Sec.5 [1], stability rules, structural rules etc.).

1.6.3.2 When systems or equipment are installed on board as part of the **Gas ready** class notation, a plan for how to preserve these systems or equipment shall be submitted for information.

Guidance note:

For piping systems, pressure vessels or tanks, preservation may typically include keeping them dry, by keeping them filled with inert gas or dry air, and also to have a dry or inert gas atmosphere around them if possible. If tanks, tank hold spaces or systems are filled with inert gas, procedures for gas freeing before safe opening up should also be covered by the plan (taking the suffocation risk into account).

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2 Ship installations preparing for later liquefied natural gas fuel conversion

2.1 Gas ready with qualifier S included

To achieve the class notation **Gas ready** with **S** included as a qualifier, the ship structures below the planned LNG fuel tank(s) shall be reinforced and designed in materials that are necessary for the tank included in the design.

If the details of the fuel containment system (LNG tanks) and its supports are not clear at newbuilding stage, the following apply:

- Weight and an installation arrangement of the fuel containment system shall as a minimum be included in the structural design for global strength. This will give the design basis and the limitation to a later retrofit installation.
- Appropriate thermal analysis will require detailed knowledge of the actual tank design. As an alternative the thermal exposure may be predefined by selected (realistic) design temperatures below supports and at structures close to the tank boundaries. The selection of material grades will be verified according to [Pt.5 Ch.7 Sec.6 Table 5](#) and will form the basis for limits to design temperatures at a later retrofit installation.

The limitations in weight and arrangement of LNG tanks and the chosen design temperatures and materials will be included in the "Appendix to the Class Certificate".

2.2 Gas ready with qualifier T included

To achieve the class notation **Gas ready** with **T** included as qualifier, the LNG fuel tank(s) shall be approved, certified and installed in line with the [Sec.5](#) rules, applicable for tanks and surrounding spaces.

2.3 Gas ready with qualifier P included

To achieve the class notation **Gas ready** with **P** included as a qualifier, the following shall be prepared for and installed on board:

- structural ducts for bunkering piping (if going through the ship)
- routing for other gas piping systems (as a minimum space for the future installation of pipe ducting shall be available, the physical installation of the pipe ducting is optional)
- bunkering station structural space
- gas valve unit room (if this is designed as a structural space)
- fuel preparation space can be included if relevant - to be agreed between yard, owner and Society.

A list of what is prepared on board for the individual ship will be included in the "Appendix to the Class Certificate".

2.4 Gas ready with qualifiers MEc or AEc included

To achieve the class notation **Gas ready** with **MEc** and/or **AEc** included as a qualifier, the related machinery shall be of a type that can be converted to gas/ dual fuel operation. The auxiliary engine capacity after conversion shall be sufficient for the ship power balance.

2.5 Gas ready with qualifiers MEi, AEi or B included

To achieve the class notation **Gas ready** with **MEi**, **AEi** and/or **B** included as a qualifier, the related machinery shall be of a type that can be operated on gas/ dual fuel.

2.6 Gas ready with qualifier Misc included

To achieve the class notation **Gas ready** with **Misc** included as qualifier, a list of additional equipment or systems not covered by the other qualifiers shall be agreed between owner and yard, and provided to the Society for acceptance. Only systems and components covered by [Sec.5](#) can be included in this list. The list shall give details of which systems and or components to be included from newbuilding stage and followed up by the Society throughout the newbuilding process as part of the **Gas ready** notation. The design, manufacturing and installation of these systems and components will then be followed up as required in related rules, and the list will be included in the "Appendix to the Class Certificate".

3 Manufacture, workmanship and testing

3.1 General

Installations on board for qualifiers **S**, **T**, **P** and **Misc** in the **Gas ready** notation, shall be handled in accordance with normal newbuilding procedures by the Society surveyor. Certification requirements, material requirements, NDT and testing requirements for the gas fuel related components and systems are outlined in [Sec.5](#). When the installations have impact on other disciplines like hull and stability, the requirements and scope given in the rules for those disciplines apply.

SECTION 9 SCRUBBER READY

1 General

1.1 Introduction

1.1.1 Objective

The rules apply to ships which, during the new building phase, are planned – and partly prepared – for later installation of an exhaust gas cleaning system (EGCS) for the removal of SO_x.

1.1.2 Scope

The notation is divided into a list of qualifiers, to identify the type and category of scrubber system that may be installed. Definition of scrubber category (*D, C, H or O*) and type (*IL or MI*) is the mandatory minimum level and includes:

- verification of main class rule compliance for connections to sea (if applicable)
- verification of space availability and arrangement for future scrubber installation with respect to class and statutory requirements
- verification of preliminary stability analysis.

Optional additional levels may be included, wherein further preparations of the ship for a later conversion can be included, up to full review of the scrubber documentation according to main class rules and certification and installation of piping and sub-systems.

1.1.3 Application

1.1.3.1 The **Scrubber ready** notation provides the basis for compliance with the requirements at the time of contract for construction of the new-building and verifies the vessel's suitability for the future scrubber installation. The scrubber system shall comply with rules in force at time of installation, regardless of **Scrubber ready** notation.

Guidance note:

For qualifier *R*, the scrubber ready documentation will serve as basis for the approval of conversion documentation if the retrofit system is the same as reviewed scrubber ready system.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.1.3.2 The notation requires pre-selection of a SO_x scrubber manufacturer, based on agreement between owner and yard. This system may however be substituted with a similar system at time of conversion, under special considerations. The scrubber manufacture used as basis for the notation should not be a prototype or in other ways be of a novel design, unless the design has been qualified by a competent third party.

Guidance note:

The choice of scrubber category and type will affect the range of options to the pre-selected system at time of conversion.

Scrubber ready with qualifiers *H* and *MI* yields the most flexibility, as these are typically the largest and most complex systems.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.1.3.3 The **Scrubber ready** class notation does not include survey requirements for follow up of the ship when in operation (beyond normal follow up of the additional overboard connections for qualifier *H* and *O*).

Guidance note:

At time of conversion a survey and evaluation of the condition of the equipment or systems installed from new building stage will be done. The test scope will depend on time elapsed from new building, number and type of installed equipment and in what way the systems and components have been preserved/ maintained.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.1.4 Definitions

Table 1 Definitions

<i>Term</i>	<i>Definition</i>
dry scrubber	scrubber system using pellets or similar dry substances through which the exhaust stream is directed to remove SO _x from the exhaust. The dry substance is removed and delivered ashore after depletion.
wet scrubber	scrubber system using water to remove SO _x from the exhaust by spraying the water into specially designed chambers in the exhaust system. Water may be discharged overboard and/or treated after use, depending on system category
EGCS	exhaust gas cleaning system
open loop	wet scrubber systems using seawater for SO _x removal and subsequently treating the wash-water before discharging back overboard
closed loop	wet scrubber system using water for SO _x removal and subsequently treating and reusing the same water. System is replenished as water evaporates
USCG	United States Coast Guard

1.2 Class notation – Scrubber ready

A ship complying with the relevant parts of this chapter can be given a **Scrubber ready** (X1, X2, X3...) notation, with a number of possible qualifier combinations as outlined in [Table 2](#).

Table 2 Notation qualifiers (Xn) and their content

	<i>(Xn)</i>	<i>Content</i>	<i>Comment</i>
<i>Scrubber ready</i>	<i>D</i>	Dry scrubber system	Mandatory mutually exclusive qualifiers.
	<i>C</i>	Wet- closed loop	
	<i>H</i>	Wet- hybrid (open and closed loop)	
	<i>O</i>	Wet- open loop	
	<i>IL</i>	In-line scrubber reactor system; individual linear scrubber unit per consumer	Mandatory mutually exclusive qualifiers.
	<i>MI</i>	Multi-inlet scrubber reactor; multiple inlets to one or more scrubber units	
	<i>HS</i>	Structural verification	Includes review and follow up of structural support for equipment
	<i>R</i>	Full class review of scrubber system documentation (except control and monitoring)	Complete review according to main class rules. Includes piping and electrical systems. Control and monitoring verification is limited according to 5.2.
	<i>Misc</i>	Scrubber systems and equipment are installed on board at new building stage	Certification and installation of parts of the scrubber systems before delivery based on agreement between owner and yard, with detailed list provided to Society for acceptance.

	(Xn)	Content	Comment
	S	Review of documentation for compliance with statutory requirements	If DNVGL is authorized by flag to issue the IAPP certificate. Review according to IMO resolution MEPC.259(68)

Guidance note:

Notation examples:

- **Scrubber ready** (H, IL, R) indicates vessel is evaluated and found suitable for installation of a hybrid inline scrubber system, including full class review of the scrubber system to be installed.
- **Scrubber ready** (O, MI, HS, S) indicates vessel is evaluated and found suitable for installation of an open multi-inlet scrubber system, including review of structural supports and statutory documentation package for the pre-selected system.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.3 Documentation

Documentation for design verification shall be submitted as required in the following tables for selected qualifiers.

The following is required to separate the design verification documentation in the tables below from the normal new-building documentation:

- The documentation shall be marked "Scrubber ready" in the start of the each drawing title.
- The documentation will be given status examined (EX) instead of approved/for information.

All documentation for other main class systems related to **Scrubber ready** notation shall be handled according to normal approval procedure as per main class rules for ships (i.e. shall not be marked according to above).

1.3.1 Documentation requirements for qualifiers D, C, H, O, IL and MI

Table 3 Documentation requirements

Object	Documentation type	Additional description	Info	App.
Scrubber ready general arrangement drawing	Z010 – General arrangement plan	Including treatment fluid bunkering station location, engine room arrangement and location of major scrubber equipment.	EX	All
Scrubber ready tank plan	H030 – Tank and capacity plan	Including free-standing tanks, if applicable, including volume, content, density.	EX	O, H, C
Scrubber ready engine room arrangement and equipment list	Z030 – Arrangement plan Z090 – Equipment list	All future scrubber equipment shall be clearly marked. The list shall include component weight. Shall also include the casing arrangement.	EX	All
Scrubber ready fire control and safety plan	G040 and G050 – fire control and safety plan	If modifications are necessary for future scrubber equipment installation and DNVGL is authorized by flag	EX	All
Scrubber ready P&ID for scrubber system	S010 – Piping diagram	Including scrubbing water supply/circulation systems, treatment fluid systems, discharge systems, wash-water treatment system. Penetrations of watertight divisions to be clearly indicated.	EX	O, H, C

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>	<i>App.</i>
<i>Scrubber ready</i> exhaust P&ID	S010 – Piping diagram		EX	All
<i>Scrubber ready</i> Principle EGCS arrangement and description	Z050 – Design philosophy or Z060 – functional description	General arrangement showing all major pipe/ cable routing and equipment, and a description of scrubber system covering max total water/ treatment fluid consumption and specification, tank capacities, and total working weight of scrubber unit (including water). Also include description of other equipment to be moved, if applicable, and the effects on the electrical installation and other ship systems.	EX	All
<i>Scrubber ready</i> pressure drop analysis	S020 – Pressure drop analysis	According to Pt.4 Ch.6 Sec.8 [3]	EX	All
<i>Scrubber ready</i> watertight integrity	B030 – Internal watertight integrity plan	A separate version of the internal watertight integrity plan where the planned changes affecting watertight integrity are highlighted. Applicable if changes to watertight integrity are required.	FI	All
<i>Scrubber ready</i> lightship particulars		Including list of added/removed weights for future scrubber conversion	EX	All
<i>Scrubber ready</i> impact evaluation for stability and load line		Shall show the impact of the scrubber installation on the vessel stability and load line	EX	All

1.3.1.1 All relevant main class documentation for electrical systems shall reflect the future scrubber system electrical consumers.

Guidance note:

For the referenced qualifiers this includes, but is not limited to; single line diagram, load balance, and short circuit calculation.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.3.2 Documentation requirements for qualifiers *H* and *O*

Table 4 Documentation requirements

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>	<i>App.</i>
<i>Scrubber ready</i> outlet description	Z210 – Design basis	Description of the design criteria and basis for selected outlet arrangement with respect to pH limit requirements as specified in IMO resolution MEPC.259(68) §10.1.2. Shall also cover outlet location relative to other ship system inlets and corrosion protection specifications.	EX	H,O

The inlet (sea chest) and overboard arrangement (dimensions, structural details etc) for the future scrubber installation shall be part of the main class documentation for the vessel. These drawings shall not have the «Scrubber ready» wording at the start of the drawing title as these will be installed at new-building stage.

1.3.3 Documentation requirements for qualifier HS

Table 5 Documentation requirements

Object	Documentation type	Additional description	Info	App.
Scrubber ready foundations for scrubber tanks	H050 – Structural drawing	Applicable for static loads >50kN	EX	All
Scrubber ready foundations for equipment	H050 – Structural drawing	Including pumps, heat exchangers, wash water treatment skids, etc. applicable for static loads >50kN	EX	All
Scrubber ready foundation for EGC unit	H050 – Structural drawing	Applicable for static loads >50kN	EX	All

1.3.4 Documentation requirements for qualifier R

The complete future scrubber system installation shall be documented according to documentation list defined in [Pt.4 Ch.6](#) and other relevant rule sets. All documentation for systems not to be installed at the new-building stage shall be marked with the initial “Scrubber ready” wording. For statutory requirements and documentation, see qualifier S.

Table 6 Documentation requirements

Object	Documentation type	Additional description	Info	App.
Scrubber ready system block diagram	I030 and I110 – System block diagrams	Shall include: Operating station, data logger, safety system, GPS interface, IAS Interface, emergency stop, SO ₂ /CO ₂ monitoring and wash-water monitoring	EX	All

1.3.5 Documentation requirements for qualifier Misc

Any systems or components to be installed on board at new-building stage are subject to normal class approval according to relevant parts of the rules ([Pt.4 Ch.6](#), [Pt.4 Ch.9](#), stability rules, structural rules, etc.) and will be given status AP or FI as defined in the referenced rules. The documentation for the actual ship installations shall not have the “Scrubber ready” wording in the start of the drawing title, and will be given normal approval/ for information status as outlined in relevant parts of the rules.

1.3.5.1 When systems or equipment are installed on board as part of the **Scrubber Ready** class notation, a plan for how to preserve these systems or equipment shall be submitted for information.

Guidance note:

For piping systems or tanks, preservation may typically include keeping them dry, by keeping them heated and/or filled with dry air, and also to have a dry atmosphere around them if possible. Tanks to be re-purposed and overboard connections are covered by normal class follow-up. If scrubber unit is installed, manufacturer specifications for preserving and inspection should be observed.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.3.6 Documentation requirements for qualifier S

If DNVGL is authorized by flag to issue the IAPP certificate, the following documents are to be examined for compliance with IMO resolution MEPC.259(68)

Table 7 Documentation requirements

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>	<i>App.</i>
<i>Scrubber ready</i> SECP	Z160 - Operation manual	SOx Emission compliance plan (SECP)	EX	All
<i>Scrubber ready</i> ETM	Z160 - Operation manual	Exhaust gas cleaning system technical manual (ETM). Scheme A or B as applicable.	EX	All
<i>Scrubber ready</i> OMM	Z160 - Operation manual	Onboard monitoring manual (OMM)	EX	All
<i>Scrubber ready</i> EGC record book	Z290 - Record	EGC Record book or electronic logging system	EX	All
<i>Scrubber ready</i> EGC Marpol verification survey plan	Z140 - Survey procedure	According to the requirements of IMO resolution MEPC.259(68) (for sea trial/Marpol verification survey)	EX	All
<i>Scrubber ready</i> wash-water treatment assessment		For systems which make use of chemicals, additives, preparations or create relevant chemicals in situ	EX	O, H

2 Ship arrangement and installation

2.1 Scrubber ready with qualifier *D*

To achieve **Scrubber ready** notation with qualifier *D* the ship shall be evaluated for installation of a dry scrubber system according to the following specifications.

2.1.1 Space allocation

2.1.1.1 Engine room casing shall be arranged with sufficient extra space for future scrubber unit, bypass (if applicable), and installation work.

2.1.1.2 Space for scrubber granulate handling systems (including storage space before and after use) shall be allocated.

2.1.2 Exhaust gas systems

See [2.2.2].

2.1.3 Supporting systems

See [2.2.4].

2.1.4 Electrical systems

See [2.2.5].

2.1.5 Fire safety and life saving

See [2.2.6].

2.1.6 Stability

See [2.2.7].

2.2 Scrubber ready with qualifier C

To achieve **Scrubber ready** notation with qualifier C the ship shall be evaluated for installation of a wet closed scrubber system according to the following specifications.

2.2.1 Space allocation

2.2.1.1 Engine room casing shall be arranged with sufficient extra space for future scrubber unit, bypass (if applicable), and installation work.

2.2.1.2 Space for future scrubber system equipment and tanks shall be arranged.

2.2.1.3 Pipe and cabling routes shall be planned, taking into account good planning practices considering pipe size, materials, installation, etc.

2.2.1.4 The location of the treatment fluid bunkering station shall be defined and space made available. The location shall be suitable for the intended service.

Guidance note:

Spray from leakages shall not endanger personnel or passengers. Visibility from passenger embarkation area should be considered.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.2.1.5 Tanks planned for repurposing to use in scrubber system (e.g. holding tanks) shall be suitable for the use and shall be isolable from the existing system.

Guidance note:

Certain tanks may not be available for repurposing due to the impact on vessel performance and safety, e.g. tanks connected by cross flooding devices, sewage holding tanks, etc.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.2.2 Exhaust gas systems

2.2.2.1 The casing arrangement shall take into account the required minimum distances for the instrumentation locations after unit, particularly regarding the requirements for monitoring at exhaust outlet.

Guidance note:

Minimum exhaust pipe length before and after scrubber unit are applicable, dependent on pipe diameter, according to IMO resolution MEPC.259(68).

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.2.2.2 For ships designed to comply with redundant propulsion or dynamic positioning, the proposed interconnection for MI scrubber systems shall not interfere with the principles of the relevant notations.

2.2.2.3 The pressure drop analysis for the future scrubber installation shall document that the new pressure drop does not exceed maximum allowable back pressure according to engine and component specifications.

2.2.3 Overboard connections

2.2.3.1 If the system is designed for discharge overboard, the arrangement is subject to special consideration, but shall in general comply with the requirements under qualifier H and O.

2.2.3.2 Cooling water supply and discharge overboard connections shall be according to main class rules for overboard connections.

2.2.4 Supporting systems

2.2.4.1 Connections to supporting systems (technical water systems, compressed air, cooling water, tank vents etc.) are to comply with the requirements under Pt.4 Ch.6 Sec.8. The supporting systems shall be readied as far as practicable for scrubber installation.

2.2.4.2 Interfaces to main alarm system and GPS systems shall be available for the future EGCS control and monitoring system installation.

2.2.5 Electrical systems

2.2.5.1 The generator capacity shall be dimensioned to sustain the added load from the future scrubber system.

Guidance note:

Electric loads to consider: pumping sea water, sludge removal, alkaline dosing, sea water cooling, induced draft fans, and process control.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.2.5.2 Space for the future scrubber system switchboards shall be available in switchboard room.

2.2.5.3 Bus bar in main switchboard room or distribution board where future scrubber consumers will be installed shall have sufficient current carrying capacity for the added consumers.

2.2.5.4 The short circuit calculation shall include all future scrubber consumers.

2.2.6 Fire safety and life saving

2.2.6.1 If authorized by flag, DNVGL will follow up statutory requirements for fire safety and life-saving. If not authorized, the flag state shall be contacted to verify compliance with SOLAS Ch.II-2.

2.2.6.2 The future scrubber installation shall not interfere with the escape route arrangement.

2.2.6.3 The scrubber ready system installation shall not require major changes to fire safety related systems at the time of conversion (e.g. redefining space, modification of fire divisions, fire detection and extinguishing system coverage).

2.2.6.4 The calculation for fixed fire extinguishing installation media (e.g. CO₂) shall be based on the increased engine room volume.

2.2.6.5 Location and number of additional fire-fighting equipment like hydrants, portable/mobile fire extinguishers shall be considered and shown in the arrangement plan.

2.2.7 Stability

2.2.7.1 The impact from the added weights of the future scrubber system on the vessel stability shall be within acceptable limits. The amount of liquids in the system at normal operating levels shall be included in the total weight.

2.2.7.2 If the total change in lightship particulars will require a new inclining test after installation of future scrubber system, this shall be noted in appendix to class certificate. If other vessel modifications have occurred before the time of conversion, a new evaluation will be required.

Guidance note:

According to the requirements of SOLAS 74 as amended, a ship must be re-inclined if the anticipated deviations in comparison with the approved lightship particulars exceed one of the following threshold values: 2% change in lightship displacement or 1% of LS' change in longitudinal center of gravity. If a periodical lightweight survey as required by SOLAS-74 has been conducted,

or if calculated values of lightship particulars have been accepted in accordance with MSC/Circ.1158, between the latest inclining experiment and the modifications, the outcome of such must be included in the evaluation as well.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Penetrations of watertight divisions (bulkheads or decks) for future scrubber installations shall be arranged such as not to change the internal watertight integrity of the vessel after the future scrubber installation is completed, unless changes to the internal watertight integrity are found acceptable by damage stability calculations.

2.2.7.3 At time of conversion for future scrubber system installation, the scope of stability approval will be dependent on whether the future scrubber installation is considered a minor or an extensive modification.

Guidance note:

The following shall be submitted for a minor modification: Calculation showing the estimated change in lightship particulars, endorsed by attending surveyor. DNV GL may require update of the damage control plan and damage control booklet, to be concluded after review of the system arrangement. The loading computer shall be updated with the additional weight and corresponding center of gravity, both of which may be added as a constant. No re-approval of the loading computer software will be required.

The following shall be submitted for a major modification: Inclining test procedure (if water ballast is used to incline the ship), inclining test report, preliminary/final stability manual, preliminary/final damage stability manual (may not be required, based on case-by-case evaluation of vessel type, applicable regulations, watertight integrity and existing damage stability calculations), damage control plan, damage control booklet, internal watertight integrity plan, and loading computer software shall be updated based on the intact and damage stability documentation and submitted for approval.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.3 Scrubber ready with qualifiers *H* or *O*

In addition to the requirements for qualifier C, the following requirements apply to achieve **Scrubber ready** notation with qualifiers *H* or *O*, wherein the vessel is evaluated for future installation of a wet hybrid- or open scrubber system:

2.3.1 Water systems

Connections to the shell and sea chests shall be completed before delivery according to the following requirements.

2.3.1.1 Inlets

- The inlets shall be sized according to required flow for the future scrubber installation.
- Inlets shall be arranged with redundancy according to [Pt.4 Ch.6 Sec.5 \[2\]](#).
- The added inlet area for the future scrubber system shall be included in sea chest grid area calculation if connected to existing sea chests.
- For ships for navigation in ice, minimum one future scrubber system inlet shall be connected to the Ice sea chest.
- The inlet valves shall be installed, locked closed, and blind flange shall be fitted inboard of the valve with signboard stating that the valve shall not be operated. The valve shall be remote operable, but not be connected to the control system.
- Dedicated sea chests for future scrubber installation shall, if applicable, be designed according to relevant main class requirements for sea chests.

2.3.1.2 Outlets

- Minimum distance piece pipe thickness shall be 15mm or shell thickness, whichever is greater.
- Special attention shall be paid to the coating in the scrubber outlet distance piece and surrounding shell area with respect to the acidic discharge from future scrubber system. Standard coating is generally considered insufficient.

- c) Discharge outlets shall be arranged such that future scrubber discharge water is not drawn into sea suction for other ship systems. The discharges shall be placed at minimum 4m aft of any sea suction for other systems. Placing the outlet forward of such a sea suction may be accepted if it is demonstrated that the discharged water is diluted sufficiently to raise the pH to 7 or above the specified minimum pH for the affected system.
- d) The overboard arrangement shall be based on a detailed analysis or proven designs, with respect to compliance with statutory requirements (MARPOL Annex VI, Reg.4 & MEPC.259(68)) to pH-level at certain distances from the outlet(s). The analysis shall in such case be submitted for review.
- e) The discharge valve(s) shall be installed, locked closed, and blind flange shall be fitted inboard of the valve with signboard stating that the valve shall not be operated. The valve shall be remote operable, but not be connected to the control system.

2.4 Scrubber ready with qualifier *HS*

2.4.1 To achieve **Scrubber ready** notation with qualifier *HS*, structural supports (e.g. for unit, tanks, pumps, cutouts, etc.) and general ship structures shall be prepared at the new-building stage according to the following specifications:

2.4.1.1 Ship structures shall as far as practicable be prepared for the required penetrations and cut-outs for the future scrubber installation. At minimum the necessary reservations shall be indicated where required for piping and equipment.

2.4.1.2 Structural supports for the future scrubber equipment shall be readied at new-building stage. For heavy equipment where the static forces exceed 50kN, the structural supports are subject for approval.

2.5 Scrubber ready with qualifier *R*

To achieve **Scrubber ready** notation with qualifier *R*, a review of the future scrubber installation system for compliance according to relevant class rules, taking into account limitations to control and monitoring scope, is required (Pt.4 Ch.6 Sec.8, electrical rules, etc.)

2.5.1 Electrical systems

2.5.1.1 All relevant main class documentation for electrical systems shall reflect the future scrubber system electrical consumers.

Guidance note:

This includes, but is not limited to, selectivity analysis showing selectivity between incoming feeder and largest outgoing consumer, making/breaking capacity of all circuit breakers vs short circuit at location, emergency stop schematic, list of ex equipment, etc.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.5.2 Control and monitoring

2.5.2.1 The scope for instrumentation review is limited to an assessment of the system block diagram, verifying the future system's ability to comply with the class and statutory requirements, and a review of the monitoring scope as specified in the system P&ID.

2.5.2.2 A full review of all required detail documentation and subsequent certification of equipment shall be carried out at the time of conversion, prior to installation on board.

2.5.2.3 If detail approval and certification of parts of the future scrubber system is to be carried out at the new-building stage, the equipment shall also be installed on board at this time. In such case the additional qualifier *Misc* is required.

2.6 Scrubber ready with qualifier S

2.6.1 To achieve **Scrubber ready** notation with qualifier *S* the future scrubber installation shall comply with Marpol annex 6 regulation 4 and 14, and the therein referenced guidelines given in IMO resolution MEPC.259(68).

2.6.1.1 The statutory documentation may be based on DNV GL pre-qualified standard document templates. In such case the documentation shall be updated with the required vessel specific data.

2.6.1.2 For EU/EFTA flagged vessels the future scrubber installation shall comply with EU directive 2012/33/EU.

2.6.1.3 If specified by owner, the future scrubber system shall comply with the requirements for USCG vessel general permits (VGP)

2.7 Scrubber ready with qualifier Misc

To achieve the class notation **Scrubber ready** with *Misc* included as qualifier, a list of systems to be installed or equipment to be certified and installed shall be agreed between owner and yard, and provided to the Society for acceptance. Only scrubber related systems or equipment may be included in this list. Instrumentation equipment shall be certified according to [Pt.4 Ch.9 Sec.2](#).

The list shall give details of which systems and or components to be included from new building stage and followed up by the Society throughout the new building process as part of the **Scrubber ready** notation. The design, manufacturing and installation of these systems and components will be followed up as required in related rules, and the list will be included in the appendix to class certificate.

3 Manufacture, workmanship and testing

3.1 General

Installations on board for **Scrubber ready** notation with qualifiers *H*, *O*, *HS* and *Misc*, shall be handled in accordance with normal new building procedures by the Society surveyor. Certification requirements, material requirements, NDT and testing requirements for the scrubber related components and systems are outlined in [Pt.4 Ch.6](#) and [Pt.4 Ch.9](#). When the installations have impact on other disciplines like hull and stability, the requirements and scope given in the class rules for those disciplines apply.

CHANGES – HISTORIC

January 2016 edition

This document supersedes October 2015 edition.

Main changes January 2016, entering into force 1 July 2016

- Sec.2 Periodically unattended machinery space - E0 and ECO
 - Table 6 and Table 10: Requirement for monitoring of temperature for uptakes of boilers has been added.
- Sec.8 Tentative rules for gas ready ships - Gas ready
 - Table 2: Boil off gas capacity estimates and system description for the fuel gas piping system has been included in the documentation requirements.
 - [1.6.3.2]: Requirement for a plan for how to preserve systems and equipment installed on board as part of the notation has been included.

October 2015 edition

This is a new document.

The rules enter into force 1 January 2016.

DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16 000 professionals are dedicated to helping our customers make the world safer, smarter and greener.

SAFER, SMARTER, GREENER