DNV·GL

RULES FOR CLASSIFICATION

Ships

Edition July 2020

Part 6 Additional class notations

Chapter 2 Propulsion, power generation and auxiliary systems

DNV GL AS

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.

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

CHANGES – CURRENT

This document supersedes the July 2019 edition of DNVGL-RU-SHIP Pt.6 Ch.2.
Numbering and/or title of items containing changes are highlighted in red colour.

Changes July 2020, entering into force 1 January 2021

Topic	*Reference*	*Description*
Arrangement of electric energy storage (EES) spaces	Sec.1 [2.2]	Limiting equipment that can be installed in EES spaces.
Ventilation of EES spaces	Sec.1 [2.3.1]	Increased requirement for EES space ventilation rates for battery system with integrated off-gas duct. Clarified ventilation requirements including closing appliances in the ventilation ducts.
Gas detection and monitoring of EES spaces	Sec.1 [2.3.2]	Introduced requirement for always gas detection and monitoring in EES spaces.
Fire integrity of EES spaces	Sec.1 [2.4.1]	Strengthened requirements for fire integrity of EES spaces with EES systems larger than 100 kWh.
Fire detection in EES spaces	Sec.1 [2.4.2]	Introduced requirement for combined smoke and temperature fire detectors.
Fire extinguishing in EES spaces	Sec.1 [2.4.3]	Limiting variants of fire extinguish system that can be used. Introduced requirements for two releases when using a gas based extinguish system.
Safety philosophy for the EES space	Sec.1 [2.5]	Reducing the documentation requirements for the EES space by changing the requirement from a safety assessment to a safety philosophy for the EES space.
System design for EES installations	Sec.1 [2.6]	Added clarification including requirement for insulation monitoring.
Instruction for emergency operation	Sec.1 [2.8.1]	Addressed that ventilation handling shall be included in the instruction for emergency operation of the EES space.
EES capacity	Sec.1 [3.2.2]	Changed the requirements for calculation of EES capacity such that the capacity is not any longer related to a specific operation or route.
Energy management system	Sec.1 [3.2.3]	Introduced requirement for monitoring remaining time that the vessel can operate on EES systems.
Battery system design	Sec.1 [4.1.2]	Clarified requirements for creepage and clearance distances, earth faults, electrical insulations and cooling liquid leakage.
Ingress protection of battery systems	Sec.1 [4.1.7]	Clarified requirements for ingress protection of battery systems.
List of alarm and monitoring parameters	Sec.1 [6.1]	Updated list of alarm and monitoring parameters.
Speed tests during sea trials	Sec.11 [1.10.1] Sec.11 [1.10.2]	Amended requirement for sea trials: the verification of achievable speed during test of dimensioning damage scenario is no longer required.

Editorial corrections

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

CONTENTS

SECTION 1 ELECTRICAL ENERGY STORAGE

1 General

1.1 Introduction

The additional class notation **Battery** facilitates the use of electrical energy storage (EES) installations on electric and hybrid vessels.

1.2 Objective

The additional class notation **Battery** sets requirement for safety and availability of EES installations onboard vessels.

1.3 Scope

The rules in this section cover design, installation and certification requirements for lithium-ion battery systems and electrochemical capacitor systems.

Guidance note:

Other EES systems will be considered on a case-by-case basis. The main principles in this section will be applied.

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1.3.1 Since commercial EES technologies are 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.

1.3.2 SOLAS or the 2000 HSC Code do not include regulations regarding fire safety measures suitable for these types of EES installations. The requirements in this section shall be complied with in addition to the general fire safety measures in SOLAS Reg.II-2/2000 HSC Code Ch.7.

1.4 Application

1.4.1 Class notation

Vessels complying with the requirements given in this section will be assigned the additional class notation **Battery(Power)** or **Battery(Safety)**, as specified in Table 1.

Table 1 Class notation

Class notation	*Qualifier*	*Purpose*	*Application*
Battery Mandatory: Yes Design requirements: [2] and [3] Survey requirements for fleet in service: Pt.7 Ch.1 Sec.2 and Pt.7 Ch.1 Sec.4	**Power**	For vessels where the EES power is used for electrical propulsion of the vessel.	— All-electric vessel, i.e. all main sources of power are based on EES. — Hybrid vessel where one of the main sources of power is based on EES. — Hybrid vessel having an operational mode where the vessel is operating on EES power only, with the other main source of power in standby. — Hybrid vessel using the EES system as a redundant source of power for main and/ or additional class notations, e.g. dynamic positioning.
	Safety	For vessels where the aggregated EES installation in one EES space has an rated capacity of 20 kWh or above and not having the **Battery(Power)** notation.	— Hybrid vessels not using the EES power as a main source of power. — Hybrid vessels using the EES power for only peak shaving and/or load levelling. — Vessels using EES power solely when moored.

1.5 References

1.5.1 Relation to other parts of the rules

The requirements in these rules are additional to the rules for main class and for other class notation. In particular:

— electrical installation is described in Pt.4 Ch.8
— control and monitoring systems are 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
— electrical shore power connection is described in Ch.7 Sec.5.

1.5.2 Standards

The test requirements for EES systems is partly based on the following standards:

— IEC 60092-101 Electrical installations in ships - Definitions and general requirements.
— IEC 62619 Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications.
— IEC 62620 Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for use in industrial applications.
— UL 810A Standard for safety - Electrochemical Capacitors.

— UN Manual of test and criteria - Sub-Section 38.3 - Lithium metal and lithium ion batteries.

1.5.3 Informative references

— Technical Reference for Li-ion Battery Explosion Risk and Fire Suppression, DNV GL Document No. 1144K9G7-12, Report No. 2019-1025.

1.6 Definitions and abbreviations

Definitions and abbreviations are given in Table 2 and Table 3.

Table 2 Definitions

Term	*Definition*
battery cell	smallest building block in a battery, a chemical unit
battery cell block	group of cells connected together in parallel configuration
battery module	assembly of cells including electronic control
battery pack	one or more modules including complete BMS and can be used as a standalone unit
battery string	battery string comprises a number of cells or modules connected in series with the same voltage level as the battery system
battery system	whole battery installation including battery modules, electrical interconnections, BMS and other safety features
C-Rate	current (A) used to charge/discharge the EES system divided by the rated ampèr-hours (Ah)
capacitor cell	single capacitor
capacitor cell block	group of capacitors connected together in parallel configuration
capacitor module	assembly of capacitors including electronic control
capacitor pack	one or more modules including complete CMS and can be used as a standalone unit
capacitor string	capacitor string comprises a number of cells or modules connected in series with the same voltage level as the capacitor system
capacitor system	whole capacitor installation including capacitor modules, electrical interconnections, CMS and other safety features
CP-Rate	power (W) used to charge/discharge the EES system divided by the rated Watt-hours (Wh)
EES converter	equipment controlling the charging and discharging of the EES system.
EES space	electrical energy storage space for lithium-ion batteries and/or electrochemical capacitors
EES system	whole EES installation including modules, electrical interconnections, control management system and other safety features
electrochemical capacitor	electric double layer capacitor that stores electrical energy in an electrochemical cell, covering also supercapacitors, ultracapacitors, asymmetric capacitors and Li-ion capacitors.
off-gas	gasses released from EES cell(s) during an abnormal incident (vaporised electrolyte, thermal runaway exhaust gas)
sealed battery	battery that remains closed and does not release either gas or liquid when operated within the limits specified by the manufacturer

Term	*Definition*
thermal runaway	accelerating self sustained temperature increase

Table 3 Abbreviations

Term	*Definition*
ACH	air changes per hour
AE	available energy
AP	available power
BMS	battery management system, a collective terminology comprising control, monitoring and protective functions of the battery system
CID	current interrupting device
CMS	capacitor management system, a collective terminology comprising control, monitoring and protective functions of the capacitor system
EES	electrical energy storage
EMS	energy management system/function, a system/function providing monitoring and control of the energy capacities of the EES system
HVIL	high voltage interlock loop
LEL	lower explosion limit
SOC	state of charge - the available capacity expressed as percentage of the rated capacity (0-100%)
SOH	state of health - reflects the general condition of an EES system and its ability to deliver the specified performance compared with a new EES system (0-100%)
WCF	worst case failure - failure mode which, after a failure, results in the largest reduction of availability of power/energy

1.7 Procedural requirements

1.7.1 Certification requirements

Products shall be certified as required by Table 4.

Table 4 Certification required for the notations, Battery(Power) and Battery(Safety).

Object	*Certificate type*	*Issued by*	*Certification standard*	*Additional description*
Lithium-ion battery system[1)]	TA	Society	— [4] — Pt.4 Ch.8 — Pt.4 Ch.9	Battery systems with capacity ≥ 20 kWh and < 50 kWh.
	PC[3)]	Society	— [4] — Pt.4 Ch.8 — Pt.4 Ch.9	Battery systems with capacity ≥ 50 kWh.

Object	Certificate type	Issued by	Certification standard	Additional description
Electrochemical capacitor system 2)	TA	Society	— [5.4] — Pt.4 Ch.8 — Pt.4 Ch.9	Electrochemical capacitor systems with capacity ≥ 0.2 kWh (720 kJ) and < 50 kWh (180 MJ).
	PC 3)	Society	— [5.4] — Pt.4 Ch.8 — Pt.4 Ch.9	Electrochemical capacitor systems with capacity ≥ 50 kWh (180 MJ).
EES converter	PC	Society	— [2.6.2] — Pt.4 Ch.8 — Pt.4 Ch.9	The EES converter, including the EES converter control system, shall be certified as outlined in Pt.4 Ch.8 Sec.1 Table 3.
Energy management system	PC	Society	— [3.2.3] — Pt.4 Ch.8 — Pt.4 Ch.9	Only applicable for the **Battery(Power)** notation. If the energy management functionality is implemented in another system, e.g. as part of the power management system (PMS) or the integrated automation system (IAS) then the systems should be certified together.

1) The battery management system (BMS) shall be certified as a part of the battery system.
2) The capacitor management system (CMS) shall be certified as a part of the electrochemical capacitor system.
3) The issuance of the product certificate (PC) may be based on a valid type approval certificate (TA), with a limited case by case design approval as stated in the type approval certificate (TA), and a manufacturer survey agreement (MSA).

Guidance note:

General description of services for certification of materials and components is given in class program DNVGL-CP-0337. Type approval program for EES systems is given in class program DNVGL-CP-0418.

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1.7.2 Documentation requirements

1.7.2.1 General

General requirements for documentation can be found in DNVGL-CG-0550 Sec.6. See DNVGL-CG-0550 Sec.5 for definition of the documentation types.

1.7.2.2 System design

Documentation related to system design shall be submitted as required by Table 5 for the **Battery(Safety)** notation and with additional documentation required by Table 6 for the **Battery(Power)** notation.

Table 5 System design, documentation requirements for Battery(Safety)

Object	Documentation type	Additional description	Info
EES spaces	Z030 – Arrangement plan	Arrangement showing EES system and other equipment inside the EES space(s) including ventilation and possible gas detection.	FI
	Z010 - Vessel arrangement	Position of EES space(s) relative to other spaces/ items.	FI
	G170 – Safety philosophy	Safety philosophy for the EES space(s), see [2.5].	FI

Object	Documentation type	Additional description	Info
	G060 – Structural fire protection drawing		AP
	G040 – Fire control plan	Plan for firefighting appliances and escape.	AP
	G200 – Fixed fire extinguishing system documentation	Fixed total flooding fire-extinguishing for the EES space(s).	AP
	Z030 – Arrangement plan	Arrangement of the fire detection in the EES space(s).	AP
	I030 - System block diagram (topology)	Fire detection system.	AP
	S012 – Ducting diagram for the ventilation system	Detailed arrangements of the ventilation ducts and openings serving the EES space(s).	AP
	Z253 – Test procedures for quay and sea trial	Test plan for the EES installation on board.	AP
	I030 - System block diagram (topology)	If applicable, gas detection system, see [2.3.2].	AP
	E090 - Table of ex installation	If applicable, see [2.3.2].	AP
	Z160 - Operation manual	See [2.8.1] and for vessels with **Battery(power)** notation [3.4.1].	FI, L
	Z163 - Maintenance manual	See [2.8.2] and for vessels with **Battery(power)** notation [3.4.2].	FI, L
Main EES power system	I030 – System block diagram (topology)	Including interfaces with: - EES converters - power and energy management systems - alarm system - other systems.	FI
Electric power system	E170 – Electrical schematic drawing	Emergency disconnection of the EES system, including location of emergency disconnection button.	AP
AP = For Approval; FI = For Information; L = Local Handling			

Table 6 System design, additional documentation requirements for class notation Battery(Power)

Object	Documentation type	Additional description	Info
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 EES systems, EES converter capacity and discharge/recharge capacity. The load balance shall reflect the operational mode stated in the system philosophy. Available propulsion power after worst case failure shall be calculated, see [3.2.2.1].	AP

Object	Documentation type	Additional description	Info
AP = For Approval; FI = For Information			

1.7.2.3 Onboard documentation

The builder shall provide the documentation required by Table 5 for use onboard the vessel.

Table 7 Onboard documentation

Object	Documentation type	Additional description
EES spaces	Z160 - Operation manual	See [2.8.1] and for vessels with **Battery(Power)** notation [3.4.1].
	Z163 - Maintenance manual	See [2.8.2] and for vessels with **Battery(Power)** notation [3.4.2].

1.7.2.4 Component certification

Components required to be delivered with the Society's product certificate shall be documented as described in Table 8.

Table 8 Component certification, documentation requirements

Object	Documentation type	Additional description	Info
Lithium-ion battery system	Z072 – Safety description	See [4.1.2.1].	AP
	E120 – Specification	Including ratings and environmental data. Short circuit current capacity shall be stated for both maximum (fully charged new battery) and minimum (discharged battery at estimated end of lifetime) capacity.	AP
	E170 – Electrical schematic drawing	Schematic drawing of the battery system showing the battery packs, strings and modules, including switchgear and control gear.	AP
	Z252 – Test procedure at manufacturer	See [4.2].	AP
	Z261 - Test report	Type test report from testing of battery cells, if the battery system is not type approved, see Table 9.	FI
	Z262 - Report from test at manufacturer	Type test report from testing of the battery system, if the battery system is not type approved Table 10.	FI
	I020 – Control system functional description	Battery management system (BMS).	AP
	I030 – System block diagram (topology)	Battery management system (BMS).	AP
	I050 – Power supply arrangement	Battery management system (BMS).	AP
	I080 – Datasheet with environmental specifications	Battery management system (BMS).	AP

Object	Documentation type	Additional description	Info
	I110 – List of controlled and monitored points	Battery management system (BMS).	AP
	I150 – Circuit diagram	Battery management system (BMS).	AP
	I320 - Software change handling procedure	Battery management system (BMS).	AP
	Z265 – Calculation report	Documentation of the SOH and SOC calculation.	FI
Electrochemical capacitor system	Z072 – Safety description	See [4.1.2.1].	AP
	E120 – Specification	Including ratings and environmental data. Short circuit current capacity shall be stated for both maximum (fully charged new capacitors) and minimum (discharged capacitors at estimated end of lifetime) capacity.	AP
	E170 – Electrical schematic drawing	Schematic drawing of the capacitor system showing the capacitor packs, strings and modules, including switchgear and control gear.	AP
	Z252 – Test procedure at manufacturer	See [5.4].	AP
	Z261 - Test report	Type test report from testing of capacitor cells, if the capacitor system is not type approved Table 11.	FI
	Z262 - Report from test at manufacturer	Type test report from testing of the capacitor system, if the capacitor system is not type approved Table 12.	FI
	I020 – Control system functional description	Capacitor management system (CMS).	AP
	I030 – System block diagram (topology)	Capacitor management system (CMS).	AP
	I050 – Power supply arrangement	Capacitor management system (CMS).	AP
	I080 – Datasheet with environmental specifications	Capacitor management system (CMS).	AP
	I110 – List of controlled and monitored points	Capacitor management system (CMS).	AP
	I150 – Circuit diagram	Capacitor management system (CMS).	AP
	I320 - Software change handling procedure	Capacitor management system (CMS).	AP
	Z160 – Operation manual		FI, L
	Z163 – Maintenance manual		FI, L
Energy management system	I200 – Control and monitoring system documentation	See [3.2.3] and Pt.4 Ch.9 Sec.1.	AP
EES converter	See Pt.4 Ch.8 Sec.1 Table 2.		

Object	Documentation type	Additional description	Info
AP = For Approval; FI = For Information; L = Local handling			

1.7.3 Survey and testing requirements

1.7.3.1 Requirements for newbuilding survey are found in [2.7] and [3.3].

1.7.3.2 Requirements for survey of the lithium-ion batteries and electrochemical capacitors at manufacturers are found in respectively [4] and [5].

2 Class notation Battery(Safety)

2.1 Design principle

2.1.1 The design shall ensure that any single failure in the EES 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.

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2.2 Arrangement

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

2.2.2 Only equipment associated with the EES system shall be placed within the EES space.

2.2.3 All equipment located at ceiling level in the EES space shall be suitable for zone 2 installation. The temperature class and gas group for the ex rated zone 2 equipment shall as minimum be T2 and IIC.

2.2.4 Pipes shall not be installed in the EES space so that EES system may be endangered in the event of leaks. If installation of pipes close to the EES system is unavoidable, the pipes should not have any flanged or screwed connections in this area.

2.2.5 Fire hydrants shall not be located inside the EES space.

2.3 Ventilation

2.3.1 General

2.3.1.1 A mechanical ventilation system is required for the EES space.

2.3.1.2 The EES space ventilation system shall be activated upon off-gas incidents from the EES system.

Guidance note:

It is recommended that the ventilation system is continuously running, see also Pt.4 Ch.1 Sec.3 [1.1.5].

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2.3.1.3 The ventilation system for EES spaces shall be an independent ducting system of any other ventilation systems serving other spaces unless the EES system is designed according to design option 1 as given by [4.1.2.7] or designed to ventilate possible off-gas into an integrated off-gas ventilation duct, in which case supply may be taken from ventilation systems serving other spaces and with exhaust directly to open air.

2.3.1.4 The ventilation ducting system shall be reasonable gas tight and able to withstand the off-gas temperature. For vessels built according to SOLAS Ch. II-2, the pipes to and from the EES space shall be made of steel.

Guidance note:

For vessels built according to other standards than SOLAS Ch. II-2 the pipes to and from the EES space should be made of steel.

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2.3.1.5 EES space ventilators shall be fitted with means of closing whenever:

— the EES space does not open directly onto an exposed deck
— the ventilation opening for the EES space is required to be fitted with a closing device according to the Load Line Convention, or
— the EES space is fitted with a fixed gas fire-extinguishing system.

When a EES space ventilator is fitted with a closing device, then a warning notice shall be provided at the closing device to mitigate the possibility of inadvertent closing.

Guidance note:

— This requirement is based on IMO MSC.1/Circ.1434.
— The warning notice could state, for example 'This closing device is to be kept open and only closed in the event of fire or other emergency - Explosive gas'.

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2.3.1.6 All ventilation inlet and exhaust evacuated directly to open air shall be to suitable areas to make sure possible toxic gases will not endanger crew or passengers.

Areas on open deck within 1.5 m of inlet or exhaust openings of EES spaces and cabinets are classified as extended hazardous area zone 2.

2.3.1.7 Inside the EES space, the ventilation exhaust suction shall be located 0.4 metre, or closer, to the ceiling. The inlet shall be located as close to the flooring as practical, such that the air is well circulated inside the EES space.

2.3.1.8 EES spaces with EES system that ventilate possible off-gas directly into the EES space

For EES systems designed to ventilate possible off-gas directly into the EES space during a failure incident, then:

— An exhaust fan of ex proof non-sparking type shall be provided in the EES space, delivering under-pressure in the EES space. Fan motors installed within the duct shall be suitable for zone 2 installation.
— The exhaust fan shall be continuously running or start automatically upon detection of off-gas from the EES system.
— The exhaust fan shall have a capacity:
    1) not less than six air changes per hour (ACH), when the EES system are designed according to design option 1 as given by [4.1.2.7].
    2) as determined by analysis but not less than six ACH, when the EES system is designed according to design option 2 given by [4.1.2.7].

Guidance note:

The amount of off-gas used for consideration or analysis should be related to the number of cells releasing off-gas during a thermal runaway in a EES cell. For Li-ion battery systems designed according to design option 2 given by [4.1.2.7] then the following formula may be used for calculation of the ventilation capacity, $ACH_{EESspace}$, provided that:

— free volume in the room is between 10 m^3 and 30 m^3
— module size is between 1 kWh and 11 kWh
— extraction duct is located not more than 0.4 metre from the ceiling

$$ACH_{EESspace} \geq \frac{1692}{v} e^{-\left(\frac{9.74v + 246}{n \cdot C}\right)}$$

where

$ACH_{EESspace}$	=	air changes per hour for the EES off gas fan [m^3/h]
v	=	free volume in the room [m^3]
C	=	capacity of one battery cell [Ah].

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2.3.1.9 EES spaces with EES system with an integrated off-gas ventilation duct

For EES systems designed to ventilate possible off-gas into an integrated off-gas ventilation duct, then:

— an inlet fan shall be provided in the EES space, delivering over-pressure in the EES space
— The inlet fan in the EES space shall either be running continuously or start automatically upon detection of off-gas from the EES system.
— The inlet fan in the EES space shall have a minimum capacity of six air changes per hour (ACH).
— EES systems designed according to design option 1 as given by [4.1.2.7] are not required to incorporate an off-gas exhaust fan in the duct.
— EES systems designed according to design option 2 as given by [4.1.2.7] shall incorporate an off-gas exhaust fan of ex proof non-sparking type in the duct. Fan motors installed within the duct shall be suitable for zone 2 installation.
— The integrated off-gas duct fan shall be running continuously or start automatically upon detection of off-gas from the EES system.
— The integrated off-gas ventilation duct inlets shall be provided with non-return valves/flaps where provided.
— The integrated off-gas ventilation shall not be fitted with fire dampers.

2.3.1.10 Local start/stop of off-gas ventilation shall be possible upon any failure in the remote or automatic control system without entering the EES space(s).

2.3.1.11 The EES space ventilation fan(s) shall have power supply from two alternative circuits. One from main source of power and one from the emergency source of power. A change over switch shall be arranged for the two supply circuits.

2.3.1.12 The following shall be monitored at a manned control station:

— ambient temperature in EES space
— indication of ventilation running in the EES space, and EES cabinets as applicable.

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

— high ambient temperature of EES space
— failure of EES ventilation and failure of either power supply for EES ventilator fan.

2.3.1.14 EES space temperature alarm and indication shall be independent of the EES system.

2.3.2 Off-gas detection and monitoring

2.3.2.1 Gas monitoring shall be arranged in the EES space. Gas monitoring sensor(s) shall be positioned to provide as early as possible detection.

Guidance note:

— The EES off-gas may be both lighter and heavier than air depending on the temperature of the off-gas, hence two detectors should be used.
— A smoke detector may also act as a gas detector.
— CO gas detector may be used as an alternative to a purpose-made gas detector.

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2.3.2.2 Gas detection shall at a level of no more than 30% LEL:

— ensure automatic disconnection of the EES system
— give alarm at bridge
— be used to start the fan in the EES space
— failures in the gas detection system shall not lead to disconnection of EES system.

2.3.2.3 The gas detection systems shall follow the power supply requirements as given for fire detection systems in Pt.4 Ch.8 Sec.2 [3.1].

2.3.2.4 The following shall be monitored and alarmed at a manned control station:

— actual gas concentration in EES space
— gas level alarm
— failure of the gas detection system.

2.3.2.5 The gas detection system used for EES space shall be independent of the EES system.

2.4 Fire safety for EES spaces

2.4.1 Fire integrity

2.4.1.1 An EES space that contains an EES system with stored energy of less than 100 kWh shall be defined as:

— areas of moderate fire hazard ('fire category B') on vessel built according to IMO HSC code
— fire category 7 (other machinery space) on a cargo vessel and on a passenger ship carrying not more than 36 passengers built according to SOLAS Ch. II-2
— fire category 11 (other machinery space) on a passenger vessel carrying more than 36 passengers built according to SOLAS Ch. II-2.

An EES space that contains an EES system with stored energy of 100 kWh or more shall be defined as:

— areas of major fire hazard ('fire category A') on vessel built according to IMO HSC code
— fire category 6 (machinery space of category A) on a cargo vessel passenger ship carrying not more than 36 passengers built according to SOLAS Ch. II-2
— fire category 12 (machinery space of category A) on a passenger vessel carrying more than 36 passengers built according to SOLAS Ch. II-2.

2.4.1.2 For vessels built according to SOLAS Ch. II-2 fire integrity of any EES spaces (above or below 100kWh) shall in addition to [2.4.1.1] 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.

For vessel built according to IMO HSC Code, the note 2 of table 7.4-1 and 7.4-2 shall not be applied (for instance, full structural fire protection is deemed necessary between a machinery space and an EES space).

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

2.4.1.4 For vessels built according to other standards than SOLAS Ch. II-2 and the IMO HSC Code, the fire category and structural fire protection shall provide equivalent protection to the above.

2.4.2 Fire detection

2.4.2.1 A fixed fire detection system shall be provided in all EES spaces. Combined smoke and heat detectors or a combination of smoke and heat detectors shall be installed. The arrangement shall comply with the international code for fire safety systems (FSS code).

2.4.2.2 The components of the fire detection system installed inside the EES space shall be of a certified safe type for use in explosive atmosphere, see [2.2.3].

2.4.3 Fire extinguishing

2.4.3.1 EES spaces shall be protected by a fixed fire extinguishing system. Any of the following systems will be accepted:

— water based system according to IMO MSC/Circ. 1165, as amended by MSC.1/Circ.1269 and MSC.1/Circ.1386
— a gaseous agent according to FSS Code Ch.5, IMO MSC/Circ.848, as amended by IMO MSC/Circ. 1267 and DNV GL Statutory Interpretations, FSS Code Ch.5
— a CO_2 system as specified in FSS Code Ch.5 and DNV GL Statutory Interpretations, FSS Code Ch.5.

Guidance note:

Water based extinguishing system is recommended due to its inherent heat absorbing capabilities.

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

2.4.3.2 Water based extinguishing systems

1) The water based systems shall be designed to discharge fresh water for 30 minutes operation.
2) The system shall be design for switch-over to seawater. At the end of the discharge of freshwater, there shall be an audible and visible alarm on the navigational bridge to notify the crew that fresh-water is no longer available for the fixed fire extinguishing system. Both manual and automatic switch-over arrangements to seawater are permitted.
3) The fresh-water specification shall also comply with maker's specification for the water supply (see IMO MSC.1/Circ. 1516 for details).
4) The water based system shall be served by dedicated fresh-water tank(s) or from utility service tanks with low-level alarms.

2.4.3.3 Gas based extinguish systems

1) For the gaseous agent or CO_2 the design concentration shall be suitable for applicable flammable gases.
2) Gaseous agents or CO_2 systems protecting a space that contains a EES system with stored energy of 100 kWh, or more, shall be provided with a second, independent charge with same capacity as the first charge (a 2 x 100% system).
3) For halocarbon clean agents (chemical gaseous agents required to discharge 95% within 10 seconds) the following shall be documented:
   — Pressure peaks and under-pressures expected during release of the extinguishing gas.
   — Structural integrity of doors and ventilation dampers in the boundary of the space when exposed to these pressure peaks and under-pressures. Doors and dampers shall remain intact after exposure.

2.4.3.4 For EES systems designed according to option 2 as given by [4.1.2.7] with an 'integrated' extinguishing agent for thermal propagation prevention, that extinguishing system shall be provided in addition to the fixed fire extinguishing system required by [2.4.3.1]. The thermal propagation prevention extinguishing agent required shall be designed to release automatically.

Guidance note:

— The extinguishing agent used for thermal propagation prevention can be the same system as the fixed fire extinguishing system as required by [2.4.3.1] if redundant capacity is ensured, i.e. minimum two separate releases.

— Automatic release of gas extinguishing agents shall be approved by the flag administration on a case-by-case basis.

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

2.5 Safety philosophy of the onboard installation

2.5.1 The arrangement of the EES spaces shall be such that the safety of passengers, crew and vessel is ensured. The safety philosophy for the EES space shall be documented. The safety philosophy should cover all potential hazards represented by the type of EES system and cover at least:

— gas development hazard (toxic, flammable, corrosive)
— fire hazard
— explosion hazard
— necessary detection, monitoring and alarm systems (off-gas detection, fire detection etc.) and ventilation
— ventilation handling in case of off-gas release and/or fire
— external hazards (fire, water ingress, etc.).

2.5.2 The safety philosophy shall be based on the actual vessel and EES system to be used. The safety description for the EES system, as required in [4.1.2.1], shall be used as basis.

2.6 System design

2.6.1 General

2.6.1.1 The outgoing circuits on a EES 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 Electrical insulation to earth of each EES system shall be monitored and low level shall give alarm.

2.6.1.3 Emergency disconnection of the EES system (as required in [4.1.2.5]) shall be arranged at the following locations:

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

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

Guidance note:

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

— It is accepted that the emergency disconnection is delayed in order to give time for 'soft' shutdown by the control system.

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

2.6.2 EES converters

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

2.6.2.2 The converters shall be designed with the needed capacity specified by the EES application.

2.6.2.3 The converters shall protect the EES system against overvoltage and undervoltage. The voltage protection shall be independent of the EES system, i.e. utilize independent voltage sensors and be independent of the battery or capacitor management system.

The protection levels shall be within the allowable operating values of the EES system.

Guidance note:

Alternatively when the vessel has several EES converters and/or a EES converter located on shore then the independent voltage protection could be implemented in the DC switchboard where the EES system is connected.

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

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

2.6.2.5 When an EES converter is located onshore then the requirements given in [2.6.2.1] and [2.6.2.3] shall be fulfilled.

2.7 Testing

2.7.1 Testing

After installation, the following tests shall be performed:

— test of correct interface between the EES converters and the EES system
— test of EES converter's independent EES voltage protection functions
— test of the EES system and its auxiliaries, including alarms, emergency disconnection and safety functions
— test of functions in the EES space (e.g. ventilation, liquid cooling, gas detection, fire detection, leakage detection) as installed.

Guidance note:

Requirements for testing of the electrical installation is given in Pt.4 Ch.8 Sec.10 [4.4]. Requirements for testing of the control systems is given in Pt.4 Ch.9 Sec.1 [4.4].

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

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 EES systems and ventilation in case of an external fire and the event of an internal thermal incident.

Guidance note:

Additional equipment (e.g. CCTV) giving situational awareness to crew may be beneficial.

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

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 Class notation Battery(Power)

3.1 General

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

3.2 System design

3.2.1 EES system

3.2.1.1 When all the main sources of power is based on EES only, the main sources of power shall consist of at least two independent EES systems located in two separate EES spaces.

3.2.1.2 The cables from the EES 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 An EES 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 EES system locally. This local operation shall be independent from any remote control (e.g. PMS, IAS) systems, in accordance with the requirements of Pt.4 Ch.9 Sec.4 [3.1.6].

Guidance note:

The local operation workstation can be located at the EES system, the switchboard room or at the EES converter. Local operation is understood as being able to connect the EES system to the switchboard. The requirement for local operation applies only for vessels where the EES is necessary in order to maintain propulsion, i.e. this does not apply to hybrid solutions where the main class propulsion requirement is fulfilled by diesel or gas fuelled propulsion engine(s) or generator(s).

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

3.2.2 EES capacity

3.2.2.1 When an EES system replaces one of the required main sources of power in Pt.4 Ch.8 Sec.2 [2.1.1], the capacity of the EES system shall be sufficient for the intended operation of the vessel. This applies both to normal operation and after a worst case failure.

Minimum remaining propulsion power after worst case failure (P_{prop_wcf}) shall be calculated based on remaining power for the propulsion motors after the worst case single failure have occurred, e.g. loss of a main switchboard or loss of a main power source. Minimum remaining propulsion power after worst case failure (P_{prop_wcf}) shall be documented in the electrical load balance.

Guidance note:

— In addition to P_{prop_wcf}, the vessels dependency of the EES will be stated in the appendix to the class certificate as an operational limitation.

— Where the EES system form a part of the dynamic positioning (DP) system, worst case failure is based on relevant requirements and failure modes for the applicable DP notation.

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

3.2.2.2 When EES systems are used as redundant power sources for dynamic positioning, the capacity of the EES systems (available power and available energy) shall be sufficient for the planned operation. See Ch.3 Sec.1 and Ch.3 Sec.2.

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

3.2.2.4 In case of over-temperature in a EES 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.

3.2.2.5 Monitoring of EES systems supplying propulsion power for dynamic positioning systems, shall follow requirements as given in Ch.3 Sec.1 [6.12], and Ch.3 Sec.2 [6.10] as applicable.

3.2.3 Energy management system

3.2.3.1 Energy management system (EMS) shall be installed.

Guidance note:

The EMS functions may be integrated in the vessel's automation system, the power management system or DP control system.

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

3.2.3.2 For EES 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 EES systems SOH and SOC.

Guidance note:

The calculation of available energy and power should take into account the possible inaccuracy of the SOC and SOH given by the EES system.

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

3.2.3.3 For a vessel depending on the stored energy in the EES for seagoing operation, the following shall be calculated:

1) Remaining time for seagoing operation (T_{op})

Guidance note:

The calculation of remaining time for seagoing operation, T_{op}, should be based on the available energy and the average power consumption for relevant period.

$$T_{op} = \frac{AE}{P_{avr}}$$

where

T_{op} = remaining time for seagoing operation [h]

AE = available energy [kWh]

P_{avr} = average power consumption for relevant period [kW].

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

2) Remaining time for seagoing operation after worst case single failure (T_{wcf}). Only applicable for vessels depending on the energy stored in EES for propulsion after worst case failure.

Guidance note:

The calculation of remaining time for seagoing operation after worst case single failure, T_{wcf}, should be based on remaining available energy and power consumption after a worst case single failure (component failure), see [3.2.2.1].

If

$$P_{prop\_wcf} > P_{cont\_wcf} - P_{aux\_wcf}$$

then

$$T_{wcf} = \frac{AE_{wcf}}{P_{prop\_wcf} + P_{aux\_wcf} - P_{cont\_wcf}}$$

where

T_{wcf} = remaining time for seagoing operation after worst case single failure (component failure) [h]

AE_{wcf} = available energy after worst case single failure (component failure) [kWh]

P_{prop_wcf} = calculated propulsion power consumption after a worst case single failure (component failure) [kW]

P_{cont_wcf} = remaining power after worst case failure, generated from 'continuous available' power sources, e.g diesel generators [kW]

P_{aux_wcf} = calculated auxiliary power consumption after a worst case single failure (component failure) [kW].

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

3) Remaining time for powering emergency consumers (T_{em}). Only applicable for vessels depending on the energy stored in the EES for supplying emergency consumers.

Guidance note:

The calculation of remaining time for powering emergency consumers, T_{em}, should be based on the remaining available energy after worst case failure and the designed power consumption for emergency consumers.

If

$$P_{em} > P_{cont\_wcf}$$

then

$$T_{em} = \frac{AE_{wcf}}{P_{em} - P_{cont\_wcf}}$$

where

T_{em} = remaining time for emergency consumers [h]

AE_{wcf} = available energy after worst case failure (fire and flooding) [kWh]

P_{em} = designed power consumption from EES for emergency consumers according to load balance [kW]

P_{cont_wcf} = remaining power after worst case failure, generated from 'continuous available' power sources, e.g diesel generators [kW].

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

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

— available energy (AE) of the EES systems
— available power (AP) of the EES systems
— remaining time for seagoing operation (T_{op})
— remaining time for seagoing operation after worst case failure (T_{wcf}) if the vessel is depending on the energy stored in the EES for propulsion after worst case failure
— remaining time for powering emergency consumers (T_{em}) if the vessel is depending on the energy stored in the EES for supplying emergency consumers.

3.2.3.5 The following warning and alarm shall be provided the navigating bridge:

— If the vessel is depending on the energy stored in the EES for propulsion after worst case failure then an individual warning shall be given at the navigating bridge when the EES system reaches minimum capacity as required for the intended operation or voyage. This warning shall be based on the remaining time for seagoing operation after worst case single failure (T_{wcf}). The warning level will be operator set accordingly to the vessels operation(s).
— If the vessel is depending on the energy stored in the EES for supplying emergency consumers then an individual alarm shall be given at the navigating bridge when the EES system reaches minimum capacity as required for powering the emergency consumers.

3.3 Testing

3.3.1 Testing

Supplementary to the tests stated in [2.7], the following shall be verified by testing:

— verify that the EES capacity (SOH) is consistent with the SOH value calculated for all the EES systems. If there is a larger deviation than +/- 5%, then the values in the EES system shall be adjusted
— charging and discharging capacities to verify maximum C-rates as specified for the intended operation of the vessel.

Guidance note:

— Verification of SOH may be performed by coulomb counting during a complete charge or discharge or other method as documented in the maintenance manual, see [3.4.2].
— Requirements for testing of the electrical installation is given in Pt.4 Ch.8 Sec.10 [4.4] and Pt.4 Ch.8 Sec.12 [2.1].
— Requirements for testing of the control systems is given in Pt.4 Ch.9 Sec.1 [4.4].

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

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 [2.8.1]:

— charging procedure
— normal operation procedures of the EES system
— local operation procedure
— conditions and procedures to prepare the EES system for extended period of standby.

3.4.2 Maintenance

A maintenance plan for the EES system shall be kept on board and shall include verification procedures for SOH in addition to the elements stated in [2.8.2].

4 Battery system

4.1 Battery system design

4.1.1 General

The requirements given in this section are related to lithium-ion 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 battery system 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 including:

— safety philosophy
— potential gas development (toxic, flammable, corrosive)
— fire risk
— explosion risk, including a description of the gas that can be released from the cell(s) during venting and thermal runaway (gas volume, release rate and gas composition)
— necessary detection, monitoring and alarm systems (gas detection, fire detection etc.) and ventilation rates for the battery space
— a suitable fire extinguish method shall be given
— internal cell failure/thermal runaway
— internal and external short circuit and earth faults
— electrical protections (over current, over voltage and under voltage)
— protection against creeping current, electrical arcing and electrolysis due to external leakage or pollution
— flooding of battery modules due to cooling liquid leakage
— 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 BMS shall communicate the voltage and current limits to the battery converter.

4.1.2.4 The battery system's main power contactors or circuit-breakers shall disconnect both poles.

4.1.2.5 The battery system shall be equipped with an independent emergency shutdown for disconnection of the battery system.

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

4.1.2.7 The design of a module should prevent propagation of a thermal event from the first cell to another cell. Alternatively, as a minimum, a system shall be designed such that a fire in one cell may spread within that module but will not propagate to another module. The amount of off-gas considered in analysis shall be dependent on the number of cells which release off-gas. Demonstration of system capability with respect to either approach shall be verified by testing as defined in [4.2.2] in accordance with one of these two options:

1. No propagation between cells within a module.
2. No propagation between modules - with or without an extinguishing agent.

Design option 2 is only accepted where the sum of the cells that propagate in the module is limited to 11 kWh.

Modules that are designed to limit propagation of a thermal event within a cell block or a sub-unit of cells shall be assessed on a case by case basis.

4.1.2.8 The main power connectors shall have an integrated safety interlock (HVIL), securing that connection/disconnection only can be performed when the battery contactor is open.

Guidance note:

HVIL is not required for fixed (bolted) connections.

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

4.1.2.9 The clearance and creepage distances as given in Pt.4 Ch.8 Sec.4 [1.1.8] shall be met based on the end of charge voltage for the battery system.

4.1.2.10 Battery modules shall be designed such that the risk of a cooling liquid leakage inside the module is minimized and do not lead to hazardous creepage currents, electrolysis, short circuit, electric arcing, earth faults or other hazards. Leakage detection inside the module shall be arranged if there is liquid cooling inside the module.

4.1.2.11 Battery systems shall be designed such that the risk of cooling liquid leakage in the battery system is minimized and do not lead to hazardous creeping currents, electrolysis, short circuit, electric arcing, earth faults or other hazards. Leakage detection shall be arranged.

Guidance note:

All main electrical connections should be located at the top of the system as far as possible.

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

4.1.3 Battery management system

4.1.3.1 The battery management system (BMS) shall:

— provide limits for charging and discharging to the battery converter
— protect against over-current, over-voltage and under-voltage by disconnection of the battery system
— protect against over-temperature by disconnection of the battery system
— provide cell and module balancing.

Guidance note:

Protection of over current may also be done by limiting the current from the battery converter.

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

4.1.3.2 The following parameters shall be measured:

— cell voltage
— cell or module 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 or module temperature
— battery string current.

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 in accordance with Pt.4 Ch.9 Sec.3 [1.5]. For vessels without a centralized main alarm system, battery alarms shall be presented at the bridge. This shall include at a minimum:

— high cell or module temperature
— over and under voltage
— battery disconnection
— tripping of battery breakers/contactor
— communication alarm
— liquid cooling leakage
— other safety protection functions.

For battery systems that are designed with independent overcharge protection based on voltage monitoring of the modules (see [4.1.5.2]) unbalanced cell voltage is also required.

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.

Guidance note:

General requirements for protective safety action, automatic or manual shutdown can be found in Pt.4 Ch.9 Sec.3 [1.1.3] and Pt.4 Ch.9 Sec.3 [1.4.10].

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

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 in accordance with Pt.4 Ch.9 Sec.2 [2.2.1] and Pt.4 Ch.9 Sec.3 [1.4.3].

4.1.5.2 The battery modules shall be equipped with an overcharge protection independent of the BMS. This independent protection shall be arranged either by:

- temperature monitoring
- voltage monitoring.

This protection shall be arranged with components independent from those used for the indication, alarm, control functions and protection functions required by [4.1.3] and [4.1.4].

For systems with cells provided with CID or similarly functioning devices, the requirement for independent overcharge protection is considered met.

If temperature sensors are arranged in close vicinity in 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 may be common for the indication, alarm, control and protection functions required under [4.1.3] and [4.1.4] and independent overcharge protection as required under [4.1.5.2]. Such arrangements shall still be designed with independency for CPUs and other electronic parts of the independent overcharge protection, i.e. no single failure shall affect both functions.

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 system shall be made of a flame-retardant material according to IEC 60092-101.

4.1.7 Ingress protection
The requirements for IP rating of the battery systems depends on the location. As a minimum, IP 44 is required.

Guidance note:

IP rating below IP 44 may be accepted based on a risk evaluation of the battery installation. The risk evaluation should particularly consider intrusion of salt water, as salt water is the last resort of fire extinguishing on board a sea going vessel.

---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.

4.2.2 Propagation testing
Propagation requirements are taken as defined in IEC 62619 (§7.3.3 and Appendix B) modified to one of the following two design options:

1. The battery system is designed for no propagation between cells within a module.

— The test shall be repeated 3 times and successful each time.
— The test shall be performed within an ambient temperature of the maximum operating temperature (+/-5°C) for the battery system.
— All cells within the module must be electrically connected, except if overcharge method is used for initiate the thermal runaway, then the cell being overcharged can be electrical disconnected.
— The module shall be considered under test for 24 hours after thermal runaway.
— If a coolant media is used to prevent propagation it shall be automatically released. It shall be tested in the same configuration with which it will be installed.
— Acceptance criteria is defined as only the cell which is directly caused to fail by testing show fire or off-gassing and that all other cells in module show no external signs of thermal runaway and still produce a measurable voltage within normal operating range. Neighbouring cells equipped with CID may have no measurable voltage if the cells' CID is activated due to high temperature. For such cells, it is acceptable that the voltage is not measurable.

2. The battery system is designed for no propagation between modules - with or without an extinguishing agent.

— The test shall be repeated 3 times and successful each time.
— The test shall be performed within an ambient temperature of the maximum operating temperature (+/-5°C) for the battery system.
— All cells within the module must be electrically connected, except if overcharge method is used for initiate the thermal runaway, then the cell being overcharged can be electrical disconnected.
— The module shall be considered under test for 24 hours after thermal runaway.
— Neighbouring modules should be located at the least favourable positions. The test plan shall include justification of why the chosen positions are considered least favourable.
— Neighbouring modules shall contain live cells in standard configuration; alternatively modules can be configured with dummy cells of similar thermal characteristics, in which case the passing criteria is that a

temperature of 85°C is not reached anywhere in the module, as detected at the least favourable locations. The test plan shall include justification of why the chosen positions are considered least favourable.
— If an extinguishing or coolant media is used to prevent propagation it shall be automatically released. It shall be tested in the same configuration with which it will be installed.
— Acceptance criteria is defined as only cells within the module which is directly caused to fail by testing show fire or off-gassing and that all cells in neighbour modules show no external signs of thermal runaway and still produce a measurable voltage within normal operating range.

4.2.3 Lithium-ion cell tests

The cells shall be type tested accordingly to Table 9.

All the cell tests shall be performed at a recognized laboratory.

Table 9 Type tests of battery cells.

Item	*Test*	*Comments*	*Test type*
1	external short circuit	IEC 62619 7.2.1 (alternatively UN38.3 T-5)	TT
2	impact	IEC 62619 7.2.2 (alternatively UN38.3 T-6)	TT
3	thermal abuse	IEC 62619 7.2.4 (alternatively UN38.3 T-2)	TT
4	forced discharge	IEC 62619 7.2.6 (alternatively UN38.3 T-8)	TT

4.2.4 Lithium-ion battery system tests

The battery system shall be tested in accordance with Table 10.

The type tests (TT) shall be carried out and witnessed by a DNV GL surveyor at the first certification.

The routine tests (RT) shall be performed and witnessed by a DNV GL surveyor for each product certification.

Table 10 Tests of battery systems.

Item	*Test*	*Comments*	*Test type*
1	propagation/internal thermal event	IEC 62619 7.3.3 - with amendments given in [4.2.2]	TT
2	overcharge with voltage	IEC 62619 8.2.2	TT
3	overcharge with current	IEC 62619 8.2.3	TT
4	overheating control	IEC 62619 8.2.4	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	function and failure response testing	normal operation and failure response of the BMS, see Pt.4 Ch.9 Sec.2 [2]	TT/RT
10	independent safety function test	— emergency disconnection function — independent temperature and or voltage based disconnection (not required for cells with CID) — HVIL	TT/RT

Item	Test	Comments	Test type
11	dielectrical strength (high voltage test)	Pt.4 Ch.8 Sec.4 [4.1.4] 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.	TT/RT
12	insulation resistance	Pt.4 Ch.8 Sec.10 Table 5.	TT/RT
13	cooling failure test	Failures of fans, loss of coolant and leakage detection tested according to specification.	TT
14	pressure test of coolant piping/ hoses	Pt.4 Ch.6 Sec.10 [4]	TT/RT

Guidance note:

The dielectrical strength and the insulation resistance routine test (RT) can be performed as tests in the production process. Documentation from testing on the actual battery components must then be presented the surveyor.

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

5 Electrochemical capacitor system and installations

5.1 General

The subsections [2], [3] and [4] are applicable for electrochemical capacitor installations with the adjustment given in [5.2], [5.3] and [5.4].

5.2 Design principles for electrochemical capacitor installation with **Battery(Safety)** notation

The subsection [2] is applicable for electrochemical capacitor installations with the following adjustments:

- [2.3.1.8] Only the requirements related to design option 1 will apply, see [4.1.2.7].
- [2.4.3.4] The requirement is not applicable.
- [2.6.1.3] **Guidance note:** The emergency disconnection should also consider emergency discharge of the electrochemical capacitor system if the electrochemical capacitors type can handle this without damage.
- [2.6.2] The following additional requirement applies: The EES converter shall protect the electrochemical capacitor system against too high inrush current.
- [2.6.2.3] Only over voltage protection is applicable.

5.3 Design principles for electrochemical capacitor installation with **Battery(Power)** notation

The subsection [3] is applicable for electrochemical capacitor installations.

5.4 Electrochemical capacitor system

The subsection [4] is applicable for electrochemical capacitor systems with the following adjustment:

Guidance note:

When the word battery is stated in subsection [4], then it shall be understood as electrochemical capacitor in this context.

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

— [4.1.2.7] Only the design option 1 is accepted.
— [4.1.3] The BMS shall be read as CMS.
— [4.1.5.2] Only independent overcharge protection by voltage monitoring is accepted for systems with cells without CID or similarly functioning devices.
— [4.2.2] Only the test for design option 1 is accepted.
— [4.2.3] The cell tests in Table 9 shall be replaced with the tests given in Table 11.

Table 11 Type tests of electrochemical capacitor cells.

Item	*Test*	*Comments*	*Test type*
1	pull out or torque	UL 810A 11.1 or 11.2	TT
2	short circuit at 55°C	UL 810A 13	TT
3	abnormal charge	UL 810A 14	TT
4	heating	UL 810A 16	TT
5	dielectric withstand	UL 810A 17	TT
6	crush	UL 810A 18.2	TT
7	impact	UL 810A 18.3	TT

— [4.2.4] The system tests in Table 10 shall be replaced with the tests given in Table 12.

Table 12 Tests of electrochemical capacitor systems.

Item	*Test*	*Comments*	*Test type*
1	propagation/internal thermal event	[4.2.2]	TT
2	short circuit at 55°C (under normal and single fault condition)	UL 810A 13	TT
3	abnormal charge (under normal and single fault condition)	UL 810A 14	TT
4	temperature rise test	UL 810A 15 with adjustment for 45°C ambient temperature	TT
5	sensor failures	detection of all failure modes of the sensors	TT
6	cell balancing	according to specification	TT
7	function and failure response testing	normal operation and failure response of the BMS, see Pt.4 Ch.9 Sec.2 [2]	TT/RT
8	independent safety function test	— emergency stop function — independent voltage based disconnection (not required for cells with CID) — HVIL	TT/RT
9	dielectrical strength (high voltage test)	Pt.4 Ch.8 Sec.4 [4.1.4]	TT/RT
10	insulation resistance	Pt.4 Ch.8 Sec.10 Table 5	TT/RT
11	cooling failure test	failures of fans, loss of coolant and leakage detection tested according to specification	TT

Item	Test	Comments	Test type
12	pressure test of coolant piping/ hoses	Pt.4 Ch.6 Sec.10 [4]	TT/RT

6 Appendix

6.1 List of alarms and monitoring parameters

The alarm and monitoring requirements in the rule text are listed in Table 13.

Table 13 List of alarms and monitoring parameters

System	Item	Monitoring/ display	Control	Alarm	Shutdown/ disconnection with alarm	Comment
EES space	Ambient temperature	Ambient temperature [2.3.1.12]		HA [2.3.1.13]		Monitoring and alarm at manned control station
	Ventilation	Status of ventilation [2.3.1.12]		Failure [2.3.1.13]	Possible shutdown of ventilation upon fire detection [2.5]	Monitoring and alarm at manned control station
	Off-gas ventilation		Manual and automatic start		Possible shutdown of ventilation upon fire detection [2.5]	
	Fire	Smoke detection in EES space [2.4.2.1]		Alarm [2.4.2.2]		Bridge
	Water based extinguishing system, end of fresh-water discharge			Alarm [2.4.3.2]		Bridge
	Gas	Gas concentration in EES space [2.3.2.4]		HA gas detection in EES space [2.3.2.4] and failure of gas detection system	Disconnection of EES system [2.3.2.2]	Alarm at bridge upon activation of the required safety actions

System	*Item*	*Monitoring/ display*	*Control*	*Alarm*	*Shutdown/ disconnection with alarm*	*Comment*
	Emergency disconnection EES system				Manual disconnection [2.6.1.3]	
EES converter	Charging / discharging		Keep current / voltage within the limits given by the BMS/ CMS [2.6.2.1] and the limits set directly in the converter [2.6.2.3]	Charging/ discharging failure [2.6.2.4]		Alarm at manned control station
EES system	Cell balancing		Control cell balancing [4.1.3.1]	HA [4.1.4.1]		IR or IL, alarm on bridge
	Cell voltage	System voltage and max, min and average cell voltage [4.1.3.3]	Protection against over voltage and under voltage [4.1.3.1]	HA, LA [4.1.4.1]		IR or IL, alarm on bridge
	Cell / module temperature	Max, min and average temp. [4.1.3.3]	Protection against over temp. [4.1.3.1]	HA [4.1.4.1]		IR or IL, alarm on bridge
	EES string current	EES string current [4.1.3.3]	Protection against over current [4.1.3.1]			IR or IL
	Charging limits		Provide charging/ discharging limits to EES converter [4.1.3.1]			
	EES system disconnection			Alarm [4.1.4.1]		IR or IL, alarm on bridge
	Tripping of EES system breaker/ contactor			Alarm [4.1.4.1]		
	Communication alarm			Alarm [4.1.4.1]		
	Liquid cooling leakage			Alarm [4.1.4.1]		IR or IL, alarm on bridge

System	*Item*	*Monitoring/ display*	*Control*	*Alarm*	*Shutdown/ disconnection with alarm*	*Comment*
	Insulation monitoring	Electrical insulation level of the EES system		LA, alarm [2.6.1.2]		Alarm at manned control station
	HVIL		Protection against unsafe connection/ disconnection of power connectors [4.1.2.8]			
Additional for **Battery(Power)** notation:						
EES system	EES system charge level	SOC and SOH [3.2.2.3]	Calculate SOC and SOH for EMS function [4.1.3.4]			Monitoring at a control station
	EES module temperature			HA, Automatic LR or request for manual LR [3.2.2.4]		
EMS	Capacity status	Available energy [3.2.3.4]	Calculate available energy [3.2.3.2]			Bridge
		Available power [3.2.3.4]	Calculate available power [3.2.3.2]			Bridge
		Remaining time for seagoing operation [3.2.3.4]	Calculate remaining time for seagoing operation [3.2.3.3]			Bridge
		Remaining time for seagoing operation after worst case single failure [3.2.3.4]	Calculate remaining time for seagoing operation after worst case single failure [3.2.3.3]	LA, warning if capacity is not sufficient for intended voyage / operation [3.2.3.5]		Monitoring and alarm at bridge

System	*Item*	*Monitoring/ display*	*Control*	*Alarm*	*Shutdown/ disconnection with alarm*	*Comment*
		Remaining time for powering emergency consumers [3.2.3.4]	Calculate remaining time for powering emergency consumers [3.2.3.3]	LA, alarm when the EES system reaches minimum capacity as required for powering the emergency consumers [3.2.3.5]		Monitoring and alarm at bridge
IR: Remote indication (presentation of values), in engine control room or another centralized control station such as the local platform/manoeuvring console IL: Local indication (presentation of values), in vicinity of the monitored component LA: Alarm for low value HA: Alarm for high value LR: Load reduction, either manual or automatic, with corresponding alarm						

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 regulation 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 regulation II-1/31.3 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, see [1.6.1].

1.4 Definitions

1.4.1 General

1.4.1.1

Table 1 Definitions

Term	*Definition*
main alarm system	centralized system for alarm handling. Located in engine room or in engine control room if provided
local (sub) alarm systems	system for monitoring a single process segment or function. Normally to have facilities for local alarm handling and with interface to 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---
protective safety system	system that is activated on occurrence of predefined abnormal process condition to bring the process / EUC to a safe state. The safety action may be automatic or manual
extension alarm system	the main alarm systems extension to the engineers' accommodation and the navigation bridge which shall be in operation when the engine room is unattended
engineers’ alarm	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 regulation 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

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Extension alarm and watch responsibility system	I200 - Control and monitoring system documentation		AP

Object	Documentation type	Additional description	For approval (AP) or For information (FI)
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

Object	Documentation type	Additional description	For approval (AP) or For information (FI)
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 DNVGL-CG-0550 Sec.6.

1.5.1.4 For a full definition of the documentation types, see DNVGL-CG-0550 Sec.5.

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 six 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 twelve months.

Guidance note:

The critical alarms for rotating machinery are typically low lube oil pressure, over-speed 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 An extension alarm system shall be installed on the navigation bridge, engineers' cabin and public spaces.

2.3.1.3 Alarms in local (sub) systems covering functionality which is required by the rules shall initiate alarm in the main alarm system. Alarms from each such local system shall either be transferred individually to the main alarm system or be arranged as one common alarm.

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.

2.3.1.4 Activation of safety shut down through any required protective safety system shall initiate separate alarm in the main alarm system.

2.3.1.5 The main 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 through the extension alarm system. 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 When the machinery spaces are unattended, any alarm condition in the main alarm system shall initiate alarm in the duty engineers' cabin and in all public spaces the duty engineer may reside, with individual or group wise indication and alarm through the extension alarm system.

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

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 regulation II-1/51.1.5)

Guidance note:

Limited time should normally be understood to be between one to three minutes.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-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 acknowledged 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 Protective safety system

2.4.1 General

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

2.4.1.2 Power failure in protective safety systems shall not cause loss of propulsion or steering functions.

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 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.

2.5 Communication

2.5.1 General

2.5.1.1 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.

2.6 Fire safety and fire detection and alarm system

2.6.1 General

2.6.1.1 A fixed fire detection and fire alarm system shall be installed in accordance with the relevant provisions of SOLAS regulation II-2/7 (Pt.4 Ch.11) in periodically unattended machinery spaces.

(SOLAS regulation II-2/ 7.4)

2.6.1.2 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.

2.6.1.3 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 regulation II-2/7.4.2)

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---

2.6.1.4 Where fire detectors are provided with timers (e.g. in workshops) for inhibiting the alarm, these shall be arranged to automatically reset the alarm upon completion of timer and shall not be possible to negate for period exceeding 15 minutes. The inhibited state shall be clearly indicated.

2.6.1.5 Fire detectors shall be type approved.

2.6.1.6 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 regulation II-2.

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

2.6.1.7 Start of fire pumps shall be arranged according to the requirements in SOLAS regulation II-2/10.2.1.2.2.2.

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 the 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 10.
— 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 11.
— 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 7.
— For gas turbines, see Pt.4 Ch.3 Sec.2 Table 8.

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. See 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

System	*Item*	*Valid for engine type [1)]*	*Gr 1 Indication alarm load reduction*	*Gr 2 Automatic start of stand-by pump with alarm [2)]*	*Gr 3 Shut down with alarm*	*Comments*
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			Fuel oil temperature: LA . Viscosity: HA .
	common rail fuel oil pressure		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			
	lubrication oil to dampers, inlet pressure	C	IR, IL, LA			
	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		LA			
	lubrication oil filter differential pressure	T	IR, HA			

System	*Item*	*Valid for engine type [1)]*	*Gr 1 Indication alarm load reduction*	*Gr 2 Automatic start of stand-by pump with alarm [2)]*	*Gr 3 Shut down with alarm*	*Comments*
3.0 Turbocharger system	lubrication oil inlet pressure	C, T	IR, IL, LA			Applicable if separately forced lubrication or if turbo charger lubrication is part of engine main lubrication system but separated by pump, throttle or pressure reduction valve.
	turbo charger lubrication oil outlet temperature, each bearing[13)]		IR, HA			Applicable only when the T/C is served by group of cylinders > 2500 kW.
	speed of turbo charger	C, T	IR, HA			Applicable only when the T/C is served by group of cylinders > 1000 kW (Category B and C T/C).
4.0 Piston cooling system	piston coolant inlet pressure (common)	C	IR or IL, LA, LR	AS		Load reduction is not required if the coolant is oil taken from the main lubrication oil system of the engine.
	piston coolant outlet temp each cylinder		HA, LR			
	piston coolant outlet flow each cylinder		LA, LR			Where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted.
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.

System	*Item*	*Valid for engine type* [1)]	*Gr 1 Indication alarm load reduction*	*Gr 2 Automatic start of stand-by pump with alarm* [2)]	*Gr 3 Shut down with alarm*	*Comments*
	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.
	oily contamination of engine cooling water system	C	A			Where cooling water is used in fuel and lubrication oil heat exchangers.
6.0 Starting and control air systems	control air reservoir pressure (if arranged)	C, T	IR or IL, LA			
	starting air pressure		IR, IL, LA			Before starting valve and after the last downstream valve of the pressure producing equipment.
	exhaust gas valve air spring pressure (safety air)	C	IR or IL, LA			Pressure readings shall be taken at the supply line locally on the engine.
7.0 Charge air system	scavenge air receiver pressure	C, T	IR			
	scavenge air receiver temperature, under each piston (fire detection)	C	HA, LR			

System	*Item*	*Valid for engine type* [1)]	*Gr 1 Indication alarm load reduction*	*Gr 2 Automatic start of stand-by pump with alarm* [2)]	*Gr 3 Shut down with alarm*	*Comments*
	scavenge air receiver temperature at scavenge air cooler outlet	C, T	IR, HA			
	scavenge air receiver water level	C	HA			
8.0 Exhaust gas system	exhaust gas temp after each cylinder	C, T	IR, HA, LR [5)]			Applicable for cylinder power > 500 kW.
	exhaust gas temp after each cylinder, deviation from average		HA			Applicable for cylinder power > 500 kW.
	exhaust gas temp before T/C [6), 7)]	C	IR, HA, LR			LR is only required when the T/C is served by group of cylinders > 2500 kW.
	exhaust gas temp after T/C		IR, HA			
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 Fuel valve coolant	pressure	C	LA	AS		If installed.
	temperature	C	HA			
11.0 Engine speed/direction of rotation	over speed protection	C, T			SH	SH shall be activated automatically. Applicable if engine power ≥ 220 kW.
	engine speed	C, T	IR			
	excessive time within barred speed range [8)]	C	A			
	wrong way	C	A			

System	*Item*	*Valid for engine type* [1)]	*Gr 1 Indication alarm load reduction*	*Gr 2 Automatic start of stand-by pump with alarm* [2)]	*Gr 3 Shut down with alarm*	*Comments*
12.0 Crankcase explosive condition[10) 11)]	oil mist detection [12)]	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 [9)]	C, 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.
13.0 Sea cooling water	cooling water pressure	C, T	IR, LA	AS		
14.0 Misfire[4)]	detection of misfire	C, T	A, LR			Chosen LR depends on permissible misfire.

Gr 1 = 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

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 engine component or system

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

LR = 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

SH = shut down with corresponding alarm.

For definitions of load reduction (LR) and shut down (SH), see Pt.4 Ch.1.

System	Item	Valid for engine type 1)	Gr 1 Indication alarm load reduction	Gr 2 Automatic start of stand-by pump with alarm 2)	Gr 3 Shut down with alarm	Comments

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) Engines shall have means to detect misfire if found necessary by the torsional vibration calculations. Example: Exhaust gas temp after each cylinder, deviation from average.
5) Alarm with request for load reduction to be given in case of high deviation from 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, see Pt.4 Ch.3 Sec.1 [5.7.10].

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.

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.
13) Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing intervals for inspection in accordance with the turbocharger manufacturer's instruction may be accepted as an alternative.

Table 5 Control and monitoring of propulsion turbines

System	*Item*	*Gr 1 Indication alarm load reduction*	*Gr 2 Automatic start of stand-by pump with alarm*	*Gr 3 Shut down with alarm*	*Comment*
1.0 Lubricating oil	*inlet pressure (after filter)*	*IR, IL, LA*	*AS*	*SH* [1)]	
	inlet temperature	*IR, HA*			
	filter differential pressure	*IR, HA*			
	level in system tank	*LA*			
2.0 Bearings	*bearing temperature*	*IR, HA*			
3.0 Turbine speed	*over-speed*	*LR*		*SH*	*LR or SH, if applicable, to be activated automatically*
4.0 Condenser system	*vacuum*	*IR, LA*		*SH*	
	vacuum pump stopped		*AS*		
	level	*IR, HA*	*AS*	*SH*	
	level	*IR, LA*			*if non-cavitating condensate pump*
	salinity	*HA*			
5.0 Cooling water (main condenser)	*inlet/outlet differential pressure*	*IR, LA*	*AS*		
6.0 Slow turning arrangement	*over-speed*			*SH*	
7.0 Gland steam	*inlet pressure to turbine*	*IR, LA, HA*			
	exhaust fan stopped	*A*			
8.0 Hydraulic system	*pressure*	*IR, LA*	*AS*		
9.0 Vibration	*level*	*HA*		*SH*	
10.0 Rotor	*axial displacement*	*IR, HA*		*SH*	

System	*Item*	*Gr 1 Indication alarm load reduction*	*Gr 2 Automatic start of stand-by pump with alarm*	*Gr 3 Shut down with alarm*	*Comment*
Gr 1 = sensor(s) for indication, alarm, load reduction (common sensor permitted but with different set points and alarm shall be activated before any load reduction) *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 *LR* = load reduction, either manual or automatic, 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) 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

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

	Gr 1 *Alarm* *Load reduction*	*Gr 2* *Automatic start of stand-by pump with alarm* [1)]	*Gr 3* *Shut down of boiler with alarm*
Deaerator, pressure	LA, HA		
Feed water			
Temperature [6)]	HA		
Pressure	LA	AS	
Feed water temperature	HA		
High pressure feed water			
Level	HA		
Fresh water generator			
Fresh water outlet, salinity	HA [4)]		
Uptake gas			
Gas temperature [7)]	HA		
Oil burner	Monitoring of the burner shall be arranged according to Pt.4 Ch.7 Sec.6 Table 7		

Gr 1 = common sensor for alarm and load reduction, alarm shall be activated prior to load reduction
Gr 2 = sensor for automatic start of standby pump
Gr 3 = sensor for shut down
LA = alarm for low value
HA = alarm for high value
A = alarm activated
AS = automatic start of standby pump with alarm
LR = load reduction, turbine slow down
SH = 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

	Gr 1 Indication alarm load reduction	*Gr 2 Automatic start of stand-by pump with alarm* [1)]	*Gr 3 Shut down with alarm*	*Comment*
1.0 Shafting				
Separate thrust bearings, temperature	*IL or IR, HA*			*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.*
Oil lubricated fluid film bearings, temperature	*IL or IR, HA*			*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.*
Stern tube lubricating oil tank, level	*LA*			
Stern tube lubricating oil, pressure or flow	*LA*			*Applicable to forced lubrication.*
2.0 Additional requirements for TMON				
Aft stern tube bearing, temperature	*HA*			*Applicable to oil lubricated systems only.*
3.0 Servo oil for CP-propeller				
Pressure	*IL, IR, LA*	*AS*		*The indicators shall be able to show sudden peaks in servo pressure.*
Level	*IL, LA*			
Differential pressure over filter	*HA*			
4.0 Gear bearing and lubricating oil				
Oil lubricated fluid film bearings (axial and radial) temperature	*IR, HA*			*Applicable for gears with a total transmitted power of 5 MW or more.*
Thrust bearing, temperature	*IR, HA, LR*			*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.*
Lubricating oil, pressure	*IL, IR, LA*	*AS*	SH	*At bearings and spray if applicable. Shut down or clutch disengagement.*
Differential pressure over filter	*IL, HA*			*Alarm in case of clogged filter.*
Lubricating oil, temperature	*IL or IR, HA*			*At inlet to bearings, i.e. after cooler.*
Lubricating oil, temperature	*IL or IR*			*In sump, or before cooler.*

	Gr 1 Indication alarm load reduction	*Gr 2 Automatic start of stand-by pump with alarm* [1]	*Gr 3 Shut down with alarm*	*Comment*
Sump level [2]	*IL or IR*			*For splash lubricated gears.*
5.0 Integrated clutch activating media				
Hydraulic oil pressure	*IL, IR, LA,* LR	*AS*	*SH*	*SH means either declutching or engine stop.*
6.0 Twist of elastic couplings				
Angular twist amplitudes	*IR, HA*		*SH*	*Applicable when failure of the elastic element leads to loss of torque transmission.* [3]
Mean twist angle	*IR, HA*			

Gr 1 = common sensor for indication, alarm, load reduction (common sensor permitted but with different set points and alarm shall be activated before any load reduction)

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

LR = 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

SH = 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

System	*Item*	*Gr 1 Indication alarm load reduction*	*Gr 2 Automatic start of stand-by pump with alarm* [1)]	*Gr 3 Shut down with alarm*	*Comment*
1.0 Fuel oil system	*leakage from jacketed high pressure pipes*	*A*			*Level monitoring of leakage tank or equivalent .*
	fuel oil pressure	LA	AS		*When fuel oil treatment system is provided.*
	ow temperature or high viscosity of heavy fuel oil	A			
	common rail fuel oil pressure	*LA*			
2.0 Lubricating oil system	*lubrication oil to main bearings, inlet pressure*	*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.*
	lubrication oil to main bearings, inlet temperature	*IR or IL, HA*			
	common rail servo oil pressure	*LA*			
3.0 Turbocharger system	*speed of turbocharger*	*IR or IL, HA*			*Applicable only when the T/C is served by group of cylinders > 1000 kW (Category B and C T/C).*
4.0 Cylinder cooling medium	*cylinder cooling inlet pressure or flow*	*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 .*
	cylinder cooling outlet temperature	*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	*start air pressure*	*LA*			

System	Item	Gr 1 Indication alarm load reduction	Gr 2 Automatic start of stand-by pump with alarm 1)	Gr 3 Shut down with alarm	Comment
6.0 Exhaust gas system	*exhaust gas temp after each cylinder 2)*	*IR or IL, HA, LR 3)*			*SH may replace LR for electric power generating engines.*
	exhaust gas temp before each turbo charger 4) 5)	*IR or IL, HA, LR*			*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.*
7.0 Hydraulic oil system	*leakage from jacketed high pressure pipes for hydraulic operation of valves*	*A*			*Level monitoring of leakage tank or equivalent.*
8.0/9.0 engine speed/direction of rotation	*engine speed*	*IR*			*For engines other than for electric power generation, local indication is an acceptable alternative.*
	over speed protection			*SH*	
10.0 Crankcase explosive condition 7)	*oil mist detection 8)*	HA		*SH*	*One oil mist detector having two independent outputs for detecting alarm and shut-down is acceptable.*
	other systems than oil mist detection 6)			*SH*	
11. Misfire 9)	*detection of misfire*	*A, LR*		*SH 10)*	

System	*Item*	*Gr 1 Indication alarm load reduction*	*Gr 2 Automatic start of stand-by pump with alarm 1)*	*Gr 3 Shut down with alarm*	*Comment*

Gr 1 = sensor(s) for indication, alarm, load reduction (common sensor permitted but with different set points and alarm shall be activated before any load reduction)

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 engine component or system

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

LR = load reduction, either manual or automatic, with corresponding alarm

SH = 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 > 500 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, see Pt.4 Ch.3 Sec.1 [5.7.10]
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) engines shall have means to detect misfire if found necessary by the torsional vibration calculations. 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.

Italic text in table is equivalent to Pt.4 Ch.3 Sec.1 Table 11.

Table 9 Control and monitoring of auxiliary turbines

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

Italic text in table is equivalent to Pt.4 Ch.3 Sec.3 Table 7.

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 7, auxiliary boilers shall be provided with monitoring according to Table 10 above.

Table 11 Control and monitoring for electrical power plant

	Gr 1 *Alarm*
1.0 Generator	
Lubricating oil, pressure [1)]	LA
Voltage	LA, HA
Frequency	LA
Disconnection of nonessential consumers	A

Gr1 = sensor for alarm
LA = alarm for low value
HA = alarm for high value
A = alarm activated.

1) to be provided if separate system.

Table 12 Monitoring of miscellaneous objects

Item	*Alarm*	*Comments*
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

Item	*Item*	*Comments*
Fuel oil service tanks, level [2),3)]	LA, HA[5)]	When automatic filling of tanks is arranged, alarm shall be initiated if the level exceeds safe level.
Lubricating oil tank, level[1)]	LA[6)]	
Lubricating oil tank, temperature [7)]	HA	
Piston coolant expansion tank, level[1)]	LA	
Cylinder cooling water in expansion tank, level [2)]	LA	
Fuel valve coolant in expansion tank, level [1)]	LA	
Sludge and drain tanks, level	HA	
Service tanks, level	LA	
Expansion tanks, level	LA	
Circulating tanks, level	LA	
Fuel oil drain collecting tanks, level	HA	

Gr1 = sensor for alarm
LA = alarm for low value
HA = alarm for high value

1) applicable to cross-head propulsion engines, see IACS UR M35
2) applicable to cross-head and trunk propulsion engines, see IACS UR M35
3) applicable to auxiliary reciprocating internal combustion engines driving generators, see IACS UR M36
4) HA required if no suitable overflow arrangement is provided
5) HA is required for propulsion engines only, if no suitable overflow arrangement is provided
6) where separate lubricating oil systems are installed (e.g. camshaft, rocker arms, etc.), individual level alarms are required for the tanks
7) where service tank or settling tanks are fitted with heating arrangements, a high temperature alarm shall be provided if the flashpoint of the fuel oil can be exceeded (SOLAS regulation II/2 4.2.5.2).

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

3.4.1 General

3.4.1.1 The general requirements to control of propulsion machinery from the navigation bridge are given in Pt.4 Ch.1.

3.4.1.2 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. (SOLAS regulation II-1/49.1.1)

3.4.1.3 Failure in the remote control system shall initiate alarm and the present speed and direction of thrust of the propeller shall be maintained.

3.4.1.4 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. (SOLAS regulation II-1/49.7)

Guidance note:

The above principle is valid for any means of stored energy intended for starting. .

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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.

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3.5.1.2 Standby generating sets shall 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 10 and Pt.4 Ch.3 Sec.1 Table 11).

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 [2.6].

4.4 Extent of monitoring

4.4.1 General

4.4.1.1 Monitoring of machinery shall comply with the requirements in [3], 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 shall not to be present in the engine room. Special measurements can be carried out according to agreement, e.g. noise measurements.

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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 Blackout recovery

5.1.3.1 It shall be tested that, after a blackout 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 regulation II-2/7.3.1).

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 one 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 five 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 is 'dead in the water', go quickly to full ahead
      vii) when the ship has reached approximately 2/3 of full speed ahead, go quickly to dead slow ahead
      viii) when the r.p.m. is nearly stabilized, go quickly to full ahead
      ix) when the ship has reached approximately half speed ahead, go to stop and back to dead slow ahead within one 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 at tempts. 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.

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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 Objective

The objective of this section is to provide requirements that will ensure that fuel cell power installations can operate safely and with a defined degree of availability.

1.2 Scope

The scope includes requirements for the design and arrangement of fuel cell power installations and the spaces containing such installations. It covers all aspects of the installation from primary fuel supply up to, and including, the exhaust gas system. Further the following is covered:

— reformers used to convert liquid or gaseous primary fuels to reformed hydrogen rich gas
— control, monitoring and safety systems
— manufacture, workmanship and testing.

The use of fuel cells is currently not covered by international conventions, hence such installations will require additional acceptance by the flag authorities.

Guidance note:

Requirements for storage, preparation and distribution of fuel are covered by Sec.5 *Gas fuelled ship installations* and Sec.6 *Low flashpoint liquid fuel engines*.

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1.3 Application

These requirements shall apply to all vessels with fuel cell power installations on board.

1.4 Class notations

1.4.1 Vessels complying with the requirements given in this section will be assigned the additional class notation **FC**, as specified in Table 1.

Table 1 Additional class notations - FC

Class notation	*Qualifier*	*Purpose*	*Application*
FC Mandatory: Yes Design requirements: Sec.3 FiS requirements: Pt.7 Ch.1 Sec.2 and Pt.7 Ch.1 Sec.3	**Power**	Fuel cell power installations intended for supply of essential, important or emergency services	Mandatory for all vessels with fuel cell power installations intended for use in essential, important or emergency services
	Safety	Fuel cell power installations NOT supplying essential, important or emergency services	Mandatory for all vessels with fuel cell power installations NOT used in essential, important or emergency services

1.5 Definitions

1.5.1

Table 2 Definitions

Term	*Definition*
Exhaust air	is exhaust from the cathode side of the fuel cell.
Exhaust gas	is exhaust from the reformer or anode side of fuel cell.
Fuel cell (FC)	is a source of electrical power in which the chemical energy of a FC fuel is converted directly into electrical and thermal energy by electrochemical oxidation.
Fuel cell power installation	is the fuel cell power system and the components and systems required to convert electrical power for the ship.
Fuel cell power system	is fuel cell(s), fuel reformer(s) and associated reformed fuel piping systems.
Fuel reformer	is the arrangement of all related fuel reforming equipment for processing gaseous or liquid primary fuels to reformed fuel for use in fuel cells.
Fuel cell space	is a space containing fuel cell power systems or parts of fuel cell power systems.
Primary fuel	is fuel supplied to the fuel cell power system.
Process air	is air supply to the reformer and /or the cathode side of the fuel cell.
Purge gas	is gas (gaseous primary fuel, reformed fuel or inert gas) released from the anode side of a dead end fuel cell.
Reformed fuel	is hydrogen rich gas from the reformer usable for the fuel cell.
Unacceptable loss of power	is when it is not possible to sustain or restore normal operation of the propulsion machinery in the event of one of the essential auxiliaries becoming inoperative, in accordance with SOLAS regulation II-1/26.3.
Ventilation air	is air used to ventilate the fuel cell space.

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 3.

Table 3 Documentation requirements for class notation FC

Object	*Documentation type*	*Additional description*	*Info*
Fuel cell power installation	Z030 – Arrangement plan	Giving location of: — machinery and boiler spaces, accommodation, service and control station spaces — FC fuel piping — ventilating pipes and ducts, doors and openings to FC spaces 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
	G010 - Risk analysis		FI
	G080 – Hazardous area classification drawing		AP
	S010 – Piping diagram (PD)		AP
	S011 – Piping and instrumentation diagram (P & ID)		AP
	Z060 – Functional description		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
	Z254 – Commissioning procedure		AP
Fuel cell	Z030 – Arrangement plan	Arrangement drawings of the fuel cell including dimensions, materials, operating temperatures, pressures, weights.	FI
	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.	FI
	Z252 – Test procedure at manufacturer	The test programme can be based on the IEC standard 62282-3-100 "Stationary fuel cell power systems-Safety", but shall also have to take the environmental and operating conditions in a ship into account.	AP

Object	*Documentation type*	*Additional description*	*Info*
Fuel cell pressure containing components	C010 – Design criteria	— design pressure — design temperature — volume(s) — fluid(s) — additional loads, if applicable — proposed set pressure of safety valve — — pressure equipment class.	AP
	C020 – Assembly 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
Fuel cell - piping	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
	S090 – Specification of piping, valves, flanges and fittings		AP
	P020 – Sizing calculations	For safety relief valves and pressure/vacuum relief valves.	AP
Fuel cell space - piping	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
	S090 – Specification of piping, valves, flanges and fittings		AP
	P020 – Sizing calculations	For safety relief valves and pressure/vacuum relief valves.	AP

Object	*Documentation type*	*Additional description*	*Info*
Fuel cell spaces – ventilation	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
	S030 – Capacity analysis		AP
	C030 – Detailed drawing	Rotating parts and casing of fans.	AP
Fuel cell spaces – gas detection and alarm system, fixed	I200 – Control and monitoring system documentation		AP
	Z030 – Arrangement plan	Detectors, call points and alarm devices.	AP
Fuel cell spaces - fire protection	G060 Structural fire protection drawing		AP
	G200 – Fixed fire extinguishing system documentation		AP
Fuel cell spaces - detection and alarm system	Z030 – Arrangement plan	Detectors, call points and alarm devices.	AP
Fuel cell spaces - electrical installation	G080 – Hazardous area classification drawing	Location of electric equipment in hazardous area shall be shown with cross reference to E090.	AP
	E090 – Table of Ex-installation		AP
	Z163 - Maintenance manual	For electrical installations in hazardous areas.	FI
	E130 - Electrical 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	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 [3.1] — 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
Fuel cell power installation–control, monitoring and safety system			
	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
	I200 – Control and monitoring system documentation		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)		FI
	Z252 - Test procedure at manufacturer		AP

Object	Documentation type	Additional description	Info
Fuel cell - manuals	Z163 - Maintenance manual		FI
	Z161 – Operation manual	— gas freeing and inerting procedures — normal operation procedures of the FC system — emergency operation procedures of the FC system	FI
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 DNVGL-CG-0550 Sec.6.

1.6.1.4 For a full definition of the documentation types, see DNVGL-CG-0550 Sec.5.

1.7 Certification

Equipment shall be certified as listed in Table 4.

Table 4 Certification requirements

Object	Certificate type	Issued by	Certification standard*	Additional description
Fuel cell power installation	PC	Society		When < 300 kW and type approved by the Society, work certificate (W) will be accepted.
Fans	PC	Society		In accordance with Pt.4 Ch.6 Sec.3.
Pressure equipment	PC	Society		In accordance with Pt.4 Ch.7.
Valves	PC	Society		In accordance with Pt.4 Ch.6.
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		
*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 listed in Table 3 shall be kept on board.

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].

1.8.1.3
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.

1.8.1.4 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.

2 Materials

2.1 General

2.1.1 Material requirements

2.1.1.1 Materials shall be accordance with the requirements in Pt.2 of the rules.

2.1.1.2 The materials shall be suitable for the intended application.

2.1.1.3 Use of flammable materials is only acceptable for electrical isolating purposes of the fuel cell stack, the fuel cell stack and shall be minimized as far as practicable and requires the approval of the Society.

2.1.2 Requirements for piping systems

2.1.2.1 Austenitic stainless steel (e.g. 304, 316, 304L and 316L) shall be used for materials in contact with reformed fuel. Other materials may be approved after special consideration.

2.1.2.2 The materials used for auxiliary piping shall meet the requirements of Pt.4 Ch.6.

2.1.2.3 The materials used for primary fuel piping shall meet the requirements of Sec.5, Sec.6 or Pt.4 Ch.6 as applicable.

2.1.2.4 The certification of materials used for primary or reformed fuel piping shall be in accordance with Sec.5, Sec.6 or Pt.4 Ch.6 as applicable.

3 Design principles for FC(Power) notation

3.1 General

3.1.1 The design shall ensure that a single failure in the FC power installation shall not lead to an unacceptable loss of power.

3.1.2 The fuel cell power installation shall be so designed that safety actions required by the Rules shall not lead to an unacceptable loss of power.

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

4 Requirements for fuel cell power systems

4.1 Piping arrangement for fuel cell power system

4.1.1 All primary and reformed fuel piping shall be fitted with secondary enclosure capable of safely containing any leakages. An arrangement where the secondary enclosure is nitrogen filled and monitored for pressure may be an acceptable solution.

4.1.2 Alternatively, the following arrangement may be accepted: All primary and reformed fuel pipes shall be fully welded. The ventilation rate in the fuel cell space shall be sufficient to dilute the gas concentration below the flammable range in all leakage scenarios, including pipe rupture. Possible liquid leakages shall be shielded from ignition sources.

4.2 Exhaust gas and exhaust air outlets

4.2.1 Exhaust air and exhaust gases from the fuel cell power systems shall be led to the open air and shall not be combined with ventilation systems.

4.2.2 If the presence of explosive gases cannot be excluded, the exhaust air and/or exhaust gas shall be arranged as an outlet from a hazardous zone.

4.3 Purge gas outlets

4.3.1 Purge piping from the fuel cell power systems shall be led separately to the open air and shall be arranged as an outlet from a hazardous zone.

5 Design principles for fuel cell spaces

5.1 Fuel cell spaces

5.1.1 Fuel cell space boundaries shall be gas tight towards other enclosed spaces in the ship.

5.1.2 Fuel cell spaces shall be designed to safely contain fuel leakages.

5.1.3 Fuel cell spaces shall be arranged to avoid the accumulation of hydrogen rich gas by having simple geometrical shape and no obstructing structures in the upper part. Large fuel cell spaces shall be arranged with a smooth ceiling sloping up towards the ventilation outlet. Thin plate ceiling to cover support structure under the deck plating is not acceptable.

5.1.4 Fuel cell spaces containing fuel reformers shall also comply with the requirements relevant for the primary fuel.

5.1.5 Tanks for intermediate storage of primary or reformed fuel, if necessary, shall be located outside the fuel cell space containing the fuel cells.

5.1.6 In general the surface temperature of components and pipes in the fuel cell space shall never be above the self- ignition temperature for the fuel used.

5.1.7 Fuel cell power systems with reformed fuel temperatures above the self-ignition temperature shall be subject to special consideration by risk analysis.

5.2 Location and access

5.2.1 Fuel cell spaces shall be arranged outside of accommodation, service and machinery spaces and control stations.

5.2.2 Where an independent and direct access to the fuel cell spaces from the open deck cannot be arranged, access to fuel cell spaces shall be through an air lock which complies with Sec.5 [3.4].

5.2.3 For small fuel cell spaces having the possibility for gas freeing of the fuel cell power system before entering, the access may be evaluated case by case considering gas tightness and need for access during normal operation.

5.3 Ventilation

5.3.1 General

5.3.1.1 Fuel cell spaces shall be equipped with a mechanical ventilation system of the extraction type providing effective ventilation of the complete space, also taking into consideration the density of potentially leaking fuel gases.

Guidance note:

To enhance ventilation in areas containing leakage sources, the use of ventilation hoods should be evaluated.

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5.3.1.2 The ventilation rate in fuel cell spaces shall be sufficient to dilute the gas/vapour concentration to below the flammable range in all leakage scenarios, including pipe rupture.

5.3.1.3 Any ducting used for the ventilation of fuel cell spaces shall not serve any other spaces.

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

5.3.1.5 Electric fan motors shall not be located in ventilation ducts for fuel cell spaces unless the motor is certified for hydrogen and other fuels.

5.3.1.6 Two fans shall be installed for the ventilation of the fuel cell space with 100% capacity each. Both fans shall be supplied from separate circuits.

Guidance note:

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

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5.3.1.7 In case of loss of ventilation or loss of negative pressure in the fuel cell space the fuel cell power system shall carry out an automatic shut down of the fuel supply to the fuel cell space.

5.3.1.8 Protective screens with a mesh spacing of not more than 13 mm shall be mounted at the outer openings of ventilation ducts.

5.3.2 Ventilation air inlet

5.3.2.1 Ventilation air inlets for fuel cell spaces shall be taken from areas, which in the absence of the considered inlet would be non-hazardous.

5.3.2.2 Ventilation 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.

5.3.3 Ventilation air outlet

5.3.3.1 Ventilation air outlets from fuel cell 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 Fire safety

6.1 General

6.1.1 General

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

6.1.1.2 The fuel cell space shall be regarded as a machinery space of category A according to SOLAS Ch.II-2 for fire protection purposes.

6.2 Fire protection

6.2.1 Construction

6.2.1.1 Fuel cell spaces shall have A60 insulation to all surrounding spaces including separation walls between fuel cell spaces.

6.3 Fire detection and alarm systems

6.3.1 Detection

6.3.1.1 An approved fixed fire detection system shall be provided for the FC spaces.

Guidance note:

The type of fire detection system should 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.

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6.3.1.2 Smoke detectors only are not considered sufficient for rapid fire detection.

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

6.3.1.4 At fire detection the ventilation of the fuel cell space shall stop automatically.

6.4 Fire extinguishing

6.4.1 General

6.4.1.1 A fixed fire-extinguishing system is required in fuel cell spaces.

6.4.1.2 The fire-extinguishing system shall be suitable for use with the specific primary and reformed fuels and fuel cell technology used.

6.4.1.3 Required safety actions at fire detection in the FC space are given in Table 7.

6.4.2 Fire Dampers

6.4.2.1 Air inlet and outlet openings shall be provided with fire dampers, which shall be operable from outside the fuel cell space.

6.4.2.2 Before release of the fire extinguishing system the fire dampers shall be closed.

7 Electrical systems

7.1 General

7.1.1 General

7.1.1.1 The requirements in this section are additional to those given in Pt.4 Ch.8.

7.1.1.2 Electrical equipment and wiring shall in general not 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 [7.2].

7.1.1.3 It shall be ensured that the fuel cell can be disconnected from the electrical load at any load condition.

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

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

Guidance note:

For definition of switch disconnector, see IEC 60947-3.

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7.1.1.6 With reference to IEC 60079-20, the following temperature class and equipment groups may be used for potential ship fuels:

Table 5 Temperature class and equipment groups

	Temperature class	*Equipment group*
Natural gas	T1	IIA
LPG (propane, butane)	T2	IIA
Hydrogen	T1	IIC
Methyl alcohol	T2	IIA
Ethyl alcohol	T2	IIB

7.2 Area classification

7.2.1 General

7.2.1.1 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 [7.2.2].

7.2.1.2 Areas and spaces other than those mentioned in [7.2.2] shall be subject to special consideration. The principles of the IEC standards shall be applied.

7.2.2 Definition of zones

Hazardous areas zone 0

7.2.2.1 The interiors of buffer tanks, reformers, pipes and equipment containing low flashpoint fuel or reformed fuel, any pipework of pressure-relief or other venting.

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 suitable for installation in zone 0.

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7.2.2.2 Hazardous areas zone 1

1) Fuel Cell spaces.
2) Areas on open deck, or semi- enclosed spaces on deck, within 3 m of any reformed fuel or purge gas outlets, or fuel cell space ventilation outlets and around other reformed fuel valves and reformed fuel pipe flanges.
3) Fuel cell exhaust air and exhaust gas outlets.
4) Areas on open deck or semi-enclosed spaces on deck, within 1.5 m of fuel cell space entrances, fuel cell space ventilation inlets and other openings into zone 1 spaces.
5) Enclosed or semi-enclosed spaces in which other sources of release of reformed fuel are located.

7.2.2.3 Hazardous areas zone 2

1) Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 as specified in [7.2.2.2], if not otherwise specified in this standard.
2) Air locks.

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

7.2.2.5 Fuel cells not certified for zone 1 need to be deenergized in case of gas detection.

8 Control, monitoring and safety systems

8.1 General

8.1.1 Functional requirements

8.1.1.1 The control, monitoring and safety systems applied to a fuel cell power installation shall be arranged to fulfil the functional requirements stated below:

— Leakages of gaseous fuel / vapour 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.
— 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.

8.1.2 Arrangement of gas control, monitoring and safety systems

8.1.2.1 Each fuel cell power installation shall be fitted with dedicated controllers for gas/vapour 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 Sec.3. 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].

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8.1.2.2 Monitoring requirements for the fuel cell power installation are given in Table 5 and Table 6. Table 6 gives alarm requirements for gas detection and other conditions, Table 7 give requirements to protective safety functions with alarm to be handled by the fuel safety system. For alarm conditions found in Table 7, separate sensors shall be arranged for the gas control and monitoring system and for the fuel safety system.

8.1.2.3 Gas/vapour detection alarms as required by [8.2.1.1] 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 cell power installation safety functions.

8.1.2.4 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.

8.1.2.5 Gas detection functionality and fuel safety functionality for a fuel supply system inside fuel cell space can be implemented in a common system unit if the system is redundant.

8.1.2.6 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.

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8.1.2.7 The output signals required to perform the safety actions specified in Table 7 shall be electrically independent of the fuel 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.

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8.1.2.8 Where gas/vapour 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.

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8.1.3 Emergency stop

8.1.3.1 Fuel cell power installations 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 and inside of fuel cell space.

8.1.4 Risk analysis

8.1.4.1 A risk 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.

Guidance note:

Typical monitoring that should be considered:

- cell voltage
- cell voltage deviations
- temperature exhaust gas
- temperature in FC stack
- electric current
- process air flow
- process air pressure
- cooling medium flow, level, pressure, temperature
- fuel flow
- fuel temperature
- fuel pressure
- gas detection in exhaust gas
- process water system level, pressure, purity
- parameters necessary to monitor lifetime/ deterioration.

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8.2 Fuel cell power installation - control and monitoring

8.2.1 Gas or vapour detection

8.2.1.1 A permanently installed gas/vapour detection system shall be provided for:

- fuel cell spaces
- air locks
- expansion tanks/degassing vessels in heating/cooling circuits in contact with fuel
- other enclosed spaces where primary/reformed fuel may accumulate.

8.2.1.2 The detection systems shall continuously monitor for gas/vapour.

8.2.1.3 Detection systems for flammable products capable of measuring gas/vapour concentrations in the range 0-100% LEL are acceptable.

8.2.1.4 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 6.

8.2.1.5 The detectors shall be located where gas/vapour may accumulate and/or in the ventilation outlets. Gas dispersal analysis or a physical smoke test shall be used to find the best arrangement.

8.2.2 Ventilation

8.2.2.1 Reduced ventilation below the required capacity shall be alarmed.

8.2.2.2 In order to verify the performance of ventilation systems, a detection system of the ventilation flow and a monitoring system of the negative fuel cell space pressure is required. A running signal from the ventilation fan motor is not sufficient to verify performance.

8.2.3 Bilge wells

8.2.3.1 Bilge wells in fuel cell spaces shall be provided with level sensors. Alarm shall be given at high level in bilge well.

Table 6 Alarm and monitoring

	Alarm conditions
Gas detection	
Fuel cell spaces 20% LEL	HA
Expansion tanks/degassing vessels in systems for heating/ cooling	HA
Air locks	HA
Other enclosed spaces where primary/reformed fuel may accumulate	HA
Bilge	
Fuel cell space	HA
Ventilation	
Reduced ventilation in fuel cell spaces	LA
Other alarm conditions	
Air lock,more than one door moved from closed position	A
Air lock, door open at loss of ventilation	A
A = Alarm activated for logical value *LA* = Alarm for low value *HA* = Alarm for high value	

8.3 Fuel cell power installation - safety

8.3.1 Safety upon gas, vapour or liquid detection

8.3.1.1 Arrangement shall be provided to detect rapidly liquid primary fuel leakages inside fuel cell spaces. Detection of liquid shall shut down the affected fuel cell power system and disconnect ignition sources.

8.3.1.2 Gas/vapour detection in a fuel cell space when two self-monitored detectors indicate a gas or vapour concentration of 40% LEL shall shut-down the affected fuel cell power system and disconnect ignition sources and shall result in automatic closing of all valves required to isolate the leakage. This will require that valves in the primary fuel system supplying liquid or gaseous fuel to the fuel cell space shall close automatically.

8.3.1.3 Gas detection in the secondary enclosure of pipes for gaseous fuel shall be designed in accordance with Sec.5 [9.3.2]

8.3.2 Safety upon loss of ventilation

8.3.2.1 Loss of ventilation in a fuel cell space shall result in an automatically shut down of the fuel cell by process control within a limited period of time. The period for the shut down by process control shall be considered on a case by case basis based on the risk analysis.

8.3.2.2 After the period has expired a safety shut down shall be carried out.

8.3.2.3 Loss of ventilation in secondary enclosure of pipes for gaseous fuel shall be designed in accordance with Sec.5 [9.3.5]

8.3.3 Manual shutdown push buttons

8.3.3.1 Means of manual emergency shutdown of fuel supply to the fuel cell space and de-energizing the ignition sources shall be provided inside a fuel cell space, in the engine control room 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 safety system and be arranged with loop monitoring.

8.3.4 Safety actions

8.3.4.1 The requirements above and Table 7 below specify fuel cell power installations safety actions required to limit the consequences of system failures.

8.3.4.2 Safety actions additional to the ones required by Table 7 may be required for unconventional or complex fuel cell power installations.

Table 7 Safety Actions

	Alarm	***Shutdown of fuel cell space valve***	***Shutdown of ignition source***	***Signal to other control/safety systems for additional action***
Liquid detection inside fuel cell space	X	X	X	
40 % LEL inside fuel cell space at 2 detectors	X	X	X	
Gas detection in the secondary enclosure of pipes	X	X		
Loss of ventilation or loss of negative pressure in a fuel cell space	X			The fuel cell shall be automatically shut down by process control
Loss of ventilation in secondary enclosure of pipes	X			The fuel cell shall be automatically shut down by process control
Fire detection	X	X	X	Shutdown of ventilation, release of fire extinguishing system
Emergency release button	X	X	X	

9 Manufacture, workmanship and testing

9.1 FC fuel piping systems

9.1.1 FC fuel pipes and ducting

9.1.1.1 Reformed fuel piping systems, as specified in [4.1.1], shall be tightness tested with hydrogen or an appropriate test gas to show that there is no leakage.

9.1.1.2 Valves in the FC piping system shall be leakage tested for the FC fuel used.

9.1.1.3 Valves for use in reformed fuel pipes, as specified in[4.1.1], shall be tightness tested (internally, externally) with hydrogen or an appropriate test gas to show that there is no leakage.

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

9.2 On board testing of FC plant

9.2.1 General

9.2.1.1 Testing after installation on board of the whole system shall be performed in different relevant load conditions (typically: "start up"; "normal running";" full load"; "load changes up/down")

9.2.1.2 It shall be verified for the following events that the FC power installation triggers an alarm and / or is automatically transferred into a safe condition:

— fire detection
— gas detection
— loss of ventilation flow
— loss of negative pressure in fuel cell space
— failure of the power supply
— failure of the programmable logic controllers (PLCs)
— triggering of the protective devices
— failure in the protective system.

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

9.2.1.3 The interaction of the FC power installation with the ship systems shall be tested as applicable:

— power generation by the FC power installation system alone
— FC power installation together with conventional shipboard generation of electrical power
— FC power installation together with batteries
— change-over to the emergency source of electrical power
— switching the FC power installation online or offline
— testing of sudden load variations and load rejection.

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

9.2.1.5 For fuel cell spaces and ventilated ducts it shall be examined and tested that underpressure and ventilation can be fully accomplished. Ventilation rate at minimum flow shall be documented. Required shutdowns and / or alarms upon ventilation falling below prescribed values shall be tested.

9.3 Survey and testing of electrical equipment in hazardous area

9.3.1 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 pressurization for an Ex(p) control panel) it shall be verified that the devices have correct settings and/or correct operation of alarms.

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 (ν, ρ, T)**. The numbers in brackets indicate the maximum viscosity in cSt at 50°C, the maximum density in kg/m^3 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

Term	*Definition*
Booster system	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
Fuel	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
Fuel additives	are chemical substances used to improve the fuel treatment efficiency and or fuel performance in diesel engines as well as minimising harmful effects

Term	Definition
Fuel quality	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
Fuel storage system	incorporates tanks for fuel storage which are not intended to influence the cleaning process (settling and drainage of contaminants)
Separator	is a permanently fitted centrifuge for fuel cleaning
Transfer system	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
Treatment system	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

Object	*Certificate type*	*Issued by*	*Certification standard**	*Additional description*
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

Object	*Documentation type*	*Additional description*	*Info*
Fuel oil system	S010 – Piping diagram (PD)	Fuel oil transfer pipes with heat tracing (including any low sulphur fuel change over system for SO_x 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

Object	Documentation type	Additional description	Info
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 DNVGL-CG-0550 Sec.6.

1.7.3
For a full definition of the documentation types, see DNVGL-CG-0550 Sec.5.

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.

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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.

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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/m^2.

---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 LNG

1 General

1.1 Objective

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

1.2 Scope

The scope for additional class notation **Gas fuelled LNG** 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 LNG** 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. Collision and grounding protection for fuel tanks are covered by statutory requirements (IGF Code). 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 LNG**.

1.4 Classification

1.4.1 Survey extent

1.4.1.1 Survey requirements for ships with the class notation **Gas fuelled LNG** are given in Pt.7 Ch.1 Sec.2 [1], 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

Terms	*Definition*
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

Terms	*Definition*
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 The spaces around the fuel tank are defined as follows: 1) *Fuel storage hold space* is the space enclosed by the ship's structure in which a fuel containment system is situated. If tank connections are located in the fuel storage hold space, it will also be a tank connection space; 2) *Interbarrier space* is the space between a primary and a secondary barrier, whether or not completely or partially occupied by insulation or other material; and 3) *Tank connection space* is a space surrounding all tank connections and tank valves that is required for tanks with such connections in enclosed spaces. **Guidance note:** A tank connection space may also contain equipment such as vaporizers or heat exchangers. Such equipment is considered to only contain potential sources of release, but not sources of ignition. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
fuel preparation room	any space containing pumps, compressors and/or vaporizers for fuel preparation purposes **Guidance note:** A tank connection space which has equipment such as vaporizers or heat exchangers installed inside is not regarded as a fuel preparation room. Such equipment is considered to only contain potential sources of release, but not sources of ignition. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
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 GVU, gas regulating unit, GRU or gas train. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Terms	*Definition*
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. Hazardous areas are divided into zone 0, 1 and 2 as defined below and according to the area classification specified in [8] *zone 0* Area in which an explosive gas atmosphere is present continuously or is present for long periods. *zone 1* Area in which an explosive gas atmosphere is likely to occur in normal operations. *zone 2* 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
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

Terms	*Definition*
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
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

Object	*Documentation type*	*Additional description*	*Info*
Propulsion and steering arrangements, general	Z050 – Design philosophy	Including information on the machinery configuration, machinery space arrangements, fuel arrangements, shut down philosophy, redundancy considerations, boil off handling, 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	For non-conventional gas fuelled propulsion machinery arrangements: 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
	Z030 - Arrangement plan	Location of fuel tank(s) with distances related to: — fire protection — inspection	AP
	Z030 - Arrangement plan	Arrangement of fuel preparation rooms and tank connection spaces with regard to cryogenic protection of the ship structure [3.3.2] and [3.3.4].	AP
	Z160 - Operation manual	See [1.8.1.1].	AP
	Z240 – Calculation report	Explosion analysis (ESD protected machinery spaces).	FI

Object	*Documentation type*	*Additional description*	*Info*
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
	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
	M150 – 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	Boil off gas rate when pressure accumulation is not 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

Object	*Documentation type*	*Additional description*	*Info*
	S060 - Pipe routing sketch	Location of tank valves as close as possible to tank	AP
	Z164 - Inspection manual	Inspection/survey plan for the liquefied gas fuel containment system, see [4.2.1.9].	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
Fuel gas safety system	I200 – Control and monitoring system documentation	Functionality as required by Table 10	AP
	G130 – Cause and effect diagram	— shall cover the safety functions as required by Table 10 — interfaces to other safety and control systems shall be included.	AP
Fuel gas piping system	S011 - Piping and instrumentation diagram (P&ID)	Including — vent lines for safety relief valves — secondary enclosures for fuel pipes including pressure relief arrangements — boil off system — bunkering lines — gas supply system — gas freeing and purging system.	AP
	S060 – Pipe routing sketch		FI
	S080 – Thermal stress analysis	When design temperature is below -110°C.	FI
	Z265 - Calculation report	Stress analysis for high pressure fuel piping.	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
	Z100 – Specification	Closing time of shutdown valves in liquefied gas fuel lines operated by the safety system.	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

Object	*Documentation type*	*Additional description*	*Info*
Fuel gas cooling system	S011 - Piping and instrumentation diagram (P&ID)		AP
Fuel gas heating system	S011 - Piping and instrumentation diagram (P&ID)		AP
Exhaust gas system	S010 – Piping diagram (PD)	Including arrangement of explosion relief or verification of strength of piping system, see [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
Ventilation systems for gas fuel system spaces	S012 – Ducting diagram (DD)	Including capacity and location of fans and their motors.	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

Object	Documentation type	Additional description	Info
External surface protection water spraying system	G200 – Fixed fire extinguishing system documentation		AP
Bunkering station and fuel preparation room 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 DNVGL-CG-0550 Sec.6.

1.6.1.3 For a full definition of the documentation types, see DNVGL-CG-0550 Sec.5.

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

Object	Certificate type	Issued by	Certification standard*	Additional description
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).

Object	*Certificate type*	*Issued by*	*Certification standard**	*Additional description*
Valves in fuel system	PC	Manufacturer		For valves with design pressure equal to or lower than 10 bar, and design temperature equal to or above 0°C.
Expansion bellows	TA	Society		In accordance with Pt.5 Ch.7 Sec.5.
Flexible hoses with couplings	TA	Society		In accordance withPt.4 Ch.6.
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.
Ventilation fans for hazardous spaces	PC	Society		Shall be certified in accordance with Pt.5 Ch.7 Sec.12.
*Unless otherwise specified the certification standard is DNV GL rules.				

1.7.1.2
For general certification requirements, see DNVGL-CG-0550 Sec.4.

1.7.1.3
For a definition of the certification types, see DNVGL-CG-0550 Sec.3.

1.8 Onboard documentation

1.8.1 Contents

1.8.1.1 An operational manual shall be prepared as required by the IGF Code Ch.18.

Guidance note:

The operation manual should include the following information:

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
   - a description of the boil off handling system if installed.
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 rooms.
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
   - GVU 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.

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1.8.1.2 A plan for periodic test of all field instruments specified in these rules shall be kept on board. 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 10) 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.

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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 -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 -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, DNVGL-CG-0550 Sec.3.

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 fittings4), 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				

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.

3.1.1.3 Areas with piping systems for gaseous fuel shall be arranged to prevent gas spreading to non-hazardous spaces.

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.

Guidance note:

Premixed engines using fuel gas mixed with air before the turbocharger shall be located in ESD protected machinery spaces.

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

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. See Sec.2 for class notations **E0** and **ECO**.

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 Unless located on open deck, 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.

Guidance note:

Fuel preparation rooms on open deck located directly above machinery spaces of category A or other rooms with high fire risk are expected to be specially considered in the risk assessment required by the IGF Code.

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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 material of the boundaries of the fuel preparation room shall have a design temperature corresponding with the lowest temperature it can be subjected to in a probable maximum leakage scenario unless the boundaries of the space, i.e. bulkheads and decks, are provided with suitable thermal protection.

Guidance note:

For fuel preparation spaces on cargo vessels, alternative solutions to full cryogenic boundary protection may be accepted based on assessments of maximum probable leakage and assessments of the safety consequences of such alternative solutions.

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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 material of the bulkheads of the tank connection space shall have a design temperature corresponding with the lowest temperature it can be subject to in a probable maximum leakage scenario.

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 special consideration. Depending on the arrangement this may include:

— segregation towards other areas on the ship
— hazardous area plans for the ship
— requirements for forced ventilation
— requirements for leakage detection (gas detection, low temperature detection)
— safety actions related to leakage detection (gas detection, low temperature detection)
— access to bunkering station from non-hazardous areas through air locks
— monitoring of bunkering station by direct line of sight or 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 hatch.

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 m^2. 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 under-pressure 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 barg. 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

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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
   — 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].

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
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 Table 5.

Table 5 Secondary barrier requirements for tanks

Basic tank type	*Secondary barrier requirements*
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]

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 4) 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], 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 it's 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 the design acceleration*a* in Table 6 in forward direction and a/2 in the aft direction, where g is gravitational acceleration.

Table 6 Design acceleration

Ship length (L)	*Design acceleration (a)*
L > 100 m	0.5 g
60 < L ≤ 100 m	$\left[2 - \frac{3(L-60)}{80}\right]_g$
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 material 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:

1) The primary barrier of all tanks shall be assumed to be at the liquefied gas fuel temperature.
2) 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.
3) 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.
4) Still air and sea water conditions shall be assumed, i.e. no adjustment for forced convection.
5) 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 .7 shall be assumed.
6) The cooling effect of the rising boil-off vapour from the leaked liquefied gas fuel shall be taken into account where applicable.
7) No credit shall be given for any means of heating, unless specially considered by the Society.

8) For members connecting inner and outer hulls, the mean temperature may be taken for determining the steel grade.
9) 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, shall be in accordance with Pt.5 Ch.7 Sec.6 Table 5 (footnote 3 covering deck and shell plating and all stiffeners attached thereto is not applicable). 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 Materials of primary and secondary barriers are defined in Pt.5 Ch.7 Sec.4 [5.1.2].

4.2.13.4 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 shall be carried out in accordance with DNVGL-CG-0129 and/or 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 leakages from pipes releasing gaseous fuel in case of leakage, to compensate for not having closable tank valves at the tank boundary. The outer shell shall be able to withstand the temperatures and the pressure build-up due to gaseous pipe leakages.

4.2.16.2 Pipes releasing liquefied fuel in case of leakage shall be protected by a secondary enclosure up to the first valve. The secondary enclosure shall be able to withstand the pressure build-up due to evaporating liquefied fuel, but the design pressure shall be not less than the design pressure of the inner tank. Leakage detection shall be provided for both the inner pipe and the secondary enclosure.

4.2.16.3 Pipes in the vacuum space shall have no branch connections.

4.2.16.4 Pipes and secondary enclosures in the vacuum space shall be fully welded.

4.2.16.5 A pipe stress analysis is required for the pipes and the secondary enclosures in the vacuum space.

4.2.16.6 Pipe routing shall compensate for expansion and contractions due to changes in temperature. The use of expansion elements is not accepted for this purpose.

4.2.16.7 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.

4.2.16.8 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 enclosures as required by [4.2.16.2] shall be provided also for pipes in the vacuum space releasing gaseous fuel in case of leakage.
— 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.

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
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.

Guidance note:

The higher loading limit option is understood to be an alternative to [4.5.1.1] and should only be applicable when the calculated loading limit using the formulae in [4.5.1.1] gives a lower value than 95%.

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

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 including after activation of the safety system required by these rules. 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.

Guidance note:

The activation of the safety system alone is not deemed as an emergency situation.

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

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 (i.e. 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 on board 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.

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].

Guidance note:

A tank connection space may be required also for tanks on open deck. This may apply for ships were restriction of hazardous areas is safety critical. A tank connection space may also be necessary in order to provide environmental protection for essential safety equipment related to the gas fuel system like tank valves, safety valves and instrumentation.

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

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.

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 automatically isolate the leakage from the source.

5.1.1.5 It shall be possible to automatically isolate the piping systems for 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.

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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 Bunkering lines shall have a design pressure not less than 20 bar.

5.1.3.4 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.

5.1.3.5 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.

5.1.3.6 Piping in the fuel system shall not be located less than 800 mm from the ship's side.

5.1.3.7 Fuel piping including vent lines shall not be routed through tanks.

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

5.1.3.9 Gas fuel piping in ESD protected machinery spaces shall be located as far as practicable from the electrical installations and tanks containing flammable liquids.

5.1.3.10 Gas fuel piping in ESD protected machinery spaces shall be protected against mechanical damage.

5.1.3.11 Fuel piping shall be capable of absorbing thermal expansion or contraction caused by extreme temperatures of the fuel without developing substantial stresses.

5.1.3.12 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.

5.1.3.13 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.

5.1.3.14 If the fuel gas contains heavier constituents that may condense in the system, means for safely removing the liquid shall be fitted.

5.1.3.15 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.

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5.1.3.16 When the design temperature is minus 110°C or colder, a complete stress analysis, taking into account all the stresses due to weight of pipes, including acceleration loads if significant, internal pressure, thermal contraction and loads induced by hog and sag of the ship shall be carried out for each branch of the piping system.

5.1.3.17 High-pressure gas lines shall be installed and protected so as to minimise the risk of injury to personnel in case of rupture.

5.1.3.18 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.

5.1.3.19 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---

5.1.3.20 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 on board, 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 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 may be waived.

5.1.4.2 The requirement in [5.1.4.1] need not be applied for fully welded liquefied fuel pipes without fittings or valves 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 gaseous fuel 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 Fully welded gaseous fuel pipes need not be arranged with secondary enclosure on open deck.

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:

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

Where

p_0	=	maximum working pressure of the inner pipe
k	=	Cp/Cv - 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 Parts of the secondary enclosure extending to air inlets and outlets on open deck shall be dimensioned for a design pressure corresponding to the requirements in [5.1.5.5] and [5.1.5.6] unless a lower design pressure may be justified by back pressure calculations.

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 10 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 Emergency shut down valves (as provided for safety functions) 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. For pressure relief valves in the bunkering lines, the set pressure shall be equal to the design pressure.

5.1.6.7 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 10. 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.

5.1.6.8 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 10, 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---

5.1.6.9 Other vents in the gas supply line shall be arranged in such a way that they do not compromise the double-block-and-bleed function.

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 seconds of actuation. Information about the closure time of the valves and their operating characteristics shall be available on board, and the closing time shall be verifiable and repeatable.

5.1.7 Expansion bellows

5.1.7.1 Expansion bellows shall normally not be installed in enclosed spaces.

5.1.7.2 Expansion 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, expansion bellows in pipes containing gaseous fuel shall only be installed in fuel preparation rooms or tank connection spaces.

5.1.7.5 If accepted, expansion bellows in systems for cryogenic liquids shall only be installed in spaces designed to withstand cryogenic leakages.

5.1.7.6 Expansion 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 [2.1.5].

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. In case the pressure relief valves are located in open air, stop valve only at the inlet of the pressure relief valve is accepted. The outlet of the pressure relief valve shall then be fitted with a blind flange.

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 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.

5.2.2.6 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.

5.2.2.7 All other fuel gas vent outlets shall be arranged in accordance with [5.2.2.5] and [5.2.2.6]. Means shall be provided to prevent liquid overflow from gas vent outlets, due to hydrostatic pressure from spaces to which they are connected.

5.2.2.8 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.

5.2.2.9 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.

5.2.2.10 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 0.015 L 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 during transfer operation between LNG fuel tanks (see Table 10).

5.3.3.4 The connections at the bunkering station shall be of dry-disconnect type. The couplings shall be of a standard type.

Guidance note:

The IGF Code is requiring an additional safety dry breakaway coupling/self-sealing quick release in the bunkering arrangement.

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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% 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% 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. Bursting discs shall not open into machinery spaces, but may be located inside the engine room casing.

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.

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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 uninterruptible power supply (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 2.

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.

Guidance note:

Double piping and gas valve unit spaces in gas safe engine rooms are considered an integral part of the fuel supply systems and, therefore, their ventilation system does not need to be independent of other fuel supply ventilation systems provided such fuel supply systems contain only gaseous fuel.

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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.

Guidance note:

Spaces enclosed in the boundaries of machinery spaces (such as purifier's room, engine room workshops and stores) are considered an integral part of machinery spaces containing gas fuelled consumers and, therefore, their ventilation system does not need to be independent of the one of machinery spaces.

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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. 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 unless located on open deck 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.

Guidance note:

The following other rooms with high fire risk should as a minimum be considered, but not be restricted to:

1) Cargo spaces except cargo tanks for liquids with flashpoint above 60°C and except cargo spaces exempted in accordance with SOLAS regulations II-2/10.7.1.2 or II-2/10.7.1.4.
2) Vehicle, ro-ro and special category spaces.
3) Service spaces (high risk): galleys, pantries containing cooking appliances, saunas, paint lockers and store-rooms having areas of 4 m^2 or more, spaces for the storage of flammable liquids and workshops other than those forming part of the machinery space, as provided in SOLAS regulations II-2/9.2.2.4, II-2/9.2.3.3 and II-2/9.2.4.
4) Accommodation spaces of greater fire risk: saunas, sale shops, barber shops and beauty parlours and public spaces containing furniture and furnishing of other than restricted fire risk and having deck area of 50 m^2 or more, as provided in SOLAS regulation II-2/9.2.2.3.

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Guidance note:

Fuel preparation rooms on open deck located directly above machinery spaces of category A or other rooms with high fire risk are expected to be specially considered in the risk assessment required by the IGF Code.

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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/m^2 for horizontal projected surfaces and 4 l/min/m^2 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.

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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 seconds 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 Fuel preparation room

7.3.4.1

Fuel preparation rooms shall be provided with a fixed fire-extinguishing system complying with the provisions of the FSS code and taking into account the necessary concentrations/application rate required for extinguishing gas fires.

7.3.5 Fire dampers

7.3.5.1 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 to the tank connection space and in the tank connection space, 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.

Guidance note:

Smoke detectors may be combined with either temperature or flame detectors to increase possibility for detection of a fire. It should be noted that flame detectors will normally activate before temperature detectors.

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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.

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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, temperature class and equipment groups listed in Table 7 can be used for potential ship fuels:

Table 7 Temperature class and equipment groups

	Temperature class	*Equipment group*
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.

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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 IEC 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 gas detection system, fuel safety system and fuel control and monitoring system. 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 gas detection function, the gas safety function and the fuel control and monitoring function 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 [1.3.2] and Pt.4 Ch.9 Sec.4 [3].

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9.1.2.2 Monitoring requirements for the fuel installation are given in Table 8, Table 9 and Table 10. Table 8 gives alarm requirements for gas detection, Table 9 gives alarm and indication requirements to be handled by the gas control and monitoring system. Table 10 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 9 and Table 10, 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 The gas detection system shall present the gas alarms as required by [9.2.4] on bridge, at the control location for bunkering and locally. If alarming depends on network communication, the functionality shall be handled by separate network segment arranged for the fuel installation safety functions.

9.1.2.5 The fuel gas safety system shall present the gas safety alarms as specified in Table 10 on 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 The gas detection system and fuel safety system for a fuel supply installation 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 10 shall be hardwired, and arranged with loop monitoring.

Guidance note:

The requirement for hardwired signals is not applicable for signals sent to other systems for additional safety actions as specified in Table 10.

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9.1.2.10 The output signals required to perform the safety actions specified in Table 10 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.

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9.1.2.11 Where gas detection shall cause shutdown in accordance with Table 10, 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.

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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
— 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.

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], 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 where secondary enclosure is required by [5.1.4].

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 from 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 10.

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 8 Gas detection alarms

Alarm conditions	
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
HA = 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 required in combination with pressure monitoring systems, but 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 9 Monitoring of fuel installations

Alarm conditions		*Comment*
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	[5.1.6.8] 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 *IL* = local indication (presentation of values) *IR* = remote indication (presentation of values) in engine control room or control location for bunkering when specified *A* = alarm activated for logical value *LA* = alarm for low value *HA* = 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 [9.2.1.2].

Guidance note:

The tank overflow protection shall be based on a direct reading of the level and not be based on indirect measurement of a value that varies for each bunkering (e.g. density used for dp-cell).

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

9.3.1.2 Where arrangements are provided for overriding the overflow control system, they shall be such that inadvertent operation is prevented, i.e. by interlocking the override function with the bunker valve. When this override is operated continuous visual indication shall be provided at the navigation bridge, continuously manned central control station or onboard safety centre. Overriding of the overflow control system when more than one LNG fuel tank is installed will be subject to special consideration.

9.3.1.3 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 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 secondary enclosure of the bunkering line shall immediately result in automatic closing of the bunkering valve.

9.3.4 Safety fuel heating

9.3.4.1 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.

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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 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 10 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 10 may be required for unconventional or complex fuel installations.

Table 10 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 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-low level in tank		LA						Stop fuel pumps
Gas detection								

Conditions	Automatic safety action with corresponding alarm					Signal to other control/ safety systems for additional action
	Alarm	*Shutdown of tank valves*	*Shutdown of master gas fuel valve*[1)]	*Shutdown of bunker connection valve*	*Isolate ignition sources in the space*	
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
Secondary enclosure of pipes for gaseous fuel outside the machinery space, 2 x 40% LEL	HA	X	X			Open vent valve between master gas valve and DDB valves
Secondary enclosure of pipes for gaseous fuel in the machinery space, 2 x 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				
Leakage detection bunkering line	A[3)]			X		
Fuel heating						
Fuel supply, temperature	LA	X	X			Stop fuel pumps open vent valve between master gas valve and DDB valves
Ventilation [4)]						
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
Fuel preparation room, loss of ventilation	A	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 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, loss of ventilation	A	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		

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
4) safety actions upon loss of ventilation may be based on loss of running signal from ventilation fan motors

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 -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 -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.

Guidance note:

Slip-on welded joints may be accepted for open ended piping above 50 mm diameter, given that the strength of the piping with such a joint is sufficient for the maximum pressure it will be subjected to, and that NDT is carried out to verify the integrity.

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

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°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°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 secondary enclosures located inside the vacuum space of vacuum insulated tanks, the requirements in 1) applies. The extent of examination may be reduced based on special consideration.

5) 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 1 . Ultrasonic testing shall be assessed according to ISO 11666 and shall at least meet the criteria for level 2.

11.2.3 Hydrostatic testing

11.2.3.1 The requirements for testing in this section apply to fuel piping inside and outside the fuel tanks. However, relaxation from these requirements for piping inside fuel tanks and open ended piping may be accepted by the Society.

11.2.3.2 After completion of manufacture, but before insulation and coating, fuel piping shall be subjected to a hydrostatic test to at least 1.5 times the design pressure in presence of the surveyor.

11.2.3.3 Joints welded on board shall be hydrostatically tested to at least 1.5 times the design pressure.

11.2.3.4 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.

11.2.3.5 Secondary enclosures for high-pressure fuel piping shall be pressure tested to the expected maximum pressure at pipe rupture, but minimum 10 bar. Secondary enclosures for low pressure fuel piping shall be tightness tested.

11.2.3.6 Secondary enclosures located inside the vacuum space of vacuum insulated tanks shall be pressure tested to 1.5 times the design pressure. Pneumatic testing may be accepted based on a safety assessment of the test procedure.

11.2.4 Functional testing

11.2.4.1 Fuel piping systems, including valves, fittings and associated equipment, shall be function tested under normal operating conditions.

11.3 Valves

11.3.1 Testing

11.3.1.1 Each type of valve intended to be used at a working temperature below -55°C shall be subject to prototype testing as given in Pt.5 Ch.7 Sec.5 [13.1].

11.3.1.2 All valves shall be subject to production testing as given in Pt.5 Ch.7 Sec.5 [13.1.2].

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 on board after installation.

11.7 Onboard testing

11.7.1 General

11.7.1.1 Control, monitoring and safety systems required by these rules, shall be tested on board in accordance with Pt.4 Ch.9 Sec.1 [4.4].

11.7.1.2 The functionality of the cause and effect diagram required by Table 2 shall be tested on board.

SECTION 6 LOW FLASHPOINT LIQUID FUELLED ENGINES - LFL FUELLED

1 General

1.1 Objective

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 $C2H_5OH$, 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**. The use of low flash point liquid fuel is covered by the IGF-code /SOLAS II-1/G/56 and 57. However, alcohols are covered by the guidelines developed as a supplement to the code.

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	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	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	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	the arrangement for the storage of fuel, including cofferdams around storage tanks
hazardous area	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] *Zone 0* = Area in which an explosive gas atmosphere is present continuously or is present for long periods. *Zone 1* = Area in which an explosive gas atmosphere is likely to occur in normal operation. *Zone 2* = 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	cargo areas for carriage of dangerous goods and cargo decks for cars with fuel in the tanks
machinery spaces	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	area not considered to be hazardous, i.e. gas safe, provided certain conditions are being met

Term	Definition
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	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	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)	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

Table 2 Abbreviation and symbols

Abbreviation	*Description*
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 3.

Table 3 Documentation required

Object	*Documentation type*	*Additional description*	*Info*
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

Object	*Documentation type*	*Additional description*	*Info*
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
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 5.	AP
	I260 - Field instruments periodic test plan		AP
	G130 - Cause and effect diagram	Covering the safety function given by Table 5. Including interfaces to other safety and control systems.	AP

Object	*Documentation type*	*Additional description*	*Info*
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
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

Object	*Documentation type*	*Additional description*	*Info*
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
Inert gas/ nitrogen system	S010 - Piping diagram (PD)		AP
Inert gas control and monitoring system	I200 - Control and monitoring system documentation		AP
AP = for approval *FI* = for information *ACO* = as carried out *L* = local handling *R* = on request *TA* = covered by type approval *VS* = vessel specific.			

1.5.1.2 For general requirements to documentation, including definition of the info codes, see DNVGL-CG-0550 Sec.6.

1.5.1.3 For a full definition of the documentation types, see DNVGL-CG-0550 Sec.5.

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 on board. 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 5) 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.

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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 4

1.5.2.2 For a definition of the certificate types, see DNVGL-CG-0550 Sec.3.

Table 4 Certification required

Object	*Certificate type*	*Issued by*	*Certification standard**	*Additional description*
Combustion control system for LFL burning engines	PC	Society		
	TA	Society		
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. See 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 DNV GL 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 5 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.

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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 accomodation spaces.

3.2.1.2 Other tanks containing LFL-fuel, e.g. drain tanks, shall not be located within machinery spaces or within accomodation spaces.

3.2.1.3 Minimum distance between the fuel tank and fuel pipes and the ship's side shell shall be at least 800 mm.

3.2.1.4 The spaces forward of the collision bulkhead (forepeak) and aft of the aftermost bulkhead (afterpeak) shall not be used as fuel tanks.

3.2.1.5 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.

3.2.1.6 Fuel tanks shall not be accepted in the double bottom on tankers.

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, other fuel tanks containing methyl/ethyl alcohol 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, see IMO MSC/Circ.677

3.2.3.3 The tanks shall have controlled venting, i.e. be fitted with pressure/vacuum (p/v) 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 shall not 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 3 m above the deck level with a vertical efflux velocity of at least 30 m/s or 20 m/s if protected by a suitable device to prevent the passage of flame.

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.

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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 LFLfuel 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 on board 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.9. 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.

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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 5.

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 5.

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 5.

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 (minimum six air changes/hour).
— 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 and for double walled fuel pipes 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 Bunkering pipes shall be double walled.

3.6.2.5 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 regardless of size.

Guidance note:

As opposed to a methanol tanker, a LFL fuel tank will continuously be emptied, implying that unless IG is provided, there will be a continuous explosive atmosphere in the tank. i.e. the frequency of occurrence of an explosive atmosphere is 100% as opposed to a tanker which will experience this during unloading and on the ballast voyage (50%). The consequence of an explosion on a non-tanker with LFL-fuel tanks is higher than on a tanker and as such the total risk increases accordingly.

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

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.

3.8 Exhaust system

3.8.1 General

3.8.1.1 The exhaust system shall be designed to prevent any accumulation of unburnt fuel.

3.8.1.2 Unless exhaust systems are designed with the strength to withstand the worst case over pressure due to ignited gas or fuel leaks, explosion relief systems shall be suitably designed and fitted.

3.8.1.3

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 should 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. It will in any case be specially considered for each installation.

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

3.8.1.4 All consumers of LFL fuel shall have a separate exhaust system.

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 and engine room

4.3.1.1 Fuel pump rooms and engine rooms shall be protected by an approved gas extinguishing system in accordance with SOLAS regulation II-2 and the FSS-code. Fixed pressure water-spraying system may also be considered. The medium shall be suitable for the extinguishing of methyl/ethyl alcohol fires.

4.3.2 Fire extinguishing on open deck

4.3.2.1 Where fuel tanks are located on open deck, there shall be a fixed fire-fighting system of alcohol resistant foam (ARAFFF-type). This shall be operated from a safe position.

4.3.2.2 The foam system shall cover the area below the fuel tank where a large spill of fuel can be expected to spread.

4.3.2.3 The bunker station shall have a fixed fire-fighting system of alcohol resistant foam (ARAFFF-type).

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

4.3.3 Portable fire fighting equipment and fire fighter's outfits

4.3.3.1 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.

4.3.3.2 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.

4.3.3.3 Fire extinguishers shall be arranged within weather tight enclosures adjacent to bunkering station and at entrance to engine rooms.

4.3.3.4 A portable dry chemical powder extinguisher, or an equivalent type, shall be located near the entrance to the bunker station.

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:

	Temperature class	*Equipment group*
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 cantered 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 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.

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 5 shall be implemented in the LFL safety system.

6.3.1.3 The signals required to activate the safety functions given in Table 5 shall be hardwired.

6.3.1.4 The signals required to activate the safety functions given in Table 5 shall be arranged with loop monitoring.

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 5.

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 5, 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 5.

6.3.5 Ventilation monitoring

6.3.5.1 Loss of ventilation shall cause alarm and/or shutdown as given in Table 5. 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 5, 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 5 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 5 shall be electrically independent of the LFL control system.

Table 5 Safety functions

Parameter	*Alarm*	*Automatic shutdown of tank valves*	*Automatic shutdown of master fuel valve*[1)]	*Automatic shutdown of bunkering connection valve*	*Comment*
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			

Parameter	*Alarm*	*Automatic shutdown of tank valves*	*Automatic shutdown of master fuel valve*[1)]	*Automatic shutdown of bunkering connection valve*	*Comment*
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			
Engine room					
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].
General					
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 6 is required for LFL engines.

Table 6 Monitoring of dual fuel diesel or LFL-only engines

System	*Item*	*Gr.1 Indication alarm load reduction*	*Gr.2 Automatic start of standby pump with alarm* [1]	*Gr.3 Shutdown with alarm*	*Comments*
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		

Gr 1 = common sensor for indication, alarm, load reduction
Gr 2 = sensor for automatic start of standby pump
Gr 3 = sensor for shutdown
LA = alarm for low value
HA = alarm for high value
A = alarm activated
SH = 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 All engine components and engine related systems shall be designed in such a way that fire and explosion risks are minimized.

7.2.1.3 Measures shall be taken to ensure effective sealing of injection or admission equipment that could potentially leak fuel into the engine room.

7.2.1.4 Measures shall be taken to ensure that LFL fuel injection pumps and injection devices are efficiently lubricated.

7.2.1.5 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 on board in accordance with Pt.4 Ch.9 Sec.1 [4.4].

8.4.1.2 The functionality of the cause and effect diagram required by Table 3 shall be tested on board.

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 N_2
   - 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 O_2-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.

Guidance note:

The aft peak tank is not accepted due to conflicting and cumbersome issues with;

- hazardous zones
- A 60 insulation and openings to accommodation
- foam monitor
- pipe routing
- life boat arrangement.

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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/m^2 for horizontal projected surfaces and 4 l/min/m^2 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

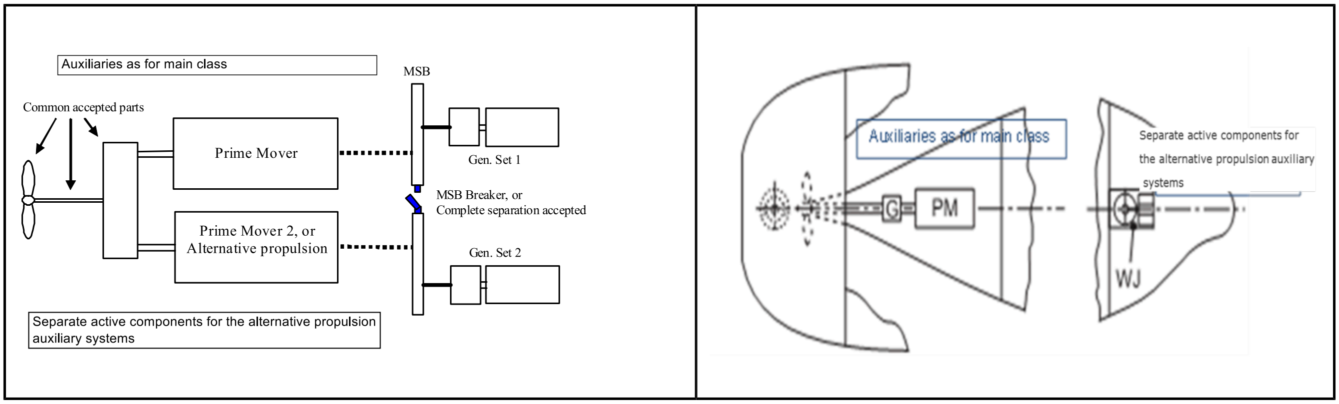

Figure 1 Examples RP(1, x)

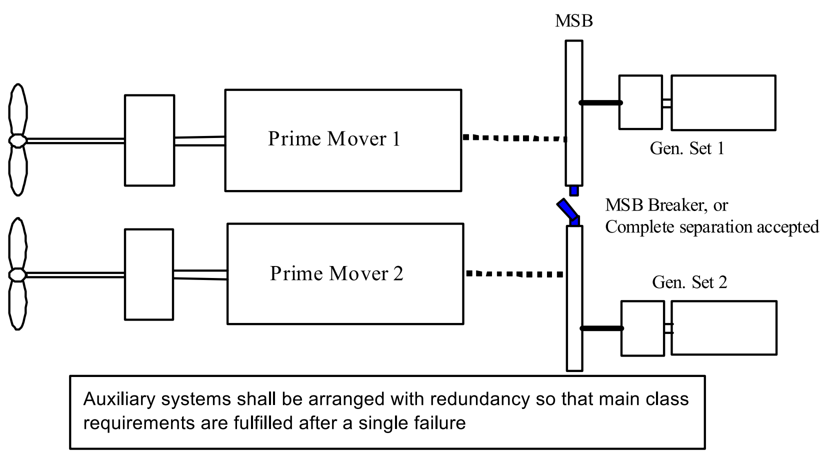

Figure 2 Examples RP(2, x)

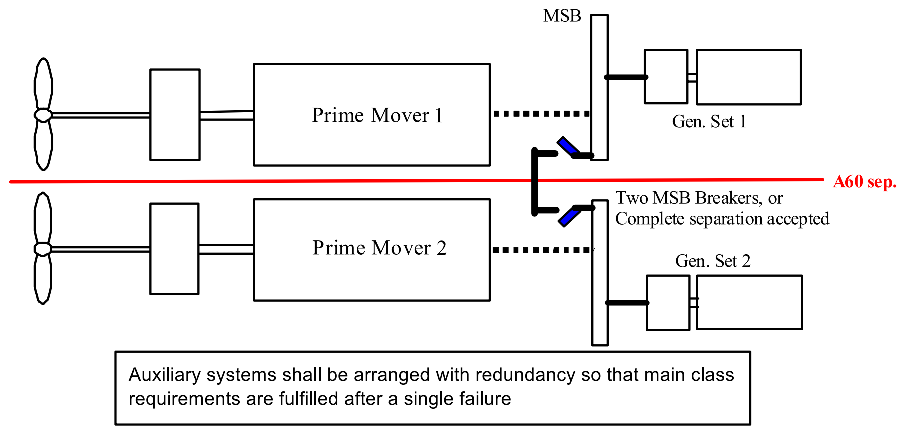

Figure 3 Examples RP(3, x)

1.4 References

1.4.1 References

1.4.1.1 For relevant international standards see Table 2.

Table 2 References

Reference	*Title*
DNV-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*
active components	are components for mechanical transfer of energy, e.g. pumps, fans, electric motors, generators, combustion engines and turbines
bulkhead deck	see Pt.3 Ch.1 Sec.4 Table 7 for definition
mutually independent	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

Term	Definition
redundancy	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
redundancy group	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 shall 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---
remaining propulsion power	is the vessels available propulsion power after the occurrence of a failure
worst case failure	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 [1.5.1.11].	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 [1.5.1.4] to [1.5.1.10].

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 DNV-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 [1.5.1.11] 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 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 shall 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 [2.2.1].

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:

a) Steering systems related to main and alternative propulsion shall be independent.
b) 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 redundancy in the steering function shall be realised by the installation of two mutually independent steering systems, e.g. two rudders or two azimuth thrusters.

Guidance note:

Vessels designed with more than 2 propulsion and/or steering systems will be subject to special evaluation.

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

3.1.1.7 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 capacity.

---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 shall 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 shall 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 When ship steering as required by [3.1.1.6] is based on rudders, the steering system for each rudder, including it's steering control and actuators, shall comply with main the class rules. This implies that each steering system shall be provided with a main- and auxiliary steering gear.

Guidance note:

In a typical installation with two independent (i.e. main and auxiliary) steering gear systems for each rudder, one pump in each system is fed from the emergency switchboard and the two other pumps (one in each system) are fed from each side of the main switchboard. In such an arrangement one single failure may initially cause stop of three pumps, which is accepted.

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

3.2.1.4 When ship steering as required by [3.1.1.6] is based on azimuth thrusters, the steering system for each thruster, including it's steering controls and power actuators shall be arranged with redundancy. Each power actuator shall have dedicated power supply.

Guidance note:

This implies that each steering system has single failure tolerance towards i.a failures in electrical components, control system units, control system power, cabling, signalling and communication buses and also rupture in hydraulic pipes.

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

3.2.1.5 If separate input devices (e.g. levers) are arranged for the redundant steering control of each thruster, see [3.2.1.5], the input devices shall be of similar design with similar operator interaction. A single input device may be accepted provided that the signals to the two control units are electrically separated.

3.2.1.6 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 seconds 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 input/output (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 in Table 6.*) 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.

Table 6 Failure modes and related minimum requirements on analysis and testing

Failure Modes:	*Minimum analysis and test requirement*
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) — easures 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 DNV-RP-D102 App.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 system shall be arranged to ensure that after failure of any active component, the remaining system has capacity to support normal full propulsion power.

Guidance note:

The intention is to avoid that duplicated propulsion plants have lower availability of normal full propulsion power than single engine propulsion plants in the event of a failure or maintenance of active components in the auxiliary systems

---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 suctions 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 were 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.

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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 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 LNG** rules for a future LNG fuelled ship design
- the main engine(s) installed can be converted to gas or 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 shall 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 the additional class notation, **Gas ready**, with qualifiers as outlined in Table 1.

Table 1 Class notation Gas ready with relevant qualifiers

	Qualifiers	*Purpose*	*Application*
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, see Pt.1 Ch.1 Sec.2 [1.3]. Structural modifications required to be done during the future conversion to support the fuel containment system (LNG fuel tank) are documented. This includes structural reinforcements and use of materials suitable for the relevant temperatures.	Mandatory for **Gas ready**.
	S	Structural preparations required to support the future fuel containment system (LNG fuel tank) are carried out. This includes structural reinforcements and use of materials suitable for the relevant temperatures.	
	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 gas or 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 gas or 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.	

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 gas or 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 gas or dual fuel engines.

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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 the drawing title.
— The documentation will be given status examined (EX) instead of approved.

Table 2 Documentation requirements for Gas ready qualifier D

Object	*Documentation type*	*Additional description*	*Info*
Propulsion and steering arrangements, general	Z050 - Design Philosophy	Including information on the machinery configuration, machinery space arrangements, fuel arrangements, shut down philosophy, redundancy considerations etc. Shall be submitted before other documentation, to give support for approval of these.	FI
Fuel gas system	Z010 - General arrangement	Gas ready installation including: — LNG tank(s) with distance from ship side — location of bunkering station — location of spaces containing fuel gas equipment — air locks — pipe routing.	EX
	Z030 - Arrangement plan	Engine room arrangement, only if not included in general arrangement.	FI
Hazardous area classification	G080 - Hazardous area classification drawing		EX
Ventilation systems for gas fuel system spaces	S012 - Ducting diagram (DD)	For fuel gas equipment spaces including: — ventilation capacity — location of inlets and outlets — segregation from other ventilation systems.	EX
Fuel gas tanks	C030 - Detailed drawing	Fuel gas tank arrangements including: — tank connection spaces — fuel preparation rooms — details for structural strength and thermal exposure calculations.	EX
Fuel gas tanks supporting structure	H050 - Structural drawing	Fuel tank support and antiflotation structure.	EX
Ship hull structure	H080 - Strength analysis	Fuel gas tank arrangements: — structural strength evaluation.	FI
	C040 - Design analysis	Fuel gas tank arrangements: — temperature calculations in way of fuel tank for determination of hull material grade selection.	FI

Object	*Documentation type*	*Additional description*	*Info*
	Z260 - Report	Summary report including description of: — required modifications to the ship hull structure at future conversion to LNG fuel — assumptions and limitations in the design — reference to documentation provided for Gas ready notation.	FI
Fuel gas piping system	S010 - Piping diagram (PD)	Fuel gas piping including: — secondary enclosures for fuel pipes — arrangement 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.	FI
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	For the gas ready installation.	EX
External surface protection, water spraying system	G200 - Fixed fire extinguishing system documentation	For the gas ready installation.	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.	FI

1.6.2 Documentation requirements for qualifier S

In addition to the documentation requirements for qualifier **D** in Table 2, the summary report shall specify the structural preparations carried out at the newbuilding stage.

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 new-building 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 wording "Gas ready" in the start of the drawing title, and will be given normal approval 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).

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2 Ship installations preparing for later liquefied natural gas fuel conversion

2.1 Gas ready qualifier D

2.1.1 General

2.1.1.1 The LNG fuelled ship design shall comply with the current requirements for class notation **Gas fuelled LNG**, see Sec.5.

2.1.2 Structural modifications

2.1.2.1 For qualifier **D**, the structural modifications required to be done during the future conversion to support the fuel containment system (LNG fuel tank) shall be documented. This includes structural reinforcements and use of materials suitable for the relevant temperatures.

2.1.2.2 Documentation of structural modifications directly related to the installation of the fuel containment system, e.g. cut out in deck, does not need to be included.

2.1.2.3 A summary report shall describe the required structural modifications for the future conversion including assumptions and limitations in the calculations.

2.1.2.4 The tank design shall have a technical documentation level confirming that the design is feasible and that no insurmountable obstacles (showstoppers) would prevent the concept from being realized. The review shall be based on at least a minimum scope of documentation agreed with DNV GL where all safety related aspects shall be covered.

Guidance note:

For conventional tank types and designs this may be confirmed by the track record of existing tanks. If the tank type, design or its application is novel, further documentation of the feasibility may be required as defined above. In such cases the review will be a separate scope of work and not covered by the **Gas ready** notation.

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2.2 Gas ready qualifier S

2.2.1 Structural preparations

2.2.1.1 For qualifier **S**, the structural preparations required to support the future fuel containment system (LNG fuel tank) shall be carried out. This includes structural reinforcements and use of materials suitable for the relevant temperatures.

2.2.1.2 Local reinforcements considered more practical to carry out at the future conversion will not be required to be carried out (i.e. structures that will need to be cut out for the installation of the fuel containment system, local insert plates around supports, as well as supports).

2.2.1.3 A summary report shall describe the structural preparations carried out and remaining structural modifications for the future conversion including assumptions and limitations in the calculations. The "Appendix to the Class Certificate" shall include a reference to the summary report.

2.2.1.4

The tank design shall have a technical documentation level confirming that the design is feasible and that no insurmountable obstacles (showstoppers) would prevent the concept from being realized. The review shall be based on at least a minimum scope of documentation agreed with DNV GL where all safety related aspects shall be covered.

Guidance note:

For conventional tank types and designs this may be confirmed by the track record of existing tanks. If the tank type, design or its application is novel, further documentation of the feasibility may be required as defined above. In such cases the review will be a separate scope of work and not covered by the Gas ready notation.

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2.3 Gas ready qualifier P

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 qualifiers MEc or AEc

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 qualifiers MEi, AEi or B

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.

3 Manufacture, workmanship and testing

3.1 General

Installations on board for **Gas ready** qualifiers **S** and **P** shall be handled in accordance with normal new-building procedures by the Society's 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.

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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.

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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.

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1.1.4 Definitions

Table 1 Definitions

Term	*Definition*
dry scrubber	scrubber system using pellets or similar dry substances through which the exhaust stream is directed to remove SO_x form 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 section may be assigned a **Scrubber ready** notation, with a number of possible qualifier combinations as outlined in Table 2.

Table 2 Scrubber ready

	Qualifier	*Description*	*Application*
Scrubber ready	**D**	Dry scrubber system	Mandatory mutually exclusive qualifiers.
	C	Wet- closed loop	
	H	Wet- hybrid (open and closed loop)	
	O	Wet- open loop	
	IL	In-line scrubber reactor system; individual linear scrubber unit per consumer	Mandatory mutually exclusive qualifiers.
	MI	Multi-inlet scrubber reactor; multiple inlets to one or more scrubber units	
	HS	Structural verification	Includes review and follow up of structural support for equipment.
	R	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 [2.5.2].
	MISC	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.

	Qualifier	Description	Application
	S	Review of documentation for compliance with statutory requirements	Ifthe Society is authorized by flag to issue the IAPP certificate. Review according to IMO resolution MEPC.259(68).

Guidance note:

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.

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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 DNV GL 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

Object	Documentation type	Additional description	Info	App.
Scrubber ready exhaust P&ID	S010 – Piping diagram		EX	All
Scrubber ready 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
Scrubber ready pressure drop analysis	S020 – Pressure drop analysis	According to Ch.7 Sec.7 [4.1.4].	EX	All
Scrubber ready 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
Scrubber ready lightship particulars		Including list of added/removed weights for future scrubber conversion.	EX	All
Scrubber ready 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.

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1.3.2 Documentation requirements for qualifiers *H* and *O*

Table 4 Documentation requirements

Object	Documentation type	Additional description	Info	App.
Scrubber ready 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.

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1.3.6 Documentation requirements for qualifier *S*

If the Society is authorized by flag to issue the IAPP certificate, the following documents shall be examined for compliance with IMO resolution MEPC.259(68).

Table 7 Documentation requirements

Object	*Documentation type*	*Additional description*	*Info*	*App.*
Scrubber ready SECP	Z160 - Operation manual	SO_x Emission compliance plan (SECP).	EX	All
Scrubber ready ETM	Z160 - Operation manual	Exhaust gas cleaning system technical manual (ETM). Scheme A or B as applicable.	EX	All
Scrubber ready OMM	Z160 - Operation manual	Onboard monitoring manual (OMM).	EX	All
Scrubber ready EGC record book	Z290 - Record	EGC Record book or electronic logging system.	EX	All
Scrubber ready EGC Marpol verification survey plan	Z140 - Survey procedure	According to the requirements of IMO resolution MEPC.259(68) (for sea trial/Marpol verification survey).	FI	All
Scrubber ready wash-water treatment assessment		For systems which make use of chemicals, additives, preparations or create relevant chemicals in situ.	FI	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.

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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.

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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).

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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.

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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, DNV GL 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. CO_2) 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.

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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.

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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

a) The inlets shall be sized according to required flow for the future scrubber installation.
b) Inlets shall be arranged with redundancy according to Pt.4 Ch.6 Sec.5 [2].
c) The added inlet area for the future scrubber system shall be included in sea chest grid area calculation if connected to existing sea chests.
d) For ships for navigation in ice, minimum one future scrubber system inlet shall be connected to the ice sea chest.
e) 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.
f) 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

a) Minimum distance piece pipe thickness shall be 15mm or shell thickness, whichever is greater.

b) 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 suctions for other ship systems. The discharges shall be placed at minimum 4 m 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. The discharge outlet shall be located well below the waterline for any operational loading condition. The distance shall be minimum 4 m or may be established by the calculation in point d)
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 50 kN, 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 cirquit breakers vs short circuit at location, emergency stop schematic, list of ex equipment, etc.

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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 shall 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.

SECTION 10 SHAFT ALIGNMENT - SHAFT ALIGN

1 Objectives

This section provides a set of requirements with the objective of enhancing the design, installation and operating margin of the propulsion shaft bearings beyond the main class requirements for shaft alignment, see Pt.4 Ch.2 Sec.4.

2 Scope

The objectives are met by the following scope additional to that of main class:

— increased range of applied hydrodynamic propeller loads
— mandatory use of oil film criterion in alignment calculations irrespective of shaft dimensions
— introduction of multi sloped aft bearing
— stricter requirements to bearing sighting
— additional monitoring requirements
— utilization of more advanced calculation methods (CFD & FEM) for **Shaft align(2)**.

3 Application

The additional class notation **Shaft align** applies to main propulsion shafting installations using oil as the lubricant medium for white metal propeller shaft bearings, complying with the design, installation and testing requirements included in this section. For geared installations, the requirement applies to the low speed shaft line.

4 Class notations

4.1 Class notations

Ships complying with the requirements given in this section may be assigned the additional class notation **Shaft align** as specified in Table 1.

Table 1 Additional class notations - Shaft align(1) and Shaft align(2)

Class notation	Qualifier	Purpose	Application
Shaft align Mandatory: No Design requirements: Sec.10 FiS requirements: Pt.7 Ch.1 Sec.2, 3 and 4	**1**	Intended for propulsion systems installed on vessels with conventional hull forms and incorporates enhanced aft bearing performance during normal and turning operating conditions.	
	2	Intended for propulsion systems requiring additional calculations to estimate hydrodynamic propeller loads during turning conditions. Typical installations are vessels with non-conventional hull forms such as asymmetric stern, twin skeg, etc.	

5 References

— Pt.4 Ch.2 Sec.4 *Shaft alignment*
— Pt.4 Ch.4 Sec.1 *Shafting*
— DNVGL-CG-0283 *Shaft alignment*.

6 Documentation requirements

Documentation shall be submitted as required by Table 2 and Table 3.

Table 2 Documentation requirements

Object	***Document type***	***Description***	***Info***
Propeller shaft aft most bearing	C040 - Design analysis	Shaft alignment calculations considering additional requirements herein	AP
	Z100 - Design specification	Alignment procedure including all details for the Class notation	AP
		Propeller shaft aft most bearing running in procedure	FI
	I200 - Control and monitoring system documentation	Details of means of warning for high temperature of tank space, if first inboard bearing is installed on top of heated tanks.	AP
Propeller shaft aft most bearing	C030 - Detailed drawing of aft propeller shaft bearing	Bearing drawing indicating details of multi slope	AP
	M010 - Material specification	Material composition of the bearing	AP
	C020 - Bearing assembly arrangement	Push fit calculations with respective bearing interference fit tolerances, housing dimensions and temperature compensation.	FI

Object	Document type	Description	Info
	I200 - Control and monitoring system documentation	Bearing temperature alarm	AP
Stern tube	C020 - Stern tube assembly	Stern tube assembly including dimensional tolerances of bearing housing	FI
	S010 - Piping drawing	Provisions to take representative lubricant samples under running conditions	FI
		Lubricant system Piping and Instrumentation drawing	AP
Propeller	I200 - Control and monitoring system documentation	Details of the means of warning at all operating locations for incomplete propeller immersion (from draft gauge or equivalent)	AP
AP = For approval; FI = For information; R = On request			

Table 3 - Additional documentation requirement for Shaft align(2)

Object	Document type	Description	Info
Shafting	C040 - Design analysis[1)]	Shaft alignment calculations including CFD aided hydrodynamic propeller loads including — influence of propulsion improvement devices (PID) where fitted — details of propeller immersion — FE analysis of bearing contact pressure in transient conditions	AP
		Shaft alignment calculations including hull deflections in all loading conditions	R
AP = For approval; FI = For information; R = On request 1) Please see DNVGL-CG-0283.			

7 Design requirements

7.1 Shaft align(1)

Shaft alignment calculation shall be approved in accordance with Pt.4 Ch.2 Sec.4 irrespective of shaft diameter.

7.1.1 Lubrication criteria

The design shall comply with aft bearing lubrication criteria defined in Pt.4 Ch.2 Sec.4 [2.1.6] irrespective of shaft diameter.

Hydrodynamically induced downward bending moment from the propeller shall be extended to 30% MCR Torque for aft bearing lubrication criterion in hot running condition .

Guidance note:

The above mentioned 30 % downward acting bending moment is considered as a criterion only for aft bearing lubrication. Impact on adjacent bearings is not required to be considered for this condition i.e. unloading of the adjacent bearing is acceptable.

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7.1.2 Aft most propeller shaft bearing design

Aft propeller shaft bearing shall be of a multi sloped design and manufactured using a white metal alloy material with tin as the major constituent.

For installations with shaft diameter less than 400 mm (single screw)/300 mm (twin screw), single sloped bearing design may be accepted provided that compliance with the aft bearing lubrication criteria is documented for the same range of hydrodynamic propeller loads defined in [7.1.1].

Guidance note:

Use of tin based white metal bearings is intended to provide superior fatigue strength. However, for installations with shaft diameter less than 400 mm (single screw)/300 mm (twin screw), white metal bearings with alternative major constituents (e.g. Lead based bearings) is acceptable.

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7.1.3 Propeller immersion

Vessel's design shall ensure complete propeller immersion under normal continuous operating conditions unless additional requirements according to [7.2.4] are complied with.

Means of warning against incomplete propeller immersion shall be provided in the wheel house and the central alarm panel. Suitable signboards shall be posted at operating locations.

Guidance note:

Alarm initiated by the aft draught gauge may be considered as a means of warning.

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7.1.4 Single stern tube bearing installations extended criteria

For single stern tube bearing installations, the design, including the maximum bearing load specified in the jack load test tolerance for the first inboard bearing, shall comply with the aft bearing lubrication criteria.

Guidance note:

A raised intermediate bearing increases the relative slope in way of the aft bearing and consequently reduces the contact area.

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7.1.5 Inboard shaft bearings on top of heated tanks

Where inboard shaft bearings are installed on top of heated tanks, the tank space shall be provided with a high temperature alarm. The alarm shall be set at the maximum temperature allowed for thermal expansion in the shaft alignment calculations.

Guidance note:

Alarm may be omitted with if shaft alignment calculations allow for thermal expansion with a minimum value of 100 °C in the tank spaces.

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7.1.6 Lubrication system

The stern tube shall be provided with a forced lubrication system fitted with a heat exchanger.

The lubrication system shall be designed to ensure satisfactory circulation of oil.

Forced lubrication may be omitted in case of retrofits, unless deemed necessary based on damage history.

7.1.7 Stern tube aft bearing temperature monitoring and alarm

Aft most bearing temperature shall be monitored and alarms shall be provided in accordance with Table 4.

7.1.8 Stern tube oil condition monitoring

Lubrication system shall be designed to make it possible to take representative oil samples under running conditions.

7.2 Shaft align(2)

7.2.1 In addition to the requirements for **Shaft align(1)** class notation, the following requirements shall be met:

7.2.2 Influence of propeller induced forces and bending moments

Shaft alignment calculations shall take into account hydrodynamically induced propeller forces and moments based on CFD aided calculations for the following conditions:

— Straight ahead running at MCR at design draught.
— Transient turning conditions, as a minimum including "hard over" turn with rudder angles of 35 deg. to both port and starboard. Turn shall be initiated from MCR straight ahead condition at design draught.
— In case normal operating conditions include partially immersed propeller, the condition expected to result in "worst case" propeller loads in terms of local bearing pressures shall be incorporated (e.g. least allowable propeller submersion combined with maximum allowed propeller RPM).
— Other critical conditions as found relevant, when motivated by experience of the designer, ship yard or the Society such as ballast condition, crash stop manoeuvers, etc.

The CFD model shall include the actual geometry of hull and propeller as well as relevant appendixes, such as struts, ducts or PID's.

Guidance note:

Guidelines for how to carry out CFD calculations are given in DNV GL class guidelines DNVGL-CG-0283

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7.2.3 Lubrication criteria

For the straight ahead running condition, the aftmost bearing lubrication criterion for "hot running condition 2" defined in Pt.4 Ch.2 Sec.4 [2.1.6] shall be complied with, applying resulting propeller loads as derived from the CFD calculations. However, an additional margin of 10% MCR torque shall be added to the predicted upward bending moment. These loads supersede the default values applicable for main class and **Shaft align(1).**

For the "hot running condition 1" compliance with the aftmost bearing lubrication criterion shall be documented applying a propeller load similar to as for **Shaft align(1)** i.e. corresponding to a downward bending moment of at least 30% MCR torque.

The lubrication criterion shall also consider operation with a partly immersed propeller when relevant.

7.2.4 Evaluation of aftmost bearing pressures

Contact area and pressure distribution in the aftmost bearing shall be calculated by means of finite element analysis. As a minimum, results for the following conditions shall be presented:

— Conditions defined in [7.2.2] above.
— Hot static condition (no hydrodynamic propeller loads).

Guidance note:

FE analysis need not include effect of an oil film. Respective criteria for pressure/contact area are defined in DNVGL-CG-0283.

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7.2.5 Hull deflections

Upon request, hull deflections including all relevant loading conditions shall be considered in the shaft alignment calculations.

Guidance note:

Predictions of hull deflections should be submitted upon request by the Society. This may typically be applicable for vessels with long shaft lines or on installations where hull deflections are expected to have a significant influence on the shaft line offsets or the aft propeller shaft bearing lubrication criteria.

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8 Alarm and monitoring

Table 4 Alarm and monitoring requirements

Item	*Grade 1 indication alarm*	*Grade 2*	*Grade 3*	*Comments*
Propeller immersion	LA			[7.1.3]
Propeller shaft aftmost bearing temperature	HA and rate of rise			[7.1.7] 1)
Heated tank space temperature below first inboard shaft bearing (if installed)	HA			[7.1.5]
LA = alarm for low value, HA = alarm for high valueL 1) Rate of rise alarm may be omitted for retrofits				

9 Installation inspection

9.1 Survey

Unless otherwise specified, all the steps included in the alignment procedure shall be witnessed by the surveyor.

9.2 Procedure

The alignment procedure shall include the following details and methods, as a minimum, in addition to the main class requirements.

9.2.1 Stern tube bearing housing

Records of measurements of the housing inner diameter in way of the bearings shall be submitted for review by the surveyor.

Laser aided sighting of vertical and horizontal offsets of the stern tube housing in way of the bearings shall be submitted for review by the attending surveyor. A minimum of 5 reference points shall be used covering the aft most bearing housing and 3 reference points for the forward bearing housing. The laser reference line shall be made concentric with the stern tube and independent of the bearings.

For pre-fabricated stern tubes delivered to the Yard with bearings assembled, records of the same from the manufacturer shall be submitted to the surveyor.

Alternative means of measurement with equivalent accuracy may be considered upon special consideration by the Society.

Guidance note:

Spigots (recess) of aft and forward seal flanges are normally concentric with the stern tube bore unless machined at an offset for adjustment of seal tolerances

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9.2.2 Aft bearing push fitting procedure

Aft bearing push fitting procedure shall be carried out in accordance with a pre-defined procedure and verified within calculated design limits.

9.2.3 Sighting of stern tube bearings after installation

Laser aided sighting of the stern tube bearings including offsets and slopes shall be carried out.

A minimum of two bearings shall be included in the laser aided sighting process, alternatively this may be a combination of the aft bearing and the first inboard support.

For the aft bearing, a minimum of 5 measurement points shall be included covering the effective length of the bearing including one at the knuckle point(s) for multiple slopes. There shall be a minimum of 3 measurement points in each of the slope segments. The laser reference line shall be the same as in [9.2.1] above.

For the forward stern tube bearing, a minimum of 2 measurement points apply.

In addition, measurements of the inner diameter of the bearings shall be submitted for review by the surveyor.

9.2.4 Gap/sag process

Gap and sag process shall be done afloat using a dial gauge or laser or any method of equivalent accuracy. Feeler gauges are not permitted.

9.2.5 Jack loads

Cold static jack loads shall be carried out in floating condition for:

— inboard shaft line bearings including forward stern tube bearing, if installed
— 3 aft most engine bearings for directly coupled two stroke engines
— the aft main gear bearing for geared propulsion plants.

Hot static jack loads may be required for alignment sensitive designs.

— If any hull deflections are incorporated in shaft alignment calculations, representative jack load tests shall be carried out as defined in the approved alignment procedure. The applicable loading conditions shall be specified for consideration and acceptance by the Society.

Guidance note:

Load cells or equivalent devices are recommended to eliminate internal friction of the jacking device used for jack load tests.

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9.3 Oil sampling points

Verification of specified oil sampling point shall be carried out.

9.4 Lubricant viscosity

Approved lubricant viscosity shall be confirmed before the sea trials and recorded. Suitable signboards shall be posted at operating locations in machinery spaces and on the stern tube system tanks reflecting the minimum approved viscosity of the oil.

9.5 Oil type compatibility

Where environmentally acceptable lubricants are used, documentation of confirmation of seal compatibility with the oil grade shall be verified by surveyor.

10 Shipboard testing

10.1 Partial propeller immersion

Operation of the shaft with incomplete propeller immersion condition is not allowed unless designed for and approved.

10.2 Running in of aft bearing

Running in of aft bearing shall be carried out in accordance with a pre-defined procedure.

10.3 Minimum RPM

It shall be verified that the minimum continuous RPM of the propeller shaft is greater than the minimum approved RPM for the low speed criterion (aft most bearing lubrication criteria). Suitable signboards shall be posted at operating locations displaying the minimum approved shaft RPM.

10.4 Rate of bearing temperature rise

Trending of aft most bearing temperature shall be carried out and documented during sea trials. Corresponding sea water temperature shall be documented.

Guidance note:

Maximum hydrodynamic propeller loads may be induced during turning conditions at maximum vessel speed, typically during a turning circle. Therefore trending of aft bearing temperature should include turning circle conditions.

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10.5 Oil analysis

Representative stern tube oil samples collected before and after the sea trials shall be landed for lab analysis, as a minimum for examination of wear elements and water content. Results shall be submitted for review by DNV GL.

Guidance note:

Oil samples are expected to be taken during running condition soon after commencement and prior to conclusion of trials.

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10.6 Test of alarms

All functions and set points of alarms as per Table 4 shall be tested.

SECTION 11 SAFE RETURN TO PORT, ORDERLY EVACUATION AND ABANDONMENT

1 General

1.1 Introduction

The overall intention of the safe return to port regulations is to increase the safety level of passenger ships through more redundant system arrangements, providing increased robustness and fault tolerance.

The regulations are given as a goal based standard in SOLAS and apply to passenger ships above a certain size. The SRtP scheme has a substantial impact on the vessel design and system arrangements and is closely linked to the operation of the vessel.

The regulations necessitate changes in the traditional work process and the scope of work for the key parties involved in a newbuilding project. It is necessary to apply a life-cycle approach to ensure that the necessary basis is developed prior to the detail design and reflected in the project specifications, and also that a sufficient basis for operations is ready for hand-over at ship delivery.

The early phase activities should involve the owner, yard/designer, flag administration and Society; and a multi-disciplinary / system-engineering based approach should be applied throughout the newbuilding project.

Guidance note:

Supporting guidance to the SRtP regulations and class notation is given in DNVGL-CG-0004 *Safe return to port*

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1.2 Objective

The purpose of the additional class notation **SRTP** is to frame the relevant goal based regulations of SOLAS in a systematic and structured class-context by:

— addressing the various implications of the regulations
— describing the key activities, work process and responsibilities
— providing requirements and acceptance criteria for system design to support the functional requirements of the goal based standard.

The objective of the **SRTP** notation is to provide a complete set of requirements applicable for any vessel that are subject to the SOLAS regulations for safe return to port (SRtP). The requirements of the notation thereby constitute the DNV GL way of implementing the goal based SRtP regulations and the basis for the issuance of the PSSC (passenger ship safety certificate) or SPS (special purpose ship) certificate.

Guidance note:

This implies that in the DNV GL statutory interpretation (DNVGL-SI-0364), the only interpretation of the SRtP regulations is a reference to this notation, thereby making the notation mandatory for the applicable vessels.

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Guidance note:

The requirements of this section are based on best practices and generally acceptable solutions to comply with the referred statutory regulations. Certain flag administrations may, however, have specific SRtP requirements additional to those of the **SRTP** notation.

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1.3 Scope

The additional class notation **SRTP** covers the scope of the SOLAS regulations for safe return to port (SRtP) and orderly evacuation and abandonment (OEA). The contents of the applicable IMO circulars are also incorporated in the rules, and the general approach of the class notation is based on the primary IMO guidance on SRtP.

Guidance note:

The regulations for SRtP and OEA are given in SOLAS II-1/Reg.8-1.2, II-2/Reg.21 and 22.

The primary IMO guidance document for SRtP is MSC.1/Circ.1369 *Interim explanatory notes for the assessment of passenger ships capabilities after a fire or flooding casualty.*

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1.4 Application

1.4.1

Passenger ships constructed on or after 1 July 2010 having length, as defined in regulation II-1/2.5, of 120 m or more or having three or more main vertical zones shall comply with the provisions of this regulation.

(SOLAS II-2/Reg.21.2 and Reg.22.1)

1.4.2 Ship types

The SRtP regulations are mandatory for:

— Passenger ships required to be issued with a PSSC – passenger ship safety certificate in accordance with the above referred SOLAS regulations.
— Special purpose ships (SPS certificate/notation according to 2008 SPS code) intended to carry more than 240 persons in total.
— Naval vessels that shall be constructed in compliance with the Naval ship code ANEP 77 - unless otherwise explicitly agreed in the project.

Guidance note:

The regulations of the ANEP scheme are equivalent to the SRtP regulations. However the casualty scenarios covered in ANEP 77 do not include flooding casualties. For such vessels, the flooding-related requirements of this notation are therefore not applicable.

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1.4.3 Recognized Organisation - RO

The **SRTP** notation is mandatory for passenger ships according to [1.4.2] for newbuilding projects where DNV GL are authorized to issue the applicable statutory certificates on behalf of the flag administration.

Guidance note:

The notation may also be offered in other newbuilding projects where compliance with the regulations is not mandatory.

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1.4.4 Application criteria - main vertical zones

1.4.4.1 Since a main vertical zone (MVZ) may be up to 48 m long, any vessel above 96 m normally has 3 or more MVZs, and the SRtP regulations apply. If, however, the extreme forward and/or aft zone(s) of the ship contain only appendages/voids/tanks without equipment, systems or storage, these zones may be considered to be of low risk and hence exempted from the MVZ criteria.

Guidance note:

See SOLAS II-2/Reg.9.2.2.1.2 - Containment of fire.

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Guidance note:

A space or appendage complying with the following:

— the space is of limited size
— the space contains only tank, void or clean open deck
— the space has only restricted access (for space below open deck)

may upon special considerations be accepted not to constitute a main vertical zone for the purposes of SOLAS II-2/Reg.21.1 and 22.1. An eventual exclusion from the SRtP regulations for a ship above 96 m shall be endorsed by the flag administration and the owner.

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1.4.4.2 Horizontal fire zones (special category- and ro-ro spaces) should not be included in the number of MVZs in the context of the application criteria for SRtP.

Guidance note:

See SOLAS II-2/Reg.20.2.2 Protection of vehicle, special category and ro-ro spaces.

See MSC.1/Circ.1369 Int. 1.

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1.5 Class notation

Vessels built and tested in accordance with the requirements of these rules will be assigned the class notation **SRTP** as outlined in Table 1

Table 1 Class notation for safe return to port

Class notation	*Qualifier*	*Purpose*	*Application*
SRTP Mandatory: Yes Design requirements: This section FiS survey requirements: Pt.7 Ch.1 Sec.6		Increased safety level of passenger ships through more redundant system arrangements, providing increased robustness and fault tolerance.	Mandatory for passengers ships, SPS ships and naval vessels in accordance with [1.4]

1.6 Structure of the SRtP rules and approach for the goal based standard

1.6.1 Structure of the SRtP rules

The SRtP rules are structured with the following subsections and contents:

— This subsection: background and introduction, overall requirements
— [2]: context of the life-cycle approach, work process and responsibilities
— [3]: general requirements and implications of SRtP
— [4]: requirements for each of the systems covered by SRtP
— [5]: general requirements and implications of OEA
— [6]: requirements for each of the systems covered by OEA

1.6.2 Approach for the goal based standard

1.6.2.1 The SRtP regulations in SOLAS are generally given on an overall/superior goal based level. In the **SRTP** notation, the goals of SOLAS are supported with functional requirements and to some extent also prescriptive requirements.

1.6.2.2 The **SRTP** notation adopts a three tiered approach based on the following principles:

a) Goals: on the top level, the SRtP goals provide the fundamental rationale and intent behind a particular rule. The goals of the class notation are basically the regulations as given in SOLAS.
b) Functional requirements: on the mid level, the goals are supported by one or more functional or performance requirements. These explain in greater detail the type of functions or performance a system shall achieve in order to fulfil the intent of the goal, either in part or in whole.
c) Detailed requirements: on the lower level, functional and performance requirements are supported by detailed rules and guidance notes. These provide a set of generally acceptable solutions to meet the goals, functional and performance requirements, either in part or in whole.

This three tiered approach is applied only in the subsections containing requirements to the SRtP and OEA systems, see [4] and [6] respectively.

1.6.2.3 Detailed requirements do not preclude the use of alternative solutions. Such solutions will be considered by their ability to meet the goal and fulfil the relevant functional and performance requirements.

1.6.2.4 In the **SRTP** class notation, each SOLAS regulation within the scope of the notation is included in the relevant subsection, thus giving the overall goal and functional requirement followed by performance requirements and/or detailed requirements as applicable. Where additional interpretations are given in IMO (MSC) circulars, these are in general incorporated in the rule requirements and the reference to the interpretation number are, where applicable, given as guidance notes.

Guidance note:

In the **SRTP** notation the basic SOLAS paragraphs are generally referred to as 'regulations' while the specific contents of the class notation is referred to as 'requirements'.

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1.7 SRtP in service

The operational implications of the SRtP and OEA regulations depend largely on the design and arrangement of all the SRtP systems. The owner and yard should in the early phase of the newbuilding project agree on the design intent and approach for the SRtP and OEA systems, with due consideration of the possible implications this may have for the planned operation.

Guidance note 1:

This include in particular the chosen design approach for system restoration after a casualty, i.e. to what extent system restoration is based on manual actions by the crew or automatic/remote restoration and operation.

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Guidance note 2:

The overall ship SRtP capabilities will be included in the 'List of operational limitations' together with the PSSC, see SOLAS Reg.V/30. These capabilities may include:

— the range, environmental conditions, speed, duration and fuel demands of the dimensioning SRtP voyage
— eventual operational restrictions, e.g. restricted area of operation
— eventual environmental limitations (e.g. ambient temperatures) for the capabilities of the safe areas.

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Guidance note 3:

The **SRTP** notation is for fleet in service followed up through the scheme for renewal of the statutory certificates (PSSC or SPS).

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1.8 Rebuild and refurbishment

All future repairs, alterations, rebuilds and modifications that may impair the design and/or arrangement of the systems covered by the SRtP requirements, or may impair the designated casualty thresholds, should be done with due regards to the SRtP requirements and design intent to ensure continued compliance with the regulations.

Guidance note:

This implies i.a. that the relevant design documentation (typically design philosophies, arrangement drawings, casualty threshold plan etc) should be duly considered in connection with repairs, alterations, rebuilds and modifications, and that the assessment report(s) and relevant operational documentation are updated as applicable.

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1.9 Procedural requirements

1.9.1 Documentation requirements

Documentation shall be submitted as required by the following tables:

— Table 2 contains the requirements for overall SRtP documentation.
— Table 3 contains documentation requirements related to each individual SRtP and OEA system including electric power systems and integrated control and safety systems.
— Table 4 contains documentation that shall be submitted only for shafted propulsion arrangements where both shafts pass through a common space (i.e within the same casualty threshold).
— Table 5 contains SRtP documentation that shall be available on board.

Guidance note 1:

Guidance to the work process, documentation sequence and expected content of specific SRtP documentation is given in class guideline DNVGL-CG-0004.

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Guidance note 2:

The various documentation requirements cover information elements, and the information elements may be combined in common documents where appropriate.

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Table 2 Overall documentation requirements for SRtP and OEA

Object	*Document type*	*Additional description*	*Info*
Safe return to port capability	Z053 - Design philosophy	SRtP design philosophy/ship's description. This is the top SRtP document, defining the basic design intent and operational criteria for the project, referring to SOLAS Reg. II-1/8-1.2, Reg.II-2/21 and 22: — main characteristics of the vessel (basic layout, number of PAX, machinery configuration) — operation (intended area of operation, planned operation, safe return to port range/distance, design ambient temperatures, intended catering level) — approach for SRtP system restoration, i.e. level of automation and/or manual actions — preliminary SRtP capabilities (speed and SRtP speed, duration of SRtP voyage, SRtP power balance, SRtP fuel supply needs, OEA power balance) — identification of all systems within the scope of the SRtP regulations — documentation strategy, which documents will be made, how will the various systems and sub-systems be covered, documentation sequence — approach for SRtP testing. Further guidance on the expected contents of the SRtP design philosophy is given in class guideline DNVGL-CG-0004.	AP
	Z030 - Arrangement plan	A zone/redundancy plan showing the separated areas dedicated for the duplicated machinery systems (in particular propulsion, steering and power generation), including also any area and deck containing auxiliary or support systems/components/cables. The alternative location for navigational equipment (SRtP bridge) shall also be identified on the plan.	AP
	Z012 - Casualty threshold plan	A general arrangement plan identifying the extent of the various casualty thresholds throughout the ship: — spaces which are provided with a fixed fire extinguishing system — spaces which are of negligible fire risk, see [3.2.4] — including all A-class and MVZ boundaries — including watertight boundaries.	AP
	Z140 - Test procedure for quay and sea trial	Identifying final tests deemed necessary for demonstrating SRtP compliance at quay and during sea trials, see [1.10].	AP

Object	*Document type*	*Additional description*	*Info*
	Z265 - Calculation report	Documenting the vessel hydrodynamical capabilities in the worst case SRtP scenario - and the basis for the SRtP capacity requirements: — compliance with the requirements for vessel speed at dimensioning environmental conditions — calculation of the duration of the dimensioning SRtP voyage. The worst case scenario is normally considered to be loss of one engine room and the appurtenant propulsion line, see [4.2]. Further guidance on the hydrodynamical calculations is given in DNVGL-CG-0004.	FI
	E040 - Electrical load balance	A document stating the calculated design values for power consumption and available power covering both the dimensioning SRtP scenario and OEA scenario.	AP
Safe areas	Z013 - Safe area plan	Identifying safe areas, spaces for medical care and location of provisions for the safe areas.	AP
	Z050 - Design philosophy	Describing the arrangement, design intent and approach for system restoration covering all basic services for the safe areas: — sanitation — potable water — food — alternate space for medical care — shelter from the weather — means of preventing stress and hypothermia — light — ventilation. The document shall also contain relevant calculations, i.a. necessary space for the safe areas.	AP

Table 3 Documentation requirements for each of the SRtP and OEA systems including electric power system and integrated control and safety system

Object	*Document type*	*Additional description*	*Info*
SRtP systems: — propulsion — steering — navigation — fuel oil — internal communication — external communication — fire water — fixed fire-extinguishing — fire detection and alarm — bilge and ballast — internal watertight doors — flooding detection — lighting — electric power generation and distribution [1] — integrated control and safety[1]	Z050 - Design philosophy	SRtP system design philosophy/concept Description of the intended system design and capabilities to remain operational upon casualties as specified in SOLAS II-1/Reg. 8-1.2, SOLAS II-2/Reg.21.3 and 22. The main contents are the following: — design intent - how the system shall be arranged (e.g. redundancy/duplication/segregation/protection) to meet the requirements — principle arrangement with location of main equipment — intended system capabilities after a casualty - criteria for remain operational — intended level of automation / manual intervention needed for system recovery — system dependencies, auxiliary and supporting systems — intended power supply/distribution. Further guidance on the expected contents of the system design philosophy is given in class guideline DNVGL-CG-0004.	AP
	Z030 - Arrangement plan	Documentation of location and arrangement of system components including routing of pipes (unless sufficiently indicated on P&IDs).	AP
	Z011 - Cable routing drawing[2]	A drawing based on a general arrangement plan (Z010) that shows physical routing of: — power cables, from the source of power to the consumer, including location of equipment — control and communication cables supporting the system or function.	AP
	Z268 - Assessment report	SRtP assessment report (FMEA - failure mode and effect analysis) Structured assessment of the effects of fire and flooding scenarios for the systems listed in SOLAS II-2/Reg. 21.4 and Reg. 22.3.1 in addition to electric power system and control and safety systems. The fire and flooding scenarios are specified in SOLAS II-1/Reg.8-1.2, SOLAS II-2/21.3 and 22. The report shall be conclusive on compliance with the SRtP regulations for the actual system design and remaining system capabilities, identify necessary manual actions needed for system recovery and identify tests to demonstrate compliance. Further guidance on the expected contents of the assessment report is given in DNVGL-CG-0004.	AP

Object	Document type	Additional description	Info
Systems intended to support safe areas: — sanitation — water — ventilation — lighting systems	Z030 - Arrangement plan	Documentation of arrangement and location of system components including routing of pipes (unless sufficiently indicated on P&IDs).	AP
	Z011 - Cable routing drawing [2]	A drawing based on a general arrangement plan (Z010) that shows physical routing of: — power cables, from the source of power to the consumer, including location of equipment — control and communication cables supporting the system or function.	AP
	Z010 - Piping diagram	Applicable for: — air conditioning chilled water system — potable water supply system — grey and black water.	AP
	Z268 - Assessment report	Structured assessment of the effects of fire and flooding scenarios for the safe area systems. The report shall be conclusive on compliance with the SRtP regulations for the actual system design and remaining system capabilities, identify necessary manual actions needed for system recovery and identify tests to demonstrate compliance. See also [1.9.2].	AP

1) For supporting functions, such as electric power distribution and integrated control and safety system, the documents may, depending on the context, be taken for information FI.

2) If a system is arranged so that SRtP compliance does not depend on physical routing of cables, cable routing drawings need not be submitted (e.g for cables routed exclusively within the zone dedicated to either of two redundant systems in accordance with the zone plan, or fire resistant cables in accordance with [3.2.5]).

Guidance note:

The required documentation that concern physical location and arrangement of the SRtP systems may preferably be shown as different information layers on general arrangement drawings.

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Table 4 Documentation required only for shafted propulsion arrangements where both shafts pass through a common space (i.e within the same casualty threshold), see [4.2.3.3].

Object	Document type	Additional description	Info
Propulsion shaft arrangement	Z030 - Arrangement plan	Arrangement and specification of means of protection	AP
	Z261 - Test report	Hydrostatic test report including reported leakage volume and statement of effect on lub oil (applicable for bearings operating under water)	AP

Table 5 SRtP On board documentation

Object	Document type	Additional description	Info
SRtP capabilities	SRtP On board documentation	The contents of Table 2 and Table 3	N/A

Object	Document type	Additional description	Info
	Z161 - Operational manual	Including details of any manual action required to ensure operation of the SRtP systems after a SRtP casualty.	N/A
	Z163 - Maintenance manual	Including specific instructions to the maintenance of SRtP systems, if applicable.	N/A

Guidance note:

The onboard documentation normally consist of the contents of Table 2 and Table 3, i.e. the complete set of SRtP design documentation, in addition to the SRtP operational manual and, if applicable, a maintenance manual.

The SRtP operational manual is normally the basis for the development of the SRtP operational procedures. The SRtP operational manual may, depending on the SRtP design approach and agreement between the owner and yard, consist of specific design documents, assessment reports or other documents or tools identifying the manual actions required for system restoration and operation following a SRtP casualty.

The onboard documentation package in itself is not subject to approval by the Society, though the package largely consist of documents that are part of the approval scope.

See MSC.1/Circ.1369 7.4.

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1.9.2 Assessment report

1.9.2.1 A systematic assessment shall be performed for each of the SRtP and OEA systems where the effects of the casualty scenarios described in [1.9.2.2] are analysed. The result of the assessment shall be documented in an assessment report (s). The report shall be conclusive on compliance for each of the SRtP systems/functions, i.e. if the systems/functions remain operational as required.

Guidance note:

The assessment and subsequent assessment report is equivalent to a failure mode and effect analysis resulting in an FMEA report, though the failure modes in the SRtP assessment include fire and flooding scenarios only.

A separate report for each of the SRtP systems/functions is recommended, covering also all sub-systems and auxiliaries needed for the specific system/function to remain operational, e.g. for propulsion where all sub-systems and auxiliaries should be included.

It is recommended that the assessment is performed by other parties/units than those responsible for the design.

Further guidance to the expected structure and contents of the assessment report is given in DNVGL-CG-0004.

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1.9.2.2 The assessment report(s) shall be self-contained / stand-alone document(s) providing the reader with adequate system information to support the understanding of the analysis and conclusions.

If the assessment is based on software models/computer based tools, the approach for the software model and also the format of the report shall be documented and agreed upon by the owner, yard and Society.

The assessment report shall list and identify the design basis/documentation basis on which the analysis is made (covering also document revision numbers the eventual computer model with appropriate identification).

1.9.2.3 The assessment report shall cover the following casualty scenarios (failure modes):

— for each SRtP system, casualties within any casualty threshold that may affect the system:
  — fire in any casualty threshold, see [3.2.1]
  — flooding in any casualty threshold, see [3.2.6]
— for each OEA system, all OEA casualties covering the complete loss of any MVZ.

1.9.2.4 The main purpose of the assessment is to confirm that the actual detail design complies with the design intention and the rules and regulations. The assessment shall therefore be based on i.a.:

— the SRtP rules and regulations (the rules of this section, SOLAS II-1/Reg.8-1.2, II-2/Reg.21 and 22, applicable MSC circulars)
— the SRtP documentation as required in Table 2 and Table 3 (and Table 4, if applicable)
— design drawings, documentation an model information to the necessary level of detail including physical location of components, routing of pipes and cables etc.

Since the report shall conclude on compliance, the assessment and the report shall be completed after the detail design has reached the necessary level of completion to ensure that all aspects are covered.

Guidance note:

The assessment may be an iterative process, the first part may be an initial assessment of the early phase design philosophies/ intentions and arrangement plans, the last part may be the final, conclusive assessment taking detailed design information and physical arrangement into account. In this way, findings from the initial steps may be used to rectify or improve system arrangements during the design phase.

Note that only the final version is required for approval.

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1.9.2.5 For SRtP systems that depend on multiple auxiliary systems or services to function, the assessment report shall focus on simultaneous availability of the auxiliary systems or services needed to support the SRtP systems.

Guidance note:

'Simultaneous availability' implies that the various auxiliary systems and services are designed and arranged coherently relative to the casualty thresholds that may otherwise impair the SRtP systems ability to remain operational.

Example 1: a propulsion system depends on several auxiliary systems, and in case of a SRtP casualty, all auxiliaries for the remaining propulsion line shall be simultaneously available to support the propulsion function.

Example 2: a bilge system may depend on i.a. available electrical power, control systems, technical water, ventilation etc. to remain operational outside the casualty threshold.

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Guidance note:

For duplicated systems that are arranged within the physical boundaries of different casualty thresholds, the assessment should focus on possible common mode failures, dependencies of auxiliary services provided from other spaces and possible cross-connections between the duplicated systems.

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1.9.2.6 The assessment shall to the extent necessary take into account the design and system arrangements developed and documented by sub-suppliers and makers.

1.9.2.7 The assessment report shall for each SRtP casualty include identification of the eventual manual actions needed for restoration of the system capabilities and eventual manual actions needed to maintain the system functionality during the SRtP voyage.

Guidance note:

The manual actions needed for system restoration and operation include actions that must be done both locally or remotely.

The list of manual actions from the assessment report may form the basis for the SRtP operational manual.

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1.9.2.8 The assessment shall identify relevant test scenarios of the subject system to verify compliance with rules and regulations as well as the design intention.

Guidance note:

This normally includes simulation of the casualty thresholds in which the key components of the system are located, or locations where a fire- or flooding casualty may have the most severe impact on the system functionality; where the manual actions needed for system recovery are most extensive.

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1.9.3 SRtP onboard documentation

The onboard documentation shall include the contents of Table 2 and Table 3 and in addition SRtP operational manual and maintenance plan as given in Table 5.

Restoration and operation of the SRtP systems after a casualty may depend on manual actions by the crew, and this shall be described in the operational manual that is part of the onboard documentation. The operational manual and the approach for SRtP system recovery should be aligned with the owner's operational organisation, manning and procedures, and the owner and yard should agree on both the approach, form and content of the yard's deliverables that shall form the basis for the owner's' SRtP operational procedure.

Guidance note:

See MSC.1/Circ.1369 7.4.

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1.9.4 Certification requirements

The systems and components covered by the SRtP requirements shall be certified according to main class requirements and applicable statutory interpretations.

Guidance note:

This implies that the SRtP notation in general does not impose additional certification requirements beyond what is already covered by main class or applicable statutory interpretations - unless additional systems or components are installed as an alternative way for systems to remain operational, e.g. communication equipment that due to it's function require certification.

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1.10 Survey, inspection, test and verification

1.10.1 Verification

The capabilities of the SRtP and OEA systems shall be surveyed, demonstrated and verified for the three categories of casualty cases (SRtP fire casualty, SRtP flooding casualty and OEA casualty) i.a. as follows:

1) Basic testing of the SRtP- and OEA systems if not already covered by main class.
2) Verification/test of relevant assumptions and findings from the SRtP assessment report(s).
3) If system restoration and operation after a casualty depends on manual actions, these shall for each SRtP system be demonstrated in accordance with the SRtP requirements for selected casualty scenarios.

   This applies to each individual SRtP system where selected casualty scenarios shall be tested to demonstrate that the system remains operational as specified in the SRtP requirements. The test shall include verification of the manual actions that may be needed for the system recovery.

   Guidance note:

   The selected scenarios should be the worst case scenarios as identified in the assessment report for the system, normally the scenarios that demand the highest number of manual actions for the specific system.

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4) Testing of a representative OEA scenario, i.e. loss of a complete main vertical zone, to demonstrate availability of the OEA systems in all other main vertical zones.

   Guidance note:

   For this test, a main vertical zone containing one (or both) engine rooms is normally selected, to verify the fire scenario where the potential loss of a complete MVZ may have the most severe consequence for the systems.

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5) The dimensioning failure scenarios shall be tested to demonstrate that the SRtP systems remain operational in a return to port mode. This includes simulated loss of the most critical spaces, normally:
   a) each engine room (ER)
   b) engine control room (ECR)
   c) main switchboard rooms (if not covered by the engine room test case)
   d) wheel house
   e) the SRtP casualty scenario that include the highest number of manual actions (unless this coincide with the above tests)
   f) eventual other critical spaces if identified in the SRtP assessment report.

Guidance note:

These tests should be conducted as realistic as possible where the effects of the simulated casualty on all SRtP systems may be observed and verified as opposed to the individual systems tests described above.

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1.10.2 Sea trials

The basic dimensioning failure scenarios as specified in item [1.10.1] 5.a) (loss of each ER) shall be tested during sea trials to:

— demonstrate that all systems required to remain operational are simultaneously available

— verify the ability for one engine room and corresponding propulsion- and steering systems to operate at the specified SRtP power demand with thermal stability and stable service of all supporting systems.

1.11 Installation

The components (e.g. valves, breakers) that must be operated manually/locally ('manual action') in order to restore or maintain the system functionality in a SRtP scenario shall be clearly marked.

For any component subject to a manual action in the context of SRtP, the means of operation shall be easily accessible.

Guidance note:

A component that requires to be operated locally/manually ('manual action') in a SRtP scenario can normally not be installed inside a space of negligible fire risk if the means for manual operation requires access to the space, see [3.2.4.3] and [3.2.4.4].

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1.12 Definition and abbreviations

Table 6 Definition of terms

Term	*Definition*
administration	the government of the state whose flag the vessel is entitled to fly
area of negligible fire risk	an area containing no or very limited components, pipes or cables so that it may be considered not to constitute a potential origin of fire. See also [3.2.4]
assessment	structured analysis of the possible consequences any incident of fire or flooding may have for the systems required to remain operational, covering all possible scenarios within the casualty threshold
assessment report	a conclusive report on the assessment, covering all systems required to remain operational, see [1.9.2]

Term	Definition
casualty threshold	the maximum physical extent of a SRtP casualty where the ship shall be capable of returning to port in accordance with SOLAS II-2/Reg.21. For further definition of fire and flooding casualty threshold, see [3.2.1] and [3.2.6] respectively
casualty threshold plan	an arrangement plan showing the extent of the casualty threshold for all decks, covering both fire and flooding casualties (flooding only relevant below bulkhead deck). For further guidance, see Table 2
dimensioning SRtP casualty	the SRtP casualty with the biggest impact on the SRtP systems, normally a fire or flooding casualty in one of the engine rooms
manual actions	manual intervention by the crew that may be necessary to restore and maintain functionality of the SRtP systems after a SRtP casualty, see [3.3.3]
OEA casualty	a fire exceeding the SRtP casualty threshold, potentially spreading to a complete MVZ
OEA power demand	the electrical power demand following the dimensioning OEA casualty; the necessary power to the OEA systems listed in [5.1]
remain operational	a general term denoting the situation after an SRtP casualty where the SRtP systems shall be able to continue it's function for the voyage back to port, outside the casualty threshold. Equivalent to the term 'maintain capabilities'
safe area	the areas designed to provide the services listed in [4.14] for all persons on board, to support habitable conditions during the SRtP voyage
spaces outside the casualty threshold	all areas of the ship except the space inside/limited by the casualty threshold
the Society	DNV GL
SRtP bridge	the alternative position from where the ship shall be manoeuvred in case of an SRtP casualty impairing the main bridge
SRtP capabilities	the defined properties of an SRtP system following an SRtP casualty
SRtP casualty	any incident of fire or flooding limited by the applicable casualty threshold
SRtP duration	the calculated duration of the dimensioning SRtP voyage
SRtP failure scenarios	equivalent to an SRtP casualty
SRtP power demand	the electrical power demand following the dimensioning SRtP casualty, at a vessel speed of 6 knots while heading into BF 8 and also providing the necessary power to all the SRtP systems listed in SOLAS II-2/Reg.21.4
SRtP propulsion power demand	the power demand for the propulsion system to provide 6 knots while heading into BF 8 following the dimensioning SRtP casualty, i.e. normally with one engine room out of operation
SRtP range	the designed maximum range of a SRtP voyage
SRtP voyage	the voyage back to port following an SRtP casualty

Table 7 Abbreviations

Abbreviation	*Description*
BWMC	Ballast Water Management Convention
COLREG	international regulations for preventing collisions at sea (navigation)
ECDIS	electronic chart display and information system (navigation)
FiS	fleet in ervice
FSS	international code for fire safety systems
FW	fresh water
GA	general alarm (internal communication)
GHz	gigahertz (communication)
GMDSS	global maritime distress safety system (external communication)
GNSS	global navigation satellite system (external communication)
IACS	International Association of Class Societies
IMO	International Maritime Organization
I/O	input/output (control systems)
IP	ingress protection
LSA	life saving appliances
MARPOL	The International Convention for the Prevention of Pollution from Ships
MED	Marine Equipment Directive (European Union)
MSC	Maritime Safety Committee (IMO)
MVZ	main vertical fire zone
OEA	orderly evacuation and abandonment
PA	public alarm (internal communication)
PSSC	passenger ship safety certificate
SOLAS	Safety Of Life At Sea
SPS	special purpose ship
SRtP	safe return to port
STCW	International Convention on Standards of Training, Certification and Watchkeeping
VHF	very high frequency (external communication)
WHO	World Health Organization

1.13 References

Table 8 External documents

Document code	*Title*
SOLAS II-1/Reg.8-1.2	System capabilities and operational information after a flooding casualty on passenger ships
SOLAS II-2/Reg.21	Casualty threshold, safe return to port and safe areas
SOLAS II-2/Reg.22	Design criteria for systems to remain operational after a fire casualty
IMO MSC.1/Circ.1369	Interim explanatory notes for the assessment of passenger ship systems' capabilities after a fire or flooding casualty
IMO MSC.1/Circ.1368	Interim clarifications of SOLAS chapter II-2 requirements regarding interrelation between the central control station, navigation bridge and safety centre
IMO MSC.1/Circ.1291	Guidelines for flooding detection systems on passenger ships
IMO MSC.1/Circ.1532	Revised guidelines on operational information for masters of passenger ships for safe return to port
IMO MSC.1/Circ.1437	Unified interpretations of SOLAS regulation II-2/21. (capabilities after a fire or flooding casualty)
IMO MSC.1/Circ.1400	Guidelines on operational information for Masters of passenger ships for safe return to port by own power or under tow
IMO MSC.1/Circ.1129	Guidance on the establishment of medical and sanitation related programmes for passenger ships
IACS UR E15	Electrical Services Required to be Operable Under Fire Conditions and Fire Resistant Cables
IACS UR M69	Qualitative Failure Analysis for Propulsion and Steering on Passenger Ships

Table 9 DNV GL documents

Document code	*Title*
DNVGL-SI-0364	SOLAS interpretations
DNVGL-CG-0004	Guidance for safe return to port projects

2 Life-cycle approach and newbuilding work process

2.1 Life cycle approach

2.1.1 Design versus operation

The SRtP regulations in SOLAS give design criteria for the SRtP systems. However, the key IMO guiding document for SRtP (MSC.1/Circ.1369) includes operational aspects of the regulations, and the practical feasability in restoration of the functions after an incident of fire or flooding. This implies that the planned operation of the ship is decisive for the design and arrangement of the systems affected by the SRtP regulations and consequently, that the design approach is decisive for a practical restoration of SRtP systems after a casualty.

2.1.2 System restoration

The design approach for restoration of the SRtP systems is crucial for the operational impact of the SRtP regulations, in particular the extent of manual actions needed for system recovery. It is therefore essential that the owner and yard/designer agree on the design approach and in particular a deliberate decision on the balancing between:

1) Highly redundant system arrangements with remote system restoration, high level of automation and remote control for the operation after a casualty, limited manual intervention.
2) Simpler system arrangements, local system restoration, low level of automation, local operation and operation based on manual actions after a casualty, extensive manual intervention.

Guidance note:

Both options (or anything in between) may be in compliance with the rules as long as the systems are designed to allow for system restoration within one hour, but the two options may impose big differences in capex and opex.

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2.1.3 Operational flexibility

The SRtP regulations require in general that the SRtP systems shall be arranged with redundancy. This implies that when key components are unavailable (e.g. due to maintenance or damage), the redundancy and SRtP capabilities of the ship may be impaired, and operational limitations may be imposed by the flag administration.

Guidance note:

It is recommended that the the owner and yard agree on an approach for system redundancy and capacity taking probable damage and maintenance scenarios into consideration.

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2.1.4 Operational decisions

In the event of an SRtP casualty, the decision on whether or not to return to port, to start system restoration and the eventual sequence of restoration, to move passengers and crew to safe areas etc. remains with the master; as for the decision on whether or not to abandon the ship in the event that a fire exceeds the SRtP casualty threshold.

Guidance note:

This implies e.g. that the one hour limit for system restoration as given in MSC.1/Circ.1369 is a design requirement and not related to practical system recovery in a real operational scenario.

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2.2 Work process

2.2.1 System engineering

The scope of the SRtP rules cover many ship systems and many technical disciplines are involved with i.a. system design, installation and verification. System arrangements and physical location of components, piping and cabling is essential for SRtP compliance, and the systems shall be designed according to a coherent design intention.

This necessitate a multi-disciplinary work process and early-phase development of philosophies and design intentions, overall arrangement drawings defining casualty thresholds and zone plans. These documents form the direction and basis for the detailed design of all SRtP systems in the subsequent project phases as well as the operational implications.

Guidance note:

It is strongly recommended for the shipyard to assign a dedicated SRtP co-ordinator/responsible in the project organisation, at the earliest possible stage.

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2.2.2 Early phase

The sequence of project activities is essential to ensure that the design intentions are implemented consistently in all relevant technical disciplines. As the system recovery and operation of the ship following a possible SRtP casualty largely depend on the design approach, the owner and designer/yard must in the early phase of the project agree on i.a.:

— the intended SRtP capabilities of the vessel, i.e. the designed SRtP operational limitations
— the approach for recovery of the SRtP systems and dependency of manual actions
— the system capabilities in a SRtP scenario, i.e. level of automation after a casualty
— the approach for SRtP compliance in cases of damage/maintenance of key components (redundancy concept)
— the approach for SRtP operational manuals and incorporation in operational procedures.

Guidance note:

It is strongly recommended to run early phase meetings and workshops between all the stakeholders to ensure that the above aspects are duly addressed as early as possible in the project.

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2.2.3 Documentation sequence

The documentation required for the **SRTP** notation shall be developed and submitted for approval in the following sequence, see Table 2 and Table 3:

Early phase:	- ship description/design philosophy - overall arrangement plans (casualty threshold plan, zone plan, safe area plan) - system design philosophies - safe area design philosophy - hydrodynamical calculation report.
Detail design phase:	- system arrangement plans - cable routing drawings.
Late phase:	- assessment reports - test procedure for quay and sea trials.

Guidance note:

The sequence of the documentation reflects the work process, which is essential for the project. The description of the above sequence with identification of the relevant systems and appurtenant documents should be included in the ship description/design philosophy document.

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3 Safe return to port - SRtP

3.1 General

3.1.1 Purpose

3.1.1.1

The purpose of this regulation is to establish design criteria for a ship' s safe return to port under its own propulsion after a casualty that does not exceed the casualty threshold stipulated in paragraph 3 and also provides functional requirements and performance standards for safe areas.

(SOLAS II-2/Reg.21.2)

Guidance note:

In the above referred SOLAS text, paragraph 3 refers to the definition of the casualty threshold, see [3.2].

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3.1.1.2 The SRtP regulations aim to ensure that the systems deemed necessary to support a safe return to port voyage after a casualty are robust and fault-tolerant with respect to incidents of fire or flooding, beyond traditional SOLAS regulations. This implies that the SRtP regulations are not intended to substitute or lower other SOLAS regulations at any point. Furthermore, the regulations aim to ensure the health and safety of passengers and crew in safe areas during a safe return to port voyage.

3.1.1.3 The SOLAS regulations for SRtP give design criteria for all the affected systems, and the primary IMO guidance document, MSC.1/Circ.1369, includes the operational aspects of the regulations. The intention is to ensure that, in case of a casualty within the defined threshold, restoration and operation of all the required systems is practicable and feasible for the crew for the duration of the voyage back to port.

3.1.2 Scope

3.1.2.1

When fire damage does not exceed the casualty threshold indicated in paragraph 3, the ship shall be capable of returning to port while providing a safe area as defined in regulation 3.5.1. To be deemed capable of returning to port, the following systems shall remain operational in the remaining part of the ship not affected by fire:

.1 propulsion;

.2 steering systems and steering-control systems;

.3 navigational systems;

.4 systems for fill, transfer and service of fuel oil;

.5 internal communication between the bridge, engineering spaces, safety centre, fire fighting and damage control teams, and as required for passenger and crew notification and mustering;

.6 external communication;

.7 fire main system;

.8 fixed fire-extinguishing systems;

.9 fire and smoke detection system;

.10 bilge and ballast system;

.11 power-operated watertight and semi-watertight doors;

.12 systems intended to support "safe areas" as indicated in paragraph 5.1.2;

.13 flooding detection systems; and

.14 other systems determined by the administration to be vital to damage control efforts.

(SOLAS II-2/Reg.21.4)

Guidance note:

In the above referred SOLAS text, paragraph 3 refers to the definition of the casualty threshold, see [3.2], paragraph 3.5.1 refers to the requirements of safe areas, see [4.14].

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3.1.2.2 The primary scope of the SRtP requirements is related to system recovery and subsequent operation, not the emergency response and ability to fight and mitigate the initial incident of fire or flooding.

3.1.2.3 The SRtP systems shall be designed to enable recovery of the intended functionality after any SRtP casualty within one hour.

Guidance note:

The intention of this requirement is to ensure a redundant and robust design arranged so that the extent of manual actions needed for system recovery after a SRtP casualty is limited, see [2.1.4] and [3.3.3].

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3.1.2.4 Requirements for the arrangement of each individual SRtP system are given in [4]. The system requirements are given in a 3-tiered approach:

1) goals
2) functional requirements
3) detailed requirements; as applicable.

3.1.2.5 The requirements for safe areas are given in [4.14].

3.1.2.6 The duration of the dimensioning voyage back to port shall be calculated under the following environmental conditions:

— 3 hours of the voyage under BF 8 conditions (see [4.2.2] for details of BF 8 conditions)
— the remaining part of the voyage heading into BF 4 conditions as follows:

  - wind speed: 7 m/s
  - significant wave height: 1 m
  - spectrum peak period: 10 s.

Guidance note 1:

The environmental conditions given for BF 8 and BF 4 are considered to be representative middle values of the defined BF 8 and BF 4 range respectively, based on calculations and meteorological statistics.

For further guidance on the calculation method, see DNVGL-CG-0004.

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Guidance note 2:

The environmental conditions assumed for the SRtP voyage determine the achievable speed with one propulsion line in operation at the SRtP load balance, and hence the duration of the dimensioning SRtP voyage.

This in turn define the basis for dimensioning the capabilities of certain systems required to remain operational, i.a. the fuel capacity to be available for each engine room after respective SRtP casualties, the provisions for the safe areas etc.

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Guidance note 3:

In a flooding scenario the vessel may have a less favourable loading condition which may impair the hydrodynamical performance and the capabilities of the vessel. Hence, even though the general requirements for systems to remain operational are the same for the fire- and the flooding scenario defined in the context of SRtP, the speed and operational capabilities of the vessel may in flooding scenarios be reduced below the designed SRtP range.

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Guidance note 4:

A safe port in the context of SRtP is assumed to be a community/port of call with a basic minimum of public services to handle the possible reception of the passengers and crew:

— basic medical services
— housing and supplies
— transportation.

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3.1.2.7 Most of the SRtP systems depend on sub-systems, auxiliary systems or other services to function. All such systems and services, shall be designed to remain operational to the extent needed to support the intended capabilities of the served SRtP system after a casualty.

3.2 SRtP casualty threshold (failure modes)

3.2.1 Casualty threshold - fire

The term 'casualty threshold' defines the maximum extent of an incident of a casualty (fire or flooding) where the ship shall remain operational according to SOLAS II-2/Reg.21.3:

> The casualty threshold, in the context of a fire, includes:
>
> .1 loss of space of origin up to the nearest "A" class boundaries, which may be a part of the space of origin, if the space of origin is protected by a fixed fire extinguishing system; or
>
> .2 loss of the space of origin and adjacent spaces up to the nearest "A" class boundaries, which are not part of the space of origin.
>
> (SOLAS II-2/Reg.21.3)

3.2.1.1 A-class boundaries refer to both bulkheads and decks.

Guidance note:

See MSC.1/Circ.1369 Int. 4.

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3.2.1.2 The rating of the A-class boundaries does not affect the application of the regulation.

Guidance note:

The casualty threshold in the context of fire therefore represents the physical extent and exposure of a possible fire originating in any space on board, limited by the arrangement of the surrounding A-class bulkheads and eventual fixed fire-fighting systems - unless the space is considered to be of negligible fire risk.

The number of fire casualty thresholds on a ship is therefore decided by the number of spaces with risk of fire and the appurtenant arrangement of A-class bulkheads and eventual fixed fire-fighting.

See MSC.1/Circ.1369 Int. 5.

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3.2.2 Fire risk

In the context of SRtP, any space is considered to constitute a fire risk unless deemed to be of negligible fire risk in accordance with [3.2.4].

3.2.3 Spreading of fire

3.2.3.1 Where a space of fire origin is not protected by a fixed fire extinguishing system, the casualty threshold extends beyond the nearest A-class boundaries to the next, including the adjacent compartment(s) in the same casualty threshold. For determining the next A-class boundaries and hence the extent of the casualty threshold, only spaces within the same MVZ shall be considered, and the casualty threshold includes spaces sideways and upwards (not downwards). The principles are illustrated in Figure 2.

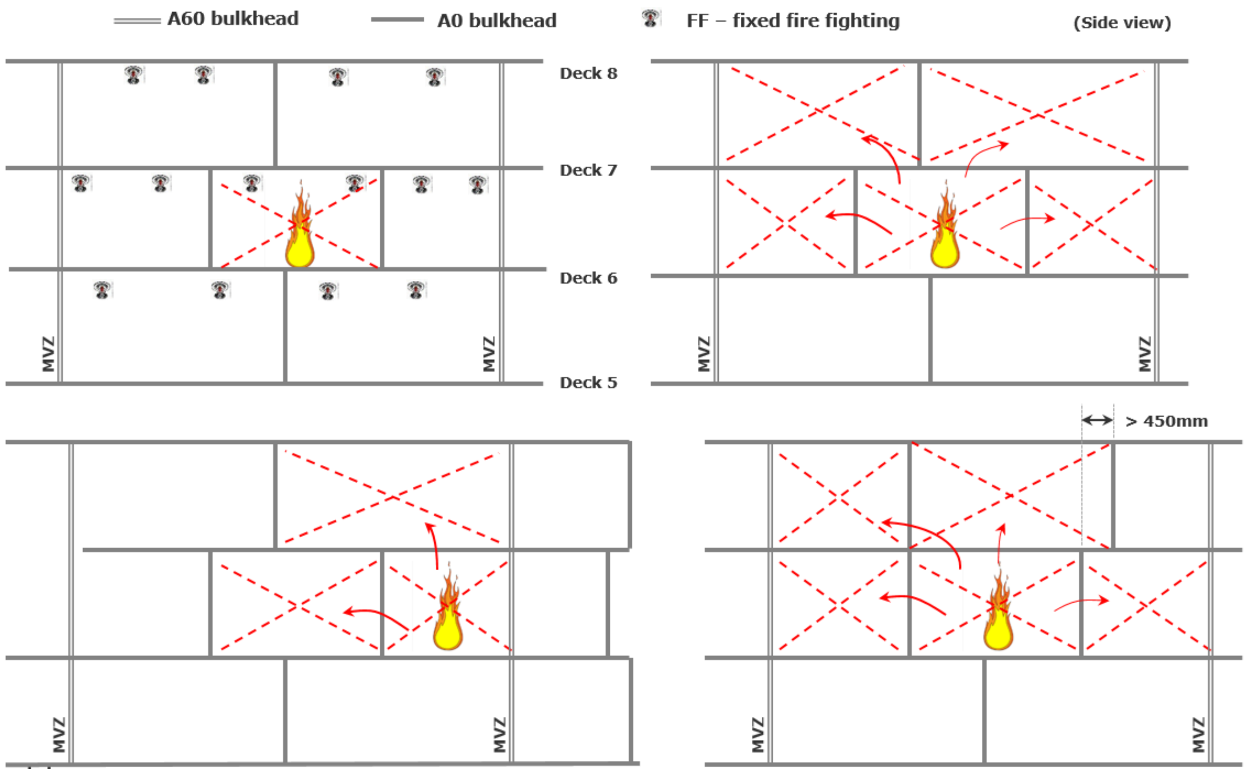

Figure 1 Spreading of fire and casualty thresholds

Guidance note:

See MSC.1/Circ.1369 Int. 7.

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Guidance note:

A fire casualty in the context of SRtP and OEA is not assumed to spread to open decks except for balconies outside passenger cabins and other particularly exposed areas like e.g. outside ventilation outlets.

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3.2.3.2 Horizontal special category- and ro-ro spaces (see [1.4.4.2]) shall be arranged in compliance with both SRtP and OEA requirements. This implies that a casualty in such a space shall not impair the ability for neither the SRtP nor OEA systems to remain operational. This applies to both fire and flooding casualties, if the space is below bulkhead deck.

3.2.4 Negligible fire risk

3.2.4.1 Spaces in which the risk of a fire break out is negligible shall not be considered as spaces of origin of fire.

3.2.4.2 If a space shall be categorized as of negligible fire risk, it shall:

— be closed at all boundaries (restricted accessibility for inspection/maintenance only)
— not contain any equipment
— not be used for any storage.

3.2.4.3 The space is allowed to contain the following equipment and still be considered as of negligible fire risk:

— pipes passing through not containing flammable liquids
— cables passing through without connections (except serving the below listed services)
— light fittings (for safety reasons)
— fire detectors
— bilge sensors for the bilge and flooding detection system
— electrical anodes and/or reference cells for vessel hull corrosion protection systems
— sensors for speed log or echo sounding systems.

Examples of such spaces include but are not limited to:

— void spaces
— trunks closed at all boundaries only containing pipes and/or electrical cables
— cofferdams
— tanks
— chain lockers
— ventilation trunks except those containing ducts presenting fire hazard such as galley range exhaust ducts, laundry exhaust ducts, category A machinery spaces ducts, special category and ro-ro spaces ducts
— cross flooding ducts connecting void spaces. In the case where connected spaces are not with a negligible fire risk, ducts should be separated from those spaces by non-watertight fire resistant boundaries to be considered as a space where fire risk is negligible
— vertical escape trunks from machinery spaces, service spaces, control stations and other crew accommodation spaces
— store rooms for gaseous fixed fire-extinguishing systems
— bus-bars enclosed in A class divisions
— "A" class enclosures within spaces of category 1, 2 or 4 only containing isolation valves or section valves forming part of the fixed fire extinguishing system for the protection of accommodation spaces, service spaces and control stations
— shaft tunnels (only used for the shafting, i.e. no storage is allowed)
— a deluge station containing the section control valves may on certain conditions, be considered as space of negligible fire risk, see [4.9.3].

3.2.4.4 Spaces other than those listed in [3.2.4.3] may, if duly justified in a fire/risk assessment, be accepted to be of negligible fire risk.

Guidance note 1:

The fire/risk assessment should in such cases take i.a. the following aspects into account:

— presence of combustible material, flammable liquids and/or flammable gases
— presence of electrical switchboards/switchgear/control gear and relevant power, electrical
— statistics on fire within spaces having the same purpose
— intended service of equipment/machinery installed and
— other factors considered appropriate for the space under consideration.

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Guidance note 2:

In the context of SRtP, the criteria for considering a space to be of 'negligible fire risk' are stricter than the general SOLAS definition of category 10 ('spaces having little or no fire risk').

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Guidance note 3:

See MSC.1/Circ. 1369 Int. 8.

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3.2.4.5 Trunks arranged as specified in [3.2.4.3], but containing valves, cable connections and joints shall be considered spaces of fire origin. If insulated to class A-60, however, loss of adjacent spaces need not be considered upon fire in such trunks and the trunks need not be considered lost upon fire in an adjacent space.

3.2.5 Impact of fire casualty

Within the fire casualty threshold, all equipment, components, cables and pipes are in general considered lost, with certain exemptions, see [3.3.4].

Cables exposed to a fire may loose the conductor insulation, and cause any kind of failure mode including short circuit, open wire or earth fault.

Guidance note:

This should in the assessment report be carefully considered for ia. emergency stop signals that may latch upon a fire, and prevent restarting and operation of units that are supposed to remain operational.

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Valves shall be considered lost within the fire casualty threshold, thereby causing an open end to the piping system.

Any fuel oil piping system located within a fire casualty threshold is considered lost upon a fire.

3.2.6 Casualty threshold - flooding

A passenger ship constructed on or after 1 July 2010 shall be designed so that the systems specified in regulation II-2/21.4 remain operational when the ship is subject to flooding of any single watertight compartment.

(SOLAS II-1/Reg.8-1.2)

The casualty threshold in the context of flooding defines the maximum extent of an incident of a flooding casualty where the ship shall remain operational according to SOLAS II-2/Reg.21.3.

The flooding scenario includes any single watertight compartment below bulkhead deck.

Guidance note:

The casualty threshold for flooding is not affected by the distance from the hull, the presence of pipes or possible sources of leakage. Further, it is assumed that the cause of the flooding is internal, hence hull penetration with consequential damage and subsequent flooding is not considered to be within the SRtP flooding casualty threshold.

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3.2.7 Impact of flooding casualty

3.2.7.1 Within the flooding casualty threshold, all equipment and components are considered lost unless designed with adequate IP (ingress protection) degree to withstand the expected water pressure at the location of the unit.

3.3 Remain operational

3.3.1 General

The intention with the SRtP requirements is to ensure that the systems are designed and arranged so that:

— the system capabilities for all the SRtP systems can be restored after the initial casualty scenario has been handled

and to:

— ensure that the SRtP systems maintain their capabilities to provide safe vessel operation during the voyage back to port.

Guidance note 1:

Consequently, the SRtP requirements aim at the ability to recover and maintain operation, not the emergency response or ability to fight and mitigate the initial casualty.

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Guidance note 2:

In the context of SRtP, the terms 'remain operational' and 'maintain capabilities' are considered as equivalent.

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3.3.2 Design intention

The general intention of the SRtP regulations is to ensure that the SRtP systems are designed and arranged with adequate redundancy and segregation so that the system remain operational with limited operator intervention.

However, if such arrangements are not feasible, certain alternative measures may upon special considerations be applied to fulfil the intention:

- manual actions for system restoration and operation during the SRtP voyage
- criteria for assuming survivability of components, cables and pipes within the casualty threshold.

3.3.3 Manual actions

3.3.3.1 Manual actions to provide system capabilities after a casualty are in the context of SRtP considered to be the following:

- Manual actions to restore ship system capabilities:
  - temporary restoration and manual operations beyond normal routines and procedures.
- Manual actions to maintain ship system capabilities:
  - manual intervention beyond normal routines and procedures needed for the SRtP systems to remain operational for the duration of the return to port voyage.

Manual actions in this context are primarily actions that must be performed locally at or near the equipment (e.g. valves, pumps, breakers).

Guidance note:

Temporary repair or mechanical intervention depending on tools or equipment is normally considered to be beyond the acceptance criteria for manual actions.

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3.3.3.2 The systems shall be designed so that the manual actions needed for restoration of all SRtP systems affected by a casualty are possible for the crew to complete within one hour.

Guidance note:

The one hour requirement is considered as a design criteria, to give direction and limitations to the design approach for the SRtP systems; i.e to what degree the systems can be designed to depend on manual actions for system restoration. The one hour limitation applies to the accumulated sum of all manual actions that are needed for restoring all SRtP systems that are affected by an SRtP casualty.

In order to ensure that the SRtP systems are designed with a limited extent of manual actions that actually allow system restoration within one hour, the theoretical number of crew members available for the system restoration is a parameter that needs to be duly considered in the design phase.

The one hour criteria is considered as a pure design requirements and therefore irrelevant for the operational phase as the system restoration and operational decision following a real operational casualty scenario is fully up to the master/crew.

See MSC.1/Circ.1369 Ch.5.2.

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3.3.3.3 Any manual action that may be required for the SRtP systems to remain operational following a casualty shall be:

1) identified and considered as part of the assessment, see [1.9.2]
2) pre-planned, pre-set and instructions as well as necessary materials available on board
3) clearly described in the documentation
4) emergency lighting and communication available at the location where the manual actions shall be performed
5) demonstrated by tests or drills.

Guidance note:

See MSC.1/Circ.1369 Ch.5.2, 6.1, 7.3, 7.4.

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3.3.3.4 If a system depend on manual actions for restoration, the physical location of the manual intervention shall be outside the casualty threshold, i.e outside the space exposed to the fire or flooding.

3.3.4 Survivability after a fire

3.3.4.1 Pipes

a) Within the fire casualty threshold, all pipes are considered lost due to the fire exposure. However, if segregated routing is practically unavoidable, the following exemptions are considered to survive a fire and remain operational:

— pipes routed through a trunk closed at all boundaries constructed to A 60[1)]

— steel pipes other than those carrying flammable liquids and passing through (not serving) spaces affected by a fire casualty provided they are of:

— substantial thickness[2)]

— adequately supported

— joined by welding [3)]

Guidance note:

1): See MSC.1/Circ.1369 int 5.

2): See ICLL 66 regulation 22(3), as interpreted by IACS UI LL36/Rev. 2 paragraph (b) or "A-60" insulated ("A-60" class insulation approved in accordance with resolution A.754(18) for bulkheads or decks may be used for this purpose).

3): Otherwise mechanical joints should be tested according to IACS UR P2.11.5.5.6 fire test or equivalent to the satisfaction of the Society.

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— plastic pipes if tested to resolution A.753(18), level 1

— metallic and non-metallic pipes tested with L1 test, as per Pt.4 Ch.6 Sec.2 Table 2.

b) Temperature increase of liquids carried shall be considered, and measures taken where necessary, so that the performance and purpose of the affected systems are maintained as intended after the casualty has occurred.

Guidance note:

See MSC.1/Circ. 1369 Int. 12.

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3.3.4.2 Cables

a) Within the fire casualty threshold, all cables are considered lost due to the fire exposure. However, if segregated routing is practically unavoidable, the following exemptions are considered to survive a fire and remain operational:

- a trunk closed at all boundaries constructed to A 60[1)]
- fire-resistant cables complying with standards IEC 60331-1 and -2 passing through (not serving) spaces may be considered to remain operational after a fire casualty provided that
  - they have no connections, joints and equipment connected to them within the space affected by the casualty
  - installation of these cables is made to support their survival[2)] in a fire casualty and during fire fighting efforts. Cables complying with both IEC 60331-1, -2 and in addition BS8491:2008 (or EN50200 for cables of smaller diameter) are accepted as an alternative way to fulfil this requirement.

Guidance note 1:

1): See MSC.1/Circ.1369 int 5.

2): This implies e.g. that the cables are shielded to avoid exposure to the physical impact of direct water spray from e.g. fire hoses or fixed installations.

See also IACS UR E15 *Electrical Services Required to be Operable Under Fire Conditions and Fire Resistant Cables*.

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Guidance note 2:

See MSC.1/Circ. 1369 Int. 13.

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3.3.5 Survivability after flooding

3.3.5.1 Cables type approved by the Society are considered to remain operational.

3.3.5.2 Pipes are considered to remain operational.

3.3.5.3 Piping systems complying with Pt.4 Ch.6 shall not be considered a source for progressive flooding.

3.3.5.4 Piping systems may be considered operational in a SRtP scenario when passing through flooded compartments if:

- the piping system is designed to work in submerged condition at the maximum external pressure it may be subjected to in a flooding scenario
- the seawater temperature does not influence the fluid behaviour in such a way that the system functionality is lost.

4 System arrangement - SRtP

4.1 General

The following subsections give requirements for each of the SRtP systems as listed in [3.1.2]. The additional requirements for the systems to remain operational in the OEA scenario are given in [6].

Guidance note:

The requirements for each system are given at the three layers described in [1.6.2] with the headings:

1) goal
2) functional requirements
3) detailed requirements.

The sequence of systems in this subsection follow the order as given in SOLAS II-2/Reg.21.4.

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4.2 Propulsion

4.2.1 Goal

The vessels propulsion system shall, after any SRtP casualty, remain operational and be capable of propelling the vessel safely back to port.

4.2.2 Functional requirements

The propulsion function is considered to remain operational when, after any SRtP casualty, at least one propulsor with all necessary auxiliaries and supporting systems are operable for the duration of the voyage back to port, and the remaining propulsion power capacity enable the ship to maintain a speed of 6 knots while heading into BF 8 characterized by the following environmental conditions:

- wind speed: 19 m/s
- significant wave height: 5 m
- spectrum peak period: 13 s

Guidance note:

These environmental conditions are considered to be a representative middle of the BF 8 range, based on calculations and meteorological statistics.

See MSC.1/Circ.1369 Int. 18.

For vessels operating in restricted areas less exposed to harsh weather, more lenient environmental conditions may be applied in agreement with the administration and the owner. The SRtP capabilities will be specified in the 'List of operational limitations' as required by SOLAS V/Reg.30.

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4.2.3 Detailed requirements

4.2.3.1 The propulsion function shall be realized by installation of at least two independent and separated propulsion systems. The duplicated propulsion systems shall be installed and located so that they are not impaired by the same SRtP casualty.

4.2.3.2 Vessels designed and built with a higher degree of redundancy/separation than twoshall be subject to special evaluation.

4.2.3.3 A shaft line, including relevant bearings, passing through a space affected by a fire or flooding casualty may be considered operational if it is enclosed in a watertight and "A" class tunnel or alternatively if:

1) in the flooding case it is documented that it can operate under water;
2) in the fire case it is protected by a dedicated water spray system capable of delivering not less than 5 $l/m^2/min$ on the protected area or equivalent.

Guidance note:

This implies that both propulsion shafts may pass through the same casualty threshold if at least one shaft is arranged as described in this paragraph.

See MSC.1/Circ.1369 Int. 19.

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For bearing arrangements according to 1) it shall be demonstrated by hydrostatic testing that the bearing maintains satisfactory oil quality after being submerged as follows:

— to the maximum hydrostatic pressure that the bearing may be exposed to in a SRtP flooding casualty
— for a period of no less than 60 minutes.
— the lubrication oil volume shall have less than 2% water content after the test.

Where the propulsion shafts for both propulsion lines are arranged within the same casualty threshold, the additional documentation listed in Table 4 shall be submitted for approval.

4.2.3.4 Both propulsion systems shall be designed to be continuously active during normal operation.

Guidance note:

Alternative propulsion arrangements may be approved upon special consideration, e.g. in connection to a specific trade or appropriate operation, provided acceptance from the administration and the owner.

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4.2.3.5 Manual intervention to regain and maintain propulsion functionality upon an SRtP casualty may be accepted provided that the general conditions for manual intervention are fulfilled, see [3.3.3].

4.2.3.6 Auxiliary systems

1) All auxiliary systems serving each propulsion function shall be arranged to be independent and separate for the duplicated propulsion systems. The auxiliary systems serving the separated propulsion systems shall be located so that they are not impaired by the same SRtP casualty, and arranged according to the same zone plan, see Table 2.

   Guidance note:

   This applies to all auxiliary systems needed to support the propulsion function, ia. fuel oil, lub oil, cooling water, ventilation, electrical power, control and safety systems, technical water, instrument air etc.

   The requirement does not apply to exhaust gas treatment systems, which is not required to remain operational in the context of SRtP.

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2) For piping systems, cross-over pipes between the segregated engine rooms are acceptable provided these have isolation valves on both sides of the separating bulkheads. This applies also to cross over facilities for ventilation ducts.

4.2.3.7 Control, monitoring and safety

The required means for safe local operation of the propulsion machinery shall be arranged so that no SRtP casualty impair both propulsion engines/propulsion lines, and the location shall be provided with adequate means of internal communication and lighting.

4.3 Steering

4.3.1 Goal

The vessels steering system shall, after any SRtP casualty, remain operational and provide necessary steering capabilities for the SRtP voyage.

4.3.2 Functional requirements

The steering function is considered to remain operational when one steering system (rudder or azimuth thruster) with its supporting components and systems is operable, after any SRtP casualty. The remaining steering system shall fulfil the capabilities that are required for the main steering gear at the maximum achievable speed.

4.3.3 Detailed requirements

4.3.3.1 The steering function shall be designed with at least two independent and separated steering systems, e.g two rudders or two azimuth thrusters. The duplicated steering systems shall be located so that they are not impaired by the same SRtP casualty.

4.3.3.2 Vessels designed and built with more than two steering arrangements are subject to special evaluation.

4.3.3.3 Manual intervention to regain and maintain steering functionality upon an SRtP casualty may be accepted provided that the general conditions for manual intervention are fulfilled, see [3.3.3].

4.3.3.4 Auxiliary systems
Auxiliary systems, serving either steering function, shall be arranged to be independent and separate for the duplicated steering systems. The auxiliary systems serving the separated steering systems shall be located so that they are not impaired by the same SRtP casualty, and arranged according to the same zone plan, see Table 2.

4.3.3.5 Control, monitoring and safety
The required means for safe local steering shall be arranged so that no SRtP casualty impair both steering units, and the location shall be provided with adequate means of internal communication and lighting.

4.4 Navigational systems

4.4.1 Goal
The navigation systems shall, after any SRtP casualty, remain operational at the the navigation bridge or the alternative location commonly denoted as the SRtP bridge.

4.4.2 Functional requirements
The navigation systems are considered to remain operational when the following equipment and associated functions are, after any SRtP casualty, available at either the main navigating bridge or at the SRtP bridge:

a) a properly adjusted standard magnetic compass
b) a receiver for a global navigation satellite system or a terrestrial radionavigation system
c) a 9 GHz radar
d) electronic chart display and information system (ECDIS) or an appropriate folio of paper nautical charts and publications
e) whistle
f) navigation lights
g) internal communications with engine control room and steering gear compartment
h) a pelorus or compass bearing device to take bearings
i) means of correcting heading and bearings to true at all times
j) means for communication with the eventual locations demanding local control
k) means for communication with proper look-out positions (if proper-look out is not provided from the SRtP bridge).

Guidance note:
Proper look-out positions are required by COLREG Rule 5 and STCW Reg.VI/2.

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The ship shall be capable of displaying the proper light configuration in compliance with the prevailing COLREG (International Regulations for Preventing Collisions at Sea).

Guidance note:

See MSC.1/Circ.1369 Int. 22.

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4.4.3 Detailed requirements

4.4.3.1 System duplication - general

The navigational systems required to remain operational shall be arranged with duplicated equipment installed at the main navigational bridge and SRtP bridge respectively. The navigational equipment and auxiliaries, associated cabling, power supplies etc. on the SRtP bridge shall be segregated from the installations on the main navigational bridge so that the duplicated systems are not impaired by the same SRtP casualty.

4.4.3.2 Whistle

The whistle system shall be arranged with two independent and segregated systems; controlled from the main navigational bridge and SRtP bridge respectively. The duplicated whistle systems, including equipment and cables, shall be located and arranged so that they are not impaired by the same SRtP casualty.

4.4.3.3 Navigation lights

The control of all navigation lights required by COLREG shall be arranged with two independent and segregated control systems, operated from the main navigational bridge and SRtP bridge respectively.
The duplicated light control systems, including equipment and cables, shall be located so that they are not impaired by the same SRtP casualty.

4.4.3.4 Compass

A separate gyro compass in lieu of a standard magnetic compass may be accepted, if approved by the administration. This gyro compass shall (if provided) be interfaced to the radar and ECDIS (if provided).

4.4.3.5 GNSS

The required GNSS shall be interfaced to the radar, and ECDIS (if provided).

4.4.3.6 Performance standard

The required navigation equipment shall conform to appropriate performance standards not inferior to those adopted by IMO.

4.5 Fuel oil

4.5.1 Goal

The fuel oil system shall, after any SRtP casualty, remain operational to provide the necessary fuel to the required propulsion- and power generation machinery; for the duration of the SRtP voyage back to port.

4.5.2 Functional requirements

The fuel oil system is considered to remain operational when, after any SRtP casualty, the system is capable of supplying the fuel oil needed for all remaining combustion machinery required for the dimensioning SRtP voyage.

The combustion machinery required to remain operational for the SRtP voyage is normally:

— the remaining propulsion line with its prime mover(s)
— the remaining power generation plant serving the SRtP power balance
— the emergency generator, if SRtP power balance depend on it
— eventual other machinery like e.g. boilers, if required for the SRtP voyage.

If the SRtP power balance depend on the emergency generator, the emergency generator shall be designed for continuous service with necessary fuel supplies for the voyage back to port - without impairing the capability and capacity required for the emergency power system.

4.5.3 Detailed requirements

4.5.3.1 The fuel oil system shall be provided by either:

1) a dedicated fuel oil treatment and transfer system for each engine room arranged with segregation, or
2) dedicated and segregated fuel oil service tanks for each engine room with sufficient volume of ready to use fuel.

Guidance note:

The fuel oil systems should be arranged according to the same zone plan as the systems it serves, see [4.2].

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4.5.3.2 No single SRtP casualty shall impair the fuel supply to both redundant units in the machinery systems required to remain operational.

4.5.3.3 The quantity of fuel that shall be available for the dimensioning SRtP voyage shall be calculated and documented, i.a. based on the following parameters:

— the hydrodynamic report where the vessel speed, propulsion power demands, and duration of the SRtP voyage is calculated for the dimensioning SRtP casualty scenario, under the required specified conditions, see [3.1.2.6]
— the SRtP power demand including the total consumption of all combustion machinery required to remain operational.

Guidance note:

For dual fuel arrangements, the fuel needed for the SRtP voyage may be based on any combination of the fuel types as long as the quantity required for the dimensioning SRtP voyage is available.

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4.5.3.4 Where one common fuel tank serves consumers in two segregated engine rooms and where the tanks have boundaries to both engine rooms, quick closing valves shall be provided in both engine rooms.

4.5.3.5 The quick closing valves shall after any SRtP casualty remain operational in the fuel oil systems that are required to remain operational.

4.6 Internal communication

4.6.1 Goal

The systems for internal communication shall, after any SRtP casualty, remain operational outside the casualty threshold.

4.6.2 Functional requirements

4.6.2.1 The systems for internal communication are considered to remain operational when two-way voice communication addressing the following stations are available after any SRtP casualty:

— bridge
— SRtP bridge
— engineering spaces
— safety centre
— all fire-fighting and damage control teams
— emergency control stations, muster and embarkation stations and strategic positions on board (see SOLAS III/6.4)
— all stations on board which require manual control or operation to sustain operation of essential SRtP systems

— look-out position(s) if required by [4.4].

Guidance note:

See MSC.1/Circ.1369 Int. 25.

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4.6.2.2 The PA systems, arranged as general alarm systems, are considered to remain operational when the system is available and served by at least one PA loop in all other MVZs than the one exposed to the SRtP casualty.

An emergency PA call station, and a general emergency alarm activation point (if combined PA/GA system) shall be provided at the SRtP bridge.

Guidance note:

See SOLAS II-2/21.4.5 and MSC.1/Circ.1369 Int. 26.

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4.6.3 Detailed requirements

4.6.3.1 Internal communication based on portable systems may be accepted provided that:

— repeaters or equivalent means remain operational outside the casualty threshold
— charging capability is available in more than one MVZ
— each space is covered by redundant repeaters' contributions.

Guidance note:

It is recommended to arrange one common two-way voice communication system for compliance with both SRtP and OEA requirements. This communication system shall then be available on all defined location [4.6.2], [6.3.3] and provide two-way communication to the fire-fighting and damage control teams.

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4.6.3.2 The PA/GA system shall be designed with:

— two (or more) independent racks
— the cables from each rack routed within different casualty thresholds.

Guidance note:

The two independent racks should preferably be installed in the forward and aft MVZs, respectively.

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4.6.3.3 The PA/GA call station, racks and loudspeakers, with cables (power and signals) shall be arranged and protected so that it is operational in the remaining parts of the ship after a SRtP casualty or in all other MVZs than the MVZ exposed to the casualty. All emergency call stations not affected by the SRtP casualty shall be able to broadcast announcement directly to all not affected areas of the ship.

Guidance note:

See MSC/Circ.808 2.5 and 3.1.

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4.7 External communication

4.7.1 Goal

The systems for external communication shall, after any SRtP casualty, remain operational at an alternative location outside the casualty threshold.

4.7.2 Functional requirements

The systems for external communication are considered to remain operational when communication via the GMDSS or the VHF marine and air band distress frequencies, are available at either the main bridge or SRtP bridge, after any SRtP casualty.

The ship shall be capable of:

1) transmitting and receiving search and rescue co-ordinating communication by:
   - portable or fixed VHF for on-scene (aeronautical) radio-communications
   - portable or fixed VHF for on-scene (survival craft/ship) radio-communications
2) providing two-way communication according to sea area aligned with the PSSC (GMDSS sea area).

Guidance note:

See MSC.1/Circ.1369 Int. 27.

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4.7.3 Detailed requirements

4.7.3.1 The additional external communication equipment, components and cables (power and signal) shall be located so that they are not impaired by the same SRtP casualties as would affect the main external communication equipment on bridge.

4.7.3.2 The external communication equipment shall be of a type approved by the administration; conform to appropriate performance standards not inferior to those adopted by IMO and MED certified as applicable.

4.8 Fire water

4.8.1 Goal

The fire water system shall, after any SRtP casualty, remain operational outside the casualty threshold.

4.8.2 Functional requirements

The fire water system is considered to remain operational when, after any SRtP casualty, SOLAS II-2/Reg. 10.2.1.5.1 is fulfilled in all MVZ other that the one exposed to the casualty. The remaining spaces outside the casualty threshold within the same MVZ may be served by hydrants from adjacent MVZs.

Guidance note:

See MSC.1/Circ.1369 Int. 28 and 53.

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4.8.3 Detailed requirements

4.8.3.1

Fire fighting in spaces outside the casualty threshold within the same MVZ may be covered by hoses connected to hydrants in the adjacent MVZs, provided that the fire water system in the MVZ containing the casualty can be isolated from the adjacent MVZs. It shall be possible to reach all areas by two hoses connected to different hydrants, and not more than two lengths of hoses may be connected. Protected branch-off from the operational part of the fire water system in the adjacent zone, with A 60 protected connection cabinet, may be arranged.

Guidance note 1:

This implies that the fire water system can be arranged so that a SRtP casualty scenario (where a casualty is limited by the boundaries of the casualty threshold) may have the same impact on the system as the OEA casualty scenario (where a casualty may impair a complete MVZ).

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Guidance note 2:

When establishing the necessary number of hoses, the eventual need for connecting two hoses must be taken into consideration. This is particularly relevant in case the system is arranged so that the fire water function within the MVZ containing the fire shall be served by hydrants in the adjacent MVZs. A water jet of 7 m may be taken into account.

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4.8.3.2 If, after a casualty, the spaces within the same MVZ as the casualty are intended to be served by hoses from the adjacent MVZs, the fire water system in each MVZ must be arranged with isolation valves on both sides of the MVZ bulkheads.

4.8.3.3 If any casualty scenario may lead to a situation where all operational fire pumps are located on either side of the MVZ exposed to fire, bypass lines with isolation valves shall be arranged in order to reach eventual spaces on the far side of the lost MVZ.

Guidance note:

See also the OEA scenario described in [6.2].

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4.9 Fixed fire extinguishing systems

4.9.1 Goal

The fixed fire extinguishing systems shall, after any SRtP casualty, remain operational outside the casualty threshold.

4.9.2 Functional requirements

The fixed fire extinguishing system is considered to remain operational when, after any SRtP casualty, all relevant regulations of SOLAS II-2 is fulfilled in all spaces outside the casualty threshold. Indication of activated sections in all other MVZs than the one containing the casualty, shall continue to function.

Guidance note:

See MSC.1/Circ.1369 Int. 33.

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4.9.3 Detailed requirements

4.9.3.1 The regulations of this chapter apply to fixed fire extinguishing systems as required in SOLAS II-2/Reg.10.4, 10.5, 10.6 and 20.6.1 and any fixed fire extinguishing installed to limit the casualty threshold.

This is not applicable for:

— local application systems in machinery spaces (SOLAS II-2/Reg.10.5.6) unless they form part of a total flooding system to protect the machinery space
— galley duct extinguishing system (SOLAS II-2/Reg.9.7.5.1.1.3)
— deep fat cooking fire extinguishing (SOLAS II-2/Reg.10.6.4)
— paint locker fire extinguishing (SOLAS II-2/Reg.10.6.31).

Guidance note:

See MSC.1/Circ.1369 Int. 29 to 36.

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4.9.3.2 Machinery spaces category A

For fixed fire extinguishing protection according to SOLAS II-2/Reg.10.5, the extinguishing system may be arranged as two completely segregated and different systems (e.g. a water based and gas based extinguishing system), each system complying with SOLAS II-2/Reg.10.4 as applicable.

Alternatively, one system may be accepted if arranged so that upon a SRtP casualty, the fixed fire extinguishing system are still functional. For the latter option special considerationshall be given with regards to arrangement of any dry pipe system.

4.9.3.3 Accommodation sprinkler system

Pump units for accommodation sprinkler systems may be segregated as 3 x 50% or 2 x 100% or equivalent.

4.9.3.4 Ro-ro and special category spaces

Guidance note:

A deluge station containing the section control valves serving the water based fixed fire extinguishing systems for ro-ro and special category spaces can be considered a space of negligible fire risk if the following is implemented:

— the space is only used as a deluge station with associated safety equipment
— only deluge valves (manual or remotely operated) and associated equipment (limit switches, any actuators, operation instructions, light, fire detectors, ventilation and any heating) are accepted inside the deluge station
— the deluge station shall be insulated to a standard of structural fire protection equivalent to that required for a control station
— all doors in the boundary of the deluge station shall be self-closing.

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4.9.3.5 Indication/alarm system for actuated sensors

The indication/alarm system for activated sections shall be arranged with redundancy, arranged so that both units are not impaired by the same SRtP casualty.

Two panels/indicating units located in continuously manned stations shall be arranged, each indicating unit shall be connected to one or both system units so that they are not impaired by the same SRtP casualty.

The signal cables from each section may be connected to:

— an I/O cabinet located within the same MVZ as the section or
— connected directly to the two system units.

4.10 Fire detection and alarm

4.10.1 Goal

The fire detection and alarm system shall, after any SRtP casualty, remain operational in all required spaces outside the casualty threshold.

4.10.2 Functional requirements

The fire detection and alarm system is considered to remain operational when the system is arranged to fulfil SOLAS II-2/Reg.7 in all spaces outside casualty threshold.

4.10.3 Detailed requirements

— Fire detection centrals shall be duplicated and segregated so that both units are not impaired by the same casualty.
— Power source and cabling for fire detection centrals shall be arranged/segregated so that both units are not impaired by the same casualty.
— Detector section arrangement/cabling shall be connected to different fire detection centrals, to provide detection in all required spaces outside the casualty.
— Requirements for section arrangement and cabling in FSS – Code 9.2.1.6, 9.2.4.3.2 shall be complied with also in the SRtP casualty scenarios.

Guidance note:

The referred paragraphs of the FSS code cover failure modes of component/cables and requirements to cable routing, which must be observed in addition to the SRtP requirements.

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4.11 Bilge

4.11.1 Goal

The bilge system shall, after any SRtP casualty, remain operational in all spaces served by the bilge system outside the casualty threshold.

4.11.2 Functional requirements

The bilge system is considered to remain operational provided:

- After any SRtP flooding casualty:
  - all spaces served by the bilge system can be drained
  - all valves controlling the bilge suction can be operated from above the bulkhead deck (as required by SOLAS II-1/Reg.35-1 3.11).
- After any SRtP fire casualty:
  - all spaces served by the bilge system outside the casualty threshold can be drained
  - all valves controlling the bilge suction can be operated. Local operation of the bilge valves serving spaces outside the casualty threshold within the same MVZ shall be available; in all other MVZs the valves shall be operable from above the bulkhead deck (as required by SOLAS II-1/Reg.35-1 3.11).

The bilge function in void spaces located within the same MVZ as the SRtP casualty need not remain operational.

A principal bilge piping arrangement is shown in Figure 3.

4.11.3 Detailed requirements

4.11.3.1 Any casualty threshold containing main bilge line serving the casualty threshold and/or other casualty thresholds shall be arranged with isolation valves on both sides of the bulkheads of the casualty threshold.

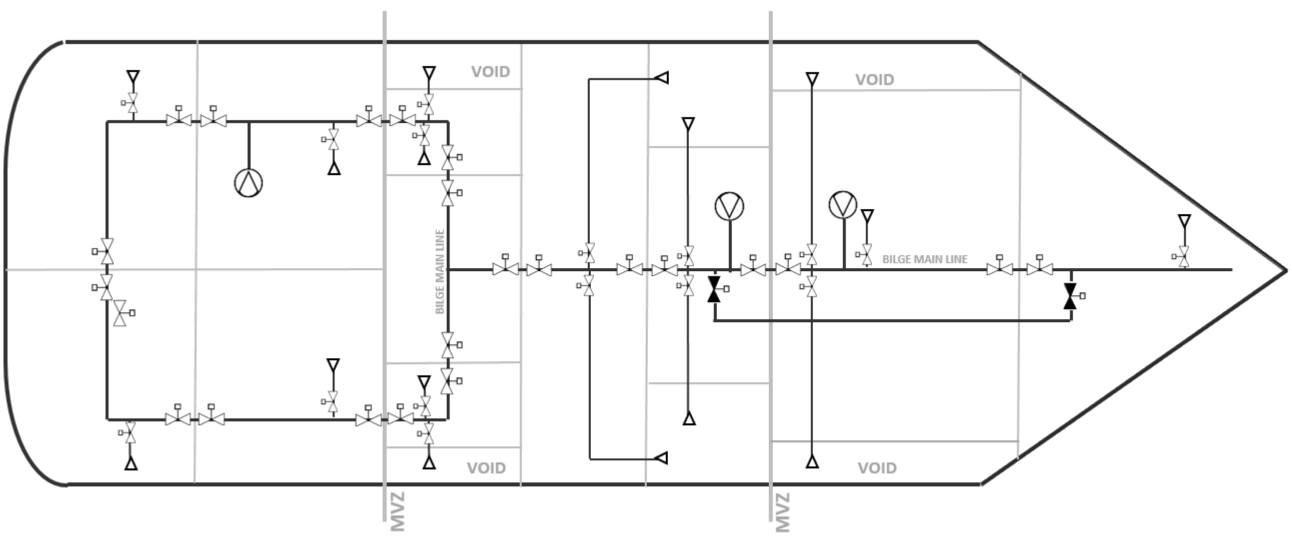

Figure 2 Principal bilge arrangement

4.11.3.2 Casualty thresholds served by the bilge systems and not containing main piping shall have redundant branch-offs from pipe sections located within different casualty thresholds. This does not apply to void spaces if served from piping systems located within the same MVZ.

4.11.3.3 If any casualty can lead to a situation where all operational bilge pumps are located on one side of the isolated casualty threshold, bypass lines with isolation valves shall be arranged to serve the system section that do not contain operational pumps.

4.11.3.4 The control system for valves controlling the bilge function shall be arranged with redundancy; both controllers located above the bulkhead deck and arranged so that they are not impaired by the same casualty. The control panels/user interface shall be connected to each of the system units.

Guidance note:

The bilge level detection and alarming functionality after a casualty is considered to be adequately covered through the flooding detection system.

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4.11.3.5 The signal cables to the bilge valves within in a MVZ shall either be:

— connected to an input/output (I/O) cabinet located above bulkhead deck within the same MVZ or
— connected directly to the two controllers.

If the valves are connected to an I/O cabinet located within the same MVZ, a casualty impairing the I/O cabinet shall not impair the means for local control of the valves.

4.11.3.6 Power (electrical and pneumatic, if applicable) shall be arranged according to the same redundancy principle as the remote control system.

4.11.3.7 Isolation valves that after an SRtP casualty must be operated in order to isolate the piping section within the casualty threshold from the remaining system may be operated locally.

Guidance note:

Such local operation is considered to be manual actions which shall be identified in the assessment report in the list of manual actions associated with the relevant casualties.

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4.11.3.8 Actuated valves for the bilge system may be installed in a space categorized as an area of negligible fire risk.

Guidance note:

Since a space of negligible fire risk shall have restricted access, the operation of eventual valves in a space of negligible fire risk after a casualty cannot be based on manual local control. This implies that any valve located within a space of negligible fire risk must be possible to operate remotely even after any SRtP casualty.

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4.11.3.9 Bilge alarm sensors can be considered as being part of the flooding detection function.

4.11.3.10 In the event of an SRtP casualty, discharge of untreated bilge directly to sea may be acceptable during the SRtP voyage, but only in cases where the safety of ship or lives at sea may otherwise be threatened.

Guidance note:

See MARPOL, Annex I, Ch.1 Reg.4.

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4.12 Ballast

4.12.1 Goal

The ballast system shall, after any SRtP casualty, remain operational outside the casualty threshold.

Guidance note:

The ballast system may normally be exempted from the SRtP regulations if duly justified and accepted by the owner and administration. The application for exemption to the administration should contain a substantiation of why the ballasting function is not required after a casualty.

If the ballasting system is not exempted from the SRtP regulations, the requirements in this subsection apply.

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4.12.2 Functional requirements

The ballast system is considered to remain operational if, after any SRtP casualty, all ballast tanks outside MVZ containing the casualty can be operated by the remaining ballast system.

Local manual control of the ballast system is acceptable after a SRtP casualty, on the general conditions for manual actions, see [3.3.3].

4.12.3 Detailed requirements

4.12.3.1 All MVZs with main ballast piping serving the MVZ or other MVZs shall be arranged with isolation valves on both sides of the MVZ bulkheads.

4.12.3.2 If a casualty lead to a situation where all operable ballast pumps are located at one side of the impaired MVZ, a bypass line with isolation valves shall be arranged to serve the system piping section in the MVZ that does not contain any operable pump.

4.12.3.3 In the event of an SRtP casualty, discharge of untreated ballast water directly to sea may be acceptable during the SRtP voyage, but only in cases where the safety of ship or lives at sea may otherwise be threatened.

Guidance note:

See IMO BWMC (Ballast Water Management Convention) Regulation A-3.1.

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4.12.3.4 Actuated valves for the ballast system are accepted to be installed in a space categorized as an area of negligible fire risk.

Guidance note:

Since a space of negligible fire risk shall have restricted access, the operation of eventual valves in a space of negligible fire risk after a casualty cannot be based on local control. This implies that any valve located within a space of negligible fire risk must be possible to operate remotely even after any SRtP casualty.

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4.13 Internal watertight doors

4.13.1 Goal

The internal watertight doors system shall, after any SRtP casualty, remain operational outside the casualty threshold.

4.13.2 Functional requirements

The internal watertight doors system is considered to remain operational when:

— after a SRtP flooding casualty, the indication at bridge as required by SOLAS II-1/Reg.13.8.2 remain operational for all doors
— after a fire casualty, the indication at bridge as required by SOLAS II-1/Reg.13.8.2 remain operational for all doors outside the casualty threshold
— after casualty on bridge, the indication as required by SOLAS II-1/Reg.13.8.2 is available for all doors at another manned location.

Guidance note:

The requirements apply to all watertight doors (power operated and non-power operated) where remote position indication at bridge is required by SOLAS.

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Guidance note:

Components for the indication system situated below bulkhead deck shall be protected against the ingress of water as described in SOLAS II-1/Reg.13.7.6.

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Guidance note:

See MSC.1/Circ.1369 Int. 39.

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

4.13.3 Detailed requirements

4.13.3.1 The door indication system shall be arranged with redundancy.

4.13.3.2 The position indication for each door shall be implemented in two different system units. These units shall be located so that they are not impaired by the same SRtP casualty.

4.13.3.3 The position indication sensors (open and closed) for a door shall be connected to both system units. The connections shall be arranged/routed so that a SRtP casualty can only impair the connection to one of the system units. If duplication of required sensors is arranged, the pair of sensors can be routed to different system units.

4.13.3.4 The bridge panel presenting the door indication and the communication to the system units shall be arranged so that a casualty can only impair one of the system units.

Guidance note:

The integrated alarm system panel at the bridge may be used as a backup means of indication.

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4.13.3.5 The power supplies to system units shall be arranged so that both units don't loose power upon a SRtP casualty. The bridge panel shall be arranged with two power supplies arranged so that they are not impaired by the same SRtP casualty.

4.14 Safe areas

4.14.1

Safe areas

5.1 Functional requirements:

.1 the safe area(s) shall generally be internal space(s); however, the use of an external space as a safe area may be allowed by the administration taking into account any restriction due to the area of operation and relevant expected environmental conditions;

.2 the safe area(s) shall provide all occupants with the following basic services to ensure that the health of passengers and crew is maintained:

.2.1 sanitation;

.2.2 water;

.2.3 food;

.2.4 alternate space for medical care;

.2.5 shelter from the weather;

.2.6 means of preventing heat stress and hypothermia;

.2.7 light; and

.2.8 ventilation;

.3 ventilation design shall reduce the risk that smoke and hot gases could affect the use of the safe area(s); and

.4 means of access to life-saving appliances shall be provided from each area identified or used as a safe area, taking into account that a main vertical zone may not be available for internal transit.

(SOLAS II-2/Reg.21.5)

4.14.1.1 The safe areas shall be designed to provide all passengers and crew with services listed in [4.14.1] to ensure safe and habitable conditions for the duration of the SRtP voyage.

Guidance note:

The main intention is to ensure that the ship is designed to have these services available in the areas designated for the purpose in the event of any casualty within the casualty threshold. Whether or not it is necessary to actually move people to the safe areas in the event of a casualty and restore functionality in that area depend on the casualty and operational situation, and will be at the masters' discretion.

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4.14.2 Goal

The safe areas shall, after any SRtP casualty, provide all passengers and crew with necessary services to ensure the health and habitability for the duration of the SRtP voyage.

4.14.3 Functional requirements

The safe areas are considered to remain operational when, after any SRtP casualty, all the services listed in [4.14.1] are available in the dedicated safe area(s) in other MVZs than the one exposed to the casualty:

— at least 1 toilet per 50 persons
— minimum 3 l of water per person per day
— food and provisions with at least the WHO recommended level of 2000 kcal / 8000 kJ. per pshelter from the weather
— the temperature kept within 10ºC and 30ºC
— light
— erson per day
— basic medical equipment and first aid provisions
— ventilation flow of minimum 4,5 m^3/h per person.

Guidance note:

See MSC.1/Circ.1369 Int. 41-51.

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4.14.4 Detailed requirements

4.14.4.1 The safe areas shall be arranged to accommodate all passengers and crew in other MVZ(s) than the one containing the casualty.

Guidance note:

This implies that at there must be two or more safe areas in different MVZs. If there are two safe areas, each area must be able to accommodate all passengers and crew, and provide the required services. If the safe areas are arranged in three or more MVZs, the safe areas must be arranged so that the total areas in the other MVZs than the one containing the casualty accommodate all passengers and crew, with the required services.

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4.14.4.2 In the event of an SRtP fire casualty, only the spaces within the casualty threshold is considered lost to the fire, but in the context of safe areas, the full MVZ containing the casualty is considered unsuited for accommodating passengers and crew during the SRtP voyage.

4.14.4.3 The required services shall be provided for the duration of the SRtP voyage, which is defined by the planned route and SRtP propulsion capabilities, see [3.1.2.6]. If the duration of the dimensioning SRtP voyage is above 12 hours, the safe area shall provide at least 2 m^2 space per person, if less than 12 hours, minimum 1 m^2 shall be provided.

4.14.4.4 The safe areas shall be provided with easy access to life saving appliances (LSA). External routes to the LSA are considered accessible also within the MVZ exposed to the fire casualty.

4.14.4.5 Requirements to the arrangement for the specific systems are given in the following subsections.

4.14.5 Sanitation

Black and grey water systems shall after any SRtP casualty remain operational in the safe area(s) assigned to the various casualties.

In the event of an SRtP casualty, discharge of untreated grey and black water directly to sea may be acceptable during the SRtP voyage, but only in cases where the safety of ship or lives at sea may otherwise be threatened, see MARPOL, Annex IV, Reg.3.

4.14.6 Water

Sanitary supply system shall after any SRtP casualty remain operational in the safe area(s) assigned to the various casualties.

Fresh water production system should remain operational, or alternatively, sufficient quantities of fresh water shall be preserved in fresh water storage tanks. For that purpose, low level alarms shall be provided for fresh water tanks. Additional quantities for hygiene and food preparations shall be included.

4.14.7 Food

Food, water and equipment for the support of the basic services to the safe areas, stored in spaces outside the relevant casualty threshold, are considered available even within the same MVZ as the casualty.

Guidance note 1:

This implies that even though the safe areas shall be arranged in other MVZs than the one containing the casualty, it is assumed that all spaces outside the casualty threshold also within the same MVZ may be accessible for storage of the provisions - and accessible from the safe areas even when located in different MVZs.

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Guidance note 2:

The food and provisions provided for the safe areas may be of any kind as decided by the owner, from dry food and bottled water to hot meals. If a galley is needed to prepare the food, the equipment and services needed shall be provided as part of the safe area.

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4.14.8 Alternate space for medical care

5.2 Alternate space for medical care

Alternate space for medical care shall conform to a standard acceptable to the administration.

(SOLAS II-2/Reg.21.5.2)

4.14.8.1 In addition to the ships' hospital or medical centre, an alternative, easily accessible location equipped with basic medical equipment and first aid provisions shall be available in a different MVZ than the primary medical centre, and provided with lighting and power supply from emergency power.

Guidance note:

See MSC.1/Circ.1369 Int. 46 and MSC.1/Circ. 1129, GUIDANCE ON THE ESTABLISHMENT OF MEDICAL AND SANITATION RELATED PROGRAMMES FOR PASSENGER SHIPS.

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4.14.9 Shelter from the weather

The use of external spaces as a safe area may upon special consideration be accepted by the administration, on condition that the required system capabilities are provided for; that the area of operation, environmental conditions and duration of the dimensioning SRtP voyage is taken into consideration.

4.14.10 Means of preventing stress and hypothermia

Means of preventing heat stress and hypothermia shall, after any SRtP casualty, be provided in the designated safe area.

Air condition (heating/cooling) for the designated safe area shall remain operational if needed to keep the temperature within this range.

4.14.11 Light

Portable rechargeable battery powered lighting may be acceptable in areas not covered by the emergency lighting system, if adequate charging capabilities are provided, see [4.18].

4.14.12 Ventilation

The ventilation for the safe areas shall remain operational with a minimum capacity of 4,5 m^3/hour per person.

4.15 Flooding detection system

4.15.1 Goal

The flooding detection system shall, after any SRtP casualty, remain operational outside the casualty threshold.

4.15.2 Functional requirements

The flooding detection system is considered to remain operational when:

— after any flooding casualty, the flooding detection alarm system on bridge as required by MSC.1/Circ. 1291 remain operational for all watertight compartments

— after any fire casualty, the flooding detection alarm system on bridge as required by MSC.1/Circ. 1291 remain operational for all watertight compartments except the watertight compartment containing the fire casualty

Guidance note:

See MSC.1/Circ.1369 Int. 40. This applies to eventual spaces below bulkhead deck where the extent of a fire casualty is less than the flooding casualty threshold.

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— after a casualty at the bridge, flooding detection alarms as required by MSC.1/Circ.1291 is operational for all watertight compartments at another manned location.

Guidance note:

See MSC.1/Circ.1291: Guidelines for flooding detection system on passenger ship.

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The functional requirements of the flooding detection system apply to both:

— flooding detection of water ingress in watertight compartments
— liquid level monitoring of tanks with means of indication at the bridge.

Guidance note:

This implies that the general requirement to remain operational also applies to the liquid level monitoring system for tanks (e.g. fuel oil, lub oil, fresh water) with indication at the bridge, i.a. that the exemption given in MSC.1/Circ.1291 7 does not apply in the context of SRtP.

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4.15.3 Detailed requirements

4.15.3.1 The flooding detection and alarm system shall be arranged with redundancy.

4.15.3.2 Components installed below bulkhead deck shall be designed with adequate IP degree to withstand the potential water head at the location of the unit.

Guidance note:

See MSC.1/Circ.1291 Item 13.

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4.15.3.3 Flooding detection functionality for each watertight space must be implemented in two system units. Redundant system units must be segregated so that both units are not impaired by the same casualty.

4.15.3.4 The flooding sensor in a space shall be connected to both system units, or if duplication of sensors are arranged, one sensor shall be connected to each system units. The connections shall be arranged/routed so that a casualty can only impair the connection to one of the system units.

Guidance note:

For spaces where two or more flooding detection sensors are required by MSC.1/Circ.1291 Item 8, it is acceptable that only one sensor is available for the alarm system after a SRtP casualty.

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

4.15.3.5 Bilge alarm sensors can be considered as being part of the flooding detection function.

4.15.3.6 The bridge alarm panel presenting the flooding alarms shall be connected to both system units. The communication shall be arranged so that a SRtP casualty can only impair the connection to one of the system units.

4.15.3.7 The power supplies to system units shall be arranged so that not both units loose power upon a SRtP casualty. The bridge panel shall be arranged with two power supplies arranged so that both units are not impaired by the same SRtP casualty.

4.16 Control, monitoring, alarm and safety systems

4.16.1 Goal

The control, monitoring, alarm and safety systems shall remain operational to the extent necessary to support the intended level of automation and control for each of the SRtP systems, while also maintaining the required safety functions.

Guidance note:

For each of the SRtP systems that is served by the an integrated or dedicated control, monitoring, alarm and safety system, the intended level of performance after a SRtP casualty must be described in the SRtP system design philosophies. The control, monitoring, alarm and safety systems shall then be designed to reflect the various needs of the SRtP systems which in turn define what 'remain operational' entails for the control, monitoring, alarm and safety systems.

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4.16.2 Functional requirements

The control, monitoring, alarm and safety system is considered to remain operational when, after any SRtP casualty, the system maintain the following functionality for each SRtP system required to remain operational:

— maintain the safety functions as required by main class and SOLAS
— support the intended operation with necessary alarming, user interface and means of control

Guidance note:

This implies e.g. that:

— In case of a casualty in one engine room, the machinery in the remaining engine room should maintain the required control, alarm, monitoring and safety functions to enable a safe operation during the SRtP voyage.
— In case of a casualty affecting the bilge system, the required bilge functionality should be maintained outside the casualty threshold, e.g. that the bilge valves shall be operable from a position above bulkhead deck.

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The control, monitoring, alarm and safety systems for each SRtP system shall be arranged to support the intended method of system restoration and operation following a SRtP casualty.

Guidance note:

The intended level of automation and remote control versus dependency of local, manual intervention and manual actions must be duly considered in this respect. If the system restoration and operation during the SRtP voyage depend on manual intervention, supervision and safety actions that is normally handled in the control, monitoring, alarm and safety systems, the manual intervention must be identified in the in the assessment reports/SRtP operation manual.

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4.17 Electrical power generation and distribution

4.17.1 Goal

The electrical power supply system shall, after any SRtP casualty, remain operational to provide electrical power to all the SRtP systems required for the voyage back to port, including the safe areas.

4.17.2 Functional requirements

The electrical power supply system is considered to remain operational when, after any SRtP casualty:

— the power plant is capable of generating the SRtP power demand[1)]

— the power distribution system is capable of supplying necessary power to all the consumers that are required to remain operational

for the duration of the SRtP voyage.

Guidance note:

1: The SRtP power demand is the electrical power demand following the dimensioning SRtP casualty, at a vessel spedd of 6 knot while heading into BF 8 and also providing the necessary power to all the SRtP systems listed in [3.1.2].

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4.17.3 Detailed requirements

4.17.3.1 The main power plant shall consist of minimum two main sources of electrical power (normally, the generating sets, but also other sources of power may be considered), two main switchboards, two sets of associated transforming equipment, converters and similar appliances constituting a part of the electrical power supply system. The duplicated components shall be located in separate engine rooms/compartments so that any SRtP casualty does not affect both systems.

4.17.3.2 After any SRtP casualty, it shall be possible to start and connect the remaining main sources of electrical power to the appurtenant main switchboard(s). Each engine room/compartment shall be arranged with stored energy and systems for starting the main source of power in a black out situation.

4.17.3.3 After a SRtP casualty, the remaining power generation and distribution system shall have sufficient capacity to supply all systems required to be operational for the SRtP voyage. Due regard shall be paid to systems that may have to be operated simultaneously. An automatic load reduction or load shedding system shall be provided if there is a risk that the remaining power generation or distribution system may be overloaded.

4.17.3.4 The emergency generator and the emergency power distribution system may be used to supplement the remaining main power source to meet the SRtP power demand, provided its ability to supply emergency consumers (Pt.5 Ch.4 Sec.3 [1.1]) is not impaired. The emergency generating set shall have sufficient capacity to supply all required emergency consumers simultaneously in addition to the demands of the SRtP systems. The requirement to emergency generators used in port Pt.4 Ch.8 Sec.2 [3.3.4] apply. If operation in a SRtP scenario depend on the emergency generator, the fuel supply system shall be arranged to support the required service for the duration of the SRtP voyage.

4.17.3.5 When systems required to remain operational in a SRtP casualty are supplied from distribution switchboards, the switchboards shall be arranged in separate compartments so that any SRtP casualty does not impair both switchboards.

4.17.3.6 In general, cables to duplicated consumers should be separated so that any SRtP casualty does not impair both cables. If separated cable installation is not feasible, alternative methods to remain operational may be acceptable, see [3.3.4.2].

4.17.3.7 SRtP systems shall in general be supplied from distribution boards located within the same MVZ as the equipment, or directly from the main or emergency switchboard (see Pt.4 Ch.8 Sec.2 [9.1.2] g).

Guidance note:

Equipment in smaller MVZs may be supplied from distribution board located in another MVZ as long as [4.17.1] is fulfilled.

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4.18 Lighting system

4.18.1 Goal

The lighting systems shall, after any SRtP casualty, remain operational in all

— areas where manning is required for SRtP system restoration, including positions where manual actions are required
— areas where manning is required for system operation during the SRtP voyage
— the safe areas assigned to the casualty (outside the MVZ containing the casualty)
— areas where lighting is required to be supplied from the emergency source of power according to Pt.5 Ch.4 Sec.3 [1.1.4].

4.18.2 Functional requirements

The lighting system is considered to remain operational when, after any SRtP casualty, the remaining lighting provides sufficient illumination to support the tasks to be performed in the required areas for the duration of the SRtP voyage.

4.18.3 Detailed requirements

4.18.3.1 Light fixtures shall in general be supplied from distribution switchboards located within the same MVZ.

4.18.3.2 Power supply to the lighting fixtures in all areas requiring lighting in a SRtP casualty shall be divided between at least two different switchboards. These switchboards shall be in separate compartments so that any SRtP casualty does not impair both systems.

4.18.3.3 In areas where manual actions are necessary for system restoration or to maintain functionality during the return to port voyage, either the fixed main- or the emergency lighting system shall remain operational after any SRtP casualty.

4.18.3.4 The access way to areas where manual actions are taken for the ship to return to port should be provided with fixed main and emergency lighting.

4.18.3.5 Portable rechargeable battery operated lighting may be acceptable for use in spaces which are not covered by the ship’s emergency lighting system. Adequate charging capability shall be available for such battery powered lighting.

4.19 Stability computer

Guidance note:

The stability computer is not among the systems that are required to remain operational following an SRtP casualty as given in SOLAS II-2/Reg.21.4, and hence the requirements of the SRtP notation do not apply.

However, SOLAS II-1/Reg.8-1.3 give requirements to the stability computer to support the master during an SRtP voyage and further guidance to the arrangement of the stability computer is given in MSC.1/Circ.1400 and 1532.

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5 Orderly Evacuation and Abandonment - OEA

5.1 General

5.1.1 Purpose

5.1.1.1

The purpose of this regulation is to provide design criteria for systems required to remain operational for supporting the orderly evacuation and abandonment of a ship, if the casualty threshold, as defined in regulation 21.3, is exceeded.

(SOLAS II-2/Reg.22.2)

Guidance note:

Regulation 21.3 refer to the casualty threshold defined for SRtP, see [3.1.1.1].

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5.1.1.2 The OEA requirements aim to ensure that, in case a fire exceeds the SRtP casualty threshold and potentially propagate to the whole MVZ, the systems deemed necessary to support an orderly evacuation are designed to remain operational for a minimum period of three hours, in all other MVZs than the one exposed to the fire.

Guidance note:

The OEA requirements do not cover flooding scenarios that exceed the SRtP casualty threshold.

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5.1.2 Scope

5.1.2.1

3.1 In case any one main vertical zone is unserviceable due to fire, the following systems shall be so arranged and segregated as to remain operational:

.1 fire main;

.2 internal communications (in support of fire-fighting as required for passenger and crew notification and evacuation);

.3 means of external communications;

.4 bilge systems for removal of fire-fighting water;

.5 lighting along escape routes, at assembly stations and at embarkation stations of life-saving appliances; and

.6 guidance systems for evacuation shall be available.

3.2 The above systems shall be capable of operation for at least 3 h based on the assumption of no damage outside the unserviceable main vertical zone. These systems are not required to remain operational within the unserviceable main vertical zones.

(SOLAS II-2/Reg.22.3)

5.1.2.2 The scope of the OEA requirements is related to the ability for the listed functions to be restored and remain operational in all other MVZs than the one exposed to the fire casualty; and not the ability to fight and mitigate the fire situation in the affected MVZ.

Guidance note:

In an OEA scenario, a complete MVZ is considered unavailable, and access to life saving appliances should be arranged to ensure availability also for any such scenario.

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5.2 OEA - casualty scenario (failure modes)

5.2.1 Fire casualty exceeding the SRtP casualty threshold

The casualty scenarios for the OEA regulation is the loss of any complete MVZ, following a proliferation of an initial fire beyond the SRtP casualty threshold. The fire is then assumed to spread and potentially affect the whole MVZ in which the fire originated.

Guidance note:

In an OEA scenario, the fire is in general not assumed to spread to open decks, except balconies outside passenger cabins and certain areas on open decks that may be specifically exposed, e.g. related to ventilation outlets.

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5.2.2 Impact within the exposed MVZ

Within the lost MVZ, all components, pipes and cables are considered lost, unless arranged as described in [5.3.2].

5.3 Remain operational

5.3.1 General

In the context of the OEA regulations, the listed functions shall remain operational in all other MVZs than the one lost to the fire, for a period of minimum three hours.

This includes power supplies and other auxiliary systems necessary for the listed systems to remain operational and addition to life saving appliances.

Local intervention and operation may be acceptable.

5.3.2 Survivability after an OEA casualty

5.3.2.1

> 3.3 Cabling and piping within a trunk constructed to an "A-60" standard shall be deemed to remain intact and serviceable while passing through the unserviceable main vertical zone for the purposes of paragraph 3.1. An equivalent degree of protection for cabling and piping may be approved by the administration.
>
> (SOLAS II-2/Reg.22.3.3)

5.3.2.2 An equivalent degree of protection in the context of OEA casualty scenarios is considered to be as follows:

Pipes

A 60 insulated steel pipes and couplings or steel pipes of substantial wall thickness with full welded connections, see [3.3.4.1].

Cables

Cabling arranged with redundancy and segregation in such a way that the system remains operational after failure/loss of either cable passing through the unserviceable main vertical zone. The redundant cables shall be separated by minimum two A-class decks and have no connections, joints or connected equipment within the unserviceable main vertical zone. At least one of the cables shall be fire resistant and installed in accordance with [3.3.4.2].

6 System arrangement - OEA

This subsection contains the additional requirements for the specific systems required to remain operational to support OEA in accordance with [5].

6.1 Electrical power generation and distribution

6.1.1 Goal

For any OEA scenario, the electrical power supply system shall remain operational to provide electrical power to all systems that are required to support an orderly evacuation and abandonment situation including life saving appliances in all other MVZs than the one exposed to fire.

6.1.2 Functional requirements

For the OEA scenario, the electrical power supply system is considered to remain operational when:

— the remaining power generation plant is capable of generating the OEA power demand[1)]
— the power distribution system is capable of supplying necessary power to all the consumers that are required to remain operational in all other MVZs that the one exposed to the fire

for a period of three hours.

Guidance note:

1): The OEA power demand is defined as the electrical power demand following the dimensioning OEA casualty; the necessary power to the OEA systems listed [5.1] (SOLAS II-2/Reg.22.3), see definitions in Table 6.

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6.1.3 Detailed requirements

6.1.3.1 The electrical power sources shall be located in separate MVZs so that not all of them are impaired in any OEA scenario. The remaining power sources shall have sufficient capacity to supply all systems required to be operational in the unaffected MVZs for at least three hours.

Guidance note 1:

The power sources may be the main- and/or the emergency source of power, centralized battery systems, local battery systems (e.g. battery systems or other power sources covering one MVZ, or battery systems dedicated to a single consumer or system).

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Guidance note 2:

The cable routing and protection of cables against fire must be carefully considered when the power source and the consumers are in different MVZs. See [5.3.2] for conditions to consider a cable passing an unserviceable MVZ to remain operational in an OEA scenario.

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6.2 Fire main

6.2.1 Goal

For any OEA scenario, the fire main shall remain operational in all other MVZs than the one exposed to the fire.

Guidance note:

If the fire main arrangement is according to [4.8.3.1] where spaces outside the casualty threshold shall be served by hoses connected to hydrants in adjacent MVZs, the OEA scenario does in general not entail requirements beyond the SRtP scenario.

See also MSC.1/Circ.1369 Int. 28 and 53.

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6.3 Internal communication

6.3.1 Goal

For any OEA scenario, the systems for internal communication shall remain operational in all other MVZs than the one exposed to the fire.

6.3.2 Functional requirements

For the OEA scenario, the internal communication system is considered to remain operational when means are available for communicating orders to fire-fighting and damage control teams; and personnel in charge of evacuation and abandonment.

The PA systems, arranged as general alarm systems, are considered to remain operational when the system is available and served by at least one PA loop in all other MVZs than the one exposed to the fire.

6.3.3 Detailed requirements

6.3.3.1 A two-way voice communication system shall be provided.

Guidance note:

If portable equipment is used it shall comply with DNVGL-SI-0364 Sec.4 [3.3.1]. Not all hand-helds are to be located in one space; sufficient units for all stations have to be provided and charging units to be stationed in more than one MVZ. The repeater system needs to remain operational when required to provide direct communication between all areas of the vessel not affected by the casualty to support communication as described in MSC.1/Circ.1369 Int. 54.

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6.3.3.2 At least one loop of the PA/GA system shall remain operational for passenger and crew notification within all MVZs not affected by the casualty. All not affected emergency call stations shall be able to broadcast announcement directly to all not affected areas of the ship.

Guidance note:

See MSC/Circ.808 2.5 and 3.1.

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6.3.3.3 The two-way voice communication system and the emergency PA call station shall be provided at the SRtP bridge. If the SRtP bridge is located in the same MVZ as the navigating bridge, a third location in a different MVZ shall be provided with the same means of communication.

Guidance note:

This communication system shall then be available on all defined location and provide 2-way voice communication to the fire-fighting and damage control teams.

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6.4 External communication

6.4.1 Goal

For any OEA scenario, the systems for external communication shall remain operational in another MVZ than the one exposed to the fire.

6.4.2 Functional requirements

For the OEA scenario, the external communication system is considered to remain operational when the ship is capable of communicating via the GMDSS or the VHF marine and air band distress frequencies even if the main GMDSS equipment is lost.

The ship shall be capable of:

1) transmitting and receiving search- and rescue co-ordinating communication by
   - — portable or fixed VHF for on-scene (aeronautical) radio-communication, and
   - — portable or fixed on-scene (survival craft/ship) radio-communication, and
2) providing two-way communication according to sea area aligned with the PSC (GMDSS sea area).

Guidance note:

See MSC.1/Circ.1369 Int. 55.

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6.4.3 Detailed requirements

The external communication equipment shall be provided at the SRtP bridge. If the SRtP bridge is located in the same MVZ as the navigating bridge, a third location in a different MVZ shall be provided with the same means of communication.

The above equipment shall be of a type approved by the administration and shall conform to appropriate performance standards not inferior to those adopted by IMO.

6.5 Bilge system

6.5.1 Goal
For any OEA scenario, the bilge system shall remain operational in all spaces served by the bilge system in the other MVZs than the one exposed to the casualty.

6.5.2 Functional requirements
For the OEA scenario, the bilge system is considered to remain operational if all spaces served by the system in all other MVZs than the one exposed to the fire can be drained.

Bilge alarm functionality is not required in this mode of operation.

6.5.3 Detailed requirements

6.5.3.1 All MVZs with main bilge piping serving the MVZ or other MVZs shall be arranged with isolation valves on both sides of the MVZ bulkheads.

6.5.3.2 If a casualty lead to a situation where all operable bilge pumps are located at one side of the lost MVZ, by pass line with isolation valves must be arranged to serve the system piping section in the MVZ without any operable pumps.

6.5.3.3 Local manual control of the bilge system is acceptable after a OEA casualty, on the general conditions for manual actions, see [3.3.3].

6.6 Lighting system

6.6.1 Goal
For any OEA scenario, lighting along escape routes, at assembly stations, at embarkation stations for life-saving appliances and the area of water into which they shall be launched shall remain operational in all other MVZs that the one exposed to fire.

6.6.2 Functional requirements
For the OEA scenario lighting is considered to remain operational when the remaining lighting provides sufficient illumination for orderly evacuation and embarkation of the vessel for a period of minimum three hours.

6.6.3 Detailed requirements
The lighting fixtures shall be arranged with integrated batteries or supplied from power sources located within the same MVZ as the lighting fixtures, and the power source shall have sufficient energy for minimum three hours of operation.

If the lighting required for the OEA scenario is not supplied from power sources located within the same MVZ as the lighting fixtures, power supply to this lighting shall be distributed between at least two power sources. These power sources shall be located in accordance with [6.1.3].

External access routes to assembly and embarkation stations for life-saving appliances are considered to remain available also in the MVZ exposed to the casualty. Lighting along these external access routes shall either be provided with integrated batteries with capacity for minimum three hours of operation or the power supply to the lighting shall be distributed between at least two power sources located in different MVZs.

6.7 Guidance system

6.7.1 Goal
For any OEA scenario, guidance systems for evacuation shall remain operational in all other MVZs than the one exposed to the fire.

6.7.2 Functional requirements

For the OEA scenario guidance systems for evacuation is considered to remain operational when escape route signage and low location lightning remain operational for at least 3 hours in all other MVZs than the one exposed to the fire.

6.7.3 Detailed requirements

Both escape route signage and low location lightning system are considered as guidance systems for evacuation under SOLAS II-2/Reg.22.3.6.

Any power source for guidance system to be duplicated and segregated to assure operation in case of casualty scenario.

SECTION 12 WIND ASSISTED PROPULSION SYSTEM - WAPS

1 General

1.1 Introduction

Wind assisted propulsion systems (WAPS) like rotor sails or wing rigs can be installed on different kind of ships. The purpose of such WAPS is the contribution to reduce the consumption of conventional fuels. WAPS shall not replace conventional propulsion means, but assist in favourable operating conditions.

1.2 Objective

The objective of this document is to provide a set of requirements for vessels intending to install a wind assisted propulsion system on board.

1.3 Scope

The class notation **WAPS** covers operational and technical safety aspects related to the installation of WAPS onboard ships.

Guidance note:

Since wind assisted propulsion systems will be under constant development and future could reveal other or different systems than mentioned in [1.1], the requirements of this class notation may need to be interpreted and supported by additional information and requirements, on a case by case basis.

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The requirements defined in this section are divided into:

a) The WAPS:

The unit itself, including all of its integral parts, systems, machinery and safety aspects.

b) The technical safety aspects of the ship and its technical periphery associated with and affected by the installation of a WAPS unit:

These are the technical installations integrated into the ships systems, such as electrical and automation, machinery and the foundation as well as safety aspects such as ship stability, are further referred to as 'ships periphery'.

For definitions and general characteristics, see DNVGL-ST-0511 Table 1-1.

1.4 Application

The additional class notation **WAPS** may be applied to all ship types with a wind assisted propulsion system installed. The **WAPS** installation shall be considered as an auxiliary propulsion systems, thus the ship shall be fully operable with main propulsion only.

1.5 Class notation

Ships with WAPS installed on board, complying with the requirements given in this section may be assigned the optional class notation **WAPS** as specified in Table 1.

Table 1 Additional class notation WAPS

Class notation	*Qualifier*	*Purpose*	*Application*
WAPS Mandatory: No Design requirements: This section FIS survey requirements: NA	<none>	Wind assisted propulsion systems installed on seagoing ships	

1.6 Procedural requirements

1.6.1 Documentation requirements

1.6.1.1 Documentation requirements for WAPS unit

The documentation requirements for different types of WAPS units are defined in DNVGL-ST-0511 Table 3-1 as defined for a TADC.

1.6.1.2 Documentation requirements for the ship

Additional documentation requirements for the integration of the WAPS into the ship systems and ship structure are defined in Table 2.

Table 2 Documentation requirements

Object	*Documentation type*	*Additional description*	*Info*
General arrangement	Z030, C020		FI
Case report manoeuvrability	N060	FMEA, on request	AP
Operational manual	Z161, Z220		FI
Test procedure for quay and sea trial	Z253		FI
Strength calculations	H080, H085	Foundation of the WAPS	FI
Arrangement plan of the foundation	C020		FI
Detail drawings of the foundation	C030		AP
Detail drawings of ship structure in way of foundation	H050		AP
Specifications of bearings, bearing lubrication system and possibly other interfaces	C030		AP
Proposal for load case combinations	C010	Incl. assumptions, restrictions, consequences	AP
Material specifications	M030		AP, TA

Object	Documentation type	Additional description	Info
Description of integration of drive unit electrical installations into on board power supply system	E010		AP
Electrical and hydraulic circuit diagrams including specification of components			AP, TA
Control system description, systematics and specification, i.e. sensors; arrangement, redundancy, alarms	E220, I200		AP
Emergency stop system description; remote start/ stop -fail safe	E220, I200		AP
Implementation into alarm and monitoring system	I200, I020		AP
AP = For approval; FI = For information; TA = Covered by type approval			

For general requirements to documentation, including definition of the info codes, see DNVGL-CG-0550 Sec.6.

For a full definition of the documentation types, see DNVGL-CG-0550 Sec.5.

1.6.2 Certification requirements

1.6.2.1 Certification requirements for a WAPS unit installed onboard a ship

The certification requirements for WAPS units, installed onboard a ship with the class notations **WAPS** are given in Table 3.

Table 3 Certification requirements

Object	Certification type	Issued by	Certification standard	Additional description
WAPS unit	PD	Manufacturer	DNVGL-ST-0511	DNVGL-ST-0511 Sec.2
PD = product declaration				

The product declaration PD is a compliance document validated and signed by the manufacturer in accordance with DNVGL-CG-0550 Sec.3.

2 Requirements

2.1 Requirements for the design of WAPS units

The WAPS unit shall fulfil all requirements as defined in DNVGL-ST-0511 Sec.2.

When a WAPS unit has a TADC, issued by the Society, full compliance with the relevant requirements given in DNVGL-ST-0511 Sec.2 has been documented.

2.2 Requirements for ships

2.2.1 General
Requirements for the installation of WAPS units on board of ships are covered by Pt.1, Pt.2, Pt.3 and Pt.4.

2.3 Focus areas

2.3.1 WAPS foundation
The WAPS foundation is the stationary part of the installation which is designed to transfer the forces excited from the WAPS to the supporting ship structure. It shall be documented that the foundation and its integration in the ship structure comprises sufficient strength under all operational and environmental design loads, in static and dynamic mode.

Loads relevant to strength assessments are given in DNVGL-ST-0511 [2.4].

2.3.2 Maneuverability
The maneuverability of a vessel may be influenced by a WAPS (active or non-active). It shall be documented that the maneuverability of the vessel is not compromised, i.e. by showing that the installed rudders/ appendages together with the main propulsion system can counteract all occurring sailing effects.

The characteristics of the manoeuvrability with active and non-active WAPS shall be made part of the operational manual, as described in DNVGL-ST-0511 [2.6].

A FMEA may be required by the Society to document the maneuverability characteristics.

Sufficient manoeuvrability shall be demonstrated during sea trial according to [3].

2.3.3 Ship intact stability
It shall be documented that sufficient intact stability is assured under design load conditions.

Forces and loads relevant to stability are described in DNVGL-ST-0511.

Guidance note:

Ship intact stability is affected by large aerodynamic and inertia forces excited by WAPS, possibly influencing yaw, pitch and heel, in a quasi-static and/ or dynamic fashion. Ship´s dynamic motion is affected in both amplitude and frequency.

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2.4 Operational manual

Operational instructions for the purpose of safe and reliable handling shall be issued in form of an operational manual which shall be delivered on board.

The operational manual shall include all relevant operational conditions, fuel save mode in different wind speeds and wind directions, measures for emergency shut-off, and for harbour operation.

2.5 Test procedure

The test procedure shall include:

1) functional testing of machinery and electrical units
2) demonstrating structural behaviour of the WAPS installation
3) demonstrating performance of weight balancing measures
4) automation system performance test.

3 Sea trials

3.1 Test conditions

The WAPS and the drive system shall be tested at a true wind speed not less than 15 kn.

Measurements shall be made to confirm that load assumptions made for the design were correct/ conservative.

Deformations and vibrations in the structural items shall be verified within pre-defined limits

It shall be demonstrated that the control system of the WAPS is designed to:

— adapt to changing wind direction and wind speed in normal operating conditions
— handle emergency situations.

3.2 Operational manual

The operational manual shall be on board and followed during the sea trials.

SECTION 13 GAS FUELLED SHIP INSTALLATIONS - GAS FUELLED LPG

1 General

1.1 Objective

The additional class notation **Gas fuelled LPG** provides criteria for the safe and environmentally friendly arrangement and installation of machinery for propulsion and auxiliary purposes.

1.2 Scope

The scope for additional class notation **Gas fuelled LPG** 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 LPG** applies to installations using LPG 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. Ships built with gas fuelled ship installations satisfying the requirements of the rules in this section, may be assigned the additional class notation **Gas fuelled LPG**.

1.4 Classification

1.4.1 Survey extent

1.4.1.1 Survey requirements for ships with the class notation **Gas fuelled LPG** are given in Pt.7 Ch.1 Sec.2 [1], Pt.7 Ch.1 Sec.2 [3], Pt.7 Ch.1 Sec.3 [3], Pt.7 Ch.1 Sec.4 [3].

1.5 Definitions

1.5.1 Terms

1.5.1.1

Table 1 Terms

Terms	*Definition*
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

Terms	*Definition*
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
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, the engine control room
design temperature	for selection of materials, the lowest temperature the materials in tank and fuel systems may be subjected to
design vapour pressure P_0	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
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	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
fuel	petroleum gas, either in its liquefied or gaseous state

Terms	*Definition*
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. 1) Fuel storage hold space is 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. 2) Interbarrier space is the space between a primary and a secondary barrier, whether or not completely or partially occupied by insulation or other material. 3) Tank connection space is a space surrounding all tank connections and tank valves that is required for tanks with such connections in enclosed spaces. **Guidance note:** A tank connection space may also contain equipment such as vaporizers or heat exchangers. Such equipment is considered to only contain potential sources of release, but not sources of ignition. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
fuel preparation room	any space containing pumps, compressors and/or vaporizers for fuel preparation purposes **Guidance note:** A tank connection space which has equipment such as vaporizers or heat exchangers inside is not regarded as a fuel preparation room. Such equipment is considered to only contain potential sources of release, but not sources of ignition. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
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 vessel 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 GVU, gas regulating unit, GRU or gas train. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Terms	Definition
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. Hazardous areas are divided into zone 0, 1 and 2 as defined below and according to the area classification specified in [8] *Zone 0:* Area in which an explosive gas atmosphere is present continuously or is present for long periods. *Zone 1:* Area in which an explosive gas atmosphere is likely to occur in normal operations. *Zone 2:* 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
LEL	lower explosion limit
length (L)	the length as defined in the international convention on load lines in force
LPG	LPG is liquefied petroleum gas, through pressurisation or cooling
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

Terms	*Definition*
semi-enclosed space	a space where the natural conditions of ventilation are notably different from those on open deck, due to the presence of structure 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
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	vapour pressure is 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

Object	*Documentation type*	*Additional description*	*Info*
Propulsion and steering arrangements, general	Z050 - Design philosophy	Including information on the machinery configuration, machinery space arrangements, fuel 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 Sec.5 1.5.4.	AP
	Z140 - Test procedure for quay or 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

Object	*Documentation type*	*Additional description*	*Info*
	Z030 - Arrangement plan I	Location of fuel tank(s) with distances related to: — collision — grounding — fire protection — inspection.	AP
	Z265 - Calculation report	Probabilistic calculation when used to determine acceptable fuel tank location.	AP
	Z160 - Operation manual	See [1.8.1.1]	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
	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
	M150 - 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
	Z265 - Calculalation report	Boil off gas rate when pressure accumulation is not used as boil off gas handling method.	FI
	M060 - Welding procedures		AP
	M010 - Material specifications, metals	Including connected pipes — forming procedure of disched 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
	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

Object	*Documentation type*	*Additional description*	*Info*
	Z100 - Specification	Safety relief valves and associated vent piping.	AP
	S060 - Pipe routing sketch	Location of tank valves as close as possible to tank.	AP
	Z164 - Inspection manual	Inspection/survey plan for the liquefied gas fuel containment system, see [4.2.1.9].	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
Fuel gas safety system	I200 - Control and monitoring system documentation	Functionality as required by Table 10.	AP
	G130 - Cause and effect diagram	— Shall cover the safety functions as required by Table 10. — Interfaces to other safety and control systems shall be included.	AP
Fuel gas piping system	S011 - Piping and instrumentation diagram (P&ID)	Including — vent lines for safety relief valves — secondary enclosures for fuel pipes including pressure relief arrangements — boil off system — bunkering lines — gas supply system — gas freeing and purging system.	AP
	S060 - Pipe routing sketch		FI
	S090 - Specification of valves, flanges and fittings	Including offsets, loops, bends, expansion elements such as bellows and slip joints.	FI
	Z140 - 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
	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

Object	*Documentation type*	*Additional description*	*Info*
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, see [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
Ventilation systems for gas fuel system spaces	S012 - Ducting diagram (DD)	Including capacity and location of fans and their motors.	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
	Z180 - 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

Object	Documentation type	Additional description	Info
Bunkering station and Fuel reparation room 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

1.6.1.2 For general requirements for documentation, including definition of the Info codes, see DNVGL-CG-0550 Sec.6.

1.6.1.3 For a full definition of the documentation types, see DNVGL-CG-0550 Sec.5.

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 Certificate required

Object	Certificate type	Issued by	Certification standard*	Additional description
Gas/dual fuel engines	PC	DNV GL		In accordance with Pt.4 Ch.3
Process pressure vessels	PC	DNV GL		Shall be certified as class I pressure vessels in accordance with Pt.4 Ch.7
Pumps	PC	DNV GL		In accordance with Pt.5 Ch.7
Compressors	PC	DNV GL		In accordance with Pt.4 Ch.5
Valves in fuel system	PC	DNV GL		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	DNV GL		For valves with design pressure above 10 bar. In accordance with Pt.5 Ch.7 Sec.5 (irrespective of size).
Valves in fuel system	PC	Manufacturer		For valves with design pressure equal to or lower than 10 bar, and design temperature equal to or above 0°C

Object	Certificate type	Issued by	Certification standard*	Additional description
Expansion bellows	PC	DNV GL		In accordance with Pt.5 Ch.7
Control and monitoring systems	PC	DNV GL		Shall be certified in accordance with Pt.4 Ch.9: — gas control systems — gas safety systems — ventilation control systems — gas detection systems — inert gas control and monitoring system
Electric motors	PC	DNV GL		Shall be certified in accordance with Pt.4 Ch.8 when used in gas supply systems and ventilation systems
Electric motor starters	PC	DNV GL		Shall be certified in accordance with Pt.4 Ch.8 when used in gas supply systems and ventilation systems
* Unless otherwise specified the certificate standard in DNV GL rules. For a definition of the certificate types, see Pt.1 Ch.3.				

1.7.1.2 For general certification requirements, see DNVGL-CG-0550 Sec.4.

1.8 Onboard documentation

1.8.1 Contents

1.8.1.1 An operational manual shall be prepared as required by the IGF Code Ch.18.

Guidance note:

The operation manual should include the following information:

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
   - a description of the boil off handling system if installed.
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
     - fuel preparation rooms
   - how to respond to loss of ventilation in:
     - the secondary enclosures in the gas fuel system
     - tank connection spaces
     - fuel preparation rooms
   - how to respond to fire in:
     - the machinery spaces
     - on deck
     - fuel preparation rooms.
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
   - GVU 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.

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1.8.1.2 A plan for periodic test of all field instruments specified in these rules shall be kept on board. 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 10) 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], Pt.5 Ch.7 Sec.6 [4].

2.1.1.3 Pipes for high pressure fuel and liquefied fuel and their secondary enclosures shall as a minimum fulfil the requirements for pipe materials with design temperature down to -55°C in Pt.5 Ch.7 Sec.6 Table 4.

2.1.1.4 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, DNVGL-CG-0550 Sec.3.

Table 4 Certification of material quality and testing

Object	*Certificate type*[1), 2)]	*Issued by*	*Cert. standard*[3)]	*Additional description*				
				Material	*Piping system*	*Nominal diameter [mm]*	*Design pressure [bar]*	*Design temp.[°C]*
Pipes (including secondary enclosures)	MC	DNV GL			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
Elbows, T-pieces etc. fabricated by welding	MC	Manufacturer		Steel	Pressure			
	TR	Manufacturer			Open ended			
Flanges	MC	Manufacturer			Pressure			
	TR	Manufacturer			Open ended			
Bodies of valves and fittings, pump housings, other pressure containing components not considered as pressure vessels	MC	DNV GL		Steel				< 0
	MC	Manufacturer						
	MC	Manufacturer		Copper alloys				
Nuts and bolts	TR	Manufacturer		Steel				

1) MC = Material certificate
2) TR = Test report
3) Unless otherwise specified, the certification standard is DNV GL rules

3 Ship arrangement

3.1 Ship arrangement principles

3.1.1 General principles

3.1.1.1 The fuel containment system shall be located in such a way that the probability for the tank(s) to be damaged following a collision or grounding is reduced to a minimum taking into account the safe operation of the ship and other hazards that may be relevant to the ship.

3.1.1.2 Fuel storage tanks shall be protected against mechanical damage.

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

3.1.1.4 Areas with piping systems for liquefied gas fuel shall be arranged to contain leakages without damaging other structures due to low temperature effects, and to prevent gas spreading to non-hazardous spaces.

3.1.1.5 Areas with piping systems for gaseous fuel shall be arranged to prevent gas spreading to nonhazardous spaces.

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.

3.3 Arrangement of other spaces containing fuel systems

3.3.1 Fuel preparation rooms

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.

3.3.1.6 Fuel preparation rooms containing liquefied gas shall be designed to safely contain low temperature leakages.

3.3.1.7 Fuel preparation room boundaries i.e. bulkheads and decks, are to be provided with suitable thermal protection to the extent necessary for safely containing a maximum probable leakage scenario.

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

3.3.1.9 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 liquefied gas fuel in a maximum probable leakage scenario. These pressure relief systems shall be constructed with materials suitable for the lowest temperatures that may arise.

3.3.1.10 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.

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

3.3.1.12 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.

3.3.2 Tank connection spaces

3.3.2.1 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 between protective cofferdams and high fire risk spaces shall be kept to a minimum.

3.3.2.2 Tank connection spaces shall be able to safely contain leakages of liquefied gas and be arranged to prevent the surrounding hull structure from being exposed to unacceptable cooling.

3.3.2.3 The material of the bulkheads of the tank connection space shall have a design temperature corresponding with the lowest temperature it can be subject to in a probable maximum leakage scenario.

3.3.2.4 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 liquefied gas fuel. These pressure relief systems shall be constructed with materials suitable for the lowest temperatures that may arise.

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

3.3.2.6 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.

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

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

3.3.3 Fuel storage hold spaces

3.3.3.1 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.

3.3.3.2 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.

3.3.3.3 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.

3.3.3.4 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.

3.3.3.5 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.

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

3.3.4 Fuel bunkering stations

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

— segregation towards other areas on the ship
— hazardous area plans for the ship
— requirements for forced ventilation
— requirements for leakage detection
— safety actions related to leakage detection
— access to bunkering station from non-hazardous areas through air locks
— monitoring of bunkering station by direct line of sight or closed-circuit television (CCTV).

3.3.4.2 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 affected by 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.

3.3.5 Gas valve unit spaces

3.3.5.1 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 hatch.

3.3.5.2 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.

3.3.5.3 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 m^2. 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 under-pressure 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.

3.5 Location of fuel containment systems

3.5.1 General

3.5.1.1 The fuel tank(s) shall be protected from external damage caused by collision or grounding in the following way:

1) The fuel tanks shall be located at a minimum distance of B/5 or 11.5 m, whichever is less, measured inboard from the ship side at right angles to the centerline at the level of the summer load line draught

   where:

   B is the greatest moulded breadth of the ship at or below the deepest draught (summer load line draught) (refer to SOLAS regulation II-1/2.8).
2) The boundaries of each fuel tank shall be taken as the extreme outer longitudinal, transverse and vertical limits of the tank structure including its tank valves.
3) For independent tanks the protective distance shall be measured to the tank shell (the primary barrier of the tank containment system). For membrane tanks the distance shall be measured to the bulkheads surrounding the tank insulation.
4) In no case shall the boundary of the fuel tank be located closer to the shell plating or aft terminal of the ship than as follows:
   1) *For passenger ships:* B/10 but in no case less than 0.8 m. However, this distance need not be greater than B/15 or 2 m whichever is less where the shell plating is located inboard of B/5 or 11.5 m, whichever is less, as required by 1).
   2) *For cargo ships:*
      1) for V_c below or equal 1,000 m^3, 0.8 m
      2) for 1,000 m^3 < V_c < 5,000 m^3, 0.75 + V_c x 0.2/4,000 m
      3) for 5,000 m^3 ≤ V_c < 30,000 m^3, 0.8 + V_c/25,000 m
      4) for V_c ≥ 30,000 m^3, 2 m

      where:

      V_c corresponds to 100% of the gross design volume of the individual fuel tank at 20°C, including domes and appendages.
5) The lowermost boundary of the fuel tank(s) shall be located above the minimum distance of B/15 or 2.0 m, whichever is less, measured from the moulded line of the bottom shell plating at the centreline.
6) For multihull ships the value of B may be specially considered.
7) The fuel tank(s) shall be abaft a transverse plane at 0.08L measured from the forward perpendicular in accordance with SOLAS regulation II-1/8.1 for passenger ships, and abaft the collision bulkhead for cargo ships

   where:

   L is the length as defined in the International Convention on Load Lines (see SOLAS regulation II-1/2.5).

3.5.1.2 As an alternative to [3.5.1.1] above, the following calculation method may be used to determine the acceptable location of the fuel tanks:

1) The value f_{CN} calculated as described in the following shall be less than 0.02 for passenger ships and 0.04 for cargo ships.[1]
2) The f_{CN} is calculated by the following formulation:

   $f_{CN} = f_l \times f_t \times f_v$

   where:

   f_l is calculated by use of the formulations for factor p contained in SOLAS regulation II-1/7-1.1.1.1. The value of x1 shall correspond to the distance from the aft terminal to the aftmost boundary of the fuel tank and the value of x2 shall correspond to the distance from the aft terminal to the foremost boundary of the fuel tank.

   f_t is calculated by use of the formulations for factor r contained in SOLAS regulation II-1/7-1.1.2, and reflects the probability that the damage penetrates beyond the outer boundary of the fuel tank. The formulation is:

   $f_t = 1 - r(x1,x2,b)$ [62]

   f_v is calculated by use of the formulations for factor v contained in SOLAS regulation II-1/7-2.6.1.1 and reflects the probability that the damage is not extending vertically above the lowermost boundary of the fuel tank. The formulations to be used are:

   $f_v = 1.0 - 0.8 \cdot ((H - d)/7.8)$, if $(H-d)$ is less than or equal to 7.8 m. f_v shall not be taken greater than 1.

   $f_v = 0.2 - (0.2 \cdot ((H - d) - 7.8)/4.7)$, in all other cases f_v shall not be taken less than 0

   where:

   H is the distance from baseline, in metres, to the lowermost boundary of the fuel tank; and

   d is the deepest draught (summer load line draught).
3) The boundaries of each fuel tank shall be taken as the extreme outer longitudinal, transverse and vertical limits of the tank structure including its tank valves.
4) For independent tanks the protective distance shall be measured to the tank shell (the primary barrier of the tank containment system). For membrane tanks the distance shall be measured to the bulkheads surrounding the tank insulation.
5) In no case shall the boundary of the fuel tank be located closer to the shell plating or aft terminal of the ship than as follows:
   1) *For passenger ships*: B/10 but in no case less than 0.8 m. However, this distance need not be greater than B/15 or 2 m whichever is less where the shell plating is located inboard of B/5 or 11.5 m, whichever is less, as required by [5.3.3.1].
   2) *For cargo ships:*
      1) for V_c below or equal 1,000 m^3, 0.8 m;
      2) for 1,000 $m^3 < V_c <$ 5,000 m^3, $0.75 + V_c \times 0.2/4{,}000$ m;
      3) for 5,000 $m^3 \leq V_c <$ 30,000 m^3, $0.8 + V_c/25{,}000$ m; and
      4) for $V_c \geq$ 30,000 m^3, 2 m

         where:

         V_c corresponds to 100% of the gross design volume of the individual fuel tank at 20°C, including domes and appendages.

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1 The value f_{CN} accounts for collision damages that may occur within a zone limited by the longitudinal projected boundaries of the fuel tank only, and cannot be considered or used as the probability for the fuel tank to become damaged given a collision. The real probability will be higher when accounting for longer damages that include zones forward and aft of the fuel tank.

2 When the outermost boundary of the fuel tank is outside the boundary given by the deepest subdivision waterline the value of b should be taken as 0.

6) In case of more than one non-overlapping fuel tank located in the longitudinal direction, f_{CN} shall be calculated in accordance with paragraph 2) for each fuel tank separately. The value used for the complete fuel tank arrangement is the sum of all values for f_{CN} obtained for each separate tank.

7) In case the fuel tank arrangement is unsymmetrical about the centerline of the ship, the calculations of f_{CN} shall be calculated on both starboard and port side and the average value shall be used for the assessment. The minimum distance as set forth in paragraph 5) shall be met on both sides.

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.

4.1.2 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.

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 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, 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---

4.2.1.3 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.

4.2.1.4 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.

4.2.1.5 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.

4.2.1.6 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
   — 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.

4.2.1.7 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.

4.2.1.8 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].

4.2.1.9 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

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
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 Table 5.

Table 5 Secondary barriers in relation to tank types

Basic tank type	*Secondary barrier requirements*
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) 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 4)
   — 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].

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 it's 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 the design acceleration (a) in Table 6 in forward direction and a/2 in the aft direction, where g is gravitational acceleration.

Table 6 Design acceleration

Ship length (L)	*Design acceleration (a)*
L > 100 m	0.5g
60 < L ≤ 100 m	[2 - 3(L-60)/80] x 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 material 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:

1) The primary barrier of all tanks shall be assumed to be at the liquefied gas fuel temperature.

2) In addition to 1), 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.
3) 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.
4) Still air and sea water conditions shall be assumed, i.e. no adjustment for forced convection.
5) 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 .7 shall be assumed.
6) The cooling effect of the rising boil-off vapour from the leaked liquefied gas fuel shall be taken into account where applicable.
7) No credit shall be given for any means of heating, unless specially considered by the Society.
8) For members connecting inner and outer hulls, the mean temperature may be taken for determining the steel grade.
9) 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, shall be in accordance with Pt.5 Ch.7 Sec.6 Table 5 (footnote 3 covering deck and shell plating and all stiffeners attached thereto is not applicable). 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 Materials of primary and secondary barriers are defined in Pt.5 Ch.7 Sec.4 [5.1.2].

4.2.13.4 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 shall be carried out in accordance with DNVGL-CG-0129 and/or 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 Portable liquefied gas fuel tanks

4.3.1 General

4.3.1.1 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.

4.3.1.2 The design life of portable fuel tanks shall not be less than 20 years.

4.3.1.3 Fuel systems utilizing portable fuel tanks shall have equivalent safety compared to permanent fuel tanks.

4.3.1.4 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.

4.3.1.5 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.

4.3.1.6 Connections to the ship piping systems shall be made by means of approved flexible hoses or other suitable means designed to provide sufficient flexibility.

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

4.3.1.8 The pressure relief system of portable tanks for liquefied gas shall be connected to a fixed venting system.

4.3.1.9 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).

4.3.1.10 Safe access to tank connections for the purpose of inspection and maintenance shall be ensured.

4.3.1.11 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.

4.4 Loading limit for liquefied gas fuel tanks

4.4.1 Loading limit curve

4.4.1.1 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%

ρR = relative density of fuel at the reference temperature

ρL = relative density of fuel at the loading temperature.

4.4.1.2 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 [4.4.1.1] shall be used.

4.5 Maintenance of fuel storage condition

4.5.1 Control of tank pressure and temperature

4.5.1.1 Means shall be provided to keep the fuel tank pressure and temperature within their design range at all times including after activation of the safety system required by these rules. 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.

4.5.1.2 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.

4.5.1.3 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.

Guidance note:

The activation of the safety system alone is not deemed as an emergency situation.

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4.5.1.4 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.

4.5.1.5 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.

4.5.1.6 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 on board without external resources.

4.6 Requirements depending on fuel tank location

4.6.1 Fuel tanks located in enclosed spaces

4.6.1.1 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.

4.6.1.2 Fuel tank connections, flanges and tank valves shall be located in a tank connection space designed to safely contain low temperature leakages.

4.6.1.3 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].

4.6.1.4 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.

4.6.1.5 Common boundaries of protective cofferdams with engine rooms or high fire risk areas shall kept to a minimum.

4.6.2 Fuel tanks not located in enclosed spaces

4.6.2.1 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].

Guidance note:

A tank connection space may be required also for tanks on open deck. This may apply for ships were restriction of hazardous areas is safety critical. A tank connection space may also be necessary in order to provide environmental protection for essential safety equipment related to the gas fuel system like tank valves, safety valves and instrumentation.

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4.6.2.2 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.

4.6.2.3 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 with fire insulation as required in [7].

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 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.

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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 If piping is connected below the liquid level of the tank it shall be protected by a secondary barrier up to the first valve.

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 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.

5.1.3.9 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.

5.1.3.10 If the fuel gas contains heavier constituents that may condense in the system, means for safely removing the liquid shall be fitted.

5.1.3.11 Where LPG fuel is intended to be used in the gaseous state and has a dew point higher than ambient temperature at the maximum expected pressure at the consumer inlet, the fuelshall be sufficiently heated and the fuel lines shall be properly heat traced.

5.1.3.12 Where LPG fuel is intended to be used in the liquid state, the pressure in the fuel manifold shall be sufficient to maintain the fuel in the liquid state.

5.1.3.13 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.

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5.1.3.14 High-pressure fuel lines shall be installed and protected so as to minimize the risk of injury to personnel in case of rupture.

5.1.3.15 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.

5.1.3.16 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---

5.1.3.17 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 on board, and to prevent operational problems due to icing.

5.1.4 Fuel piping systems containing liquefied fuels

5.1.4.1 Piping systems for liquefied 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 liquid leakages, this requirement can be waived.

5.1.4.2 The requirement in [5.1.4.1] need not be applied for fully welded liquefied fuel pipes without fittings or valves 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 the lowest temperature it may be exposed to.

5.1.5 Fuel piping systems containing gaseous fuels

5.1.5.1 Piping systems containing gaseous fuel 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, 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 Fully welded gaseous fuel pipes need not be arranged with secondary enclosure on open deck.

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:

$$p = p_0(2/(k+1))^{k/(k-1)}$$

where:

$p0$ = maximum working pressure of the inner pipe

k = Cp/Cv - constant pressure specific heat divided by constant volume specific heat.

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 10 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 Emergency shut down valves (as provided for safety functions) 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.

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5.1.6.6 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 10. 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.

5.1.6.7 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 10, 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---

5.1.6.8 For piping systems containing gaseous fuel, an arrangement that automatically ventilates the pipe between the master gas valve and the double block and bleed valve when a leakage is detected, shall be fitted. The pipe between the double block and bleed valve and the gas injection valves, shall also be automatically vented.

5.1.6.9 For piping systems containing liquefied fuel, an arrangement that automatically de-pressurizes the fuel supply piping after the master gas valve when a leakage is detected, shall be fitted.

5.1.6.10 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.

5.1.6.11 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.

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5.1.6.12 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.

5.1.6.13 Shutdown valves in liquefied gas fuel piping systems operated by the safety system shall close fully and smoothly within 30 seconds of actuation. Information about the closure time of the valves and their operating characteristics shall be available on board, and the closing time shall be verifiable and repeatable.

5.1.7 Expansion bellows

5.1.7.1 Expansion bellows shall normally not be installed in enclosed spaces.

5.1.7.2 Expansion 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, expansion bellows in pipes containing gaseous fuel shall only be installed in fuel preparation rooms or tank connection spaces.

5.1.7.5 If accepted, expansion bellows in systems for liquefied fuel shall only be installed in spaces designed to contain liquefied fuel leakages.

5.1.7.6 Expansion 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. In case the pressure relief valves are located in open air, stop valve only at the inlet of the pressure relief valve is accepted. The outlet of the pressure relief valve shall then be fitted with a blind flange.

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 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 25 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

as required by the IGC Code for gas tankers. Shorter distances may be justified by risk analysis including a gas dispersion analysis applying the maximum tank venting scenario.

For small ships and ship types where the operation limits the possible location of the outlet, lesser heights and than given above may be accepted.

5.2.2.6 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.

5.2.2.7 All other fuel gas vent outlets shall be arranged in accordance with [5.2.2.5] and [5.2.2.6]. Means shall be provided to prevent liquid overflow from gas vent outlets, due to hydrostatic pressure from spaces to which they are connected.

5.2.2.8 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.

5.2.2.9 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.

5.2.2.10 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 0.015 L 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.

5.3.2 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 during transfer operation between fuel tanks (see Table 10).

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% 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% 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. Bursting discs shall not open into machinery spaces, but may be located inside the engine room casing.

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 three meters, unless efficient shielding is provided.

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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.

5.6.1.2 The heating circuit expansion tank shall be fitted with a gas detector and shall be vented to open air.

5.6.2 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 2.

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 The number and capacity of the ventilation fans serving:

— tank connection 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.

6.1.1.9 The ventilation system arrangement shall take into account that leaking gas is heavier than air. This implies that spaces shall typically be arranged with extraction ventilation taking air from the low points in the space, while inlet air is supplied at the top.

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 When located in 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.

6.1.4.3 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.

Guidance note:

Spaces enclosed in the boundaries of machinery spaces (such as purifier's room, engine room workshops and stores) are considered an integral part of machinery spaces containing gas fuelled consumers and, therefore, their ventilation system does not need to be independent of the one of machinery spaces.

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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. 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.

7.3 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 meters 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/m^2 for horizontal projected surfaces and 4 l/min/m^2 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 meters, 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.

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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 seconds 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 Fuel preparation room

7.3.4.1 Fuel preparation rooms shall be provided with a fixed fire-extinguishing system complying with the provisions of the FSS code and taking into account the necessary concentrations and application rate required for extinguishing gas fires.

7.3.5 Fire dampers

7.3.5.1 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 to the tank connection space and in the tank connection space, 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.

Guidance note:

Smoke detectors may be combined with either temperature or flame detectors to increase possibility for detection of a fire. It should be noted that flame detectors will normally activate before temperature detectors.

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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 analyzed and documented.

Guidance note:

See IEC 60812.

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8.1.1.4 Electrical equipment and wiring shall in general not 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, temperature class and equipment groups listed in Table 7 may be used for potential ship fuels:

Table 7 Temperature class and equipment groups

	Temperature class	*Equipment group*
LPG (propane, butane)	T2	IIA

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 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.

8.1.1.8 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 [6.1.6.1], 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.

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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 open deck above and in the vicinity of any gas outlet intended for the passage of liquefied gas or large volumes of vapour mixture, within a vertical cylinder of unlimited height and 6 m radius centered upon the center of the outlet, and within a hemisphere of 6 m radius below the outlet.
4) 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.
5) 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.
6) Enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. secondary enclosures around fuel pipes, semi-enclosed bunkering stations.
7) A space protected by an airlock is considered as non-hazardous area during normal operation but will require electrical equipment suitable for zone 1 if such equipment is required to operate following loss of differential pressure between the protected space and the hazardous area.

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) Spaces 4 m beyond the cylinder and 4 m beyond the sphere defined in [8.2.2.2].
3) Air locks.
4) 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 pressurization, 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 pressurization 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 IEC 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 liquid 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 gas detection system, fuel safety system and fuel control and monitoring system. 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 gas detection function, the gas safety function and the fuel control and monitoring function 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 [1.3.2] and Pt.4 Ch.9 Sec.4 [3].

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9.1.2.2 Monitoring requirements for the fuel installation are given in Table 8, Table 9 and Table 10. Table 8 gives alarm requirements for gas detection, Table 9 gives alarm and indication requirements to be handled by the gas control and monitoring system. Table 10 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 9 and Table 10, 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 The gas detection system shall present the gas alarms as required by [9.2.4] on bridge, at the control location for bunkering and locally. If alarming depends on network communication, the functionality shall be handled by separate network segment arranged for the fuel installation safety functions.

9.1.2.5 The fuel gas safety system shall present the gas safety alarms as specified in Table 10 on 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 The gas detection system and fuel safety system for a fuel supply installation can be implemented in a common system unit if the system is redundant.

9.1.2.7 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].

9.1.2.8 The signals required to support the safety functions given in Table 10 shall be hardwired, and arranged with loop monitoring.

Guidance note:

The requirement for hardwired signals is not applicable for signals sent to other systems for additional safety actions as specified in Table 10.

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9.1.2.9 The output signals required to perform the safety actions specified in Table 10 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.

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9.1.2.10 Where gas detection shall cause shutdown in accordance with Table 10, 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.

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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 center
— engine control room
— fire control station
— 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.

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], 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 where secondary enclosure is required by [5.1.4].

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 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 liquefied fuel 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
- 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 from 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 In every installation, the number and the positions of detectors shall be determined with due regard to the size and layout of the compartment, the composition and density of the fuel and the dilution from compartment purging or ventilation and stagnant areas, and each space shall be covered by sufficient number of detectors to allow for voting in accordance with Table 10.

9.2.4.6 The detectors shall generally be located at a low level where gas may accumulate and in the ventilation outlets. Gas dispersal analysis or a physical smoke test shall be used to find the best arrangement.

Table 8 Gas detection alarms

Alarm conditions	
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 fuel outside the machinery space, 20% LEL	HA
Secondary enclosure of pipes for fuel in the machinery space, 30% LEL	HA
Expansion tanks in systems for heating of fuel gas	HA
Air locks	HA
Above engine in 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
HA= 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 engineroom. 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 9 Monitoring of fuel installations

Alarm conditions		*Comment*
Fuel containtment system		
Level in tank	IL, IR, HA	alarm at 95% of tank volume
Tank pressure	IL, IR*, HA*,LA*	alarm level below opening pressure of relief devices 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	HA*	
Bilge		
Tank connection space, level in bilge well	HA	
Fuel preparation room, level in bilge well	HA	
Other spaces containing liquefied fuel 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		

Alarm conditions		*Comment*
Reduced ventilation in tank connection space	LA	
Reduced ventilation in fuel preparation room	LA	
Reduced ventilation in fuel preparation room	LA	
Other alarm conditions		
Air lock, more than one door moved from closed position	A	local alarm on both sides of air lock, Sec.3 [4.2.1]
Air lock, door open at loss of ventilation	A	Sec.3 4.2.5
Malfunction of double-block-and-bleed valves	A	Sec.5 1.7.9 and Sec.5 [4.1.2]
Temperature monitoring bulkhead shaft glands and bearings	IR, HA	
Low oxygen alarm in N_2 spaces	A	local alarm, Sec.5 [4.2.3]
*also to be indicated on bridge IL = Local indication (presentation of values) IR = Remote indication (presentation of values) in engine control room or control location for bunkering when specified A = Alarm activated for logical value LA = Alarm for low value HA = 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 [9.2.1.2].

Guidance note:

The tank overflow protection shall be based on a direct reading of the level and not be based on indirect measurement of a value that varies for each bunkering (e.g. density used for dp-cell).

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

9.3.1.2 Where arrangements are provided for overriding the overflow control system, they shall be such that inadvertent operation is prevented, i.e. by interlocking the override function with the bunker valve. When this override is operated continuous visual indication shall be provided at the navigation bridge, continuously manned central control station or onboard safety centre. Overriding of the overflow control system when more than one LNG fuel tank is installed will be subject to special consideration.

9.3.1.3 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 fuel pump 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 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 and the master gas fuel valve.

9.3.2.4 Gas detection in the secondary enclosure of pipes for 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.

For gaseous fuels 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.

For liquid fuels, the master gas fuel valve shall close, and the lines shall be automatically de-pressurized.

9.3.3 Safety upon liquefied fuel leakage detection

9.3.3.1 Low temperature detection in bilge wells of tank connection spaces, fuel preparation rooms or other spaces containing liquefied fuel 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 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 secondary enclosure of the bunkering line shall immediately result in automatic closing of the bunkering valve.

9.3.4 Safety fuel heating

9.3.4.1 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 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.

9.3.5.2 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.

9.3.5.3 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.

9.3.5.4 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 and the master gas fuel valve.

9.3.5.5 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 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 10 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 10 may be required for unconventional or complex fuel installations.

Table 10 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-low level in tank		LA						Stop fuel pumps

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	
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
Secondary enclosure of pipes for fuel outside the machinery space, 2x 40% LEL		HA	X	X	X			De-pressurize as described in [9.3.2.4]
Secondary enclosure of pipes for fuel in the machinery space, 2x 60% LEL		HA			X			De-pressurize as described in [9.3.2.4]
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		A	X	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 De-pressurize as described in [9.3.2.4]

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	
Ventilation								
Tank connection space, loss of ventilation		A	X					Stop fuel pumps in the space
Fuel preparation room, loss of ventilation		A		X				Stop machinery in the space
Secondary enclosure of pipes for fuel outside the machinery space, loss of ventilation		A	X	X	X			De-pressurize as described in [9.3.2.4]
Secondary enclosure of pipes for fuel in the machinery space, loss of ventilation		A			X			De-pressurize as described in [9.3.2.4]
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								
High pressure pipe in machinery space		A			X			De-pressurize as described in [9.3.2.4]
Manual shutdown buttons								
Emergency shutdown of supply to the machinery space					X			De-pressurize as described in [9.3.2.4]
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 in Sec.5.

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 Sec.5 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 Ventilation for the enclosure shall be as outlined in Sec.5 for ESD protected machinery spaces, but shall in addition be arranged with 2 x 100% capacity fans from different electrical circuits.

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 -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 -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°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°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
   — 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 [6.1].

11.2.3 Hydrostatic testing

11.2.3.1 The requirements for testing in this section apply to fuel piping inside and outside the fuel tanks. However, relaxation from these requirements for piping inside fuel tanks and open-ended piping may be accepted by the Society.

11.2.3.2 After completion of manufacture, but before insulation and coating, fuel piping shall be subjected to a hydrostatic test to at least 1.5 times the design pressure in presence of the surveyor.

11.2.3.3 Joints welded on board shall be hydrostatically tested to at least 1.5 times the design pressure.

11.2.3.4 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.

11.2.3.5 Secondary enclosures for high-pressure fuel piping shall be pressure tested to the expected maximum pressure at pipe rupture, but minimum 10 bar. Secondary enclosures for low pressure fuel piping shall be tightness tested.

11.2.4 Functional testing

11.2.4.1 Fuel piping systems, including valves, fittings and associated equipment, shall be function tested under normal operating conditions.

11.3 Valves

11.3.1 Testing

11.3.1.1 Each type of valve intended to be used at a working temperature below -55°C shall be subject to prototype testing as given in Pt.5 Ch.7 Sec.5 [13.1].

11.3.1.2 All valves shall be subject to production testing as given in Pt.5 Ch.7 Sec.5 [13.1.2].

11.4 Expansion

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 [5.1.6.13]. The shutdown valves with actuators shall be function tested when the valve is subjected to full working pressure. The testing may be carried out on board after installation.

11.7 Onboard testing

11.7.1 General

11.7.1.1 Control, monitoring and safety systems required by these rules, shall be tested on board in accordance with Pt.4 Ch.9 Sec.1 [4.4].

11.7.1.2 The functionality of the cause and effect diagram required by Table 2 shall be tested on board.

CHANGES – HISTORIC

July 2019 edition

Amendments October 2019, entering into force as from date of publication

Topic	*Reference*	*Description*
Alternative solutions to full cryogenic boundary protection	Sec.5 [3.3.2.2]	Added guidance note to clarify expectations to alternative solutions.
Fuel tanks located directly above machinery space of category A	Sec.5 [4.7.1.5]	Removed limitation for location of type C tanks above category A machinery spaces.
	Sec.5 [4.7.2.3]	Previous Sec.5 [4.7.2.3] deleted. Removed limitation for tanks in non-enclosed locations above category A machinery spaces.
Pressure relief valves	Sec.5 [5.1.6.6]	Removed requirement for pressure relief valves to discharge to the vent mast.
Slip-on welded joints > 50 mm	Sec.5 [11.2.1.1]	Added guidance note to clarify expectations to slip-on welded joints > 50 mm.

Changes July 2019, entering into force 1 January 2020

Topic	*Reference*	*Description*
Clarification and adjustment of some of the requirements for battery systems and installation of energy storage systems	Sec.1 [1.3]	Removed the requirement for notation **Shore power** when the EES charger is located on shore.
	Sec.1 [1.4]	Clarification of when the additional class notation **Battery(Power)** is mandatory.
	Sec.1 [1.7.2]	Updated document requirements.
	Sec.1 [2.3]	Clarification of the requirements for ventilation and gas detection in EES spaces.
	Sec.1 [2.6.2]	Included requirements for EES converters when EES converter is located on shore.
	Sec.1 [3.2.3.2], Sec.1 [3.3.1]	Addressing that the measurement and calculation of SOC and SOH do have some inaccuracy.
	Sec.1 [4.1.5.2]	Changed the requirements for independent temperature protection to independent overcharge protection and by that gives opening for independent overvoltage protection and current interrupting device as an alternative.
	Sec.1 [4]	Included requirements for liquid cooled battery systems and clarification of some battery system requirements
	Sec.1 Table 4	Updated certification requirements.
Supercapacitors as energy storage system	Sec.1 [1.5.2]	Introduced reference to the UL 810A standard for electrochemical capacitors.

Topic	Reference	Description
	Sec.1 [1.6]	Updated definitions for electrochemical capacitors and electrical energy storage systems.
	Sec.1 [1.1]	Restructured the text such that it is generic for the different types of electrical energy storage (EES) solutions.
	Sec.1 [1.1], Sec.1 [2], Sec.1 [3], Sec.1 [6]	Change the name battery to EES (electrical energy storage).
	Sec.1 [5]	Completely new subsection setting requirements for electrochemical capacitors systems.
New Gas fuelled notation	Sec.5 [1]	Class notation name changed to **Gas fuelled LNG**.
Fire protection of fuel preparation rooms on open deck	Sec.5 [3.3.1.3] and Sec.5 [7.2.2.2]	The following text is added to fuel preparation room: "unless located on open deck". Guidance note added that fuel preparation rooms on open deck located directly above machinery spaces of category A or other high fire risk spaces are expected to be specifically considered in the risk assessment required by the IGF Code.
Alternative loading limit option	Sec.5 [4.5.1.2]	Guidance note added reflecting IACS UI GF16 on alternative loading limit option.
Design pressure for parts of secondary enclosures extending to air inlets and outlets on open deck	Sec.5 [5.1.5.7]	Revised to include option of justifying a lower design pressure for parts of the secondary enclosures extending to air inlets and outlets on open deck by back pressure calculations.
Set pressure of pressure relief valves in bunkering lines	Sec.5 [5.1.6.6]	The text following text is added: "For pressure relief valves in the bunkering lines, the set pressure shall be equal to the design pressure."
Double-block-and-bleed function in gas valve unit	Sec.5 [5.1.6.9]	New requirement included related to arrangement preventing other vents compromising the double-block-and-bleed function.
Dry breakaway coupling in bunkering arrangement	Sec.5 [5.3.3.4]	Requirement for dry breakaway coupling deleted. Guidance note about IGF Code requirement for dry breakaway coupling in bukering arrangement added.
Delete A-0 requirements for navigation bridge windows	Sec.5 [7.2.2.1]	The phrase ", and any boundaries above that, including navigation bridge windows, shall have A-0 class divisions" and related guidance note removed.
Other rooms with high fire risk	Sec.5 [7.2.2.2]	Guidance note added reflecting IACS UI GF17 on other rooms with high fire risk.
Guidance note on fire detection	Sec.5 [7.4.1.2]	Guidance note added regarding combination of different types of fire detectors to increase possibility of detection of a fire.
Alarm handling and presentation	Sec.5 [9.1.2.1], Sec.5 [9.1.2.4],Sec.5 [9.1.2.5], Sec.5 [9.1.2.7]	Rule text clarified with respect to required alarm handling and presentation.
Loop monitoring for signals required to support safety functions	Sec.5 [9.1.2.9]	The following part of the text is deleted "..unless they are inherently fail safe".

Topic	Reference	Description
Assessment of NDT	Sec.5 [11.2.2.4]	Acceptance criteria for assessment for RT clarified and acceptance criteria for assessment of UT added.
Secondary enclosures for pipes in the vacuum space releasing liquefied fuel in case of leakage	Sec.5 [4.2.16]	Additional requirements for vacuum insulated tanks rewritten to require secondary enclosures for pipes in the vacuum space releasing liquefied fuel in case of leakage.
	Sec.5 [5.1.3.5]	The text "If piping is connected below the liquid level of the tank it shall be protected by a secondary barrier up to the first valve" deleted as covered by the revised text in Sec.5 [4.5.1.2].
	Sec.5 [11.2.2.3]	NDT requirement for secondary enclosures located inside the vacuum space of vacuum insulated tanks added.
	Sec.5 [11.2.3.6]	Hydrostatic testing requirement for secondary enclosures located inside the vacuum space of vacuum insulated tanks added.
Flow sensors in ventilation systems	Sec.5 Table 10	Added footnote.
Segregation of fuel tanks	Sec.6 [3.2.2.1]	Included other fuel tanks as acceptable boundary for methyl/ ethyl fuel tanks.
Tank vent outlets	Sec.6 [3.2.3.12]	Outlets for purging and gas freeing have been changed from 2 to 3 m above deck level. It has also been included that 20 m/ s is acceptable if the outlet is protected by a suitable device to prevent the passage of flame.
Ventilation requirement	Sec.6 [3.4.1.5]	It has been detailed that the ventilation requirement for the entry space is 6 air changes/hour.
Double walled fuel pipes	Sec.6 [3.5.2.4]	2x50% capacity for fans serving double walled fuel pipes has been introduced, as this space also is hazardous.
Fire Safety	Sec.6 [4.3]	Amended paragraph Sec.6 [4.3.1] and Sec.6 [4.3.1.1], while new requirements for ships other than tankers have been included based on the outcome of CCC5 (Technical provisions for the safety of ships using low flashpoint fuels).
Loop monitoring	Sec.6 [6.3.1.4]	Sensor loops failure are normally occurring much more often than for manual buttons which are often mounted in relatively good environmental conditions. Safety signal availability is very crucial to safety, and to be in line with Control systems (Pt.4 Ch.9), where loop monitoring is required for essential systems, the option of inherently safe equipment has been removed.
Discharge depth	Sec.9 [2.3.1.2]	Added to requirement Sec.9 [2.3.1.2] C) that "The discharge outlet shall be located well below the waterline for any operational loading condition. The distance shall be minimum 4 m or may be established by the calculation in point d)".
Change in rule text	Sec.10 [7.1.2]	Guidance note added.
	Sec.10 [7.1.6]	Revised text.
New class notation **SRTP**	Sec.11	New class notation covering safe return to port, orderly evacuation and abandonment.

Topic	Reference	Description
New class notation **WAPS**	Sec.12	New class notation covering wind assisted propulsion systems.
New class notation **Gas fuelled LPG**	Sec.13	The requirements is based on **Gas fuelled LNG** notation and the functional requirements in the IGF Code Part A. The requirements have been modified to account for the difference in fuel properties between LNG and LPG, and the differences in system requirements. LPG is stored at higher temperatures than LNG and leaking gas has a higher density than air. Consequently, the risk of damage to the ship structure from low temperature leakages is reduced when LPG is used as a fuel. Also, IMO has decided that the concept of ESD protected machinery spaces cannot be used for gases where the density of the fuel is higher than the density of air. The requirements in the rule proposal reflects this.

July 2018 edition

Amendments July 2018

Topic	Reference	Description
Clarification of closing time for tank valves	Sec.5 [5.3.3.3]	A description has been added with reference to Sec.5 Table 9, to make the intention of the rule clear, hence that we only require 5 seconds closing time for tank valves when triggered by high alarm during transfer between LNG fuel tanks.
Rule alignment with IGF Code	Sec.5 [1.8.1.1]	A reference to the requirement in the IGF Code has been added, and the detailed requirements for the operation manual are moved to a new guidance note.
	Sec.5 [5.1.6.5]	The text regarding fail safe operation for remote operated valves has been amended, from being applicable to all remotely operated valves to only apply to emergency shutdown valves.
	Sec.5 [5.1.6.7]	The requirement for an automatically operated shut off valve on liquid lines at the fuel gas preparation room entry is removed, and related texts in Sec.5 [9.3.2.3], Sec.5 [9.3.5.5] and Sec.5 Table 9 are also amended.
	Sec.5 [5.2.2.3]	A relaxation has been added for the requirement for isolation valve at outlet of the safety relief valve, for pressure relief valves located in open air.
	Sec.5 [5.2.2.5]	Requirement for remaining relief capacity with one safety relief valve out of operation is removed, hence we will accept 2 times 50% capacity for the safety relief valves, also without a spare valve available on board.
	Sec.5 [9.3.4.1]	The requirement is deleted, as the low temperature monitoring after the vaporizer, and corresponding shut down actions, will also detect loss of heating medium flow.

January 2018 edition

Changes January 2018, entering into force 1 July 2018

Topic	*Reference*	*Description*
Adapt requirements from recent industry development	Sec.3 [7.1.1.6]	Added requirements to temperature class and equipment groups for fuel cell installations.
Alignment of rules for fuel cells with gas as fuel and low flashpoint liquid rules	Sec.3 [6]	Removed requirements that is covered by the mandatory notations **Gas fuelled** and **LFL fuelled**.
Amendment of the IGF Code wrt fire protection	Sec.5 [7.2.2.1]	New guidance note.
Clarifications	Sec.1 [1.1], Sec.1 [1.2] & Sec.1 [1.3]	Clarification of scope of **Battery** notation.
	Sec.1 [1.4], Sec.1 [1.5]	Revised the tables.
	Sec.1 [2.3.1.3]	Revised the ventilation requirements when more than one battery cell can go into thermal runaway.
	Sec.1 [2.6.2.3] & Sec.1 [2.7.1]	Clarification of the independent voltage and current protection functions in the battery charger.
	Sec.1 [4.1.2.1]	Clarification of the content of the safety description for the battery system.
	Sec.1 [4.1.2.7], Sec.1 [4.1.3], & Sec.1 [4.1.5]	Clarification of requirements for HVIL, BMS, alarms and safety functions for the battery system.
	Sec.1 [5]	Included an appendix summarizing all the alarm and monitoring requirements that are given in the battery power rules.
NMA circular RSV 12 - 2016	Sec.1 [1.3.2]	Changed the size from 50 kWh to 20 kWh of battery capacity for requiring the **Battery(Safety)** notation.
	Sec.1 [4.1.2.6]	Revised the requirements for thermal runaway propagation protection.
	Sec.1 [4.2.2]	Included detailed requirements for propagation testing.
Ventilation and fire safety requirements of battery spaces	Sec.1 [2.3]	Updated the requirements for ventilation in battery spaces.
	Sec.1 [2.4]	Updated the requirements for fire safety of battery spaces.
IEC 62619 standard	Sec.1 [4.2]	Updated the test requirements to align with the IEC 62619 standard.
Alignment with IACS UR F32	Sec.2 [2.6.1.4]	Guidance note regarding inhibition of fire detector alarms has been changed into a requirement in accordance with UR F32.8.
Updates to reflect the IGF code with respect to fuel cells	Sec.3 [1.1]	Text has been adjusted according to the new definition (according draft of the IGF-code for fuel cells).
	Sec.3 [1.2]	Clarification of scope including a description what is not covered by this section.
	Sec.3 [1.5]	Terms have been added or modified.

Topic	*Reference*	*Description*
	Sec.3 [2]	Aligned with IGF code material requirements.
	Sec.3 [3]	Aligned with IGF code with respect to 'unacceptable loss of power'.
	Sec.3 [4]	Implementing proposed IGF code requirements for fuel cell power systems with respect to increased safety of installations.
	Sec.3 [6]	Aligned the requirements with IGF code.
	Sec.3 [8]	Aligned the requirements with the IGF code.
	Sec.3 [9]	Aligned requirements to manufacture, workmanship and testing with the IGF code.
	Sec.3 Table 3	Documentation requirements have been aligned with the IGF code and other changes made to the requirements to fuel cells.
	Sec.3 Table 4	Introduced product certification as requirement for fans in the ventilation system of fuel cell power system installations.
Implementation of results from research and development activities in DNV GL	Sec.3 [5]	Revised with respect to design principles for fuel cell spaces. The subsection gives requirements for safe installation of the fuel cell power installation on board.
	Sec.3 [7.1.1.3]	New requirement: It shall be ensured that the fuel cell can be disconnected from the electrical load at any load condition.
	Sec.3 [7.2.2.2]	The definition of hazardous areas zone 1 and zone 2 has been modified.
New docreq item for pipe routing sketch in fuel gas tanks	Sec.5 Table 2	New document requirement.
Secondary enclosure for LNG pipes on open deck	Sec.5 [5.1.4.2], Sec.5 [5.1.5.3]	Aligned requirements with the IGF Code.
	Sec.5 [9.2.1.7], Sec.5 [9.3.3.2]	Text amended to clarify that leakage detection in bunkering line is only required where secondary enclosure is required.
Fire extinguishing for fuel preparation room	Sec.5 [7.3.4.1]	Added new text: "Fuel preparation rooms shall be provided with a fixed fire-extinguishing system complying with the provisions of the FSS Code and taking into account the necessary concentrations/application rate required for extinguishing gas fires."
LNG fuel tank level gauging/ high alarm/overflow protection	Sec.5 [9.2.1.2]	Guidance note deleted.
	Sec.5 [9.3.1.1]	Reference to [9.2.1.1] deleted. New Guidance note added: "The tank overflow protection shall be based on a direct reading of the level and not be based on indirect measurement of a value that varies for each bunkering (e.g. density used for dp-cell)."

Topic	Reference	Description
Override of overflow control system	Sec.5 [9.3.1.2]	Added new text: "Where arrangements are provided for overriding the overflow control system, they shall be such that inadvertent operation is prevented, i.e. by interlocking the override function with the bunker valve. When this override is operated continuous visual indication is to be provided at the navigation bridge, continuously manned central control station or onboard safety centre. Overriding of the overflow control system when more than one LNG fuel tank is installed will be subject to special consideration."
New notation for shaft alignment	Sec.10	New section.

July 2017 edition

Changes July 2017, entering into force 1 January 2018

Topic	Reference	Description
Design of bunkering lines	Sec.5 [5.1.3.3]	New requirement is added: "Bunkering lines shall have a design pressure not less than 20 bar."
Alignment with changes to the IGF Code	Sec.5 [7.4.1.1]	Amended text: "the ventilation trunk to the tank connection space and in the tank connection space" inserted instead of "the ventilation trunk for fuel containment system below deck".
Implementation of IACS Res REC 148	Sec.5 Table 2	New documentation requirement for inspection/survey plan added for fuel gas tanks.
UI IGF Code (MSC.1/ Circ.1558)	Sec.5 Table 1	Guidance note added: "A tank connection space may also contain equipment such as vaporizers or heat exchangers. Such equipment is considered to only contain potential sources or release, but not sources of ignition."
	Sec.5 Table 1	Guidance note added: "A tank connection space which has equipment such as vaporizers or heat exchangers installed inside is not regarded as a fuel preparation room. Such equipment is considered to only contain potential sources of release, but not sources of ignition."
	Sec.5 [3.3.6.1]	Amended list related to special considerations for semi-enclosed and enclosed bunkering stations
	Sec.5 [4.6.1.1]	Added text: "including after activation of the safety system required by these Rules."
	Sec.5 [4.6.1.3]	Added guidance note: "The activation of the safety system alone is not deemed as an emergency situation."
	Sec.5 [4.7.2.1]	Guidance note added: "A tank connection space may be required also for tanks on open deck. This may apply for ships were restrictions of hazardous areas are safety critical. A tank connection space may also be necessary in order to provide environmental protection for essential safety equipment related to the gas fuel system like tank valves, safety valves and instrumentation."

Topic	*Reference*	*Description*
	Sec.5 [6.1.4.3]	Guidance note added: "Double piping and gas valve unit spaces in gas safe engine rooms are considered an integral part of the fuel supply systems and, therefore, their ventilation system does not need to be independent of other fuel supply ventilation systems provided such fuel supply systems contain only gaseous fuel."
	Sec.5 [6.1.5.1]	Guidance note added: "Spaces enclosed in the boundaries of machinery spaces (such as purifier's room, engine room workshops and stores) are considered an integral part of machinery spaces containing gas fuelled consumers and, therefore, their ventilation system does not need to be independent of the one of machinery spaces."
General maintenance	Sec.5 Table 1	Definition for fuel containment system corrected to the exact wording of the IGF Code.
	Sec.5 Table 3	New certification requirement added for flexible hoses with couplings with reference to Pt.4 Ch.6.
	Sec.5 [5.5.1.2]	Guidance note related to location of bursting disks lifted as rule text: "Bursting discs shall not open into machinery spaces, but may be located inside the casing."
Exhaust system	Sec.6 [3.8]	Requirements for exhaust system have been introduced
Aft peak tank	Sec.6 [11.1.2.2]	A guidance note giving a description of fuel tank location on tankers has been included
Drain tanks	Sec.6 [3.2.1.2]	A requirement for location of tanks with LFL has been introduced
Alignment with IGF code - Bunkering pipes	Sec.6 [3.6.2.4]	A clarification that bunkering pipes also have to be double walled has been introduced (already stated for fuel transfer and fuel supply)
Cargo area tankers	Sec.6 [3.2.2.1]	A guidance note introduced to specify that fuel tanks shall be located in the double bottom on tankers
Distance	Sec.6 [3.2.1.3]	A clarification that the distance is regarding side shell has been included
Inert requirement	Sec.6 [3.7.1.1]	It has been specified that size is not relevant for the requirement
Engines	Sec.6 [3.7.1.1]	A requirement for engine design has been included
Inerting	Sec.6 [3.7.1.1]	A guidance note describing the issue with inerting has been introduced
Redundant propulsion	Sec.7 [3.1.1.6]	Clarification of the wording in both requirement and guidance note, partially moved from the old paragraph in Sec.2 [3.2.1.2] - no intended change in the content.
	Sec.7 [3.1.1.7]	Clarification of the wording in guidance note - no intended change in the content.
	Sec.7 [3.2.1.2]	The old paragraph [3.2.1.2] is moved and merged with Sec.1 [3.1.1.6] - no intended change in the content.
	Sec.7 [3.2.1.3]	New paragraph - to clarify the redundancy requirements when applied to a vessel with traditional rudder - no intended change in the content.
	Sec.7 [3.2.1.4]	New paragraph - to clarify the redundancy requirements when applied to a vessel with propulsion thrusters. The requirement is relaxed as redundancy is now accepted as a design principle for the main-and auxiliary steering for each thruster.

Topic	Reference	Description
	Sec.7 [3.2.1.5]	New paragraph - to ensure that the two steering systems for each thruster have a uniform operator interface. The requirement is strengthened.
	Sec.7 [3.3.1.2]	Clarification of the wording in both requirement and guidance note, and also a relaxation in the requirement for remaining capability after a failure in active component.
Clarification of qualifier D and S regarding structural modifications	Sec.8 Table 1	Additional description for qualifier D regarding structural modifications added. Description for qualifier S amended.
	Sec.8 Table 2	Documentation requirements for qualifier D amended to make scope more clear.
	Sec.8 [1.6.2]	Documentation requirements for qualifier S amended to make scope more clear.
	Sec.8 [2.1]	Requirements for qualifier D included to make scope more clear.
	Sec.8 [2.2]	Requirements for qualifier S amended to make scope more clear.
Deletion of qualifier T and Misc	Sec.8 Table 1	Qualifiers T and Misc deleted from the table.
	Sec.8 [2.2]	Requirements related to qualifier T are deleted as this qualifier is deleted.
	Sec.8 [2.6]	Requirements related to qualifier Misc are deleted as this qualifier is deleted.
	Sec.8 [3.1]	Reference to qualifiers T and Misc deleted as these qualifiers are deleted.
Editorial corrections	Sec.8	

January 2017 edition

Main changes January 2017, entering into force 1 January 2017

• Sec.2 Periodically unattended machinery space - E0 and ECO

— References to SOLAS are standardized and updated.
— Sec.2 [2.3.3.1]: Requirement to indicate on the bridge when the audible alarm is silenced in the watch-keeping engineer's cabin is deleted.
— Sec.2 Table 1: Definitions updated for clarification.
— Sec.2 [3]: Requirements to alarm systems updated for clarification.
— Sec.2 [4]: Sec.2 [3.4.1]: Deleted requirements which are covered by main class.
— Sec.2 [5]: Requirements to internal communication described in a dedicated subsection.
— Sec.2 [3.1.1]: Added reference to gas turbines.
— Sec.2 Table 4, Sec.2 Table 13: Updated according to IACS UR M35.
— Sec.2 Table 8, Sec.2 Table 13: Updated according to IACS M36.

• Sec.5 Gas fuelled ship installations - Gas fuelled

— Sec.5 [1.3]: The information related to lack of international conventions for the use of gas as fuel in ships is deleted due to entry into force of IGF code.

— Sec.5 Table 2: The document requirements are updated.
— Sec.5 Table 3: The additional description is amended with a clarification related to prototype test of expansion bellows.
— Sec.5 [1.8]: It has been added that the operation manual shall include a description of the boil-off system when installed.
— Sec.5 [4.2.13]: The text in [4.2.13.2] and [4.2.13.3] is amended for compliance with the IGF code.
— Sec.5 [4.7.2]: A reference to the fire insulation requirement is added in [4.7.2.3].
— Sec.5 [5.1.3]: A requirement for thermal stress analysis is added in [5.1.3.15].
— Sec.5 [5.1.7]: The text in [5.1.7.1] is amended for compliance to the IGF code.
— Sec.5 [5.1.7]: A requirement is added in [5.1.7.4], related to where expansion bellows are allowed in pipes containing gaseous fuel.
— Sec.5 [11.7]: Requirement for onboard testing is added.

July 2016 edition

This document supersedes the January 2016 edition.

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.

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.