NR445 C DT R06 JANUARY 2024

RULES FOR THE CLASSIFICATION OF OFFSHORE UNITS

NR445 - JANUARY 2024

PART C
FACILITIES

OFFSHORE UNITS

BUREAU
VERITAS

BUREAU VERITAS
RULES FOR THE CLASSIFICATION OF OFFSHORE UNITS

NR445 - JANUARY 2024

This version of the document takes precedence over previous revision. Unless otherwise specified, these rules apply to ships for which contracts are signed on or after January 1st, 2024. The Society may refer to the contents hereof before January 1st, 2024, as and when deemed necessary or appropriate.

The PDF electronic version of this document available on the Bureau Veritas Marine & Offshore website https://marine-offshore.bureauveritas.com/ is the official version and shall prevail if there are any inconsistencies between the PDF version and any other available version.

These rules are provided within the scope of the Bureau Veritas Marine & Offshore General Conditions, enclosed at the end of Part A of NR467, Rules for the Classification of Steel Ships. The latest version of these General Conditions is available on the Bureau Veritas Marine & Offshore website.

PART A
CLASSIFICATION AND SURVEYS
NR445 A DT R07 JANUARY 2024

PART B
STRUCTURAL SAFETY
NR445 B DT R06 JANUARY 2024

PART C
FACILITIES
NR445 C DT R06 JANUARY 2024

PART D
SERVICE NOTATIONS
NR445 D DT R08 JANUARY 2024

BUREAU VERITAS MARINE & OFFSHORE

Tour Alto
4 place des Saisons
92400 Courbevoie - France
+33 (0)1 55 24 70 00

marine-offshore.bureauveritas.com/rules-guidelines

NR445

RULES FOR THE CLASSIFICATION OF OFFSHORE UNITS

Part C
Facilities

Chapter 1	Machinery and Piping
Chapter 2	Electrical Installations
Chapter 3	Control Systems and Automation
Chapter 4	Safety Features
Chapter 5	SUSTAINABILITY

January 2024

Table of Content

Chapter 1 Machinery and Piping

Section 1 General Requirements

1 General 29

1.1 Application
1.2 Documentation to be submitted
1.3 Definitions

2 Design and construction 29

2.1 General
2.2 Availability
2.3 Materials, welding and testing
2.4 Power transmission
2.5 Vibrations
2.6 Operation in inclined position
2.7 Ambient conditions
2.8 Power of machinery
2.9 Safety devices
2.10 Fuels

3 Arrangement and installation on board 32

3.1 General
3.2 Ventilation in machinery spaces
3.3 Air intakes
3.4 Hot surfaces and fire protection
3.5 Safety devices on moving parts
3.6 Gauges
3.7 Bolting down
3.8 Gratings
3.9 Machinery remote control, alarms and safety systems
3.10 Communications

4 Tests and trials 34

4.1 Works tests
4.2 Trials on board

Section 2 Diesel Engines

1 General 35

1.1 Application
1.2 Documentation flow for diesel engine
1.3 Definitions

2 Design and construction 40

2.1 Materials and welding
2.2 Crankshaft
2.3 Crankcase
2.4 Scavenge manifolds
2.5 Systems
2.6 Starting air system
2.7 Control and monitoring

3 Arrangement and installation 48

3.1 Starting arrangements
3.2 Turning gear
3.3 Trays
3.4 Exhaust gas system
3.5 Air intakes

4 Type tests, material tests, workshop inspection and testing, certification 49

- 4.1 Type testing
- 4.2 Material and non-destructive tests
- 4.3 Factory acceptance test
- 4.4 Certification

5 Additional requirements for diesel engines in hazardous areas 60

- 5.1

Section 3 Pressure Equipment

1 General 61

- 1.1 Principles
- 1.2 Application
- 1.3 Definitions
- 1.4 Classes
- 1.5 Applicable Rules
- 1.6 Documentation to be submitted

2 Design and construction - Scantlings of pressure parts 66

- 2.1 General
- 2.2 Materials
- 2.3 Permissible stresses
- 2.4 Cylindrical, spherical and conical shells with circular cross-sections subject to internal pressure
- 2.5 Dished heads subject to pressure on the concave (internal) side
- 2.6 Dished heads subject to pressure on the convex (external) side
- 2.7 Flat heads
- 2.8 Openings and branches (nozzles)
- 2.9 Regular pattern openings - Tube holes
- 2.10 Water tubes, superheaters and economiser tubes of boilers
- 2.11 Additional requirements for fired pressure vessels
- 2.12 Additional requirements for vertical boilers and fire tube boilers
- 2.13 Bottles containing pressurised gases
- 2.14 Heat exchangers

3 Design and construction - Equipment 94

- 3.1 All pressure vessels
- 3.2 Boilers and steam generators
- 3.3 Thermal oil heaters and thermal oil installation
- 3.4 Special types of pressure vessels
- 3.5 Other pressure vessels

4 Design and construction - Fabrication and welding 99

- 4.1 General
- 4.2 Welding design
- 4.3 Miscellaneous requirements for fabrication and welding
- 4.4 Preparation of parts to be welded
- 4.5 Tolerances after construction
- 4.6 Preheating
- 4.7 Post-weld heat treatment
- 4.8 Welding samples
- 4.9 Specific requirements for class 1 vessels
- 4.10 Specific requirements for class 2 vessels
- 4.11 Specific requirements for class 3 vessels

5 Design and construction - Control and monitoring 111

- 5.1 Boiler control and monitoring system
- 5.2 Pressure vessel instrumentation
- 5.3 Thermal oil heater control and monitoring
- 5.4 Control and monitoring requirements

6 Arrangement and installation 115

6.1 Foundations
6.2 Boilers
6.3 Pressure vessels
6.4 Thermal oil heaters

7 Material test, workshop inspection and testing, certification 116

7.1 Material testing
7.2 Workshop inspections
7.3 Hydrostatic tests
7.4 Certification

Section 4 Steam Turbines

1 General 119

1.1 Application
1.2 Documentation to be submitted

2 Design and construction 119

2.1 Materials
2.2 Design and constructional details
2.3 Welded fabrication
2.4 Control, monitoring and shut-off devices

3 Arrangement and installation 123

3.1 Foundations
3.2 Jointing of mating surfaces
3.3 Piping installation
3.4 Hot surfaces
3.5 Alignment
3.6 Circulating water system
3.7 Gratings
3.8 Drains
3.9 Instruments

4 Material tests, workshop inspection and testing, certification 123

4.1 Material tests
4.2 Inspections and testing during construction
4.3 Certification

Section 5 Gas Turbines

1 General 126

1.1 Application
1.2 Definition of rated power
1.3 Documentation to be submitted

2 Design and construction 127

2.1 Materials
2.2 Stress analyses
2.3 Design and constructional details
2.4 Welded fabrication
2.5 Control, monitoring and shut-off devices

3 Arrangement and installation 130

3.1 Foundations
3.2 Joints of mating surfaces
3.3 Piping installation
3.4 Hot surfaces
3.5 Alignment
3.6 Gratings
3.7 Drains
3.8 Instruments

4 Material tests, workshop inspection and testing, certification 131

4.1 Type tests - General
4.2 Type tests of turbines not admitted to an alternative inspection scheme
4.3 Type tests of turbines admitted to an alternative inspection scheme
4.4 Material tests
4.5 Inspections and testing during construction
4.6 Certification

Section 6 Gearing

1 General 135

1.1 Application

Section 7 Piping Systems

1 General 136

1.1 Application
1.2 Documentation to be submitted
1.3 Definitions
1.4 Symbols and units
1.5 Class of piping systems

2 General requirements for design and construction 138

2.1 Materials
2.2 Thickness of pressure piping
2.3 Toughness of carbon steels
2.4 Calculation of high temperature pipes
2.5 Junction of pipes
2.6 Protection against overpressure
2.7 Flexible hoses and expansion joints
2.8 Valves and accessories
2.9 Sea inlets and overboard discharges
2.10 Control and monitoring

3 Welding of steel piping 156

3.1 Application
3.2 General
3.3 Design of welded joints
3.4 Preparation of elements to be welded and execution of welding
3.5 Post-weld heat treatment
3.6 Inspection of welded joints

4 Bending of pipes 160

4.1 Application
4.2 Bending process
4.3 Heat treatment after bending

5 Arrangement and installation of piping systems 161

5.1 General
5.2 Piping systems serving hazardous areas
5.3 Location of tanks and piping system components
5.4 Passage through watertight bulkheads or decks
5.5 Independence of lines
5.6 Prevention of progressive flooding
5.7 Provision for expansion
5.8 Supporting of the pipes
5.9 Protection of pipes
5.10 Valves, accessories and fittings
5.11 Additional arrangements for flammable fluids

6 Bilge systems 166

6.1 Principle
6.2 Design of bilge systems
6.3 Arrangement of bilge suctions
6.4 Draining of particular spaces
6.5 Bilge pumps
6.6 Size of bilge pipes
6.7 Bilge accessories
6.8 Materials
6.9 Bilge piping arrangement

7 Ballast systems 171

7.1 Principle
7.2 Design of ballast systems
7.3 Ballast pumping arrangement
7.4 Drainage and sediment control
7.5 Requirements for installation of ballast water treatment systems (BWTS)
7.6 Design of integrated cargo and ballast systems on tankers

8 Scuppers and sanitary discharges 173

8.1 Application
8.2 Principle
8.3 Drainage from spaces below the freeboard deck or within enclosed superstructures and deckhouses on the freeboard deck
8.4 Drainage of superstructures or deckhouses not fitted with efficient weathertight doors
8.5 Arrangement of discharges from spaces below the margin line
8.6 Arrangement of discharges from spaces above the margin line
8.7 Summary table of overboard discharge arrangements
8.8 Valves and pipes
8.9 Arrangement of scuppers and sanitary discharge piping

9 Air, sounding and overflow pipes 177

9.1 Air pipes
9.2 Sounding pipes
9.3 Overflow pipes
9.4 Constructional requirements applying to sounding, air and overflow pipes

10 Cooling systems 182

10.1 Application
10.2 Principle
10.3 Design of sea water cooling systems
10.4 Design of fresh water cooling systems
10.5 Design of oil cooling systems
10.6 Control and monitoring
10.7 Arrangement of cooling systems

11 Fuel oil systems 184

11.1 Application
11.2 Principle
11.3 General
11.4 Design of fuel oil filling and transfer systems
11.5 Arrangement of fuel oil tanks and bunkers
11.6 Design of fuel oil tanks and bunkers
11.7 Design of fuel oil heating systems
11.8 Design of fuel oil treatment systems
11.9 Design of fuel supply systems
11.10 Helicopter refuelling facilities
11.11 Control and monitoring
11.12 Construction of fuel oil piping systems
11.13 Arrangement of fuel oil piping systems

12 Lubricating oil systems 192

12.1 Application
12.2 Principle
12.3 General
12.4 Design of engine lubricating oil systems
12.5 Design of steam turbine lubrication systems
12.6 Design of lubricating oil tanks
12.7 Control and monitoring
12.8 Construction of lubricating oil piping systems

13 Thermal oil systems 195

13.1 Application
13.2 Principle
13.3 General
13.4 Design of thermal oil heaters and heat exchangers
13.5 Design of storage, expansion and draining tanks
13.6 Design of circulation and heat exchange systems
13.7 Control and monitoring
13.8 Construction of thermal oil piping systems
13.9 Thermal oil piping arrangements

14 Hydraulic systems 198

14.1 Application
14.2 General design
14.3 General
14.4 Design of hydraulic pumps and accessories
14.5 Design of hydraulic tanks and other components
14.6 Control and monitoring

15 Steam systems 200

15.1 Application
15.2 Principle
15.3 Design of steam lines

16 Boiler feed water and condensate systems 201

16.1 Application
16.2 Principle
16.3 Design of boiler feed water systems
16.4 Design of condensate systems
16.5 Control and monitoring
16.6 Arrangement of feed water and condensate piping

17 Compressed air systems 203

17.1 Application
17.2 Principle
17.3 Design of starting air systems
17.4 Design of control and monitoring air systems
17.5 Design of air compressors
17.6 Control and monitoring of compressed air systems
17.7 Materials
17.8 Arrangement of compressed air piping systems

18 Exhaust gas systems 205

18.1 General
18.2 Design of exhaust systems
18.3 Materials
18.4 Arrangement of exhaust piping systems
18.5 Additional requirements for exhaust gas treatment systems

19 Oxyacetylene welding systems 208

19.1 Application
19.2 Definitions
19.3 Design of oxyacetylene welding systems
19.4 Arrangement of oxyacetylene welding systems

20 Certification, inspection and testing of piping systems 210

20.1 Application
20.2 Type tests of flexible hoses and expansion joints
20.3 Type tests of air pipe closing appliances
20.4 Testing of materials
20.5 Hydrostatic testing of piping systems and their components
20.6 Testing of piping system components during manufacturing
20.7 Inspection and testing of piping systems

Section 8 Thrusters

1 General 217

1.1 Application
1.2 Definitions
1.3 Thrusters intended for propulsion
1.4 Documentation to be submitted

2 Design and construction 218

2.1 Materials
2.2 Transverse thrusters and azimuth thrusters
2.3 Alarm, monitoring and control systems

3 Testing and certification 220

3.1 Material tests
3.2 Testing and inspection
3.3 Certification

Section 9 Refrigerating Installations

1 General 221

1.1 Application

2 Minimum design requirements 221

2.1 Refrigerating installation components
2.2 Refrigerants
2.3 Special requirements for ammonia (R717)

Section 10 Self Elevating Systems

1 General 223

1.1

Section 11 Tests on Board

1 General 224

1.1 Application
1.2 Purpose of the tests on board the unit
1.3 Documentation to be submitted

2 General requirements for on board tests 224

2.1 Trials at the moorings
2.2 Sea trials

3 On board tests for machinery 224

3.1 Tests of boilers
3.2 Tests of diesel engines
3.3 Tests of steam turbines
3.4 Tests of gas turbines
3.5 Tests of gears
3.6 Tests of piping systems

4 Inspection of machinery after sea trials 227

4.1 General
4.2 Diesel engines

Table of Content

Appendix 1 Plastic Pipes

1 General 228

- 1.1 Application
- 1.2 Use of plastic pipes
- 1.3 Definitions
- 1.4 Recognised standards

2 Design of plastic piping systems 228

- 2.1 General
- 2.2 Strength
- 2.3 Requirements depending on service and/or location
- 2.4 Pipe and fitting connections

3 Arrangement and installation of plastic pipes 232

- 3.1 General
- 3.2 Supporting of the pipes
- 3.3 Provision for expansion
- 3.4 External loads
- 3.5 Earthing
- 3.6 Penetration of fire divisions and watertight bulkheads or decks
- 3.7 Systems connected to the hull
- 3.8 Application of fire protection coatings

4 Certification, inspection and testing of plastic piping 234

- 4.1 Certification
- 4.2 Quality control during manufacture
- 4.3 Testing after installation on board
- 4.4 Test specification for plastic pipes

Appendix 2 Type Testing Procedure for Crankcase Explosion Relief Valves

1 General 237

- 1.1 Scope
- 1.2 Recognised standards
- 1.3 Purpose
- 1.4 Approval

2 Type testing procedure 237

- 2.1 Test facilities
- 2.2 Explosion test process
- 2.3 Valves to be tested
- 2.4 Method
- 2.5 Assessment and records
- 2.6 Design series qualification
- 2.7 Report

Appendix 3 Type Approval of Mechanical Joints

1 General 241

- 1.1 Scope
- 1.2 Documentation
- 1.3 Materials

2 Testing, procedures and requirements 241

- 2.1 Aim of the tests
- 2.2 Test fluid
- 2.3 Test program
- 2.4 Selection of test specimen
- 2.5 Mechanical joint assembly
- 2.6 Test results acceptance criteria
- 2.7 Methods of tests

Appendix 4 Dual Fuel Engines supplied with Low Pressure Gas and Dual Fuel Gas Turbines

1 General 246

1.1 Scope
1.2 Design principles

2 Additional requirements for dual fuel engines 246

2.1 Air inlet manifolds
2.2 Gas supply to the cylinders
2.3 Gas Ignition in the cylinders
2.4 Exhaust manifold
2.5 Crankcase
2.6 Instrumentation and safeties

3 Additional requirements for dual fuel gas turbines 248

3.1 General
3.2 Protection against liquid presence in the gas supply
3.3 Instrumentation and safeties

Chapter 2 Electrical Installations

Section 1 General

1 Application 250

1.1 General
1.2 Propelled units
1.3 References to other regulations and standards

2 National Authorities requirements 250

2.1 International Regulations
2.2 National Authorities requirements
2.3 Statutory requirements

3 Documentation to be submitted 251

3.1

4 Definitions 251

4.1 General
4.2 Essential services
4.3 Services for habitability
4.4 Emergency services
4.5 Safety voltage
4.6 Low-voltage systems
4.7 High-voltage systems
4.8 Basic insulation
4.9 Supplementary insulation
4.10 Double insulation
4.11 Reinforced insulation
4.12 Earthing
4.13 Normal operational and habitable condition
4.14 Emergency condition
4.15 Main source of electrical power
4.16 Black start condition
4.17 Main generating station
4.18 Main switchboard
4.19 Emergency switchboard
4.20 Emergency source of electrical power
4.21 Section boards
4.22 Distribution board
4.23 Final sub-circuit
4.24 Hazardous areas

4.25 High fire risk areas
4.26 Certified safe-type equipment
4.27 Voltage and frequency transient
4.28 Environmental categories

Section 2 General Design Requirements

1 Environmental conditions 257

1.1 General
1.2 Ambient air temperatures
1.3 Humidity
1.4 Sea water temperatures
1.5 Salt mist
1.6 Cold climate precautions
1.7 Inclinations
1.8 Vibrations

2 Quality of power supply 258

2.1 General
2.2 a.c. distribution systems
2.3 d.c. distribution systems
2.4 Harmonic distortions

3 Electromagnetic susceptibility 259

3.1

4 Materials 260

4.1 General
4.2 Insulating materials for windings
4.3 Insulating materials for cables

5 Construction 260

5.1 General
5.2 Degree of protection of enclosures

6 Protection against explosion hazard 261

6.1 Protection against explosive gas or vapour atmosphere hazard

Section 3 System Design

1 Distribution systems 262

1.1 Supply systems
1.2 Maximum voltages

2 Sources of electrical power 263

2.1 Main source of electrical power

3 Emergency power sources and circuits 265

3.1 Emergency power source
3.2 Transitional source
3.3 Services to be supplied by the emergency source
3.4 Services to be operable after emergency shutdown

4 System earthing 267

4.1 General requirements
4.2 Earthed distribution systems
4.3 Insulated distribution systems
4.4 Impedance earthed distribution system
4.5 Cross-sectional area of earthing connections

5 Distribution 268

5.1 General requirements for distribution systems
5.2 Distribution systems with hull return
5.3 Main distribution of electrical power
5.4 Emergency distribution of electrical power
5.5 Shore supply

5.6 Supply of motors
5.7 Specific requirements for special power services
5.8 Power supply to the speed control systems of generator sets
5.9 Power supply to lighting installations
5.10 Special lighting services
5.11 Navigation lights
5.12 Offshore structure marking
5.13 Installation of water-based local application fire-fighting systems (FWBLAFFS)

6 Degrees of protection of the enclosures 272

6.1 General
6.2 Installation of electrical and electronic equipment in engine rooms protected by fixed water-based local application fire-fighting systems (FWBLAFFS)

7 Diversity (demand) factors 274

7.1 General

8 Environmental categories of the equipment 274

8.1 Environmental categories

9 Electrical protection 274

9.1 General requirements for overcurrent protection
9.2 Short-circuit currents
9.3 Selection of equipment
9.4 Protection against short-circuit
9.5 Continuity of supply and continuity of service
9.6 Protection against overload
9.7 Localisation of overcurrent protection
9.8 Protection of generators
9.9 Protection of circuits
9.10 Protection of motors
9.11 Protection of storage batteries
9.12 Protection of shore power connection
9.13 Protection of measuring instruments, pilot lamps and control circuits
9.14 Protection of transformers

10 System components 279

10.1 General

11 Electrical cables 279

11.1 General
11.2 Choice of insulation
11.3 Choice of protective covering
11.4 Cables in refrigerated spaces
11.5 Cables in areas with a risk of explosion
11.6 Cables in circuits required to be operable under fire condition
11.7 Cables for submerged bilge pumps
11.8 Internal wiring of switchboards and other enclosures for equipment
11.9 Current carrying capacity of cables
11.10 Minimum nominal cross-sectional area of conductors
11.11 Choice of cables

Section 4 Rotating Machines

1 Constructional requirements for generators and motors 287

1.1 Mechanical construction
1.2 Sliprings, commutators and brushes
1.3 Terminal connectors
1.4 Electrical insulation

2 Special requirements for generators 287

2.1 Prime movers, speed governors and overspeed protection
2.2 A.c. generators

3 Testing of rotating machines 288

3.1 General
3.2 Shaft material
3.3 Tests

4 Description of test 289

4.1 Technical documentation and visual inspection
4.2 Insulation resistance measurement
4.3 Winding resistance measurement
4.4 Verification of the voltage regulation
4.5 Rated load test and temperature rise measurements
4.6 Overcurrent test - Overtorque test
4.7 Verification of the steady short circuit current
4.8 Overspeed test
4.9 Dielectric strength test
4.10 No load test
4.11 Verification of degree of protection
4.12 Verification of bearings

Section 5 Transformers

1 Constructional requirements 292

1.1 General
1.2 Construction
1.3 Terminals
1.4 Voltage variation, short-circuit conditions and parallel operation
1.5 Electrical insulation and temperature rise

2 Testing 293

2.1 General
2.2 Tests on transformers
2.3 Insulation tests

Section 6 Semiconductor Converters

1 Constructional requirements 295

1.1 Construction
1.2 Protection
1.3 Parallel operation with other power sources
1.4 Temperature rise
1.5 Insulation test

2 Requirements for uninterruptible power system (UPS) units as alternative and/or transitional power 296

2.1 Definitions
2.2 Design and construction
2.3 Location
2.4 Performance

3 Testing 297

3.1 General
3.2 Tests on converters
3.3 Additional testing and survey for uninterruptible power system (UPS) units as alternative and/or transitional power

Section 7 Storage Batteries and Chargers

1 Constructional requirements for batteries 299

1.1 General
1.2 Vented batteries
1.3 Valve-regulated sealed batteries
1.4 Tests on batteries
1.5 Battery maintenance

2 Constructional requirements for chargers 300
- 2.1 Characteristics
- 2.2 Tests on chargers

Section 8 Switchgear and Controlgear Assemblies

1 Constructional requirements for main and emergency switchboards 301
- 1.1 Construction
- 1.2 Busbars and bare conductors
- 1.3 Internal wiring
- 1.4 Switchgear and controlgear
- 1.5 Auxiliary circuits
- 1.6 Instruments
- 1.7 Synchronisation of generators

2 Constructional requirements for section boards and distribution boards 304
- 2.1 Construction

3 Testing 304
- 3.1 General
- 3.2 Inspection of equipment, check of wiring and electrical operation test
- 3.3 High voltage test
- 3.4 Measurement of insulation resistance

Section 9 Cables

1 General 306
- 1.1 Type approval

2 Constructional requirements 306
- 2.1 Construction
- 2.2 Conductors
- 2.3 Insulating materials
- 2.4 Inner covering, fillers and binders
- 2.5 Protective coverings (armour and sheath)
- 2.6 Identification

3 Testing 307
- 3.1 Type tests
- 3.2 Routine tests

Section 10 Miscellaneous Equipment

1 Switchgear and controlgear, protective devices 308
- 1.1 General
- 1.2 Circuit-breakers
- 1.3 Protection devices

2 Electrical slip ring assemblies 308
- 2.1 Applicable requirements
- 2.2 Construction
- 2.3 Testing
- 2.4 Description of tests

3 Lighting fittings 310
- 3.1 Applicable requirements
- 3.2 Construction

4 Accessories 311
- 4.1 Applicable requirements
- 4.2 Construction

5 Plug-and-socket connections 311
- 5.1 Applicable requirements

6 Heading and cooking appliances 311
6.1 Applicable requirements
6.2 General
6.3 Space heaters
6.4 Cooking appliances
6.5 Fuel oil and lube oil heaters
6.6 Water heaters

Section 11 Location

1 General 313
1.1 Location
1.2 Areas with a risk of explosion
2 Main electrical system 313
2.1 Location in relation to the emergency system
2.2 Main switchboard
3 Emergency electrical system 313
3.1 Spaces for the emergency source
3.2 Location in relation to the main electrical system
3.3 Emergency switchboard
3.4 Alternative arrangement of emergency source installation
3.5 Emergency battery
4 Distribution boards 314
4.1 Distribution boards for cargo spaces and similar spaces
4.2 Distribution board for navigation lights
5 Cable runs 314
5.1 General
5.2 Location of cables in relation to the risk of fire and overheating
5.3 Location of cables in relation to electromagnetic interference
5.4 Services with a duplicate feeder
5.5 Emergency circuits
6 Storage batteries 315
6.1 General
6.2 Large vented batteries
6.3 Moderate vented batteries
6.4 Small vented batteries
6.5 Valve regulated sealed batteries
6.6 Ventilation

Section 12 Installation

1 General 318
1.1 Protection against injury or damage caused by electrical equipment
1.2 Protection against damage to electrical equipment
1.3 Accessibility
1.4 Electrical equipment in environmentally controlled spaces
2 Earthing of non-current carrying parts 318
2.1 Parts which are to be earthed
2.2 Methods of earthing
2.3 Earthing connections
2.4 Connection to the unit’s structure
2.5 Earthed distribution systems
2.6 Aluminium superstructures
3 Rotating machines 320
3.1
4 Semiconductor converters 320
4.1 Semiconductor power converters

5 Vented type storage batteries 320

5.1 General
5.2 Protection against corrosion

6 Switchgear and controlgear assemblies 321

6.1 Main switchboard
6.2 Emergency switchboard
6.3 Section boards and distribution boards

7 Cables 322

7.1 General
7.2 Radius of bend
7.3 Fixing of cables
7.4 Mechanical protection
7.5 Penetrations of bulkheads and decks
7.6 Expansion joints
7.7 Cables in closed pipes or conduits
7.8 Cables in casings or trunking and conduits with removable covers
7.9 Cable ends
7.10 Joints and tappings (branch circuit)
7.11 Earthing and continuity of metal coverings of cables
7.12 Earthing and continuity of metal pipes, conduits and trunking or casings
7.13 Precautions for single-core cables for a.c.
7.14 Cables in refrigerated spaces
7.15 Cables in areas with a risk of explosion
7.16 Cables and apparatus for services required to be operable under fire conditions
7.17 Cables in the vicinity of radio equipment
7.18 Cable trays/protective casings made of plastics materials

8 Various appliances 328

8.1 Lighting fittings
8.2 Heating appliances
8.3 Heating cables and tapes or other heating elements

Section 13 High Voltage Installations

1 General 329

1.1 Field of application
1.2 Nominal system voltage
1.3 High-voltage, low-voltage segregation

2 System design 329

2.1 Distribution
2.2 Degrees of protection
2.3 Insulation
2.4 Neutral earthing system
2.5 Protection

3 Rotating machinery 331

3.1 Stator windings of generators
3.2 Temperature detectors
3.3 Tests

4 Power transformers 332

4.1 General

5 Cables 332

5.1 General

6 Switchgear and controlgear assemblies 332

6.1 General
6.2 Construction
6.3 Auxiliary systems
6.4 High voltage test

7 Installation 333

7.1 Electrical equipment
7.2 Cables

Section 14 Communications, Safeties and Alarms

1 General 334

1.1

2 General emergency alarm system 334

2.1 General

3 Public address system 335

3.1 General

4 Combined general emergency alarm-public address system 335

4.1 General

5 Fire alarm and gas detection systems 335

5.1 Fire alarm system
5.2 Gas detection system

6 Internal communications 336

6.1 General

7 Helicopter communications 336

7.1 General

Section 15 Specific Requirements for Electrical Installations in Hazardous Areas

1 Application 337

1.1 General
1.2 References to other regulations and standards

2 Electrical systems 337

2.1 General
2.2 Distribution systems and protection

3 Emergency conditions 338

3.1 General

4 Selection of electrical equipment 338

4.1 General
4.2 Selection according to zones

5 Installation requirements 339

5.1 Electrical cables
5.2 Earthing and bonding
5.3 Electromagnetic radiation

6 Miscellaneous installations 340

6.1 Electrical installations in battery rooms
6.2 Electrical installations in paint stores
6.3 Electrical installations in stores for welding gas (acetylene) bottles

7 Inspection and maintenance 341

7.1 Maintenance or modification of safety electrical apparatus

Section 16 Propulsion Plant

1 Design requirements 342

1.1 General

Section 17 Testing

1 General 343

1.1 Rule application
1.2 Insulation-testing instruments

2 Type approved components 343

2.1

3 Insulation resistance 343

3.1 Lighting and power circuits
3.2 Internal communication circuits
3.3 Switchboards
3.4 Generators and motors

4 Earth 344

4.1 Electrical constructions
4.2 Metal-sheathed cables, metal pipes or conduits

5 Operational tests 344

5.1 Generating sets and their protective devices
5.2 Switchgear
5.3 Safety systems
5.4 Consuming devices
5.5 Communication systems
5.6 Installations in areas with a risk of explosion
5.7 Voltage drop

Appendix 1 Indirect Test Method for Synchronous Machines

1 General 346

1.1 Test method

Appendix 2 Indirect Test Method for Induction Machines (Static Torque Method)

1 General 348

1.1 Test method

Chapter 3 Control Systems and Automation

Section 1 General Requirements

1 General 350

1.1 Field of application
1.2 Regulations and standards
1.3 Definitions
1.4 General

2 Documentation 352

2.1 General
2.2 Documents to be submitted
2.3 Documents for computer based system
2.4 Documents for type approval of equipment

3 Environmental and supply conditions 354

3.1 General
3.2 Power supply conditions

4 Materials and construction 354

4.1 General
4.2 Type approved components

Section 2 Design Requirements

1 General 355
1.1
2 Power supply of automation systems 355
2.1 General
3 Control systems 355
3.1 General
3.2 Local control
3.3 Remote control systems
3.4 Automatic control systems
4 Remote control of valves 356
4.1
5 Alarm system 356
5.1 General requirements
5.2 Alarm functions
6 Safety system 357
6.1 Design
6.2 Function
6.3 Shutdown
6.4 Standby systems
6.5 Testing

Section 3 Computer Based Systems

1 General requirements 358
1.1 General
1.2 System type approval
1.3 System operation
1.4 System reliability
1.5 System failure
1.6 System redundancy
1.7 System categories
2 Hardware 359
2.1 General
2.2 Housing
3 Software 360
3.1 General
3.2 Software development quality
4 Data transmission link 360
4.1 General
4.2 Hardware support
4.3 Transmission software
4.4 Transmission operation
4.5 Redundant network
4.6 Additional requirements for wireless data links
4.7 Protection against modifications
5 Man-machine interface 362
5.1 General
5.2 System functional indication
5.3 Input devices
5.4 Output devices
5.5 Workstations
5.6 Computer dialogue
6 Integrated systems 363
6.1 General

7 Expert system 363

7.1

8 System testing 363

8.1

9 System maintenance 363

9.1

Section 4 Constructional Requirements

1 General 364

1.1 General
1.2 Materials
1.3 Component design
1.4 Environmental and supply conditions

2 Electrical and/or electronic systems 364

2.1 General
2.2 Electronic system
2.3 Electrical system

3 Pneumatic systems 365

3.1

4 Hydraulic systems 365

4.1

5 Automation consoles 365

5.1 General
5.2 Indicating instruments
5.3 VDU's and keyboards

Section 5 Installation Requirements

1 General 367

1.1

2 Sensors and components 367

2.1 General
2.2 Temperature elements
2.3 Pressure elements
2.4 Level switches

3 Cables 367

3.1 Installation
3.2 Cable terminations

4 Pipes 368

4.1

5 Automation consoles 368

5.1 General

Section 6 Testing

1 General 369

1.1 General

2 Type approval 369

2.1 General
2.2 Hardware type approval
2.3 Software type approval
2.4 Loading instruments
2.5 Oil mist detection system

3	Acceptance testing	376
	3.1 General 3.2 Tests and evidence 3.3 Hardware testing 3.4 Software testing	
4	On board tests	378
	4.1 General	

Section 7 Unattended Machinery Spaces (AUTO)

1	General	379
	1.1 Application 1.2 Communication system	
2	Documentation	379
	2.1 Documents to be submitted	
3	Fire and flooding precautions	379
	3.1 Fire prevention 3.2 Fire detection 3.3 Fire fighting 3.4 Protection against flooding	
4	Control of machinery	381
	4.1 General 4.2 Auxiliary system 4.3 Control of electrical installation	
5	Alarm system	387
	5.1 General 5.2 Alarm system design 5.3 Machinery alarm system	
6	Safety systems	387
	6.1 General	
7	Testing	387
	7.1 General	

Chapter 4 Safety Features

Section 1 General

1	Scope - Classification requirements	390
	1.1 General 1.2 Requirements applicable to piping 1.3 Surveys and tests	
2	Statutory requirements	390
	2.1 International Regulations 2.2 National Authorities requirements	
3	Definitions	391
	3.1 General 3.2 Machinery spaces, working spaces, hazardous areas 3.3 Service spaces 3.4 Control stations, central control room 3.5 Accommodation and corridors 3.6 Deck and bulkhead fire ratings and fire materials 3.7 Fire Test Procedures Code 3.8 Fire damper	

Table of Content

4 Type approved products 394

4.1 General

5 Fire safety 395

5.1 General
5.2 Alternative design and arrangement

Section 2 Arrangement of Unit or Installation

1 General 396

1.1 Principles of design
1.2 Risk analyses - Safety level

2 Location and arrangement of areas 396

2.1 Relative location and separation of areas
2.2 Location and arrangement of accommodation and control stations
2.3 Arrangement of wellhead area
2.4 Location and arrangement of helideck area
2.5 Location and arrangement of cranes and lay down areas
2.6 General orientation of the unit or installation

Section 3 Hazardous Areas

1 Definitions 398

1.1 Hazardous areas
1.2 Zones
1.3 Enclosed spaces
1.4 Semi-enclosed spaces
1.5 Open spaces
1.6 Sources of release

2 Classification of hazardous areas 399

2.1
2.2 Provisions regarding mobile and fixed offshore units
2.3 Extension of hazardous areas due to emergency conditions

3 Recognised codes 401

3.1

4 Openings, access, ventilation, piping conditions affecting the extent of hazardous areas 401

4.1 Openings, access and ventilation
4.2 Pipings

5 Ventilation 402

5.1 General
5.2 Air inlets and discharges
5.3 Capacity of ventilation system to hazardous area spaces
5.4 Open and semi-enclosed areas
5.5 Gas safe compartments
5.6 Ventilation material and equipment
5.7 Ventilation and operation of rooms or buildings protected by pressurization
5.8 Value of overpressure and of protective gas flow
5.9 Failure of the pressurization

6 Machinery installation in hazardous areas 404

6.1 General
6.2 Compressors and pumps

Section 4 Structural Fire Protection

1 General requirements 406

1.1 General
1.2 Fire integrity of bulkheads and decks

2 Penetrations in fire-resisting divisions 408

2.1 Penetrations in A class divisions
2.2 Penetrations in B class divisions
2.3 Pipes penetrating A or B class divisions

3 Protection of openings in fire-resisting divisions 408

3.1 Doors in fire-resisting divisions
3.2 Windows and sidescuttles
3.3 Openings and access in machinery and working spaces

4 Protection of accommodation spaces, service spaces and control stations 409

4.1

5 Ventilation systems 410

5.1 Ducts and dampers
5.2 Arrangement of ducts
5.3 Details of duct penetrations
5.4 Exhausts ducts from galley range
5.5 Control of fire growth

Section 5 Detection, Controls, Communications and Alarms

1 Alarms 412

1.1 General alarms
1.2 Ventilation alarms
1.3 Mud systems level alarms

2 Detection systems general design 412

2.1 General

3 Fixed fire detection and fire alarm systems 412

3.1 Definition
3.2 General
3.3 Engineering specifications

4 Gas detection system 416

4.1 Combustible gas detection and alarm system
4.2 Hydrogen sulphide detection and alarm system
4.3 Portable gas monitoring devices
4.4 Respiratory protection equipment for hydrogen sulphide

Section 6 Suppression of Fire: Fire Fighting

1 Application 419

1.1

2 Fire fighting water supply 419

2.1 General
2.2 Fire pumps
2.3 Fire mains and hydrants
2.4 Particular arrangements

3 Portable fire-extinguishers 421

3.1 General
3.2 Type and design
3.3 Arrangement of fire extinguishers

4 Fixed fire-extinguishing systems 422

4.1 Types of fixed fire-extinguishing systems
4.2 Closing appliances for fixed gas fire-extinguishing systems
4.3 Storage rooms of fire-extinguishing medium
4.4 Water pumps for other fire-extinguishing systems

5 Fire-extinguishing arrangements in machinery spaces 422

5.1 Machinery spaces arrangement
5.2 Machinery spaces containing oil-fired boilers or oil fuel units
5.3 Machinery spaces of category A containing internal combustion machinery
5.4 Machinery spaces containing steam turbines or enclosed steam engines
5.5 Other machinery spaces
5.6 Fixed local application fire-extinguishing systems

6 Fire-extinguishing arrangements in service spaces 425

6.1 Spaces containing flammable liquid
6.2 Deep-fat cooking equipment

7 Additional fire-extinguishing arrangements on drilling units 425

7.1 Fixed fire-extinguishing systems on drilling and well test areas
7.2 Fixed fire-extinguishing systems on mud processing area

Section 7 Suppression of Fire: Structural Integrity

1 Material of hull, superstructures, structural bulkheads, decks and deckhouses 426

1.1 General

2 Structure of aluminium alloy 426

2.1 General

3 Machinery spaces of category A 426

3.1 Crowns and casings
3.2 Floor plating

4 Materials of overboard fittings 426

4.1 General

Section 8 Escape

1 Notification of people on board 427

1.1 General emergency alarm system

2 Means of escape 427

2.1 General requirements
2.2 Means of escape from control stations, accommodation spaces and service spaces
2.3 Means of escape from machinery spaces
2.4 Fibre Reinforced Plastic (FRP) Gratings

Section 9 Fire Plan

1 Fire control plans 430

1.1 Compilation of the fire control plans
1.2 Location of the fire control plans

Section 10 Helicopter Facilities

1 General 431

1.1 Application
1.2 Contents
1.3 Definitions
1.4 Recognised codes

2 Structure 431

2.1 Construction of steel or other equivalent materials
2.2 Construction of aluminium or other low melting point metals
2.3 Means of escape

3 Fire-fighting appliances 432

3.1 General

4 Helicopter refuelling and hangar facilities 432
4.1 "No smoking" signs
4.2 Hangar, refuelling and maintenance facilities
4.3 Arrangement of spaces containing the refuelling installations
5 Occasional and emergency helicopter operations 434
5.1 General
6 Operations manual 434
6.1 General

Section 11 Fire Safety Systems

1 General 435
1.1 Application
1.2 Statutory requirements
1.3 Use of toxic extinguishing media
2 International shore connections 435
2.1 Engineering specifications
3 Fire extinguishers 436
3.1 Type approval
3.2 Engineering specifications
4 Fixed gas fire-extinguishing systems 437
4.1 Engineering specifications
4.2 Equivalent fixed gas fire-extinguishing systems
4.3 Requirements of steam systems
5 Fixed foam fire-extinguishing systems 441
5.1 General
5.2 Fixed high-expansion foam fire-extinguishing systems
5.3 Fixed low-expansion foam fire-extinguishing systems
6 Fixed pressure water-spraying and water-mist fire-extinguishing systems 444
6.1 Engineering specifications
6.2 Particular requirements for wellhead, production and drilling areas
6.3 Fixed water-based local application fire-fighting systems
7 Automatic sprinkler, fire detection and fire alarm systems 445
7.1 Engineering specifications
8 Fire-fighters' outfits 447
8.1
9 Recharging of air cylinders 447
9.1

Section 12 Additional Class Notation LSA

1 General 448
1.1 Definitions
1.2 Classification requirements
1.3 National Authorities requirements
1.4 Approval of appliances and equipment
1.5 Alternative design and arrangements
2 Survival crafts 449
2.1 Surface units
2.2 Other units or installations
2.3 Survival craft stowage, launching stations, launching and recovery arrangements

3 Rescue boat 451

3.1 General
3.2 Stowage of rescue boats
3.3 Rescue boat embarkation, launching and recovery arrangements

4 Lifebuoys 452

4.1 Total number
4.2 Types

5 Lifejackets, immersion suits, visual signals and other life-saving appliances 452

5.1 Lifejackets
5.2 Immersion suits
5.3 Visual signals
5.4 Line-throwing appliances

6 Distribution of life-saving equipment 453

6.1 Lifejackets
6.2 Immersion suits
6.3 Buoys
6.4 Assembly and embarkation places

7 Radio life-saving appliances 453

7.1 Two-way VHF radiotelephone apparatus
7.2 Search and rescue locating device

8 Operating instructions 453

8.1

9 Means of escape 454

9.1 General requirements
9.2 Exits
9.3 Escape routes

10 Enclosed spaces 454

10.1

Chapter 5 SUSTAINABILITY

Section 1 General Requirements

1 Scope and application 456

1.1 Scope

2 Definitions and abbreviations 456

2.1 Definitions related to sea pollution
2.2 Definitions related to air pollution
2.3 Definitions related to greenhouse gases
2.4 Abbreviations

3 Documents to be submitted 458

3.1 General

4 Onboard surveys 461

4.1 Initial surveys tests
4.2 Periodical tests and measurements done by the Owner

Section 2 Requirements for the Additional Class Notation SUSTAINABILITY-1

1 Prevention of sea and air pollution 462

1.1 International regulations
1.2 Waste management
1.3 Waste minimization and recycling program
1.4 Prevention of pollution by oil
1.5 Wastewaters
1.6 Garbage and hazardous wastes
1.7 Hull anti-fouling systems
1.8 Ballast water management
1.9 Refrigeration systems
1.10 Fire-fighting systems
1.11 Emission of nitrogen oxides (NOx)
1.12 Emission of sulphur oxides (SOx)
1.13 Emission of hydrocarbon vapours and Volatile Organic Compounds (VOC)

2 Energy efficiency and GHG emission management plan 470

2.1 General
2.2 Description of the unit
2.3 Monitoring systems
2.4 Mitigation measures
2.5 Emission reduction and energy efficiency improvement
2.6 Management and crew training

3 Preparation for unit recycling 471

3.1 GREEN PASSPORT

4 Enhancement of people well-being on board 471

4.1 Habitability
4.2 Noise and vibrations

Section 3 Requirements for the Additional Class Notation SUSTAINABILITY-2

1 Prevention of sea and air pollution 472

1.1 Waste management
1.2 Wastewaters
1.3 Prevention of pollution by oil
1.4 Refrigeration systems
1.5 Emission of sulphur oxides (SOx)

2 Enhancement of people well-being on board 473

2.1 Habitability
2.2 Noise and vibrations

Part C
Facilities

CHAPTER 1
MACHINERY AND PIPING

Section 1	General Requirements
Section 2	Diesel Engines
Section 3	Pressure Equipment
Section 4	Steam Turbines
Section 5	Gas Turbines
Section 6	Gearing
Section 7	Piping Systems
Section 8	Thrusters
Section 9	Refrigerating Installations
Section 10	Self Elevating Systems
Section 11	Tests on Board
Appendix 1	Plastic Pipes
Appendix 2	Type Testing Procedure for Crankcase Explosion Relief Valves
Appendix 3	Type Approval of Mechanical Joints
Appendix 4	Dual Fuel Engines supplied with Low Pressure Gas and Dual Fuel Gas Turbines

Section 1 General Requirements

1 General

1.1 Application

1.1.1 The present Chapter applies to the design, construction, installation, tests and trials of machinery systems and associated equipment, boilers and pressure vessels, piping systems and manoeuvring systems installed on board classed offshore units, as indicated in each Section of this Chapter and as far as class is concerned only.

For self-propelled units, refer to the applicable requirements of the Ship Rules, in particular as regards shafting, propellers and steering gears.

1.2 Documentation to be submitted

1.2.1 Before the actual construction is commenced, the Manufacturer, Designer or Builder is to submit to the Society the documents (plans, diagrams, specifications and calculations) requested in the relevant Sections of this Chapter.

1.3 Definitions

1.3.1 Machinery spaces of Category A

Machinery spaces of Category A are those spaces and trunks to such spaces which contain:

- *internal combustion machinery used for main propulsion, or*
- *internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW, or*
- *any oil fired boiler or fuel oil unit,* or
- gas generators, incinerators, waste disposal units, etc., which use oil fired equipment.

1.3.2 Machinery spaces

Machinery spaces are all machinery spaces of Category A and all other spaces containing propulsion machinery, boilers, fuel oil units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilising, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

1.3.3 Fuel oil unit

Fuel oil unit is the equipment used for the preparation of fuel oil for delivery to an oil fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 0,18 N/mm^2.

For the purpose of this definition, inert gas generators are to be considered as oil fired boilers and gas turbines are to be considered as internal combustion engines.

1.3.4 Dead ship condition

Dead ship condition is the condition under which the main propulsion plant, boilers and auxiliaries are not in operation due to the absence of power.

2 Design and construction

2.1 General

2.1.1 *When alternative design or arrangements deviate from the prescriptive provisions of the Code, an engineering analysis, evaluation and approval of the design and arrangements should be carried out in accordance with SOLAS regulation II-1/55 based on the guidelines developed by the Organization.*

Note 1: Refer to the Guidelines on alternative design and arrangements for SOLAS chapters II-1 and III (MSC.1/Circ.1212).

2.1.2 *The machinery requirements of Part D, Chapter 1 provide an acceptable degree of protection from fire or other physical injuries. They apply to both marine and industrial equipment.*

2.1.3 *All machinery, electrical equipment, boilers and other pressure vessels, associated piping systems, fittings and wiring are to be of a design and construction adequate for the service for which they are intended and are to be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards. The design is to have regard to materials used in construction, and to the marine and industrial purposes for which the equipment is intended, the working conditions and the environmental conditions to which it will be subjected.*

2.2 Availability

2.2.1 *Means are to be provided to ensure that machinery can be brought into operation from the "dead ship" condition without external aid.*

2.2.2 *Consideration is to be given to the consequences of the failure of systems and equipment essential to the safety of the unit.*

2.2.3 *Means are to be provided whereby normal operation of vital systems such as ballast systems in column stabilized units, jacking systems in self-elevating units or control of blow-out preventers, can be sustained or restored even though one of the essential auxiliaries becomes inoperable.*

2.3 Materials, welding and testing

2.3.1 General

Materials, welding and testing procedures are to be in accordance with the requirements of NR216 Rules on Materials and Welding for the Classification of Ships and Offshore Units and those given in the other Sections of this Chapter. In addition, for machinery components fabricated by welding, the requirements given in [2.3.2] apply.

2.3.2 Welded machinery components

Welding processes and welders are to be approved by the Society in accordance with NR216, Chapter 12.

References to welding procedures adopted are to be clearly indicated on the plans submitted for approval.

Joints transmitting loads are to be either:

- full penetration butt-joints welded on both sides, except when an equivalent procedure is approved
- full penetration T- or cruciform joints.

For joints between plates having a difference in thickness greater than 3 mm, a taper having a length of not less than 4 times the difference in thickness is required. Depending on the type of stress to which the joint is subjected, a taper equal to three times the difference in thickness may be accepted.

T-joints on scalloped edges are not permitted.

Lap-joints and T-joints subjected to tensile stresses are to have a throat size of fillet welds equal to 0,7 times the thickness of the thinner plate on both sides.

In the case of welded structures including cast pieces, the latter are to be cast with appropriate extensions to permit connection, through butt-welded joints, to the surrounding structures, and to allow any radiographic and ultrasonic examinations to be easily carried out.

Where required, preheating and stress relieving treatments are to be performed according to the welding procedure specification.

2.4 Power transmission

2.4.1 *All gearing and every shaft and coupling used for transmission of power to machinery are to be designed and constructed so that they will withstand the maximum working stresses to which they will be subjected in all service conditions, taking into account the type of engines by which they are driven or which they form part.*

2.5 Vibrations

2.5.1 Builders and manufacturers are to give *special consideration to the design, construction and installation of* machinery intended for essential services *so that any mode of their vibrations shall not cause undue stresses in this machinery in the normal operating ranges.*

2.6 Operation in inclined position

2.6.1 *Main propulsion machinery and all auxiliary machinery essential to the propulsion and the safety of the unit are to be, as fitted in the unit, designed to operate when the unit is upright and when inclined at any angle of list either way and trim by bow or stern as stated in Tab 1, Tab 2 and Tab 3.*

The Society may permit deviations from angles given in the aforesaid tables, taking into consideration the type, size and service conditions of the unit.

Machinery with a horizontal rotation axis is generally to be fitted on board with such axis arranged alongships. If this is not possible, the Manufacturer is to be informed at the time the machinery is ordered.

2.7 Ambient conditions

2.7.1 Machinery and systems covered by the Rules are to be designed to operate properly under the ambient conditions specified in Tab 4, unless otherwise specified in each Section of this Chapter.

Table 1 : Conditions of inclination for column-stabilized offshore units

Equipment	Propulsion	Angles of inclination (degree)	
		Static	Dynamic
Equipment intended for essential services **(1)**	self-propelled	15 in any direction	22,5 in any direction
	not propelled	15 in any direction	no requirement
Equipment intended for emergency purposes **(2)**	self-propelled	25 in any direction, or the angle of inclination resulting from the worst assumed damaged condition, whichever is the less	no requirement
	not propelled		

(1) Essential services are defined in Ch 2, Sec 1, [4.2].
(2) Emergency services are defined in Ch 2, Sec 1, [4.4].

Table 2 : Conditions of inclination for self-elevating offshore units

Equipment	Propulsion	Angles of inclination (degree) **(3)**	
		Static	Dynamic
Equipment intended for essential services **(1)**	self-propelled	10 in any direction	15 in any direction
	not propelled	10 in any direction	no requirement
Equipment intended for emergency purposes **(2)**	self-propelled	15 in any direction, or the angle of inclination resulting from the worst assumed damaged condition, whichever is the less	no requirement
	not propelled		

(1) Essential services are defined in Ch 2, Sec 1, [4.2].
(2) Emergency services are defined in Ch 2, Sec 1, [4.4].
(3) Higher inclination angles as per Tab 1 may be required for self-elevating units having a rectangular upper pontoon with L/B > 3.

Table 3 : Conditions of inclination for surface offshore units

Equipment	Propulsion	Angles of inclination (degree) **(3)**	
		Static	Dynamic
Equipment intended for essential services **(1)**	self-propelled	5 fore and aft 15 athwartship **(4)**	7,5 fore and aft 22,5 athwartship **(4)**
	not propelled	5 fore and aft 15 athwartship **(4)**	no requirement
Equipment intended for emergency purposes **(2)**	self-propelled	10 fore and aft 22,5 athwartship, or the angle of inclination resulting from the worst assumed damaged condition, whichever is the less	10 fore and aft 22,5 athwartship, or the angle of inclination resulting from the worst assumed damaged condition, whichever is the less
	not propelled		

(1) Essential services are defined in Ch 2, Sec 1, [4.2].
(2) Emergency services are defined in Ch 2, Sec 1, [4.4].
(3) Fore-and-aft and athwartship inclinations may occur simultaneously.
(4) For units having the service notation **liquefied gas storage**, the equipment intended for essential services is to remain operable with the unit flooded to a final athwartship inclination up to a maximum of 30°.

Table 4 : Ambient conditions

AIR TEMPERATURE	
Location, arrangement	Temperature range (°C)
In enclosed spaces	between 0 and +45 **(2)**
On machinery components, boilers In spaces subject to higher or lower temperatures	according to specific local conditions
On exposed decks	between −25 and +45 **(1)**
WATER TEMPERATURE	
Coolant	Temperature (°C)
Sea water or, if applicable, sea water at charge air coolant inlet	up to +32

(1) Electronic appliances are to be designed for an air temperature up to 55°C (for electronic appliances see also Part C, Chapter 2).
(2) Different temperatures may be accepted by the Society in the case of units operating in restricted zones.

2.8 Power of machinery

2.8.1 Unless otherwise stated in each Section of this Chapter, where scantlings of components are based on power, the values to be used are determined as follows:

- for main propulsion machinery, the power/rotational speed for which classification is requested
- for auxiliary machinery, the power/rotational speed which is available in service.

2.9 Safety devices

2.9.1 *Where risk from overspeeding of machinery exists, means are to be provided to ensure that the safe speed is not exceeded.*

2.9.2 *Where main or auxiliary machinery including pressure vessels or any parts of such machinery are subject to internal pressure and may be subject to dangerous overpressure, means shall be provided, where practicable, to protect against such excessive pressure.*

2.9.3 *Machinery, where applicable, is to be provided with automatic shut-off arrangements or alarms in the case of failures, such as lubricating oil supply failure, which could lead rapidly to complete breakdown, damage or explosion.*

The Society may permit provisions for overriding automatic shut-off devices.

See also the specific requirements given in the other Sections of this Chapter.

2.10 Fuels

2.10.1 General

When it is intended to burn fuels having a flashpoint (closed cup test) below 60°C but not less than 43°C, this fact is to be clearly indicated on the submitted documents. Vent heads with flame arresters are to be fitted to vent pipes. Other arrangements are to be specially considered by the Society.

2.10.2 Fuel oils employed for engines and boilers are, in general, to have a flash point (determined using the closed cup test) of not less than 60°C. However, for engines driving emergency generators, fuel oils having a flash point of less than 60°C but not less than 43°C are acceptable.

For units operating in restricted zones, or whenever special precautions are taken to the Society’s satisfaction, fuel oils having a flash point of less than 60°C but not less than 43°C may be used for engines and boilers, provided that, from previously effected checks, it is evident that the temperature of spaces where fuel oil is stored or employed will be at least 10°C below the fuel oil flash point at all times.

The use of process gas and crude oil as fuel for boilers or propulsion engines is allowed subject to the requirements of Pt D, Ch 1, Sec 19.

The use of boil-off gas for boilers and propulsion engines is allowed for units complying with the requirement of NR542 Classification of Floating Gas Units.

2.10.3 Machinery and piping systems for the usage of fuel oil having a flashpoint less than 60°C shall also comply with the following:

a) For oil fuel having a flashpoint of less than 60°C but not less than 43°C, oil tanks except those arranged in double bottom compartments shall be located outside of machinery spaces of category A.

b) For oil fuel having a flashpoint of less than 43°C, where permitted, the following provisions are to be complied with:
   - oil tanks are to be located outside machinery spaces and the arrangements adopted have to be specially approved by the Society
   - provisions for the measurement of oil temperature should be provided on the suction pipe of oil fuel pump
   - stop valves and/or cocks are to be provided to the inlet side and outlet side of the oil fuel strainers
   - pipe joints of welded construction or of circular cone type or spherical type union joint are to be applied as much as possible.

2.10.4 Arrangements for the storage and handling of fuel oils intended for helicopters are to comply with the provisions of Ch 4, Sec 10.

3 Arrangement and installation on board

3.1 General

3.1.1 *Adequate provisions and arrangements should be made to facilitate safe access, cleaning, inspection and of machinery, including boilers and pressure vessels.*

Easy access to the various parts of the propulsion machinery is to be provided by means of metallic ladders and gratings fitted with strong and safe handrails.

Spaces containing main and auxiliary machinery are to be provided with adequate lighting and ventilation.

3.1.2 The installation of mechanical equipment and machinery in hazardous areas is to comply with the provisions of Ch 4, Sec 3, [6].

3.2 Ventilation in machinery spaces

3.2.1 Machinery spaces are to be sufficiently ventilated so as to ensure that when machinery or boilers therein are operating at full power in all weather conditions, including heavy weather, a sufficient supply of air is maintained to the spaces for the operation of the machinery.

This sufficient amount of air is to be supplied through suitably protected openings arranged in such a way that they can be used in all weather conditions, taking into account Regulation 19 of the 1966 Load Line Convention.

Special attention is to be paid both to air delivery and extraction and to air distribution in the various spaces. The quantity and distribution of air are to be such as to satisfy machinery requirements for developing maximum continuous power.

The ventilation is to be so arranged as to prevent any accumulation of flammable gases or vapours.

3.3 Air intakes

3.3.1 Air intakes for internal combustion engines are not to be less than 3 m from the hazardous areas as defined in Ch 4, Sec 1, [3.2].

3.4 Hot surfaces and fire protection

3.4.1 Surfaces, having temperature exceeding 60°C, with which the crew are likely to come into contact during operation are to be suitably protected or insulated.

Surfaces of machinery with temperatures above 220°C, e.g. steam, thermal oil and exhaust gas lines, silencers, exhaust gas boilers and turbochargers, are to be effectively insulated with non-combustible material or equivalently protected to prevent the ignition of combustible materials coming into contact with them. Where the insulation used for this purpose is oil absorbent or may permit the penetration of oil, the insulation is to be encased in steel sheathing or equivalent material.

Fire protection, detection and extinction is to comply with the requirements of Part C, Chapter 4.

3.5 Safety devices on moving parts

3.5.1 Suitable protective devices on access restrictions are to be provided in way of moving parts (flywheels, couplings, etc.) in order to avoid accidental contact of personnel with moving parts.

3.6 Gauges

3.6.1 All gauges are to be grouped, as far as possible, near each manoeuvring position; in any event, they are to be clearly visible.

3.7 Bolting down

3.7.1 Bedplates of machinery are to be securely fixed to the supporting structures by means of foundation bolts which are to be distributed as evenly as practicable and of a sufficient number and size so as to ensure proper fitting.

Where the bedplates bear directly on the inner bottom plating, the bolts are to be fitted with suitable gaskets so as to ensure a tight fit and are to be arranged with their heads within the double bottom.

Continuous contact between bedplates and foundations along the bolting line is to be achieved by means of chocks of suitable thickness, carefully arranged to ensure a complete contact.

3.7.2 Chocking resins are to be type approved.

3.7.3 Where stays are provided for fixing the upper part of engines to the unit's structure in order, for example, to reduce the amplitude of engine vibrations, such stays are to be so designed as to prevent damage to these engines further to deformation of the shell plating in way of the said stays. The stays are to be connected to the hull in such a way as to avoid abnormal local loads on the structure of the unit.

3.8 Gratings

3.8.1 Gratings in engine rooms are to be metallic, divided into easily removable panels.

3.9 Machinery remote control, alarms and safety systems

3.9.1 For remote control systems of main propulsion machinery and essential auxiliary machinery and relevant alarms and safety systems, the requirements of Part C, Chapter 3 apply.

3.9.2 *An engineers' alarm shall be provided to be operated from the engine control room or at the manoeuvring platform as appropriate, and shall be clearly audible in the engineers' accommodation.*

3.10 Communications

3.10.1 *At least two independent means are to be provided for communicating orders from the navigating bridge to the position in the machinery space or in the control room from which the speed and the direction of the thrust of the propellers are normally controlled; one of these is to be an engine room telegraph, which provides visual indication of the orders and responses both in the machinery space and on the navigating bridge,* with audible alarm mismatch between order and response.

Appropriate means of communication shall be provided from the navigating bridge and the engine room to any other position from which the speed and direction of thrust of the propellers may be controlled.

The second means for communicating orders is to be fed by an independent power supply and is to be independent of other means of communication.

Where the main propulsion system of the unit is controlled from the navigating bridge by a remote control system, the second means of communication may be the same bridge control system.

The engine room telegraph is required in any case, even if the remote control of the engine is foreseen, irrespective of whether the engine room is attended.

For units operating in restricted zones, these requirements may be relaxed at the Society’s discretion.

4 Tests and trials

4.1 Works tests

4.1.1 Equipment and its components are subjected to works tests which are detailed in the relevant Sections of this Chapter. The Surveyor is to be informed in advance of these tests.

Where such tests cannot be performed in the workshop, the Society may allow them to be carried out on board, provided this is not judged to be in contrast either with the general characteristics of the machinery being tested or with particular features of the installation. In such cases, the Surveyor is to be informed in advance and the tests are to be carried out in accordance with the provisions of NR216 relative to incomplete tests.

All boilers, all parts of machinery, all steam, hydraulic, pneumatic and other systems and their associated fittings which are under internal pressure shall be subjected to appropriate tests including a pressure test before being put into service for the first time as detailed in the other Sections of this Chapter.

4.2 Trials on board

4.2.1 Trials on board of machinery are detailed in Ch 1, Sec 11.

Section 2 Diesel Engines

1 General

1.1 Application

1.1.1 Diesel engines listed below are to be designed, constructed, installed, tested and certified in accordance with the requirements of this Section, under the supervision and to the satisfaction of the Society's Surveyors:

a) main propulsion engines

b) engines driving electric generators, including emergency generators

c) engines driving other auxiliaries essential for the safety of the unit, when they develop a power of 110 kW and over.

All other engines are to be designed and constructed according to sound marine practice and delivered with the relevant works' certificate (see NR216, Ch 1, Sec 1, [4.2.3]).

Engines intended for propulsion of lifeboats and compression ignition engines intended for propulsion of rescue boats are to comply with the relevant Rule requirements.

Engines intended to be used in hazardous areas are to comply with the provisions of Article [5] and Ch 4, Sec 3, [6].

Additional requirements for control and safety systems for dual fuel engines are given in Ch 1, App 4 and Pt C, Ch 1, App 2 of the Ship Rules.

Requirements for turbochargers are given in Pt C, Ch 1, Sec 17 of the Ship Rules.

1.2 Documentation flow for diesel engine

1.2.1 Document flow for obtaining a type approval certificate

- For the initial engine type, the engine designer prepares the documentation in accordance with requirements in Tab 1 and Tab 2 and forwards to the Society according to the agreed procedure for review.
- Upon review and approval of the submitted documentation (evidence of approval), it is returned to the engine designer.
- The engine designer arranges for a Surveyor to attend an engine type test and upon satisfactory testing the Society issues a type approval certificate.

1.2.2 Document flow for engine certificate

a) The engine type must have a type approval certificate. For the first engine of a type, the type approval process and the engine certification process (ECP) may be performed simultaneously.

b) Engines to be installed in specific applications may require the engine designer/licensor to modify the design or performance requirements. The modified drawings are forwarded by the engine designer to the engine builder/licensee to develop production documentation for use in the engine manufacture in accordance with Tab 3.

c) The engine builder/licensee develops a comparison list of the production documentation to the documentation listed in Tab 1 and Tab 2.

If there are differences in the technical content on the licensee's production drawings/documents compared to the corresponding licensor's drawings, the licensee must obtain agreement to such differences from the licensor.

If the designer acceptance is not confirmed, the engine is to be regarded as a different engine type and is to be subjected to the complete type approval process by the licensee.

d) The engine builder/licensee submits the comparison list and the production documentation to the Society according to the agreed procedure for review/approval.

e) The Society returns documentation to the engine builder/licensee with confirmation that the design has been approved. This documentation is intended to be used by the engine builder/licensee and their subcontractors and attending Surveyors. As the attending Surveyors may request the engine builder/licensee or their subcontractors to provide the actual documents indicated in the list, the documents are necessary to be prepared and available for the Surveyors.

f) The attending Surveyors, at the engine builder/licensee/subcontractors, will issue product certificates as necessary for components manufactured upon satisfactory inspections and tests.

g) The engine builder/licensee assembles the engine, tests the engine with a Surveyor present. An engine certificate is issued by the Surveyor upon satisfactory completion of assembly and tests.

1.2.3 Approval of diesel engine components

Components of engine designer's design which are covered by the type approval certificate of the relevant engine type are regarded as approved whether manufactured by the engine manufacturer or sub-supplied. For components of subcontractor's design, necessary approvals are to be obtained by the relevant suppliers (e.g. exhaust gas turbochargers, charge air coolers, etc.).

Table 1 : Document to be submitted for information, as applicable

No.	Item
1	Engine particulars (e.g. Data sheet with general engine information, Project Guide, Marine Installation Manual)
2	Engine cross section
3	Engine longitudinal section
4	Bedplate and crankcase of cast design
5	Thrust bearing assembly **(1)**
6	Frame/framebox/gearbox of cast design **(2)**
7	Tie rod
8	Connecting rod
9	Connecting rod, assembly **(3)**
10	Crosshead, assembly **(3)**
11	Piston rod, assembly **(3)**
12	Piston, assembly **(3)**
13	Cylinder jacket/ block of cast design **(2)**
14	Cylinder cover, assembly **(3)**
15	Cylinder liner
16	Counterweights (if not integral with crankshaft), including fastening
17	Camshaft drive, assembly **(3)**
18	Flywheel
19	Fuel oil injection pump
20	Shielding and insulation of exhaust pipes and other parts of high temperature which may be impinged as a result of a fuel system failure, assembly
	For electronically controlled engines, construction and arrangement of:
21	• Control valves
22	• High-pressure pumps
23	• Drive for high pressure pumps
24	Operation and service manuals **(4)**
25	FMEA (for engine control system) **(5)**
26	Production specifications for castings and welding (sequence)
27	Evidence of quality control system for engine design and in service maintenance
28	Quality requirements for engine production
29	Type approval certification for environmental tests, control components **(6)**

(1) If integral with engine and not integrated in the bedplate.
(2) Only for one cylinder or one cylinder configuration.
(3) Including identification (e.g. drawing number) of components.
(4) Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.
(5) Where engines rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves, a failure mode and effects analysis (FMEA) is to be submitted to demonstrate that failure of the control system will not result in the operation of the engine being degraded beyond acceptable performance criteria for the engine.
(6) Tests are to demonstrate the ability of the control, protection and safety equipment to function as intended under the specified testing conditions (see Ch 3, Sec 6, [2]).

Table 2 : Documentation to be submitted for approval, as applicable

No.	Item
1	Bedplate and crankcase of welded design, with welding details and welding instructions **(1)** **(2)**
2	Thrust bearing bedplate of welded design, with welding details and welding instructions **(1)**
3	Bedplate/oil sump welding drawings **(1)**
4	Frame/framebox/gearbox of welded design, with welding details and instructions **(1)** **(2)**
5	Engine frames, welding drawings **(1)** **(2)**
6	Crankshaft, details, each cylinder No.
7	Crankshaft, assembly, each cylinder No.
8	Crankshaft calculations (for each cylinder configuration) according to the attached data sheet and Ship rules Pt C, Ch 1, App1
9	Thrust shaft or intermediate shaft (if integral with engine)
10	Shaft coupling bolts
11	Material specifications of main parts with information on non-destructive material tests and pressure tests **(3)**
	Schematic layout or other equivalent documents on the engine of:
12	• Starting air system
13	• Fuel oil system
14	• Lubricating oil system
15	• Cooling water system
16	• Hydraulic system
17	• Hydraulic system (for valve lift)
18	• Engine control and safety system
19	Shielding of high pressure fuel pipes, assembly **(4)**
20	Construction of accumulators (for electronically controlled engine)
21	Construction of common accumulators (for electronically controlled engine)
22	Arrangement and details of the crankcase explosion relief valve (see [2.3]) **(5)**
23	Calculation results for crankcase explosion relief valves ([2.3])
24	Details of the type test program and the type test report) **(6)**
25	High pressure parts for fuel oil injection system **(7)**
26	Oil mist detection and/or alternative alarm arrangements (see [2.3])
27	Details of mechanical joints of piping systems (Ch 1, Sec 7, [2.5])
28	Documentation verifying compliance with inclination limits (see Ch 1, Sec 1, [2.6])
29	Documents as required in Ch 3, Sec 3, as applicable

(1) For approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.
(2) For each cylinder for which dimensions and details differ.
(3) For comparison with Society requirements for material, NDT and pressure testing as applicable.
(4) All engines.
(5) Only for engines of a cylinder diameter of 200 mm or more or a crankcase volume of 0,6 m^3 or more.
(6) The type test report may be submitted shortly after the conclusion of the type test.
(7) The documentation to contain specifications for pressures, pipe dimensions and materials.

Table 3 : Documentation for the inspection of components and systems

No.	Item
1	Engine particulars
2	Material specifications of main parts with information on non-destructive material tests and pressure tests **(1)**
3	Bedplate and crankcase of welded design, with welding details and welding instructions **(2)**
4	Thrust bearing bedplate of welded design, with welding details and welding instructions **(2)**
5	Frame/framebox/gearbox of welded design, with welding details and instructions **(2)**
6	Crankshaft, assembly and details
7	Thrust shaft or intermediate shaft (if integral with engine)
8	Shaft coupling bolts
9	Bolts and studs for main bearings
10	Bolts and studs for cylinder heads and exhaust valve (two stroke design)
11	Bolts and studs for connecting rods
12	Tie rods
	Schematic layout or other equivalent documents on the engine of: **(3)**
13	• Starting air system
14	• Fuel oil system
15	• Lubricating oil system
16	• Cooling water system
17	• Hydraulic system
18	• Hydraulic system (for valve lift)
19	• Engine control and safety system
20	Shielding of high pressure fuel pipes, assembly **(4)**
21	Construction of accumulators for hydraulic oil and fuel oil
22	High pressure parts for fuel oil injection system **(5)**
23	Arrangement and details of the crankcase explosion relief valve (see [2.3]) **(6)**
24	Oil mist detection and/or alternative alarm arrangements (see [2.3])
25	Cylinder head
26	Cylinder block, engine block
27	Cylinder liner
28	Counterweights (if not integral with crankshaft), including fastening
29	Connecting rod with cap
30	Crosshead
31	Piston rod
32	Piston, assembly **(7)**
33	Piston head
34	Camshaft drive, assembly **(7)**
35	Flywheel

(1) For comparison with Society requirements for material, NDT and pressure testing as applicable.
(2) For approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.
(3) Details of the system so far as supplied by the engine manufacturer such as: main dimensions, operating media and maximum working pressures.
(4) All engines.
(5) The documentation to contain specifications for pressures, pipe dimensions and materials.
(6) Only for engines of a cylinder diameter of 200 mm or more or a crankcase volume of 0,6 m^3 or more.
(7) Including identification (e.g. drawing number) of components.
(8) Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.
(9) Required for engines that rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves.
(10) Documents modified for a specific application are to be submitted to the Society for information or approval, as applicable. See [1.2.2], item b).

No.	Item
36	Arrangement of foundation (for main engines only)
37	Fuel oil injection pump
38	Shielding and insulation of exhaust pipes and other parts of high temperature which may be impinged as a result of a fuel system failure, assembly
39	Construction and arrangement of dampers
	For electronically controlled engines, assembly drawings or arrangements of:
40	• Control valves
41	• High-pressure pumps
42	• Drive for high pressure pumps
43	• Valve bodies, if applicable
44	Operation and service manuals **(8)**
45	Test program resulting from FMEA (for engine control system) **(9)**
46	Production specifications for castings and welding (sequence)
47	Type approval certification for environmental tests, control components **(10)**
48	Quality requirements for engine production

(1) For comparison with Society requirements for material, NDT and pressure testing as applicable.
(2) For approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.
(3) Details of the system so far as supplied by the engine manufacturer such as: main dimensions, operating media and maximum working pressures.
(4) All engines.
(5) The documentation to contain specifications for pressures, pipe dimensions and materials.
(6) Only for engines of a cylinder diameter of 200 mm or more or a crankcase volume of 0,6 m^3 or more.
(7) Including identification (e.g. drawing number) of components.
(8) Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.
(9) Required for engines that rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves.
(10) Documents modified for a specific application are to be submitted to the Society for information or approval, as applicable. See [1.2.2], item b).

1.3 Definitions

1.3.1 Engine type

In general, the type of an engine is defined by the following characteristics:

- the cylinder diameter
- the piston stroke
- the method of injection (direct or indirect injection)
- the kind of fuel (liquid, gaseous or dual-fuel)
- the working cycle (4-stroke, 2-stroke)
- the gas exchange (naturally aspirated or supercharged)
- the maximum continuous power per cylinder at the corresponding speed and/or brake mean effective pressure corresponding to the above-mentioned maximum continuous power
- the method of pressure charging (pulsating system or constant pressure system)
- the charging air cooling system (with or without intercooler, number of stages, etc.)
- the cylinder arrangement (in-line or V-type).

1.3.2 Engine power

The maximum continuous power is the maximum power at ambient reference conditions (see [1.3.3]) which the engine is capable of delivering continuously, at nominal maximum speed, in the period of time between two consecutive overhauls.

Power, speed and the period of time between two consecutive overhauls are to be stated by the Manufacturer and agreed by the Society.

The rated power is the maximum power at ambient reference conditions (see [1.3.3]) which the engine is capable of delivering as set after works trials (fuel stop power) at the maximum speed allowed by the governor.

The rated power for engines driving electric generators is the nominal power, taken at the net of overload, at ambient reference conditions (see [1.3.3]), which the engine is capable of delivering as set after the works trials (see [4.3]).

1.3.3 Ambient reference conditions

The power of engines as per [1.1.1] items a), b) and c) is to be referred to the following conditions:

- barometric pressure = 0,1 MPa
- relative humidity = 60%
- ambient air temperature = 45°C
- sea water temperature (and temperature at inlet of sea water cooled charge air cooler) = 32°C.

In the case of units operating in restricted zones, different temperatures may be accepted by the Society.

The engine Manufacturer is not expected to provide the above ambient conditions at a test bed. The rating is to be adjusted according to a recognised standard accepted by the Society.

1.3.4 Same type of engines

Two diesel engines are considered to be of the same type when they do not substantially differ in design and construction characteristics, such as those listed in the engine type definition as per [1.3.1], it being taken for granted that the documentation concerning the essential engine components listed in Tab 1, Tab 2 and Tab 3, and associated materials employed has been submitted, examined and, where necessary, approved by the Society.

1.3.5 Substantive modifications or major modifications or major changes

Design modifications, which lead to alterations in the stress levels, operational behaviour, fatigue life or an effect on other components or characteristics of importance such as emissions.

1.3.6 Low, medium and high-speed engines

Low-Speed Engines means diesel engines having a rated speed of less than 300 rpm.

Medium-Speed Engines means diesel engines having a rated speed of 300 rpm and above, but less than 1400 rpm.

High-Speed Engines means diesel engines having a rated speed of 1400 rpm and above.

2 Design and construction

2.1 Materials and welding

2.1.1 Crankshaft materials

In general, crankshafts are to be of forged steel having a tensile strength not less than 400 N/mm^2 and not greater than 1000 N/mm^2.

The use of forged steels of higher tensile strength is subject to special consideration by the Society in each case.

The Society, at its discretion and subject to special conditions (such as restrictions in operating zones), may accept crankshafts made of cast carbon steel, cast alloyed steel of appropriate quality and manufactured by a suitable procedure having a tensile strength as follows:

a) between 400 N/mm^2 and 560 /mm^2 for cast carbon steel

b) between 400 N/mm^2 and 700 N/mm^2 for cast alloyed steel.

The Society, at its discretion and subject to special conditions (such as restrictions in ship navigation), may also accept crankshafts made of cast iron for engines of a nominal power not exceeding 110 kW with a significative in service behaviour either in marine or industry. The cast iron is to be of “SG” type (spheroidal graphite) of appropriate quality and manufactured by a suitable procedure.

2.1.2 Welded frames and foundations

Steels used in the fabrication of welded frames and bedplates are to comply with the requirements of NR216.

Welding is to be in accordance with the requirements of Ch 1, Sec 1, [2.3].

2.2 Crankshaft

2.2.1 Check of the scantling

The check of crankshaft strength is to be carried out in accordance with Pt C, Ch 1, App 1 of the Ship Rules.

2.3 Crankcase

2.3.1 Strength

Crankcase construction and crankcase doors are to be of sufficient strength to withstand anticipated crankcase pressures that may arise during a crankcase explosion taking into account the installation of explosion relief valves required by [2.3.4]. Crankcase doors are to be fastened sufficiently securely for them not be readily displaced by a crankcase explosion.

2.3.2 Ventilation and drainage

Ventilation of crankcase, and any arrangement which could produce a flow of external air within the crankcase, is in principle not permitted.

Vent pipes, where provided, are to be as small as practicable. If provision is made for the forced extraction of gases from the crankcase (e.g. for detection of explosive mixtures), the vacuum in the crankcase is not to exceed:

$2{,}5\ 10^{-4}$ MPa

To avoid interconnection between crankcases and the possible spread of fire following an explosion, crankcase ventilation pipes and oil drain pipes for each engine are to be independent of any other engine.

2.3.3 Warning notice

A warning notice is to be fitted, preferably on a crankcase door on each side of the engine, or alternatively on the control stand.

This warning notice is to specify that whenever overheating is suspected in the crankcase, the crankcase doors or sight holes are not to be opened until a reasonable time has elapsed after stopping the engine, sufficient to permit adequate cooling of the crankcase.

2.3.4 Crankcase explosion relief valves

a) Diesel engines of a cylinder diameter of 200 mm and above or a crankcase gross volume of 0,6 m^3 and above are to be provided with crankcase explosion relief valves in accordance with the following requirements.

b) Engines having a cylinder bore not exceeding 250 mm, are to have at least one valve near each end, but over eight crankthrows, an additional valve is to be fitted near the middle of the engine.

Engines having a cylinder bore exceeding 250 mm, but not exceeding 300 mm, are to have at least one valve in way of each alternate crankthrow, with a minimum of two valves.

Engines having a cylinder bore exceeding 300 mm are to have at least one valve in way of each main crankthrow.

c) Additional relief valves are to be fitted on separate spaces of the crankcase, such as gear or chain cases for camshaft or similar drives, when the gross volume of such spaces is 0,6 m^3 or above. Scavenge spaces in open connection to the cylinders are to be fitted with explosion relief valves.

d) The free area of each relief valve is not to be less than 45 cm^2.

e) The combined free area of the valves fitted on an engine is not to be less than 115 cm^2 per cubic metre of the crankcase gross volume.

Note 1: The total volume of the stationary parts within the crankcase may be discounted in estimating the crankcase gross volume (rotating and reciprocating components are to be included in the gross volume).

f) Crankcase explosion relief valves are to be provided with lightweight spring-loaded valve discs or other quick-acting and self closing devices to relieve a crankcase of pressure in the event of an internal explosion and to prevent any inrush of air thereafter.

g) The valve discs in crankcase explosion relief valves are to be made of ductile material capable of withstanding the shock of contact with stoppers at the full open position.

h) Crankcase explosion relief valves are to be designed and constructed to open quickly and to be fully open at a pressure not greater than 0,02 MPa.

i) Crankcase explosion relief valves are to be provided with a flame arrester that permits flow for crankcase pressure relief and prevents passage of flame following a crankcase explosion.

j) Crankcase explosion relief valves are to be type tested in a configuration that represents the installation arrangements that will be used on an engine.

The purpose of type testing crankcase explosion valves is to:

1) verify the effectiveness of the flame arrester
2) verify that the valve closes after an explosion
3) verify that the valve is gas/air tight after an explosion
4) establish the level of overpressure protection provided by the valve.

Where crankcase relief valves are provided with arrangements for shielding emissions from the valve following an explosion, the valve is to be type tested to demonstrate that the shielding does not adversely affect the operational effectiveness of the valve.

Type testing procedure is to comply with Ch 1, App 2.

k) Crankcase explosion relief valves are to be provided with a copy of the manufacturer's installation and maintenance manual that is pertinent to the size and type of valve being supplied for installation on a particular engine. The manual is to contain the following information:

- description of valve with details of function and design limits
- copy of type test certification
- installation instructions
- maintenance in service instructions to include testing and renewal of any sealing arrangements
- actions required after a crankcase explosion.

l) A copy of the installation and maintenance manual required in k) above is to be provided on board the unit.

m) Valves are to be provided with suitable markings that include the following information:
  - name and address of manufacturer
  - designation and size
  - month / year of manufacture
  - approved installation orientation.

2.3.5 Oil mist detection

a) Oil mist detection arrangements (or engine bearing temperature monitors or equivalent devices) are required:
  - for alarm and slow down purposes for low speed diesel engines of 2250 kW and above or having cylinders of more than 300 mm bore
  - for alarm and automatic shutoff purposes for medium and high speed diesel engines of 2250 kW and above or having cylinders of more than 300 mm bore.

  Oil mist detection arrangements are to be of a type approved and tested in accordance with Pt C, Ch 3, App 1 of the Ship Rules, and comply with items b) and c) below. Engine bearing temperature monitors or equivalent devices used as safety devices have to be of a type approved by the Society for such purposes.

Note 1: An equivalent device for high speed engines could be interpreted as measures applied to high speed engines where specific design features to preclude the risk of crankcase explosions are incorporated.

b) The oil mist detection system and arrangements are to be installed in accordance with the engine designer's and oil mist manufacturer's instructions/recommendations. The following particulars are to be included in the instructions:
  - schematic layout of engine oil mist detection and alarm system showing location of engine crankcase sample points and piping or cable arrangements together with pipe dimensions to detector
  - evidence of study to justify the selected location of sample points and sample extraction rate (if applicable) in consideration of the crankcase arrangements and geometry and the predicted crankcase atmosphere where oil mist can accumulate
  - the manufacturer's maintenance and test manual
  - information relating to type or in-service testing of the engine with engine protection system test arrangements having approved types of oil mist detection equipment.

c) A copy of the oil mist detection equipment maintenance and test manual required by b) is to be provided on board unit.

d) Oil mist detection and alarm information is to be capable of being read from a safe location away from the engine.

e) Each engine is to be provided with its own independent oil mist detection arrangement and a dedicated alarm.

f) Oil mist detection and alarm systems are to be capable of being tested on the test bed and board under engine at standstill and engine running at normal operating conditions in accordance with test procedures that are acceptable to the Society.

g) The oil mist detection arrangements are to provide an alarm indication in the event of a foreseeable functional failure in the equipment and installation arrangements.

h) The oil mist detection system is to provide an indication that any lenses fitted in the equipment and used in determination of the oil mist level have been partially obscured to a degree that will affect the reliability of the information and alarm indication.

i) Where oil mist detection equipment includes the use of programmable electronic systems, the arrangements are to be in accordance with the Society requirements for such systems.

j) Plans of showing details and arrangements of oil mist detection and alarm arrangements are to be submitted for approval in accordance with Tab 2 under item 18.

k) The equipment together with detectors is to be tested when installed on the test bed and on board unit to demonstrate that the detection and alarm system functionally operates. The testing arrangements are to be to the satisfaction of the Society.

l) Where sequential oil mist detection arrangements are provided the sampling frequency and time is to be as short as reasonably practicable.

m) Where alternative methods are provided for the prevention of the build-up of oil mist that may lead to a potentially explosive condition within the crankcase details are to be submitted for consideration of the Society. The following information is to be included in the details to be submitted for consideration:
  - engine particulars – type, power, speed, stroke, bore and crankcase volume
  - details of arrangements prevent the build up of potentially explosive conditions within the crankcase, e.g. bearing temperature monitoring, oil splash temperature, crankcase pressure monitoring, recirculation arrangements
  - evidence to demonstrate that the arrangements are effective in preventing the build up of potentially explosive conditions together with details of in-service experience
  - operating instructions and the maintenance and test instructions.

n) Where it is proposed to use the introduction of inert gas into the crankcase to minimise a potential crankcase explosion, details of the arrangements are to be submitted to the Society for consideration.

2.4 Scavenge manifolds

2.4.1 Fire extinguishing

For two-stroke crosshead type engines, scavenge spaces in open connection (without valves) to the cylinders are to be connected to a fixed fire-extinguishing system, which is to be entirely independent of the fire-extinguishing system of the machinery space.

2.4.2 Blowers

Where a single two-stroke propulsion engine is equipped with an independently driven blower, alternative means to drive the blower or an auxiliary blower are to be provided ready for use.

2.4.3 Relief valves

Scavenge spaces in open connection to the cylinders are to be fitted with explosion relief valves in accordance with [2.3.4].

2.5 Systems

2.5.1 General

In addition to the requirements of the present sub-article, those given in Ch 1, Sec 7 are to be satisfied.

Flexible hoses in the fuel and lubricating oil system are to be limited to the minimum and are to be type approved.

Unless otherwise stated in Ch 1, Sec 7, propulsion engines are to be equipped with external connections for standby pumps for:

- fuel oil supply
- lubricating oil and cooling water circulation.

2.5.2 Fuel oil system

a) Relief valves discharging back to the suction of the pumps or other equivalent means are to be fitted on the delivery side of the pumps.

In fuel oil systems for propulsion machinery, filters are to be fitted and arranged so that an uninterrupted supply of filtered fuel oil is ensured during cleaning operations of the filter equipment, except when otherwise stated in Ch 1, Sec 7.

b) *All external high pressure fuel delivery lines between the high pressure fuel pumps and fuel injectors are to be protected with a jacketed piping system capable of containing fuel from a high pressure line failure.*

A jacketed pipe incorporates an outer pipe into which the high pressure fuel pipe is placed, forming a permanent assembly.

The jacketed piping system is to include a means for collection of leakages and arrangements are to be provided with an alarm in case of a fuel line failure.

If flexible hoses are used for jacketing purposes, these are to be approved by the Society.

When in fuel oil return piping the pulsation of pressure with peak to peak values exceeds 2 MPa, jacketing of this piping is also required as above.

c) *For units operating in restricted zones, the requirements given in a) may be relaxed at the Society's discretion.*

2.5.3 Lubricating oil system

Efficient filters are to be fitted in the lubricating oil system when the oil is circulated under pressure.

In such lubricating oil systems for propulsion machinery, filters are to be arranged so that an uninterrupted supply of filtered lubricating oil is ensured during cleaning operations of the filter equipment, except when otherwise stated in Ch 1, Sec 7.

Relief valves discharging back to the suction of the pumps or other equivalent means are to be fitted on the delivery side of the pumps.

The relief valves may be omitted provided that the filters can withstand the maximum pressure that the pump may develop.

Where necessary, the lubricating oil is to be cooled by means of suitable coolers.

2.5.4 Charge air system

a) Requirements relevant to design, construction, arrangement, installation, tests and certification of exhaust gas turbochargers are given in Pt C, Ch 1, Sec 14 of the Ship Rules.

b) When two-stroke propulsion engines are supercharged by exhaust gas turbochargers which operate on the impulse system, provision is to be made to prevent broken piston rings entering turbocharger casings and causing damage to blades and nozzle rings.

2.6 Starting air system

2.6.1 The requirements given in [3.1] apply.

2.7 Control and monitoring

2.7.1 General

In addition to those of this item, the general requirements given in Part C, Chapter 3 apply.

2.7.2 Alarm

The lubricating oil system of diesel engines with a power equal to or in excess of 37 kW is to be fitted with alarms to give audible and visual warning in the event of an appreciable reduction in pressure of the lubricating oil supply.

2.7.3 Governors of main and auxiliary engines

Each engine, except the auxiliary engines for driving electric generators for which [2.7.5] applies, is to be fitted with a speed governor so adjusted that the engine does not exceed the rated speed by more than 15%.

2.7.4 Overspeed protective devices of main and auxiliary engines

In addition to the speed governor:

- each main propulsion engine having a rated power of 220 kW and above, which can be declutched or which drives a controllable pitch propeller, and
- each auxiliary engine having a rated power of 220 kW and above, except those for driving electric generators, for which [2.7.6] applies,

is to be fitted with a separate overspeed protective device so adjusted that the engine cannot exceed the rated speed n by more than 20%; arrangements are to be made to test the overspeed protective device.

Equivalent arrangements may be accepted subject to special consideration by the Society in each case.

The overspeed protective device, including its driving mechanism or speed sensor, is to be independent of the governor.

2.7.5 Governors for auxiliary engines driving electric generators

a) Auxiliary engines intended for driving electric generators of the main and emergency sources of electrical power are to be fitted with a speed governor which will prevent transient frequency variations in the electrical network in excess of ±10% of the rated frequency with a recovery time to steady state conditions not exceeding 5 seconds, when the maximum electrical step load is switched on or off.

   In the case when a step load equivalent to the rated output of a generator is switched off, a transient speed variation in excess of 10% of the rated speed may be acceptable, provided this does not cause the intervention of the overspeed device as required by [2.7.4].

b) At all loads between no load and rated power, the permanent speed variation is not to be more than 5% of the rated speed.

c) Prime movers are to be selected in such a way that they meet the load demand within the unit's mains and, when running at no load, can satisfy the requirement in item a) above if suddenly loaded to 50% of the rated power of the generator, followed by the remaining 50% after an interval sufficient to restore speed to steady state. Steady state conditions (see Note 1) are to be achieved in not more than 5 s.

Note 1: Steady state conditions are those at which the envelope of speed variation does not exceed ±1% of the declared speed at the new power.

d) Application of the electrical load in more than 2 load steps can only be allowed if the conditions within the unit's mains permit the use of those auxiliary engines which can only be loaded in more than 2 load steps (see Fig 1 for guidance) and provided that this is already allowed for in the designing stage.

   This is to be verified in the form of system specifications to be approved and to be demonstrated at unit's trials. In this case, due consideration is to be given to the power required for the electrical equipment to be automatically switched on after blackout and to the sequence in which it is connected.

   This also applies to generators to be operated in parallel and where the power is to be transferred from one generator to another, in the event that any one generator is to be switched off.

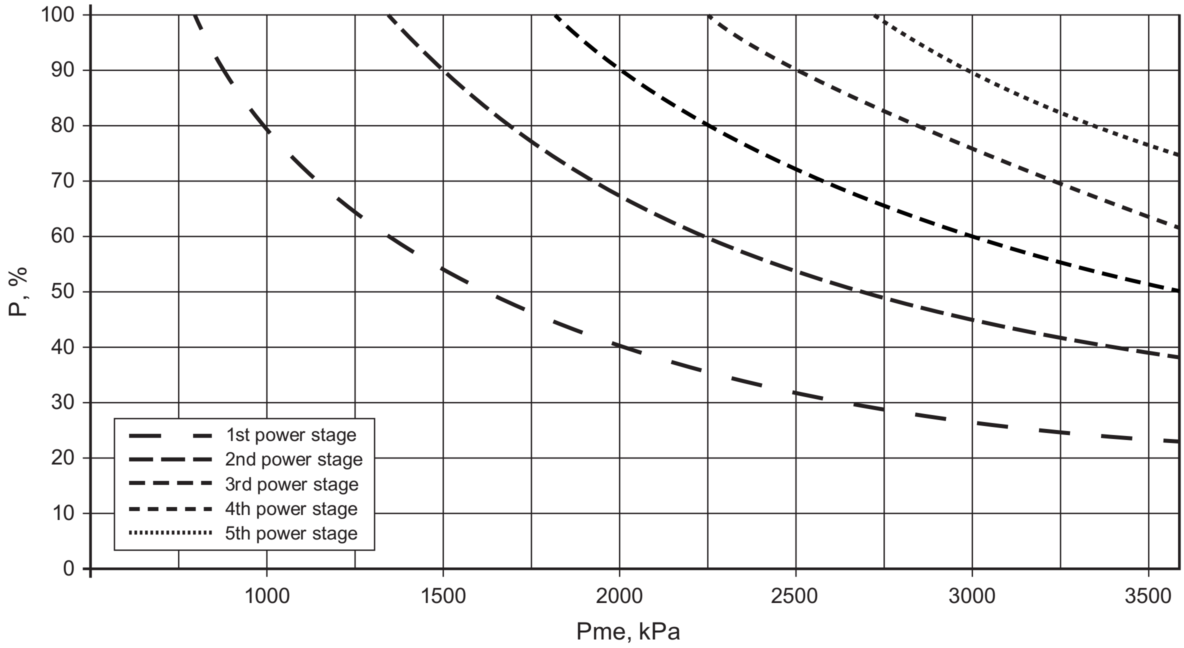
e) Emergency generator sets must satisfy the governor conditions as per items a) and b) even when:

   - their total consumer load is applied suddenly, or
   - their total consumer load is applied in steps, subject to the maximum step load is declared and demonstrated.

f) For alternating current generating sets operating in parallel, the governing characteristics of the prime movers are to be such that, within the limits of 20% and 100% total load, the load on any generating set will not normally differ from its proportionate share of the total load by more than 15% of the rated power in kW of the largest machine or 25% of the rated power in kW of the individual machine in question, whichever is the lesser.

   For alternating current generating sets intended to operate in parallel, facilities are to be provided to adjust the governor sufficiently finely to permit an adjustment of load not exceeding 5% of the rated load at normal frequency.

Figure 1 : Reference values for maximum possible sudden power increases P as a function of brake mean effective pressure, P_{me}, at declared power (four-stroke diesel engines)



2.7.6 Overspeed protective devices of auxiliary engines driving electric generators

In addition to the speed governor, auxiliary engines of rated power equal to or greater than 220 kW driving electric generators are to be fitted with a separate overspeed protective device, with a means for manual tripping, adjusted so as to prevent the rated speed from being exceeded by more than 15%.

This device is to automatically shut down the engine.

2.7.7 Use of electronic governors

a) Type approval

Electronic governors and their actuators are to be type approved by the Society.

b) Electronic governors for main propulsion engines

If an electronic governor is fitted to ensure continuous speed control or resumption of control after a fault, an additional separate governor is to be provided unless the engine has a manually operated fuel admission control system suitable for its control.

A fault in the governor system is not to lead to sudden major changes in propulsion power or direction of propeller rotation.

Alarms are to be fitted to indicate faults in the governor system.

The acceptance of electronic governors not in compliance with the above requirements will be considered by the Society on a case by case basis, when fitted on units with two or more main propulsion engines.

c) Electronic governors for auxiliary engines driving electric generators

In the event of a fault in the electronic governor system the fuel admission is to be set to “zero”.

Alarms are to be fitted to indicate faults in the governor system.

The acceptance of electronic governors fitted on engines driving emergency generators will be considered by the Society on a case by case basis.

2.7.8 Summary tables

Diesel engines installed on units without automation notations are to be equipped with monitoring equipment as detailed in Tab 4 or Tab 5 for main propulsion, in Tab 6 for auxiliary services and in Tab 7 for emergency respectively.

For small units, units operating in restricted zones or platforms installed in sheltered coastal areas, the acceptance of a reduction in the monitoring equipment required in Tab 4, Tab 5 and Tab 6 may be considered.

The alarms are to be visual and audible.

The indicators are to be fitted at a normally attended position (on the engine or at the local control station).

Table 4 : Monitoring of main propulsion cross-head (slow speed) diesel engines

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Main Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Fuel oil pressure after filter (engine inlet)		local					
Fuel oil viscosity before injection pumps or fuel oil temperature before injection pumps (for engine running on heavy fuel)		local					
Leakage from high pressure pipes where required	H						
Lubricating oil to main bearing and thrust bearing pressure	L	local					
	LL			X			
Lubricating oil to cross-head bearing pressure when separate	L	local					
	LL			X			
Lubricating oil to camshaft pressure when separate	L	local					
	LL			X			
Turbocharger lubricating oil inlet pressure		local					
Lubricating oil inlet temperature		local					
Thrust bearing pads or bearing outlet temperature	H	local					
Main, crank, cross-head bearing, oil outlet temp	H						
Oil mist concentration in crankcase (or engine bearing temperature monitors or equivalent devices) **(5)**	H		X				
Cylinder fresh cooling water system inlet pressure	L	local **(3)**					
Cylinder fresh cooling water outlet temperature or, when common cooling space without individual stop valves, the common cylinder water outlet temperature		local					
Piston coolant inlet pressure on each cylinder **(1)**	L	local					
Piston coolant outlet temperature on each cylinder**(1)**		local					
Piston coolant outlet flow on each cylinder **(1)** **(2)**	L						
Speed of turbocharger		local					
Scavenging air receiver pressure		local					
Scavenging air box temperature (detection of fire in receiver)		local					
Exhaust gas temperature		local **(4)**					
Engine speed / direction of speed (when reversible)		local					
	H			X			
Fault in the electronic governor system	X						

(1) Not required, if the coolant is oil taken from the main cooling system of the engine.
(2) Where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted.
(3) For engines of 220 KW and above.
(4) Indication is required after each cylinder, for engines of 500 kW/cylinder and above.
(5) For engine of 2250 KW and above or having cylinders of more than 300 mm bore.

Table 5 : Monitoring of main propulsion trunk-piston (medium or high speed) diesel engines

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Main Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Fuel oil pressure after filter (engine inlet)		local					
Fuel oil viscosity before injection pumps or fuel oil temperature before injection pumps (for engine running on heavy fuel)		local					
Leakage from high pressure pipes where required	H						
Lubricating oil to main bearing and thrust bearing pressure	L	local					
	LL			X			
Lubricating oil filter differential pressure	H	local					
Turbocharger lubricating oil inlet pressure **(1)**		local					
Lubricating oil inlet temperature		local					
Oil mist concentration in crankcase (or engine bearing temperature monitors or equivalent devices) **(3)**	H			X			
Cylinder fresh cooling water outlet temperature or, when common cooling space without individual stop valves, the common cylinder water outlet temperature		local					
Scavenging air receiver pressure		local					
Scavenging air box temperature (detection of fire in receiver)		local					
Exhaust gas temperature		local **(2)**					
Engine speed / direction of speed (when reversible)		local					
	H			X			
Fault in the electronic governor system	X						

(1) If without integrated self-contained oil lubrication system.
(2) Indication is required after each cylinder, for engines of 500 kW/cylinder and above.
(3) For engine of 2250 KW and above or having cylinders of more than 300 mm bore.

Table 6 : Monitoring of trunk-piston diesel engines used for auxiliary services

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Fuel oil viscosity or temperature before injection (for engine running on heavy fuel)		local					
Fuel oil pressure		local					
Fuel oil leakage from pressure pipes	H						
Lubricating oil pressure	L	local		X			
Oil mist concentration in crankcase (or engine bearing temperature monitors or equivalent devices) **(1)**	H			X			
Pressure or flow of cooling water, if not connected to main system	L	local					
Temperature of cooling water or cooling air		local					
Engine speed		local					
	H			X			
Fault in the electronic governor system	X						

(1) For engine of 2250 KW and above or having cylinders of more than 300 mm bore.

Table 7 : Monitoring of emergency diesel engines

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Fuel oil leakage from pressure pipes	H	local					
Lubricating oil temperature **(1)**	H	local					
Lubricating oil pressure	L	local					
Oil mist concentration in crankcase **(2)**	H	local					
Pressure or flow of cooling water **(1)**	L	local					
Temperature of cooling water or cooling air		local					
Engine speed		local					
	H			X **(1)**			

(1) Not applicable to emergency generator of less than 220 kW.

(2) For engines having a power of more than 2250kW or a cylinder bore of more than 300 mm.

Note 1: The safety and alarm systems are to be designed to 'fail safe'. The characteristics of the 'fail safe' operation are to be evaluated on the basis not only of the system and its associated machinery, but also the complete installation, as well as the unit.

Note 2: Regardless of the engine output, if shutdowns additional to those above specified except for the overspeed shutdown, they are to be automatically overridden when the engine is in automatic or remote control mode during navigation.

Note 3: The alarm system is to function in accordance with AUT notation, with additional requirements that grouped alarms are to be arranged on the bridge.

Note 4: In addition to the fuel oil control from outside the space, a local means of engine shutdown is to be provided.

Note 5: The local indications are to be provided within the same space as the diesel engines and are to remain operational in the event of failure of the alarm and safety systems.

3 Arrangement and installation

3.1 Starting arrangements

3.1.1 Mechanical air starting

a) Air starting the main and auxiliary engines is to be arranged in compliance with Ch 1, Sec 7, [17.3.1].

b) The total capacity of air compressors and air receivers is to be in compliance with Ch 1, Sec 7, [17.3.2] and Ch 1, Sec 7, [17.3.3].

c) The main starting air arrangements for main propulsion or auxiliary diesel engines are to be adequately protected against the effects of backfiring and internal explosion in the starting air pipes. To this end, the following safety devices are to be fitted:

- an isolating non-return valve, or equivalent, at the starting air supply connection to each engine.
- a bursting disc or flame arrester:
  - in way of the starting valve of each cylinder, for direct reversing engines having a main starting air manifold
  - at least at the supply inlet to the starting air manifold, for non-reversing engines.

  The bursting disc or flame arrester above may be omitted for engines having a bore not exceeding 230 mm.

Other protective devices will be specially considered by the Society.

The requirements of this item c) do not apply to engines started by pneumatic motors.

d) Compressed air receivers are to comply with the requirements of Ch 1, Sec 3. Compressed air piping and associated air compressors are to comply with the requirements of Ch 1, Sec 7.

3.1.2 Electrical starting

a) Where main internal combustion engines are arranged for electrical starting, at least two separate batteries are to be fitted.

The arrangement is to be such that the batteries cannot be connected in parallel.

Each battery is to be capable of starting the main engine when in cold and ready to start condition.

The combined capacity of batteries is to be sufficient to provide within 30 min., without recharging, the number of starts required in [3.1.1] b) in the event of air starting.

b) Electrical starting arrangements for auxiliary engines are to have two separate storage batteries or may be supplied by two separate circuits from main engine storage batteries when these are provided. In the case of a single auxiliary engine, one battery is acceptable. The combined capacity of the batteries is to be sufficient for at least three starts for each engine.

c) The starting batteries are only to be used for starting and for the engine's alarm and monitoring. Provision is to be made to maintain the stored energy at all times.

d) Each charging device is to have at least sufficient rating for recharging the required capacity of batteries within 6 hours.

3.1.3 Special requirements for starting arrangements for emergency generating sets

a) Emergency generating sets are to be capable of being readily started in their cold condition at a temperature of 0°C. If this is impracticable, or if lower temperatures are likely to be encountered, provision acceptable to the Society shall be made for the maintenance of heating arrangements, to ensure ready starting of the generating sets.

b) Each emergency generating set arranged to be automatically started shall be equipped with starting devices approved by the Society with a stored energy capability of at least three consecutive starts.

The source of stored energy shall be protected to preclude critical depletion by the automatic starting system, unless a second independent means of starting is provided. In addition, a second source of energy shall be provided for an additional three starts within 30 minutes, unless manual starting can be demonstrated to be effective.

c) The stored energy is to be maintained at all times, as follows:

- *electrical and hydraulic starting systems shall be maintained from the emergency switchboard*
- *compressed air starting systems shall be provided in accordance with Ch 1, Sec 7, [17.3.4].*

d) Where automatic starting is not required, manual starting, such as manual cranking, inertia starters, manually charged hydraulic accumulators, or powder charge cartridges, is permissible where this can be demonstrated as being effective.

e) When manual starting is not practicable, the requirements of b) and c) are to be complied with, except that starting may be manually initiated.

3.2 Turning gear

3.2.1 Each engine is to be provided with hand-operated turning gear; where deemed necessary, the turning gear is to be both hand and mechanically-operated.

The turning gear engagement is to inhibit starting operations.

3.3 Trays

3.3.1 Trays fitted with means of drainage are to be provided in way of the lower part of the crankcase and, in general, in way of the parts of the engine, where oil is likely to spill in order to collect the fuel oil or lubricating oil dripping from the engine.

3.4 Exhaust gas system

3.4.1 In addition to the requirements given in Ch 1, Sec 7, the exhaust system is to be efficiently cooled or insulated in such a way that the surface temperature does not exceed 220°C (see also Ch 1, Sec 1, [3.4]).

3.5 Air intakes

3.5.1 Air intakes for internal combustion engines are to be led from a safe area. In addition, these internal combustion engines, where used in association with equipment processing flammable substances, are to be fitted with an automatic device to prevent overspeeding in the event of accidental ingestion of flammable gases and/or vapours.

Note 1: The present requirement is not applicable to gas turbines

3.5.2 Exhaust pipes from internal combustion engines are to be let well clear of hazardous areas and, where such engines are used in association with equipment processing flammable substances, are to be fitted with efficient spark arresters.

4 Type tests, material tests, workshop inspection and testing, certification

4.1 Type testing

4.1.1 Objectives

The type testing is to be arranged to represent typical foreseen service load profiles, as specified by the engine builder, as well as to cover for required margins due to fatigue scatter and reasonably foreseen in-service deterioration. This applies to:

- Parts subjected to high cycle fatigue (HCF) such as connecting rods, cams, rollers and spring tuned dampers where higher stresses may be provided by means of elevated injection pressure, cylinder maximum pressure, etc.
- Parts subjected to low cycle fatigue (LCF) such as “hot” parts when load profiles such as idle - full load - idle (with steep ramps) are frequently used.
- Operation of the engine at limits as defined by its specified alarm system, such as running at maximum permissible power with the lowest permissible oil pressure and/or highest permissible oil inlet temperature.

4.1.2 Validity

a) Type testing is required for every new engine type intended for installation onboard units subject to classification.

b) A type test carried out for a particular type of engine at any place of manufacture will be accepted for all engines of the same type built by licensees or the licensor, subject to each place of manufacture being found to be acceptable to the Society.

c) A type of engine is defined by:

- bore and stroke
- injection method (direct or indirect)
- valve and injection operation (by cams or electronically controlled)
- kind of fuel (liquid, dual-fuel, gaseous)
- working cycle (4-stroke, 2-stroke)
- turbo-charging system (pulsating or constant pressure)
- the charging air cooling system (e.g. with or without intercooler)
- cylinder arrangement (in-line or V) (see Note 1)
- cylinder power, speed and cylinder pressures (see Note 2).

Note 1: One type test will be considered adequate to cover a range of different numbers of cylinders. However, a type test of an in-line engine may not always cover the V-version. Subject to the individual Societies' discretion, separate type tests may be required for the V-version. On the other hand, a type test of a V-engine covers the in-line engines, unless the bmep is higher.

Items such as axial crankshaft vibration, torsional vibration in camshaft drives, and crankshafts, etc. may vary considerably with the number of cylinders and may influence the choice of engine to be selected for type testing.

Note 2: The engine is type approved up to the tested ratings and pressures (100% corresponding to MCR).

Provided documentary evidence of successful service experience with the classified rating of 100% is submitted, an increase (if design approved, only crankshaft calculation and crankshaft drawings, if modified) may be permitted without a new type test if the increase from the type tested engine is within:

- 5% of the maximum combustion pressure, or
- 5% of the mean effective pressure, or
- 5% of the rpm

Providing maximum power is not increased by more than 10%, an increase of maximum approved power may be permitted without a new type test provided engineering analysis and evidence of successful service experience in similar field applications (even if the application is not classified) or documentation of internal testing are submitted if the increase from the type tested engine is within:

- 10% of the maximum combustion pressure, or
- 10% of the mean effective pressure, or
- 10% of the rpm.

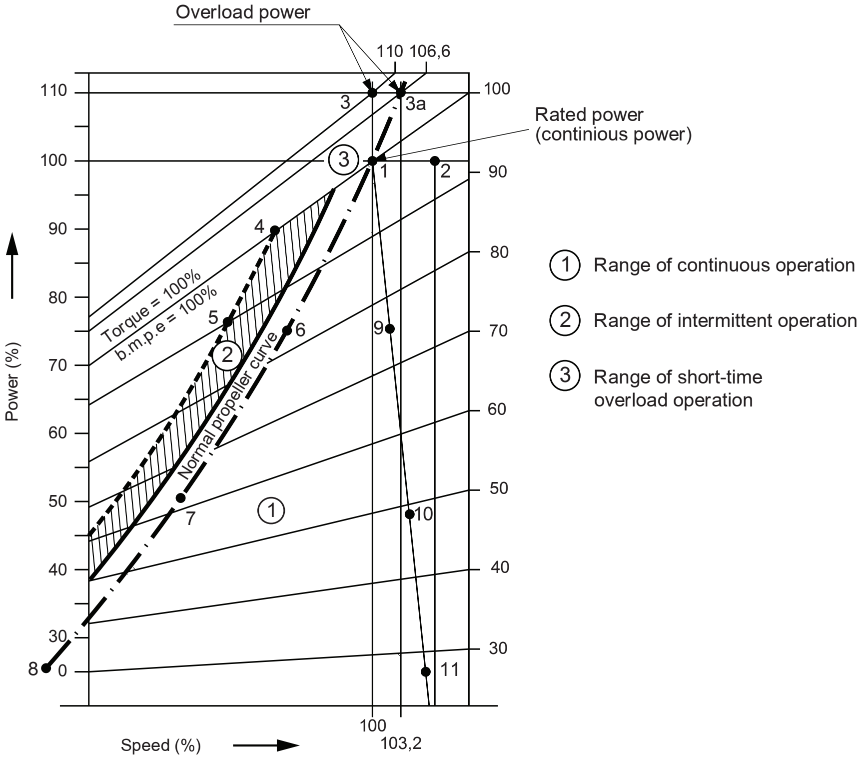
d) De-rated engine

If an engine has been design approved, and internal testing per Stage A (see [4.1.4]) is documented to a rating higher than the one type tested, the Type Approval may be extended to the increased power/mep/rpm upon submission of an Extended Delivery Test Report at:

- test at over speed (only if nominal speed has increased)
- rated power, i.e. 100% output at 100% torque and 100% speed corresponding to load point 1 (see Fig 2), 2 measurements with one running hour in between
- maximum permissible torque (normally 110%) at 100% speed corresponding to load point 3 (see Fig 2) or maximum permissible power (normally 110%) and speed according to nominal propeller curve corresponding to load point 3a (see Fig 2), 0,5 hour
- 100% power at maximum permissible speed corresponding to load point 2 (see Fig 2), 0,5 hour.

e) An integration test demonstrating that the response of the complete mechanical, hydraulic and electronic system is as predicted maybe carried out for acceptance of sub-systems (Turbo Charger, Engine Control System, Dual Fuel, Exhaust Gas treatment…) separately approved. The scope of these tests shall be proposed by the designer/licensor taking into account of impact on engine.

Figure 2 : Load points



4.1.3 Safety precautions

a) Before any test run is carried out, all relevant equipment for the safety of attending personnel is to be made available by the manufacturer/shipyard and is to be operational, and its correct functioning is to be verified.

b) This applies especially to crankcase explosive conditions protection, but also over-speed protection and any other shut down function.

c) The inspection for jacketing of high-pressure fuel oil lines and proper screening of pipe connections (as required in [4.1.7], item i) is also to be carried out before the test runs.

d) Interlock test of turning gear is to be performed when installed.

4.1.4 Test programme

a) The type testing is divided into 3 stages:

- Stage A - internal tests.

  This includes some of the testing made during the engine development, function testing, and collection of measured parameters and records of testing hours. The results of testing required by the Society or stipulated by the designer are to be presented to the Society before starting stage B.

- Stage B - witnessed tests.

  This is the testing made in the presence of the Surveyor.

- Stage C - component inspection.

  This is the inspection of engine parts to the extent as required by the Society.

b) The complete type testing program is subject to approval by the Society. The extent the Surveyor’s attendance is to be agreed in each case, but at least during stage B and C.

c) Testing prior to the witnessed type testing (stage B and C), is also considered as a part of the complete type testing program.

d) Upon completion of complete type testing (stage A through C), a type test report is to be submitted to the Society for review. The type test report is to contain:

- overall description of tests performed during stage A. Records are to be kept by the builders QA management for presentation to the Society
- detailed description of the load and functional tests conducted during stage B
- inspection results from stage C.

e) High speed engines for marine use are normally to be subjected to an endurance test of 100 hours at full load. Omission or simplification of the type test may be considered for the type approval of engines with long service experience from non-marine fields or for the extension of type approval of engines of a well-known type, in excess of the limits given in [4.1.2].

Propulsion engines for high speed vessels that may be used for frequent load changes from idle to full are normally to be tested with at least 500 cycles (idle - full load - idle) using the steepest load ramp that the control system (or operation manual if not automatically controlled) permits. The duration at each end is to be sufficient for reaching stable temperatures of the hot parts.

4.1.5 Measurements and recordings

a) During all testing the ambient conditions (air temperature, air pressure and humidity) are to be recorded.

b) As a minimum, the following engine data are to be measured and recorded:

- engine r.p.m.
- torque
- maximum combustion pressure for each cylinder (see Note 1)
- mean indicated pressure for each cylinder (see Note 1)
- charging air pressure and temperature
- exhaust gas temperature
- fuel rack position or similar parameter related to engine load
- turbocharger speed
- all engine parameters that are required for control and monitoring for the intended use (propulsion, auxiliary, emergency).

Note 1: For engines where the standard production cylinder heads are not designed for such measurements, a special cylinder head made for this purpose may be used. In such a case, the measurements may be carried out as part of Stage A and are to be properly documented. Where deemed necessary e.g. for dual fuel engines, the measurement of maximum combustion pressure and mean indicated pressure may be carried out by indirect means, provided the reliability of the method is documented.

Calibration records for the instrumentation used to collect data as listed above are to be presented to - and reviewed by the attending Surveyor.

Additional measurements may be required in connection with the design assessment.

4.1.6 Stage A - internal tests

a) During the internal tests, the engine is to be operated at the load points important for the engine designer and the pertaining operating values are to be recorded. The load conditions to be tested are also to include the testing specified in the applicable type approval programme.

b) At least the following conditions are to be tested:

- Normal case:

  The load points 25%, 50%, 75%, 100% and 110% of the maximum rated power for continuous operation, to be made along the normal (theoretical) propeller curve and at constant speed for propulsion engines (if applicable mode of operation i.e. driving controllable pitch propellers), and at constant speed for engines intended for generator sets including a test at no load and rated speed.
- The limit points of the permissible operating range. These limit points are to be defined by the engine manufacturer.
- For high speed engines, the 100 hr full load test and the low cycle fatigue test apply as required in connection with the design assessment.
- Specific tests of parts of the engine, required by the Society or stipulated by the designer.

4.1.7 Stage B - witnessed tests

a) The tests listed below are to be carried out in the presence of a Surveyor. The achieved results are to be recorded and signed by the attending Surveyor after the type test is completed.

b) The over-speed test is to be carried out and is to demonstrate that the engine is not damaged by an actual engine overspeed within the overspeed shutdown system set-point. This test may be carried out at the manufacturer’s choice either with or without load during the speed overshoot.

c) The engine is to be operated according to the power and speed diagram (see Fig 2). The data to be measured and recorded when testing the engine at the various load points have to include all engine parameters listed in [4.1.5]. The operating time per load point depends on the engine size (achievement of steady state condition) and on the time for collection of the operating values. Normally, an operating time of 0,5 hour can be assumed per load point, however sufficient time should be allowed for visual inspection by the Surveyor.

d) The load points (see Fig 2) are:
- Rated power (MCR), i.e. 100% output at 100% torque and 100% speed corresponding to load point 1, normally for 2 hours with data collection with an interval of 1 hour. If operation of the engine at limits as defined by its specified alarm system (e.g. at alarm levels of lub oil pressure and inlet temperature) is required, the test should be made here.
- 100% power at maximum permissible speed corresponding to load point 2.
- Minimum permissible speed at 100% torque, corresponding to load point 4.
- Minimum permissible speed at 90% torque corresponding to load point 5 (Applicable to propulsion engines only).
- Part loads e.g. 75%, 50% and 25% of rated power and speed according to nominal propeller curve (i.e. 90.8%, 79.3% and 62.9% speed) corresponding to points 6, 7 and 8 or at constant rated speed setting corresponding to points 9, 10 and 11, depending on the intended application of the engine.
- Crosshead engines not restricted for use with C.P. propellers are to be tested with no load at the associated maximum permissible engine speed.

e) During all these load points, engine parameters are to be within the specified and approved values.

f) Operation with damaged turbocharger:

For 2-stroke propulsion engines, the achievable continuous output is to be determined in the case of turbocharger damage.

Engines intended for single propulsion with a fixed pitch propeller are to be able to run continuously at a speed (r.p.m.) of 40% of full speed along the theoretical propeller curve when one turbocharger is out of operation. (The test can be performed by either by-passing the turbocharger, fixing the turbocharger rotor shaft or removing the rotor).

g) Functional tests:
- Verification of the lowest specified propulsion engine speed according to the nominal propeller curve as specified by the engine designer (even though it works on a water- brake). During this operation, no alarm shall occur.
- Starting tests, for non-reversible engines and/or starting and reversing tests, for reversible engines, for the purpose of determining the minimum air pressure and the consumption for a start.
- Governor tests: tests for compliance with [2.7] are to be carried out.

h) Integration test:

For electronically controlled diesel engines, integration tests are to verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes. The scope of these tests is to be agreed with the Society for selected cases based on the FMEA required in Tab 2, item 18.

i) Fire protection measures:

Screening of pipe connections in piping containing flammable liquids and insulation of hot surfaces:
- The engine is to be inspected for jacketing of high-pressure fuel oil lines, including the system for the detection of leakage, and proper screening of pipe connections in piping containing flammable liquids.
- Proper insulation of hot surfaces is to be verified while running the engine at 100% load, alternatively at the overload approved for intermittent use. Readings of surface temperatures are to be done by use of Infrared Thermoscanning Equipment. Equivalent measurement equipment may be used when so approved by the Society. Readings obtained are to be randomly verified by use of contact thermometers.

4.1.8 Stage C - Opening up for Inspections

a) The crankshaft deflections are to be measured in the specified (by designer) condition (except for engines where no specification exists).

b) High speed engines for marine use are normally to be stripped down for a complete inspection after the type test.

c) For all the other engines, after the test run the components of one cylinder for in-line engines and two cylinders for V-engines are to be presented for inspection as follows (engines with long service experience from non-marine fields can have a reduced extent of opening):
- piston removed and dismantled
- crosshead bearing dismantled
- guide planes
- connecting rod bearings (big and small end) dismantled (special attention to serrations and fretting on contact surfaces with the bearing backsides)
- main bearing dismantled
- cylinder liner in the installed condition
- cylinder head, valves disassembled
- cam drive gear or chain, camshaft and crankcase with opened covers. (The engine must be turnable by turning gear for this inspection.)

d) For V-engines, the cylinder units are to be selected from both cylinder banks and different crank throws.

e) If deemed necessary by the surveyor, further dismantling of the engine may be required.

4.1.9 If an electronically controlled diesel engine has been type tested as a conventional engine the Society may waive tests required by this article provided the results of the individual tests would be similar.

4.1.10 If an electronically controlled diesel engine has been type tested as a conventional engine the Society may waive tests required by this article provided the results of the individual tests would be similar.

4.2 Material and non-destructive tests

4.2.1 List of components

Engine components are to be tested in accordance with Tab 8 and with the requirements of NR216.

Symbols used on Tab 8 are defined as below:

C : Chemical composition
CD : Crack detection by MPI (magnetic particul inspection) or DP (dye penetration inspection)
CH : Crosshead engines
D : Cylinder bore diameter (mm)
GJL : Gray cast iron
GJS : Spheroidal graphite cast iron
GS : Cast steel
M : Mechanical properties
SC : Society certificate
TR : Test report
UT : Ultrasonic testing
W : Work certificate
X : Visual examination of accessible surfaces by the Surveyor.

For components and materials not listed in Tab 8, consideration shall be given by the Society upon full details being submitted and reviewed.

Table 8 : Summary of required documentation for engine components

Part **(1) (2) (3) (4)**	Material properties **(5)**	Non-destructive examination **(6)**	Hydraulic testing **(7)**	Dimensional inspection, including surface condition	Visual inspection (Surveyor)	Applicable to engines:	Component certificate
Welded bedplate	W(C+M)	W(UT+CD)			fit-up + post-welding	All	
Bearing transverse girders GS	W(C+M)	W(UT+CD)			X	All	SC
Welded frame box	W(C+M)	W(UT+CD)			fit-up + post-welding	All	SC
Cylinder block GJL			W **(8)**			CH	
Cylinder block GJS			W **(8)**			CH	
Welded cylinder frames	W(C+M)	W(UT+CD)			fit-up + post-welding	CH	SC
Engine block GJL			W **(8)**			> 400 kW/cyl	
Engine block GJS	W(M)		W **(8)**			> 400 kW/cyl	
Cylinder liner	W(C+M)		W **(8)**			D > 300 mm	
Cylinder head GJL			W			D > 300 mm	
Cylinder head GJS			W			D > 300 mm	
Cylinder head GS	W(C+M)	W(UT+CD)	W		X	D > 300 mm	SC
Forged cylinder head	W(C+M)	W(UT+CD)	W		X	D > 300 mm	SC
Piston crown GS	W(C+M)	W(UT+CD)			X	D > 400 mm	SC
Forged piston crown	W(C+M)	W(UT+CD)			X	D > 400 mm	SC
Crankshaft: made in one piece	SC(C+M)	W(UT+CD)		W	Random, of fillets and oil bores	All	SC

Part **(1) (2) (3) (4)**	Material properties **(5)**	Non-destructive examination **(6)**	Hydraulic testing **(7)**	Dimensional inspection, including surface condition	Visual inspection (Surveyor)	Applicable to engines:	Component certificate
Semi-built crankshaft	See below	See below		See below	See below	All	SC
Crank throw	SC(C+M)	W(UT+CD)		W	Random, of fillets and shrink fittings	All	
Forged main journal and journals with flange	SC(C+M)	W(UT+CD)		W	Random, of shrink fittings	All	
Exhaust gas valve cage			W			CH	
Piston rod, if applicable	SC(C+M)	W(UT+CD) CD again after final machining (grinding)			Random	D > 400 mm	SC
Cross head	SC(C+M)	W(UT+CD) CD again after final machining (grinding)			Random	CH	SC
Connecting rod with cap	SC(C+M)	W(UT+CD)		W	Random, of all surfaces, in particular those shot peened	All	SC
Coupling bolts for crankshaft	SC(C+M)	W(UT+CD)		W	Random, of interference fit	All	SC
Bolts and studs for main bearings	W(C+M)	W(UT+CD)				D > 300 mm	
Bolts and studs for cylinder heads	W(C+M)	W(UT+CD)				D > 300 mm	
Bolts and studs for connecting rods	W(C+M)	W(UT+CD)		TR of thread making		D > 300 mm	
Tie rod	W(C+M)	W(UT+CD)		TR of thread making	Random	CH	SC
High pressure fuel injection pump body			W			D > 300 mm	
			TR			D ≤ 300 mm	
High pressure fuel injection valves (only for those not autofretted)			W			D > 300 mm	
			TR			D ≤ 300 mm	
High pressure fuel injection pipes including common fuel rail	W(C+M)		W for those that are not autofretted			D > 300 mm	
			TR for those that are not autofretted			D ≤ 300 mm	
High pressure common servo oil system	W(C+M)		W			D > 300 mm	
			TR			D ≤ 300 mm	
Cooler, both sides **(9)**	W(C+M)		W			D > 300 mm	

Part **(1) (2) (3) (4)**	Material properties **(5)**	Non-destructive examination **(6)**	Hydraulic testing **(7)**	Dimensional inspection, including surface condition	Visual inspection (Surveyor)	Applicable to engines:	Component certificate
Accumulator of common rail fuel or servo oil system	W(C+M)		W			All engines with accumulators with a capacity of > 0,5 l	
Piping, pumps, actuators, etc. for hydraulic drive of valves, if applicable	W(C+M)		W			> 800 kW/cyl	
Engine driven pumps (oil, water, fuel, bilge)			W			> 800 kW/cyl	
Bearings for main, crosshead, and crankpin	TR(C)	TR (UT for full contact between basic material and bearing metal)		W		> 800 kW/cyl	

Note 1: Symbols used in this Table are listed in [4.2.1].

(1) For turbochargers, see Ship Rules, Pt C, Ch 1, Sec 14.

(2) Crankcase safety valves are to be type tested in accordance with Ch 1, App 2 and documented according to [2.3.4].

(3) Oil mist detection systems are to be type tested in accordance with Ship Rules, Pt C, Ch 3, App 1 and documented according to [2.3.5].

(4) For Speed governor and overspeed protective devices, see [2.7].

(5) Material properties include chemical composition and mechanical properties, and also surface treatment such as surface hardening (hardness, depth and extent), peening and rolling (extent and applied force).

(6) Non-destructive examination means e.g. ultrasonic testing, crack detection by MPI or DP.

(7) Hydraulic testing is applied on the water/oil side of the component. Items are to be tested by hydraulic pressure at the pressure equal to 1,5 times the maximum working pressure. High pressure parts of the fuel injection system are to be tested by hydraulic pressure at the pressure equal to 1,5 maximum working pressure or maximum working pressure plus 300 bar, whichever is the less. Where design or testing features may require modification of these test requirements, special consideration may be given.

(8) Hydraulic testing is also required for those parts filled with cooling water and having the function of containing the water which is in contact with the cylinder or cylinder liner.

(9) Charge air coolers need only be tested on the water side.

4.3 Factory acceptance test

4.3.1 Safety precautions

a) Before any test run is carried out, all relevant equipment for the safety of attending personnel is to be made available by the manufacturer / shipyard and is to be operational.

b) his applies especially to crankcase explosive conditions protection, but also to over-speed protection and any other shut down function.

c) The overspeed protective device is to be set to a value, which is not higher than the overspeed value that was demonstrated during the type test for that engine. This set point shall be verified by the surveyor.

4.3.2 General

a) Before any official testing, the engines shall be run-in as prescribed by the engine manufacturer.

b) Adequate test bed facilities for loads as required in [4.3.3] shall be provided. All fluids used for testing purposes such as fuel, lubrication oil and cooling water are to be suitable for the purpose intended, e.g. they are to be clean, preheated if necessary and cause no harm to engine parts. This applies to all fluids used temporarily or repeatedly for testing purposes only.

c) Engines are to be inspected for:

- Jacketing of high-pressure fuel oil lines including the system used for the detection of leakage.
- Screening of pipe connections in piping containing flammable liquids.
- Insulation of hot surfaces by taking random temperature readings that are to be compared with corresponding readings obtained during the type test. This shall be done while running at the rated power of engine. Use of contact thermometers may be accepted at the discretion of the attending Surveyor. If the insulation is modified subsequently to the Type Approval Test, the Society may request temperature measurements as required by [4.1.7], item g).

d) These inspections are normally to be made during the works trials by the manufacturer and the attending surveyor, but at the discretion of the Society parts of these inspections may be postponed to the shipboard testing.

4.3.3 Works trials (Factory Acceptance Test)

a) Objectives

The purpose of the works trials is to verify design premises such as power, safety against fire, adherence to approved limits (e.g. maximum pressure), and functionality and to establish reference values or base lines for later reference in the operational phase.

b) Records

1) The following environmental test conditions are to be recorded:
   - ambient air temperature
   - ambient air pressure
   - atmospheric humidity.

2) For each required load point, the following parameters are normally to be recorded:
   - power and speed
   - fuel index (or equivalent reading)
   - maximum combustion pressures (only when the cylinder heads installed are designed for such measurement)
   - exhaust gas temperature before turbine and from each cylinder (to the extent that monitoring is required in Ch 1, Sec 14 of the Ship Rules and [2.7])
   - charge air temperature
   - charge air pressure
   - turbocharger speed (to the extent that monitoring is required in Ch 1, Sec 14 of the Ship Rules).

3) Calibration records for the instrumentation are, upon request, to be presented to the attending Surveyor.

4) For all stages at which the engine is to be tested, the pertaining operational values are to be measured and recorded by the engine manufacturer. All results are to be compiled in an acceptance protocol to be issued by the engine manufacturer. This also includes crankshaft deflections if considered necessary by the engine designer.

5) In each case, all measurements conducted at the various load points are to be carried out at steady state operating conditions. However, for all load points provision should be made for time needed by the Surveyor to carry out visual inspections. The readings for MCR, i.e. 100% power (rated maximum continuous power at corresponding rpm) are to be taken at least twice at an interval of normally 30 minutes.

c) Test loads

1) Test loads for various engine applications are given below. In addition, the scope of the trials may be expanded depending on the engine application, service experience, or other relevant reasons.

Note 1: Alternatives to the detailed tests may be agreed between the manufacturer and the Society when the overall scope of tests is found to be equivalent.

2) Propulsion engines driving propeller or impeller only:
   - 100% power (MCR) at corresponding speed n_0: at least 60 min.
   - 110% power at engine speed 1,032n_0: Records to be taken after 15 minutes or after steady conditions have been reached, whichever is shorter.

Note 2: 110% test load is only required once for each different engine/turbocharger configuration.

   - Approved intermittent overload (if applicable): testing for duration as agreed with the manufacturer.
   - 90% (or normal continuous cruise power), 75%, 50% and 25% power in accordance with the nominal propeller curve, the sequence to be selected by the engine manufacturer.
   - Reversing manoeuvres (if applicable).

Note 3: After running on the test bed, the fuel delivery system is to be so adjusted that overload power cannot be given in service, unless intermittent overload power is approved by the Society. In that case, the fuel delivery system is to be blocked to that power.

3) Engines driving generators for electric propulsion:
   - 100% power (MCR) at corresponding speed n_0: at least 60 min.
   - 110% power at engine speed n_0: 15 min. - after having reached steady conditions.
   - Governor tests for compliance with [2.7] are to be carried out.
   - 75%, 50% and 25% power and idle, the sequence to be selected by the engine manufacturer.

Note 4: After running on the test bed, the fuel delivery system is to be adjusted so that full power plus a 10% margin for transient regulation can be given in service after installation onboard.

The transient overload capability is required so that the required transient governing characteristics are achieved also at 100% loading of the engine, and also so that the protection system utilised in the electric distribution system can be activated before the engine stalls.

4) Engines driving generators for auxiliary purposes:

Tests to be performed as in [4.3.3].

5) Propulsion engines also driving power take off (PTO) generator:
   - 100% power (MCR) at corresponding speed n_0: at least 60 min.
   - 110% power at engine speed n_0: 15 min. - after having reached steady conditions.
   - Approved intermittent overload (if applicable): testing for duration as agreed with the manufacturer.
   - 90% (or normal continuous cruise power), 75%, 50% and 25% power in accordance with the nominal propeller curve or at constant speed n_0, the sequence to be selected by the engine manufacturer.

Note 5: After running on the test bed, the fuel delivery system is to be adjusted so that full power plus a margin for transient regulation can be given in service after installation onboard. The transient overload capability is required so that the electrical protection of downstream system components is activated before the engine stalls. This margin may be 10% of the engine power but at least 10% of the PTO power.

6) Engines driving auxiliaries:
   - 100% power (MCR) at corresponding speed n_0: at least 30 min.
   - 110% power at engine speed n_0: 15 min. - after having reached steady conditions.
   - Approved intermittent overload (if applicable): testing for duration as agreed with the manufacturer.
   - For variable speed engines, 75%, 50% and 25% power in accordance with the nominal power consumption curve, the sequence to be selected by the engine manufacturer.

Note 6: After running on the test bed, the fuel delivery system is normally to be so adjusted that overload power cannot be delivered in service, unless intermittent overload power is approved. In that case, the fuel delivery system is to be blocked to that power.

d) Turbocharger matching with engine

1) Compressor chart

Turbochargers shall have a compressor characteristic that allows the engine, for which it is intended, to operate without surging during all operating conditions and also after extended periods in operation.

For abnormal, but permissible, operation conditions, such as misfiring and sudden load reduction, no continuous surging shall occur.

In this item, surging and continuous surging are defined as follows:

- surging means the phenomenon, which results in a high pitch vibration of an audible level or explosion-like noise from the scavenger area of the engine
- continuous surging means that surging happens repeatedly and not only once.

2) Surge margin verification

Category C turbochargers used on propulsion engines are to be checked for surge margins during the engine workshop testing as specified below. These tests may be waived if successfully tested earlier on an identical configuration of engine and turbocharger (including same nozzle rings).

- For 4-stroke engines:

  The following shall be performed without indication of surging:
  - with maximum continuous power and speed (=100%), the speed shall be reduced with constant torque (fuel index) down to 90% power
  - with 50% power at 80% speed (= propeller characteristic for fixed pitch), the speed shall be reduced to 72% while keeping constant torque (fuel index).
- For 2-stroke engines:

  The surge margin shall be demonstrated by at least one of the following methods:
  - The engine working characteristic established at workshop testing of the engine shall be plotted into the compressor chart of the turbocharger (established in a test rig). There shall be at least 10% surge margin in the full load range, i.e. working flow shall be 10% above the theoretical (mass) flow at surge limit (at no pressure fluctuations), or,
  - Sudden fuel cut-off to at least one cylinder shall not result in continuous surging and the turbocharger shall be stabilised at the new load within 20 seconds. For applications with more than one turbocharger the fuel shall be cut-off to the cylinders closest upstream to each turbocharger.

    This test shall be performed at two different engine loads:
    - the maximum power permitted for one cylinder misfiring
    - the engine load corresponding to a charge air pressure of about 0,6 bar (but without auxiliary blowers running).
  - No continuous surging and the turbocharger shall be stabilised at the new load within 20 seconds when the power is abruptly reduced from 100% to 50% of the maximum continuous power.

e) Integration tests

For electronically controlled engines, integration tests are to be made to verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes and the tests considered as a system are to be carried out at the works. If such tests are technically unfeasible at the works, however, these tests may be conducted during sea trial. The scope of these tests is to be agreed with the Society for selected cases based on the FMEA required in Tab 1.

f) Component inspections

Random checks of components to be presented for inspection after works trials are left to the discretion of each Society.

4.4 Certification

4.4.1 Type approval certificate

a) For each type of engine that is required to be approved, a type approval certificate is to be obtained by the engine designer. The process details for obtaining a type approval certificate are given below (see also [1.2]). This process consists of the engine designer obtaining from the Society:

- drawing and specification approval
- conformity of production
- approval of type testing programme
- type testing of engines
- review of the obtained type testing results
- evaluation of the manufacturing arrangements
- issue of a type approval certificate.

The manufacturing facility of the engine presented for the type approval test is to be assessed in accordance with NR320 Certification Scheme for the Classification of Marine Units.

b) Type approval certificate renewal

A renewal of type approval certificates will be granted upon:

- the submission of modified documents or new documents with substantial modifications replacing former documents compared to the previous submission(s), or alternatively,
- a declaration that no substantial modifications have been applied since the last issuance of the type approval certificate.

c) Validity of type approval certificate

The limit of the duration facility of the type approval certificate shall comply with requirements of NR320. The maximum period of validity of a type approval certificate is 5 years.

The type approval certificate will be invalid if there are substantial modifications in the design, in the manufacturing or control processes or in the characteristics of the materials unless approved in advance by the Society.

4.4.2 Engine certificate

a) Each diesel engine manufactured for a shipboard application is to have an engine certificate. This process consists of the engine builder/licensee obtaining design approval of the engine application specific documents, submitting a comparison list of the production drawings to the previously approved engine design drawings referenced in [4.4.1] forwarding the relevant production drawings and comparison list for the use of the Surveyors at the manufacturing plant and shipyard if necessary, engine testing and upon satisfactorily meeting the Rule requirements, the issuance of an engine certificate.

For those cases when a licensor – licensee agreement does NOT apply, an “engine designer” shall be understood as the entity that has the design rights for the engine type or is delegated by the entity having the design rights to modify the design.

b) Society’s requirements for production facilities comprising manufacturing facilities and processes, machining tools, quality assurance, testing facilities, etc. shall be assessed according to NR320 requirements.

4.4.3 Certification of engine components

a) The engine manufacturer is to have a quality control system that is suitable for the actual engine types to be certified by the Society. The quality control system is also to apply to any sub-suppliers. The Society reserves the right to review the system or parts thereof. Materials and components are to be produced in compliance with all the applicable production and quality instructions specified by the engine manufacturer. The Society requires that certain parts are verified and documented by means of Society Certificate (SC), Work Certificate (W) or Test Report (TR).

b) Society Certificate (SC)

This is a document issued by the Society stating:

- conformity with Rule requirements
- that the tests and inspections have been carried out on the certified product itself, or on samples taken from the certified product itself
- that the inspection and tests were performed in the presence of the Surveyor or in accordance with an Alternative Survey Scheme according to NR320.

c) Work’s Certificate (W)

This is a document signed by the manufacturer stating:

- conformity with requirements
- that the tests and inspections have been carried out on the certified product itself, or on samples taken from the raw material, used for the product to be certified
- that the tests were witnessed and signed by a qualified representative of the applicable department of the manufacturer.

A Work's Certificate may be considered equivalent to a Society Certificate and endorsed by the Society under the following cases:

- the test was witnessed by the Society Surveyor; or
- an Alternative Survey Scheme according to NR320 is in place between the Society and the manufacturer or material supplier; or
- the Work's certificate is supported by tests carried out by an accredited third party that is accepted by the Society and independent from the manufacturer and/or material supplier.

d) Test Report (TR)

This is a document signed by the manufacturer stating:

- conformity with requirements
- that the tests and inspections have been carried out on samples from the current production.

e) The documents above are used for product documentation as well as for documentation of single inspections such as crack detection, dimensional check, etc. If agreed to by the Society, the documentation of single tests and inspections may also be arranged by filling in results on a control sheet following the component through the production.

f) The Surveyor is to review the TR and W for compliance with the agreed or approved specifications. SC means that the Surveyor also witnesses the testing, batch or individual, unless an Alternative Survey Scheme, according to NR320, provides other arrangements.

g) The manufacturer is not exempted from responsibility for any relevant tests and inspections of those parts for which documentation is not explicitly requested by the Society.

Manufacturing works is to be equipped in such a way that all materials and components can be consistently produced to the required standard. This includes production and assembly lines, machining units, special tools and devices, assembly and testing rigs as well as all lifting and transportation devices.

5 Additional requirements for diesel engines in hazardous areas

5.1

5.1.1 General

Diesel engines may be fitted in zone 2 hazardous areas according to Ch 4, Sec 3, [6] provided they are designed, manufactured, tested and maintained according to a recognised standard, such as EN 1834-1 “Safety Requirements for Design and Construction of Engines for Use in Potentially Explosive Atmospheres”, as amended.

5.1.2 Particular requirements

As a minimum, the following requirements are to be complied with:

- Exhaust manifold is to be water cooled.
- Maximum exposed surface and exhaust temperatures at full rated power of the engine are generally not to exceed 200°C (this may be lowered according to the gas processed).
- Efficient flame arrester is to be provided in air intake.
- Efficient flame trap and spark arresters are to be provided in exhaust system.
- Aluminium fittings are not acceptable unless suitably coated as a protection against igniting sparking.
- Pneumatic/hydraulic or hand starting arrangements are to be provided. Electrical starting arrangements will be subject to particular examination by the Society.
- Minimum flame path is not to be less than 13 mm.
- Provision is to be made to prevent overspeeding in the event of accidental ingestion of low flash vapours/gas.
- Air intake and exhaust are to be led from and to safe areas.
- All belts are to be of anti-static type.
- Cylinders and crankcases are to be provided with safety devices. Relief valves or breathers on engines are to be fitted with flame traps or alternatively discharge into the induction system downstream of the flame arrester and upstream of the shut off valve if fitted.
- Dipstick and/or filler caps are to be screwed or effectively secured by other means.

Section 3 Pressure Equipment

1 General

1.1 Principles

1.1.1 Scope of the Rules

The boilers and other pressure vessels, associated piping systems and fittings are to be of a design and construction adequate for the service for which they are intended and is to be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards. The design is to have regard to materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

So these Rules apply to “pressure equipment” for the following requirements:

- be safe in sight of pressure risk
- be safe in sight of other risks, moving parts, hot surfaces
- ensure capability of propulsion and other essential services.

“Pressure equipment” means pressure vessels, piping (Ch 1, Sec 7), safety accessories and pressure accessories.

1.1.2 Overpressure risk

Where main or auxiliary boilers and other pressure vessels or any parts thereof may be subject to dangerous overpressure, means are to be provided where practicable to protect against such excessive pressure.

1.1.3 Propulsion capability

Means are to be provided whereby normal operation of main boilers can be sustained or restored even through one of the essential auxiliaries become inoperative. Special consideration is to be given to the malfunctioning of:

- the source of steam supply
- the boiler feed water systems
- the fuel oil supply system for boilers
- the mechanical air supply for boilers.

However the Society, having regard to overall safety considerations, may accept a partial reduction in propulsion capability from normal operation.

1.1.4 Tests

All boilers and other pressure vessels including their associated fittings which are under internal pressure are to be subjected to appropriate tests including a pressure test before being put into service for the first time (see also [7]).

1.2 Application

1.2.1 Pressure vessels covered by the Rules

The requirements of this Section apply to:

- all fired or unfired pressures vessels of metallic construction, including the associated fittings and mountings with maximum allowable pressure greater than 0,5 bar above atmospheric pressure with the exception of those indicated in [1.2.2]
- all boilers and other steam generators, including the associated fittings and mountings with maximum allowable pressure greater than 0,5 bar above atmospheric pressure with the exception of those indicated in [1.2.2].

1.2.2 Pressure vessels not covered by the Rules

Among others the following boilers and pressure vessels are not covered by the Rules and are to be considered on a case by case basis:

a) boilers with design pressure $p > 10$ MPa

b) pressure vessel intended for radioactive material

c) equipment comprising casings or machinery where the dimensioning, choice of material and manufacturing rules are based primarily on requirements for sufficient strength, rigidity and stability to meet the static and dynamic operational effects or other operational characteristics and for which pressure is not a significant design factor. Such equipment may include:
   - engines including turbines and internal combustion engines
   - steam engines, gas/steam turbines, turbo-generators, compressors, pumps and actuating devices

d) small pressure vessels included in self-contained domestic equipment.

1.3 Definitions

1.3.1 Pressure vessel

"Pressure vessel" means a housing designed and built to contain fluids under pressure including its direct attachments up to the coupling point connecting it to other equipment. A vessel may be composed of more than one chamber.

1.3.2 Fired pressure vessel

Fired pressure vessel is a pressure vessel which is completely or partially exposed to fire from burners or combustion gases or otherwise heated pressure vessel with a risk of overheating.

a) Boiler

Boiler is one or more fired pressure vessels and associated piping systems used for generating steam or hot water at a temperature above 120°C.

Any equipment directly connected to the boiler, such as economisers, superheaters and safety valves, is considered as part of the boiler, if it is not separated from the steam generator by means of any isolating valve. Piping connected to the boiler is considered as part of the boiler upstream of the isolating valve and as part of the associated piping system downstream of the isolating valve.

b) Thermal oil heater

Thermal oil heater is one or more fired pressure vessels and associated piping systems in which organic liquids (thermal oils) are heated. When heated by electricity thermal oil heater is considered as an unfired pressure vessel.

1.3.3 Unfired pressure vessel

Any pressure vessel which is not a fired pressure vessel is an unfired pressure vessel.

a) Heat exchanger

A heat exchanger is an unfired pressure vessel used to heat or cool a fluid with an another fluid. In general heat exchangers are composed of a number of adjacent chambers, the two fluids flowing separately in adjacent chambers. One or more chambers may consist of bundles of tubes.

b) Steam generator

A steam generator is a heat exchanger and associated piping used for generating steam. In general in these Rules, the requirements for boilers are also applicable for steam generators, unless otherwise indicated.

1.3.4 Safety accessories

"Safety accessories" means devices designed to protect pressure equipment against the allowable limits being exceeded. Such devices include:

- devices for direct pressure limitation, such as safety valves, bursting disc safety devices, buckling rods, controlled safety pressure relief systems, and
- limiting devices, which either activate the means for correction or provide for shutdown or shutdown and lockout, such as pressure switches or temperature switches or fluid level switches and safety related measurement control and regulation devices.

1.3.5 Design pressure

The design pressure is the pressure used by the manufacturer to determine the scantlings of the vessel. This pressure cannot be taken less than the maximum working pressure and is to be limited by the set pressure of the safety valve, as prescribed by the applicable Rules. Pressure is indicated as gauge pressure above atmospheric pressure, vacuum is indicated as negative pressure.

1.3.6 Design temperature

a) Design temperature is the actual metal temperature of the applicable part under the expected operating conditions, as modified in Tab 1. This temperature is to be stated by the manufacturer and is to take in account of the effect of any temperature fluctuations which may occur during the service.

b) The design temperature is not to be less than the temperatures stated in Tab 1, unless specially agreed between the manufacturer and the Society on a case by case basis.

1.3.7 Volume

Volume V means the internal volume of a chamber, including the volume of nozzles to the first connection or weld and excluding the volume of permanent internal parts.

1.3.8 Boiler heating surface

Heating surface is the area of the part of the boiler through which the heat is supplied to the medium, on the side exposed to fire or hot gases.

Table 1 : Minimum design temperature

Type of vessel	Minimum design temperature
Pressure parts of pressure vessels and boilers not heated by hot gases or adequately protected by insulation	Maximum temperature of the internal fluid
Pressure vessel heated by hot gases	25°C in excess of the temperature of the internal fluid
Water tubes of boilers mainly subjected to convection heat	25°C in excess of the temperature of the saturated steam
Water tubes of boilers mainly subjected to radiant heat	50°C in excess of the temperature of the saturated steam
Superheater tubes of boilers mainly subjected to convection heat	35°C in excess of the temperature of the saturated steam
Superheater tubes of boilers mainly subjected to radiant heat	50°C in excess of the temperature of the saturated steam
Economiser tubes	35°C in excess of the temperature of the internal fluid
For combustion chambers of the type used in wet-back boilers	50°C in excess of the temperature of the internal fluid
For furnaces, fire-boxes, rear tube plates of dry-back boilers and other pressure parts subjected to similar rate of heat transfer	90°C in excess of the temperature of the internal fluid

1.3.9 Maximum steam output

Maximum steam output is the maximum quantity of steam than can be produced continuously by the boiler or steam generator operating under the design steam conditions.

1.3.10 Toxic and corrosive substances

Toxic and corrosive substances are those which are listed in the IMO “International Maritime Dangerous Goods Code (IMDG Code)”, as amended.

1.3.11 Liquid and gaseous substances

a) Liquid substances are liquids having a vapour pressure at the maximum allowable temperature of not more than 0,5 bar above normal atmospheric pressure.

b) Gaseous substances are gases, liquefied gases, gases dissolved under pressure, vapours and also those liquids whose vapour pressure at the maximum allowable temperature is greater than 0,5 bar above normal atmospheric pressure.

1.3.12 Ductile material

For the purpose of this Section, ductile material is a material having an elongation over 12%.

1.3.13 Incinerator

Incinerator is a facility on board the unit for incinerating solid garbage approximating in composition to household garbage and liquid garbage deriving from the operation of the unit (e.g. domestic garbage, cargo-associated garbage, maintenance garbage, operational garbage, cargo residue, and fishing gear), as well as for burning sludge with a flash point above 60°C.

These facilities may be designed to use the heat energy produced.

Incinerators are not generally pressure vessels, however when their fittings are of the same type than those of boilers the requirements for these fittings apply.

1.4 Classes

1.4.1 Significant parameters

Pressure vessels are classed in three class in consideration of:

- the type of equipment: pressure vessel or steam generator
- the state (gaseous or liquid) of the intended fluid contents
- the substances listed or not in the IMDG Code
- the design pressure p, in MPa
- the design temperature T, in °C
- the actual thickness of the vessel t_A , in mm
- the volume V, in litres.

1.4.2 Pressure vessel classification

Pressure vessels are classed as indicated in Tab 2.

Table 2 : Pressure vessel classification

Equipment	Class 1	Class 2	Class 3
Steam generators or boilers	$p > 3,2$ and $V > 2$ or $p\,V > 20$ and $V > 2$	if not class 1 or class 3	$p\,V \le 5$ or $V \le 2$
Pressure vessels for toxic substances	all	–	–
Pressure vessels for corrosive substances	$p > 20$ or $p\,V > 20$ or $T > 350$	if not in class 1	–
Pressure vessels for gaseous substances	$p > 100$ or $p\,V > 300$	$V > 1$ and $p\,V > 100$ and not in class 1	all pressure vessels which are not class 1 or class 2
Pressure vessels for liquid substances	$V > 10$ and $p\,V > 1000$ and $p > 50$	$V \le 10$ and $p > 100$ or $1 < p \le 50$ and $p\,V > 1000$	all pressure vessels and heat exchangers which are not class 1 or class 2
Pressure vessels for thermal oil	$p > 1,6$ or $T > 300$	if not class 1 or class 3	$p \le 0,7$ and $T \le 150$
Pressure vessels for fuel oil, lubricating oil or flammable hydraulic oil	$p > 1,6$ or $T > 150$	if not class 1 or class 3	$p \le 0,7$ and $T \le 60$
Whatever type of equipment	$t_A > 40$	$15 < t_A \le 40$	–
Note 1: Whenever the class is defined by more than one characteristic, the equipment is to be considered belonging to the highest class of its characteristics, independently of the values of the other characteristics.			

1.4.3 Implication of class

The class of a pressure vessel has, among others, implication in:

- design
- material allowance
- welding design
- efficiency of joints
- examination and non-destructive tests
- thermal stress relieving.

See Tab 24.

1.5 Applicable Rules

1.5.1 Alternative standards

a) Boilers and pressure vessels are to be designed, constructed, installed and tested in accordance with the applicable requirements of this Section.

b) The acceptance of national and international standards as an alternative to the requirements of this Section may be considered by the Society on a case by case basis.

1.6 Documentation to be submitted

1.6.1 General

Documents mentioned in the present sub-article are to be submitted for class 1 and class 2 and not for class 3, unless the equipment is considered as critical.

1.6.2 Boilers and steam generators

The plans listed in Tab 3 are to be submitted.

The drawings listed in Tab 3 are to contain:

- the constructional details of all pressure parts, such as shells, headers, tubes, tube plates, nozzles
- strengthening members, such as stays, brackets, opening reinforcements and covers
- installation arrangements, such as saddles and anchoring system,

as well as the information and data indicated in Tab 4.

1.6.3 Pressure vessels

The plans listed in Tab 5 are to be submitted.

The drawings listed in Tab 5 are to contain the constructional details of:

- pressure parts, such as shells, headers, tubes, tube plates, nozzles, opening reinforcements and covers
- strengthening members, such as stays, brackets and reinforcements.

1.6.4 Incinerators

Incinerators are to be considered on a case by case basis, based on their actual arrangement, using the applicable requirements for boilers and pressure vessels.

Table 3 : Drawings to be submitted for boilers and steam generators

No.	A/I **(1)**	Item
1	I	General arrangement plan, including valves and fittings
2	A	Material specifications
3	A	Sectional assembly
4	A	Evaporating parts
5	A	Superheater
6	A	De-superheater
7	A	Economiser
8	A	Air heater
9	A	Tubes and tube plates
10	A	Nozzles and fittings
11	A	Safety valves and their arrangement
12	A	Boiler seating
13	I	Fuel oil burning arrangement
14	I	Forced draft system
15	I	Refractor or insulation arrangement
16	A	Boiler instrumentation, monitoring and control system
17	A	Type of safety valves and their lift, discharge rate and setting
18	A	Welding details, including at least: • typical weld joint design • welding procedure specifications • post-weld heat treatment
(1) A = To be submitted for approval ; I = To be submitted for information		

Table 4 : Information and data to be submitted for boilers and steam generators

No.	Item
1	Design pressure and temperature
2	Pressure and temperature of the superheated steam
3	Pressure and temperature of the saturated steam
4	Maximum steam production per hour
5	Evaporating surface of the tube bundles and water-walls
6	Heating surface of the economiser, superheater and air-heater
7	Surface of the furnace
8	Volume of the combustion chamber
9	Temperature and pressure of the feed water
10	Type of fuel to be used and fuel consumption at full steam production
11	Number and capacity of burners

Table 5 : Drawings, information and data to be submitted for pressure vessels and heat exchangers

No.	A/I **(1)**	Item
1	I	General arrangement plan, including nozzles and fittings
2	A	Sectional assembly
3	A	Safety valves (if any) and their arrangement
4	A	Material specifications
5	A	Welding details, including at least: • typical weld joint design • welding procedure specifications • post-weld heat treatments
6	I	Design data, including at least design pressure and design temperatures (as applicable)
7	A	For seamless (extruded) pressure vessels, the manufacturing process, including: • a description of the manufacturing process with indication of the production controls normally carried out in the manufacturer's works • details of the materials to be used (specification, yield point, tensile strength, impact strength, heat treatment) • details of the stamped marking to be applied
8	I	Type of fluid or fluids contained

(1) A = To be submitted for approval ; I = To be submitted for information

2 Design and construction - Scantlings of pressure parts

2.1 General

2.1.1 Application

a) In general, the formulae in the present Article do not take into account additional stresses imposed by effects other than pressure, such as stresses deriving from the static and dynamic weight of the pressure vessel and its content, external loads from connecting equipment and foundations, etc. For the purpose of the Rules, these additional loads may be neglected, provided it can reasonably be presumed that the actual average stresses of the vessel, considering all these additional loads, would not increase more than 10% with respect to the stresses calculated by the formulae in this Article.

b) Where it is necessary to take into account additional stresses, such as dynamic loads, the Society reserves the right to ask for additional requirements on a case by case basis.

2.1.2 Alternative requirements

When pressure parts are of an irregular shape, such as to make it impossible to check the scantlings by applying the formulae of this Article, the approval is to be based on other means, such as burst and/or deformation tests on a prototype or by another method agreed upon between the manufacturer and the Society.

2.2 Materials

2.2.1 Materials for high temperatures

a) Materials for pressure parts having a design temperature exceeding the ambient temperature are to be selected by the Manufacturer and to have mechanical and metallurgical properties adequate for the design temperature. Their allowable stress limits are to be determined as a function of the temperature, as per [2.3.2].

b) When the design temperature of pressure parts exceeds 400°C, alloy steels are to be used. Other materials are subject of special consideration by the Society.

2.2.2 Materials for low temperatures

Materials for pressure parts having a design temperature below the ambient temperature are to have notch toughness properties suitable for the design temperature.

2.2.3 Cast iron

Cast iron is not to be used for:

a) class 1 and class 2 pressure vessels

b) class 3 pressure vessels with design pressure $p > 1,6$ MPa or product $p \cdot V > 1000$, where V is the internal volume of the pressure vessel in litres

c) bolted covers and closures of pressure vessels having a design pressure $p > 1$ MPa, except for covers intended for boiler shells, for which [3.2.4] applies.

Spheroidal cast iron may be used subject to the agreement of the Society following special consideration. However, it is not to be used for parts, having a design temperature exceeding 350°C.

2.2.4 Valves and fittings for boilers

a) Ductile materials are to be used for valves and fittings intended to be mounted on boilers. The material is to have mechanical and metallurgical characteristics suitable for the design temperature and for the thermal and other loads imposed during the operation.

b) Grey cast iron is not to be used for valves and fittings which are subject to dynamic loads, such as safety valves and blow-down valves, and in general for fittings and accessories having design pressure p exceeding 0,3 MPa and design temperature T exceeding 220°C.

c) Spheroidal cast iron is not to be used for parts having a design temperature T exceeding 350°C.

d) Bronze is not to be used for parts having design temperature T exceeding 220°C for normal bronzes and 260°C for bronzes suitable for high temperatures. Copper and aluminium brass are not to be used for fittings with design temperature T above 200°C and copper-nickel fittings with design temperature T exceeding 300°C.

2.2.5 Alternative materials

In the case of boilers or pressure vessels constructed in accordance with one of the standards considered acceptable by the Society as per [1.5], the material specifications are to be in compliance with the requirements of the standard used.

2.3 Permissible stresses

2.3.1 The permissible stresses K, in N/mm^2, for steels, to be used in the formulae of this Article, may be determined from Tab 6, Tab 7, Tab 8 and Tab 9, where R_m is the ultimate strength of the material, in N/mm^2. For intermediate values of the temperature, the value of K is to be obtained by linear interpolation.

Table 6 : Permissible stresses K for carbon steels intended for boilers and thermal oil heaters

Carbon steel	T (°C)	≤ 50	100	150	200	250	300	350	400
R_m = 360 N/mm^2 Grade HA	$t \leq 15$ mm	133	109	107	105	94	77	73	72
	15 mm $< t \leq 40$ mm	128	106	105	101	90	77	73	72
	40 mm $< t \leq 60$ mm	122	101	99	95	88	77	73	72
R_m = 360 N/mm^2 Grades HB, HD	$t \leq 15$ mm	133	127	116	103	79	79	72	69
	15 mm $< t \leq 40$ mm	133	122	114	102	79	79	72	69
	40 mm $< t \leq 60$ mm	133	112	107	99	79	79	72	69
R_m = 410 N/mm^2 Grade HA	$t \leq 15$ mm	152	132	130	126	112	94	89	86
	15 mm $< t \leq 40$ mm	147	131	124	119	107	94	89	86
	40 mm $< t \leq 60$ mm	141	120	117	113	105	94	89	86
R_m = 410 N/mm^2 Grades HB, HD	$t \leq 15$ mm	152	147	135	121	107	95	88	84
	15 mm $< t \leq 40$ mm	152	142	133	120	107	95	88	84
	40 mm $< t \leq 60$ mm	152	134	127	117	107	95	88	84
R_m = 460 N/mm^2 Grades HB, HD	$t \leq 15$ mm	170	164	154	139	124	111	104	99
	15 mm $< t \leq 40$ mm	169	162	151	137	124	111	104	99
	40 mm $< t \leq 60$ mm	162	157	147	136	124	111	104	99
R_m = 510 N/mm^2 Grades HB, HD	$t \leq 60$ mm	170	170	169	159	147	134	125	112

Table 7 : Permissible stresses K for carbon steels intended for other pressure vessels

Carbon steel	T (°C)	≤ 50	100	150	200	250	300	350	400
R_m = 360 N/mm^2 Grade HA	$t \leq 15$ mm	133	117	115	112	100	83	78	77
	15 mm $< t \leq 40$ mm	133	114	113	108	96	83	78	77
	40 mm $< t \leq 60$ mm	130	108	105	101	94	83	78	77
R_m = 360 N/mm^2 Grades HB, HD	$t \leq 15$ mm	133	133	123	110	97	85	77	73
	15 mm $< t \leq 40$ mm	133	131	122	109	97	85	77	73
	40 mm $< t \leq 60$ mm	133	119	115	106	97	85	77	73
R_m = 410 N/mm^2 Grade HA	$t \leq 15$ mm	152	141	139	134	120	100	95	92
	15 mm $< t \leq 40$ mm	152	134	132	127	114	100	95	92
	40 mm $< t \leq 60$ mm	150	128	121	112	112	100	95	92
R_m = 410 N/mm^2 Grades HB, HD	$t \leq 15$ mm	152	152	144	129	114	101	94	89
	15 mm $< t \leq 40$ mm	152	152	142	128	114	101	94	89
	40 mm $< t \leq 60$ mm	152	143	139	125	114	101	94	89
R_m = 460 N/mm^2 Grades HB, HD	$t \leq 15$ mm	170	170	165	149	132	118	111	105
	15 mm $< t \leq 40$ mm	170	170	161	147	132	118	111	105
	40 mm $< t \leq 60$ mm	170	167	157	145	132	118	111	105
R_m = 510 N/mm^2 Grades HB, HD	$t \leq 60$ mm	189	189	180	170	157	143	133	120

Table 8 : Permissible stresses K for alloy steels intended for boilers and thermal oil heaters

Alloy steel	T(°C)	≤ 50	100	150	200	250	300	350	400	450	475	500	525	550	575	600
0,3Mo	t ≤ 60 mm	159	153	143	134	125	106	100	94	91	89	87	36			
1Cr 0,5Mo	t ≤ 60 mm	167	167	157	144	137	128	119	112	106	104	103	55	31	19	
2,25Cr 1Mo **(1)**	t ≤ 60 mm	170	167	157	147	144	137	131	125	119	115	112	61	41	30	22
2,25Cr 1Mo **(2)**	t ≤ 60 mm	170	167	164	161	159	147	141	130	128	125	122	61	41	30	22

(1) Normalised and tempered

(2) Normalised and tempered or quenched and tempered

Table 9 : Permissible stresses K for alloy steels intended for other pressure vessels

Alloy steel	T(°C)	≤ 50	100	150	200	250	300	350	400	450	475	500	525	550	575	600
0,3Mo	t ≤ 60 mm	159	159	153	143	133	113	107	100	97	95	93	38			
1Cr 0,5Mo	t ≤ 60 mm	167	167	167	154	146	137	127	119	113	111	110	59	33	20	
2,25Cr 1Mo **(1)**	t ≤ 60 mm	183	174	167	157	154	146	140	133	127	123	119	65	44	32	23
2,25Cr 1Mo **(2)**	t ≤ 60 mm	174	174	174	172	170	157	150	139	137	133	130	65	44	32	23

(1) Normalised and tempered

(2) Normalised and tempered or quenched and tempered

2.3.2 Direct determination of permissible stress

The permissible stresses K, where not otherwise specified, may be taken as indicated below.

a) Steel:

The permissible stress is to be the minimum of the values obtained by the following formulae:

$$K = \frac{R_{m,20}}{2,7}$$

$$K = \frac{R_{S,MIN,T}}{A}$$

$$K = \frac{S_A}{A}$$

where:

$R_{m,20}$: Minimum tensile strength at ambient temperature (20°C), in N/mm^2

$R_{S,MIN,T}$: Minimum between R_{eH} and $R_{p\,0,2}$ at the design temperature T, in N/mm^2

S_A : Average stress to produce creep rupture in 100000 hours, in N/mm^2, at the design temperature T

A : Safety factor taken as follows, when reliability of $R_{S,MIN,T}$ and S_A values are proved to the Society's satisfaction:

- 1,6 for boilers and other steam generators
- 1,5 for other pressure vessels
- specially considered by the Society if average stress to produce creep rupture in more than 100000 hours is used instead of S_A

In the case of steel castings, the permissible stress K, calculated as above, is to be decreased by 20%. Where steel castings are subjected to non-destructive tests, a smaller reduction up to 10% may be taken into consideration by the Society.

b) Spheroidal cast iron:

The permissible stress is be to the minimum of the values obtained by the following formulae:

$$K = \frac{R_{m,20}}{4,8}$$

$$K = \frac{R_{S,MIN,T}}{3}$$

c) Grey cast iron:

The permissible stress is obtained by the following formula:

$$K = \frac{R_{m,20}}{10}$$

d) Copper alloys:

The permissible stress is obtained by the following formula:

$$K = \frac{R_{m,T}}{4}$$

where:

$R_{m,T}$: Minimum tensile strength at the design temperature T, in N/mm^2.

e) Aluminium and aluminium alloys:

The permissible stress is to be the minimum of the values obtained by the following formulae:

$$K = \frac{R_{m,T}}{4}$$

$$K = \frac{R_{e,H}}{1,5}$$

where:

$R_{e,H}$: Minimum yield stress, in N/mm^2.

f) Additional conditions:

- in special cases the Society reserves the right to apply values of permissible stress K lower than those specified above, in particular for lifting appliance devices and steering gear devices
- in the case of boilers or other steam generators, the permissible stress K is not to exceed 170 N/mm^2
- for materials other than those listed above the permissible stress is to be agreed with the Society on a case by case basis.

2.4 Cylindrical, spherical and conical shells with circular cross-sections subject to internal pressure

2.4.1 Cylindrical shell thickness

a) The minimum thickness of cylindrical, spherical and conical shells with circular cross-sections is not to be less than the value t, in mm, calculated by one of the following formulae, as appropriate. Cylindrical tube plates pierced by a great number of tube holes are to have thickness calculated by the applicable formulae in [2.4.3], [2.4.4], [2.4.5] and [2.9.2].

b) The thicknesses obtained by the formulae in [2.4.3], [2.4.4] and [2.4.5] are “net” thicknesses, as they do not include any corrosion allowance. The thickness obtained by the above formulae is to be increased by 0,75 mm. See also [2.4.7].

2.4.2 Efficiency

a) The values of efficiency e to be used in the formulae in [2.4.3], [2.4.4] and [2.4.5] are indicated in Tab 10.

b) The manufacturer may propose a factor e lower than those indicated in Tab 10 where consistent with the factor used in the formulae of [2.4.3], [2.4.4] and [2.4.5] and with the provisions of specific requirements according to class as per [4.9], [4.10] or [4.11]. The proposed efficiency factor is to be agreed by the Society.

Table 10 : Efficiency of unpierced shells

Case	e
Seamless shells	1
Shells of class 1 vessels **(1)**	1
Shells of class 2 vessels (with partial radiographic examination of butt-joints)	0,85
Shells of class 2 vessels with actual thickness ≤ 15 mm (without radiographic examination of butt-joints)	0,75
(1) In special cases the Society reserves the right to take a factor e < 1, depending on the welding procedure adopted for the welded joint.	

2.4.3 Cylindrical shells

a) When the ratio external diameter/inside diameter is equal to or less than 1,5, the minimum thickness of cylindrical shells is given by the following formula:

$$t = \frac{pD}{(2K - p)e}$$

where:

p : Design pressure, in MPa

D : Inside diameter of vessel, in mm

K : Permissible stress, in N/mm^2, obtained as specified in [2.3]

e : Efficiency of welded joint, the value of which is given in [2.4.2].

b) The minimum thickness of shells having ratio external diameter/inside diameter exceeding 1,5 is subject of special consideration.

2.4.4 Spherical shells

a) When the ratio external diameter/inside diameter is equal to or less than 1,5, the minimum thickness of spherical shells is given by the following formula:

$$t = \frac{pD}{(4K - p)e}$$

For the meaning of the symbols, see [2.4.3].

b) The minimum thickness of shells having ratio external diameter/inside diameter exceeding 1,5 is subject of special consideration.

2.4.5 Conical shells

a) The following formula applies to conical shells of thickness not exceeding 1/6 of the external diameter in way of the large end of the cone:

$$t = \frac{pD}{(2K - p)e \cdot \cos\varphi}$$

For the meaning of the symbols, see [2.4.3].

D is measured in way of the large end of the cone and φ is the angle of slope of the conical section of the shell to the pressure vessel axis (see Fig 1). When φ exceeds 75°, the shell thickness is to be taken as required for flat heads, see [2.7].

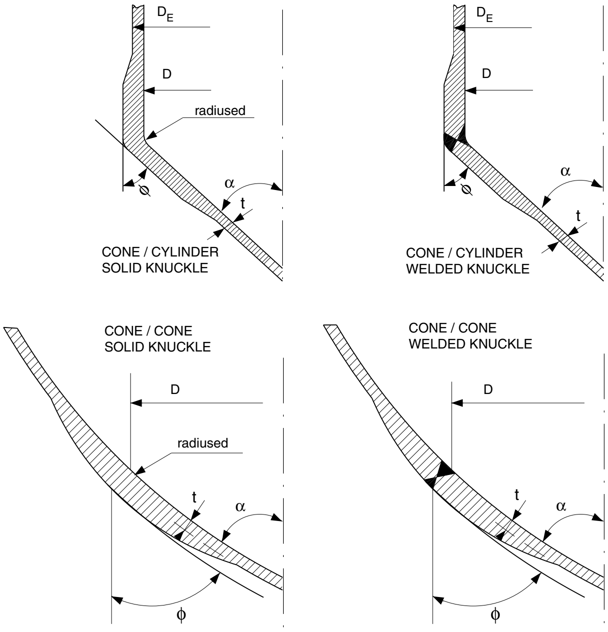
b) The minimum thickness of shells having thickness exceeding 1/6 of the external diameter in way of the large end of the cone is subject of special consideration.

c) Conical shells may be made of several ring sections of decreasing thickness. The minimum thickness of each section is to be obtained by the formula in a) using for D the maximum diameter of the considered section.

d) In general, the junction with a sharp angle between the conical shell and the cylindrical or other conical shell, having different angle of slope, is not allowed if the angle of the generating line of the shells to be assembled exceeds 30°.

e) The shell thickness in way of knuckles is subject of special consideration by the Society.

Figure 1 : Conic shells



2.4.6 Minimum thickness of shells

Irrespective of the value calculated by the formulae in [2.4.3], [2.4.4] or [2.4.5], the thickness t of shells is not to be less than one of the following values, as applicable:

- for pressure vessels: $t = 3 + D/1500$ mm
- for unpierced plates of boilers: $t = 6,0$ mm
- for boiler cylindrical tube plates: $t = 9,5$ mm.

No corrosion allowance needs to be added to the above values.

2.4.7 Corrosion allowance

The Society reserves the right to increase the corrosion allowance value in the case of vessels exposed to particular accelerating corrosion conditions. The Society may also consider the reduction of this factor where particular measures are taken to effectively reduce the corrosion rate of the vessel.

2.5 Dished heads subject to pressure on the concave (internal) side

2.5.1 Dished head for boiler headers

Dished heads for boiler headers are to be seamless.

2.5.2 Dished head profile

The following requirements are to be complied with for the determination of the profile of dished heads (see Fig 2 (a) and (b)).

a) Ellipsoidal heads:

$H \geq 0,2\ D$

where:

H : External depth of head, in mm, measured from the start of curvature at the base.

b) Torispherical heads:

$R_{IN} \leq D$

$r_{IN} \geq 0,1\ D$

$r_{IN} \geq 3\ t$

$H \geq 0,18\ D$

where:

R_{IN} : Internal radius of the spherical part, in mm

r_{IN} : Internal knuckle radius, in mm

H : External depth of head calculated by the following formula (see Fig 2 (b)):

$H = R_E - [(R_E - 0,5\ D) \cdot (R_E + 0,5\ D - 2\ r_E)]^{0,5}$

where:

R_E : External radius of the spherical part, in mm

r_E : External knuckle radius, in mm.

2.5.3 Required thickness of solid dished heads

a) The minimum thickness of solid (not pierced) hemispherical, torispherical, or ellipsoidal unstayed dished heads, subject to pressure on the concave (internal) side, is to be not less than the value t, in mm, calculated by the following formula:

$$t = \frac{pDC}{2Ke}$$

where:

C : Shape factor, obtained from the graph in Fig 3, as a function of H/D and t/D.

For other symbols, see [2.4.3].

b) The thickness obtained by the formula in item a) is “net” thickness, as it does not include any corrosion allowance. The thickness obtained by the above formula is to be increased by 0,75 mm. See also [2.4.7].

2.5.4 Composed torispherical heads

a) Torispherical heads may be constructed with welded elements of different thicknesses (see Fig 4).

b) Where a torispherical head is built in two sections, the thickness of the torispherical part is to be obtained by the formula in [2.5.3], while the thickness of the spherical part may be obtained by the formula in [2.4.4].

c) The spherical part may commence at a distance from the knuckle not less than:

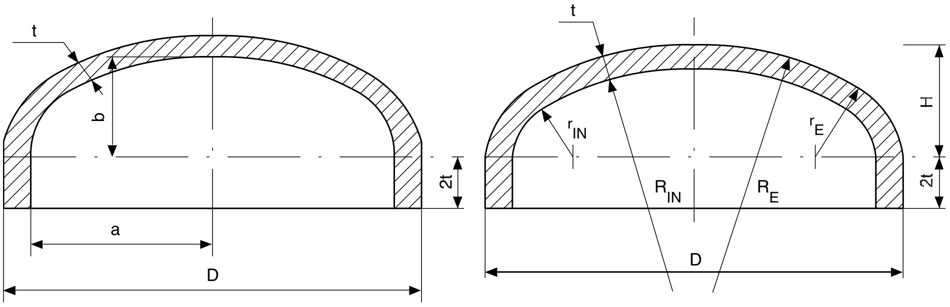
$0,5 \cdot (R_{IN} \cdot t)^{0,5}$

where:

R_{IN} : Internal radius of the spherical part, in mm

t : Knuckle thickness, in mm.

Figure 2 : Dished head profiles



(a) ELLIPSOIDAL HEAD

(b) TORISPHERICAL HEAD

Figure 3 : Shape factor for dished heads

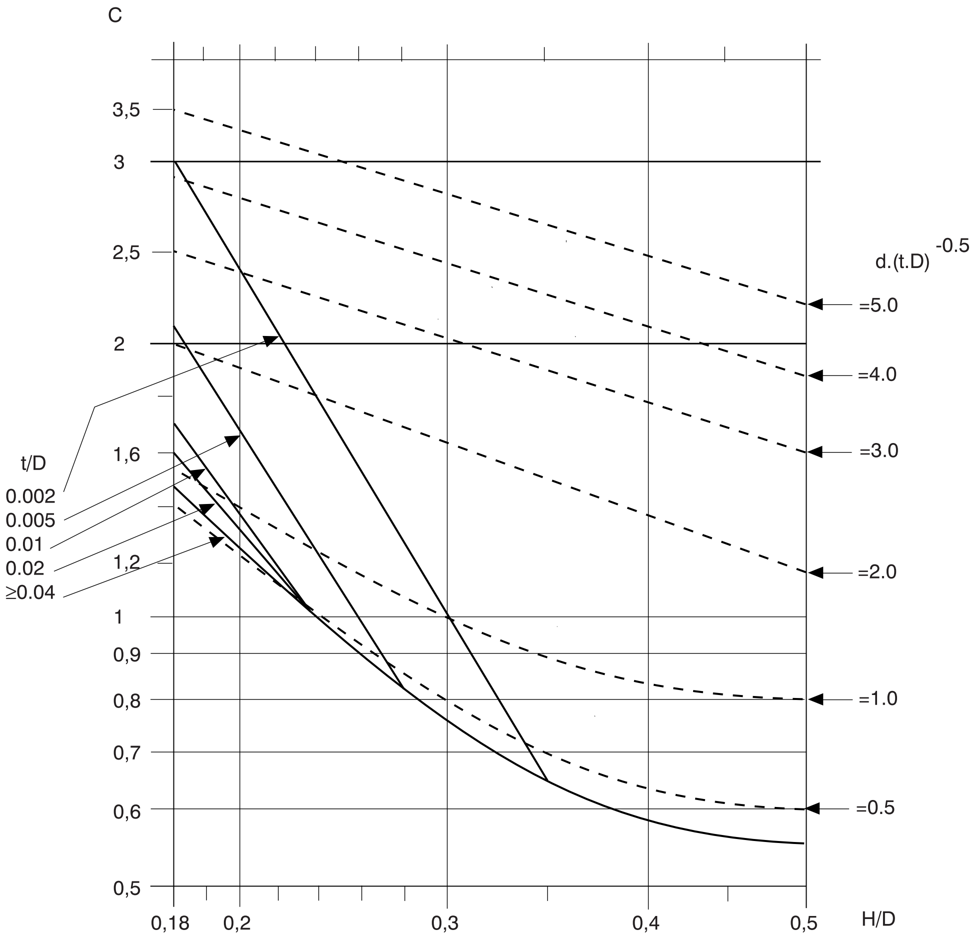
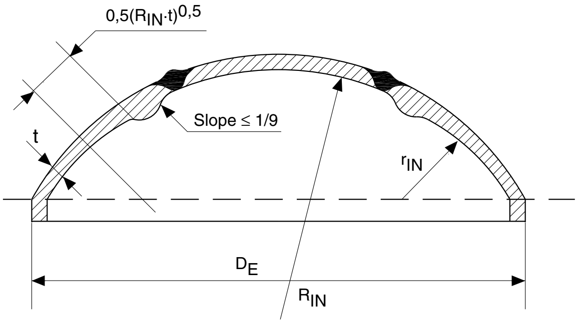


Figure 4 : Composed torispherical head



2.5.5 Minimum thickness of dished heads

Irrespective of the values calculated in [2.5.2] and [2.5.3], the thickness t of dished heads is not to be less than:

- 3 + D_E / 1500 mm for normal pressure vessels
- 6 mm for boiler pressure vessels.

No corrosion allowance needs to be added to the above values.

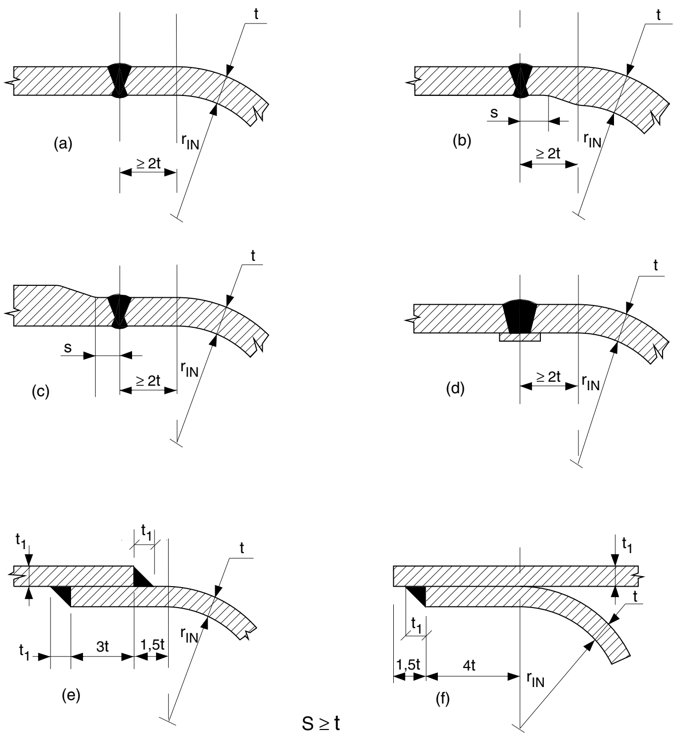
2.5.6 Connection of heads to cylindrical shells

The heads are to be provided, at their base, with a cylindrical skirt not less than 2t in length and with a thickness in no case less than the Rule thickness of a cylindrical shell of the same diameter and the same material, calculated by the formula given in [2.4.3] using the same efficiency factor e adopted for calculation of the head thickness. Fig 5 and Fig 6 show typical admissible attachments of dished ends to cylindrical shells.

In particular, hemispherical heads not provided with the above skirt are to be connected to the cylindrical shell if the latter is thicker than the head, as shown in Fig 5.

Other types of connections are subject to special consideration by the Society.

Figure 5 : Typical attachment of dished heads to cylindrical shells

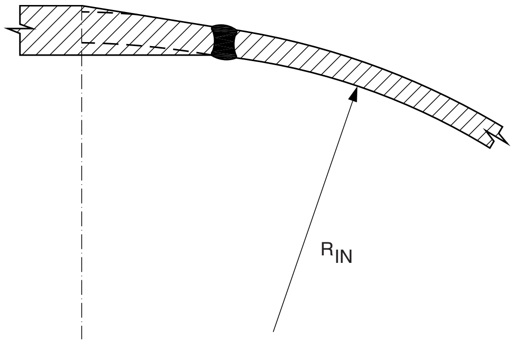


Types shown in (a), (b) and (c) are acceptable for all pressure vessels.

Type shown in (d) is acceptable for class 2 and class 3 pressure vessels.

Types shown in (e) and (f) are acceptable for class 3 pressure vessels only.

Figure 6 : Connection of hemispherical head to the cylindrical shell



2.6 Dished heads subject to pressure on the convex (external) side

2.6.1 The calculation of the minimum thickness is to be performed according to a standard accepted by the Society.

In addition, the thickness of torispherical or ellipsoidal heads under external pressure is no to be less than 1,2 times the thickness required for a head of the same shape subject to internal pressure.

2.7 Flat heads

2.7.1 Unstayed flat head minimum thickness

a) The minimum thickness of unstayed flat heads is not to be less than the value t, in mm, calculated by the following formula:

$$t = D\left(\frac{100p}{CK}\right)^{0,5}$$

where:

p : Design pressure, in MPa

K : Permissible stress, in N/mm², obtained as specified in [2.3]

D : Diameter of the head, in mm. For circular section heads, the diameter D is to be measured as shown in Fig 7 and Fig 8 for various types of heads. For rectangular section heads, the equivalent value for D may be obtained from the following formula:

$$D = a\left[3{,}4 - 2{,}4\left(\frac{a}{b}\right)\right]^{0{,}5}$$

a and b being the smaller and larger side of the rectangle, respectively, in mm

C : The values given below, depending on the various types of heads shown in Fig 7 and Fig 8:

Fig 7(a) : C = 400 for circular heads

Fig 7(b) : C = 330 for circular heads

Fig 7(c) : C = 350 for circular heads

Fig 7(d) : C = 400 for circular heads and
C = 250 for rectangular heads

Fig 7(e) : C = 350 for circular heads and
C = 200 for rectangular heads

Fig 7(f) : C = 350 for circular heads

Fig 7(g) : C = 300 for circular heads

Fig 7(h) : C = 350 for circular heads and
C = 200 for rectangular heads

Fig 8(i) : C = 350 for circular heads and
C = 200 for rectangular heads

Fig 8(j) : C = 200 for circular heads

Fig 8(k) : C = 330 for circular heads

Fig 8(l) : C = 300 for circular heads

Fig 8(m) : C = 300 for circular heads

Fig 8(n) : C = 400 for circular heads

Fig 8(o) : C = value obtained from the following formula, for circular heads:

$$C = \frac{100}{0{,}3 + \frac{1{,}9Fh}{pD^3}}$$

where:

h : Radial distance, in mm, from the pitch centre diameter of bolts to the circumference of diameter D, as shown in Fig 8(o)

F : Total bolt load, in N, to be taken as the greater of the following values F_1 and F_2:

$F_1 = 0{,}785\ D\ p\ (D + m\ b)$

$F_2 = 9{,}81\ y\ D\ b$

with:

b : Effective half contact width of the gasket, in mm, calculated as follows:

$b = 0{,}5\ N$ for $N \leq 13$ mm, and

$b = 1{,}8\ N^{0{,}5}$ for $N > 13$ mm

where N is the geometric contact width of the gasket, in mm, as indicated in Fig 8 (o)

m, y : Adimensional coefficients, whose values are given in Tab 11, depending on the type of gasket.

The adoption of one of the above-mentioned heads is subject to the Society's approval depending upon its use. Types of heads not shown in Fig 7 and Fig 8 are to be the subject of special consideration by the Society.

b) The thickness obtained by the formulae in a) is "net" thickness, as it does not include any corrosion allowance. The thickness obtained by the above formula is to be increased by 1 mm. See also [2.4.7].

2.7.2 Stayed flat head minimum thickness

For the minimum thickness of stayed flat heads, see [2.12.3].

Figure 7 : Types of unstayed flat heads (1)

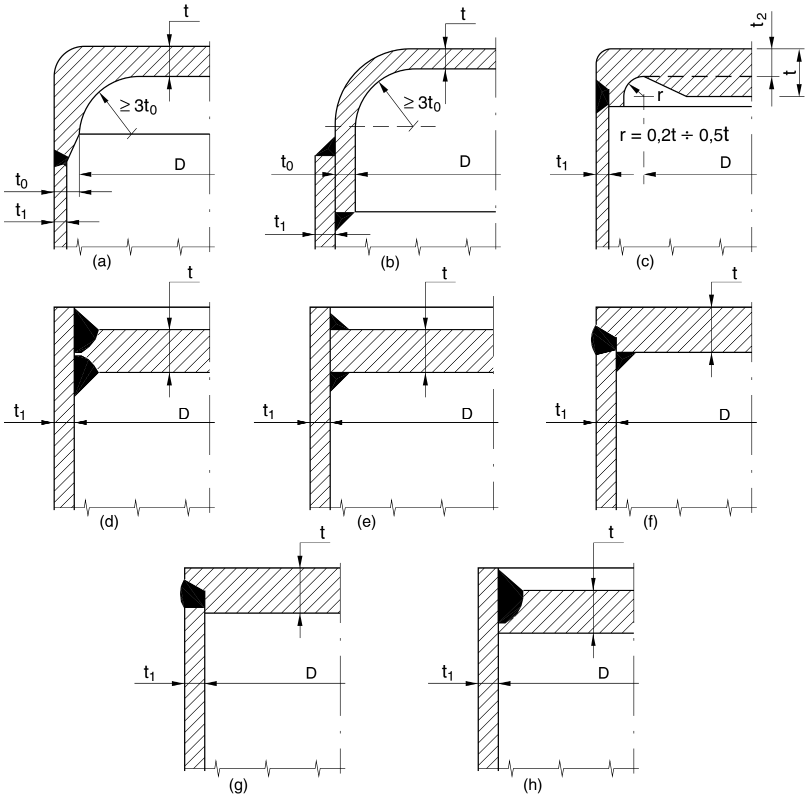


Figure 8 : Types of unstayed flat heads (2)

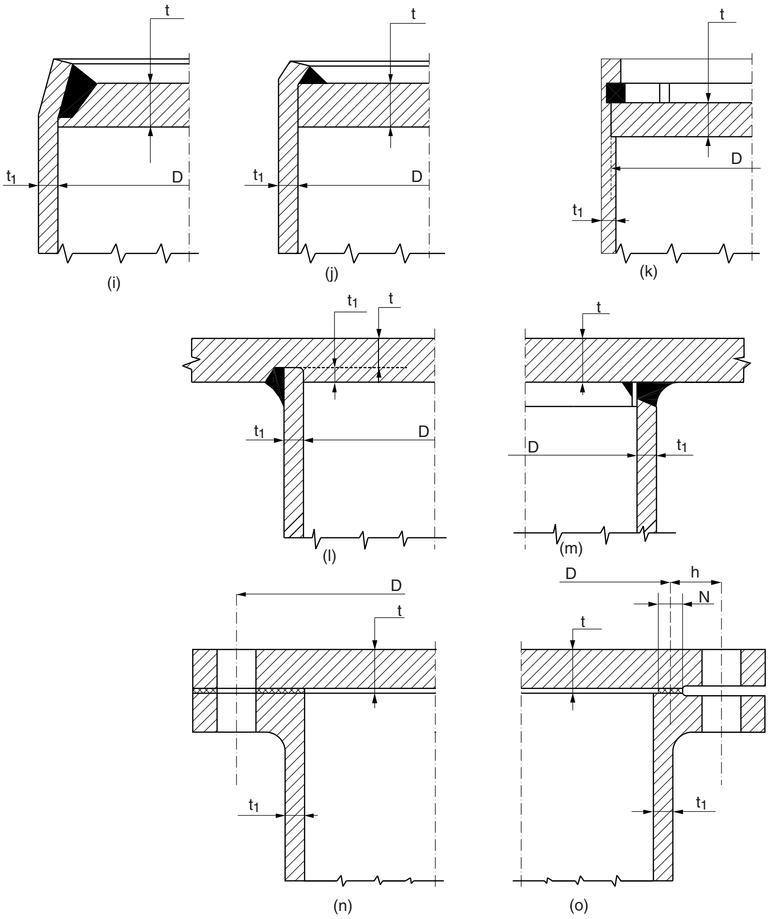


Table 11 : Coefficients m and y

Type of gasket	m	y
Self-sealing, metal or rubber (e.g. O-ring)	0	0
Rubber with cotton fabric	10	0,88
Rubber with reinforcing fabric with or without metal wire:		
- 3 layers	18	4,85
- 2 layers	20	6,4
- 1 layers	22	8,2
Synthetic fibre with suitable binders:		
- 3,0 mm thick	16	3,5
- 1,5 mm thick	22	8,2
Organic fibre	14	2,4
Metal spiral lined with synthetic fibre:		
- carbon steel	20	6,4
- stainless steel	24	9,9
Synthetic fibre with plain metal lining:		
- copper	28	14,0
- iron	30	16,8
- stainless steel	30	20,0
Solid metal:		
- copper	38	28,7
- iron	44	39,8
- stainless steel	52	57,5

2.8 Openings and branches (nozzles)

2.8.1 Nozzles thickness

a) The thickness e_b, in mm, of nozzles attached to shells and headers of boilers is not to be less than:

$$e_b = \frac{d_E}{25} + 2{,}5$$

where d_E is the outside diameter of nozzle, in mm.

The thickness of the nozzle is, however, to be not less than the thickness required for the piping system attached to the vessel shell calculated at the vessel design pressure, and need not to be greater than the thickness of the shell to which it is connected.

b) The thickness of the nozzle attached to shells and headers of other pressure vessels is not to be less than the thickness required for the piping system attached to the vessel shell calculated at the vessel design pressure, and need not be greater than the thickness of the shell to which it is connected.

c) Where a branch is connected by screwing, the thickness of the nozzle is to be measured at the root of the thread.

2.8.2 Nozzle connection to vessel shell

a) In general, the axis of the nozzle is not to form an angle greater than 15° with the normal to the shell.

b) Fig 30 to Fig 33 show some typical acceptable connections of nozzles to shells. Other types of connections are to be considered by the Society on a case by case basis.

2.8.3 Openings in shells

a) In general, the largest dimensions of the openings in shells are not to exceed:

- for shells up to 1500 mm in diameter D_E:

  1/2 D_E, but not more than 500 mm

- for shells over 1500 mm in diameter D_E:

  1/3 D_E, but not more than 1000 mm,

where D_E is the vessel external diameter, in mm.

Greater values may be considered by the Society on a case by case basis.

b) In general, in oval or elliptical openings the ratio major diameter/minor diameter is not to exceed 2.

2.8.4 Openings compensation in cylindrical shells

a) Compensation methods

For cylindrical shells with openings, the efficiency of the main body is to be satisfied by one of the following methods:

- by increasing the wall thickness of main body compared with that of the cylindrical shell without opening: see Fig 9
- by branches which have been provided with a wall thickness of that required on account of the internal pressure: see Fig 10 and Fig 11
- by reinforcing pads or rings analogous to increasing the wall thickness: see Fig 12 and Fig 13
- by a combination of previous reinforcement.

b) Definitions

Effective lengths ℓ_{rs} required for calculation of efficiency and of compensations is to be taken as:

$$\ell_{rs} = \min(\sqrt{Dt_a}, \ell_{s1})$$

where:

D : Outside diameter, in mm

t_a : Available thickness, in mm

ℓ_{s1} : Transition length, in mm, according to Fig 9 and Fig 10.

Figure 9 : Reinforcement by increasing the wall thickness of the main body with opening

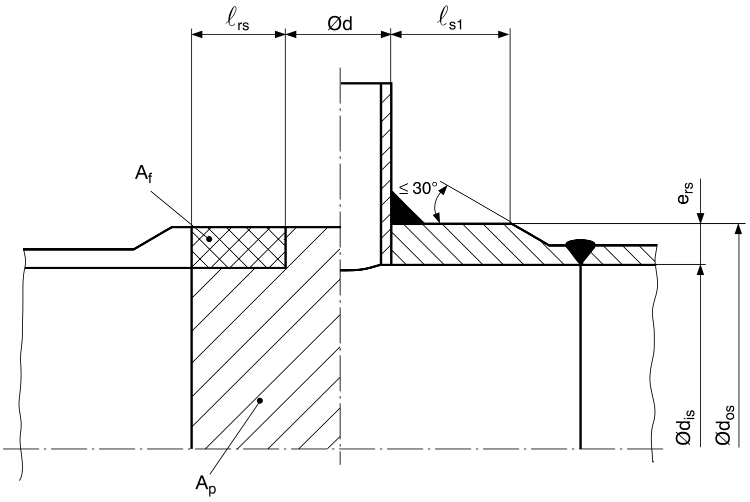
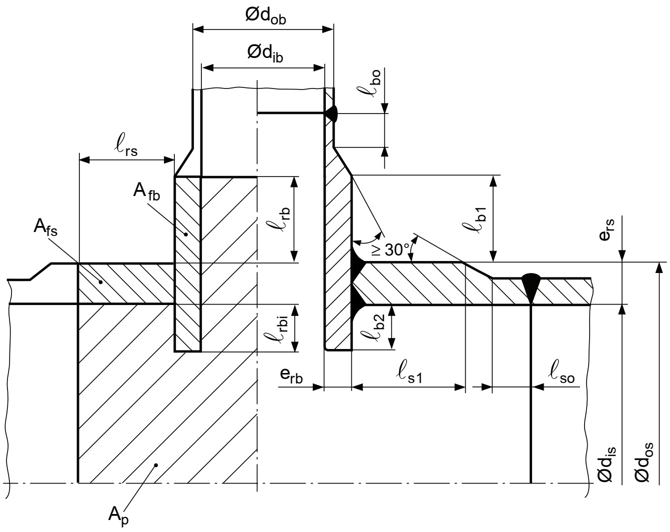


Figure 10 : Reinforcement by set-through and full penetration welded branch



c) Basic calculation

The required wall thickness without allowance of a cylindrical shell is determined with the following formula (see [2.4.3]):

$$t = \frac{pD}{(2K-p)e}$$

With the available thickness t_a, we obtain the available efficiency e_a and the maximum diameter d_{obmax} of an unreinforced opening when the average stress of the main body is equal to the permissible stress K:

$$e_a = \frac{pD_i}{(2K-p)t_a}$$

$$d_{obmax} = 2\left[\frac{\ell_{rs}}{e_a} - \ell_{rs}\right]$$

where:

D_i : Internal diameter of the main body, in mm.

d) Isolated opening reinforcement

The reinforcement of isolated openings as indicated in Fig 9 to Fig 13 are to be in respect with:

$$\frac{A_p}{A_f} \leq \frac{K}{p} - 0{,}5$$

where:

K : Permissible stress in the shell, in N/mm²

A_f : Total area of cross section (wall and branch and pad)

A_p : Total area under pressure p.

In Fig 9 to Fig 13, ℓ_{rs}, ℓ_{rb} and ℓ_{rbi} are effective lengths for calculation of efficiencies and compensation, equal to:

- for shell:

$$\ell_{rs} = \min(\sqrt{(D+e_{rs})e_{rs}}, \ell_{s1})$$

- for external branch projection:

$$\ell_{rb} = \min(\sqrt{(d_{ib}+e_{rb})e_{rb}}, \ell_{b1})$$

- for internal branch projection:

$$\ell_{rbi} = \min(0,5\sqrt{(d_{ib}+e_{rb})e_{rb}}, \ell_{b2})$$

Figure 11 : Reinforcement by welded on branch

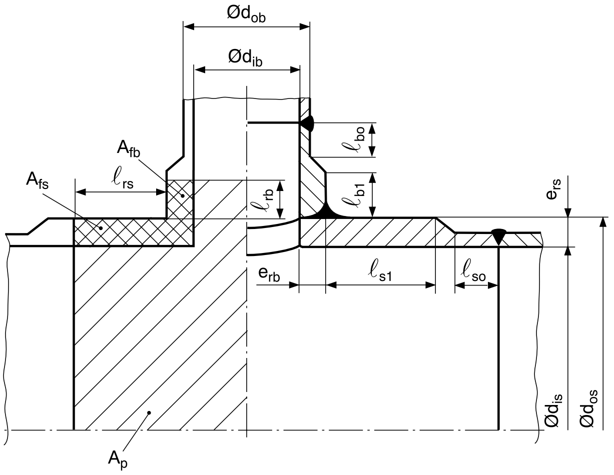


Figure 12 : Opening with reinforcing pad

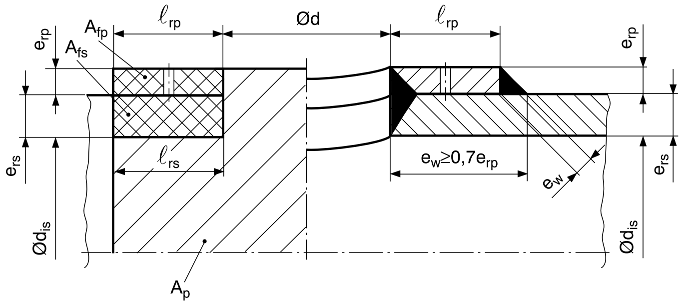
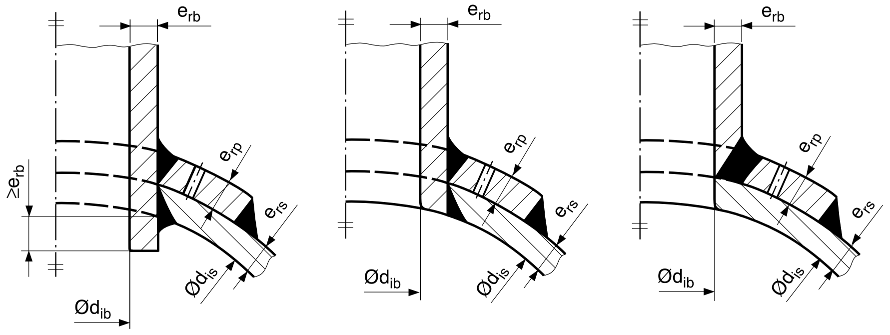


Figure 13 : Opening with reinforcing pad and full penetration branch



a) set through welded branch b) set in welded branch c) set on welded branch

e) Condition of isolated openings

- Full case

  Adjacent openings are to be treated as isolated openings if the centre distance P_ϕ, in accordance with Fig 16, is not less than:

  $$\frac{\left(\frac{d_{ib1}}{2}+e_{rb1}\right)}{\cos\Psi_1}+\frac{\left(\frac{d_{ib2}}{2}+e_{rb2}\right)}{\cos\Psi_2}+2\sqrt{(d_{is}+e_{rs})e_{rs}}$$

  For variable definition see Fig 14 and Fig 15.

- Simplification
  - For openings without branch:

    $e_{rb} = 0$ and $\Psi = 0$
  - For openings with nozzles perpendicular to shell:

    The openings are to be treated as isolated openings if the centre distance P_ϕ in accordance with Fig 16 is not less than:

    $$\left(\frac{d_{ib1}}{2}+e_{rb1}\right)+\left(\frac{d_{ib2}}{2}+e_{rb2}\right)+2\sqrt{(d_{is}+e_{rs})e_{rs}}$$

Figure 14 : Angle definition for cylindrical shell with oblique branch

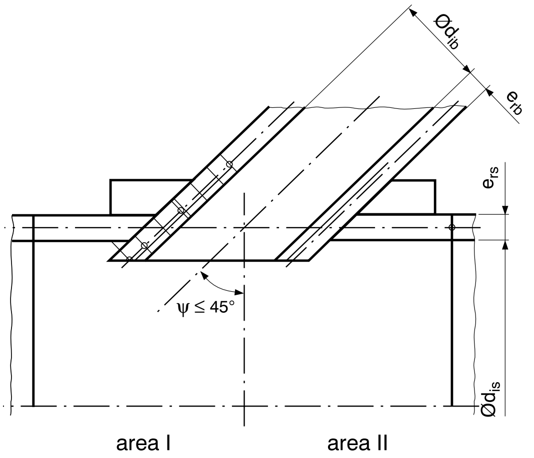
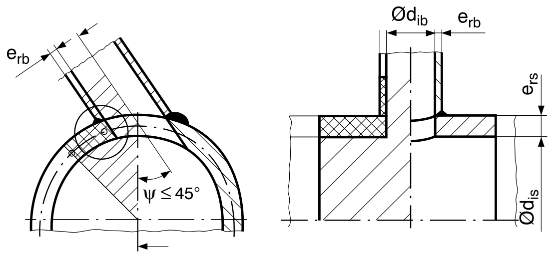


Figure 15 : Angle definition for cylindrical shell with non-radial branch

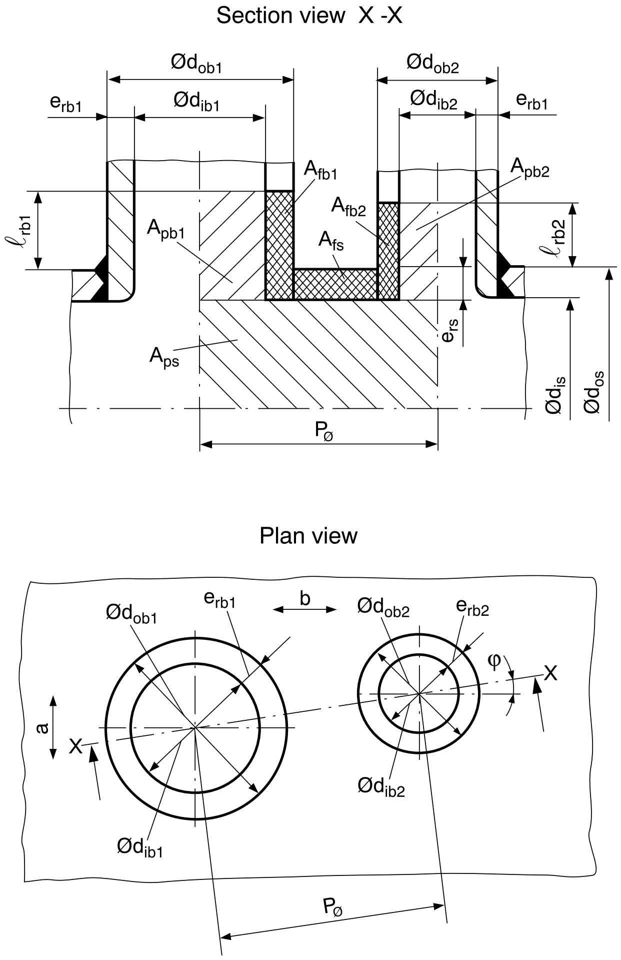


f) Adjacent openings

Where the condition of isolated openings is not fulfilled, the compensation is to be calculated, using Fig 16, as per the following formula:

$$\frac{A_p}{A_f} \le \frac{K}{p} - 0,5$$

Figure 16 : Load diagram for cylindrical shell with adjacent branches



a : Circumferential direction
b : Longitudinal direction

2.8.5 Openings in dished heads

a) The openings in dished heads may be circular, elliptical or oval.

b) The largest diameter of the non-compensated opening is not to exceed one half of the external diameter of the head.

c) The opening is to be so situated that its projection, or its reinforcement projection in the case of compensated openings, is completely contained inside a circle having its centre at the centre of the head and a diameter of 0,8 D, D being the external diameter of the head (see Fig 17). However, a small reinforced opening for drainage may be accepted outside the indicated area.

d) In the case of non-compensated openings (for this purpose, flanged openings are also to be considered as non-compensated), the head thickness is not to be less than that calculated by the formula in [2.5.3] using the greatest of the shape factors C obtained from the graph in Fig 3 as a function of:

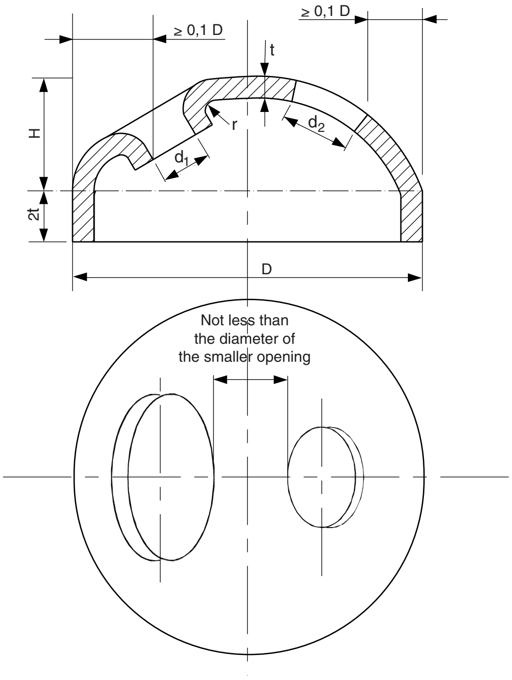
- H / D and t / D, or
- H / D and $d\,(t\,D)^{-0,5}$

where d is the diameter of the largest non-compensated opening in the head, in mm. For oval and elliptical openings, d is the width of the opening in way of its major axis.

e) In all cases the diameter D of the head base, the head thickness t and the diameter d of the largest non-compensated opening are to be such as to meet the following requirements:

- the position of non-compensated openings in the heads is to be as shown in Fig 17
- for flanged openings, the radius r of the flanging (see Fig 17) is not to be less than 25 mm
- the thickness of the flanged part may be less than the rule thickness.

Figure 17 : Openings on dished heads



2.8.6 Opening compensation in dished heads

a) Where openings are cut in dished heads and the proposed thickness of the head is less than that calculated by the formula in [2.5.3] with the greatest of the shape factor C according to [2.5.3] the opening is to be compensated, the openings are to be compensated.

b) Fig 30, Fig 31, Fig 32 and Fig 33 show typical connections of nozzles and compensating rings.

c) The opening is considered sufficiently compensated when the head thickness t is not less than that calculated in accordance with [2.5.3] and using the shape-factor C obtained from the graph in Fig 3 using the value:

$$\left(d - \frac{A}{t}\right)(tD)^{-0,5}$$

instead of:

$d\ (t\ D)^{-0,5}$

where:

A : Area, in mm², of the total transverse section of the compensating parts

t : Actual thickness of the head, in mm, in the zone of the opening under consideration.

d) When A / t > d, the coefficient C is to be determined using the curve corresponding to the value:

$d\ (t\ D)^{-0,5} = 0$

e) If necessary, calculations are to be repeated.

2.8.7 Compensation criteria

In the evaluation of the area A, the following is also to be taken into consideration:

a) The material that may be considered for compensating an opening is that located around the opening up to a distance l from the edge of the opening. The distance l, in mm, is the lesser obtained from the following formulae:

$l = 0,5\ d$

$l = (2\ R_{IN}\ t)^{0,5}$

where:

d : Diameter of the opening, in mm

R_{IN} : Internal radius of the spherical part, in mm, in the case of hemispherical or torispherical heads

In the case of ellipsoidal heads, R_{IN} is to be calculated by the following formula (see Fig 2 (a):

$$R_{IN} = \frac{[a^4 - x^4(a^2 - b^2)]^{3/2}}{a^4 b}$$

where:

a : Half the major axis of the elliptical meridian section of the head, in mm

b : Half the minor axis of the above section, in mm

x : Distance between the centre of the hole and the rotation axis of the shell, in mm.

b) In the case of nozzles or pads welded in the hole, the section corresponding to the thickness in excess of that required is to be considered for the part which is subject to pressure and for a depth h, in mm, both on the external and internal sides of the head, not greater than:

$(d_B\ t_B)^{0,5}$

where d_B and t_B are the diameter of the opening and the thickness of the pad or nozzle, in mm, respectively.

c) The area of the welding connecting nozzle and pad reinforcements may be considered as a compensating section.

d) If the material of reinforcement pads, nozzles and collars has a permissible stress lower than that of the head material, the area A, to be taken for calculation of the coefficient C, is to be reduced proportionally.

2.8.8 Openings in flat end plates

The maximum diameter of an unreinforced opening in a flat end plate is to be determined from the equation:

$$d_{max} = 8e_{rh}\left[1,5\frac{e_{rh}^2}{e_{ch}^2} - 1\right]$$

where:

e_{rh} : Actual thickness of the flat end, in mm

e_{ch} : Required calculated thickness of the flat end, in mm.

2.8.9 Opening compensation in flat end plate

Reinforcement of branch openings is to be achieved by taking account of locally disposed material, including the attachment welds, in excess of the minimum requirements for end plate and branch thickness as shown in Fig 18. The branch thickness is to be increased where required. Compensation is to be considered adequate when the compensating area Y is equal to or greater than the area X requiring compensation.

Area X is to be obtained by multiplying 25% of the inside radius of the branch by the thickness of the flat end plate, calculated for the part of the end plate under consideration.

Area Y is to be measured in a plane through the axis of the branch parallel to the surface of the flat end plate, and is to be calculated as follows:

a) For that part of the branch which projects outside the boiler, calculate the full sectional area of the branch up to a distance ℓ_b from the actual outer surface of the flat end plate and deduct from it the sectional area that the branch would have within the same distance if its thickness were calculated in accordance with equation given in [2.4.3]

b) Add to it the full sectional area of that part of the branch that projects inside the boiler (if any) up to a distance ℓ_b from the inside surface of the flat end plate

c) Add to it the sectional area of the fillet welds

d) Add to it the area obtained by multiplying the difference between the actual flat end plate thickness and its thickness calculated for the part of the end plate under consideration by the length ℓ_s

e) Add to it the area of the compensating plate (if any) within the limits of reinforcement shown in Fig 18.

Where material having a lower allowable stress than that of the flat end plate is taken as compensation, its effective area is to be reduced in the ratio of the allowable stresses at the calculation temperature. No credit is to be taken for the additional strength of material having a higher allowable stress than that of the flat end plate

Welds attaching branches and compensating plates are to be capable of transmitting the full strength of the reinforcing area and all other loadings to which they may be subjected.

2.8.10 Covers

a) Circular, oval and elliptical inspection openings are to be provided with steel covers. Inspection openings with a diameter not exceeding 150 mm may be closed by blind flanges.

b) The thickness of the opening covers is not to be less than the value t, in mm, given by the following formula:

$$t = 1,22a\left(\frac{pC}{K}\right)^{0,5}$$

where:

a : The minor axis of the oval or elliptical opening, measured at half width of gasket, in mm

b : The major axis of the oval or elliptical opening, measured at half width of the gasket, in mm

C : Coefficient in Tab 12 as a function of the ratio b/a of the axes of the oval or elliptical opening, as defined above. For intermediate values of the ratio b/a, the value of C is to be obtained by linear interpolation.

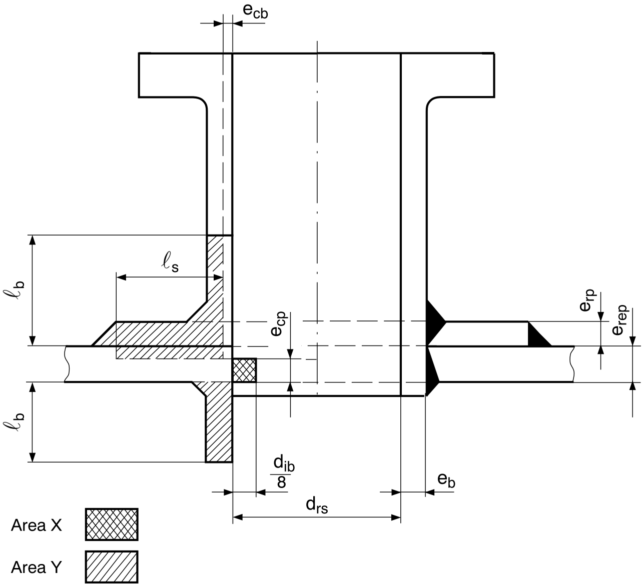
For circular openings the diameter d, in mm, is to be used in the above formula instead of a.

c) The thickness obtained by the formula in item a) is “net” thickness, as it does not include any corrosion allowance. The thickness obtained by the above formula is to be increased by 1 mm for classification purpose. See also [2.4.7].

Table 12 : Coefficient C for oval or elliptical covers

b/a	1,00	1,05	1,10	1,15	1,20	1,25	1,30	1,40	1,50	1,60
C	0,206	0,220	0,235	0,247	0,259	0,271	0,282	0,302	0,321	0,333
b/a	1,70	1,80	1,90	2,00	2,50	3,00	3,50	4,00	4,50	5,00
C	0,344	0,356	0,368	0,379	0,406	0,433	0,449	0,465	0,473	0,480

Figure 18 : Compensation for branch in flat end plate



e_{cp} : Thickness calculated in accordance with equation in [2.8.1] for the part under consideration

e_{cb} : Thickness calculated taking efficiency = 1

ℓ_b : The smaller of the two values: 2,5 e_{rep} and (2,5 e_b + e_{rp})

ℓ_s : The greater of the two values: (e_{rep} + 75) and (d_{ib} / 4)

Area Y is not to be less than area X.

The compensating plate is required only in cases where area Y would otherwise be less than area X.

2.9 Regular pattern openings - Tube holes

2.9.1 Definition

Openings may be considered as regular pattern openings when not less than three non isolated openings are disposed in regularly staggered rows in longitudinal or circular direction of a shell.

In such a case, instead of a direct calculation of the compensation of openings, the thickness of the shell could be calculated by application of applicable formulae given in [2.4], [2.5] with a reduced efficiency e as indicated in [2.9.2] and [2.9.3].

This requirement apply for pressure vessels and for boiler.

2.9.2 Efficiency factor of tube holes in cylindrical tube plates

The efficiency factor e of pipe holes in cylindrical shells pierced by tube holes is to be determined by direct calculation or by another suitable method accepted by the Society. In the case of cylindrical holes of constant diameter and radial axis, the efficiency factor e may be determined by the following formula (see Fig 19):

$$e = \frac{1}{\frac{s}{s-d}[1-(0,5\sin^2\alpha)]+m\sin2\alpha}$$

where:

s : Pitch of the hole row considered, in mm

d : Diameter of holes, in mm. The hole diameter d may be reduced by the amount Y/e_{cp} where Y is the compensating area, in mm², of nozzle and welds and e_{cp} the calculated unpierced shell thickness, see [2.8.9] and Fig 18

α : Angle between the axis of hole row considered and the axis of the cylinder (α = 0° if the hole row is parallel to the cylinder generating line; α = 90° for circumferential hole row)

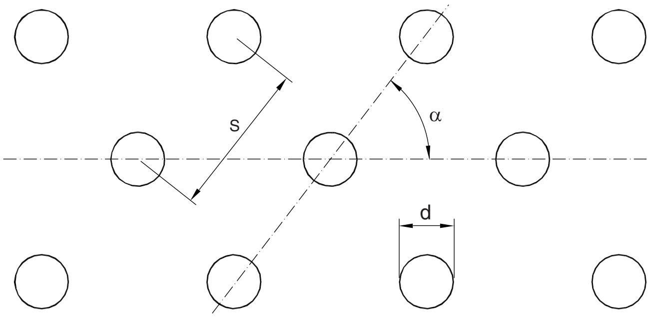
m : Coefficient depending upon the ratio d/s, as obtained from Tab 13. For intermediate values of d/s, the value of m is to be obtained by linear interpolation.

The value of e actually used is to be the smallest calculated value for either longitudinal, diagonal or circumferential rows of holes.

Table 13 : Coefficient m

d/s	0,30	0,35	0,40	0,45	0,50	0,55	0,60	0,65	0,70	0,75	0,80
m	0,137	0,175	0,220	0,274	0,342	0,438	0,560	0,740	1,010	1,420	2,060

Figure 19 : Hole pattern in cylindrical shells



2.9.3 Welded shells with tube holes and efficiency factor of different hole patterns

Where shells have welding butts and/or different groups of hole patterns, the value to be assumed for the efficiency e in the formulae is the minimum of the values calculated separately for each type of welding (as per [2.4.2]) and for each configuration of holes (as per [2.9.1]).

2.9.4 Rectangular section headers

a) For seamless type headers of rectangular section design, the wall thickness t, in mm, in way of corner fillets and the thickness t_1, in mm, of any drilled wall is not to be less than those given by the following formulae, as appropriate (see Fig 20):

$$t = \left(\frac{100pM_1}{K}\right)^{0,5}$$

$$t_1 = \left(\frac{100pM_2}{eK}\right)^{0,5}$$

where (see also Fig 20):

t : Wall thickness at the corners, in mm

t_1 : Thickness of drilled wall, in mm

p : Design pressure, in MPa

K : Permissible stress, in N/mm^2, obtained as specified in [2.3]

a : Internal half width of the header, in a direction parallel to the wall under consideration, in mm

b : Internal half width of the header, in a direction normal to the wall under consideration, in mm

c : Distance between the axis of the hole row considered and the centreline of the header wall, in mm

e : Efficiency factor of holes in the wall, determined by the following formulae:

$$e = \frac{s-d}{s} \qquad \text{for } d < a$$

$$e = \frac{s-0,67d}{s} \qquad \text{for } a \le d < 1,3a$$

$$e = \frac{s-0,33d}{s} \qquad \text{for } d \ge 1,3a$$

where:

s : Pitch of the holes, in mm, of the longitudinal or diagonal row under consideration. For a staggered pattern of holes the pitch of the diagonal row is to be considered

d : Diameter of the holes, in mm

M_1 : Coefficient to be calculated by the following formula:

$$M_1 = \frac{a^2 + b^2 - ab}{50}$$

M_2 : Coefficient (to be taken always positive) to be calculated by one of the following formulae, as appropriate:

- for a non-staggered pattern of holes:

$$M_2 = \frac{b^2 - \frac{1}{2}a^2 - ab + \frac{3}{2}c^2}{50}$$

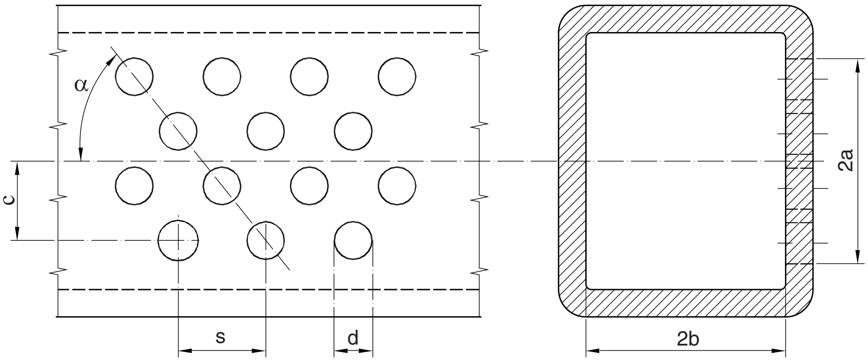
- for a staggered pattern of holes:

$$M_2 = \frac{b^2 - \frac{1}{2}a^2 - ab}{50}\cos\alpha$$

where α is the angle between the axis of the diagonal row of the holes under consideration and the axis of the header, in the case of a staggered pattern of holes.

b) The thickness obtained by the formulae in a) is “net” thickness, as it does not include any corrosion allowance. The thickness obtained by the above formula is to be increased by 1,5 mm. See also [2.4.7].

Figure 20 : Rectangular section headers



2.10 Water tubes, superheaters and economiser tubes of boilers

2.10.1

a) The thickness of tubes of evaporating parts, economisers and superheaters exposed to gases which are subject to internal pressure is not to be less than the value t given by the following formula:

$$t = \frac{pd}{2K + p} + 0{,}3$$

where:

p : Design pressure, in MPa

K : Permissible stress, in N/mm^2, obtained as specified in [2.3]

d : Outside diameter of tube, in mm.

However, irrespective of the value calculated by the formulae in item a), the thickness t of tubes is not to be less than the values given in Tab 14.

b) The values of t determined by the above-mentioned formula are to be considered as theoretical values for straight tubes, not taking account of the manufacturing tolerance. Where the tubes are not sized precision tubes, the thickness calculated by the formula in item a) is to be increased by 12,5% to take into account the manufacturing tolerance. For bent tubes, the thickness of the thinner part in way of the bend is not to be less than that given by the formula.

c) Whenever abnormal corrosion and erosion may occur during service, the corrosion constant of 0,3 in the formula may be increased to the satisfaction of the Society.

d) The thickness of tubes which form an integral part of the boiler and which are not exposed to combustion gases is to comply with the requirements for steam pipes (see Ch 1, Sec 7, [15]).

Table 14 : Minimum thickness of water tubes

Outside diameter, in mm	Minimum thickness, in mm, of tubes subject to internal pressure of cylindrical boilers and water tube boilers having the feed water system	
	Closed type, if equipped with suitable devices for reducing the oxygen concentration in the water	Open type, not equipped with suitable devices for reducing the oxygen concentration in the water
< 38	1,8	2,9
38 - 48,3	2,0	2,9
51 - 63,5	2,4	2,9
70	2,6	3,2
76,1 - 88,9	2,9	3,2
101,6 - 127	3,6	–

2.11 Additional requirements for fired pressure vessels

2.11.1 Insulation for headers and combustion chambers

Those parts of headers and/or combustion chambers which are not protected by tubes and are exposed to radiant heat or to high temperature gases are to be covered by suitable insulating material.

2.11.2 Connections of tubes to drums and tube plates

Tubes are to be adequately secured to drums and/or tube plates by expansion, welding or other appropriate procedure.

a) Where the tubes are secured by expanding or equivalent process, the height of the shoulder bearing the tube, measured parallel to the tube axis, is to be at least 1/5 of the hole diameter, but not less than 9 mm for tubes normal to the tube plate or 13 mm for tubes angled to the tube plate. The tubes ends are not to project over the other face of the tube plate more than 6 mm.

b) The tube ends intended to be expanded are to be partially annealed when the tubes have not been annealed by the manufacturer.

2.12 Additional requirements for vertical boilers and fire tube boilers

2.12.1 General

The scantlings of the shells of vertical boilers and fire tube boilers are to be determined in accordance with [2.4].

2.12.2 Ends of vertical boilers

a) The minimum thickness of the dished ends forming the upper part of vertical boilers and subject to pressure on their concave face is to be determined in accordance with [2.5].

b) When the end is supported in its centre by an uptake, the minimum thickness t, in mm, is to be calculated with the following formula:

$$t = 0{,}77\frac{pR_I}{K}$$

where:

p : Design pressure, in MPa

K : Permissible stress, in N/mm^2, obtained as specified in [2.3]

R_I : Radius of curvature at the centre of the end measured internally. R_I is not to exceed the external diameter of the shell.

c) The thickness obtained by the formula in item b) is “net” thickness, as it does not include any corrosion allowance. The thickness obtained by the above formula is to be increased by 0,7 mm. See also [2.4.7].

d) For ends supported by an uptake at their centre, the corner radius measured internally is not to be less than 4 times the end thickness or 65 mm, whichever is the lesser and the inside radius of curvature on the flange to uptake is not to be less than twice the end thickness or 25 mm, whichever is the lesser.

2.12.3 Supported flat head

a) Breathing space

- Stays are to give breathing space around the furnace tube connections and tube nests and equally divide the unstayed areas. Breathing space between furnace tube and tube nests are to be a minimum of 50 mm or 5% of the shell outside diameter, whichever is the larger, but need not be more than 100 mm.
- Breathing space between furnace tube and shell depends on the thickness of the plate of the type of end and of the dimensions of the boiler but is to be not less than 50 mm or, for bowling hoop furnaces tubes, not less than 75 mm.

b) The thickness of stayed flat heads, or of heads supported by flanges, is not to be less than the value t, in mm, given by the following formula:

$$t = D\left[\frac{100p}{CC_1K(1 + C_2B^2)}\right]^{0{,}5}$$

where:

B : Ratio of the thickness of the large washer or doubler, where fitted, to the thickness of the plate:

$B = t_1 / t$

The value of B is to be taken between 0,67 and 1

K : Permissible stress, in N/mm^2, obtained as specified in [2.3]

C :
- C = 1,00 when the plate is not exposed to flame
- C = 0,88 when the plate is exposed to flame

C_1 :
- C_1 = 462 when the plate is supported by welded stay
- C_1 = 704 for plates supported by flanges or equivalent

C_2 :
- C_2 = 0 when no doublers are fitted
- C_2 = 0,85 when a complete doubling plate is fitted, adequately joined to the base plate.

The value of D is to be in accordance with the following provisions:

- In the parts of the flat heads between the stays:

  D : Diameter, in mm, of the largest circle which can be drawn through the centre of at least three stays without enclosing any other stay, where the stays are not evenly spaced (see Fig 21); or

  $D = (a^2 + b^2)^{0,5}$ where the stays are evenly spaced, considering the most unfavourable condition

  where:

  a : Distance between two adjacent rows of stays, in mm

  b : Pitch of stays in the same row, in mm.

- In the parts of the flat heads between the stays and the boundaries, where flat heads are generally supported by flanges or shapes, or connected to other parts of the boiler:

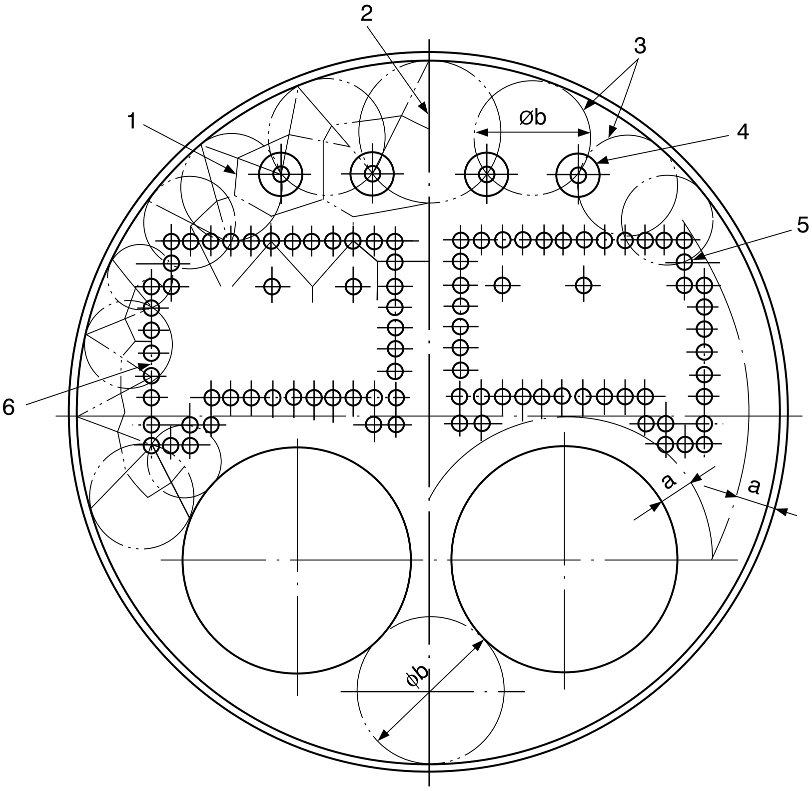
  D : Diameter, in mm, of the largest circle which can be drawn through not less than three points of support (stay centres or points of tangency of the circle with the contour line). To this end, the contour of the part under consideration is to be drawn at the beginning of the flanging or connection curve if its inside radius does not exceed 2,5 times the thickness of the plate, or, where such radius is greater, at the above-mentioned distance (of 2,5 times the thickness of the plate) from the ideal intersection with other surfaces (see Fig 21).

c) When applying the formulae for calculation of thickness of heads covered by this sub-article, the position of plates in the most unfavourable condition is to be considered.

d) Where various types of supports are provided, the value of C_1 should be the arithmetic mean of the values of C_1 appropriate to each type of support.

e) The thickness obtained by the formulae in a), is "net" thickness, as it does not include any corrosion allowance. The thickness obtained by the above formula is to be increased by 1 mm. See also [2.4.7].

Figure 21 : Flat heads



Key:

1 : Boundaries of areas supported by individual stays

2 : To establish the area supported by bar stays or stay tubes in boundary rows, the boundary of the loaded area is to terminate at the centre of the associated main circle

3 : Main circles, diameter b

4 : Bar stays

5 : Stay tubes

6 : Termination of boundary areas where stay tubes are situated in the boundary rows only.

2.12.4 Flat tube plates

a) Flat tube plates in tube bundles

The thickness of the parts of flat tube plates contained in the tube bundle and supported by stay tubes is not to be less than the value t, in mm, given by the following formula:

$$t = s\left(\frac{p}{2{,}8K}\right)^{0{,}5}$$

where:

p : Design pressure, in MPa

K : Permissible stress, in N/mm², obtained as specified in [2.3]

s : Pitch of stay tubes, taken as the greatest mean pitch of the stay tubes supporting a quadrilateral portion of the plate, in mm.

Moreover the spacing of tube holes (diameter d) is to be such that the minimum width, in mm, of any ligament between the tube holes is to be not less than:

- for expanded tubes: (0,125 d + 12,5) mm
- for welded tubes:
  - for gas entry temperatures greater than 800°C: (0,125 d + 9) mm, but need not exceed 15 mm
  - for gas entry temperatures less than or equal to 800°C: 0,125 d + 7) mm, but need not exceed 15 mm.

Moreover the calculated thickness of tube plates is to be not less than the following:

- 12 mm where the tubes are expanded into the tube plate when the diameter of the tube hole does not exceed 50 mm, or 14 mm when the diameter of the tube hole is greater than 50 mm, or
- 6 mm where the tubes are attached to the tube plate by welding only.

b) Flat tube plates of combustion chamber in vertical boilers

Where tube plates contained in the tube bundle are simultaneously subject to compression due to the pressure in the combustion chamber, their thickness, as well as complying with the requirements in item a) is not to be less than the value t, in mm, given by the following formula:

$$t = \frac{p l s_1}{1{,}78(s_1 - d)K}$$

where:

l : Depth of the combustion chamber, in mm

s_1 : Horizontal pitch of tubes, in mm

d : Inside diameter of plain tubes, in mm.

For the meaning of other symbols, see item a).

c) Tube plates outside tube bundles

For those parts of tube plates which are outside the tube bundle, the formula in [2.13.3] is to be applied, using the following coefficients C_1 and C_2:

$C_1 = 390$

$C_2 = 0{,}55$

Doublers are only permitted where the tube plate does not form part of a combustion chamber.

d) Tube plates not supported by stays

Flat tube plates which are not supported by stay tubes (e.g. in heat exchangers), are subject of special consideration by the Society (see also [2.14]).

e) Stay and stay tube scantling

- The diameter of solid stays of circular cross-section is not to be less than the value d calculated by the following formula:

  $$d = \left(\frac{pA}{K}\right)^{0{,}5}$$

  where:

  d : Minimum diameter, in mm, of the stay throughout its length

  A : Area supported by the stay, in mm²

  K : $K = R_m / 7$

  R_m : Minimum ultimate tensile strength of the stay material, in N/mm².

  The cross section of tube stays is to be equivalent to that of a solid stay supporting the same area, whose diameter is calculated by the above formula.

  Stays which are not perpendicular to the supported surface are to be of an adequately increased diameter depending on the component of the force normal to the plate.

- Where articulated stays are used, articulation details are to be designed assuming a safety factor for articulated elements not less than 5 with respect to the value of R_m and a wear allowance of 2 mm.

  The articulation is to be of the fork type and the clearance of the pin in respect of the holes is not to exceed 1,5 mm. The pin is to bear against the jaws of the fork and its cross-sectional area is not to be less than 80% of the cross-sectional area of the stay. The width of material around the holes is not to be less than 13 mm.
- Where stays are flanged for joining to the plate, the thickness of the flange is not to be less than one half the diameter of the stay.
- For welded connections of stays to tube plates, see Fig 37.

f) Stay and stay tubes construction

- In general, doublers are not to be fitted in plates exposed to flame.
- As far as possible, stays are to be fitted perpendicularly to the supported surface.
- Long stays in double front boilers and, in general, stays exceeding 5 m in length, are to be supported at mid-length.
- Where the ends of stay tubes are of increased thickness, the excess material is to be obtained by forging and not by depositing material by means of welding.
- After forging, the ends of stay tubes are to be stress relieved.

g) Gusset stays

Tube plate may be supported by gussets stays with full penetration welds to plate and shell.

The general shape and the scantling are to be in accordance with a standard accepted by the Society.

h) Girders

Where tops of combustion chambers, or similar structures, are supported by girders of rectangular section associated with stays, the thickness of the single girder or the aggregate thickness of all girders, at mid-length, is not to be less than the value t determined by the appropriate formula below, depending upon the number of stays.

- In case of an odd number of stays:

$$t = \frac{pL(L-s)l}{0{,}25 R_m a^2} \cdot \frac{n+1}{n}$$

- In case of an even number of stays:

$$t = \frac{pL(L-s)l}{0{,}25 R_m a^2} \cdot \frac{n+2}{n+1}$$

where:

p : Design pressure, in MPa
a : Depth of the girder plate at mid-length, in mm
L : Length of girder between supports, in mm
s : Pitch of stays, in mm
n : Number of stays on the girder
l : Distance between centres of girders, in mm
R_m : Minimum ultimate tensile strength of the material used for the plates, in N/mm^2.

The above formulae refer to the normal arrangement where:

- The stays are regularly distributed over the length L.
- The distance from the supports of the outer stays does not exceed the uniform pitch s.
- When the tops of the combustion chambers are connected to the sides with curved parts with an external radius less than 0,5 l, the distance of end girders from the inner part of the side surface does not exceed l.
- When the curvature radius mentioned under item just above exceeds 0,5 l, the distance of the end girders from the beginning of the connection does not exceed 0,5 l.

In other cases a direct calculation is to be made using a safety factor not less than 5, with respect to the minimum value of the tensile strength R_m.

i) Ogee rings

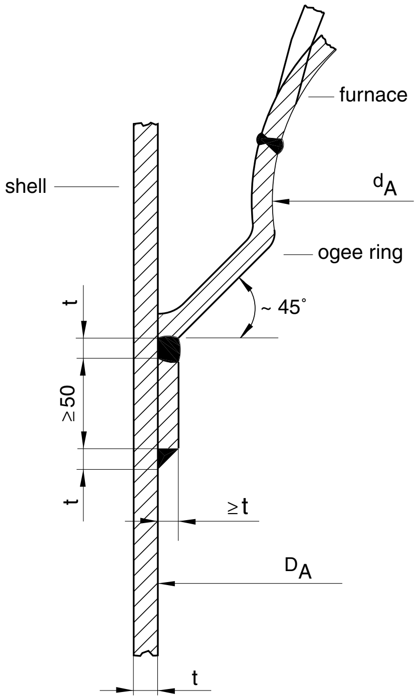
The thickness of ogee rings connecting the furnaces to the shell in vertical auxiliary boilers (see Fig 22), where the latter support the weight of the water above the furnace, is not to be less than the value t, in mm, given by the following formula:

$t = [1{,}02 \cdot 10^{-3}\ p\ D_A\ (D_A - d_A)]^{0{,}5} + 1$

where:

p : Design pressure, in MPa
D_A : Inside diameter of boiler shell, in mm
d_A : Inside diameter of the lower part of the furnace where it joins the ogee ring, in mm.

Figure 22 : Ogee ring



2.12.5 Fire tubes

a) The thickness of fire tubes subject to external pressure in cylindrical boilers is not to be less than the value t, in mm, calculated by the following formula:

$$t = \frac{pd}{0{,}15R_m} + 1{,}8$$

where:

p : Design pressure, in MPa

d : Outside diameter of tube, in mm

R_m : Minimum ultimate tensile strength of the tube material, in N/mm^2.

The minimum acceptable thickness is given in Tab 15.

b) The values of t determined by the above-mentioned formula are to be considered as theoretical values for straight tubes, not taking account of the manufacturing tolerance. Where the tubes are not sized precision tubes, the thickness calculated by the formula in a) is to be increased by 12,5% to take into account the manufacturing tolerance. In the case of bent tubes, the thickness of the thinner part in way of the bend is not to be less than that given by the above formula.

c) Whenever abnormal corrosion and erosion may occur during service the corrosion constant of 1,8 in the formula may be increased to the satisfaction of the Society.

Table 15 : Minimum thickness of fire tubes

Nominal outside diameter	Lowest nominal thickness t
d ≤ 88,9	3,00
88,9 < d ≤ 114,3	3,15
114,3 < d ≤139,7	3,50
139,7 < d ≤168,3	3,99

2.12.6 Furnaces general points

a) Thermal design of furnace tubes.

The heat input for a given furnace tube inside diameter is not to exceed a value compatible with the chosen design temperature. Burners with a fixed firing rate are not to be used for heat inputs exceeding 1 MW per furnace tube.

b) The minimum thickness of furnaces is to be calculated for elastic buckling and plastic deformation in accordance with the requirements of a Standard for pressure vessels subject to external pressure accepted by the Society.

c) However, the minimum thicknesses of furnaces and cylindrical ends of combustion chambers of fire tube boilers are to be not less than the value t given by the appropriate formulae in [2.12.7], [2.12.8] and [2.12.9].

d) The thickness of furnaces is not to be less than 8 mm for plain furnace and 10 mm for corrugated furnace and the stays are to be spaced such that the thickness does not exceed 22 mm.

e) All the thicknesses obtained for furnaces by the formulae in [2.12.7], [2.12.8], [2.12.9] and [2.12.4] are "net" thicknesses, as they do not include any corrosion allowance. The thicknesses obtained by the above formulae are to be increased by 1 mm. See also [2.4.7].

2.12.7 Plain furnace tubes

a) Plain furnace tube

The minimum thickness t of plain cylindrical furnaces is to be not less than the greater value, in mm, obtained from the following formulae:

$$t = \frac{B}{2}\left[1 + \sqrt{1 + \frac{0,12Du}{(1+5D/L)B}}\right]$$

$$t = D^{0,6}\left[\frac{LS_2p}{2,6E}\right]^{0,4}$$

where:

$$B = \frac{pDS_1}{2R_{S,MIN,T}(1+5D/L)}$$

S_1 : Safety factor, equal to 2,5

L : Unstayed length of furnace, in mm

u : Departure from circularity, in %, equal to:

$$u = \frac{2(D_{max} - D_{min})}{D_{max} + D_{min}} \cdot 100$$

u is to be taken as 1,5% for plain furnace tubes

S_2 : Safety factor for buckling, equal to:

- 3 for $u \leq 1,5\%$
- 4 for $1,5\% < u \leq 2\%$

E : Elastic modulus, in MPa, at design temperature T, in °C, and equal to:

$E = 208800 - 93,4\ T$

b) Stiffeners

Stiffeners welded to furnaces tubes according to a standard accepted by the Society may be considered as providing effective stiffening (reduction of L in upper formulae).

2.12.8 Corrugated furnace tubes

The minimum thickness of corrugated furnace tubes, in mm, is to be determined by:

$$t = \frac{pD_E}{0,26R_m}$$

where:

D_E : External diameter of the furnace, in mm, measured at the bottom of the corrugation.

This formula apply for Fox and Morisson type furnaces tubes. The scantling of furnaces of other types and the use of stiffeners are to be especially considered by the Society.

2.12.9 Hemispherical furnaces

The minimum thickness t, in mm, of hemispherical furnaces is not to be less than the value given by the following equation:

$$t = \frac{pD_E}{120}$$

2.13 Bottles containing pressurised gases

2.13.1 General

a) The following requirements apply to bottles intended to contain pressurised and/or liquefied gases at ambient temperature, made by seamless manufacturing processes.

b) In general, such bottles are to have an outside diameter not exceeding 420 mm, a length not exceeding 2000 mm and a capacity not exceeding 150 litres (see also [3.4.1]).

c) For bottles exceeding the above capacity and dimensions, the following requirements may be applied at the discretion of the Society.

2.13.2 Cylindrical shell

The wall thickness of the cylindrical shell is not to be less than the value t, in mm, determined by the following formula:

$$t = \frac{p_H D_E}{2K + p_H}$$

where:

p_H : Hydrostatic test pressure, in MPa. This pressure is to be taken as 1,5 times the setting pressure of the safety valves with the following exceptions:

- in addition, for CO_2 bottles, this pressure is not to be less than 25 MPa
- for refrigerants, the value of hydrostatic test pressure is given in Part F, Chapter 7 of the Ship Rules

D_E : Outside diameter of tube, in mm

$K = R_{S,MIN} / 1,3$

$R_{S,MIN}$: Value of the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p\,0,2}$), at the ambient temperature, in N/mm^2. In no case is the value $R_{S,MIN}$ to exceed:

- 0,75 R_m for normalised steels
- 0,90 R_m for quenched and tempered steels.

2.13.3 Dished heads

Dished ends are to comply with the following requirements:

a) Hemispherical ends: the thickness of the ends is to be not less than the thickness calculated for spherical shells in accordance with [2.4.4]

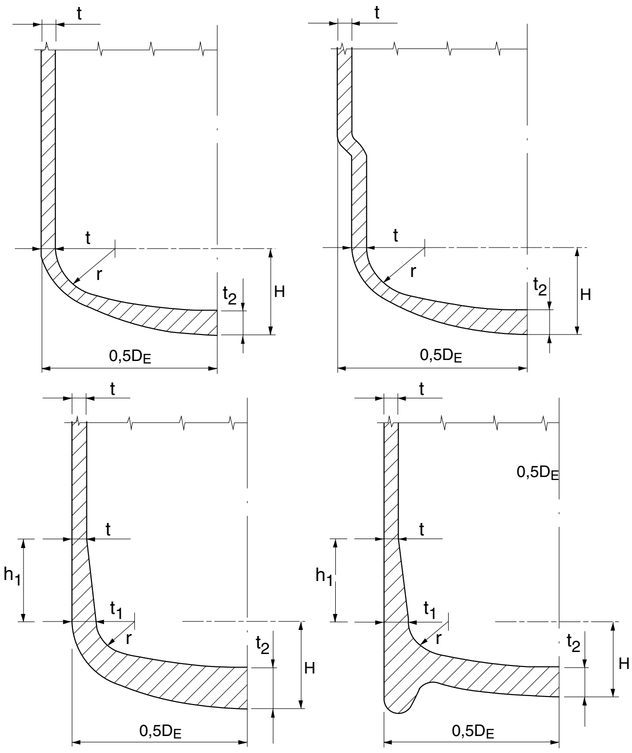
b) Convex ends: see Fig 23

c) Concave base ends: see Fig 24

d) Ends with openings: see Fig 25

e) Other types of ends are to be specially considered by the Society.

Figure 23 : Dished convex ends



$H/D_E \geq 0,20$ $r \geq 0,075D_E$ $t_1 \geq 1,25\,t$ $t_2 \geq 1,5\,t$ $h_1 \geq 6\,t$

Figure 24 : Dished concave ends

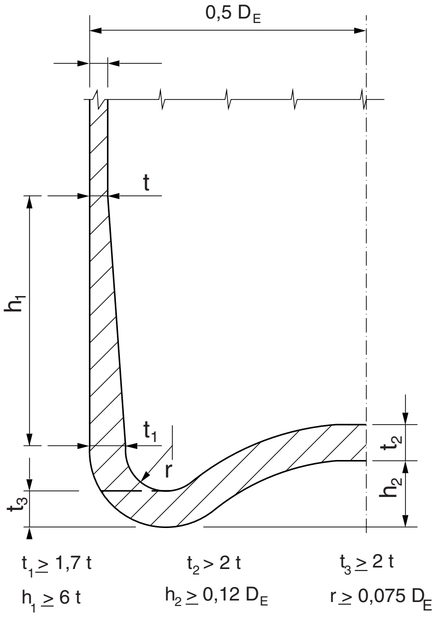
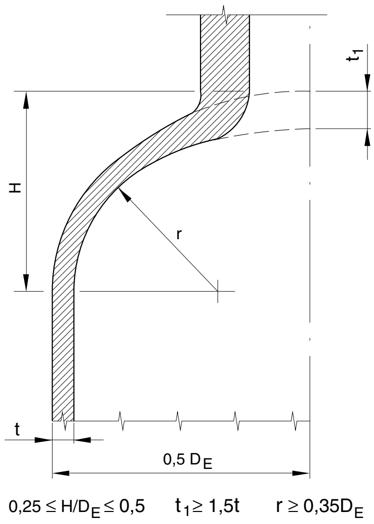


Figure 25 : Heads with openings



2.14 Heat exchangers

2.14.1 Scantlings

a) Vessels are to be designed in accordance with the applicable requirements stated in [2.4] and [2.5].

b) Tubes are to be designed in accordance with [2.10.1].

c) Tube plates are to be designed in accordance with a standard accepted by the Society.

2.14.2 Thermal oil heat exchangers

The provisions of [2.14.1] apply also to thermal oil heat exchangers. However, irrespective of the thickness obtained by the formula in [2.10.1], the tube thickness of oil fired and exhaust fired thermal oil heaters is to be not less than the values indicated in Tab 16.

Table 16 : Minimum thickness of thermal oil heat exchanger tubes

Outside diameter, in mm	Minimum thickness, in mm, of tubes subject to internal pressure of oil fired and exhaust fired thermal oil heaters
< 63,5	2,4
70 - 89	2,9
> 89	3,6

3 Design and construction - Equipment

3.1 All pressure vessels

3.1.1 Drainage

a) Each air pressure vessel is to be fitted with a drainage device allowing the evacuation of any oil or water accumulated in the vessel.

b) Drainage devices are also to be fitted on other vessels, in particular steam vessels, in which condensation water is likely to accumulate.

3.2 Boilers and steam generators

3.2.1 Safety valve arrangement

a) Every steam boiler and every steam generator with a total heating surface of 50 m^2 and above is to be provided with not less than two spring loaded safety valves of adequate capacity. For steam boilers and steam generators having heating surface less than 50 m^2, only one safety valve need be fitted.

b) Where a superheater is an integral part of the boiler, at least one safety valve is to be located on the steam drum and at least one at the superheater outlet. The valves fitted at the superheater outlet may be considered as part of the boiler safety valves required in item a), provided that their capacity does not account for more than 25% of the total capacity required in [3.2.2], unless specially considered by the Society.

c) Where fitted, superheaters which may be shut-off from the boiler are to be provided with at least one safety valve; such valve(s) cannot be considered as part of the boiler safety valves required in item a).

d) In the case of boilers fitted with a separate steam accumulator, safety valves may be fitted on the accumulator if no shut-off is provided between it and the boiler and if the connecting pipe is of a size sufficient to allow the whole steam production to pass through, without increasing the boiler pressure more than 10% above the design pressure.

3.2.2 Relieving capacity of safety valves

a) The relieving capacity of each safety valve Q, in kg/h, is to be determined by the appropriate formula below in order that:

$Q \geq W$

- saturated steam:

$$Q = \frac{CA(10P + 1,05)}{100}$$

- superheated steam:

$$Q = \frac{CA(10P + 1,05)}{100}\sqrt{\frac{v}{v_S}}$$

where:

W : Maximum steam production, in kg/h, as defined by the maximum power of the heating equipment; otherwise the value of W is to be based on evaporating capacities (referring to evaporating surfaces of the boiler concerned) less than the following:

  - 14 $kg/(m^2 \cdot h)$ for exhaust gas heated boilers
  - 29 $kg/(m^2 \cdot h)$ for oil fired boilers
  - 60 $kg/(m^2 \cdot h)$ for water walls of oil fired boilers

A : Aggregate area, in mm^2, of the orifices in way of the seat of the valve, deducting the obstructions corresponding to the guides and the conformation of the valve in full lift position

p : Maximum working pressure of the boiler or other steam generator, in MPa. For superheated steam safety valves, P is to be the pressure at the superheater outlet

C : Coefficient with the following values:

  - 4,8 for ordinary safety valves, i.e. where the valve lift is at least 1/24 of the internal diameter of the seat
  - 10 for high lift safety valves, i.e. where the valve lift is at least 1/12 of the internal diameter of the seat
  - 20 for full lift safety valves, i.e. where the valve lift is at least 1/4 of the internal diameter of the valve

Higher values of coefficient C may be admitted for safety valves of approved type and having undergone, in the presence of the Surveyor or according to a procedure considered as equivalent by the Society, capacity tests with conditions of pressure and temperature comparable to those of the plant considered. In such a case, coefficient C is to be, as a rule, taken as 90% of the resulting value from the capacity test.

v : Specific volume of saturated steam at the pressure corresponding to the superheater outlet

v_S : Specific volume of superheated steam at the temperature corresponding to the superheater outlet.

b) When the safety valves are fitted at the superheater outlet. Their relieving capacity is to be such that, during the discharge of safety valves, a sufficient quantity of steam is circulated through the superheater to avoid damage.

c) The orifice diameter in way of the safety valves seat is not to be less than 40 mm. Where only one safety valve need be fitted, the orifice minimum diameter is not to be less than 50 mm. Valves of large relieving capacity with 15 mm minimum diameter may be accepted for boilers with steam production not exceeding 2000 kg/h.

d) Independently of the above requirements, the aggregate capacity of the safety valves is to be such as to discharge all the steam that can be generated without causing a transient pressure rise of more than 10% over the design pressure.

3.2.3 Miscellaneous safety valve requirements

a) Safety valves operated by pilot valves

The arrangement on the superheater of large relieving capacity safety valves, operated by pilot valves fitted in the saturated steam drum, is to be specially considered by the Society.

b) Safety valve setting

- Safety valves are to be set under steam in the presence of the Surveyor to a pressure not higher than 1,03 times the design pressure.
- Safety valves are to be so constructed that their setting may not be increased in service and their spring may not be expelled in the event of failure. In addition, safety valves are to be provided with simple means of lifting the plug from its seat from a safe position in the boiler or engine room.
- Where safety valves are provided with means for regulating their relieving capacity, they are to be so fitted that their setting cannot be modified when the valves are removed for surveys.

c) Safety valve fitting on boiler

- The safety valves of a boiler are to be directly connected to the boiler and separated from other valve bodies.
- Where it is not possible to fit the safety valves directly on the superheater headers, they are to be mounted on a strong nozzle fitted as close as practicable to the superheater outlet. The cross-sectional area for passage of steam through restricted orifices of the nozzles is not to be less than 1/2 the aggregate area of the valves, calculated with the formulae of [2.3.2] when $C \leq 10$, and not less than the aggregate area of the valves when $C > 10$.
- Safety valve bodies are to be fitted with drain pipes of a diameter not less than 20 mm for double valves, and not less than 12 mm for single valves, leading to the bilge or to the hot well. Valves or cocks are not to be fitted on drain pipes.

d) Exhaust pipes

- the minimum cross-sectional area of the exhaust pipes of safety valves which have not been experimentally tested is not to be less than C times the aggregate area A
- the cross-sectional area of the exhaust manifold of safety valves is to be not less than the sum of the areas of the individual exhaust pipes connected to it
- silencers fitted on exhaust manifolds are to have a free passage area not less than that of the manifolds
- the strength of exhaust manifolds and pipes and associated silencers is to be such that they can withstand the maximum pressure to which they may be subjected, which is to be assumed not less than 1/4 of the safety valve setting pressure
- in the case that the discharges from two or more valves are led to the same exhaust manifold, provision is to be made to avoid the back pressure from the valve which is discharging influencing the other valves
- exhaust manifolds are to be led to the open and are to be adequately supported and fitted with suitable expansion joints or other means so that their weight does not place an unacceptable load on the safety valve bodies.

e) Steam generator heated by steam

Steam heated steam generators are also to be protected against possible damage resulting from failure of the heating coils. In this case, the area of safety valves calculated as stated in [3.2.2] may need to be increased to the satisfaction of the Society, unless suitable devices limiting the flow of steam in the heating coils are provided.

3.2.4 Other requirements

Access arrangement

a) Boilers are to be provided with openings in sufficient number and size to permit internal examination, cleaning and maintenance operations. In general, all pressure vessels which are part of a boiler with inside diameter exceeding 1200 mm, and those with inside diameter exceeding 800 mm and length exceeding 2000 mm, are to be provided with access manholes.

b) Manholes are to be provided in suitable locations in the shells, headers, domes, and steam and water drums, as applicable. The “net” (actual hole) dimension of elliptical or similar manholes is to be not less than 300mm x 400mm. The “net” diameter of circular manholes (actual hole) cannot be less than 400 mm. The edges of manholes are to be adequately strengthened to provide compensation for vessel openings in accordance with [2.8.4], [2.8.6] and [2.8.9], as applicable.

c) In pressure vessels which are part of a boiler and are not covered by the requirement in item a) above, or where an access manhole cannot be fitted, at least the following openings are to be provided, as far as practicable:

- head holes: minimum dimensions:

  220mm x 320mm (320 mm diameter if circular)
- handholes: minimum dimensions:

  87mm x 103mm
- sight holes: minimum diameter:

  50 mm.

d) Sight holes may only be provided when the arrangement of manholes, head holes, or handholes is impracticable.

e) Covers for manholes and other openings are to be made of ductile steel, dished or welded steel plates or other approved design. Grey cast iron may be used only for small openings, such as handholes and sight holes, provided the design pressure p does not exceed 1 MPa and the design temperature T does not exceed 220°C.

f) Covers are to be of self-closing internal type. Small opening covers of other type may be accepted by the Society on a case by case basis.

g) Covers of the internal type are to have a spigot passing through the opening. The clearance between the spigot and the edge of the opening is to be uniform for the whole periphery of the opening and is not to exceed 1,5 mm.

h) Closing devices of internal type covers, having dimensions not exceeding 180mm x 230mm, may be fitted with a single fastening bolt or stud. Larger closing devices are to be fitted with at least two bolts or studs.

i) Covers are to be designed so as to prevent the dislocation of the required gasket by the internal pressure. Only continuous ring gaskets may be used for packing.

Fittings

a) In general, cocks and valves are to be designed in accordance with the requirements in Ch 1, Sec 7, [2.8.2].

b) Cocks, valves and other fittings are to be connected directly or as close as possible to the boiler shell.

c) Cocks and valves for boilers are to be arranged in such a way that it can be easily seen when they are open or closed and so that their closing is obtained by a clockwise rotation of the actuating mechanism.

Boiler burners

Burners are to be arranged so that they cannot be withdrawn unless the fuel supply to the burners is cut off.

Allowable water levels

a) In general, for water tube boilers the lowest permissible water level is just above the top row of tubes when the water is cold. Where the boiler is designed not to have fully submerged tubes, when the water is cold, the lowest allowable level indicated by the manufacturer is to be indicated on the drawings and submitted to the Society for consideration.

b) For fire tube boilers with combustion chamber integral with the boiler, the minimum allowable level is to be at least 50 mm above the highest part of the combustion chamber.

c) For vertical fire tube boilers the minimum allowable level is 1/2 of the length of the tubes above the lower tube sheet.

Steam outlets

a) Each boiler steam outlet, if not serving safety valves, integral superheaters and other appliances which are to have permanent steam supply during boiler operation, is to be fitted with an isolating valve secured either directly to the boiler shell or to a standpipe of substantial thickness, as short as possible, and secured directly to the boiler shell.

b) The number of auxiliary steam outlets is to be reduced to a minimum for each boiler.

c) Where several boilers supply steam to common mains, the arrangement of valves is to be such that it is possible to positively isolate each boiler for inspection and maintenance. In addition, for water tube boilers, non-return devices are to be fitted on the steam outlets of each boiler.

d) Where steam is used for essential auxiliaries (such as whistles, steam operated steering gears, steam operated electric generators, etc.) and when several boilers are fitted on board, it is to be possible to supply steam to these auxiliaries with any one of these boilers out of operation.

e) Each steam stop valve exceeding 150 mm nominal diameter is to be fitted with a bypass valve.

Feed check valves

a) Each fired boiler supplying steam to essential services is to be fitted with at least two feed check valves connected to two separate feed lines. For unfired steam generators a single feed check valve may be allowed.

b) Feed check valves are to be secured directly to the boiler or to an integral economiser. Water inlets are to be separated. Where, however, feed check valves are secured to an economiser, a single water inlet may be allowed provided that each feed line can be isolated without stopping the supply of feed water to the boiler.

c) Where the economisers may be bypassed and cut off from the boiler, they are to be fitted with pressure-limiting type valves, unless the arrangement is such that excessive pressure cannot occur in the economiser when cut off.

d) Feed check valves are to be fitted with control devices operable from the stokehold floor or from another appropriate location. In addition, for water tube boilers, at least one of the feed check valves is to be arranged so as to permit automatic control of the water level in the boiler.

e) Provision is to be made to prevent the feed water from getting in direct contact with the heated surfaces inside the boiler and to reduce, as far as possible and necessary, the thermal stresses in the walls.

Drains

Each superheater, whether or not integral with the boiler, is to be fitted with cocks or valves so arranged that it is possible to drain it completely.

Water sample

a) Every boiler is to be provided with means to supervise and control the quality of the feed water. Suitable arrangements are to be provided to preclude, as far as practicable, the entry of oil or other contaminants which may adversely affect the boiler.

b) For this purpose, boilers are to be fitted with at least one water sample cock or valve. This device is not to be connected to the water level standpipes.

c) Suitable inlets for water additives are to be provided in each boiler.

Marking of boilers

a) Each boiler is to be fitted with a permanently attached plate made of non-corrosive metal, with indication of the following information, in addition to the identification marks (name of manufacturer, year and serial number):
   - the design pressure
   - the design temperature
   - the test pressure and the date of the test.

b) Markings may be directly stamped on the vessel if this does not produce notches having an adverse influence on its behaviour in service.

c) For lagged vessels, these markings are also to appear on a similar plate fitted above the lagging.

3.3 Thermal oil heaters and thermal oil installation

3.3.1 General

a) The following requirements apply to thermal oil heaters in which organic liquids (thermal oils) are heated by oil fired burners, exhaust gases or electricity to temperatures below their initial boiling point at atmospheric pressure.

b) Thermal oils are only to be used within the limits set by the manufacturer.

c) Means are to be provided for manual operation. However, at least the temperature control device on the oil side and flow monitoring are to remain operative even in manual operation.

d) Means are to be provided for manual operation. During manual operation the automated functioning of at least the temperature control device on the thermal oil side as well as the flow monitoring is to be maintained.

3.3.2 Thermal oil heater design

a) Heaters are to be so constructed that neither the surfaces nor the thermal oil becomes excessively heated at any point. The flow of the thermal oil is to be ensured by forced circulation.

b) The surfaces which come into contact with the thermal oil are to be designed for the design pressure, subject to the minimum pressure of 1 MPa.

c) Copper and copper alloys are not permitted.

d) Heaters heated by exhaust gas are to be provided with inspection openings at the exhaust gas intake and outlet.

e) Oil fired heaters are to be provided with inspection openings for examination of the combustion chamber. The opening for the burner may be considered as an inspection opening, provided its size is sufficient for this purpose.

f) Heaters are to be fitted with means enabling them to be completely drained.

g) Thermal oil heaters heated by exhaust gas are to be fitted with a permanent system for extinguishing and cooling in the event of fire, for instance a pressure water spraying system.

3.3.3 Safety valves of thermal oil heaters

Each heater is to be equipped with at least one safety valve having a discharge capacity at least equal to the increase in volume of the thermal oil at the maximum heating power. During discharge the pressure may not increase above 10% over the design pressure.

3.3.4 Pressure vessels of thermal oil heaters

The design pressure of all vessels which are part of a thermal oil system, including those open to the atmosphere, is to be taken not less than 0,2 MPa.

3.3.5 Equipment of the expansion, storage and drain tanks

For the equipment to be installed on expansion, storage and drain tanks, see Ch 1, Sec 7, [13].

3.3.6 Marking

Each thermal oil heater and other pressure vessels which are part of a thermal oil installation are to be fitted with a permanently attached plate made of non-corrosive metal, with indication of the following information, in addition to the identification marks (name of manufacturer, year and serial number):

- Heaters
  - maximum allowable heating power
  - design pressure
  - maximum allowable discharge temperature
  - minimum flow rate
  - liquid capacity
- Vessels
  - design pressure
  - design temperature
  - capacity.

3.4 Special types of pressure vessels

3.4.1 Seamless pressure vessels (bottles)

Each bottle is to be marked with the following information:

- name or trade name of the manufacturer
- serial number
- type of gas
- capacity
- test pressure
- empty weight
- test stamp.

3.4.2 Steam condensers

a) The water chambers and steam spaces are to be fitted with doors for inspection and cleaning.

b) Where necessary, suitable diaphragms are to be fitted for supporting tubes.

c) Condenser tubes are to be removable.

d) High speed steam flow, where present, is to be prevented from directly striking the tubes by means of suitable baffles.

e) Suitable precautions are to be taken in order to avoid corrosion on the circulating water side and to provide an efficient grounding.

3.5 Other pressure vessels

3.5.1 Safety valves arrangement

a) General

- Pressure vessels which are part of a system are to be provided with safety valves, or equivalent devices, if they are liable to be isolated from the system safety devices. This provision is also to be made in all cases in which the vessel pressure can rise, for any reason, above the design pressure.
- In particular, air pressure vessels which can be isolated from the safety valves ensuring their protection in normal service are to be fitted with another safety device, such as a rupture disc or a fusible plug, in order to ensure their discharge in case of fire. This device is to discharge to the open.
- Safety devices ensuring protection of pressure vessels in normal service are to be rated to operate before the pressure exceeds the maximum working pressure by more than 5%
- where two or more pressure vessels are interconnected by a piping system of adequate size so that no branch of piping may be shut off, it is sufficient to provide them with one safety valve and one pressure gauge only.

b) Heat exchangers

Special attention is to be paid to the protection against overpressure of vessels, such as heat exchangers, which have parts that are designed for a pressure which is below that to which they might be subjected in the case of rupture of the tubular bundles or coils contained therein and that have been designed for a higher pressure.

3.5.2 Other requirements

a) Access arrangement

The access requirements for boilers stated in [3.2.4] are also applicable for other pressure vessels.

b) Corrosion protection

Vessels and equipment containing media that might lead to accelerated corrosion are to be suitably protected.

c) Marking

- Each pressure vessel is to be fitted with a permanently attached plate made of non-corrosive metal, with indication of the following information, in addition to the identification marks (name of manufacturer, year and serial number):
  - the design pressure
  - the design temperature
  - the test pressure and the date of the test.
- Markings may be directly stamped on the vessel if this does not produce notches having an adverse influence on its behaviour in service.
- For smaller pressure vessels the indication of the design pressure only may be sufficient.

4 Design and construction - Fabrication and welding

4.1 General

4.1.1 Base materials

a) These requirements apply to boilers and pressure vessels made of steel of weldable quality.

b) Fabrication and welding of vessels made of other materials are to be the subject of special consideration.

4.1.2 Welding

a) Weldings are to be performed in accordance with welding procedures approved by the Society.

b) Manual and semi-automatic welding is to be performed by welders qualified by the Society.

c) The conditions under which the welding procedures, welding equipment and welders operate are to correspond to those specified in the relevant approvals or qualifications.

d) Both ordinary and special electric arc welding processes are covered in the following requirements.

4.1.3 Cutting of plates

a) Plates are to be cut by flame cutting, mechanical machining or a combination of both processes. For plates having a thickness less than 25 mm, cold shearing is admitted provided that the sheared edge is removed by machining or grinding for a distance of at least one quarter of the plate thickness with a minimum of 3 mm.

b) For flame cutting of alloy steel plates, preheating is to be carried out if necessary.

c) The edges of cut plates are to be examined for laminations, cracks or any other defect detrimental to their use.

4.1.4 Forming of plates

a) The forming processes are to be such as not to impair the quality of the material. The Society reserves the right to require the execution of tests to demonstrate the suitability of the processes adopted. Forming by hammering is not allowed.

b) Unless otherwise justified, cold formed shells are to undergo an appropriate heat treatment if the ratio of internal diameter after forming to plate thickness is less than 20. This heat treatment may be carried out after welding.

c) Before or after welding, hot formed plates are to be normalised or subjected to another treatment suitable for their steel grade, if hot forming has not been carried out within an adequate temperature range.

d) Plates which have been previously butt-welded may be formed under the following conditions:

- Hot forming

  After forming, the welded joints are to be subjected to X-ray examination or equivalent. In addition, mechanical tests of a sample weld subjected to the same heat treatment are to be carried out.
- Cold forming

  Cold forming is only allowed for plates having a thickness not exceeding:
  - 20 mm for steels having minimum ultimate tensile strength R_m between 360 N/mm^2 and 410 N/mm^2
  - 15 mm for steels having R_m between 460 N/mm^2 and 510 N/mm^2 as well as for steels 0,3Mo, 1Mn0,5Mo, 1Mn0,5MoV and 0,5Cr0,5Mo.

  Cold forming is not allowed for steels 1Cr0,5Mo and 2,25Cr1Mo.
- Weld reinforcements are to be carefully ground smooth prior to forming.
- A proper heat treatment is to be carried out after forming, if the ratio of internal diameter to thickness is less than 36, for steels: 460 N/mm^2, 510 N/mm^2, 0,3Mo, 1Mn0,5Mo, 1Mn0,5MoV and 0,5Cr0,5Mo.
- After forming, the joints are to be subjected to X-ray examination or equivalent and to a magnetic particle or liquid penetrant test.
- Refer to Fig 26 for definition of thickness to be taken in account.

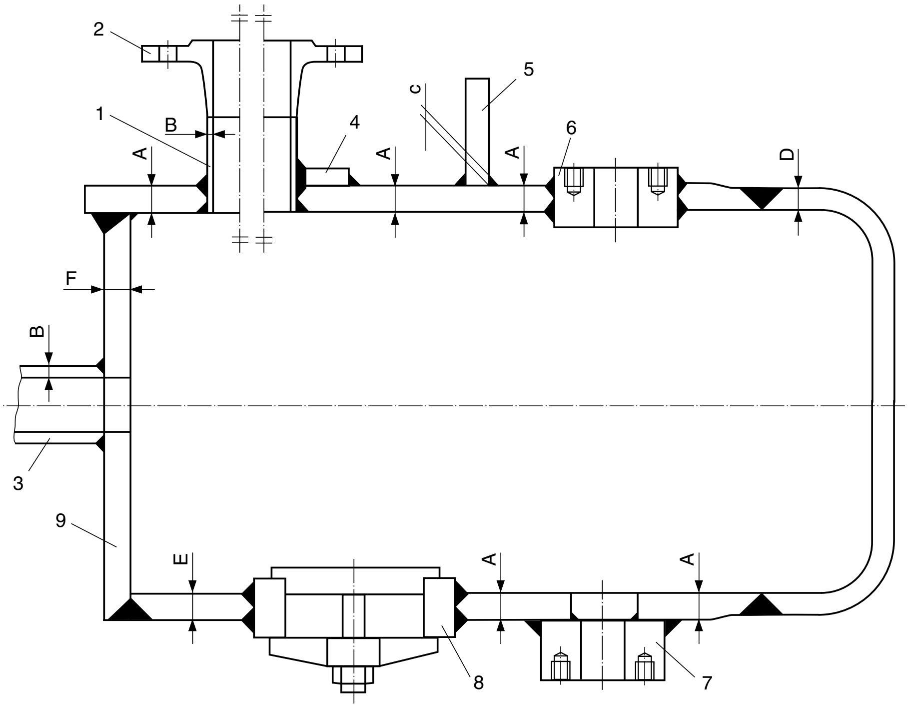
4.2 Welding design

4.2.1 Main welded joints

a) All joints of class 1 and 2 pressure parts of boilers and pressure vessels are to be butt-welded, with the exception of welding connecting flat heads or tube sheets to shells, for which partial penetration welds or fillet welds may be accepted.

Fig 26 show examples of acceptable welding for class 1 and 2 pressure vessels.

Figure 26 : Example of acceptable joints and thickness to be considered for forming and post-weld heat treatment



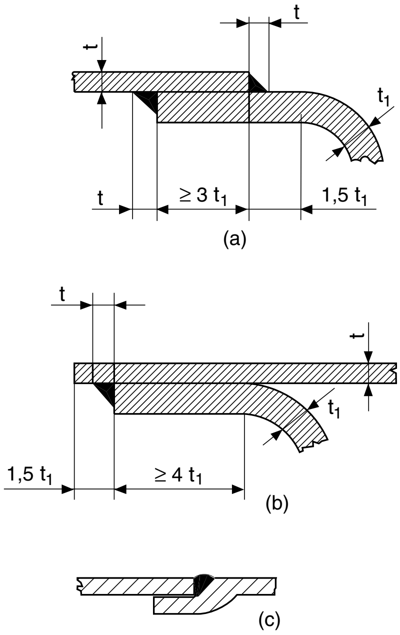
Key

1: Nozzle (set in); **2**: Flange; **3**: Nozzle (set on); **4**: Reinforcing plate; **5**: Non-pressure part;

6: Pad (set in); **7**: Pad (set on); **8**: Manhole frame; **9**: Flat plate.

b) Joints of class 3 pressure vessels are also subject to the requirement in a), however connection of dished heads to shells by lap welds may be accepted. Fig 27 shows some acceptable details of circumferential lap welds for class 3 pressure vessels.

Figure 27 : Example of acceptable lap-joints



Details (b) and (c) may be used only for pressure vessels having internal diameter less than 600mm.

4.2.2 Shell longitudinal and circumferential welds

Longitudinal and circumferential joints are to be welded from both sides of the plate. Welding from one side may be allowed only when there is evidence that the welding process permits a complete penetration and a sound weld root. If a backing strip is used, it is to be removed after welding and prior to any non-destructive examination. However, the backing strip may be retained in circumferential joints of class 2 vessels, having a thickness not exceeding 15 mm, and of class 3 vessels, provided that the material of the backing strip is such as not to adversely affect the weld.

4.2.3 Plates of unequal thickness

a) If plates of unequal thickness are butt-welded and the difference between thicknesses is more than 3 mm, the thicker plate is to be smoothly tapered for a length equal to at least four times the offset, including the width of the weld. For longitudinal joints the tapering is to be made symmetrically on both sides of the plate in order to obtain alignment of middle lines.

b) If the joint is to undergo radiographic examination, the thickness of the thicker plate is to be reduced to that of the thinner plate next to the joint and for a length of at least 30 mm.

4.2.4 Dished heads

a) For connection of a hemispherical end with a cylindrical shell, the joint is to be arranged in a plane parallel to that of the largest circle perpendicular to the axis of the shell and at such a distance from this plane that the tapering of the shell made as indicated in [2.5.6] is wholly in the hemisphere.

b) For torispherical ends made of parts assembled by welding, no welded joint is normally admitted along a parallel in the knuckle nor at a distance less than 50 mm from the beginning of the knuckle.

4.2.5 Welding location

The location of main welded joints is to be chosen so that these joints are not submitted to appreciable bending stresses.

4.2.6 Accessories and nozzles

a) Attachment of accessories by welds crossing main welds or located near such welds is to be avoided; where this is impracticable, welds for attachment of accessories are to completely cross the main welds rather than stop abruptly on or near them.

b) Openings crossing main joints or located near main joints are also to be avoided as far as possible.

c) Doubling plates for attachment of accessories such as fixing lugs or supports are to be of sufficient size to ensure an adequate distribution of loads on pressure parts; such doubling plates are to have well rounded corners. Attachment of accessories such as ladders and platforms directly on the walls of vessels such that they restrain their free contraction or expansion is to be avoided.

d) Welded connections of nozzles and other fittings, either with or without local compensation, are to be of a suitable type, size and preparation in accordance with the approved plans.

4.2.7 Connections of stays to tube plates

a) Where stays are welded, the cross-sectional area of the weld is to be at least 1,25 times the cross-section of the stay.

b) The cross-sectional area of the end welding of welded stay tubes is to be not less than 1,25 times the cross-sectional area of the stay tube.

4.2.8 Type of weldings

Fig 28 to Fig 37 indicate the type and size of weldings of typical pressure vessel connections. Any alternative type of welding or size is to be the subject of special consideration by the Society.

4.3 Miscellaneous requirements for fabrication and welding

4.3.1 Welding position

a) As far as possible, welding is to be carried out in the downhand horizontal position and arrangements are to be foreseen so that this can be applied in the case of circumferential joints.

b) When welding cannot be performed in this position, tests for qualification of the welding process and the welders are to take account thereof.

4.3.2 Cleaning of parts to be welded

a) Parts to be welded are, for a distance of at least 25 mm from the welding edges, to be carefully cleaned in order to remove any foreign matter such as rust, scale, oil, grease and paint.

b) If the weld metal is to be deposited on a previously welded surface, all slag or oxide is to be removed to prevent inclusions.

Figure 28 : Types of joints for unstayed flat heads (1)

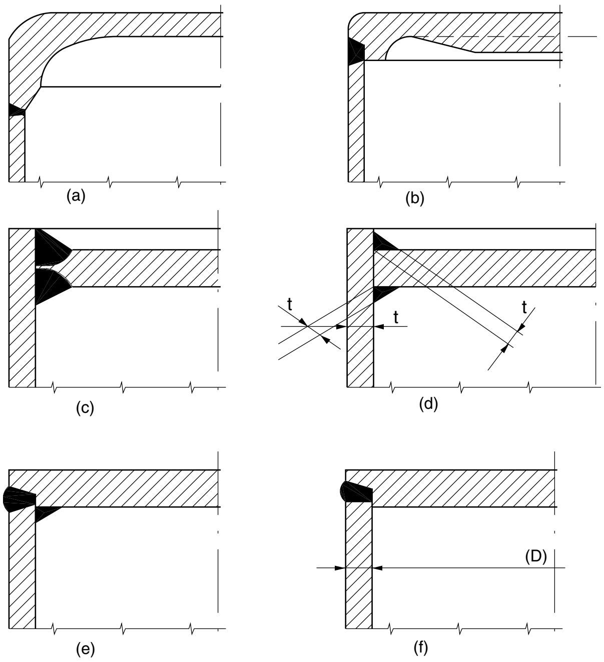
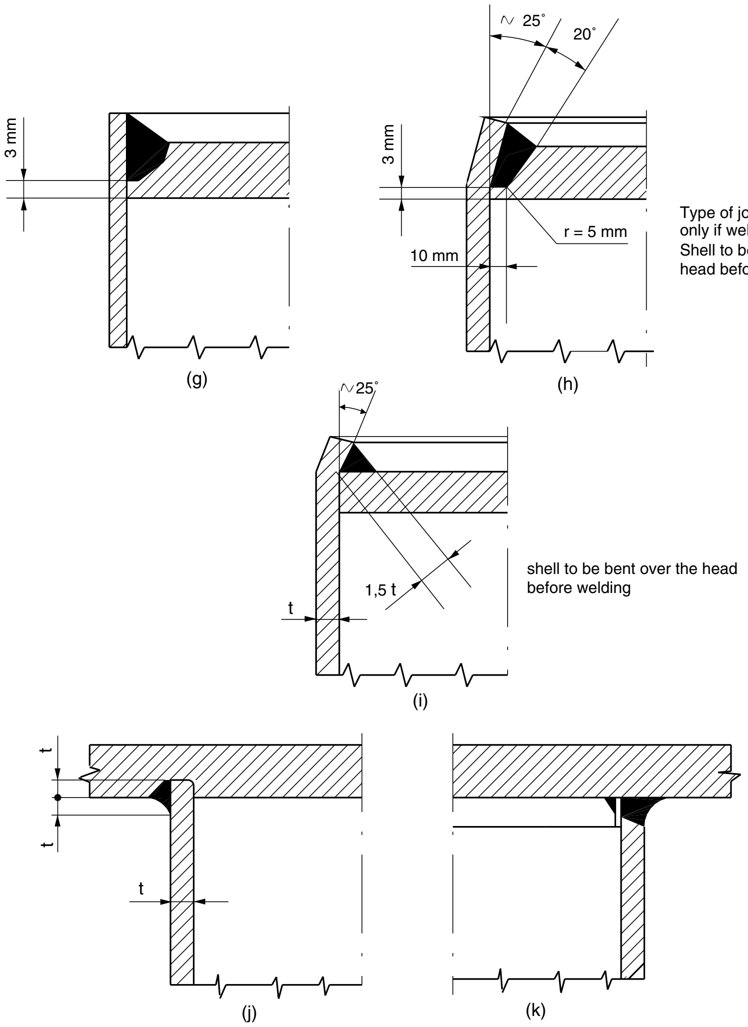


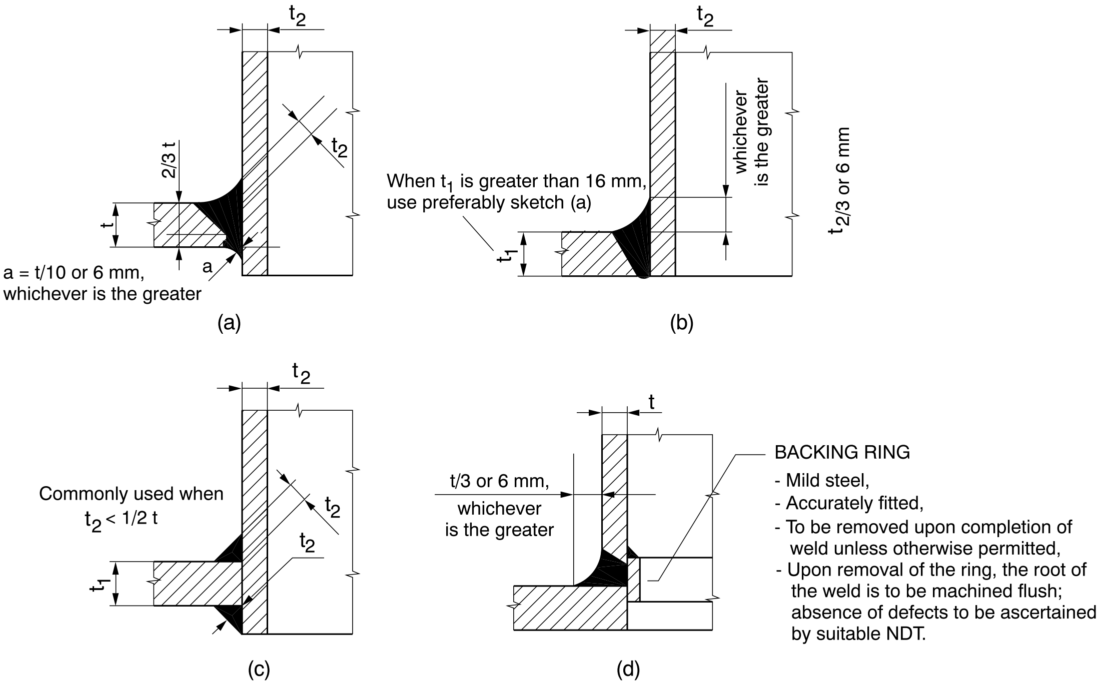
Figure 29 : Types of joints for unstayed flat heads (2)



Type of joint permitted only if welded in flat position. Shell to be bent over the head before welding.

shell to be bent over the head before welding

Figure 30 : Types of joints for nozzles and reinforced rings (1)



BACKING RING
- Mild steel,
- Accurately fitted,
- To be removed upon completion of weld unless otherwise permitted,
- Upon removal of the ring, the root of the weld is to be machined flush; absence of defects to be ascertained by suitable NDT.

Figure 31 : Types of joints for nozzles and reinforcing rings (2)

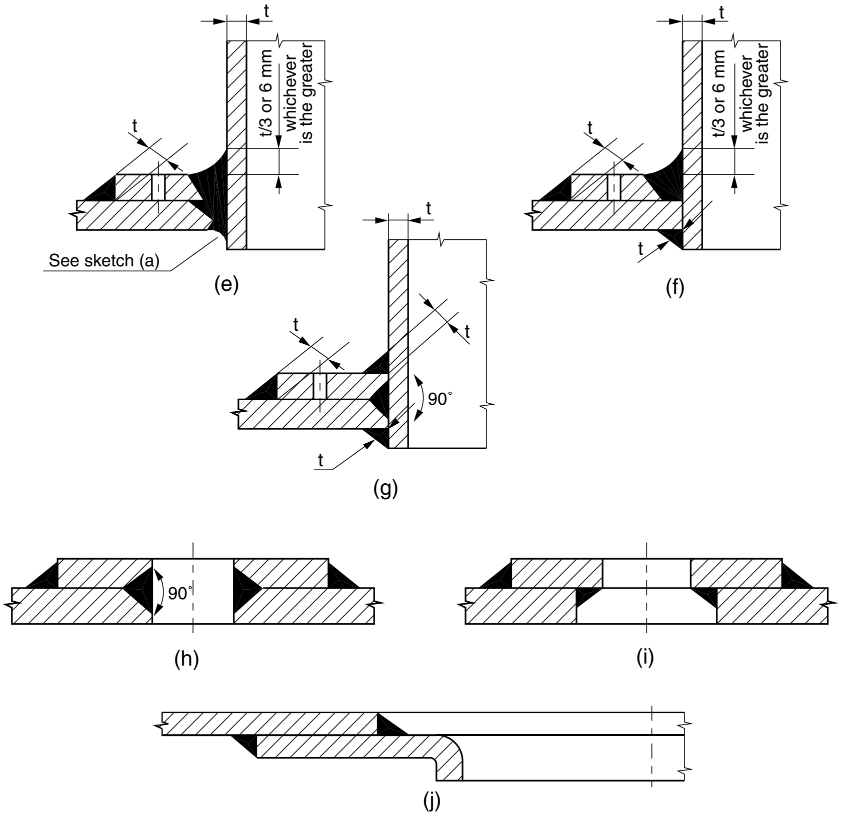


Figure 32 : Types of joints for nozzles and reinforcing rings (3)

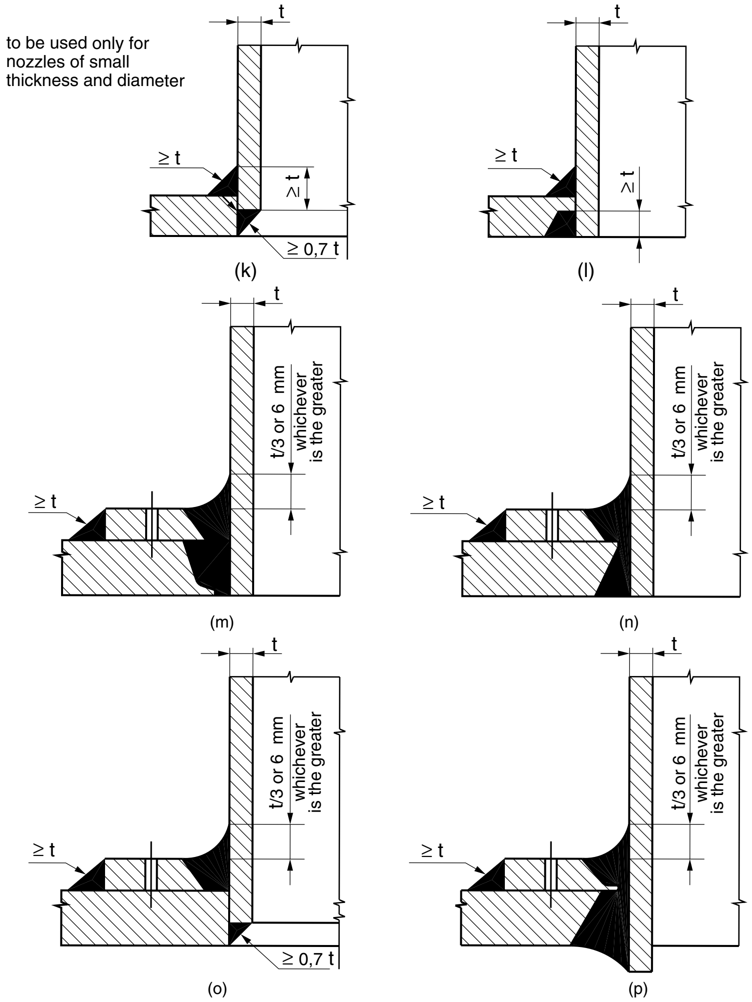
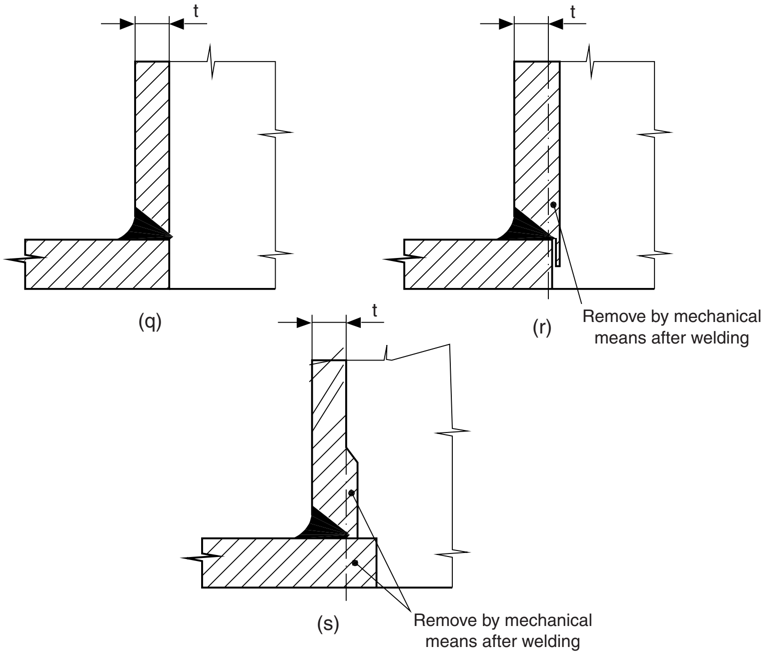


Figure 33 : Types of joints for nozzles (4)



Note: Where preparations of Fig 33 are carried out, the shell is to be carefully inspected to ascertain the absence of lamination.

Figure 34 : Types of joints for flanges to nozzles

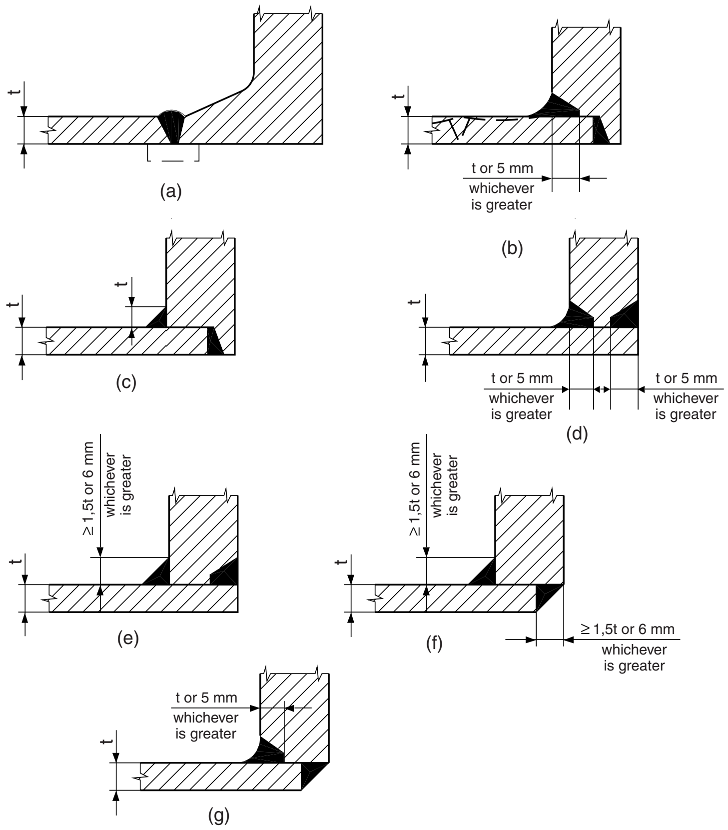


Figure 35 : Types of joints for tubesheets to shell (1)

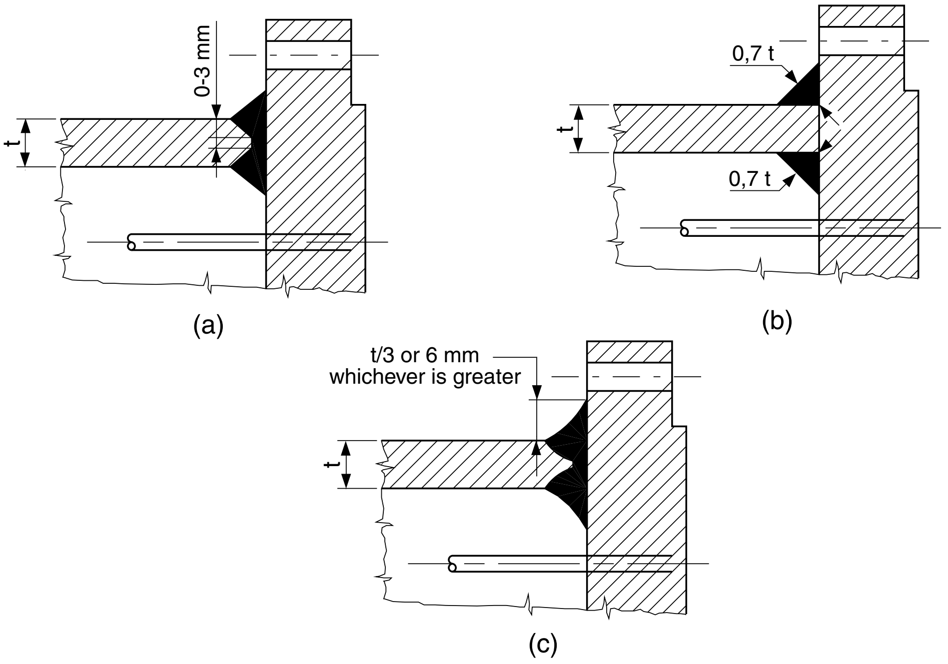
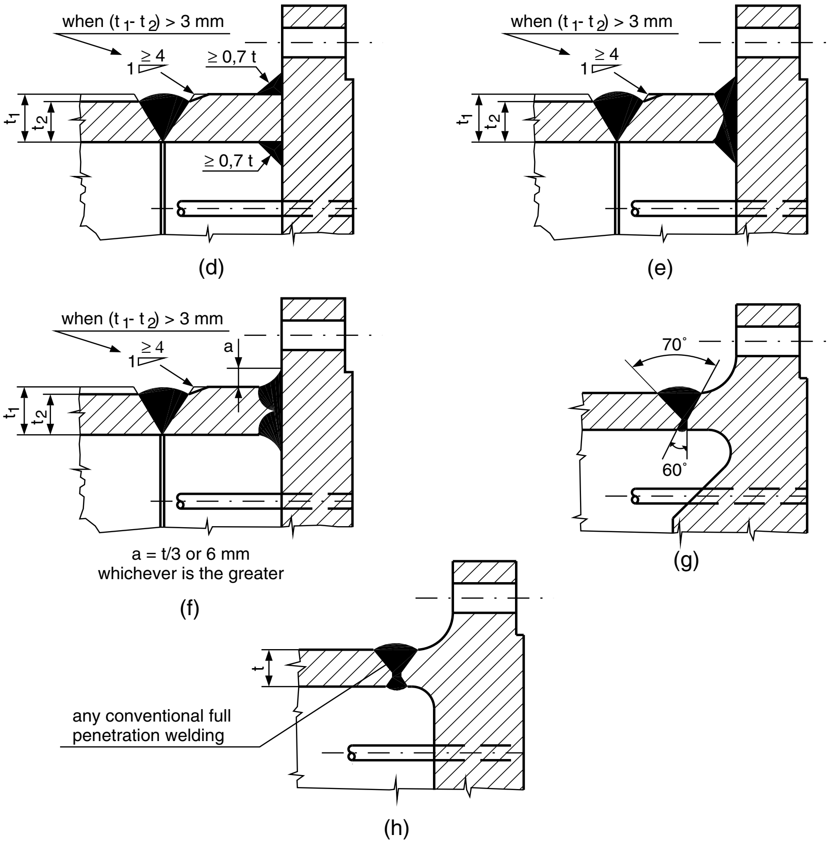
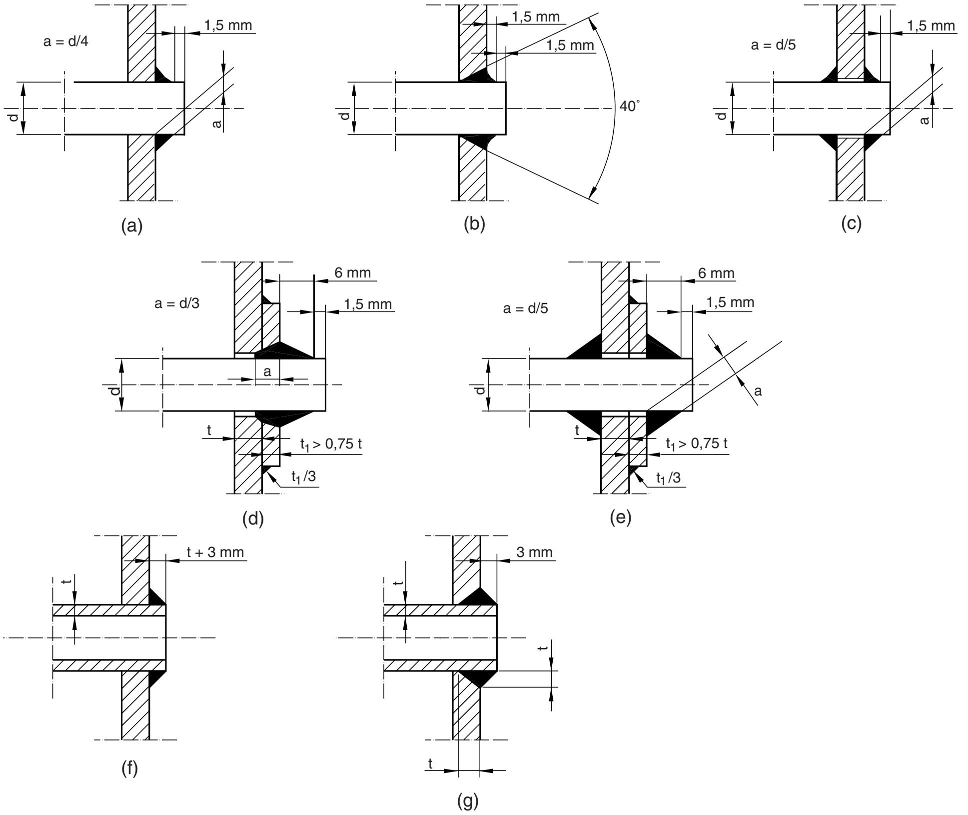


Figure 36 : Types of joints for tubesheets to shells (2)



Preparation shown on sketches (d), (e) and (f) are to be used when the joint is accessible from outside only.

Figure 37 : Type of joints for stays and stay tubes



4.3.3 Protection against adverse weather conditions

a) Welding of pressure vessels is to be done in a sheltered position free from draughts and protected from cold and rain.

b) Unless special justification is provided, no welding is to be performed if the temperature of the base metal is less than 0°C.

4.3.4 Interruption in welding

If, for any reason, welding is stopped, care is to be taken on restarting to obtain a complete fusion.

4.3.5 Backing weld

When a backing weld is foreseen, it is to be carried out after suitable chiseling or chipping at the root of the first weld, unless the welding process applied does not call for such an operation.

4.3.6 Appearance of welded joints

a) Welded joints are to have a smooth surface without under-thickness; their connection with the plate surface is to be gradual without undercutting or similar defects.

b) The weld reinforcement of butt welds, on each side of the plate, is not to exceed the following thickness:

- 2,5 mm for plates having a thickness not exceeding 12 mm
- 3 mm for plates having a thickness greater than 12 mm but less than 25 mm
- 5 mm for plates having a thickness at least equal to 25 mm.

4.4 Preparation of parts to be welded

4.4.1 Preparation of edges for welding

a) Grooves and other preparations of edges for welding are to be made by machining, chipping or grinding. Flame cutting may also be used provided that the zones damaged by this operation are removed by machining, chipping or grinding. For alloy steel plates, preheating is to be provided, if needed, for flame cutting.

b) Edges prepared are to be carefully examined to check that there are no defects detrimental to welding.

4.4.2 Abutting of parts to be welded

a) Abutting of parts to be welded is to be such that surface misalignment of plates does not exceed:

- 10% of the thickness of the plate with a maximum of 3 mm for longitudinal joints
- 10% of the thickness of the plate plus 1 mm with a maximum of 4 mm for circumferential joints.

b) For longitudinal joints, middle lines are to be in alignment within 10% of the thickness of the thinner plate with a maximum of 3 mm.

c) Plates to be welded are to be suitably retained in position in order to limit deformation during welding. The arrangements are to be such as to avoid modification of the relative position of parts to be welded and misalignment, after welding, exceeding the limits indicated above.

d) Temporary welds for abutting are to be carried out so that there is no risk of damage to vessel shells. Such welds are to be carefully removed after welding of the vessel and before any heat treatment. Non-destructive testing of the corresponding zones of the shell may be required by the Surveyor if considered necessary.

e) Accessories such as doubling plates, brackets and stiffeners are to be suitable for the surface to which they are to be attached.

4.5 Tolerances after construction

4.5.1 General

The sizes and shape of vessels are to be checked after welding for compliance with the design taking into account the tolerances given below. The Society reserves the right to stipulate smaller values for these tolerances for vessels subjected to special loads.

Any defect in shape is to be gradual and there is to be no flat area in way of welded joints.

Measurements are to be taken on the surface of the parent plate and not on the weld or other raised part.

4.5.2 Straightness

The straightness of cylindrical shells is to be such that their deviation from the straight line does not exceed 0,6% of their length, with a maximum of 15 mm for each 5 m of length.

4.5.3 Out-of-roundness

a) Out-of-roundness of cylindrical shells is to be measured either when set up on end or when laid flat on their sides; in the second case, measures of diameters are to be repeated after turning the shell through 90° about its axis and out-of-roundness is to be calculated from the average of the two measures of each diameter.

b) For any transverse section, the difference between the maximum and minimum diameters is not to exceed 1% of the nominal diameter D with a maximum of:

   (D + 1250) / 200, D being expressed in mm.

   For large pressure vessels, this limit may be increased by a maximum of 0,2% of the internal diameter of the vessel. Any possible out-of-roundness within the above limit is to be gradual and there are to be no localised deformations in way of the welded joints.

4.5.4 Irregularities

Irregularities in profile of cylindrical shells, checked by a 20° gauge, are not to exceed 5% of the thickness of the plate plus 3 mm. This value may be increased by 25% if the length of the irregularity does not exceed one quarter of the distance between two circumferential seams, with a maximum of 1 mm.

4.6 Preheating

4.6.1

a) Preheating, to be effectively maintained during the welding operation, may be required by the Society when deemed necessary in relation to a number of circumstances, such as the type of steel, thickness of the base material, welding procedure and technique, type of restraint, and heat treatment after welding, if any.

b) The preheating temperature is to be determined accordingly. However, a preheating temperature of approximately 150°C is required for 0,5Mo or 1Cr0,5Mo type steel, and approximately 250°C for 2,25Cr1Mo type steel.

c) These requirements also apply to welding of nozzles, fittings, steam pipes and other pipes subject to severe conditions.

4.7 Post-weld heat treatment

4.7.1 General

a) When post-weld heat treatment of a vessel is to be carried out, such treatment is to consist of:
   - heating the vessel slowly and uniformly up to a temperature suitable for the grade of steel
   - maintaining this temperature for a duration determined in relation to the actual thickness t_A of the vessel and the grade of steel
   - slowly cooling the vessel in the furnace down to a temperature not exceeding 400°C, with subsequent cooling allowed out of the furnace in still air.

b) As far as possible, vessels are to be heat treated in a single operation. However, when the sizes of the vessels are such that heat treatment requires several operations, care is to be taken such that all the parts of the vessels undergo heat treatment in a satisfactory manner. In particular, a cylindrical vessel of great length may be treated in sections in a furnace if the overlap of the heated sections is at least 1500 mm and if parts outside the furnace are lagged to limit the temperature gradient to an acceptable value.

4.7.2 Thermal stress relieving

Upon completion of all welding, including connections of nozzles, doublers and fittings, pressure vessels of classes 1 and 2, boilers and associated parts are to be subjected to an effective stress relieving heat treatment in the following cases:

- Pressure vessels of classes 1 and 2 containing fluids at a temperature not less than the ambient temperature, where the thickness exceeds that indicated in Tab 17
- Boilers and steam generators for thicknesses higher than 20 mm or, depending upon the type of steel, for lower thicknesses as required for class 1 pressure vessels.

Applications at temperatures less than the ambient temperature and/or steels other than those indicated above are to be the subject of special consideration by the Society.

Stress relieving heat treatment is not to be required when the minimum temperature of the fluid is at least 30°C higher than the KV-notch impact test temperature specified for the steel; this difference in temperature is also to be complied with for welded joints (both in heat-affected zones and in weld metal).

Pressure vessels and pipes of class 3 and associated parts are not required to be stress relieved, except in specific cases.

4.7.3 Heat treatment procedure

The temperature of the furnace at the time of introduction of the vessel is not to exceed 400°C.

a) The heating rate above 400°C is not to exceed:
   - 220°C per hour if the maximum thickness is not more than 25 mm, or
   - $(5500 / t_A)$°C per hour, with a minimum of 55°C per hour, if the maximum thickness t_A, in mm, is more than 25 mm

b) The cooling rate in the furnace is not to exceed:
   - –280°C per hour if the maximum thickness is not more than 25 mm, or
   - $-(7000 / t_A)$°C per hour, with a minimum of –55°C per hour, if the maximum thickness t_A, in mm, is more than 25 mm.

Unless specially justified, heat treatment temperatures and duration for maintaining these temperatures are to comply with the values in Tab 18.

Table 17 : Thermal stress relieving

Grade	Thickness (mm) above which post-weld heat treatment is required	
	Boilers	Unfired pressure vessels
R_m = 360 N/mm² Grade HA R_m = 410 N/mm² Grade HA	14,5	14,5
R_m = 360 N/mm² Grade HB R_m = 410 N/mm² Grade HB	20	30
R_m = 360 N/mm² Grade HD R_m = 410 N/mm² Grade HD	20	38
R_m = 460 N/mm² Grade HB R_m = 510 N/mm² Grade HB	20	25
R_m = 460 N/mm² Grade HD R_m = 510 N/mm² Grade HD	20	35
0,3Mo 1Mn 0,5Mo 1Mn 0,5MoV 0,5Cr 0,5Mo	20	20
1Cr 0,5Mo 2,25Cr 1Mo	ALL	ALL

Table 18 : Heat treatment procedure

Grade	Temperatures	Time per 25 mm of maximum thickness	Minimum time
Carbon steels	580-620°C	1 hour	1 hour
0,3Mo 1Mn 0,5Mo 1Mn 0,5MoV 0,5Cr 0,5Mo	620-660°C	1 hour	1 hour
1Cr 0,5Mo	620-660°C	1hour	2 hours
2,25Cr 1Mo	600-750°C **(1)**	2 hours	2 hours

(1) The temperature is to be chosen, with a tolerance of ± 20°C, in this temperature range in order to obtain the required mechanical characteristics

4.7.4 Alternatives

When, for special reasons, heat treatment is carried out in conditions other than those given in [4.7.2], all details regarding the proposed treatment are to be submitted to the Society, which reserves the right to require tests or further investigations in order to verify the efficiency of such treatment.

4.7.5 Execution of heat treatment

Furnaces for heat treatments are to be fitted with adequate means for controlling and recording temperature; temperatures are to be measured on the vessel itself. The atmosphere in the furnaces is to be controlled in order to avoid abnormal oxidation of the vessel.

4.7.6 Treatment of test plates

Test plates are normally to be heated at the same time and in the same furnace as the vessel.

When separate heat treatment of test plates cannot be avoided, all precautions are to be taken such that this treatment is carried out in the same way as for the vessel, specifically with regard to the heating rate, the maximum temperature, the duration for maintaining this temperature and the cooling conditions.

4.7.7 Welding after heat treatment

a) Normally, welding after heat treatment is only allowed if:
   - the throat of welding fillets does not exceed 10 mm
   - the largest dimension of openings in the vessel for the accessories concerned does not exceed 50 mm.

b) Any welding of branches, doubling plates and other accessories on boilers and pressure vessels after heat treatment is to be submitted for special examination by the Society.

4.8 Welding samples

4.8.1 Test plates for welded joints

a) Test plates of sufficient size, made of the same grade of steel as the shell plates, are to be fitted at each end of the longitudinal joints of each vessel so that the weld in the test plates is the continuation of these welded joints. There is to be no gap when passing from the deposited metal of the joint to the deposited metal of the test plate.

b) No test plate is required for circumferential joints if these joints are made with the same process as longitudinal joints. Where this is not the case, or if there are only circumferential joints, at least one test plate is to be welded separately using the same welding process as for the circumferential joints, at the same time and with the same welding materials.

c) Test plates are to be stiffened in order to reduce as far as possible warping during welding. The plates are to be straightened prior to their heat treatment which is to be carried out in the same conditions as for the corresponding vessel (see also [4.7.6]).

d) After radiographic examination, the following test pieces are to be taken from the test plates:
- one test piece for tensile test on welded joint
- two test pieces for bend test, one direct and one reverse
- three test pieces for impact test
- one test piece for macrographic examination.

4.8.2 Mechanical tests of test plates

a) The tensile strength on welded joint is not to be less than the minimum specified tensile strength of the plate.

b) The bend test pieces are to be bent through an angle of 180° over a former of 4 times the thickness of the test piece. There is to be no crack or defect on the outer surface of the test piece exceeding in length 1,5 mm transversely or 3 mm longitudinally. Premature failure at the edges of the test piece is not to lead to rejection. As an alternative, the test pieces may be bent through an angle of 120° over a former of 3 times the thickness of the test piece.

c) The impact energy measured at 0°C is not to be less than the values given in NR216 for the steel grade concerned.

d) The test piece for macrographic examination is to permit the examination of a complete transverse section of the weld. This examination is to demonstrate good penetration without lack of fusion, large inclusions and similar defects. In case of doubt, a micrographic examination of the doubtful zone may be required.

4.8.3 Re-tests

a) If one of the test pieces yields unsatisfactory results, two similar test pieces are to be taken from another test plate.

b) If the results for these new test pieces are satisfactory and if it is proved that the previous results were due to local or accidental defects, the results of the re-tests may be accepted.

4.9 Specific requirements for class 1 vessels

4.9.1 General

The following requirements apply to class 1 pressure vessels, as well as to pressure vessels of other classes, whose scantlings have been determined using an efficiency of welded joint e greater than 0,90.

4.9.2 Non-destructive tests

a) All longitudinal and circumferential joints of class 1 vessels are to be subject of 100% radiographic or equivalent examination with the following exceptions:
- for pressure vessels or parts designed to withstand external pressures only, at the Society’s discretion, the extent may be reduced up to approximately 30% of the length of the joints. In general, the positions included in the examinations are to include all welding crossings.
- for vessels not intended to contain toxic or dangerous matters, made of carbon steels having thickness below 20 mm when the joints are welded by approved automatic processes at the Society’s discretion, the extent may be reduced up to approximately 10% of the length of the joints. In general, the positions included in the examinations are to include all welding crossings.
- for circumferential joints having an external diameter not exceeding 175 mm, at the Society’s discretion, the extent may be reduced up to approximately 10% of the total length of the joints.

b) Fillet welds for parts such as doubling plates, branches or stiffeners are to undergo a spot magnetic particle test for at least 10% of their length. If magnetic particle tests cannot be used, it is to be replaced by liquid penetrant test.

c) Welds for which non destructive tests reveal unacceptable defects, such as cracks or areas of incomplete fusion, are to be rewelded and are then to undergo a new non destructive examination.

4.9.3 Number of test samples

a) During production, at least one test plate for each 20 m of length (or fraction) of longitudinal weldings is to be tested as per [4.8.2].

b) During production, at least one test plate for each 30 m of length (or fraction) of circumferential welding is to be tested as per [4.8.2].

c) When several vessels made of plates of the same grade of steel, with thicknesses varying by not more than 5 mm, are welded successively, only one test plate may be accepted per each 20 m of length of longitudinal joints (or fraction) and per each 30 m of circumferential welding (or fraction) provided that the welders and the welding process are the same. The thickness of the test plates is to be the greatest thickness used for these vessels.

4.10 Specific requirements for class 2 vessels

4.10.1 General

For vessels whose scantlings have been determined using an efficiency of welded joint e greater than 0,90, see [4.9.1].

4.10.2 Non-destructive tests

All longitudinal and circumferential joints of class 2 vessels are to be subjected to radiographic or equivalent examination to an extent of 10% of each weld length. This examination is to cover all the junctions between welds.

This extension may be increased at the Society's discretion depending on the actual thickness of the welded plates.

For actual thickness ≤ 15 mm, this examination can be omitted. In this case, the value of the efficiency should be as indicated in Tab 10.

4.10.3 Number of test samples

In general, the same requirements of [4.9.3] apply also to class 2 pressure vessels. However, test plates are required for each 50 m of longitudinal and circumferential weldings (or fraction).

4.11 Specific requirements for class 3 vessels

4.11.1 For vessels whose scantlings have been determined using an efficiency of welded joint e greater than 0,90, see [4.9.1].

Heat treatment, mechanical tests and non-destructive tests are not required for welded joints of other class 3 vessels.

5 Design and construction - Control and monitoring

5.1 Boiler control and monitoring system

5.1.1 Local control and monitoring

Means to effectively operate, control and monitor the operation of oil fired boilers and their associated auxiliaries are to be provided locally. The functional condition of the fuel, feed water and steam systems and the boiler operational status are to be indicated by pressure gauges, temperature indicators, flow-meter, lights or other similar devices.

5.1.2 Emergency shut-off

Means are to be provided to shut down boiler forced draft or induced draft fans and fuel oil service pumps from outside the space where they are located, in the event that a fire in that space makes their local shut-off impossible.

5.1.3 Water level indicators

a) Each boiler is to be fitted with at least two separate means for indicating the water level. One of these means is to be a level indicator with transparent element. The other may be either an additional level indicator with transparent element or an equivalent device. Level indicators are to be of an approved type.

b) The transparent element of level indicators is to be made of glass, mica or other appropriate material.

c) Level indicators are to be located so that the water level is readily visible at all times. The lower part of the transparent element is not to be below the safety water level defined by the builder.

d) Level indicators are to be fitted either with normally closed isolating cocks, operable from a position free from any danger in case of rupture of the transparent element or with self-closing valves restricting the steam release in case of rupture of this element.

5.1.4 Water level indicators - Special requirements for water tube boilers

a) For water tube boilers having an athwarships steam drum more than 4 m in length, a level indicator is to be fitted at each end of the drum.

b) Water tube boilers serving turbine propulsion machinery are to be fitted with a high-water-level audible and visual alarm (see also Tab 20).

5.1.5 Water level indicators - Special requirements for fire tube boilers (vertical and cylindrical boilers)

a) For cylindrical boilers, the two water level indicators mentioned in [5.1.3] are to be distributed at each end of the boiler; i.e. double front cylindrical boilers are to have two level indicators on each front.

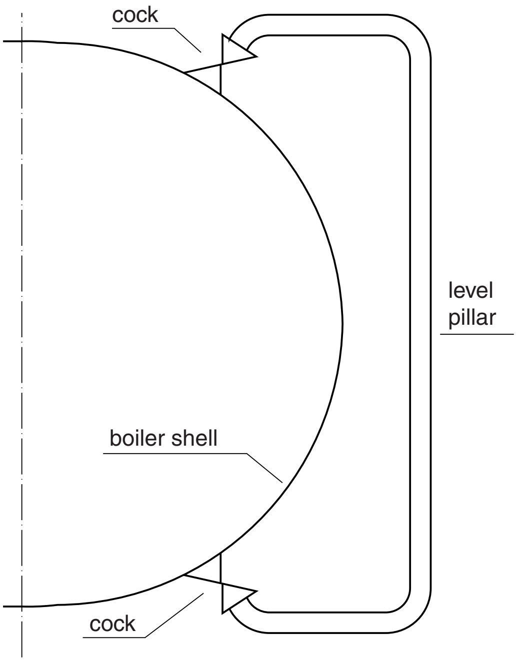
b) A system of at least two suitably located and remote controlled gauge-cocks may be considered as the equivalent device mentioned in [5.1.3] for cylindrical boilers having a design pressure lower than 1 MPa, for cylindrical boilers having a diameter lower than 2 m and for vertical boilers having height lower than 2,3 m. Gauge-cocks are to be fixed directly on the boiler shell.

c) Where level indicators are not fixed directly on the boiler shell, but on level pillars, the internal diameter of such pillars is not to be less than the value d_N given in Tab 19. Level pillars are to be either fixed directly on the boiler shell or connected to the boiler by pipes fitted with cocks secured directly to the boiler shell. The internal diameter of these pipes d_C is not to be less than the values given in Tab 19. The upper part of these pipes is to be arranged so that there is no bend where condense water can accumulate. These pipes are not to pass through smoke boxes or uptakes unless they are located inside metallic ducts having internal diameter exceeding by not less than 100 mm the external diameter of the pipes. Fig 38 shows the sketch of a level pillar arrangement.

Table 19 : Minimum internal diameters d_N and d_C

Internal diameter of the boiler	d_N (mm)	d_C (mm)
D > 3 m	60	38
2,30 m ≤ D ≤ 3 m	50	32
D < 2,30 m	45	26

Figure 38 : Level pillar arrangement



5.1.6 Pressure control devices

a) Each boiler is to be fitted with a steam pressure gauge so arranged that its indications are easily visible from the stokehold floor. A steam pressure gauge is also to be provided for superheaters which can be shut off from the boiler they serve.

b) Pressure gauges are to be graduated in units of effective pressure and are to include a prominent legible mark for the pressure that is not to be exceeded in normal service.

c) Each pressure gauge is to be fitted with an isolating cock.

d) Double front boilers are to have a steam pressure gauge arranged in each front.

5.1.7 Temperature control devices

Each boiler fitted with a superheater is to have an indicator or recorder for the steam temperature at the superheater outlet.

5.1.8 Automatic shut-off of oil fired propulsion and auxiliary boilers

a) Each burner is to be fitted with a flame scanner designed to automatically shut off the fuel supply to the burner in the event of flame failure. In the case of failure of the flame scanner, the fuel to the burner is to be shut off automatically.

b) A low water condition is to automatically shut off the fuel supply to the burners. The shut-off is to operate before the water level reaches a level so low as to affect the safety of the boiler and no longer be visible in the gauge glass. Means are to be provided to minimise the risk of shut-off provoked by the effect of roll and pitch and/or transients. This shut-off system need not be installed in auxiliary boilers which are under local supervision and are not intended for automatic operation.

c) Forced draft failure is to automatically shut off the fuel supply to the burners.

d) Loss of boiler control power is to automatically shut off the fuel supply to the burners.

5.1.9 Alarms

Any actuation of the fuel-oil shut-off listed in [5.1.8] is to operate a visual and audible alarm.

5.1.10 Additional requirements for boilers fitted with automatic control systems

a) The flame scanner required in [5.1.8], item a) is to operate within 6 seconds from the flame failure.

b) A timed boiler purge with all air registers open is to be initiated manually or automatically when boilers are fitted with an automatic ignition system. The purge time is based on a minimum of 4 air changes of the combustion chamber and furnace passes. Forced draft fans are to be operating and air registers and dampers are to be open before the purge time commences.

c) Means are to be provided to bypass the flame scanner control system temporarily during a trial-for-ignition for a period of 15 seconds from the time the fuel reaches the burners. Except for this trial-for-ignition period, no means are to be provided to bypass one or more of the burner flame scanner systems unless the boiler is locally controlled.

d) Where boilers are fitted with an automatic ignition system, and where residual fuel oil is used, means are to be provided for lighting of burners with igniters lighting properly heated residual fuel oil. In the case of flame failure, the burner is to be brought back into automatic service only in the low-firing position.

e) An alarm is to be activated whenever a burner operates outside the limit conditions stated by the manufacturer.

f) Immediately after normal shutdown, an automatic purge of the boiler equal to the volume and duration of the pre-purge is to occur. Following automatic fuel valve shut-off, the air flow to the boiler is not to automatically increase; post-purge in such cases is to be carried out under manual control.

g) Propulsion and auxiliary boilers associated with propulsion machinery intended for centralised, unattended operations are to comply with the requirements of Part C, Chapter 3.

5.2 Pressure vessel instrumentation

5.2.1

a) Pressure vessels are to be fitted with the necessary devices for checking pressure, temperature and level, where it is deemed necessary.

b) In particular, each air pressure vessel is to be fitted with a local manometer.

5.3 Thermal oil heater control and monitoring

5.3.1 Local control and monitoring

Suitable means to effectively operate, control and monitor the operation of oil fired thermal oil heaters and their associated auxiliaries are to be provided locally. The functional condition of the fuel, thermal oil circulation, forced draft and flue gas systems is to be indicated by pressure gauges, temperature indicators, flow-meter, lights or other similar devices.

5.3.2 Flow control and monitoring

a) A flow indicator of the thermal oil is to be provided.

b) The flow detection is to be representative of the flow in each heated element.

c) The flow detection is not to be based on a measurement of the pressure-drop through the heating element.

d) Oil fired or exhaust gas heaters are to be provided with a flow monitor limit-switch. If the flow rate falls below a minimum value the firing system is to be switched off and interlocked.

5.3.3 Manual control

During manual operation the automated functioning of at least the temperature control device on the thermal oil side as well as the flow monitoring is to be maintained.

5.3.4 Leakage monitoring

Oil tanks are to be equipped with a leakage detector which, when actuated, shuts down and interlocks the thermal oil firing system. If the oil fired heater is on stand-by, the starting of the burner is to be blocked if the leakage detector is actuated.

5.4 Control and monitoring requirements

5.4.1 Tab 20, Tab 21, Tab 22 and Tab 23 summarise the control and monitoring requirements for main propulsion boilers, auxiliary boilers, oil fired thermal oil heaters and exhaust gas thermal oil heaters and incinerators, respectively.

Table 20 : Main propulsion boilers

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Boiler			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Fuel oil							
• Fuel oil delivery pressure or flow	L						
• Fuel oil temperature after heater or viscosity fault	L+H	local					
• Master fuel oil valve position (open / close)		local					
• Fuel oil input burner valve position (open / close)		local					
Combustion							
• Flame failure of each burner	X						
• Failure of atomizing fluid	X					5	
• Boiler casing and economizer outlet smoke temperature (in order to detect possible fire outbreak)	H						
	HH			X			
Air							
• Air register position		local					
General steam							
• Superheated steam pressure	L+H	local					
					X		
• Superheated steam temperature	H	local					
• Lifting of safety valve (or equivalent: high pressure alarm for instance)	X						
• Water level inside the drum of each boiler	L+H	local**(1)**					
	LL			X			
					X		
(1) Duplication of level indicator is required							

Table 21 : Auxiliary boilers

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Boiler			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Water level	L+H	local					
	LL			X			
Circulation stopped (when forced circulation boiler)	X			X			
Fuel oil temperature or viscosity **(2)**	L+H	local					
Flame failure	X			X			
Temperature in boiler casing (Fire)	H						
Steam pressure	H(**1**)	local		X			
(1) When the automatic control does not cover the entire load range from zero load **(2)** Where heavy fuel is used							

Table 22 : Thermal oil system

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Thermal fluid temperature heater outlet	H	local		X(**1**)			
Thermal fluid pressure pump discharge	H	local		X			
Thermal fluid flow through heating element	L LL	local		 X(**1**)			
Expansion tank level	L LL	local		 X(**2**)			
Expansion tank temperature	H						
Forced draft fan stopped	X			X			
Heavy fuel oil temperature or viscosity	H+L	local					
Burner flame failure	X			X			
Flue gas temperature heater outlet	H HH			 X(**2**)			

(1) Shut-off of heat input only

(2) Stop of fluid flow and shut-off of heat input

Table 23 : Incinerators

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Incinerator			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Flame failure	X			X			
Furnace temperature	H			X			
Exhaust gas temperature	H						
Fuel oil pressure		local					
Fuel oil temperature or viscosity **(1)**	H+L	local					

(1) Where heavy fuel is used

Table 24 : Pressure vessel certification

Class	Drawing / Calculation		Material testing		Hydraulic test	
	Manufacturer	The Society	Manufacturer	The Society	Manufacturer	The Society
1	X	review	X	witness + workshop inspection	X	witness
2	X	review	X	review	X	witness
3	X	–	X	review	X	witness

Note 1: Certificates of the Manufacturer and the Society to be issued for all cases for pressure vessels covered by the Rules of the Society.

6 Arrangement and installation

6.1 Foundations

6.1.1 For boilers and pressure vessels bolting down to their foundations, see Ch 1, Sec 1, [3.7.1]. Where necessary, they are also to be secured to the adjacent hull structures by suitable ties.

Where chocks are required to be fitted between the boilers and their foundations, they are to be of cast iron or steel.

6.2 Boilers

6.2.1 Thermal expansion

Means are to be provided to compensate thermal expansion of boilers.

6.2.2 Minimum distance of boilers from vertical bulkheads and fuel tanks

a) The distance between boilers and vertical bulkheads is to be not less than the minimum distance necessary to provide access for inspection and maintenance of the structure adjacent to the boiler.

b) In addition to the requirement in a), the distance of boilers from fuel oil tanks is to be such as to prevent the possibility that the temperature of the tank bulkhead may approach the flash point of the oil.

c) In any event, the distance between a boiler and a vertical bulkhead is not to be less than 450 mm.

6.2.3 Minimum distance of boilers from double bottom

a) Where double bottoms in way of boilers may be used to carry fuel oil, the distance between the top of the double bottom and the lower metal parts of the boilers is not to be less than:
   - 600 mm, for cylindrical boilers
   - 750 mm, for water tube boilers.

b) The minimum distance of vertical tube boilers from double bottoms not intended to carry oil may be 200 mm.

6.2.4 Minimum distance of boilers from ceilings

a) A space sufficient for adequate heat dissipation is to be provided on the top of boilers.

b) Oil tanks are not permitted to be installed in spaces above boilers.

6.2.5 Installation of boilers on engine room flats

Where boilers are installed on an engine room flat and are not separated from the remaining space by means of a watertight bulkhead, a coaming of at least 200 mm in height is to be provided on the flat. The area surrounded by the coaming may be drained into the bilge.

6.2.6 Drip trays and gutterways

Boilers are to be fitted with drip trays and gutterways in way of burners so arranged as to prevent spilling of oil into the bilge.

6.2.7 Hot surfaces

Hot surfaces with which the crew are likely to come into contact during operation are to be suitably guarded or insulated. See Ch 1, Sec 1, [3.4.1].

6.2.8 Registers fitted in the smoke stacks of oil fired boilers

Where registers are fitted in smoke stacks, they are not to obstruct more than two thirds of the cross-sectional area of gas passage when closed. In addition, they are to be provided with means for locking them in open position when the boiler is in operation and for indicating their position and degree of opening.

6.3 Pressure vessels

6.3.1 Safety devices on multiple pressure vessels

Where two or more pressure vessels are interconnected by a piping system of adequate size so that no branch of piping may be shut off, it is sufficient to provide them with one safety valve and one pressure gauge only.

6.4 Thermal oil heaters

6.4.1 In general, the requirements of [6.2] for boilers are also applicable to thermal oil heaters.

7 Material test, workshop inspection and testing, certification

7.1 Material testing

7.1.1 General

Materials, including welding consumables, for the constructions of boilers and pressure vessels are to be certified by the material manufacturer in accordance with the appropriate material specification.

7.1.2 Boilers, other steam generators, and oil fired and exhaust gas thermal oil heaters

In addition to the requirement in [7.1.1], testing of materials intended for the construction of pressure parts of boilers, other steam generators, oil fired thermal oil heaters and exhaust gas thermal oil heaters is to be witnessed by the Surveyor.

7.1.3 Class 1 pressure vessels and heat exchangers

In addition to the requirement in [7.1.1], testing of materials intended for the construction of class 1 pressure parts of pressure vessels and heat exchangers is to be witnessed by the Surveyor.

This requirement may be waived at the Society's discretion for mass produced small pressure vessels (such as accumulators for valve controls, gas bottles, etc.).

7.2 Workshop inspections

7.2.1 Boilers and individually produced class 1 and 2 pressure vessels

The construction, fitting and testing of boilers and individually produced class 1 and 2 pressure vessels are to be attended by the Surveyor, at the builder's facility.

7.2.2 Mass produced pressure vessels

Construction of mass produced pressure vessels which are type approved by the Society need not be attended by the Surveyor.

7.3 Hydrostatic tests

7.3.1 General

Hydrostatic tests of all class 1, 2 and 3 pressure vessels are to be witnessed by the Surveyor with the exception of mass produced pressure vessels which are built under the conditions stated in [7.2.2].

7.3.2 Testing pressure

a) Upon completion, pressure parts of boilers and pressure vessels are to be subjected to a hydraulic test under a pressure p_t defined below as a function of the design pressure p:

- $p_t = 1,5\ p$ where $p \leq 4$ MPa
- $p_t = 1,4\ p + 0,4$ where $4 \text{ MPa} < p \leq 25$ Mpa
- $P_t = p + 10,4$ where $p > 25$ MPa

b) The test pressure may be determined as a function of a pressure lower than p; however, in such case, the setting and characteristics of the safety valves and other overpressure protective devices are also to be determined and blocked as a function of this lower pressure.

c) If the design temperature exceeds 300°C, the test pressure p_t is to be as determined by the following formula:

$$p_t = 1{,}5\frac{K_{100}}{K}p$$

where:

p : Design pressure, in MPa

K_{100} : Permissible stress at 100°C, in N/mm^2

K : Permissible stress at the design temperature, in N/mm^2.

d) Consideration is to be given to the reduction of the test pressure below the values stated above where it is necessary to avoid excessive stress. In any event, the general membrane stress is not to exceed 90% of the yield stress at the test temperature.

e) Economisers which cannot be shut off from the boiler in any working condition are to be submitted to a hydraulic test under the same conditions as the boilers.

f) Economisers which can be shut off from the boiler are to be submitted to a hydraulic test at a pressure determined as a function of their actual design pressure p.

7.3.3 Hydraulic test of boiler and pressure vessel accessories

a) Boilers and pressure vessel accessories are to be tested at a pressure p_t which is not less than 1,5 times the design pressure p of the vessels to which they are attached.

b) The test pressure may be determined as a function of a pressure lower than p; however, in such case, the setting and characteristics of the safety valves and other overpressure protective devices are also to be determined and blocked as a function of this lower pressure.

7.3.4 Hydraulic test procedure

a) The hydraulic test specified in [7.3.1] is to be carried out after all openings have been cut out and after execution of all welding work and of the heat treatment, if any. The vessel to be tested is to be presented without lagging, paint or any other lining and the pressure is to be maintained long enough for the Surveyor to proceed with a complete examination.

b) Hydraulic tests of boilers are to be carried out either after installation on board, or at the manufacturer's plant. Where a boiler is hydrotested before installation on board, the Surveyor may, if deemed necessary, request to proceed with a second hydraulic test on board under a pressure at least equal to 1,1 p. For this test, the boiler may be fitted with its lagging. However, the Surveyor may require this lagging to be partially or entirely removed as necessary.

c) For water tube boilers, the hydraulic test may also be carried out separately for different parts of the boiler upon their completion and after heat treatment. For drums and headers, this test may be carried out before drilling the tube holes, but after welding of all appendices and heat treatment. When all parts of the boiler have been separately tested and following assembly the boiler is to undergo a hydraulic test under a pressure of 1,25 p.

7.3.5 Hydraulic tests of condensers

Condensers are to be subjected to a hydrostatic test at the following test pressures:

- steam space: 0,1 MPa
- water space: maximum pressure which may be developed by the pump with closed discharge valve increased by 0,07 MPa. However, the test pressure is not to be less than 0,2 MPa. When the characteristics of the pump are not known, the hydrostatic test is to be carried out at a pressure not less than 0,35 MPa.

7.4 Certification

7.4.1 Certification of boilers and individually produced pressure vessels

Boilers and individually produced pressure vessels of classes 1, 2 and 3 are to be certified by the Society in accordance with the procedures stated in Part A.

7.4.2 Mass produced pressure vessels

Small mass produced pressure vessels of classes 1, 2 and 3 may be accepted provided they are type approved by the Society in accordance with the procedures stated in Part A.

Section 4 Steam Turbines

1 General

1.1 Application

1.1.1 Propulsion turbines and turbines for essential services

The requirements of this Section apply to:

a) all propulsion turbines

b) turbines intended for essential services.

1.1.2 Auxiliary turbines driving generators

In addition to the requirements contained in this Section, auxiliary turbines driving electric generators are to comply with those of Ch 3, Sec 3.

1.2 Documentation to be submitted

1.2.1 For propulsion turbines and turbines driving machinery intended for essential services, the plans and data listed in Tab 1 are to be submitted.

All listed plans are to be constructional plans complete with all dimensions and are to contain full indication of the types of materials employed.

Table 1 : Documents to be submitted

No	A/I **(1)**	Item
1	I	Sectional assembly
2	A	Rotors and discs, revolving and stationary blades for each turbine
3	A	Fastening details of revolving and stationary blades
4	A	Casings
5	A	Schematic diagram of control and safety devices
6	I	General specification of the turbine, including an operation and instruction manual
7	I	Maximum power and corresponding maximum rotational speed, and the values of pressure and temperature at each stage
8	A	Material specifications of the major parts, including their physical, chemical and mechanical properties, the data relevant to rupture and creep at elevated temperatures, when the service temperature exceeds 400°C, the fatigue strength, the corrosion resistance and the heat treatments
9	I	Distribution box
10	A	Strength calculations of rotors, discs and blades and blade vibration calculations
11	A	Where the rotors, stators or other components of turbines are of welded construction, all particulars on the design of welded joints, welding conditions, heat treatments and non-destructive examinations after welding
(1) A = To be submitted for approval ; I = To be submitted for information		

2 Design and construction

2.1 Materials

2.1.1 Rotating components

a) Rotors, shafts and discs of turbines are to be of forged steel. In general, the forgings are to have minimum tensile strength R_m within the limits in Tab 2.

b) Rotors of small turbines may be built of special cast steels.

c) Turbine blades are to be built of corrosion-resistant materials.

Table 2 : Limits of R_m

Steel	R_m limits (N/mm^2)
Carbon and carbon-manganese steel	$400 < R_m < 600$
Alloy steels for rotors	$500 < R_m < 800$
Alloy steels for discs and other forgings	$500 < R_m < 1000$

2.1.2 Static components

The casings and diaphragms of turbines are to be built of forged or cast steels capable of withstanding the pressures and temperatures to which they are subjected. Cast iron may be used for temperatures up to 300°C.

2.2 Design and constructional details

2.2.1 Rotors and stators

a) All components of turbines are to be free from defects and are to be built and installed with tolerances and clearances such as to allow thermal expansion and to minimise the distortions of casings and rotors in all expected service conditions.

b) Particular care is to be devoted to preventing condensation water from accumulating in the blade spaces of the casings. Adequate drain tubes and cocks are to be arranged in a suitable position, in the lower parts of the casings. Cocks are to be easy to operate.

c) When labyrinth packings are used, the steam supply pipes to the sealing system are to be so arranged that condensed steam may not enter the turbine.

d) Particular attention is to be paid to the connection of pipes to the turbine stators in order to avoid abnormal loads in service.

e) Smooth fillets are to be provided at changes of section of rotors, discs and blade roots. The holes in discs are to be well rounded and polished.

2.2.2 Bearings

a) Turbine bearings are to be so located that their lubrication is not impaired by overheating from adjacent hot parts.

b) Lubricating oil is to be prevented from dripping on high temperature parts.

c) Suitable arrangements for cooling the bearings after the turbines have been stopped may also be required, at the discretion of the Society.

2.2.3 Turning gear

a) Main propulsion turbines are to be equipped with turning gear for both directions of rotation. The rotors of auxiliary turbines are to be capable of being turned by hand.

b) The engagement of turning gear is to be visually indicated at the control platform.

c) An interlock is to be provided to ensure that the turbine cannot be started up when the turning gear is engaged.

2.2.4 Interlock

The simultaneous admission of steam to the ahead and astern turbines is to be prevented by interlocks. Brief overlapping of the ahead and astern valves during manoeuvring may be permitted.

2.2.5 Turbine exhaust

a) Sentinel valves or other equivalent means are to be provided at the exhaust end of all turbines. The valve discharge outlets are to be clearly visible and suitably guarded, as necessary.

b) Where, in auxiliary steam turbines, the inlet steam pressure exceeds the pressure for which the exhaust casing and associated piping up to the exhaust valve are designed, means to relieve the excess pressure are to be provided.

2.2.6 Water accumulation prevention

a) Non-return valves or other approved means are to be fitted in bled steam connections to prevent steam and water returning into the turbines.

b) Bends are to be avoided in steam piping in which water may accumulate.

2.2.7 Steam strainers

Efficient steam strainers are to be provided close to the inlets to ahead and astern high pressure turbines or alternatively at the inlets to manoeuvring valves.

2.2.8 Emergency arrangements

a) In single screw ships fitted with compound main turbine installations the arrangements are to be such as to enable safe navigation when the steam led to any one of the turbines is cut off. For this purpose the steam may be led direct to the low pressure (L.P.) turbine and either the high pressure (H.P.) or medium pressure (M.P.) turbine can exhaust direct to the condenser.

Adequate arrangements and controls are to be provided for these operating conditions so that the pressure and temperature of the steam will not exceed those which the turbines and condenser can safely withstand.

The necessary pipes and valves for these arrangements are to be readily available and properly marked. A fit up test of all combinations of pipes and valves is to be performed prior to the first sea trials.

The permissible power/speeds when operating without one of the turbines (all combinations) is to be specified and information provided on board.

The operation of the turbines under emergency conditions is to be assessed for the potential influence on shaft alignment and gear teeth loading conditions.

b) Units classed for unrestricted service and fitted with a steam turbine propulsion plant and only one main boiler are to be provided with means to ensure emergency propulsion in the event of failure of the main boiler.

2.3 Welded fabrication

2.3.1 The manufacturer's requirements relative to the welding of turbine rotors or major forged or cast pieces, where permitted, are to be readily identifiable when the plans are submitted to the Society for approval. Requirements relative to fabrication, welding, heat treatments, examinations, testing and acceptance will be stipulated on a case by case basis.

In general, all weldings are to be carried out by qualified welders in accordance with qualified welding procedures and using approved consumables.

2.4 Control, monitoring and shut-off devices

2.4.1 Governors

a) Turbines for main propulsion machinery equipped with controllable pitch propellers, disengaging couplings or electrical transmission systems are to be fitted with an additional speed governor which, in the event of a sudden loss of load, prevents the revolutions from increasing to the trip speed.

b) The speed increase of turbines driving electric generators -except those for electrical propeller drive- resulting from a change from full load to no-load may not exceed 5% on the resumption of steady running conditions. The transient speed increase resulting from a sudden change from full load to no-load conditions is not to exceed 10% and is to be separated by a sufficient margin from the trip speed.

2.4.2 Overspeed devices

a) Each main and auxiliary turbine is to be provided with an overspeed protective device to prevent the rotational speed from exceeding the maximum rotational by more than 15%. The device is to be actuated by the turbine shaft.

b) Where two or more steam turbines are coupled to the same gear wheel, the Society may accept the fitting of only one overspeed device for all the coupled turbines.

c) For turbines driving electric generators, the overspeed protective device mentioned in a) is also to be fitted with a means for manual tripping.

d) Where exhaust steam from auxiliary systems is led to the main turbine, provision is to be made to cut off the steam automatically when the overspeed protective device is activated.

2.4.3 Rotor axial displacement

A quick-closing valve is to be provided which automatically shuts off the steam supply in the event of axial displacement of the rotor beyond the permissible limits stated by the manufacturer. The device controlling the valve is to be actuated by the turbine shaft.

2.4.4 Emergency oil supply

For the emergency lubricating oil supply, see Ch 1, Sec 7, [12.5].

2.4.5 Bearing lubrication failure

a) Main ahead turbines are to be provided with a quick-closing valve which automatically shuts off the steam supply in the event of a dangerous reduction in oil pressure in the bearing lubricating system.

b) This arrangement is to be such as to ensure the admission of steam to the astern turbine for braking purposes.

2.4.6 Shut-off arrangement

a) Arrangements are to be provided for shutting off the steam to the main turbines by a suitable hand trip device controlling the steam admission valve situated at the control platform and at the turbine itself.

b) Hand tripping for auxiliary turbines is to be arranged in the proximity of the turbine overspeed protective device.

c) The hand trip device is any device which is operated manually irrespective of the way the action is performed, i.e. mechanically or by means of external power.

d) The quick-closing valves are also to be manually operable at the turbine and from the control platform.

e) Re-setting of the quick-closing valve device may be effected only at the turbine or from the control platform with the control valves in the closed position.

f) Where the valves are operated by hydraulic oil systems fitted for automatic operation, they are to be fed by two pumps: one main pump and one standby pump. In any event, the standby pump is to be independent. In special cases, at the Society’s discretion, a hand-operated pump may be accepted as a standby pump.

g) The starting up of any turbine is to be possible only when the quick-closing devices are ready for operation.

h) A quick-closing device is to be provided which automatically shuts off the steam supply in the event of an increase in pressure or water level in the condenser beyond the permissible limits.

2.4.7 Summary Tables

Tab 3 and Tab 4 summarise the minimum control and monitoring requirements for main propulsion and auxiliary turbines, respectively.

Table 3 : Main propulsion turbine

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Turbine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
• Main turbine speed		local					
	H			X			
					X		
• Main turbine axial displacement	X	local		X			
• Main turbine vibration	H	local					
Lubricating oil							
• Supply pressure		local					
	L			X(**2**)			
• Level of gravity tank	L(**1**)	local					

(1) Sensor to be located near the normal level
(2) This is not to prevent astern operation for braking

Table 4 : Auxiliary turbine

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Turbine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Overspeed	H	local		X			
Rotor displacement	X	local		X			
Vibration	H	local					
Lubricating oil supply pressure	L			X			
Lubricating oil level in gravity tank	L						

3 Arrangement and installation

3.1 Foundations

3.1.1 Shipyards and Manufacturers are to take care that foundations of turbines and connected reduction gears are to be designed and built so that hull movements do not give rise to significant movements between reduction gears and turbines. In any event, such movements are to be absorbed by suitable couplings.

3.2 Jointing of mating surfaces

3.2.1 The mating flanges of casings are to form a tight joint without the use of any interposed material.

3.3 Piping installation

3.3.1 Pipes and mains connected to turbine casings are to be fitted in such a way as to minimise the thrust loads and moments.

3.4 Hot surfaces

3.4.1 Hot surfaces with which the crew are likely to come into contact during operation are to be suitably guarded or insulated. See Ch 1, Sec 1, [3.4].

3.5 Alignment

3.5.1 The Shipyard and the Manufacturer are to take particular care in the alignment of turbine-reduction gearing, taking account of all causes which may alter the alignment from cold conditions to normal service conditions.

When a structural tank is fitted in way of the turbine or gearing foundations, the expected tank temperature variations are to be taken into account during alignment operations.

Propulsion turbines are to be fitted with indicators showing the axial movements of rotors with respect to casings and the sliding movements of casings on the sliding feet.

3.6 Circulating water system

3.6.1 The circulating water system with vacuum ejectors is to be so arranged that water may not enter the low pressure turbines.

3.7 Gratings

3.7.1 Gratings and any other structures in way of the sliding feet or flexible supports are to be so arranged that turbine casing expansion is not restricted.

3.8 Drains

3.8.1 Turbines and the associated piping systems are to be equipped with adequate means of drainage.

3.9 Instruments

3.9.1 Main and auxiliary turbines are to be fitted with callipers and micrometers of a suitable type for verifying the alignment of rotors and pinion and gear-wheel shafts.

This check is to be performed to the Surveyor’s satisfaction at the time of installation.

4 Material tests, workshop inspection and testing, certification

4.1 Material tests

4.1.1 Parts to be tested

The materials for the construction of the parts listed in Tab 5 are to be tested in compliance with the requirements of NR216.

Magnetic particle or liquid penetrant tests are required for the parts listed in Tab 5 and are to be effected by the Manufacturer in positions agreed upon by the Surveyor, where Manufacturer’s experience shows defects are most likely to occur.

For important structural parts of the turbine, in addition to the above-mentioned non-destructive tests, examination of welded seams by approved methods of inspection may be required.

Where there are grounds to doubt the soundness of any turbine component, non-destructive tests using approved detecting methods may be required.

Table 5 : Material and non-destructive tests

Turbine component	Material tests (mechanical properties and chemical composition)	Non-destructive tests	
		Magnetic particle or liquid penetrant	Ultrasonic or X Ray examination
Rotating parts (turbine rotors, shafts, stiff and flexible couplings, bolts for couplings and other dynamically stressed parts, integral pinions and gears)	all	all	sample
Stationary parts (castings and plates for casings)	all	spot as agreed between the Manufacturer and the Surveyor	–
Blades	sample	sample	sample
Piping and associated fittings	as required in the appropriate Section of the Rules	as required in the appropriate Section of the Rules	as required in the appropriate Section of the Rules

4.1.2 Special auxiliary turbines

In the case of auxiliary turbines with a steam inlet temperature of up to 250°C, the extent of the tests stated in Tab 5 may be limited to the disc and shaft materials.

4.2 Inspections and testing during construction

4.2.1 Inspections during construction

The following inspections and tests are to be carried out in the presence of the Surveyor during the construction of all turbines which are indicated in [1.1.1]. For shipboard tests, see Ch 1, Sec 11, [3.3].

- material tests, as required (see [4.1])
- welded fabrication (see [4.2.2])
- non-destructive examination of turbine blades (see [4.2.3])
- hydrostatic tests (see [4.2.4])
- safety valves (see [4.2.5])
- thermal stability test of rotor (see [4.2.6])
- rotor balancing and overspeed test (see [4.2.7] and [4.2.8])
- shop trials (see [4.2.9]).

4.2.2 Welded fabrication

Welded fabrication and testing is to be attended by the Surveyor, as may be deemed necessary by the Society.

4.2.3 Turbine blades

When turbine blades are calculated using a permissible stress $K > R_m/4$, all turbine rotor blades are to be checked by dye penetrants or other equivalent method.

4.2.4 Hydrostatic tests

a) Turbine and nozzle casings are to be subjected to a hydrostatic test at the greater of the following test pressures:
    - 1,5 times the working pressure
    - 1,5 times the starting pressure
    - the test pressure is not to be less than 0,2 N/mm^2.

b) The turbine casings may be temporarily subdivided by diaphragms in order to obtain different pressure values for the various stages, if necessary.

c) Where it is not possible to perform hydrostatic tests, the manufacturer may submit to the Society, for consideration, alternative proposals for testing the integrity of turbine casings and the absence of defects therein.

d) For the bodies of quick-closing, safety, manoeuvring and control valves, the test pressure is to be 1,5 times the maximum allowable working pressure of the boiler (approval pressure). The sealing efficiency of these valves when closed is to be tested at 1,1 times the working pressure.

e) Intermediate coolers and heat exchangers are to be subjected to a hydrostatic test at 1,5 times the working pressure.

f) Pressure piping, valves and other fittings are to be subjected to hydrostatic tests in compliance with the normal requirements for these items.

4.2.5 Safety valves

All valves required in [2.4] are to be tested at their setting pressure in the presence of the Surveyor, as specified by the turbine manufacturer.

4.2.6 Thermal stability test of rotors

Solid forged and welded rotors of propulsion turbines are to be subjected to a thermal stability test where the service temperature exceeds 400°C. This test is to be carried out after heat treatment and rough machining or at a later stage of fabrication, in accordance with a procedure approved by the Society.

4.2.7 Balancing of rotors

Finished rotors, complete with all fittings and blades, are to be dynamically balanced in a balancing machine of appropriate sensitivity in relation to the size of the rotor. Normally this test is to be carried out with the primary part of the flexible coupling, if any.

4.2.8 Overspeed test of rotors

Finished rotors, complete with all fittings and blades, are to be subjected for at least 3 minutes to an overspeed test at the greater of the following values:

- 5% above the setting speed of the overspeed tripping device
- 15% above the maximum design speed.

The Society may waive this requirement provided that it can be demonstrated by the manufacturer, using an acceptable direct calculation procedure, that the rotor is able to safely withstand the above values of overspeed and that rotors are free from defects, as verified by means of non-destructive tests.

4.2.9 Shop trials

Where turbines are subjected to a trial run at the factory, the satisfactory functioning of the control, safety and monitoring equipment is to be verified by the Manufacturer during the trial run. Such verification is in any event to take place not later than the commissioning of the plant aboard ship.

In general, propulsion steam turbines are to be subjected to a works trial under steam but without load, up to the service rotational speed, as far as possible. In the course of the works trials, the overspeed devices for both main and auxiliary turbines are to be set.

4.3 Certification

4.3.1 Turbines required to be certified

For turbines required to be certified as per [1.1.1], Society's certificates (C) (see NR216, Ch 1, Sec 1, [4.2.1]) are required for material tests of rotating components and blades listed in Tab 5 and for works trials as per [4.2.1]. Provided the manufacturer has a quality assurance system accepted by the Society, a reduced number of inspections in the presence of the Surveyor may be agreed.

4.3.2 Turbines not required to be certified

For turbines not required to be certified as per [1.1.1], manufacturer's certificates including details of tests and inspections carried out at the shop are to be submitted. The acceptance of these turbines is, however, subject to their satisfactory performance during dock and sea trials.

4.3.3 Type approved turbines

For mass produced turbines which are requested to be type approved by the Society, the tests and trials on a prototype are to be carried out in the presence of the Surveyor as stated in [4.3.1]. The minimum required attendance of the Surveyor at the production tests and trials will be agreed between the manufacturer and the Society on a case by case basis.

Section 5 Gas Turbines

1 General

1.1 Application

1.1.1 Propulsion turbines and turbines for essential services

The requirements of this Section apply to:

a) all propulsion turbines

b) turbines intended for essential services and for the safety of the unit.

1.1.2 Turbines for auxiliary generators

In addition to the requirements contained in this Section, auxiliary turbines driving electric generators are to comply with the applicable requirements of Ch 3, Sec 3.

1.1.3 Type approval

Turbines intended for propulsion and essential services are to be type approved by the Society.

1.2 Definition of rated power

1.2.1 Rated power is the maximum constant power that the turbine can develop at constant speed in the range of air inlet temperature between 0°C and 35°C. This power is to be considered with 0 intake and exhaust losses and with an air relative humidity of 60%.

1.3 Documentation to be submitted

1.3.1 For propulsion turbines and turbines intended for driving machinery for essential services, the plans listed in Tab 1 are to be submitted.

The listed constructional plans are to be complete with all dimensions and are to contain full indication of the types of materials used.

Table 1 : Documents to be submitted

No.	A/I **(1)**	Item
1	I	Sectional assembly
2	A	Detailed drawings of rotors, casings, blades, combustion chambers and heat exchangers **(2)**
3	A	Material specifications of the major parts, including their physical, chemical and mechanical properties, the data relevant to rupture and creep at elevated temperatures, the fatigue strength, the corrosion resistance and the heat treatments **(2)**
4	A	Where the rotors, stators or other components of turbines are of welded construction, all particulars on the design of welded joints, welding procedures and sequences, heat treatments and non-destructive examinations after welding **(2)**
5	I	General specification of the turbine, including instruction manual, description of structures and specification of the properties of fuel and lubricating oil to be used
6	I	Details of operating conditions, including the pressure and temperature curves in the turbine and compressor at the rated power and corresponding rotational speeds, and details of permissible temporary operation beyond the values for the rated power
7	A	Diagrammatic layout of the fuel system, including control and safety devices, and of the lubricating oil system
8	A	Cooling system layout, if applicable
9	I	Where applicable, background information on previous operating experience in similar applications
10	I	Maintenance and overhaul procedures
11	A	Stress and temperature analysis in blades, rotors and combustion chamber **(2)**
12	A	Life time calculation of hot and high stress parts **(2)**
13	A	Blade and rotor vibration analysis **(2)**
14	A	Details of automatic safety devices together with failure mode and effect analysis **(2)**

(1) A = To be submitted for approval ; I = To be submitted for information

(2) As an alternative, the Society may, on a case by case basis, consider reviewing a number of selected packages relative to important and critical parts of the turbine, where all the design, construction, inspection, testing and acceptance criteria used by the manufacturer are clearly described, provided the Quality Assurance system of the manufacturer is approved and certified by the Society.

2 Design and construction

2.1 Materials

2.1.1 Approved materials

a) Gas turbine materials are to fulfil the requirements imposed by the operating conditions of the individual components. In the choice of materials, account is to be taken of effects such as creep, thermal fatigue, oxidation and corrosion to which individual components are subject when in service. Evidence of the suitability of the materials is to be supplied to the Society in the form of details of their chemical and mechanical properties and of the heat treatment applied. Where composite materials are used, their method of manufacture is to be described.

b) Turbine blades are to be built of corrosion and heat-resistant materials.

2.2 Stress analyses

2.2.1 Calculation

a) The manufacturer is to submit the results of calculation of the stresses on each rotor under the most severe service conditions.

b) Fatigue analysis on each rotor, taking into account the stress concentrations, is also to be submitted.

c) The results of previous in-service experience on similar applications may be considered by the Society as an alternative to items a) and b) above.

The calculations and analyses (see also [1.3.1]) are to be carried out in accordance with criteria agreed by the Society. Data on the design service life and test results used to substantiate calculation assumptions are also to be provided.

2.2.2 Vibrations

The range of service speeds is not to give rise to unacceptable bending vibrations or to vibrations affecting the entire installation. Calculations of the critical speeds including details of their basic assumptions are to be submitted.

2.3 Design and constructional details

2.3.1 Rotors and stators

a) All components of turbines and compressors are to be free from defects and are to be built and installed with tolerances and clearances in order to allow thermal expansion and to minimise the distortions of casings and rotors in all expected service conditions.

b) Adequate drain tubes and cocks are to be arranged in a suitable position, in the lower parts of the casings. Cocks are to be easily operated.

c) Suitable protective devices are to be provided in order to prevent heat, noise or possible failure of rotating parts from causing injury to personnel. If, to this end, the whole gas turbine is enclosed in a protective covering, the covering is to be adequately ventilated inside.

d) Particular attention is to be paid to the connection in the casings of pipes to the turbine stators in order to avoid abnormal loads in service.

e) Smooth fillets are to be provided at changes of sections of rotors, discs and blade roots. The holes in discs are to be well rounded and polished.

2.3.2 Access and inspection openings

a) Access to the combustion chambers is to be ensured. Means are to be provided to inspect the burner cans or combustion chamber without having to remove the gas generator.

b) Inspection openings are to be provided to allow the gas turbine flow path air to be inspected with special equipment, e.g. a bore-scope or similar, without the need for dismantling.

2.3.3 Bearings

a) Turbine bearings are to be so located that their lubrication is not impaired by overheating from hot gases or adjacent hot parts.

b) Lubricating oil or fuel oil is to be prevented from dripping on high temperature parts.

c) Suitable arrangements for cooling the bearings after the turbines have been stopped are to be provided, if necessary to prevent bearing cooking.

d) Roller bearings are to be identifiable and are to have a life adequate for their intended purpose. In any event, their life cannot be less than 40000 hours.

2.3.4 Turning gear

a) Main propulsion turbines are to be equipped with turning gear or a starter for cranking. The rotors of auxiliary turbines are to be capable of being turned by hand.

b) The engagement of the turning gear or starter is to be visually indicated at the control platform.

c) An interlock is to be provided to ensure that the main turbine cannot be started up when the turning gear is engaged.

2.3.5 Cooling

The turbines and their external exhaust system are to be suitably insulated or cooled to avoid excessive outside temperature.

2.3.6 Air supply

a) The air intake ducting is to be equipped to prevent extraneous substances from entering the compressor and turbine.

b) Measures are to be taken to control the salinity of the combustion air, to meet the manufacturer's specification.

c) Cleaning equipment is to be provided to remove deposits from compressors and turbines.

d) Means are to be provided to prevent the formation of ice in the air intake.

2.3.7 Turbine exhaust arrangement

a) The gas exhaust arrangement is to be designed in such a way as to prevent the entrance of gases into the compressor.

b) Silencers or other equivalent arrangements are to be provided in the gas exhaust, to limit the airborne noise at one metre distance from the turbine to not more than 110 dB (A) in unmanned machinery spaces and not more than 90 dB (A) in manned spaces.

2.3.8 Multi-turbine installations

Multi-turbine installations are to have separate air inlets and exhaust systems to prevent recirculation through the idle turbine.

2.3.9 Fuel

a) Where the turbine is designed to burn non-distillate fuels, a fuel treatment system is to be provided to remove, as far as practicable, the corrosive constituents of the fuel or to inhibit their action in accordance with the manufacturer's specification.

b) Suitable means are to be provided to remove the deposits resulting from the burning of the fuel while avoiding abrasive or corrosive action, if applicable.

c) Gas turbines burning boil-off gases of liquefied gas cargo tanks will be specially considered by the Society taking into account the requirements of Pt D, Ch 9, Sec 16 of the Ship Rules.

2.3.10 Start-up equipment

a) Gas turbines are to be fitted with start-up equipment enabling them to be started up from the "shutdown" condition.

b) Provisions are to be made so that any dangerous accumulation of liquid or gaseous fuel inside the turbines is thoroughly removed before any attempt at starting or restarting.

c) Starting devices are to be so arranged that firing operation is discontinued and the main fuel valve is closed within a pre-determined time when ignition is failed.

d) The starting system is to be so designed as to satisfy the requirements dealing with diesel engine starting insofar as they apply.

2.3.11 Astern power

For main propulsion machinery with reverse gearing, controllable pitch propellers or an electrical transmission system, astern running is not to cause any overloading of the propulsion machinery.

2.3.12 Emergency operation

a) In installations with more than one propeller and connected shafting and more than one turbine, the failure of any gas turbine unit connected to a shafting line is not to affect the continued, independent operation of the remaining units.

b) In installations with only one propeller and connected shafting, driven by two or more main turbines, care is to be taken to ensure that, in the event of one of the turbines failing, the others are able to continue operation independently.

c) Units classed for unrestricted service and fitted with only one propeller and connected shafting driven by a gas turbine are to be provided with means to ensure emergency propulsion in the event of failure of the main turbine.

2.4 Welded fabrication

2.4.1 The manufacturer's requirements relative to the welding of turbine rotors or major forged or cast pieces, where permitted, are to be readily identifiable by the Society in the plans submitted for approval.

In general, all weldings are to be carried out by qualified welders in accordance with qualified welding procedures using approved consumables.

2.5 Control, monitoring and shut-off devices

2.5.1 Control and monitoring arrangement

For each main propulsion system, the associated control and monitoring equipment is to be grouped together at each location from which the turbine may be controlled.

2.5.2 Governors and speed control system

a) Propulsion turbines which may be operated in no-load conditions are to be fitted with a control system capable of limiting the speed to a value not exceeding 10% of the maximum continuous speed.

b) Turbines for main propulsion machinery equipped with controllable pitch propellers, disengaging couplings or an electrical transmission system are to be fitted with a speed governor which, in the event of a sudden loss of load, prevents the revolutions from increasing to the trip speed.

c) In addition to the speed governor, turbines driving electric generators are to be fitted with a separate overspeed protective device, with a means for manual tripping, adjusted so as to prevent the rated speed from being exceeded by more than 15%.

d) The speed increase of turbines driving electric generators - except those for electrical propeller drive - resulting from a change from full load to no-load is not to exceed 5% on the resumption of steady running conditions. The transient speed increase resulting from a sudden change from full load to no-load conditions is not to exceed 10% and is to be separated by a sufficient margin from the trip speed. Alternative requirements may be considered by the Society on a case by case basis based on the actual turbine design and arrangement.

2.5.3 Monitoring system

The main operating parameters (pressure, temperature, rpm, etc.) are to be adequately monitored and displayed at the control console.

Table 2 : Main propulsion and auxiliary turbines

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Turbine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
• Control system failure	X						
• Automatic starting failure	X						
Mechanical monitoring of gas turbine							
• Speed		local					
					X		
	H			X			
• Rotor axial displacement (Not applicable to roller bearing)		local					
	H			X			
• Vibration	H	local					
• Performed number of cycle of rotating part	H						
Gas generator monitoring							
• Flame and ignition failure	X			X			
• Fuel oil supply pressure	L	local					
• Fuel oil supply temperature	H	local					
• Cooling medium temperature	H	local					
• Exhaust gas temperature or gas temperature in specific locations of flow gas path (Alarm before shutdown)		local					
	H			X			
• Pressure at compressor inlet (alarm before shutdown)		local					
	L			X			
Lubricating oil							
• Turbine supply pressure		local					
	L			X			
• Differential pressure across lubricating oil filter	H	local					
• Bearing or lubricating oil (discharge) temperature	H	local					

2.5.4 Emergency shut-off

a) An emergency push-button shut-off device is to be provided at the control console.

b) Any shut-off device provided in pursuance of the above is to shut off the fuel supply as near the burners as possible.

2.5.5 Quick-closing devices

a) Re-setting of the quick-closing device may be effected only at the turbine or from the control platform with the fuel supply control valve in the closed position.

b) When the devices are operated by hydraulic oil systems fitted for automatic operation, they are to be fed by two pumps: one main pump and one standby pump. In any event, the standby pump is to be independent. In special cases, a hand-operated pump may be accepted as a standby pump.

c) The starting up of any turbine is to be possible only when the quick-closing devices are ready for operation.

2.5.6 Automatic temperature controls

The following turbine services are to be fitted with automatic temperature controls so as to maintain steady state conditions within the normal operating range of the main gas turbine:

a) lubricating oil supply and discharge

b) fuel oil supply (or, alternatively, automatic control of fuel oil viscosity)

c) exhaust gas in specific locations of the flow gas path as determined by the manufacturer.

2.5.7 Indicators, alarm and shutdown

Tab 2 indicates the minimum control and monitoring requirements for main propulsion and auxiliary turbines.

3 Arrangement and installation

3.1 Foundations

3.1.1 Manufacturers and Shipyards are to arrange foundations of turbines and connected reduction gears to be so designed and built that hull movements do not give rise to significant movements between reduction gears and turbines. In any event, such movements are to be absorbed by suitable couplings.

3.2 Joints of mating surfaces

3.2.1 The mating flanges of casings are to form a tight joint without the use of any interposed material.

3.3 Piping installation

3.3.1 Pipes and mains connected to turbine and compressor casings are to be fitted in such a way as to minimise the thrust loads and moments. If flexible hoses are used for this purpose, they are to comply with the requirements in Ch 1, Sec 7, [2.6].

3.4 Hot surfaces

3.4.1 Hot surfaces with which the crew are likely to come into contact during operation are to be suitably guarded or insulated. See Ch 1, Sec 1, [3.4].

3.5 Alignment

3.5.1

a) The Manufacturer is to take particular care in the alignment of turbine-reduction gearing, taking account of all causes which may alter the alignment from cold conditions to normal service conditions.

b) When a structural tank is fitted in way of the turbine or gearing foundations, the expected tank temperature variations are to be taken into account during alignment operations.

c) Propulsion turbines are to be fitted with indicators showing the axial movements of rotors with respect to casings and the sliding movements of casings on the sliding feet. Such indicators are to be fitted in an easily visible position. This requirement does not apply to turbines fitted with roller bearings.

3.6 Gratings

3.6.1 Gratings and any other structures in way of the sliding feet or flexible supports are to be so arranged that turbine casing expansion is not restricted.

3.7 Drains

3.7.1 Turbines and the associated piping systems are to be equipped with adequate means of drainage.

3.8 Instruments

3.8.1 Main and auxiliary turbines are to be fitted with callipers and micrometers of a suitable type for verifying the alignment of rotors and pinion and gear-wheel shafts, when necessary.

At the time of installation on board, this check is to be performed in the presence and to the satisfaction of the Surveyor.

4 Material tests, workshop inspection and testing, certification

4.1 Type tests - General

4.1.1 Upon finalisation of the design for production of every new turbine type intended for installation on board ships, one turbine is to be presented for type testing as required below.

A type test carried out for a particular type of turbine at any manufacturer's works will be accepted for all turbines of the same type built by licensees and licensors.

Turbines which are subjected to type testing are to be tested in accordance with the scope specified below, it being taken for granted that:

- the turbine is optimised as required for the conditions of the type test
- the investigations and measurements required for reliable turbine operation have been carried out during preliminary internal tests by the turbine manufacturer
- the documentation to be submitted as required in [1.3.1] has been examined and, when necessary, approved by the Society and the latter has been informed regarding the nature and extent of investigations carried out during pre-production stages.

4.2 Type tests of turbines not admitted to an alternative inspection scheme

4.2.1 General

Turbines for which the Manufacturer is not admitted to testing and inspections according to an alternative inspection scheme (see NR320 Certification Scheme of Materials and Equipment for the Classification of Marine Units, Sec 1, [3.2]), are to be type tested in the presence of the Surveyor in accordance with the following requirements.

The type test is subdivided into three stages:

a) Stage A - Preliminary internal tests carried out by the manufacturer

   Stage A includes functional tests and collection of operating values including testing hours during the internal tests, the relevant results of which are to be presented to the Surveyor during the type test. Testing hours of components which are inspected are to be stated by the manufacturer.

b) Stage B - Type approval test

   The type approval test is to be carried out in the presence of the Surveyor.

c) Stage C - Inspection of main turbine components.

After completion of the test programme, the main turbine components are to be inspected.

The turbine manufacturer is to compile all results and measurements for the turbine tested during the type test in a type test report, which is to be submitted to the Society.

4.2.2 Stage A - Internal tests (functional tests and collection of operating data)

a) During the internal tests the turbine is to be operated at the load points considered important by the turbine manufacturer and the relevant operating values are to be recorded.

b) The load points may be selected according to the range of application.

c) Functional tests under normal operating conditions include:

   1) The load points 25%, 50%, 75%, 100% of the rated power for which type approval is requested, to be carried out:
      - along the nominal (theoretical) propeller curve and at constant speed, for propulsion turbines
      - at constant speed, for turbines intended for generating sets.

   2) The limit points of the permissible operating range.

      These limit points are to be defined by the turbine manufacturer.

d) An alternative testing program may be agreed between the manufacturer and the Society on a case by case basis.

4.2.3 Stage B - Type approval tests in the presence of the Surveyor

During the type test, the tests listed below are to be carried out in the presence of the Surveyor and the results are to be recorded in a report signed by both the turbine manufacturer and the Surveyor.

Any departures from this programme are to be agreed upon by the manufacturer and the Society.

a) Load points

   The load points at which the turbine is to be operated according to the power/speed diagram are those listed below. The data to be measured and recorded when testing the turbine at various load points are to include all necessary parameters for turbine operation.

The operating time per load point depends on the turbine characteristics (achievement of steady-state condition) and the time for collection of the operating values.

Normally, an operating time of 0,5 hour per load point can be assumed.

At the maximum continuous power as per the following item (1) an operating time of two hours is required. Two sets of readings are to be taken at a minimum interval of one hour.

1) test at maximum continuous power P: i.e. 100% output at 100% torque and 100% speed.
2) test at maximum permissible torque (normally 110% of nominal torque T) at 100% speed; or test at maximum permissible power and speed according to the nominal propeller curve.
3) tests at partial loads, e.g. 75%, 50%, 25% of maximum continuous power P and speed according to the nominal propeller curve.

b) Additional tests
   - test at lowest turbine speed according to the nominal propeller curve
   - starting tests
   - governor tests
   - testing and rating of the safety systems.

4.2.4 Evaluation of test results

The results of the tests and checks required by [4.2.3] will be evaluated by the attending Surveyor. Normally the main operating data to be recorded during the tests are those listed in [4.3.4].

The values of temperatures and pressures of media, such as cooling media, lubricating oil, exhaust gases, etc., are to be within limits which, in the opinion of the Surveyor, are appropriate for the characteristics of the turbine tested.

4.2.5 Stage C - Inspection of turbine components

Immediately after the test run as per [4.2.3], a selected number of components agreed between the manufacturer and the Society are to be presented for inspection to the Surveyor.

4.3 Type tests of turbines admitted to an alternative inspection scheme

4.3.1 General

Turbines admitted to testing and inspections according to an alternative inspection scheme (see NR320, Sec 1, [3.2]) are to be type tested in the presence of the Surveyor in accordance with the following requirements.

The selection of the turbine to be tested from the production line is to be agreed upon with the Surveyor.

4.3.2 Type test

The programme of the type test is to be in general as specified below, P being the rated power and n the corresponding speed.

Any departures from this programme are to be agreed upon by the manufacturer and the Society.

a) 6 hours at full power
b) 10 hours shared at different partial loads (25%, 50%, 75% and 90% of power P);
c) 2 hours at intermittent loads
d) starting tests
e) testing of speed governor, overspeed device and lubricating oil system failure alarm device
f) testing of the minimum speed along the nominal (theoretical) propeller curve, for main propulsion turbines driving fixed pitch propellers, and of the minimum speed with no brake load, for main propulsion turbines driving controllable pitch propellers or for auxiliary turbines.

The tests at the above-mentioned outputs are to be combined together in working cycles which are to be repeated in succession for the entire duration within the limits indicated.

In particular, the full power test is to be carried out at the end of each cycle.

The partial load tests specified in (b) are to be carried out:

- along the nominal (theoretical) propeller curve and at constant speed, for propulsion turbines
- at constant speed, for turbines intended for generating sets.

In the case of prototype turbines, the duration and programme of the type test will be specially considered by the Society.

4.3.3 Alternatives

In cases of turbines for which the manufacturer submits documentary evidence proving successful service experience or results of previous bench tests, the Society may, at its discretion, allow a type test to be carried out, in the presence of the Surveyor according to a programme to be agreed upon in each instance.

4.3.4 Data to be recorded

During the type test, at least the following particulars are to be recorded:

a) ambient air temperature, pressure and atmospheric humidity in the test room

b) cooling medium temperature at the inlet of the turbine

c) characteristics of the fuel and lubricating oil used during the test

d) turbine speed

e) brake power

f) brake torque

g) intake and exhaust losses

h) lubricating oil pressure and temperature

i) exhaust gas temperature in locations of the flow gas path selected by the manufacturer

j) minimum starting air pressure and flow rate necessary to purge and start the turbine in cold condition, if applicable.

4.3.5 Inspection of main turbine components and evaluation of test results

The provisions of [4.2.4] and [4.2.5] are to be complied with, as far as applicable.

4.4 Material tests

4.4.1 The materials for the construction of the parts listed in Tab 3 are to be tested in compliance with the requirements of NR216.

Magnetic particle or liquid penetrant tests are required for the parts listed in Tab 3 and are to be effected by the Manufacturer in positions agreed upon by the Surveyor, where Manufacturer’s experience shows defects are most likely to occur.

For important structural parts of the turbine, in addition to the above-mentioned non-destructive tests, examination of welded seams by approved methods of inspection may be required.

Where there are grounds to doubt the soundness of any turbine component, non-destructive tests using approved detecting methods may be required.

Table 3 : Material and non-destructive tests

Turbine component	Material tests (Mechanical properties and chemical composition)	Non-destructive tests	
		Magnetic particle or liquid penetrant	Ultrasonic or X Ray examination
Rotating parts (compressors and turbine rotors, shafts, stiff and flexible couplings, bolts for couplings and other dynamically stressed parts, integral pinions and gears)	all	all	all
Stationary parts (castings for casings intended for a temperature exceeding 230°C and plates for casings intended for a temperature exceeding 370°C or pressure exceeding 4 Mpa)	all	spot as agreed between the Manufacturer and the Surveyor	–
Blades	sample	sample	sample
Piping and associated fittings	as required in the appropriate Section of the Rules	as required in the appropriate Section of the Rules	as required in the appropriate Section of the Rules

4.5 Inspections and testing during construction

4.5.1 Inspections during construction

The following inspections and tests are to be carried out in the presence of a Surveyor during the construction of all turbines which are indicated in [1.1.1]. For on-board trials see Ch 1, Sec 11, [3.4].

- Material tests as required (see Ch 1, Sec 4, [4.1])
- Welding fabrication (see [4.5.2])
- Hydrostatic tests (see [4.5.3])
- Rotor balancing and overspeed test (see [4.5.4] and [4.5.5])
- Shop trials (See [4.5.6]).

4.5.2 Welding fabrication

Welding fabrication and testing is to be attended by the Surveyor, as may be deemed necessary by the Society.

4.5.3 Hydrostatic tests

Finished casing parts and heat exchangers are to be subjected to hydrostatic testing at 1,5 times the maximum permissible working pressure. If it is demonstrated by other means that the strength of casing parts is sufficient, a tightness test at 1,1 times the maximum permissible working pressure may be accepted by the Society. Where the hydrostatic test cannot be performed, alternative methods for verifying the integrity of the casings may be agreed between the manufacturer and the Society on a case by case basis.

4.5.4 Balancing of rotors

Finished rotors, complete with all fittings and blades, are to be dynamically balanced in a balancing machine of appropriate sensitivity in relation to the size of the rotor. Normally this test is to be carried out with the primary part of the flexible coupling, if any.

4.5.5 Overspeed test of rotors

Finished rotors, complete with all fittings and blades, are to be subjected for at least 3 minutes to an overspeed test at the greater of the following values:

- 5% above the setting speed of the overspeed tripping device
- 15% above the maximum design speed.

The Society may waive this requirement provided that it can be demonstrated by the manufacturer, using an acceptable direct calculation procedure, that the rotor is able to safely withstand the above overspeed values and that rotors are free from defects, as verified by means of non-destructive tests.

4.5.6 Shop trials

For shop trials, see [4.2.3] and [4.3.2].

4.6 Certification

4.6.1 Type approval certificate and its validity

Subject to the satisfactory outcome of the type tests and inspections specified in [4.2] or [4.3], the Society will issue to the engine manufacturer a “Type Approval Certificate” valid for all turbines of the same type.

4.6.2 Testing certification

a) Turbines admitted to an alternative inspection scheme

Works’ certificates (W) (see NR216, Ch 1, Sec 1, [4.2.3]) are required for components and tests indicated in Tab 3 and tests and trials listed in [4.5.1]. However, the Society reserves the right to request that the shop trials be witnessed by a Surveyor on a case by case basis.

b) Engines not admitted to an alternative inspection scheme

Society’s certificates (C) (see NR216, Ch 1, Sec 1, [4.2.1]) are required for material tests of rotating components and blades listed in Tab 3 and for works trials as per [4.5.3] and [4.5.4].

Works’ certificates (W) (see NR216, Ch 1, Sec 1, [4.2.3]) are required for the other items listed in Tab 3 and for trials described in [4.5.2], [4.5.5] and [4.5.6].

Section 6 Gearing

1 General

1.1 Application

1.1.1 Gearing systems installed onboard offshore units covered by the present Rules are to comply with relevant requirements of the Ship Rules related to design, construction, installation, certification, inspection and testing (see [1.1.2]).

1.1.2 References to the Ship Rules

The list of references to the applicable requirements of the Ship Rules is given in Tab 1.

Table 1 : Applicable requirements for gearing

Item No.	Requirement	Reference in the Ship Rules
1	Application	Pt C, Ch 1, Sec 6, [1.1]
2	Documentation to be submitted	Pt C, Ch 1, Sec 6, [1.2]
3	Design of gears, load capacity, tooth bending capacity	Pt C, Ch 1, Sec 6, [2] and Pt C, Ch 1, Sec 6, [3]
4	Design and construction	Pt C, Ch 1, Sec 6, [4]
5	Installation	Pt C, Ch 1, Sec 6, [5]
6	Certification, inspection and testing	Pt C, Ch 1, Sec 6, [6]

Section 7 Piping Systems

1 General

1.1 Application

1.1.1

a) General requirements applying to all piping systems are contained in Articles:
- Article [2] for their design and construction
- Article [3] for the welding of steel pipes
- Article [4] for the bending of pipes
- Article [5] for their arrangement and installation
- Article [20] for their certification, inspection and testing.

b) Specific requirements for unit piping systems and machinery piping systems are given in Articles [6] to [19].

c) For cooling systems, fuel oil systems, lubricating oil system and starting air systems serving propulsion plants of self-propelled units, refer to the applicable requirements of the Ship Rules.

d) In particular cases, such as units operating in restricted zones, the Society may accept attenuations to the provisions of this Section, on a case by case basis.

1.2 Documentation to be submitted

1.2.1 Documents

The documents listed in Tab 1 are to be submitted.

Table 1 : Documents to be submitted

No.	I/A **(1)**	Document **(2)**
1	A	Drawing showing the arrangement of the sea chests and valves located on the shell
2	A	Diagram of the bilge and ballast systems (in and outside machinery spaces)
3	A	Specification of the central priming system intended for bilge pumps, when provided
4	A	Diagram of the scuppers and sanitary discharge systems
5	A	Diagram of the air, sounding and overflow systems
6	A	Diagram of cooling systems (sea water and fresh water)
7	A	Diagram of fuel oil system
8	A	Drawings of the fuel oil tanks not forming part of the unit’s structure
9	A	Diagram of the lubricating oil system
10	A	Diagram of the thermal oil system
11	A	Diagram of the hydraulic systems intended for essential services or located in machinery spaces
12	A	Diagram of steam system, including safety valve exhaust and drain pipes
13		For high temperature steam pipes:
	A	• stress calculation note
	I	• drawing showing the actual arrangement of the piping in three dimensions
14	A	Diagram of the boiler feed water and condensate system
15	A	Diagram of the compressed air system
16	A	Diagram of the hydraulic and pneumatic remote control systems
17	A	Diagram of the remote level gauging system
18	A	Diagram of the exhaust gas system
19	A	Diagram of drip trays and gutterway draining system
20	A	Arrangement of the ventilation system
21	A	Diagram of the oxyacetylene welding system
22	A	Drawings and specification of valves and accessories, where required in [2.8]

(1) A = To be submitted for approval ; I = To be submitted for information

(2) Diagrams are also to include, where applicable, the (local and remote) control and monitoring systems and automation systems.

1.2.2 Additional information

The information listed in Tab 2 are also to be submitted.

Table 2 : Information to be submitted

No.	I/A **(1)**	Document
1	I	Nature, service temperature and pressure of the fluids
2	A	Material, external diameter and wall thickness of the pipes
3	A	Type of the connections between pipe lengths, including details of the weldings, where provided
4	A	Material, type and size of the accessories
5	A	Capacity, prime mover and, when requested, location of the pumps
6	A	For plastic pipes: • the chemical composition • the physical and mechanical characteristics in function of temperature • the characteristics of inflammability and fire resistance • the resistance to the products intended to be conveyed

(1) A = To be submitted for approval ; I = To be submitted for information

1.3 Definitions

1.3.1 Piping and piping systems

a) Piping includes pipes and their connections, flexible hoses and expansion joints, valves and their actuating systems, other accessories (filters, level gauges, etc.) and pump casings.

b) Piping systems include piping and all the interfacing equipment such as tanks, pressure vessels, heat exchangers, pumps and centrifugal purifiers, but do not include boilers, turbines, internal combustion engines and reduction gears.

Note 1: The equipment other than piping is to be designed in accordance with the relevant Sections of Part C, Chapter 1.

1.3.2 Design pressure

a) The design pressure of a piping system is the pressure considered by the manufacturer to determine the scantling of the system components. It is not to be taken less than the maximum working pressure expected in this system or the highest setting pressure of any safety valve or relief device, whichever is the greater.

b) The design pressure of a boiler feed system is not to be less than 1,25 times the design pressure of the boiler or the maximum pressure expected in the feed piping, whichever is the greater.

c) The design pressure of steam piping located upstream of pressure reducing valves (high pressure side) is not to be less than the setting pressure of the boiler or superheater safety valves.

d) The design pressure of a piping system located on the low pressure side of a pressure reducing valve where no safety valve is provided is not to be less than the maximum pressure on the high pressure side of the pressure reducing valve.

e) The design pressure of a piping system located on the delivery side of a pump or a compressor is not to be less than the setting pressure of the safety valve for displacement pumps or the maximum pressure resulting from the operating (head-capacity) curve for centrifugal pumps, whichever is the greater.

1.3.3 Design temperature

The design temperature of a piping system is the maximum temperature of the medium inside the system.

1.3.4 Flammable oils

Flammable oils include fuel oils, lubricating oils, thermal oils and hydraulic oils.

1.4 Symbols and units

1.4.1 The following symbols and related units are commonly used in this Section. Additional symbols, related to some formulae indicated in this Section, are listed wherever it is necessary.

p : Design pressure, in MPa
T : Design temperature, in °C
t : Rule required minimum thickness, in mm
D : Pipe external diameter, in mm.

1.5 Class of piping systems

1.5.1 Purpose of the classes of piping systems

Piping systems are subdivided into three classes, denoted as class I, class II and class III, for the purpose of acceptance of materials, selection of joints, heat treatment, welding, pressure testing and the certification of fittings.

1.5.2 Definitions of the classes of piping systems

a) Classes I, II and III are defined in Tab 3.

b) The following systems are not covered by Tab 3:

- cargo piping for oil products, chemical products and liquefied gas
- fluids for refrigerating plants.

Table 3 : Class of piping systems

Media conveyed by the piping system	Class I	Class II **(1)** **(4)**	Class III **(7)**
Toxic media	without special safeguards **(3)**	not applicable	not applicable
Corrosive media	without special safeguards **(3)**	with special safeguards **(3)**	not applicable
Flammable media: • heated above flashpoint, or • having flashpoint < 60°C Hydrocarbon gas Liquefied gas	without special safeguards **(3)**	with special safeguards **(3)**	not applicable
Oxyacetylene	irrespective of p	not applicable	not applicable
Steam	p > 1,6 or T > 300	other **(2)**	p ≤ 0,7 and T ≤ 170
Thermal oil	p > 1,6 or T > 300	other **(2)**	p ≤ 0,7 and T ≤ 150
Fuel oil **(8)** Lubricating oil Flammable hydraulic oil **(5)**	p > 1,6 or T > 150	other **(2)**	p ≤ 0,7 and T ≤ 60
Other media **(5)** **(6)**	p > 4 or T > 300	other **(2)**	p ≤ 1,6 and T ≤ 200

(1) Valves under static pressure on oil fuel tanks or lubricating oil tanks belong to class II.
(2) Pressure and temperature conditions other than those required for class I and class III.
(3) Safeguards for reducing leakage possibility and limiting its consequences:
e.g. pipes led in positions where leakage of internal fluids will not cause a potential hazard or damage to surrounding areas which may include the use of pipe ducts, shielding, screening etc.
(4) Valves and fittings fitted on the unit's side and collision bulkhead belong to class II. See also [20.5.3], item b).
(5) Steering gear hydraulic piping system belongs to class I irrespective of p and T.
(6) Including water, air, gases, non-flammable hydraulic oil.
(7) The open ended pipes, irrespective of T, generally belong to class III (as drains, overflows, vents, exhaust gas lines, boiler escape pipes, etc.).
(8) Design pressure for fuel oil systems is to be determined in accordance with Tab 4.
Note 1: p : Design pressure, as defined in [1.3.2], in MPa.
Note 2: T : Design temperature, as defined in [1.3.3], in °C.
Note 3: Flammable media generally include the flammable liquids as oil fuel, lubricating oil, thermal oil and flammable hydraulic oil.

Table 4 : Definition of the design pressure for fuel oil systems

Working pressure P, in bar	Working temperature T, in °C	
	T ≤ 60	T > 60
P ≤ 7	3 bar or max. working pressure, whichever is the greater	3 bar or max. working pressure, whichever is the greater
P > 7	max. working pressure	14 bar or max. working pressure, whichever is the greater

2 General requirements for design and construction

2.1 Materials

2.1.1 General

Materials to be used in piping systems are to be suitable for the medium and the service for which the piping is intended.

2.1.2 Use of metallic materials

a) Metallic materials are to be used in accordance with Tab 5.

b) Materials for class I and class II piping systems are to be manufactured and tested in accordance with the appropriate requirements of NR216.

c) Materials for class III piping systems are to be manufactured and tested in accordance with the requirements of acceptable national or international standards or specifications.

d) Mechanical characteristics required for metallic materials are specified in NR216.

Table 5 : Conditions of use of metallic materials in piping systems

Material	Allowable classes	Maximum design temperature**(1)**	Particular conditions of use
Carbon and carbon-manganese steels	III, II, I	400 **(2)**	Class I and II pipes are to be seamless drawn pipes **(3)**
Copper and aluminium brass	III, II, I	200	• Not to be used in fuel oil systems, except for class III pipes of a diameter not exceeding 25 mm not passing through fuel oil tanks • Not to be used for boiler blow-down valves and pieces for connection to the shell plating **(4)**
Copper-nickel	III, II, I	300	
Special high temperature resistant bronze	III, II, I	260	
Stainless steel	III, II, I	300	Austenitic stainless steel is not to be used for sea water systems
Spheroidal graphite cast iron	III, II**(5)**	350	• Minimum elongation is not to be less than 12% on a gauge length of 5,65 $S^{0,5}$, where S is the actual cross-sectional area of the test piece • Not to be used for boiler blow-down valves and pieces for connection to the shell plating
Grey cast iron	III II **(6)**	220	Grey cast iron is not to be used for the following systems: • boiler blow-down systems and other piping systems subject to shocks, high stresses and vibrations • bilge lines in tanks • parts of scuppers and sanitary discharge systems located next to the hull below the freeboard deck • sea inlet and discharge valves and fittings • valves fitted on the collision bulkhead • valves fitted to fuel oil and lubricating oil tanks under static pressure head • class II fuel oil systems
Aluminium and aluminium alloys	III, II	200	Aluminium and aluminium alloys are not to be used on the following systems: • flammable oil systems • sounding and air pipes of fuel oil tanks • fire-extinguishing systems • bilge system in boiler or machinery spaces or in spaces containing fuel oil tanks or pumping units • scuppers and overboard discharges except for pipes led to the bottoms or to the shell above the freeboard deck or fitted at their upper end with closing means operated from a position above the freeboard deck • boiler blow-down valves and pieces for connection to the shell plating

(1) Maximum design temperature is not to exceed that assigned to the class of piping.

(2) Higher temperatures may be accepted if metallurgical behaviour and time dependent strength (ultimate tensile strength after 100 000 hours) are in accordance with national or international standards or specifications and if such values are guaranteed by the steel manufacturer.

(3) Pipes fabricated by a welding procedure approved by the Society may also be used.
Pipes having flash welded longitudinal seams are not to be used for oil fuel systems, for heating coils in oil tanks, nor for pressures exceeding 4 bar.
Where rimmed steel is used for pipes manufactured by electric resistance or induction welding processes, the design temperature is limited to 400°C.

(4) Pipes made of copper and copper alloys are to be seamless.

(5) Use of spheroidal cast iron for class I piping systems will be given special consideration by the Society.

(6) Use of grey cast iron is not allowed when the design pressure exceeds 1,3 MPa.

2.1.3 Use of plastics

a) Plastics may be used for piping systems belonging to class III in accordance with Ch 1, App 1. The use of plastics for other systems or in other conditions will be given special consideration.

b) Plastics intended for piping systems dealt with in this Section are to be of a type approved by the Society.

2.2 Thickness of pressure piping

2.2.1 Calculation of the thickness of pressure pipes

a) The thickness t, in mm, of pressure pipes is to be determined by the following formula but, in any case, is not to be less than the minimum thickness given in Tab 6 to Tab 9.

$$t = \frac{t_0 + b + c}{1 - \frac{a}{100}}$$

where:

t_0 : Coefficient, in mm, equal to:

$$t_0 = \frac{pD}{2Ke + p}$$

with:

p and D : As defined in [1.4.1]

K : Permissible stress defined in [2.2.2]

e : Weld efficiency factor to be:

- equal to 1 for seamless pipes and pipes fabricated according to a welding procedure approved by the Society
- specially considered by the Society for other welded pipes, depending on the service and the manufacture procedure.

b : Thickness reduction due to bending defined in [2.2.3], in mm

c : Corrosion allowance defined in [2.2.4], in mm

a : Negative manufacturing tolerance percentage:

- equal to 10 for copper and copper alloy pipes, cold drawn seamless steel pipes and steel pipes fabricated according to a welding procedure approved by the Society
- equal to 12,5 for hot laminated seamless steel pipes
- subject to special consideration by the Society in other cases.

b) The thickness thus determined does not take into account the particular loads to which pipes may be subjected. Attention is to be drawn in particular to the case of high temperature and low temperature pipes.

2.2.2 Permissible stress

a) The permissible stress K is given:

- in Tab 10 for carbon and carbon-manganese steel pipes
- in Tab 11 for alloy steel pipes, and
- in Tab 12 for copper and copper alloy pipes,

as a function of the temperature. Intermediate values may be obtained by interpolation.

b) Where, for carbon steel and alloy steel pipes, the value of the permissible stress K is not given in Tab 10 or Tab 11, it is to be taken equal to the lowest of the following values:

$$\frac{R_{m,20}}{2,7} \qquad \frac{R_e}{A} \qquad \frac{S_R}{A} \qquad S$$

where:

$R_{m,20}$: Minimum tensile strength of the material at ambient temperature (20°C), in N/mm^2

R_e : Minimum yield strength or 0,2% proof stress at the design temperature, in N/mm^2

S_R : Average stress to produce rupture in 100000 h at design temperature, in N/mm^2

S : Average stress to produce 1% creep in 100000 h at design temperature, in N/mm^2

A : Safety factor to be taken equal to:

- 1,6 when R_e and S_R values result from tests attended by the Society
- 1,8 otherwise.

c) The permissible stress values adopted for materials other than carbon steel, alloy steel, copper and copper alloy will be specially considered by the Society.

Table 6 : Minimum wall thickness for steel pipes

External diameter (mm)	Minimum nominal wall thickness (mm)			Minimum reinforced wall thickness (mm) **(2)**	Minimum extra-reinforced wall thickness (mm) **(3)**
	Pipes in general **(1)**	Vent, overflow and sounding pipes for integral tanks **(1) (5)**	Sea water pipes, bilge and ballast systems **(1) (4)**		
10,2 - 12,0	1,6	–	–	–	–
13,5 - 19,3	1,8	–	–	–	–
20,0	2,0	–	–	–	–
21,3 - 25,0	2,0	–	3,2	–	–
26,9 - 33,7	2,0	–	3,2	–	–
38,0 - 44,5	2,0	4,5	3,6	6,3	7,6
48,3	2,3	4,5	3,6	6,3	7,6
51,0 - 63,5	2,3	4,5	4,0	6,3	7,6
70,0	2,6	4,5	4,0	6,3	7,6
76,1 - 82,5	2,6	4,5	4,5	6,3	7,6
88,9 - 108,0	2,9	4,5	4,5	7,1	7,8
114,3 - 127,0	3,2	4,5	4,5	8,0	8,8
133,0 - 139,7	3,6	4,5	4,5	8,0	9,5
152,4 - 168,3	4,0	4,5	4,5	8,8	11,0
177,8	4,5	5,0	5,0	8,8	12,7
193,7	4,5	5,4	5,4	8,8	12,7
219,1	4,5	5,9	5,9	8,8	12,7
244,5 - 273,0	5,0	6,3	6,3	8,8	12,7
298,5 - 368,0	5,6	6,3	6,3	8,8	12,7
406,4 - 457,2	6,3	6,3	6,3	8,8	12,7

(1) Attention is drawn to the special requirements regarding:
- bilge and ballast systems
- scupper and discharge pipes
- sounding, air and overflow pipes
- ventilation systems
- oxyacetylene welding systems
- CO_2 fire-extinguishing systems (see Ch 4, Sec 11)
- cargo lines (see Pt D, Ch 10, Sec 3 of the Ship Rules). The wall thickness is to be subject to special consideration by the Society.

(2) Reinforced wall thickness applies to pipes passing through tanks containing a fluid distinct from that conveyed by the pipe.

(3) Extra-reinforced wall thickness applies to pipes connected to the shell below the freeboard deck.

(4) The minimum wall thickness for bilge lines and ballast lines through deep tanks is to be subject to special consideration by the Society. The ballast lines within oil cargo tanks (where permitted) is to be subject to special consideration by the Society (see Pt D, Ch 1, Sec 18, [2.1.2]).

(5) For sounding pipes, except those for flammable cargoes, the minimum wall thickness is intended to apply only to the part outside the tank.

Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards.

Note 2: For pipes efficiently protected against corrosion, the thickness may be reduced by an amount up to 1 mm.

Note 3: The thickness of threaded pipes is to be measured at the bottom of the thread.

Note 4: The minimum thickness listed in this table is the nominal wall thickness and no allowance is required for negative tolerance and reduction in thickness due to bending.

Note 5: For nominal diameters ND > 450 mm, the minimum wall thickness is to be in accordance with a national or an international standard, but is not to be less than the minimum wall thickness of the appropriate column indicated for 450 mm pipe size.

Note 6: Exhaust gas pipe minimum wall thickness is to be subject to special consideration by the Society.

Table 7 : Minimum wall thickness for copper and copper alloy pipes

External diameter (mm)	Minimum wall thickness (mm)	
	Copper	Copper alloy
8 - 10	1,0	0,8
12 - 20	1,2	1,0
25 - 44,5	1,5	1,2
50 - 76,1	2,0	1,5
88,9 - 108	2,5	2,0
133 - 159	3,0	2,5
193,7 - 267	3,5	3,0
273 - 457,2	4,0	3,5
470	4,0	3,5
508	4,5	4,0
Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards.		

Table 8 : Minimum wall thickness for austenitic stainless steel pipes

External diameter (mm)	Minimum wall thickness (mm)
10,2 to 17,2	1,0
21,3 to 48,3	1,6
60,3 to 88,9	2,0
114,3 to 168,3	2,3
219,1	2,6
273,0	2,9
323,9 to 406,4	3,6
over 406,4	4,0
Note 1: Diameters and thicknesses according to national or international standards may be accepted.	

Table 9 : Minimum wall thickness for aluminium and aluminium alloy pipes

External diameter (mm)	Minimum wall thickness (mm)
0 - 10	1,5
12 - 38	2,0
43 - 57	2,5
76 - 89	3,0
108 - 133	4,0
159 - 194	4,5
219 - 273	5,0
above 273	5,5
Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards. **Note 2:** For sea water pipes, the minimum thickness is not to be less than 5 mm.	

Table 10 : Permissible stresses for carbon and carbon-manganese steel pipes

Specified minimum tensile strength (N/mm^2)	Design temperature (°C)												
	≤50	100	150	200	250	300	350	400	410	420	430	440	450
320	107	105	99	92	78	62	57	55	55	54	54	54	49
360	120	117	110	103	91	76	69	68	68	68	64	56	49
410	136	131	124	117	106	93	86	84	79	71	64	56	49
460	151	146	139	132	122	111	101	99	98	85	73	62	53
490	160	156	148	141	131	121	111	109	98	85	73	62	53

Table 11 : Permissible stresses for alloy steel pipes

Type of steel	Specified minimum tensile strength (N/mm²)	Design temperature (°C)									
		≤50	100	200	300	350	400	440	450	460	470
1Cr1/2Mo	440	159	150	137	114	106	102	101	101	100	99
2 1/4Cr1Mo annealed	410	76	67	57	50	47	45	44	43	43	44
2 1/4Cr1Mo normalised and tempered below 750°C	490	167	163	153	144	140	136	130	128	127	116
2 1/4Cr1Mo normalised and tempered above 750°C	490	167	163	153	144	140	136	130	122	114	105
1/2Cr 1/2Mo 1/4V	460	166	162	147	120	115	111	106	105	103	102

Type of steel	Specified minimum tensile strength (N/mm²)	Design temperature (°C)									
		480	490	500	510	520	530	540	550	560	570
1Cr1/2Mo	440	98	97	91	76	62	51	42	34	27	22
2 1/4Cr1Mo annealed	410	42	42	41	41	41	40	40	40	37	32
2 1/4Cr1Mo normalised and tempered below 750°C	490	106	96	86	79	67	58	49	43	37	32
2 1/4Cr1Mo normalised and tempered above 750°C	490	96	88	79	72	64	56	49	43	37	32
1/2Cr 1/2Mo 1/4V	460	101	99	97	94	82	72	62	53	45	37

Table 12 : Permissible stresses for copper and copper alloy pipes

Material (annealed)	Specified minimum tensile strength (N/mm²)	Design temperature (°C)										
		≤50	75	100	125	150	175	200	225	250	275	300
Copper	215	41	41	40	40	34	27,5	18,5				
Aluminium brass	325	78	78	78	78	78	51	24,5				
Copper-nickel 95/5 and 90/10	275	68	68	67	65,5	64	62	59	56	52	48	44
Copper-nickel 70/30	365	81	79	77	75	73	71	69	67	65,5	64	62

2.2.3 Thickness reduction due to bending

a) Unless otherwise justified, the thickness reduction b due to bending is to be determined by the following formula:

$$b = \frac{Dt_0}{2,5\rho}$$

where:

ρ : Bending radius measured on the centre line of the pipe, in mm

D : As defined in [1.4.1]

t_0 : As defined in [2.2.1].

b) When the bending radius is not given, the thickness reduction is to be taken equal to:

$$\frac{t_0}{10}$$

c) For straight pipes, the thickness reduction is to be taken equal to 0.

2.2.4 Corrosion allowance

The values of corrosion allowance c are given for steel pipes in Tab 13 and for non-ferrous metallic pipes in Tab 14.

Table 13 : Corrosion allowance for steel pipes

Piping system	Corrosion allowance (mm)
Superheated steam	0,3
Saturated steam	0,8
Steam coils in cargo tanks and liquid fuel tanks	2,0
Feed water for boilers in open circuit systems	1,5
Feed water for boilers in closed circuit systems	0,5
Blow-down systems for boilers	1,5
Compressed air	1,0
Hydraulic oil	0,3
Lubricating oil	0,3
Fuel oil	1,0
Thermal oil	1,0
Fresh water	0,8
Sea water	3,0
Refrigerants referred to in Ch 1, Sec 9	0,3
Cargo systems for floating production storage and offloading units	2,0

Note 1: For pipes passing through tanks, an additional corrosion allowance is to be considered in order to account for the external corrosion.
Note 2: The corrosion allowance of pipes efficiently protected against corrosion may be reduced by no more than 50%.
Note 3: When the corrosion resistance of alloy steels is adequately demonstrated, the corrosion allowance may be disregarded.

Table 14 : Corrosion allowance for non-ferrous metal pipes

Piping material **(1)**	Corrosion allowance (mm) **(2)**
Copper	0,8
Brass	0,8
Copper-tin alloys	0,8
Copper-nickel alloys with less than 10% of Ni	0,8
Copper-nickel alloys with at least 10% of Ni	0,5
Aluminium and aluminium alloys	0,5

(1) The corrosion allowance for other materials will be specially considered by the Society. Where their resistance to corrosion is adequately demonstrated, the corrosion allowance may be disregarded.
(2) In cases of media with high corrosive action, a higher corrosion allowance may be required by the Society.

2.2.5 Tees

As well as complying with the provisions of [2.2.1] to [2.2.4], the thickness t_T of pipes on which a branch is welded to form a Tee is not to be less than that given by the following formula:

$$t_T = \left(1 + \frac{D_1}{D}\right) t_0$$

where:

D_1 : External diameter of the branch pipe

D : As defined in [1.4.1]

t_0 : As defined in [2.2.1].

Note 1: This requirement may be dispensed with for Tees provided with a reinforcement or extruded.

2.3 Toughness of carbon steels

2.3.1 Whichever the standard used, the carbon steel toughness is to comply with Tab 15.

Table 15 : Toughness test temperatures for carbon steels, in °C

Minimum service temperature T (°C)	Wall thickness e (mm)					
	$e \le 6,2$	$6,2 < e \le 12,6$	$12,6 < e \le 25,4$	$25,4 < e \le 38$	$38 < e \le 50,8$	$50,8 < e$
$30 < T$	NR	NR	NR	NR	NR	Special study to be performed
$20 < T \le 30$	NR	NR	20	20	20	
$10 < T \le 20$	NR	NR	0	0	0	
$0 < T \le 10$	NR	NR	0	–10	–10	
$-10 < T \le 0$	NR	20	0	–20	–20	
$-20 < T \le -10$	NR	0	–10	–20	–20	
$-30 < T \le -20$	NR	0	–20	–30	–30	
$T \le -30$	Special study to be performed					

Note 1: NR = not required.

Note 2: The Table is valid for:

- Charpy V-notch test (longitudinal direction) on piping materials and welds with minimum impact energy 34 J average and 22 J minimum on samples 10 mm x 10 mm
- carbon steels with yield strength not more than 420 MPa.

Note 3: The test temperatures may be 10°C higher for post weld heat treated welds.

Note 4: The service temperature T is the lowest temperature to which the pipe may be submitted in service, depending upon the ambient temperature (water or air) and upon the fluid temperature.

2.4 Calculation of high temperature pipes

2.4.1 General

For steam piping having a design temperature exceeding 400°C, calculations are to be submitted to the Society concerning the stresses due to internal pressure, piping weight and any other external load, and to thermal expansion, for all cases of actual operation and for all lengths of piping.

The calculations are to include, in particular:

- the components, along the three principal axes, of the forces and moments acting on each branch of piping
- the components of the displacements and rotations causing the above forces and moments
- all parameters necessary for the computation of forces, moments and stresses
- an isometric sketch of the pipes showing the main geometrical characteristics of the various pipes lines (diameter, thickness, curvature, etc.), the identification and type of the support, and the coordinates of the typical points considered.

In way of bends, the calculations are to be carried out taking into account, where necessary, the pipe ovalisation and its effects on flexibility and stress increase.

A certain amount of cold springing, calculated on the basis of expected thermal expansion, is to be applied to the piping during installation. Such springing is to be neglected in stress calculations; it may, however, be taken into account in terms of its effect on thrusts on turbines and other parts.

2.4.2 Thermal stress

The combined stress σ_{ID}, in N/mm^2, due to thermal expansion, calculated by the following formula:

$$\sigma_{ID} = (\sigma^2 + 4\ \tau^2)^{0,5}$$

is to be such as to satisfy the following equation:

$$\sigma_{ID} \le 0,75\ K_{20} + 0,25\ K_T$$

where:

σ : Value of the longitudinal stress due to bending moments caused by thermal expansion, increased, if necessary, by adequate factors for bends, in N/mm^2; in general it is not necessary to take account of the effect of axial force

τ : Value of the tangential stress due to torque caused by thermal expansion, in N/mm^2; in general it is not necessary to take account of the effect of shear force

K_{20} : Value of the permissible stress for the material employed, calculated according to [2.2.2], for a temperature of 20°C, in N/mm^2

K_T : Value of the permissible stress for the material employed, calculated according to [2.2.2], for the design temperature T, in N/mm^2.

2.4.3 Longitudinal stresses

The sum of longitudinal stresses σ_L , in N/mm^2, due to pressure, piping weight and any other external loads is to be such as to satisfy the following equation:

$\sigma_L \leq K_T$

where K_T is defined in [2.4.2].

2.4.4 Alternative limits for permissible stresses

Alternative limits for permissible stresses may be considered by the Society in special cases or when calculations have been carried out following a procedure based on hypotheses other than those considered above.

2.5 Junction of pipes

2.5.1 General

a) The junctions between metallic pipe lengths or between metallic pipe lengths and fittings are to be made by:

- direct welding (butt-weld, socket-weld)
- bolted flanges (welded-on or screwed-on)
- threaded sleeve joints, or
- mechanical joints (see [2.5.5]).

The joints are to comply with a recognised standard or to be of a design proven to be suitable for the intended purpose and acceptable to the Society. See also [2.1.2].

The expression “mechanical joints” means devices intended for direct connection of pipe lengths other than by welding, flanges or threaded joints described in [2.4.2], [2.4.3] and [2.4.4].

b) The number of joints in flammable oil piping systems is to be kept to the minimum necessary for mounting and dismantling purposes.

c) The gaskets and packings used for the joints are to suit the design pressure, the design temperature and the nature of the fluids conveyed.

d) The junction between plastic pipes is to comply with Ch 1, App 1.

2.5.2 Welded metallic joints

a) Welded joints are to be used in accordance with Tab 16. Welding and non-destructive testing of welds are to be carried out in accordance with Article [3].

b) Butt-welded joints are to be of full penetration type, with or without special provision for a high quality of root side.

The expression “special provision for a high quality of root side” means that butt welds were accomplished as double welded or by use of a backing ring or inert gas back-up on first pass, or other similar methods accepted by the Society.

c) Slip-on sleeve and socket welded joints are to have sleeves, sockets and weldments of adequate dimensions in compliance with a standard recognised by the Society.

2.5.3 Metallic flange connections

a) In general, the metallic flange connections used for piping systems are to be in compliance with a standard recognised by the Society.

b) The material used for flanges and gaskets is to be suitable for the nature and temperature of the fluid, as well as pipes on which the flanges are to be fitted.

c) The dimensions and configuration of flanges and bolts are to be chosen in accordance with recognised standard intended for design pressure and design temperature of the piping system. Otherwise, the flange connections are subject to special consideration.

d) Flanges are to be attached to the pipes by welding or screwing. Examples of acceptable metallic flange connections are shown in Fig 1. However, other types of flange connections may be also considered by the Society in each particular case, provided that they are in accordance with national or international standards applicable to the piping system and recognise the boundary fluids, design pressure and temperature conditions, external or cyclic loading and location.

e) Permitted applications are indicated in Tab 17.

Table 16 : Use of welded and threaded metallic joints in piping systems

Joints	Permitted classes of piping	Restrictions of use
Butt-welded, with special provision for a high quality of root side **(1)**	III, II, I	no restrictions
Butt-welded, without special provision for a high quality of root side **(1)**	III, II	no restrictions
Slip-on sleeve and socket welded **(2)**	III	no restrictions
Threaded sleeve joints with tapered thread **(3)**	I	not allowed for: • pipes with outside diameter of more than 33,7 mm • pipes inside tanks • piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur **(4)**
	III, II	not allowed for: • pipes with outside diameter of more than 60,3 mm • pipes inside tanks • piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur **(4)**
Threaded sleeve joints with parallel thread and tightening suitable for intended design conditions **(3)**	III	not allowed for: • pipes with outside diameter of more than 60,3 mm • pipes inside tanks • piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur **(4)**

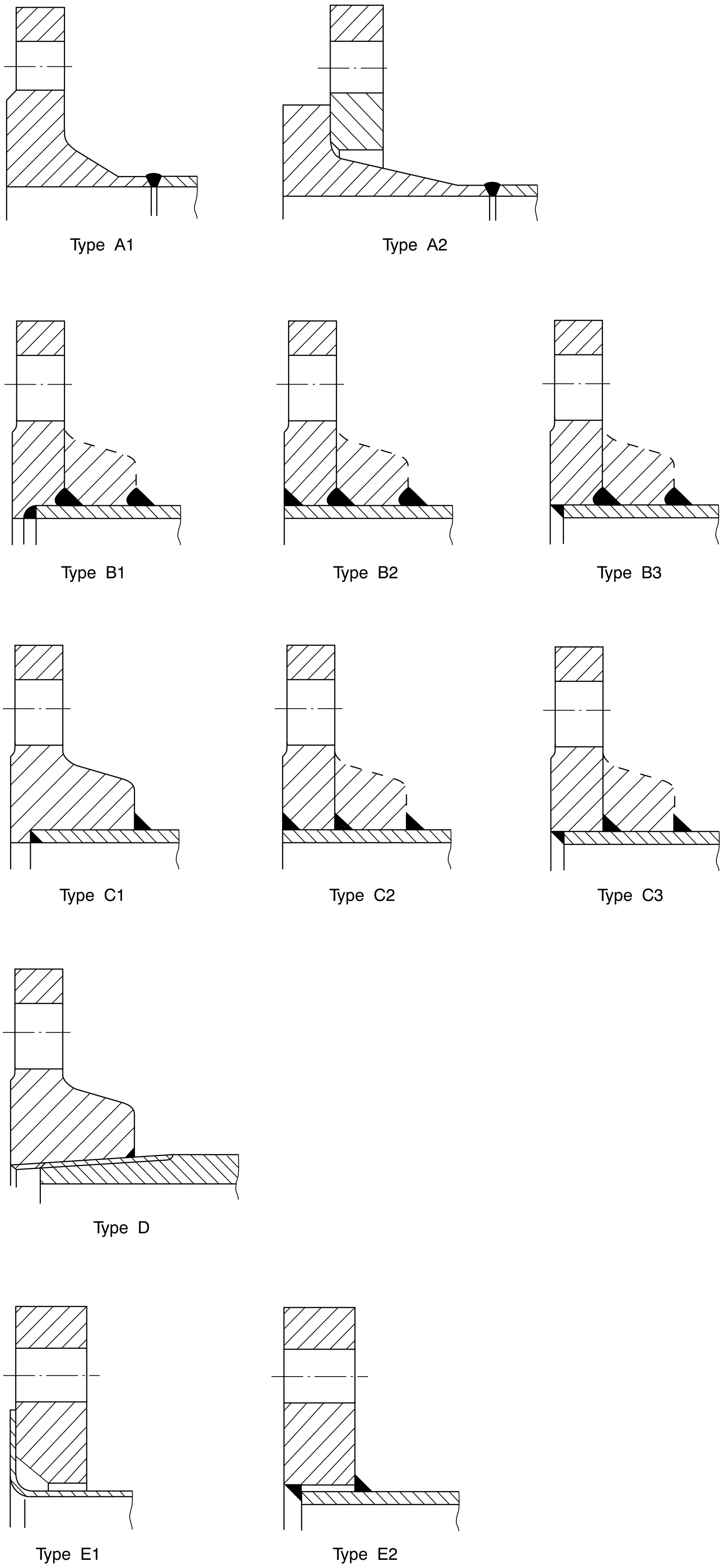
(1) For expression “special provision for a high quality of root side” see [2.5.2] b).
(2) Particular cases may be allowed by the Society for piping systems of Class I and II having outside diameter ≤ 88,9 mm except for piping systems conveying toxic media or services where fatigue, severe erosion or crevice corrosion is expected to occur.
(3) In particular cases, sizes in excess of those mentioned above may be accepted by the Society if found in compliance with a recognised national and/or international standard.
(4) May be accepted for accessory lines and instrumentation lines with external diameters up to 25 mm.
Note 1: Other applications will be specially considered by the Society.

Table 17 : Use of metallic flange connections in piping systems (types as shown in Fig 1)

Type of media conveyed	Class of piping (see Tab 3)		
	I	II	III
Toxic or corrosive media Flammable media (where heated above flashpoint or having flashpoint < 60°C) Liquefied gases	A1, A2, B1, B2, B3 **(1) (2) (4)**	A1, A2, B1, B2, B3, C1, C2, C3 **(1) (4)**	not applicable
Fuel oil Lubricating oil	A1, A2, B1, B2, B3	A1, A2, B1, B2, B3, C1, C2, C3	A1, A2, B1, B2, B3, C1, C2, C3, E2
Steam Thermal oil	A1, A2, B1, B2, B3 **(2) (3)**	A1, A2, B1, B2, B3, C1, C2, C3, D, E2 **(6)**	A1, A2, B1, B2, B3, C1, C2, C3, D, E2
Other media as water, air, gases (refrigerants), non-flammable hydraulic oil, etc.	A1, A2, B1, B2, B3 **(3)**	A1, A2, B1, B2, B3, C1, C2, C3, D, E2 **(6)**	A1, A2, B1, B2, B3, C1, C2, C3, D, E1, E2 **(5) (6) (7)**

(1) When design pressure p (see [1.3.2]) exceeds 1 MPa, types A1 and A2 only.
(2) For nominal diameter ND ≥ 150 mm, types A1 and A2 only.
(3) When design temperature T (see [1.3.3] exceeds 400°C, types A1 and A2 only.
(4) For cargo piping of chemical products, IBC Code Ch. 5, 5.3 is to be applied. For cargo piping of gas products, IGC Code Ch. 5, 5.4 is to be applied.
(5) Type E2 only, for design pressure p ≤ 1,6 Mpa and design temperature T ≤ 150°C.
(6) Types D and E1 only, for design temperature T ≤ 250°C.
(7) Type E1 only, for water pipelines and for open ended lines (e.g. drain, overflow, air vent piping, etc.).

Figure 1 : Examples of metallic flange connections


Type A1

Type A2

Type B1

Type B2

Type B3

Type C1

Type C2

Type C3

Type D

Type E1

Type E2

Note 1: For type D, the pipe and flange are to be screwed with a tapered thread and the diameter of the screw portion of the pipe over the thread is not to be appreciably less than the outside diameter of the unthreaded pipe. For certain types of thread, after the flange has been screwed hard home, the pipe is to be expanded into the flange.

Note 2: The leg length of the fillet weld, as well as the dimension of the groove penetration in the flange, is to be in general equal to 1,5 times the pipe thickness but not less than 5 mm.

2.5.4 Slip-on threaded joints

a) Slip-on threaded joints having pipe threads where pressure-tight joints are made on the threads with parallel or tapered threads are to comply with requirements of a recognised national or international standard and are to be acceptable to the Society.

b) Slip-on threaded joints may be used for piping systems in accordance with Tab 16.

c) Threaded joints may be accepted also in CO_2 piping systems, provided that they are used only inside protected spaces and in CO_2 cylinder rooms.

2.5.5 Mechanical joints

Due to the great variations in design and configuration of mechanical joints, specific recommendation regarding calculation method for theoretical strength calculations is not specified. The Type Approval is to be based on the results of testing of the actual joints.

Below specified requirements are applicable to pipe unions, compression couplings, slip-on joints as shown in Fig 2. Similar joints complying with these requirements may be acceptable.

a) The application and pressure ratings of different mechanical joints are to be approved by the Society. The approval is to be based on the Type Approval procedure given in Ch 1, App 3 including pipe unions, compression couplings, slip-on joints and similar joints are to be of approved type for the service conditions and the intended application.

b) Where the application of mechanical joints results in reduction in pipe wall thickness due to the use of bite type rings or other structural elements, this is to be taken into account in determining the minimum wall thickness of the pipe to withstand the design pressure.

c) Construction of mechanical joints is to prevent the possibility of tightness failure affected by pressure pulsation, piping vibration, temperature variation and other similar adverse effects occurring during operation on board.

d) Material of mechanical joints is to be compatible with the piping material and internal and external media.

e) As far as applicable, the mechanical joints are to be tested to a burst pressure of 4 times the design pressure. For design pressures above 200 bar the required burst pressure is to be specially considered by the Society.

f) In general, mechanical joints are to be of fire resistant type as required by Tab 18.

g) Mechanical joints, which in the event of damage could cause fire or flooding, are not to be used in piping sections directly connected to the shell openings or tanks containing flammable fluids.

h) The mechanical joints are to be designed to withstand internal and external pressure as applicable and, where used in suction lines, are to be capable of operating under vacuum.

i) The number of mechanical joints in flammable liquid systems is to be kept to a minimum. In general, flanged joints conforming to recognised standards are to be used.

j) Piping in which a mechanical joint is fitted is to be adequately adjusted, aligned and supported. Supports or hangers are not to be used to force alignment of piping at the point of connection.

k) Slip-on joints are not to be used in pipelines in cargo holds, tanks, and other spaces which are not easily accessible, unless approved by the Society. Application of these joints inside tanks may be permitted only for the same media that is in the tanks. Unrestrained slip-on joints are to be used only in cases where compensation of lateral pipe deformation is necessary. Usage of these joints as the main means of pipe connection is not permitted.

l) Application of mechanical joints and their acceptable use for each service is indicated in Tab 18; dependence upon the class of piping, pipe dimensions, working pressure and temperature is indicated in Tab 19.

m) In some particular cases, sizes in excess of those mentioned above may be accepted by the Society if they are in compliance with a recognised national and/or international standard.

n) Application of various mechanical joints may be accepted as indicated by Tab 18. However, in all cases, acceptance of the joint type is to be subject to approval for the intended application, and subject to conditions of the approval and applicable Rules.

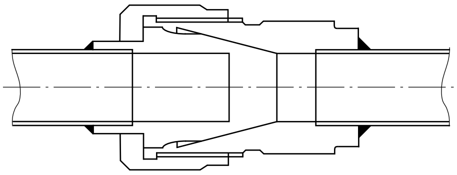
o) Mechanical joints are to be tested in accordance with a program approved by the Society, which is to include at least the following:

   1) leakage test
   2) vacuum test (where necessary)
   3) vibration (fatigue) test
   4) fire endurance test (where necessary)
   5) burst pressure test
   6) pressure pulsation test (where necessary)
   7) assembly test (where necessary)
   8) pull out test (where necessary).

p) The installation of mechanical joints is to be in accordance with the manufacturer’s assembly instructions. Where special tools and gauges are required for installation of the joints, these are to be supplied by the manufacturer.

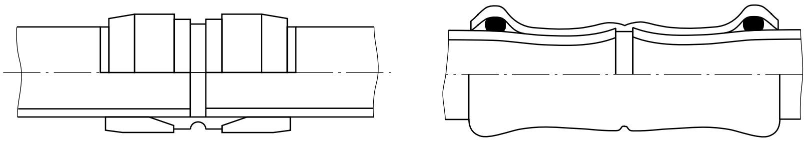
Figure 2 : Examples of mechanical joints

Pipe Unions



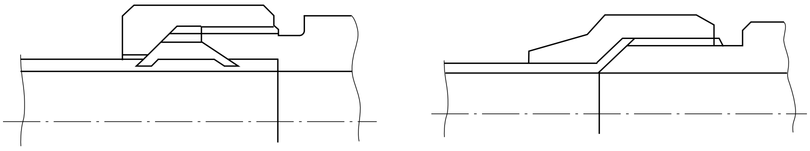
Welded and brazed types

Compression Couplings



Swage type

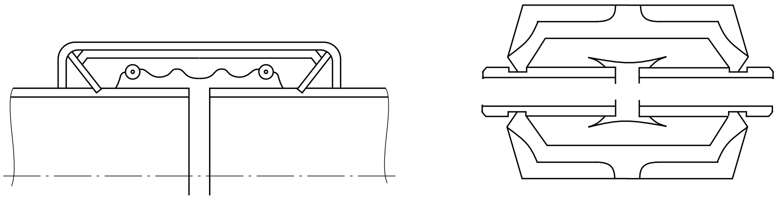
Press type



Bite type

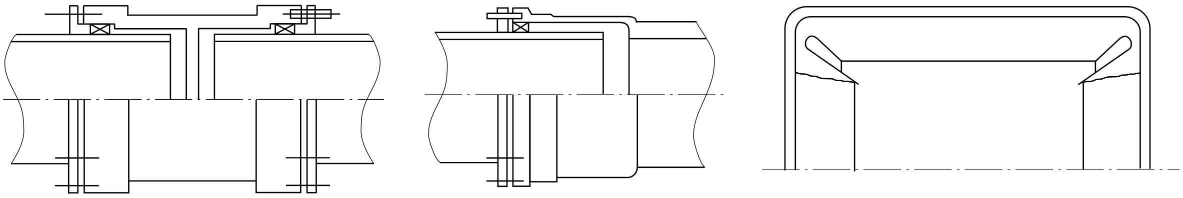
Flared type

Slip-on Joints



Grip type

Machine grooved type



Slip types

Table 18 : Application of mechanical joints

Systems		Kind of connections		
		Pipe unions	Compression couplings**(6)**	Slip-on joints
Flammable fluids (flash point ≤ 60°C)				
1	Cargo oil lines	+	+	+ **(5)**
2	Crude oil washing lines	+	+	+ **(5)**
3	Vent lines	+	+	+ **(3)**
Inert gas				
4	Water seal effluent lines	+	+	+
5	Scrubber effluent lines	+	+	+
6	Main lines	+	+	+ **(2)(5)**
7	Distribution lines	+	+	+ **(5)**
Flammable fluids (flash point > 60°C)				
8	Cargo oil lines	+	+	+ **(5)**
9	Fuel oil lines	+	+	+ **(2)(3)**
10	Lubricating oil lines	+	+	+ **(2)(3)**
11	Hydraulic oil	+	+	+ **(2)(3)**
12	Thermal oil	+	+	+ **(2)(3)**
Sea water				
13	Bilge lines	+	+	+ **(1)**
14	Fire main and water spray	+	+	+ **(3)**
15	Foam system	+	+	+ **(3)**
16	Sprinkler system	+	+	+ **(3)**
17	Ballast system	+	+	+ **(1)**
18	Cooling water system	+	+	+ **(1)**
19	Tank cleaning services	+	+	+
20	Non-essential systems	+	+	+
Fresh water				
21	Cooling water system	+	+	+ **(1)**
22	Condensate return	+	+	+ **(1)**
23	Non-essential systems	+	+	+
Sanitary/Drains/Scuppers				
24	Deck drains (internal)	+	+	+ **(4)**
25	Sanitary drains	+	+	+
26	Scuppers and discharge (overboard)	+	+	–
Sounding/Vent				
27	Water tanks/Dry spaces	+	+	+
28	Oil tanks (flash point > 60°C)	+	+	+ **(2)(3)**
Miscellaneous				
29	Starting/Control air **(1)**	+	+	–
30	Service air (non-essential)	+	+	+
31	Brine	+	+	+
32	CO_2 system **(1)**	+	+	–
33	Steam	+	+	+ **(7)**

Note 1:

+ : Application is allowed

– : Application is not allowed.

(1) Inside machinery spaces of category A - only approved fire resistant types.

(2) Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.

(3) Approved fire resistant types.

(4) Above free board deck only.

(5) In pump rooms and open decks - only approved fire resistant types.

(6) If compression couplings include any components which readily deteriorate in case of fire, they are to be of approved fire resistant type as required for Slip-on joints.

(7) Restrained slip-on joints (which are provided with stopping bolts for axially restraining the coupling from pull-out) may be accepted in steam lines on open decks with a design pressure of 10 bar or less, provided that the associated pipes are suitably supported and anchored.

Table 19 : Application of mechanical joints depending upon the class of piping

Types of joints	Classes of piping systems		
	Class I	Class II	Class III
Pipe Unions			
Welded and brazed types	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Compression Couplings			
Swage type	+	+	+
Bite type Flared type	+ (OD ≤ 60,3 mm) + (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm) + (OD ≤ 60,3 mm)	+ +
Press type	–	–	+
Slip-on Joints			
Machine grooved type	+	+	+
Grip type	–	+	+
Slip type	–	+	+
Note 1: (+) Application is allowed, (–) Application is not allowed.			

2.6 Protection against overpressure

2.6.1 General

a) These requirements deal with the protection of piping systems against overpressure, with the exception of heat exchangers and pressure vessels, which are dealt with in Ch 1, Sec 3, [2.4].

b) Safety valves are to be sealed after setting.

2.6.2 Protection of flammable oil systems

Provisions shall be made to prevent overpressure in any flammable oil tank or in any part of the flammable oil systems, including the filling lines served by pumps on board.

2.6.3 Protection of pump and compressor discharges

a) Provisions are to be made so that the discharge pressure of pumps and compressors cannot exceed the pressure for which the pipes located on the discharge of these pumps and compressors are designed.

b) When provided on the pump discharge for this purpose, safety valves are to lead back to the pump suction or to any other suitable place.

c) The discharge capacity of the safety valves installed on pumps and compressors is to be such that the pressure at the discharge side cannot exceed by more than 10% the design pressure of the discharge pipe in the event of operation with closed discharge.

2.6.4 Protection of pipes

a) Pipes likely to be subjected to a pressure exceeding their normal working pressure are to be provided with safety valves or equivalent overpressure protecting devices.

b) In particular, pipes located on the low pressure side of pressure reducing valves are to be provided with safety valves unless they are designed for the maximum pressure on the high pressure side of the pressure reducing valve. See also [1.3.2] and [2.10.1].

c) The discharge capacity of the devices fitted on pipes for preventing overpressure is to be such that the pressure in these pipes cannot exceed the design pressure by more than 10%.

2.7 Flexible hoses and expansion joints

2.7.1 General

a) Definitions:

- Flexible hose assembly: short length of metallic or non-metallic hose normally with prefabricated end fittings ready for installation
- Expansion joint: an assembly designed to safely absorb the heat-induced expansion and contraction, to allow relative movement between pipes and the ship's structure as required in [5.7].

b) Flexible hoses and expansion joints are to be of a type approved by the Society. Unless otherwise specified, they are to comply with the requirements of this sub-article.

c) The requirements of this sub-article apply to flexible hoses and expansion joints of metallic or non-metallic material intended for a permanent connection between a fixed piping system and items of machinery. The requirements may also be applied to temporarily connected flexible hoses or hoses of portable equipment.

d) Unless otherwise specified, the requirements of this sub-article do not apply for flexible hose assemblies and expansion joints intended to be used in fire extinguishing systems.

e) Flexible hose assemblies and expansion joints intended for piping systems with a design temperature below the ambient temperature are subject to special consideration by the Society.

f) Specific requirements for flexible hoses and expansion joints intended for cargo pipe lines are given in:

- Pt D, Ch 1, Sec 18 for flexible hoses and expansion joints fitted in produced oil and process piping
- NR542 for flexible hoses and expansion joints intended for liquefied gas
- IMO IBC Code for flexible hoses and expansion joints intended for chemical products.

2.7.2 General conditions of use applicable to flexible hoses and expansion joints

a) Unless otherwise specified, the Society may permit the use of flexible hoses and expansion joints, made of both metallic and non-metallic materials, provided they are approved for the intended service. They may be accepted for use in oil fuel, lubricating, hydraulic and thermal oil systems, fresh water and sea water cooling systems, compressed air systems, bilge and ballast systems, Class III steam systems and exhaust gas systems where they comply with the requirements of this sub-article.

b) For steam systems, the flexible hose assemblies and expansion joints are to be of metallic construction.

c) The position of flexible hose assemblies and expansion joints is to be clearly shown on the drawings listed in [1.2.1] and [1.2.2] when submitted to the Society.

d) A flexible hose assembly or an expansion joint is to be selected for the intended location and application taking into consideration ambient conditions, compatibility with fluids under working pressure and temperature conditions consistent with the manufacturer's instructions and any requirements of the Society.

e) The arrangement and installation of the flexible hose assemblies and expansion joints are also to comply with [5.10.3].

2.7.3 Specific conditions of use applicable to flexible hoses

a) Flexible hose assembly is not accepted in high pressure fuel oil injection systems.

b) Flexible hose assemblies for essential services or containing either flammable or toxic media are not to exceed 1,5 m in length.

2.7.4 General requirements for the design of flexible hoses and expansion joints

a) Flexible hoses and expansion joints are to be designed and constructed in accordance with recognised National or International standards acceptable to the Society.

b) Acceptance of a flexible hose assembly or an expansion joint is subject to satisfactory prototype testing in accordance with the provisions of [20.2].

c) The material, design and construction are to be at least suitable for:

- marine environment and external contact with hydrocarbons
- internal contact and resistance to the fluid they are to convey
- maximal pressure and temperature of fluid they are to convey
- maximum expected forces due to vibrations
- maximum expected impulse peak pressure.

The metallic materials are to comply with [2.1.2].

d) Where rubber materials are intended for use in bilge, ballast, compressed air, oil fuel, lubricating, hydraulic and thermal oil systems, the construction is to incorporate a single, double or more, closely woven integral wire braid or other suitable material reinforcement acceptable to the Society.

Flexible hoses and expansion joints of plastic materials for the same purposes, such as Teflon or Nylon, which are unable to be reinforced by incorporating closely woven integral wire braid, are to have suitable material reinforcement, as far as practicable.

Rubber or plastic material hoses and expansion joints used in oil supply lines to burners are to have external wire braid protection in addition to the reinforcement mentioned above.

e) Flexible hose assemblies and expansion joints constructed of non-metallic materials, which are intended for installation in piping systems for flammable media or in sea water systems where failure may result in flooding, are to be of fire-resistant type except in cases where such hoses are installed on open decks as defined in NR467, Pt C, Ch 4, Sec 5, [1.4.3], item b)(10) and not used for fuel oil lines.

Fire resistance is to be demonstrated by testing in accordance with the standards specified in Tab 37 and Tab 39.

f) Flexible hoses and expansion joints are to be complete with approved end fittings in accordance with manufacturer's specification. The end connections that do not have a flange are to comply with [2.5.5] as applicable and each type of hose/fitting combination is to be subject to prototype testing to the same standard as that required by the hose or expansion joint with particular reference to pressure and impulse tests.

2.7.5 Specific requirements for the design of flexible hoses

The hose clamps and similar types of end attachments are not acceptable for use in piping systems for steam, flammable media, starting air systems or for sea water systems where failure may result in flooding. In other piping systems, the use of hose clamps may be accepted where the working pressure is less than 0,5 MPa and provided that there are double clamps at each end connection.

2.7.6 Marking

Flexible hoses or expansion joints are to be permanently marked by the manufacturer with the following details:

- manufacturer's name or trademark
- date of manufacture (month/year)
- designation type reference
- nominal diameter
- pressure rating
- temperature rating.

Where a flexible hose assembly or an expansion joint is made up of items from different manufacturers, the components are to be clearly identified and traceable to evidence of prototype testing.

2.8 Valves and accessories

2.8.1 General

a) Valves and accessories are normally to be built in accordance with a recognised standard. Otherwise, they are subject to special consideration for approval by the Society.

Valves and fittings in piping systems are to be compatible with the pipes to which they are attached in respect of their strength (see [1.3.2] for design pressure) and are to be suitable for effective operation at the maximum working pressure they will experience in service.

Valves and accessories which are fitted:

- in a class I piping system, or
- in a class II piping system, or
- on the unit shell, on the collision bulkhead, on fuel oil tanks or on lubricating oil tanks under static pressure,

are to be subject to the applicable testing and inspection required by the Rules. See [20.7.1].

b) Shut-off valves are to be provided where necessary to isolate pumps, heat exchangers, pressure vessels, etc., from the rest of the piping system when necessary, and in particular:

- to allow the isolation of duplicate components without interrupting the fluid circulation
- for survey or repair purposes.

2.8.2 Design of valves and accessories

a) Materials of valve and accessory bodies are to comply with the provisions of [2.1].

b) Connections of valves and accessories with pipes are to comply with the provisions of [2.5].

c) All valves and accessories are to be so designed as to prevent the loosening of covers and glands when they are operated.

d) Valves are to be so designed as to shut with a right-hand (clockwise) motion of the wheels.

e) Valves are to be provided with local indicators showing whether they are open or shut, unless this is readily apparent.

2.8.3 Valves with remote control

a) Unless otherwise specified, the valves and cocks which can not be fitted in places where they are at all times readily accessible are to be provided with remote control.

b) The remote control system and means of local operation are to be independent. For shipside valves and valves on the collision bulkhead, the means for local manual operation are to be permanently attached.

c) For submerged valves in ballast, cargo, or other tanks where accepted by the Society, local manual operation may be by extended spindle or portable hand pump.

The manual operation by hand pump is to have the control lines to each submerged valve provided with the quick coupling connections, as close to the valve actuator as practicable, to allow easy connection of the hand pump. For shipside valves and valves on the collision bulkhead, the hand pump is to be permanently attached and fitted to the quick coupling connection. For other valves, not less than two portable hand pumps are to be provided.

d) In the case of valves which are to be provided with remote control in accordance with the Rules, opening and/or closing of the valves by local manual means is not to render the remote control system inoperable.

e) Power failure of the remote control system is not to cause an undesired change of the valve position.

f) Unless otherwise specified, indicators are to be provided on the remote controls to show whether the valves are open or closed.

The indicators for local manual control are to comply with [2.8.2], item e).

g) Where valves of piping systems are arranged for remote control and are power operated, a secondary means of operating the valves, which may be manual control, is to be provided.

2.9 Sea inlets and overboard discharges

2.9.1 General

Except where expressly stated in Article [8], the requirements of this sub-article do not apply to scuppers and sanitary discharges.

2.9.2 Design of sea inlets and overboard discharges

a) All sea inlets and discharges in the shell plating are to be fitted with efficient and accessible arrangements for preventing the accidental admission of water into the unit.

b) Sea inlets and overboard discharges are to be fitted with valves complying with [2.8] and [2.9.3].

c) Inlet and discharge valves in compartments situated below the assigned load line (normally unattended compartments) are to be provided with remote controlled valves.

Where remote operation is provided by power actuated valves for sea-water inlets and discharges for operation of essential systems, the failure of which may affect the safety of the unit, power supply failure of the control system is not to result in:

- closing of open valves
- opening of closed valves

Note 1: For surface and self-elevating units, and subject to special consideration, the remote operation of the valves may be omitted, when the space containing the valve is normally attended and provided with a high bilge water level detection.

d) Sea inlets are to be so designed and arranged as to limit turbulence and to avoid the admission of air due to motion of the unit.

e) Sea inlets are to be fitted with gratings complying with [2.9.4].

f) Provisions are to be made for clearing sea inlet gratings.

g) Sea chests are to be suitably protected against corrosion.

h) Sea water suction lines are to be fitted with strainers having a free passage area of at least twice that of the sea suction valve.

2.9.3 Valves

a) Sea inlet and overboard discharge valves are to be secured:

- directly on the shell plating, or
- on sea chests built on the shell plating, with scantlings in compliance with Part B or Part D of the Rules, or
- on extra-reinforced and short distance pieces attached to the shell (see Tab 6).

b) The bodies of the valves and distance pieces are to have a spigot passing through the plating without projecting beyond the external surface of such plating or of the doubling plates and stiffening rings, if any.

c) Valves are to be secured by means of:

- bolts screwed through the plating with a countersunk head, or
- studs screwed in heavy pads themselves secured to the hull or chest plating, without penetration of the plating by the stud holes.

d) The use of butterfly valves will be specially considered by the Society. In any event, butterfly valves not fitted with flanges are not to be used for water inlets or overboard discharges unless provisions are made to allow disassembling at sea of the pipes served by these valves without any risk of flooding.

e) The valves are to be provided with indicators showing whether they are open or closed.

f) The materials of the valve bodies and connecting pieces are to comply with Tab 5.

g) Valves located on the unit shell and serving piping systems made of plastics are to comply with Ch 1, App 1, [3.7.1].

2.9.4 Gratings

a) Gratings are to have a free flow area not less than twice the total section of the pipes connected to the inlet.

b) When gratings are secured by means of screws with a countersunk head, the tapped holes provided for such screws are not to pass through the plating or doubling plates outside distance pieces or chests.

c) Screws used for fixing gratings are not to be located in the corners of openings in the hull or of doubling plates.

d) In the case of large sea inlets, the screws used for fixing the gratings are to be locked and protected from corrosion.

e) When gratings are cleared by use of compressed air or steam devices, the chests, distance pieces and valves of sea inlets and outlets thus arranged are to be so constructed as to withstand the maximum pressure to which they may be subjected when such devices are operating.

2.9.5 Connections for blow-down of boilers

a) Blow-down pipes of boilers are to be provided with cocks or valves placed as near the end of the pipes as possible, while remaining readily accessible and located above the engine room floor.

b) Blow-down valves are to be so designed that it is easy to ascertain whether they are open or shut. Where cocks are used, the control keys are to be such that they cannot be taken off unless the cocks are shut. Where valves are used, the control-wheels are to be permanently fixed to the spindle.

c) A protection ring is to be fitted on the shell plating, outside, at the end of the blow-down pipes. The spigot of the valve referred to in [2.9.3], item b), is to pass through this ring.

2.10 Control and monitoring

2.10.1 General

a) Local indicators are to be provided for at least the following parameters:

- pressure, in pressure vessels, at pump or compressor discharge, at the inlet of the equipment served, on the low pressure side of pressure reducing valves
- temperatures, in tanks and vessels, at heat exchanger inlet and outlet
- levels, in tanks and vessels containing liquids.

b) Safeguards are to be provided where an automatic action is necessary to restore acceptable values for a faulty parameter.

c) Automatic controls are to be provided where it is necessary to maintain parameters related to piping systems at a pre-set value.

2.10.2 Level gauges

Level gauges used in flammable oil systems are to be of a type approved by the Society and are subject to the following conditions:

- Their failure or overfilling of the tank is not to permit release of fuel into the space. The use of cylindrical gauges is prohibited. The Society may permit the use of oil-level gauges with flat glasses and self-closing valves between the gauges and fuel tanks.
- Their glasses are to be made of heat-resistant material and efficiently protected against shocks.

3 Welding of steel piping

3.1 Application

3.1.1

a) The following requirements apply to welded joints belonging to class I or II piping systems.

They may also be applied to class III piping systems, at the discretion of the Society.

b) This article does not apply to refrigerated cargo installation piping systems operating at temperatures lower than minus 40°C.

c) The requirements for qualification of welding procedures are given in NR216.

3.2 General

3.2.1 Welding processes

a) Welded joints of pipes are to be made by means of electric arc or oxyacetylene welding, or any other previously approved process.

b) When the design pressure exceeds 0,7 MPa, oxyacetylene welding is not permitted for pipes with an external diameter greater than 100 mm or a thickness exceeding 6 mm.

3.2.2 Location of joints

The location of welded joints is to be such that as many as possible can be made in a workshop. The location of welded joints to be made on board is to be so determined as to permit their joining and inspection in satisfactory conditions.

3.3 Design of welded joints

3.3.1 Types of joints

a) Except for the fixing of flanges on pipes in the cases mentioned in Fig 1 and for the fixing of branch pipes, joints between pipes and between pipes and fittings are to be of the butt-welded type. However, for class I pipes with an internal diameter not exceeding 50 mm and for class II pipes, socket welded connections of approved types may be used.

b) For butt-welded joints between pipes or between pipes and flanges or other fittings, correctly adjusted backing rings may be used; such rings are to be either of the same grade of steel as the elements to be welded or of such a grade as not to adversely influence the weld; if the backing ring cannot be removed after welding, it is to be correctly profiled.

3.3.2 Assembly of pipes of unequal thickness

If the difference of thickness between pipes to be butt-welded exceeds 10% of the thickness of the thinner pipe plus 1 mm, subject to a maximum of 4 mm, the thicker pipe is to be thinned down to the thickness of the thinner pipe on a length at least equal to 4 times the offset, including the width of the weld if so desired.

3.3.3 Accessories

a) When accessories such as valves are connected by welding to pipes, they are to be provided with necks of sufficient length to prevent abnormal deformations during the execution of welding or heat treatment.

b) For the fixing by welding of branch pipes on pipes, it is necessary to provide either a thickness increase as indicated in [2.2.5] or a reinforcement by doubling plate or equivalent.

3.4 Preparation of elements to be welded and execution of welding

3.4.1 General

Attention is drawn to the provisions of Ch 1, Sec 3, which apply to the welding of pressure pipes.

3.4.2 Edge preparation for welded joints

The preparation of the edges is preferably to be carried out by mechanical means. When flame cutting is used, care is to be taken to remove the oxide scales and any notch due to irregular cutting by matching, grinding or chipping back to sound metal.

3.4.3 Abutting of parts to be welded

a) The elements to be welded are to be so abutted that surface misalignments are as small as possible.

b) As a general rule, for elements which are butt-welded without a backing ring the misalignment between internal walls is not to exceed the lesser of:

- the value given in Tab 20 as a function of thickness t and internal diameter d of these elements, and
- t/4.

Where necessary, the pipe ends are to be bored or slightly expanded so as to comply with these values; the thickness obtained is not to be less than the rule thickness.

c) In the case of welding with a backing ring, smaller values of misalignment are to be obtained so that the space between the backing ring and the internal walls of the two elements to be assembled is as small as possible; normally this space is not to exceed 0,5 mm.

d) The elements to be welded are to be adequately secured so as to prevent modifications of their relative position and deformations during welding.

3.4.4 Protection against adverse weather conditions

a) Pressure pipes are to be welded, both on board and in the shop, away from draughts and sudden temperature variations.

b) Unless special justification is given, no welding is to be performed if the temperature of the base metal is lower than 0°C.

3.4.5 Preheating

a) Preheating is to be performed as indicated in Tab 21, depending on the type of steel, the chemical composition and the pipe thickness.

b) The temperatures given in Tab 21 are based on the use of low hydrogen processes. Where low hydrogen processes are not used, the Society reserves the right to require higher preheating temperatures.

Table 20 : Maximum value of misalignment

d (mm)	t (mm)		
	$t \leq 6$	$6 < t \leq 10$	$10 < t$
$d < 150$	1,0	1,0	1,0
$150 \leq d < 300$	1,0	1,5	1,5
$300 \leq d$	1,0	1,5	2,0

Table 21 : Preheating temperature

Type of steel		Thickness of thicker part, in mm	Minimum preheating temperature (°C)
C and C-Mn steels	$C + \frac{Mn}{6} \leq 0,40$	t ≥ 20 **(2)**	50
	$C + \frac{Mn}{6} > 0,40$	t ≥ 20 **(2)**	100
0,3 Mo		t ≥ 13 **(2)**	100
1 Cr 0,5 Mo		t < 13	100
		t ≥ 13	150
2,25 Cr 1 Mo **(1)**		t < 13	150
		t ≥ 13	200
0,5 Cr 0,5 Mo V **(1)**		t < 13	150
		t ≥ 13	200

(1) For 2,25 Cr 1 Mo and 0,5 Cr 0,5 Mo V grades with thicknesses up to 6 mm, preheating may be omitted if the results of hardness tests carried out on welding procedure qualification are considered acceptable by the Society.

(2) For welding in ambient temperature below 0°C, the minimum preheating temperature is required independent of the thickness unless specially approved by the Society.

3.5 Post-weld heat treatment

3.5.1 General

a) As far as practicable, the heat treatment is to be carried out in a furnace. Where this is impracticable, and more particularly in the case of welding on board, the treatment is to be performed locally by heating uniformly a circular strip, extending on at least 75 mm on both sides of the welded joint; all precautions are to be taken to permit accurate checking of the temperature and slow cooling after treatment.

b) For austenitic and austenitic ferritic steels, post-weld head treatment is generally not required.

3.5.2 Heat treatment after welding other than oxyacetylene welding

a) Stress relieving heat treatment after welding other than oxyacetylene welding is to be performed as indicated in Tab 22, depending on the type of steel and thickness of the pipes.

b) The stress relieving heat treatment is to consist in heating slowly and uniformly to a temperature within the range indicated in Tab 22, soaking at this temperature for a suitable period, normally one hour per 25 mm of thickness with a minimum of half an hour, cooling slowly and uniformly in the furnace to a temperature not exceeding 400°C and subsequently cooling in still atmosphere.

c) In any event, the heat treatment temperature is not to be higher than $(T_T - 20)$°C, where T_T is the temperature of the final tempering treatment of the material.

3.5.3 Heat treatment after oxyacetylene welding

Stress relieving heat treatment after oxyacetylene welding is to be performed as indicated in Tab 23, depending on the type of steel.

Table 22 : Heat treatment temperature

Type of steel	Thickness of thicker part, in mm	Stress relief treatment temperature (°C)
C and C-Mn steels	t ≥ 15 **(1)** **(3)**	550 to 620
0,3 Mo	t ≥ 15 **(1)**	580 to 640
1 Cr 0,5 Mo	t ≥ 8	620 to 680
2,25 Cr 1 Mo 0,5 Cr 0,5 Mo V	any **(2)**	650 to 720

(1) Where steels with specified Charpy V notch impact properties at low temperature are used, the thickness above which post-weld heat treatment is to be applied may be increased, subject to the special agreement of the Society.

(2) For 2,25Cr 1Mo and 0,5Cr 0,5Mo V grade steels, heat treatment may be omitted for pipes having thickness lower than 8 mm, diameter not exceeding 100 mm and service temperature not exceeding 450°C.

(3) For C and C-Mn steels, stress relieving heat treatment may be omitted up to 30 mm thickness, subject to the special agreement of the Society.

Table 23 : Heat treatment after oxyacetylene welding

Type of steel	Heat treatment and temperature (°C)
C and C-Mn	Normalising 880 to 940
0,3 Mo	Normalising 900 to 940
1Cr-0,5Mo	Normalising 900 to 960 Tempering 640 to 720
2,25Cr-1Mo	Normalising 900 to 960 Tempering 650 to 780
0,5Cr-0,5Mo-0,25V	Normalising 930 to 980 Tempering 670 to 720

3.6 Inspection of welded joints

3.6.1 General

a) The inspection of pressure pipe welded joints is to be performed at the various stages of the fabrication further to the qualifications defined in [3.1.1], item c).

b) The examination mainly concerns those parts to be welded further to their preparation, the welded joints once they have been made and the conditions for carrying out possible heat treatments.

c) The required examinations are to be carried out by qualified operators in accordance with procedures and techniques to the Surveyor's satisfaction.

3.6.2 Visual examination

Welded joints, including the inside wherever possible, are to be visually examined.

3.6.3 Non-destructive examinations

Non-destructive tests required are given in:

- Tab 24 for class I pipes
- Tab 25 for class II pipes.

Table 24 : Class I pipe - Type of welded joints

Class I pipe outer diameter D	Butt welded joint	Fillet weld for flange connection	Other welded joint which cannot be radiographed
Frequency of testing	• for D > 75 mm: every weld • for D ≤ 75 mm: minimum 10% of welds selected in agreement with the Surveyor	• for D > 75 mm: every weld • for D ≤ 75 mm: minimum 10% of welds selected in agreement with the Surveyor	• for D > 75 mm: every weld • for D ≤ 75 mm: minimum 10% of welds selected in agreement with the Surveyor
Extent of testing	full length	full length	full length
Type of testing	radiographic or equivalent accepted by the Society	magnetic particle or liquid penetrant	magnetic particle or liquid penetrant

Table 25 : Class II pipe - Type of welded joints

Class II pipe outer diameter D	Butt welded joint	Fillet weld for flange connection	Other welded joint which cannot be radiographed
Frequency of testing	for D > 100 mm: minimum 10% of welds selected in agreement with the Surveyor	for D > 100 mm: minimum 10% of welds selected in agreement with the Surveyor	for D > 100 mm: minimum 10% of welds selected in agreement with the Surveyor
Extent of testing	full length	full length	full length
Type of testing	radiographic or equivalent accepted by the Society	magnetic particle or liquid penetrant	magnetic particle or liquid penetrant

3.6.4 Defects and acceptance criteria

a) Joints for which non-destructive examinations reveal unacceptable defects are to be re-welded and subsequently to undergo a new non-destructive examination. The Surveyor may require that the number of joints to be subjected to non-destructive examination is larger than that resulting from the provisions of [3.6.3].

b) Acceptance criteria and repairs

- Indications evaluated to be crack, lack of fusion or lack of penetration for class I pipes are not acceptable. Indications evaluated to be crack or lack of fusion in welds for class II pipes are not acceptable. Other types of imperfection are to be assessed in accordance with a recognised standard accepted by the Society.
- Unacceptable indications are to be eliminated and repaired where necessary. The repair welds are to be examined on their full length using magnetic particle or liquid penetrant test and ultrasonic or radiographic testing.

  When unacceptable indications are found, additional area of the same weld length are to be examined unless the indication is judged isolated without any doubt. In case of automatic welded joints, additional NDE is to be extended to all areas of the same weld length.

  The extent of examination can be increased at the surveyor's discretion when repeated non-acceptable indications are found.

4 Bending of pipes

4.1 Application

4.1.1 This Article applies to pipes made of:

- alloy or non-alloy steels
- copper and copper alloys.

4.2 Bending process

4.2.1 General

The bending process is to be such as not to have a detrimental influence on the characteristics of the materials or on the strength of the pipes.

4.2.2 Bending radius

Unless otherwise justified, the bending radius measured on the centreline of the pipe is not to be less than:

- twice the external diameter for copper and copper alloy pipes
- 3 times the external diameter for cold bent steel pipes.

4.2.3 Acceptance criteria

a) The pipes are to be bent in such a way that, in each transverse section, the difference between the maximum and minimum diameters after bending does not exceed 10% of the mean diameter; higher values, but not exceeding 15%, may be allowed in the case of pipes which are not subjected in service to appreciable bending stresses due to thermal expansion or contraction.

b) The bending is to be such that the depth of the corrugations is as small as possible and does not exceed 5% of their length.

4.2.4 Hot bending

a) In the case of hot bending, all arrangements are to be made to permit careful checking of the metal temperature and to prevent rapid cooling, especially for alloy steels.

b) Hot bending is to be generally carried out in the temperature range 850°C-1000°C for all steel grades; however, a decreased temperature down to 750°C may be accepted during the forming process.

4.3 Heat treatment after bending

4.3.1 Copper and copper alloy

Copper and copper alloy pipes are to be suitably annealed after cold bending if their external diameter exceeds 50 mm.

4.3.2 Steel

a) After hot bending carried out within the temperature range specified in [4.2.4], the following applies:

- for C, C-Mn and C-Mo steels, no subsequent heat treatment is required
- for Cr-Mo and C-Mo-V steels, a subsequent stress relieving heat treatment in accordance with Tab 22 is required.

b) After hot bending performed outside the temperature range specified in [4.2.4], a subsequent new heat treatment in accordance with Tab 23 is required for all grades.

c) After cold bending at a radius lower than 4 times the external diameter of the pipe, a heat treatment in accordance with Tab 23 is required.

5 Arrangement and installation of piping systems

5.1 General

5.1.1 Unless otherwise specified, piping and pumping systems covered by the Rules are to be permanently fixed on board the unit.

5.2 Piping systems serving hazardous areas

5.2.1 Piping systems are to be designed and arranged to preclude direct communication between:

- hazardous areas of different classifications
- hazardous and non-hazardous areas.

5.3 Location of tanks and piping system components

5.3.1 Flammable oil systems

Location of tanks and piping system components conveying flammable fluids under pressure is to comply with [5.11].

5.3.2 Piping systems with open ends

Attention is to be paid to the requirements for the location of open-ended pipes on board units having to comply with the provisions of [5.6].

5.3.3 Pipe lines located inside tanks

a) The passage of pipes through tanks, when permitted, normally requires special arrangements such as reinforced thickness or tunnels, in particular for:
   - bilge pipes
   - ballast pipes
   - scuppers and sanitary discharges
   - air, sounding and overflow pipes
   - fuel oil pipes.

b) Junctions of pipes inside tanks are to be made by welding or flange connections. See also [2.5.3].

5.3.4 Overboard discharges

a) All discharges in the shell plating below the freeboard deck shall be fitted with efficient and accessible arrangements for preventing the accidental admission of water into the ship.

b) In manned machinery spaces, the valves may be controlled locally and shall be provided with indicators showing whether they are open or closed.

c) Overboard discharges are to be so located as to prevent any discharge of water into the lifeboats while they are being lowered.

5.3.5 Piping and electrical apparatus

As far as possible, pipes are not to pass near switchboards or other electrical apparatus. If this requirement is impossible to satisfy, gutterways or masks are to be provided wherever deemed necessary to prevent projections of liquid or steam on live parts.

5.4 Passage through watertight bulkheads or decks

5.4.1 General

Where penetrations of watertight bulkheads and internal decks are necessary for piping and ventilation, arrangements are to be made to maintain the watertight integrity.

For penetrations of watertight bulkheads or decks by plastic pipes, refer to Ch 1, App 1, [3.6.2].

5.4.2 Materials

Lead or other heat sensitive materials are not to be used in piping systems which penetrate watertight subdivision bulkheads or decks, where deterioration of such systems in the event of fire would impair the watertight integrity of the bulkhead or decks.

This applies in particular to the following systems:

- bilge system
- ballast system
- scuppers and sanitary discharge systems.

5.4.3 Passing-through arrangements

Where bolted connections are used when passing through watertight bulkheads or decks, the bolts are not to be screwed through the plating.

Where welded connections are used, they are to be welded on both sides of the bulkhead or deck.

Penetrations of watertight bulkheads or decks and fire divisions by plastic pipes are to comply with Ch 1, App 1, [3.6.2].

5.4.4 Passage through the collision bulkhead

a) Except as provided in b) the collision bulkhead may be pierced below the bulkhead deck by not more than one pipe for dealing with fluid in the forepeak tank, provided that the pipe is fitted with a screw-down valve capable of being operated from above the bulkhead deck, the valve chest being secured inside the forepeak to the collision bulkhead. the Society may, however, authorize the fitting of this valve on the after side of the collision bulkhead provided that the valve is readily accessible under all service conditions and the space in which it is located is not a cargo space. All valves shall be of steel, bronze or other approved ductile material. Valves of ordinary cast iron or similar material are not acceptable.

b) If the forepeak is divided to hold two different kinds of liquids the Society may allow the collision bulkhead to be pierced below the bulkhead by two pipes, each of which is fitted as required by a), provided the Society is satisfied that there is no practical alternative to the fitting of such a second pipe and that, having regard to the additional subdivision provided in the forepeak, the safety of the unit is maintained

c) The remote operation device of the valve referred to in a) is to include an indicator to show whether the valve is open or shut.

5.5 Independence of lines

5.5.1 Piping systems carrying non-hazardous fluids are generally to be separate from piping systems which may contain hazardous fluids. Cross connection of the piping systems may be permitted where means for avoiding possible contamination of the non-hazardous fluid system by the hazardous medium are provided.

5.5.2 As a general rule, bilge and ballast lines are to be entirely independent and distinct from lines conveying produced oil, lubricating oil and fuel oil, with the exception of:

- pipes located between collecting boxes and pump suctions
- pipes located between pumps and overboard discharges
- pipes supplying compartments likely to be used alternatively for ballast, fuel oil or liquid or dry cargoes, provided such pipes are fitted with blind flanges or other appropriate change-over devices, in order to avoid any mishandling.

5.6 Prevention of progressive flooding

5.6.1 Principle

a) In order to comply with the subdivision and damage stability requirements of Pt B, Ch 1, Sec 3, provision is to be made to prevent any progressive flooding of a dry compartment served by any open-ended pipe, in the event that such pipe is damaged or broken in any other compartment by collision or grounding.

b) For this purpose, if pipes are situated within assumed flooded compartments, arrangements are to be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage. However, the Society may permit minor progressive flooding if it is demonstrated that its effects can be easily controlled and the safety of the unit is not impaired. Refer to Pt B, Ch 1, Sec 3.

5.6.2 Extent of damage

For the definition of the assumed transverse extent of damage, reference is to be made to Pt B, Ch 1, Sec 3.

5.6.3 Piping arrangement

a) The assumed transverse extent of damage is not to contain any pipe with an open end in a compartment located outside this extent, except where the section of such pipe does not exceed 710 mm^2.

Note 1: Where several pipes are considered, the limit of 710 mm^2 applies to their total section.

b) Where the provisions of a) cannot be fulfilled, and after special examination by the Society, pipes may be situated within the assumed transverse extent of damage penetration provided that:
  - either a closable valve operable from above the bulkhead deck is fitted at each penetration of a watertight subdivision and secured directly on the bulkhead, or
  - a closable valve operable from above the bulkhead deck is fitted at each end of the pipe concerned, the valves and their control system being inboard of the assumed extent of damage, or
  - the tanks to which the pipe concerned leads are regarded in the damage stability calculations as being flooded when damage occurs in a compartment through which the pipe passes.

c) Valves required to be operable from above the bulkhead deck are to be fitted with an indicator to show whether the valve is open or shut.

Where the valve is remote controlled by other than mechanical means, and where the remote control system is located, even partly, within the assumed extent of damage penetration, this system is to be such that the valve is automatically closed by loss of power.

d) Air and overflow pipes are to be so arranged as to prevent the possibility of flooding of other tanks in other watertight compartments in the event of any one tank being flooded.

This arrangement is to be such that in the range of positive residual righting levers beyond the angle of equilibrium stage of flooding, the progressive flooding of tanks or watertight compartments other than that flooded does not occur.

5.7 Provision for expansion

5.7.1 General

Piping systems are to be so designed and pipes so fixed as to allow for relative movement between pipes and the unit’s structure, having due regard to the:

- temperature of the fluid conveyed
- coefficient of thermal expansion of the pipes material
- deformation of the unit’s structure.

5.7.2 Fitting of expansion devices

All pipes subject to thermal expansion and those which, due to their length, may be affected by deformation of the hull, are to be fitted with expansion pieces or loops.

5.8 Supporting of the pipes

5.8.1 General

Unless otherwise specified, the fluid lines referred to in this Section are to consist of pipes connected to the unit's structure by means of collars or similar devices.

5.8.2 Arrangement of supports

Builders are to take care that:

a) The arrangement of supports and collars is to be such that pipes and flanges are not subjected to abnormal bending stresses, taking into account their own mass, the metal they are made of, and the nature and characteristics of the fluid they convey, as well as the contractions and expansions to which they are subjected.

b) Heavy components in the piping system, such as valves, are to be independently supported.

5.9 Protection of pipes

5.9.1 Protection of sea water pipes from mechanical damage

Seawater pipes in storage compartments other than those containing liquid are to be protected from impact of stored goods where they are liable to be damaged.

5.9.2 Protection against corrosion and erosion

a) Pipes are to be efficiently protected against corrosion, particularly in their most exposed parts, either by selection of their constituent materials, or by an appropriate coating or treatment.

b) The layout and arrangement of sea water pipes are to be such as to prevent sharp bends and abrupt changes in section as well as zones where water may stagnate. The inner surface of pipes is to be as smooth as possible, especially in way of joints. Where pipes are protected against corrosion by means of galvanising or other inner coating, arrangements are to be made so that this coating is continuous, as far as possible, in particular in way of joints.

c) If galvanised steel pipes are used for sea water systems, the water velocity is not to exceed 3 m/s.

d) If copper pipes are used for sea water systems, the water velocity is not to exceed 2 m/s.

e) Arrangements are to be made to avoid galvanic corrosion.

f) If aluminium bras pipes are used for sea water systems, the water velocity is not to exceed 3 m/s

g) If 90/10 copper-nickel-iron pipes are used for sea water systems, the water velocity is not to exceed 3,5 m/s

h) If 70/30 copper-nickel pipes are used for sea water systems, the water velocity is not to exceed 5 m/s

i) If GRP pipes are used for sea water systems, the water velocity is not to exceed 5 m/s.

5.9.3 Protection against frosting

Pipes are to be adequately insulated against cold wherever deemed necessary to prevent frost.

This applies specifically to pipes passing through refrigerated spaces and which are not intended to ensure the refrigeration of such spaces.

5.9.4 Protection of high temperature pipes and components

a) All pipes and other components where the temperature may exceed 220°C are to be efficiently insulated. Where necessary, precautions are to be taken to protect the insulation from being impregnated with flammable oils.

b) Particular attention is to be paid to lagging in way of flanges.

5.10 Valves, accessories and fittings

5.10.1 General

Cocks, valves and other accessories are generally to be arranged so that they are easily visible and accessible for manoeuvring, control and maintenance. They are to be installed in such a way as to operate properly.

5.10.2 Valves and accessories

a) In machinery spaces and tunnels, the cocks, valves and other accessories of the fluid lines referred to in this Section are to be placed:

- above the floor, or
- when this is not possible, immediately under the floor, provided provision is made for their easy access and control in service.

b) Control-wheels of low inlet valves are to rise at least 0,45 m above the lowest floor.

5.10.3 Flexible hoses and expansion joints

a) Flexible hoses and expansion joints are to be in compliance with [2.7]. They are to be installed in clearly visible and readily accessible locations.

b) The number of flexible hoses and expansion joints is to be limited and kept to minimum.

c) In general, flexible hoses and expansion joints are to be limited to a length necessary to provide for relative movement between fixed and flexibly mounted items of machinery/equipment or systems.

d) The installation of a flexible hose assembly or an expansion joint is to be in accordance with the manufacturer's instructions and use limitations, with particular attention to the following:

- orientation
- end connection support (where necessary)
- avoidance of hose contact that could cause rubbing and abrasion
- minimum bend radii.

e) Flexible hose assemblies or expansion joints are not to be installed where they may be subjected to torsion deformation (twisting) under normal operating conditions.

f) Where flexible hoses or an expansion joint are intended to be used in piping systems conveying flammable fluids that are in close proximity of heated surfaces, the risk of ignition due to failure of the hose assembly and subsequent release of fluids is to be mitigated, as far as practicable, by the use of screens or other similar protection, to the satisfaction of the Society.

g) The adjoining pipes are to be suitably aligned, supported, guided and anchored.

h) Isolating valves are to be provided permitting the isolation of flexible hoses intended to convey flammable oil or compressed air.

i) Expansion joints are to be protected against over extension or over compression.

j) Where they are likely to suffer external damage, flexible hoses and expansion joints of the bellows type are to be provided with adequate protection.

5.10.4 Thermometers

Thermometers and other temperature-detecting elements in fluid systems under pressure are to be provided with pockets built and secured so that the thermometers and detecting elements can be removed while keeping the piping under pressure.

5.10.5 Pressure gauges

Pressure gauges and other similar instruments are to be fitted with an isolating valve or cock at the connection with the main pipe.

5.10.6 Name plates

a) Accessories such as cocks and valves on the fluid lines referred to in this Section are to be provided with nameplates indicating the apparatus and lines they serve except where, due to their location on board, there is no doubt as to their purpose.

b) Nameplates are to be fitted at the upper part of air and sounding pipes.

5.11 Additional arrangements for flammable fluids

5.11.1 General

All necessary precautions are to be taken to reduce fire risks from flammable liquids, such as:

- drips
- leaks under pressure
- overflow
- hydrocarbon accumulation in particular under lower floors
- discharges of oil vapours during heating
- soot or unburnt residue in smoke stacks or exhaust pipes.

Unless otherwise specified, the requirements in [5.11.3] apply to:

- fuel oil systems, in all spaces
- lubricating oil systems, in machinery spaces
- other flammable oil systems, in locations where means of ignition are present.

5.11.2 Prohibition of carriage of flammable oils in forepeak tanks of surface units

In surface units, fuel oil, lubricating oil and other flammable oils are not to be carried in forepeak tanks or tanks forward of the collision bulkhead.

5.11.3 Prevention of flammable oil leakage ignition

a) As far as practicable, the piping arrangement in the flammable oil systems shall comply generally with the following:
   - The conveying of flammable oils through accommodation and service spaces is to be avoided. Where it is not possible, the arrangement may be subject to special consideration by the Society, provided that the pipes are of a material approved having regard to the fire risk.
   - The pipes are not to be located immediately above or close to the hot surfaces (exhaust manifolds, silencers, steam pipelines, boilers, etc.), electrical installations or other sources of ignition. Otherwise, suitably protection (screening and effective drainage to the safe position) is to be provided to prevent of spraying or leakage onto the sources of ignition.
   - Parts of the piping systems conveying heated flammable oils under pressure exceeding 0,18 MPa are to be placed above the platform or in any other position where defects and leakage can readily be observed. The machinery spaces in way of such parts are to be adequately illuminated.

b) No flammable oil tanks are to be situated where spillage or leakage therefrom can constitute a hazard by falling on:
   - hot surfaces, including those of boilers, heaters, steam pipes, exhaust manifolds and silencers
   - electrical equipment
   - air intakes
   - other sources of ignition.

c) Parts of flammable oil systems under pressure exceeding 0,18 MPa such as pumps, filters and heaters are to comply with the provisions of item b) above.

d) Mechanical joints, expansion joints and flexible parts of flammable oil lines are to be screened or otherwise suitably protected to avoid as far as practicable oil spray or oil leakages onto hot surfaces, into machinery air intakes, or on other sources of ignition.

e) Any relief valve of fuel oil and lubricating oil systems is to discharge to a safe position, such as an appropriate tank.

f) Appropriate means are to be provided to prevent undue opening (due to vibrations) of air venting cocks fitted on equipment or piping containing flammable liquid under pressure.

5.11.4 Provisions for flammable oil leakage containment

a) Tanks used for the storage of flammable oils together with their fittings are to be so arranged as to prevent spillages due to leakage or overfilling.

b) Drip trays with adequate drainage to contain possible leakage from flammable fluid systems are to be fitted:
   - under independent tanks
   - under burners
   - under purifiers and any other oil processing equipment
   - under pumps, heat exchangers and filters
   - under valves and all accessories subject to oil leakage
   - surrounding internal combustion engines.

c) The coaming height of drip trays is to be appropriate for the service and not less than 75 mm.

d) Where boilers are located in machinery spaces on ‘tweendecks and the boiler rooms are not separated from the machinery spaces by watertight bulkheads, the ‘tweendecks are to be provided with oil-tight coamings at least 200 mm in height.

e) Where drain pipes are provided for collecting leakages, they are to be led to an appropriate drain tank.

f) The draining system of the room where thermal fluid heaters are fitted, as well as the save all of the latter, are not to allow any fire extension outside this room. See also [13.3.2].

5.11.5 Drain tank

The drain tank is not to form part of an overflow system and is to be fitted with an overflow alarm device.

5.11.6 Valves

All valves and cocks forming part of flammable oil systems are to be capable of being operated from readily accessible positions and, in machinery spaces, from above the working platform.

5.11.7 Level switches

Level switches fitted to flammable oil tanks are to be contained in a steel or other fire-resisting enclosure.

6 Bilge systems

6.1 Principle

6.1.1 General

An efficient bilge pumping system shall be provided, capable of pumping from and draining any watertight compartment other than a space permanently appropriated for the carriage of fresh water, water ballast, fuel oil or liquid cargo and for which other efficient means of pumping are provided, under all practical conditions, whether the unit is upright or inclined as specified in Ch 1, Sec 1, Tab 1, Ch 1, Sec 1, Tab 2 and Ch 1, Sec 1, Tab 3.

Note 1: Bilge pumping system is not intended at coping with water ingress resulting from structural or main sea water piping damage.

6.1.2 Availability of the bilge system

The bilge system is to be able to work while the other essential installations of the unit, especially the fire-fighting installations, are in service.

6.1.3 Prevention of pollution by oil

The discharge of oily effluents associated with the normal operation of machinery systems is subject to MARPOL 73/78, Annex I.

The discharge of oily effluents associated with offshore processing and the discharge of production water and displacement water are subject to national or regional regulations, as applicable.

Piping systems intended for machinery oily effluents are to be completely independent from any piping system intended for other oily effluents.

6.2 Design of bilge systems

6.2.1 General

a) The bilge pumping system is to consist of pumps connected to a bilge main line so arranged as to allow the draining of all spaces mentioned in [6.1.1] through bilge branches, distribution boxes and bilge suctions, except for some small spaces where individual suctions by means of hand pumps may be accepted.

b) The bilge pumping system is to be so arranged that any accumulated water can be drained even when the unit has an inclination up to 5° in any direction.

c) Automatic means are to be provided to detect the presence of water in the compartments which are adjacent to the sea or adjacent to tanks containing liquids and in void compartments through which pipes conveying liquids pass.

   In the event of water detection, an alarm is to be given in a manned control room.

d) If the Society is satisfied that the safety of the unit is not impaired, the bilge pumping arrangements and the means to detect the presence of water may be dispensed with in particular compartments.

6.2.2 Prevention of inadvertent flooding Independence of the lines

a) The arrangement of the bilge and ballast pumping system shall be such as to prevent the possibility of water passing from the sea and from water ballast spaces into dry compartments and machinery spaces, or from one compartment to another.

b) Provisions are to be made to prevent any deep tank having bilge and ballast connections being inadvertently flooded from the sea when containing products other than sea water, or being discharged through a bilge pump when containing water ballast.

c) Bilge lines are to be entirely independent and distinct from other lines except where permitted in [5.5].

d) Hazardous and non-hazardous areas are to be provided with separate drainage or pumping arrangement.

e) On floating production storage and offloading units, the arrangements for the draining of:
  - cofferdams located at the fore and aft ends of the cargo area
  - other cofferdams and void spaces located within the cargo area
  - cargo pump rooms and other pump rooms
  - pipe tunnels,

  are to comply with the provisions of Pt D, Ch 1, Sec 12, [2.2].

6.3 Arrangement of bilge suctions

6.3.1 General

In all cases, arrangements are to be made such as to allow a free and easy flow of water to bilge suctions.

6.3.2 Number and distribution of bilge suctions

The bilge suctions in spaces below the bulkhead deck are to be so located that it is possible to drain the accumulated liquid in those spaces by:

a) Where the bottom of the space, bottom plating or top of the double bottom slopes down to the centreline by more than 5°:
  - in machinery spaces containing essential machinery such as engines, bilge pumps or ballast pumps, at least one branch centreline suction, one direct centreline suction and one emergency bilge suction
  - in machinery spaces other than those containing essential machinery, at least one centreline branch suction and one direct centreline suction
  - in dry compartments other than machinery spaces, at least one branch centreline suction.

b) Where the bottom of the space is horizontal or slopes down to the sides:
  - in machinery spaces containing essential machinery such as engines, bilge pumps or ballast pumps, at least one branch suction on each side, one direct suction on each side and one emergency bilge suction
  - in machinery spaces other than those containing essential machinery, at least one branch suction and one direct suction on each side
  - in dry compartments other than machinery spaces, at least one branch suction on each side.

c) Dry compartments other than those containing essential machinery can be drained to other spaces provided with bilge pumping capability.

6.3.3 Branch bilge suctions

Branch bilge suctions are to be arranged as required in [6.3.2].

Additional branch bilge suctions may be required if the tank top is of particular design or shows discontinuity.

6.3.4 Direct bilge suctions

The direct bilge suction is to be led direct to an independent power bilge pump and so arranged that it can be used independently of the main bilge line.

The use of ejectors for pumping through the direct suction will be given special consideration.

6.3.5 Emergency bilge suction

a) The emergency bilge suction required in [6.3.2] is to be led directly from the drainage level of the concerned space to the largest available independent power driven pump other than a bilge pump.

b) The emergency bilge suction is to be located at the lowest possible level.

6.4 Draining of particular spaces

6.4.1 Draining of cofferdams

Cofferdams adjacent to the sea or to tanks containing liquids and cofferdams through which piping conveying liquid passes are to be drained by permanently installed bilge or drainage systems.

Note 1: Portable pumping means may be accepted only where:

- the wetted surface of the compartment, as defined in [6.6.2], is less than 130 m^2
- the height of the compartment does not exceed 7,3 m
- the pump is located above the cofferdam top
- the pump has suitable NPSH.

Note 2: Cofferdams which are not provided with bilge or drainage systems in compliance with the above are to be accounted for in the unit stability analysis.

6.4.2 Draining of chain lockers

Chain lockers are to be capable of being drained by a permanently installed bilge or drainage system or by portable means. Means are to be provided for removal of mud and debris from the bilge or drainage system.

6.4.3 Draining of tunnels

a) Tunnels are to be drained by means of suctions connected to the main bilge system. Such suctions are generally to be located in wells at the aft end of the tunnels.

b) Where the top of the double bottom, in the tunnel, slopes down from aft to forward, an additional suction is to be provided at the forward end of this space.

6.4.4 Draining of refrigerated spaces

Provision is to be made for the continuous drainage of condensate in refrigerated and air cooler spaces. To this end, valves capable of blanking off the water draining lines of such spaces are not to be fitted, unless they are operable from an easily accessible place located above the load waterline.

6.5 Bilge pumps

6.5.1 Number and arrangement of pumps

a) At least two power pumps connected to the main bilge system are to be provided. One of the pump is to be dedicated to bilge pumping.

b) Each pump may be replaced by a group of pumps connected to the bilge main, provided their total capacity meets the requirements specified in [6.5.4].

c) Where portable means of pumping are permitted, at least two pumps are to be available on board.

6.5.2 Use of ejectors

One of the pumps may be replaced by a hydraulic ejector connected to a high pressure water pump and capable of ensuring the drainage under similar conditions to those obtained with the other pump.

6.5.3 Use of other pumps for bilge duties

Other pumps, such as fire, general service, sanitary service or ballast pumps, may be used for bilge duties provided that:

- they meet the capacity requirements
- suitable piping arrangements are made, complying with the provisions of [6.5.6]
- pumps are available for bilge duty when necessary.

6.5.4 Capacity of the pumps

a) Each power bilge pump is to be capable of pumping water through the required main bilge pipe at a speed of not less than 2 m/s.

b) The capacity of each pump or group of pumps is not to be less than:

$Q = 0{,}00565\ d^2$

where:

Q : Minimum capacity of each pump or group of pumps, in m^3/h

d : Internal diameter, in mm, of the bilge main as defined in [6.6.4].

c) If the capacity of one of the pumps or one of the groups of pumps is less than the Rule capacity, the deficiency may be compensated by an excess capacity of the other pump or group of pumps; as a rule, such deficiency is not permitted to exceed 30% of the Rule capacity.

d) The capacity of hand pumps is to be based on one movement once a second.

e) Where an ejector is used in lieu of a driven pump, its suction capacity is not to be less than the required capacity of the pump it replaces.

6.5.5 Other characteristics of the pumps

a) Bilge pumps are to be of the self-priming type. Centrifugal pumps are to be fitted with efficient priming means, unless an approved priming system is provided to ensure the priming of pumps under normal operating conditions.

b) Circulating or cooling water pumps connected to an emergency bilge suction need not be of the self-priming type.

c) Hand pumps are to have a maximum suction height not exceeding 7,30 m and to be operable from a position located above the load waterline.

6.5.6 Connection of power pumps

a) Bilge pumps and other power pumps serving essential services which have common suction or discharge are to be connected to the pipes in such a way that:

  - compartments and piping lines remain segregated in order to prevent possible intercommunication
  - the operation of any pump is not affected by the simultaneous operation of other pumps.

b) The isolation of any bilge pump for examination, repair or maintenance is to be made possible without impeding the operation of the remaining bilge pumps.

6.5.7 Electrical supply of submersible pump motors

a) Where submersible bilge pumps are provided, arrangements are to be made to start their motors from a convenient position above the bulkhead deck.

b) Where an additional local-starting device is provided at the motor of a permanently installed submersible bilge pump, the circuit is to be arranged to provide for the disconnection of all control wires therefrom at a position adjacent to the starter installed on the deck.

6.6 Size of bilge pipes

6.6.1 General

The diameter of the bilge pipes fitted to surface units is to comply with the relevant requirements of Pt C, Ch 1, Sec 10 of the Ship Rules.

The following requirements apply to units other than surface units.

6.6.2 Branch bilge suction pipes

The internal diameter, in mm, of branch suctions from each compartment is not to be less than the diameter given by the following formula, to the nearest 5 mm:

$$d_1 = 2,15\sqrt{A} + 25$$

where:

A : Wetted surface, in m^2, of the compartment, excluding stiffening members, when the compartment is half filled with water.

d_1 is not to be less than 50 mm.

6.6.3 Distribution box branch pipes

The cross-section of any branch pipe connecting the bilge main to a bilge distribution box is not to be less than the sum of the cross-sections required for the two largest branch suctions pipes connected to this box. However, this cross-section need not exceed that of the main bilge line.

6.6.4 Main bilge line

The internal diameter, in mm, of the main bilge line is not to be less than the diameter given by the following formula:

$$d = 3,36\sqrt[3]{\Delta} + 25$$

where:

Δ : Maximum unit displacement when fully loaded, in metric tons.

d is not to be less than the combined areas of the two largest branch suctions.

6.6.5 Direct suctions

The internal diameter of direct suctions pipes is not to be less than that required for the main bilge line.

6.6.6 Emergency suctions

The internal diameter of emergency bilge suction pipes is not to be less than that of the pump inlet.

6.6.7 Scuppers in aft spaces

Any scupper provided for draining aft spaces and discharging to the tunnel is to have an internal diameter not less than 35 mm.

6.7 Bilge accessories

6.7.1 Drain valves on watertight bulkheads

a) The fitting of drain valves or similar devices is not allowed on the collision bulkhead.

b) On other watertight bulkheads, the fitting of drain valves or similar devices is allowed unless practical alternative draining means exist. Such valves are to be easily accessible at all times and operable from above the freeboard deck. Means indicating whether the valves are open or closed are to be provided.

6.7.2 Screw-down non-return valves

a) Accessories are to be provided to prevent intercommunication of compartments or lines which are to remain segregated from one another. For this purpose, screw-down non-return devices or similar devices are to be fitted:
  - on the pipe connections to bilge distribution boxes or to the alternative valves, if any
  - on direct and emergency suctions in machinery spaces
  - on the suctions of pumps which also have connections from the sea or from compartments normally intended to contain liquid
  - on flexible bilge hose connections
  - on the suctions of water bilge ejectors
  - at the open end of bilge pipes passing through deep tanks
  - in compliance with the provisions for the prevention of progressive flooding, if applicable.

b) Screw-down and other non-return valves are to be of a recognised type which does not offer undue obstruction to the flow of water.

6.7.3 Mud boxes

In machinery spaces and shaft tunnels, termination pipes of bilge suctions are to be straight and vertical and are to be led to mud boxes so arranged as to be easily inspected and cleaned.

The lower end of the termination pipe is not to be fitted with a strum box.

6.7.4 Strum boxes

a) In compartments other than machinery spaces and shaft tunnels, the open ends of bilge suction pipes are to be fitted with strum boxes or strainers having holes not more than 10 mm in diameter. The total area of such holes is to be not less than twice the required cross-sectional area of the suction pipe.

b) Strum boxes are to be so designed that they can be cleaned without having to remove any joint of the suction pipe.

6.7.5 Bilge wells

a) The wells provided for draining the various compartments are to be of a capacity not less than 0,15 m^3. In small compartments, smaller cylindrical wells may be fitted.

b) For surface units, bilge wells are to comply with the provisions of Pt B, Ch 4, Sec 4 of the Ship Rules.

6.7.6 Liquid sealed traps

a) The bilge line of refrigerated spaces is to be provided with liquid sealed traps of adequate size arranged for easy cleaning and refilling with brine. These traps are to be fitted with removable grids intended to hold back waste products when defrosting.

b) Where drain pipes from separate refrigerated rooms join a common main, each of these pipes is to be provided with a liquid sealed trap.

c) As a general rule, liquid sealed traps are to be fitted with non-return valves. However, for refrigerated spaces not situated in the unit bottom, non-return valves may be omitted, provided this arrangement does not impair the integrity of the watertight subdivision.

6.8 Materials

6.8.1 *All bilge pipes used in or under coal bunkers or fuel storage tanks or in boiler or machinery spaces, including spaces in which oil-settling tanks or fuel oil pumping units are situated, shall be of steel or other suitable material non-sensitive to heat.*

6.9 Bilge piping arrangement

6.9.1 Passage through double bottom compartments

Bilge pipes are not to pass through double bottom compartments. If such arrangement is unavoidable, the parts of bilge pipes passing through double bottom compartments are to have reinforced thickness, as per Tab 6 for steel pipes.

6.9.2 Passage through deep tanks

The parts of bilge pipes passing through deep tanks intended to contain water ballast, fresh water, liquid cargo or fuel oil are normally to be contained within pipe tunnels. Alternatively, such parts are to have reinforced thickness, as per Tab 6 for steel pipes, and are to be made either of one piece or several pieces assembled by welding, by reinforced flanges or by devices deemed equivalent for the application considered; the number of joints is to be as small as possible. These pipes are to be provided at their ends in the holds with non-return valves.

6.9.3 Provision for expansion

Where necessary, bilge pipes inside tanks are to be fitted with expansion bends. Sliding joints are not permitted for this purpose.

6.9.4 Connections

Connections used for bilge pipes passing through tanks are to be welded joints or reinforced flange connections.

6.9.5 Access to valves and distribution boxes

All distribution boxes and manually operated valves in connection with the bilge pumping arrangement shall be in positions which are accessible under ordinary circumstances.

Hand-wheels of valves controlling emergency bilge suctions are to rise at least 0,45 m above the manoeuvring floor.

7 Ballast systems

7.1 Principle

7.1.1 General

Each unit is to be provided with a ballasting system capable of adjusting the trim and the draught of the unit at any time, in particular when required for stability purposes.

7.1.2 Availability of the ballast system

The ballast system is to be able to work while the other essential installations of the unit, especially the bilge and fire-fighting installations, are in service.

The ballast system is to be so arranged that any ballast tank can be ballasted and deballasted by means of two independent pumps.

7.1.3 Ballast Water Exchange

Units where ballast water exchange operations are foreseen are to comply with the relevant requirements of NR467, Pt C, Ch 1, Sec 10, [7.3].

7.2 Design of ballast systems

7.2.1 Independence of ballast lines

Ballast lines are to be entirely independent and distinct from other lines except where permitted in [5.5].

7.2.2 Prevention of undesirable communication between spaces or with the sea

Ballast systems in connection with bilge systems are to be so designed as to avoid any risk of undesirable communication between spaces or with the sea. See [6.2.2].

7.3 Ballast pumping arrangement

7.3.1 Filling and suction pipes

a) All tanks including aft and fore peak and double bottom tanks intended for ballast water are to be provided with suitable filling and suction pipes connected to the pumps.

b) Small tanks used for the carriage of domestic fresh water may be served by hand pumps.

c) Suctions are to be so positioned that the transfer of sea water can be suitably carried out in the normal operating conditions of the unit. In particular, two suctions may be required in long compartments.

7.3.2 Pumps

Bilge pumps may be used for ballast water transfer provided the provisions of [6.5.3] are fulfilled.

7.3.3 Passage of ballast pipes through tanks

If not contained in pipe tunnels, the ballast steel pipes passing through tanks intended to contain fresh water, fuel oil or liquid cargo are:

- to have reinforced thickness, as per Tab 6
- to consist either of a single piece or of several pieces assembled by welding, by reinforced flanges or by devices deemed equivalent for the application considered
- to have a minimal number of joints in these lines
- to have expansion bends in these lines within the tank, where needed
- not to have slip joints.

7.3.4 Ballast valves and piping arrangements

a) Ballast tank valves

Valves controlling flow to ballast tanks are to be arranged so that they remain closed at all times except when ballasting. Where butterfly valves are used, they are to be of a type able to prevent movement of the valve position due to vibration or flow of fluids.

b) Remote control valves

Remote control valves, where fitted, are to be arranged so that they close and remain closed in the event of loss of control power. The valves may remain in the last ordered position upon loss of power, provided that there is a readily accessible manual means to close the valves upon loss of power.

Remote control valves are to be clearly identified as to the tanks they serve and are to be provided with position indicators at the ballast control station.

c) Ballast piping arrangements

The piping arrangements are to comply with the requirements of [5.6] concerning the prevention of progressive flooding. The pipes, if damaged, which are located within the extent of assumed damage, are not to affect damage stability considerations.

7.3.5 Control and indicating systems

A central ballast control station should be provided. It should be located above the worst damage waterline and in a space not within the assumed extent of damage referred to in Part C, Chapter 3 and adequately protected from weather. It should be provided with the following control and indicating systems, having appropriate audible and visual alarms, where applicable:

- *ballast pump control system*
- *ballast pump status-indicating system*
- *ballast valve control system*
- *ballast valve position-indicating system*
- *tank level indicating system*
- *draught indicating system*
- *heel and trim indicators*
- *power availability indicating system (main and emergency)*
- *ballast system hydraulic/pneumatic pressure-indicating system.*

7.4 Drainage and sediment control

7.4.1 All ballast and preload tanks and related piping systems should be designed to facilitate effective drainage and removal of sediments. Coatings which could entrain sediments and harmful aquatic organisms should be avoided.

Note 1: Refer to the Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens, adopted by the Organization by resolution A.868(20).

7.5 Requirements for installation of ballast water treatment systems (BWTS)

7.5.1 Capacity

The approved capacity of the ballast water treatment system (BWTS) is not to be less than the maximum expected flow rate of the ballast pumps. If any, the operating restrictions to be observed during the ballast water treatment (e.g. limitation of the number of ballast pumps in simultaneous operation) are to be displayed in way of the BWTS control position and noted in the ship's ballast water management plan.

7.5.2 Location

The equipment intended for the treatment of ballast water may be located in machinery spaces provided that the safety requirements below are satisfied.

7.5.3 Installation in hazardous space

The ballast water treatment system, if intended to be fitted in locations where flammable atmospheres may be present, is to comply with the relevant safety regulations for such spaces. Any electrical equipment of the system is to be located in a non-hazardous area, or is to be certified as safe for use in a hazardous area. Any moving parts, which are fitted in hazardous areas, are to be arranged so as to avoid the formation of static electricity.

7.5.4 Chemicals and hazardous by-products

Arrangements are to be made for:

- dealing with the possible production of hazardous by-products (aqueous or gaseous) during the ballast water treatment process
- the safe storage and handling of chemicals.

The risks of fire, spillage, release of hazardous vapours and exposure of the crew, during both normal operations and emergency situations, are to be taken into account. The location of the chemical storage tanks and handling equipment, the ventilation and fire-fighting systems and the draining arrangements are to be considered in this respect.

The relevant provisions of IMO Circular BWM.2/Circ.20 are to be satisfied.

Adequate personal and protective equipment is to be provided for all normal operations and emergency situations.

Note 1: IMO Circular BWM.2/Circ.20: Guidance to ensure safe handling and storage of chemicals and preparations used to treat ballast water and the development of safety procedures for risks to the ship and crew resulting from the treatment process.

7.5.5 Materials

The selection of materials (including their coatings) used for the piping system containing treated ballast water is to take into account the risk of corrosion, which may be increased by the treatment process.

Chemical storage tanks and piping are to be made of suitable material, resistant to corrosion.

7.5.6 Additional requirements for FPSOs and FSUs

In FPSOs and FSUs, the equipment intended for the treatment of ballast water from tanks located in the cargo area is not to be located in machinery spaces, except when:

- it is used only during ballasting operations, and
- the ballast water discharge piping does not pass through the machinery spaces.

7.6 Design of integrated cargo and ballast systems on tankers

7.6.1 Application

The following requirements are applicable to integrated cargo and ballast systems installed on FPSOs and FSUs, irrespective of their size.

Within the scope of these requirements, integrated cargo and ballast system means any integrated hydraulic and/or electric system used to drive both cargo and ballast pumps (including active control and safety systems and excluding passive components, e.g. piping).

7.6.2 Functional requirements

The operation of cargo and/or ballast systems may be necessary, under certain emergency circumstances, to enhance the safety of the unit.

As such, measures are to be taken to prevent cargo and ballast pumps becoming inoperative simultaneously due to a single failure in the integrated cargo and ballast system, including its control and safety systems.

7.6.3 Design features

The following design features are, inter alia, to be fitted:

a) The emergency stop circuits of the cargo and ballast systems are to be independent from the circuits for the control systems. A single failure in the control system circuits or the emergency stop circuits are not to render the integrated cargo and ballast system inoperative.

b) Manual emergency stops of the cargo pumps are to be arranged in a way that they are not to cause the stop of the power pack making ballast pumps inoperable.

c) The control systems are to be provided with backup power supply, which may be satisfied by a duplicate power supply from the main switch board. The failure of any power supply is to provide audible and visible alarm activation at each location where the control panel is fitted.

d) In the event of failure of the automatic or remote control systems, a secondary means of control is to be made available for the operation of the integrated cargo and ballast system. This is to be achieved by manual overriding and/or redundant arrangements within the control systems.

8 Scuppers and sanitary discharges

8.1 Application

8.1.1 This Article applies to:

- scuppers and sanitary discharge systems, and
- discharges from sewage tanks.

Discharges in connection with machinery operation are dealt with in [2.9].

8.2 Principle

8.2.1

a) Scuppers, sufficient in number and suitable in size, are to be provided to permit the drainage of water likely to accumulate in the spaces which are not located in the unit's bottom.

b) The number of scuppers and sanitary discharge openings in the shell plating is to be reduced to a minimum either by making each discharge serve as many as possible of the sanitary and other pipes, or in any other satisfactory manner.

c) Except otherwise specified, the design of scuppers and sanitary discharges shall generally comply with recognised national or international standard acceptable to the Society (reference is made to ISO 15749-1 to -5, as applicable).

8.3 Drainage from spaces below the freeboard deck or within enclosed superstructures and deckhouses on the freeboard deck

8.3.1 Normal arrangement

Scuppers and sanitary discharges from spaces below the freeboard deck or from within superstructures and deckhouses on the freeboard deck fitted with watertight doors are to be led to:

- the bilge in the case of scuppers, or
- suitable sanitary tanks in the case of sanitary discharges.

8.3.2 Alternative arrangement

The scuppers and sanitary discharges may be led overboard provided that:

- the spaces drained are located above the load waterline formed by a 5° heel, to port or starboard, at a draft corresponding to the assigned summer freeboard, and
- the pipes are fitted with efficient means of preventing water from passing inboard in accordance with:
  - [8.5] where the spaces are located below the margin line
  - [8.6] where the spaces are located above the margin line.

Note 1: The margin line is defined as a line drawn at least 76 mm below the upper surface of the freeboard deck.

8.4 Drainage of superstructures or deckhouses not fitted with efficient weathertight doors

8.4.1 Scuppers leading from superstructures or deckhouses not fitted with watertight doors are to be led overboard.

8.5 Arrangement of discharges from spaces below the margin line

8.5.1 Normal arrangement

Each separate discharge led though the shell plating from spaces below the margin line is to be provided with one automatic non-return valve fitted with positive means of closing it from above the bulkhead or freeboard deck.

8.5.2 Alternative arrangement when the inboard end of the discharge pipe is above the summer waterline by more than 0,01 L

Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0,01 L, the discharge may have two automatic non-return valves without positive means of closing, provided that the inboard valve:

- is above the deepest subdivision load line, and
- is always accessible for examination under service conditions.

8.6 Arrangement of discharges from spaces above the margin line

8.6.1 General

The provisions of this sub-article are applicable only to those discharges which remain open during the normal operation of the unit. For discharges which must necessarily be closed at sea, such as gravity drains from topside ballast tanks, a single screw-down valve operated from the deck may be accepted.

8.6.2 Normal arrangement

Normally, each separate discharge led though the shell plating from spaces above the margin line is to be provided with:

- one automatic non-return valve fitted with positive means of closing it from a position above the bulkhead or freeboard deck, or
- one automatic non-return valve and one sluice valve controlled from above the bulkhead or freeboard deck.

8.6.3 Alternative arrangement when the inboard end of the discharge pipe is above the summer waterline by more than 0,01 L

Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0,01 L, the discharge may have two automatic non-return valves without positive means of closing, provided that:

- the inboard valve is above the level of the tropical load waterline so as to always be accessible for examination under service conditions, or
- where this is not practicable, a locally controlled sluice valve is interposed between the two automatic non-return valves.

8.6.4 Alternative arrangement when the inboard end of the discharge pipe is above the summer waterline by more than 0,02 L

Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0,02 L, a single automatic non-return valve without positive means of closing may be accepted subject to the approval of the Society.

Note 1: This requirement is not applicable for surface floating gas units covered by NR542.

8.6.5 Arrangement of discharges through manned machinery spaces

Where sanitary discharges and scuppers lead overboard through the shell in way of manned machinery spaces, the fitting at the shell of a locally operated positive closing valve together with a non-return valve inboard may be accepted. The operating position of the valve will be given special consideration by the Society.

8.6.6 Arrangement of discharges through the shell more than 450 mm below the freeboard deck or less than 600 mm above the summer load waterline

Scupper and discharge pipes originating at any level and penetrating the shell either more than 450 millimetres below the freeboard deck or less than 600 millimetres above the summer load waterline are to be provided with a non-return valve at the shell. Unless required by [8.6.2] to [8.6.4], this valve may be omitted if the piping is of substantial thickness, as per Tab 27.

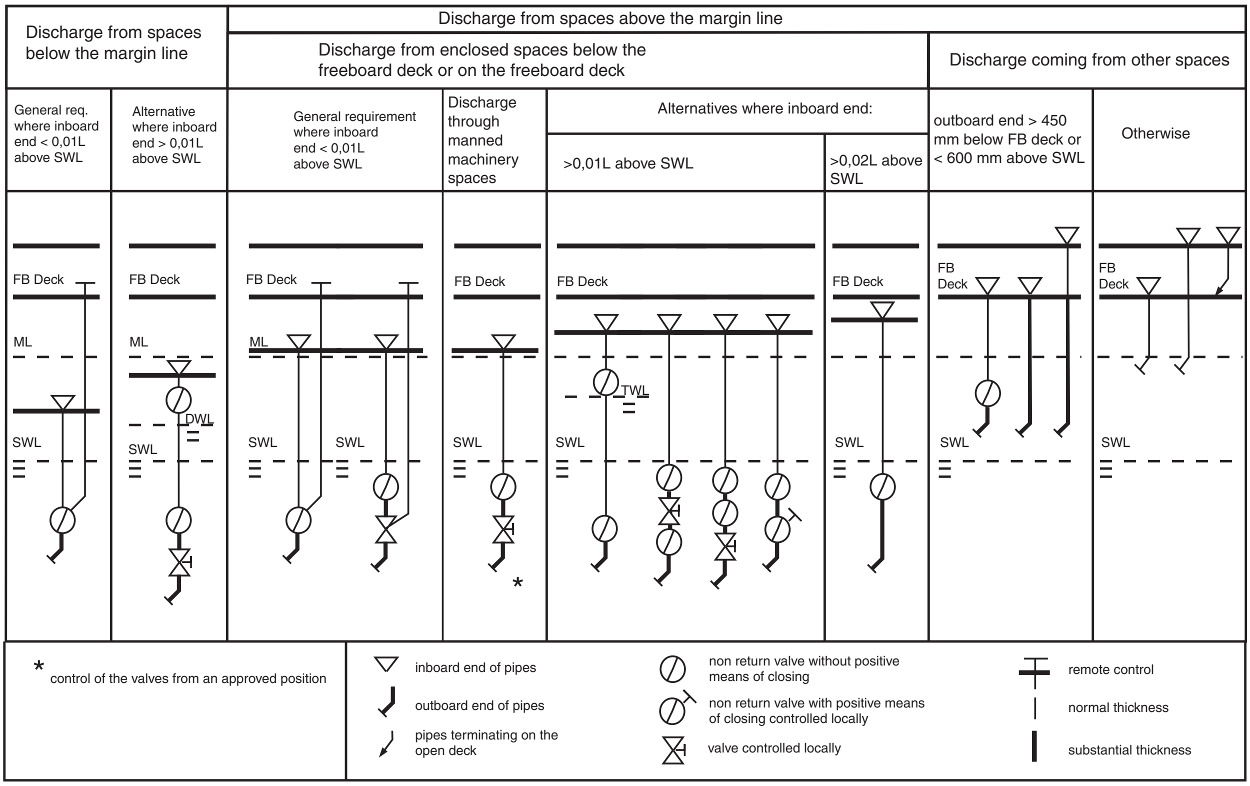
8.6.7 Arrangement of discharges through the shell less than 450 mm below the freeboard deck and more than 600 mm above the summer load waterline

Scupper and discharge pipes penetrating the shell less than 450 millimetres below the freeboard deck and more than 600 millimetres above the summer load waterline are not required to be provided with a non-return valve at the shell.

8.7 Summary table of overboard discharge arrangements

8.7.1 The various arrangements acceptable for scuppers and sanitary overboard discharges are summarised in Fig 3.

Figure 3 : Overboard discharge arrangement



8.8 Valves and pipes

8.8.1 Materials

a) All shell fittings and valves are to be of steel, bronze or other ductile material. Valves of ordinary cast iron or similar material are not acceptable. All scupper and discharge pipes are to be of steel or other ductile material. Refer to [2.1].

b) Plastic is not to be used for the portion of discharge line from the shell to the first valve.

8.8.2 Thickness of pipes

a) The thickness of scupper and discharge pipes led to the bilge or to draining tanks is not to be less than that required in [2.2].

b) The thickness of scupper and discharge pipes led to the shell is not to be less than the minimum thickness given in Tab 26 and Tab 27.

Table 26 : Thickness of scupper and discharge pipes led to the shell, according to their location

Applicable requirement	[8.5.1]	[8.5.2]	[8.6.2]	[8.6.3]	[8.6.4]	[8.6.5]	[8.6.6] with valve	[8.6.6] without valve	[8.6.7]
Pipe location									
Between the shell and the first valve	Thickness according to Tab 27, column 1, or 0,7 times that of the shell side plating, whichever is the greater **(1)**							NA	NA
Between the first valve and the inboard end	Thickness according to Tab 27, column 2							NA	NA
Below the freeboard deck	NA							Thickness according to Tab 27, column 1	Thickness according to Tab 27, column 2
Above the freeboard deck	NA							Thickness according to Tab 27, column 2	Thickness according to Tab 27, column 2

(1) However, this thickness is not required to exceed that of the plating.
Note 1: NA = not applicable.

Table 27 : Minimum thickness of scupper and discharge pipes led to the shell

External diameter of the pipe d (mm)	Column 1 substantial thickness (mm)**(1)**	Column 2 normal thickness (mm)
$d \leq 80,0$	7,00	4,50
155	9,25	4,50
180	10,00	5,00
220	12,50	5,80
$230 \leq d$	12,50	6,00

(1) For pipes connected to the shell below the freeboard deck, refer to minimum extra-reinforced wall thicknesses given in Tab 6.
Note 1: Intermediate sizes may be determined by interpolation.

8.8.3 Operation of the valves

a) Where valves are required to have positive means of closing, such means is to be readily accessible and provided with an indicator showing whether the valve is open or closed.

b) Where plastic pipes are used for sanitary discharges and scuppers, the valve at the shell is to be operated from outside the space in which the valve is located.

Where such plastic pipes are located below the summer waterline (timber summer load waterline), the valve is to be operated from a position above the freeboard deck.

Refer also to Ch 1, App 1.

8.9 Arrangement of scuppers and sanitary discharge piping

8.9.1 Overboard discharges and valve connections

a) Overboard discharges are to have pipe spigots extending through the shell plate and welded to it, and are to be provided at the internal end with a flange for connection to the valve or pipe flange.

b) Valves may also be connected to the hull plating in accordance with the provisions of [2.9.3], item c).

8.9.2 Passage through tanks

a) As a rule, scupper and sanitary discharge pipes are not to pass through fuel oil tanks.

b) Where scupper and discharge pipes pass unavoidably through fuel oil tanks and are led through the shell within the tanks, the thickness of the piping is not to be less than that given in Tab 27, column 1 (substantial thickness). It need not, however, exceed the thickness of the adjacent rule shell plating.

c) Scupper and sanitary discharge pipes are normally not to pass through fresh and drinking water tanks.

d) For passage through cargo oil tanks, see Pt D, Ch 1, Sec 18.

8.9.3 Passage through storage compartments other than tanks

Where scupper and sanitary discharge pipes are led through storage compartments other than tanks, the pipes and the valves with their controls are to be adequately protected by means of strong casings or guards.

8.9.4 Passage through watertight bulkheads or decks

a) The intactness of machinery space bulkheads and of tunnel plating required to be of watertight construction is not to be impaired by the fitting of scuppers discharging to machinery spaces or tunnels from adjacent compartments which are situated below the freeboard deck.

b) Such scuppers may, however, be led into a strongly constructed scupper drain tank situated in the machinery space or tunnel, but close to the above-mentioned adjacent compartments and drained by means of a suction of appropriate size led from the main bilge line through a screw-down non-return valve.

8.9.5 Discharge in refrigerated spaces

No scupper pipe from non-refrigerated spaces is to discharge in refrigerated spaces.

8.9.6 Discharge from galleys and their stores

Discharges from galleys and their stores are to be kept separate from other discharges and be drained overboard or in separate drainage tanks; alternatively, discharges are to be provided with adequate devices against odours and overflow.

8.9.7 Discharge from aft spaces

Where spaces located aft of the aft peak bulkhead not intended to be used as tanks are drained by means of scuppers discharging to the shaft tunnel, the provisions of [6.4.2] item c) are to be complied with.

8.9.8 Drainage from helidecks

Drainage facilities in way of helidecks shall be constructed of steel and shall lead directly overboard independent of any other system.

They are to be designed to prevent collections of liquids and liquids from spreading to or falling on other parts of the unit having regard to the use of fire fighting equipment and the possible spillage of fuel.

8.9.9 Scupper tank

a) The scupper tank air pipe is to be led to above the freeboard deck.

b) Provision is to be made to ascertain the level of water in the scupper tank.

9 Air, sounding and overflow pipes

9.1 Air pipes

9.1.1 Principle

Air pipes are to be fitted to all tanks, double bottoms, cofferdams, tunnels and other compartments which are not fitted with alternative ventilation arrangements, in order to allow the passage of air or liquid so as to prevent excessive pressure or vacuum in the tanks or compartments, in particular in those which are fitted with piping installations.

The open ends of the air pipes are to be so arranged as to prevent the free entry of sea water in the compartments.

With respect to the stability of the unit in damaged condition, all compartments having their air pipe open end located in a space assumed flooded are also to be considered flooded.

9.1.2 Number and position of air pipes

a) Air pipes are to be so arranged and the upper part of compartments so designed that air or gas likely to accumulate at any point in the compartments can freely evacuate.

b) Air pipes are to be fitted opposite the filling pipes and/or at the highest parts of the compartments, the unit being assumed to be on an even keel.

c) In general, two air pipes are to be fitted for each compartment, except in small compartments, where only one air pipe may be accepted. When the top of the compartment is of irregular form, the position of air pipes will be given special consideration by the Society.

Note 1: Two air vents are normally required for long tanks e.g. a ballast tank in a double hull unit.

In machinery spaces, two air vents are not normally required.

d) Where only one air pipe is provided, it is not to be used as a filling pipe.

9.1.3 Location of open ends of air pipes

a) Air pipes of double bottom compartments, tunnels, deep tanks and other compartments which can come into contact with the sea or be flooded in the event of hull damage are to be led to above the bulkhead deck or the freeboard deck.

Note 1: In units not provided with a double bottom, air pipes of small cofferdams or tanks not containing fuel oil or lubricating oil may discharge within the space concerned.

b) Air pipes of tanks intended to be pumped up are to be led to the open above the bulkhead deck or the freeboard deck.

c) Air pipes other than those of flammable oil tanks may be led to enclosed cargo spaces situated above the freeboard deck, provided that:
   - overflow pipes are fitted in accordance with [9.3.4], where the tanks may be filled by pumping
   - enclosed cargo spaces are fitted with scuppers discharging overboard and being capable of draining all the water which may enter through the air pipes without giving rise to any water accumulation
   - suitable drainage arrangement is to be fitted below the air pipe outlet, leading to the nearest scupper
   - such arrangement is not to impair integrity of fire divisions or watertight decks and bulkheads subject to the damage stability requirements.

d) The air pipe of the scupper tank is to be led to above freeboard deck.

e) The location of air pipes for flammable oil tanks is also to comply with [9.1.7].

9.1.4 Height of air pipes

a) The height of air pipes extending above the freeboard deck or superstructure deck from the deck to the point where water may have access below is to be at least:
   - 760 mm on the freeboard deck, and
   - 450 mm on the superstructure deck.

   This height is to be measured from the upper face of the deck, including sheathing or any other covering, up to the point where water may penetrate inboard.

b) Where these heights may interfere with the working of the unit, a lower height may be approved, provided the Society is satisfied that this is justified by the closing arrangements and other circumstances. Satisfactory means which are permanently attached are to be provided for closing the openings of the air pipes.

c) The height of air pipes may be required to be increased on units subject to damage stability requirements since the air pipe outlets should be above final water line at any damaged condition assumed by the Damage stability examination as defined in Pt B, Ch 1, Sec 3, [3].

d) The height of air pipes discharging through the side of the superstructure is to be at least 2,3 m above the summer load waterline.

9.1.5 Fitting of closing appliances

a) Satisfactory appliances which are permanently attached are to be provided for closing the openings of air pipes in order to prevent the free entry of water into the spaces concerned, except for pipes of tanks fitted with cross-flooding connections.

b) Automatic closing appliances are to be fitted in the following cases:
   - where air pipes to ballast and other tanks extend above the freeboard or superstructure decks
   - where, with the unit at its deepest load waterline, the openings are immersed at an angle of heel of 40° or, at the angle of down-flooding if the latter is less than 40°
   - where, as per [9.1.3] item c), air pipes terminate in enclosed spaces
   - where, as per [9.1.4] item b), air pipes have a height lower than that required in [9.1.4] item a).

   See also Pt B, Ch 1, Sec 3.

c) Automatic closing appliances are to be of a type approved by the Society. Requirements for type tests are given in [20.3].

d) For units subject to specific buoyancy or stability requirements, the fitting of closing appliances to air pipes will be given special consideration.

9.1.6 Design of closing appliances

a) When closing appliances are requested to be of an automatic type, they are to comply with the following:
   - They are to prevent free entry of water into the tanks.
   - They are to allow the passage of air or liquid to prevent excessive pressure or vacuum coming on the tank.
   - They are to be so designed that they withstand both ambient and working conditions up to an inclination of –40° to +40° without failure or damage.
   - They are to be so designed as to allow inspection of the closure and the inside of the casing as well as changing of the seals.
   - Where they are of the float type, suitable guides are to be provided to ensure unobstructed operation under all working conditions of heel and trim.
   - Efficient seating arrangements are to be provided for the closures.
   - They are to be self-draining.
   - The clear area through an air pipe closing appliance is to be at least equal to the area of the inlet.
   - The maximum allowable tolerances for wall thickness of floats is not to exceed ±10% of the nominal thickness.
   - Their casings are to be of approved metallic materials adequately protected against corrosion.
   - Closures and seats made of non-metallic materials are to be compatible with the media to be carried in the tank and with sea water at ambient temperatures between –25°C and +85°C.

b) Where closing appliances are not of an automatic type, provision is to be made for relieving vacuum when the tanks are being pumped out. For this purpose, a hole of approximately 10 mm in diameter may be provided in the bend of the air pipe or at any other suitable position in the closing appliance.

c) Wooden plugs and trailing canvas are not permitted in position 1 or position 2, as defined in Pt B, Ch 1, Sec 2 of the Ship Rules.

9.1.7 Special arrangements for air pipes of flammable oil tanks

a) Air pipes from fuel oil and thermal oil tanks are to discharge to a safe position on the open deck where no danger will be incurred from issuing oil or gases.

Where fitted, wire gauze diaphragms are to be of corrosion resistant material and readily removable for cleaning and replacement. The clear area of such diaphragms is not to be less than the cross-sectional area of the pipe.

b) Air pipes of lubricating or hydraulic oil storage tanks not subject to flooding in the event of hull damage may be led to machinery spaces, provided that in the case of overflowing the oil cannot come into contact with electrical equipment, hot surfaces or other sources of ignition.

c) Location and arrangement of vent pipes serving fuel oil tanks and lubrication tanks are to be done in a way providing protection against ingress of seawater or rain water in case of accidental vent pipes damage.

d) Air pipes of fuel oil service, settling and lubrication oil tanks likely to be damaged by impact forces are to be adequately reinforced.

e) Where seawater or rainwater may enter fuel oil service, settling and lubrication oil tanks through broken air pipes, arrangements such as water traps with:

- automatic draining, or
- alarm for water accumulation,

are to be provided.

9.1.8 Construction of air pipes

a) Where air pipes to ballast and other tanks extend above the freeboard deck or superstructure deck, the exposed parts of the pipes are to be of substantial construction, with a minimum wall thickness of at least:

- 6,0 mm for pipes of 80 mm or smaller external diameter
- 8,5 mm for pipes of 165 mm or greater external diameter.

Intermediate minimum thicknesses may be determined by linear interpolation.

b) Air pipes with height exceeding 900 mm are to be additionally supported.

c) In each compartment likely to be pumped up, and where no overflow pipe is provided, the total cross-sectional area of air pipes is not to be less than 1,25 times the cross-sectional area of the corresponding filling pipes.

d) The internal diameter of air pipes is not to be less than 50 mm, except for tanks of less than 2 m^3.

e) Air pipes from several tanks or spaces may be led into a common main line, provided that:

- The tanks or spaces are not intended for liquids which are not compatible and that the arrangement could not effect unacceptable condition for the unit.
- The cross-sectional area of the air pipes main is generally not less than the aggregate cross-sectional area of the two largest pipes discharging into the main. However, a reduced value may be considered for acceptance in each particular case on the basis of back pressure calculation submitted for all normal working conditions.
- As far as practical, each separate air pipe is fitted to the common air pipe from the top side.
- Where no overflow pipes are provided, the cross-sectional area of a common air pipe from several tanks is not less than 1,25 times the area of the common filling pipeline for these tanks.
- Where the tanks or spaces are situated at the shell side, the connections to the air pipes main are to be above the freeboard deck. Where it is not practical, different position proposed as far as possible above the deepest load waterline may be considered for acceptance. For vessels subject to damage stability requirements these connections should be above final water line at any damaged condition assumed by the Damage stability examination as defined in Pt B, Ch 1, Sec 3, [3].

f) Vents acting also as overflows may be accepted provided all the requirements applicable to both vents and overflows are complied with.

g) Where tanks are fitted with cross flooding connections, the air pipes are to be of adequate area for these connections.

9.2 Sounding pipes

9.2.1 Principle

a) Sounding devices are to be fitted to tanks intended to contain liquids as well as to all compartments which are not readily accessible at all times.

b) Void compartments adjacent to the sea or tanks containing liquids are to be fitted with separate sounding pipes or means to determine the liquid level in the tank.

Note 1: Void compartments which do not comply with the requirement of item b) are to be accounted for in the unit's stability analysis.

c) The requirement given in b) is also applicable for void compartments through which piping carrying liquids passes.

d) For compartments normally intended to contain liquids, the following systems may be accepted in lieu of sounding pipes:

- a level gauge of an approved type efficiently protected against shocks, or
- a remote level gauging system of an approved type, provided an emergency means of sounding is available in the event of failure affecting such system.

9.2.2 Position of sounding pipes

Sounding pipes are to be located as close as possible to suction pipes.

9.2.3 Termination of sounding pipes

a) As a general rule, sounding pipes are to end above the bulkhead deck or the freeboard deck in easily accessible places and are to be fitted with efficient, permanently attached, metallic closing appliances.

b) In machinery spaces and tunnels, where the provisions of item a) cannot be satisfied, short sounding pipes led to readily accessible positions above the floor and fitted with efficient closing appliances may be accepted.

9.2.4 Special arrangements for sounding pipes of flammable oil tanks

a) Where sounding pipes are used in flammable (except lubricating) oil systems, they are to terminate in the open air, where no risk of ignition of spillage from the sounding pipe might arise. In particular, they are not to terminate in passenger or crew spaces. As a general rule, they are not to terminate in machinery spaces. However, where the Society considers that this requirement is impracticable, it may permit termination in machinery spaces on condition that the following provisions are satisfied:

   1) in addition, an oil-level gauge is provided meeting the provisions of [2.10.2]

   2) the sounding pipes terminate in locations remote from ignition hazards unless precautions are taken, such as the fitting of effective screens, to prevent the fuel oil in the case of spillage through the terminations of the sounding pipes from coming into contact with a source of ignition

   3) the terminations of sounding pipes are fitted with self-closing blanking devices and with a small diameter self-closing control cock located below the blanking device for the purpose of ascertaining before the blanking device is opened that fuel oil is not present. Provision is to be made so as to ensure that any spillage of fuel oil through the control cock involves no ignition hazard.

b) For lubricating oil and fuel oil leakage tanks less than 2 m^3, the oil-level gauge mentioned in a) 1) and the control cock mentioned in a) 3) need not be provided on condition that the sounding pipes are fitted with appropriate means of closure.

c) Short sounding pipes may be used for tanks other than double bottom tanks without the additional closed level gauge provided an overflow system is fitted.

9.2.5 Closing appliances

a) Self-closing appliances are to be fitted with cylindrical plugs having counterweights such as to ensure automatic closing.

b) Closing appliances not required to be of the self-closing type may consist of a metallic screw cap secured to the pipe by means of a chain or a shut-off valve.

9.2.6 Construction of sounding pipes

a) Sounding pipes are normally to be straight. If it is necessary to provide bends in such pipes, the curvature is to be as small as possible to permit the ready passage of the sounding apparatus.

b) The sounding arrangement of compartments by means of bent pipes passing through other compartments will be given special consideration by the Society. Such an arrangement is normally accepted only if the compartments passed through are cofferdams or are intended to contain the same liquid as the compartments served by the sounding pipes.

c) Bent portions of sounding pipes are to have reinforced thickness and be suitably supported.

d) The internal diameter of sounding pipes is not to be less than 32 mm. Where sounding pipes pass through refrigerated spaces, or through the insulation of refrigerated spaces in which the temperature may be below 0°C, their internal diameter is to be at least 60 mm.

e) For mobile offshore drilling units, the internal diameter of sounding pipes is not to be less than 38 mm. Where a sounding pipe exceeds 20 m in length, the internal diameter is to be increased to at least 50 mm.

f) Doubling plates are to be placed under the lower ends of sounding pipes in order to prevent damage to the hull. When sounding pipes with closed lower ends are used, the closing plate is to have reinforced scantlings.

9.3 Overflow pipes

9.3.1 Principle

Overflow pipes are to be fitted to tanks:

- which can be filled by pumping and are designed for a hydrostatic pressure lower than that corresponding to the height of the air pipe, or
- where the cross-sectional area of air pipes is less than that prescribed in [9.1.8], item d).

9.3.2 Design of overflow systems

a) Overflow pipes are to be led:

  - either outside, or
  - in the case of fuel oil or lubricating oil, to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes.

b) Where tanks containing the same or different liquids are connected to a common overflow system, the arrangement is to be such as to prevent any risk of:

  - intercommunication between the various tanks due to movements of liquid when emptying or filling, or, due to the inclination of the unit
  - overfilling of any tank from another assumed flooded due to hull damage.

  For this purpose, overflow pipes are to be led to a high enough point above the deepest load waterline or, alternatively, non-return valves are to fitted where necessary.

c) Arrangements are to be made so that a compartment cannot be flooded from the sea through the overflow in the event of another compartment connected to the same overflow main being bilged. To this end, the openings of overflow pipes discharging overboard are as a rule to be placed above the deepest load waterline and are to be fitted where necessary with non-return valves on the plating, or, alternatively, overflow pipes from tanks are to be led to a point above the deepest load waterline.

d) Where deep tanks which can be used to contain liquid or dry cargo or fuel oil are connected to a common overflow system, arrangements are to be made so that liquid or vapours from other compartments cannot enter such tanks when carrying dry cargo.

e) Where tanks alternately containing fuel oil and ballast water are connected to a common overflow system, arrangements are to be made to prevent the ballast water overflowing into the tanks containing fuel oil and vice-versa.

f) Additional requirements for units subject to damage stability checks are given in [5.6.3].

9.3.3 Overflow tanks

a) Overflow tanks are to have a capacity sufficient to receive the delivery of the pumps for at least 10 minutes.

b) Overflow tanks are to be fitted with an air pipe complying with [9.1] which may serve as an overflow pipe for the same tank. When the vent pipe reaches a height exceeding the design head of the overflow tank, suitable means are to be provided to limit the actual hydrostatic head on the tank.

  Such means are to discharge to a position which is safe in the opinion of the Society.

c) An alarm device is to be provided to give warning when the oil reaches a predetermined level in the tank, or alternatively, a sight-flow glass is to be provided in the overflow pipe to indicate when any tank is overflowing. Such sight-flow glasses are only to be placed on vertical pipes and in readily visible positions.

9.3.4 Specific arrangements for construction of overflow pipes

a) The internal diameter of overflow pipes is not to be less than 50 mm.

b) In each compartment which can be pumped up, the total cross-sectional area of overflow pipes is not to be less than 1,25 times the cross-sectional area of the corresponding filling pipes.

c) The cross-sectional area of the overflow main is not to be less than the aggregate cross-sectional area of the two largest pipes discharging into the main.

d) Where overflow sight glasses are provided, they shall be in a vertically dropping line on readily visible position, fitted with adequate protection from mechanical damage and well lit.

  The overflow sight glasses are not to be used in fuel oil systems.

  Use of the overflow sight glasses in lubricating oil systems may be accepted provided that:

  - they are so designed that oil does not impinge on the glass
  - the glass is to be of heat resisting quality.

  In manned machinery spaces of ships other than passenger ships, if it is justified that other technical solution would not be practical, acceptance of the overflow sight glasses in fuel oil systems shall be subject to special consideration by the Society in each particular case, taking into consideration the installation conditions and categorization of the space.

9.4 Constructional requirements applying to sounding, air and overflow pipes

9.4.1 Materials

a) Sounding, air and overflow pipes are to be made of steel or any other material approved for the application considered.

b) Exposed parts of sounding, air and overflow pipes are to be made of approved metallic materials.

9.4.2 Minimum thickness of steel pipes

The minimum thickness of sounding, air and overflow steel pipes is given in Tab 6.

9.4.3 Passage of pipes through certain spaces

a) Air pipes and sounding pipes led through refrigerated cargo holds or spaces are to be suitably insulated.

b) When sounding, air and overflow pipes made of steel are permitted to pass through ballast tanks or fuel oil tanks, they are to be of reinforced thickness, in accordance with Tab 6.

c) Sounding, air and overflow pipes passing through cargo holds are to be adequately protected.

9.4.4 Self-draining of pipes

Air pipes and overflow pipes are to be so arranged as to be self-draining when the unit is on an even keel.

9.4.5 Name plates

Nameplates are to be fixed at the upper part of air pipes and sounding pipes.

10 Cooling systems

10.1 Application

10.1.1 This Article applies to all cooling systems using the following cooling media:

- sea water
- fresh water
- lubricating oil.

Air cooling systems will be given special consideration.

10.2 Principle

10.2.1 General

Sea water and fresh water cooling systems are to be so arranged as to maintain the temperature of the cooled media (lubricating oil, hydraulic oil, charge air, etc.) for propulsion machinery and essential equipment within the manufacturers’ recommended limits during all operations, under the inclination angles and the ambient conditions specified in Ch 1, Sec 1.

10.2.2 Availability of cooling systems

Each cooling system serving an essential equipment or installation is to be so designed that, in the event of one essential component of the system being inoperative, the cooling function is maintained. Partial reduction of operating capability of the equipment or installation may be accepted, however, when it is demonstrated that the safe operation of the unit is not impaired.

10.3 Design of sea water cooling systems

10.3.1 General

a) Sea water cooling of engines and other essential equipment is to be capable of being supplied by two different means.

b) Where required, standby pumps are not to be connected to the sea inlet serving the other sea water pumps, unless permitted under [10.7.1], item b).

10.3.2 Centralised cooling systems

a) In the case of centralised cooling systems, i.e. systems serving a group of engines, reduction gears, compressors and other essential equipment, the following sea water pumps and heat exchangers are to be arranged:
   - one main cooling water pump, which may be driven by the engines, of a capacity sufficient to provide cooling water to all the equipment served
   - one independently driven standby pump of at least the same capacity
   - two heat exchangers, each having at least 50% of the total capacity necessary to provide cooling water to all the equipment served.

b) Where the cooling system is served by a group of identical pumps, the capacity of the standby pump needs only to be equivalent to that of each of these pumps.

c) Ballast pumps or other suitable sea water pumps of appropriate capacity may be used as standby pumps, provided arrangements are made against overpressure in the cooling system.

d) In cases of centralised cooling systems serving only a group of auxiliary engines, the second means of cooling may consist of a connection to a cooling water pump serving another installation, provided such pump is of sufficient capacity to provide cooling water to both that installation and the auxiliary engines.

10.3.3 Individual cooling of auxiliary engines

Where each auxiliary engine is served by its own cooling circuit, no second means of cooling is required.

10.3.4 Cooling of steam plants

a) Steam plants are to be fitted with:
   - a main circulating pump
   - a standby pump capable of ensuring the circulation in the main condenser in the event of failure of the main circulating pump.

b) Where the installation includes more than one propulsive unit, the standby pump is not required, provided a branch pipe is fitted between the discharges of the circulating pumps of each unit.

c) In lieu of the main circulating pump, a sea inlet scoop system may be accepted, provided that an additional means is fitted to ensure the circulation of sea water to the condenser when the ship is manoeuvring. Such means may be:
   - an additional independent pump, or
   - a connection to an available pump of sufficient capacity.

10.3.5 Cooling of other essential equipment

a) The second means of cooling required in [10.3.1] for essential equipment may consist of a connection to a ballast pump or other suitable sea water pump of sufficient capacity, provided arrangements are made against overpressure in the cooling system (see [10.7.4], item b)).

b) However, where such essential equipment is duplicate, this second means may be omitted when justifications are provided as regards the operating capability of the unit with the cooling circuit of one set of equipment disabled.

10.4 Design of fresh water cooling systems

10.4.1 General

Fresh water cooling systems are to be designed according to the applicable requirements of [10.3].

10.4.2 Cooling systems

a) Fresh water cooling systems of essential equipment are to include at least:
   - one main cooling water pump, which can be driven by the equipment
   - one independently driven standby pump.

b) The standby pump may be omitted provided an emergency connection to a suitable sea water system is fitted and arranged with a suitable change-over device. Provisions against overpressure in the cooling system are to be made in accordance with [10.7.4], item b).

c) The standby pump may also be omitted in the case of redundancy of the cooled equipment.

10.4.3 Expansion tanks

Fresh water expansion tanks are to be provided with at least:

- a de-aerating device
- a water level indicator
- a filling connection
- a drain.

10.4.4 Protection of contamination by oil

Suitable means are to be provided in fresh water cooling systems comprising fuel oil or lubricating oil heat exchangers in order to detect any contamination of the water by fuel oil or lubricating oil.

If cooling water is used for heating of oil, the heating coils are to be located on the pressure side of the cooling pumps and connected by welding, with no detachable connections where mixing of oil and water may occur. Alternatively a primary and secondary system arrangement may be used.

10.5 Design of oil cooling systems

10.5.1 General

Oil cooling systems are to be designed according to the applicable requirements of [10.3].

10.5.2 Second means of cooling

The second means of cooling requested in [10.3.1] may consist of a satisfactory connection to a lubricating oil pump of sufficient capacity. Arrangements are to be made against overpressure in the cooling system.

10.6 Control and monitoring

10.6.1 Alarms are to be provided for water cooling systems in accordance with Tab 28, in addition to the requirements stated for diesel engines in Ch 1, Sec 2 and for steam plants in Ch 1, Sec 4.

Note 1: Some departures from Tab 28 may be accepted by the Society in the case of units operating in restricted zones.

Table 28 : Cooling systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Sea water pump pressure or flow	L	local					
Fresh water pump pressure or flow	L	local					
Level in cooling water expansion tank	L	local					

10.7 Arrangement of cooling systems

10.7.1 Sea inlets

a) At least two sea inlets complying with [2.9] are to be provided for the cooling system, one for each means of cooling required in [10.3.1].

b) The two sea inlets may be connected by a cross-over supplying both main cooling pump and standby cooling pump.

c) When the second means of cooling is a spare pump, the two sea inlets are to be provided in any event, both serving the main cooling pump.

d) The sea inlets are to be low inlets, so designed as to remain submerged under all normal operating conditions.

In general, one sea inlet is to be arranged on each side of the unit.

e) One of the sea inlets may be that of the ballast pump or of the general service pump.

10.7.2 Coolers

a) Coolers are to be fitted with isolating valves at the inlets and outlets.

b) Coolers external to the hull (chest coolers and keel coolers) are to be fitted with isolating valves at the shell.

10.7.3 Filters

a) Where engines intended for essential services are directly cooled by sea water, both in normal service and in emergency operating conditions, filters are to be fitted on the suction of cooling pumps.

b) These filters are to be so arranged that they can be cleaned without interrupting the cooling water supply.

10.7.4 Pumps

a) Cooling pumps for which the discharge pressure may exceed the design pressure of the piping system are to be fitted with relief valves in accordance with [2.6].

b) Where general service pumps, ballast pumps or other pumps may be connected to a cooling system, arrangements are to be made, in accordance with [2.6], to avoid overpressure in any part of the cooling system.

10.7.5 Air venting

Cocks are to be installed at the highest points of the pipes conveying cooling water to the water jackets for venting air or gases likely to accumulate therein. In the case of closed fresh water cooling systems, the cock is to be connected to the expansion tank.

11 Fuel oil systems

11.1 Application

11.1.1 Scope

This Article applies to all fuel oil systems supplying any kind of installation.

The fuel oils used on board are to comply with Ch 1, Sec 1, [2.10].

11.1.2 Requirements applying to fuel oil systems and not contained in this Section

Additional requirements are given:

- for fuel oil supply equipment forming part of engines, gas turbines, boilers, thermal heaters and incinerators, in the corresponding sections
- for the installation of purifiers, in Part C, Chapter 4
- for the location and scantling of tanks forming part of the unit's structure, in Pt B, Ch 3, Sec 1 and Pt B, Ch 3, Sec 3.
- for helicopter refuelling facilities, in Ch 4, Sec 10, [4].

11.2 Principle

11.2.1 General

a) Fuel oil systems are to be so designed as to ensure the proper characteristics (purity, viscosity, pressure) of the fuel oil supply to engines and boilers.

b) Fuel oil systems are to be so designed as to prevent:
   - overflow or spillage of fuel oil from tanks, pipes, fittings, etc.
   - fuel oil from coming into contact with sources of ignition
   - overheating and seizure of fuel oil.

c) Fuel oils used for engines and boilers are to have a flashpoint complying with the provisions of Ch 1, Sec 1, [2.10].

11.2.2 Availability of fuel systems

a) Fuel oil systems are to be so designed that, in the event of one essential component of the system being inoperative, the fuel oil supply to boilers and engines can be maintained. Partial reduction of the operating capability may be accepted, however, when it is demonstrated that the safe operation of the unit is not impaired.

b) Fuel oil tanks are to be so arranged that, in the event of damage to any one tank, complete loss of the fuel supply to essential services does not occur.

c) Where engines and boilers are operated with heavy fuel oils, provisions are to be made to supply them with fuel oils which do not need to be heated.

11.3 General

11.3.1 Arrangement of fuel oil systems

Arrangements for the storage, distribution and utilisation of the fuel oil are to be such as to ensure the safety of the unit and persons on board.

The provisions of [5.11] are to be complied with.

11.3.2 Provision to prevent overpressure

Provisions are to be made to prevent overpressure in any oil tank or in any part of the fuel oil system. Any relief valve is to discharge to a safe position.

11.3.3 Ventilation

The ventilation of machinery spaces is to be sufficient under all normal conditions to prevent accumulation of oil vapour.

11.3.4 Access

Spaces where fuel oil is stored or handled are to be readily accessible.

11.4 Design of fuel oil filling and transfer systems

11.4.1 General

a) A system of pumps and piping for filling and transferring fuel oil is to be provided.

b) Provisions are to be made to allow the transfer of fuel oil from any storage, settling or service tank to another tank.

11.4.2 Filling systems

a) Filling pipes of fuel oil tanks are to terminate on open deck or in filling stations isolated from other spaces and efficiently ventilated. Suitable coamings and drains are to be provided to collect any leakage resulting from filling operations.

   The means are to be provided for the filling lines to prevent of possible overpressure during the bunkering operation, which could be caused by pumps from outboard filling station. For that purpose a warning label may be accepted with clearly declared design pressure of the filling lines and the local pressure gauge fitted in vicinity of the filling connection.

b) Arrangements are to be made to avoid overpressure in the filling lines which are served by pumps on board. Where safety valves are provided for this purpose, they are to discharge to the overflow tank referred to in [9.3.3] or to other safe positions deemed satisfactory.

11.4.3 Independence of fuel oil transfer lines

Except where permitted, the fuel oil transfer piping system is to be completely separate from the other piping systems of the unit.

11.4.4 Transfer pumps

a) At least two means of transfer are to be provided. One of these means is to be a power pump. The other may consist of:

- a standby pump, or, alternatively
- an emergency connection to another suitable power pump.

Note 1: Where provided, purifiers may be accepted as means of transfer.

b) Where necessary, transfer pumps are to be fitted on their discharge side with a relief valve leading back to the suction of the pump or to any other place deemed satisfactory.

11.5 Arrangement of fuel oil tanks and bunkers

11.5.1 Location of fuel oil tanks

a) No fuel oil tank is to be situated where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces.

b) Fuel oil tanks and bunkers are not to be situated immediately above boilers or in locations where they could be subjected to high temperatures, unless specially agreed by the Society. In general, the distance between fuel oil tanks and boilers is not to be less than 450 mm. Where boilers are situated above double bottom fuel oil tanks, the distance between the double bottom tank top and the lower metallic part of the boilers is not to be less than:

- 750 mm for water tube boilers
- 600 mm for cylindrical boilers.

c) As far as practicable, fuel oil tanks are to be part of the unit's structure and are to be located outside machinery spaces of category A. Where fuel oil tanks, other than double bottom tanks, are necessarily located adjacent to or within machinery spaces of category A, at least one of their vertical sides is to be contiguous to the machinery space boundaries, and is preferably to have a common boundary with the double bottom tanks, and the area of the tank boundary common with the machinery spaces is to be kept to a minimum. Where such tanks are situated within the boundaries of machinery spaces of category A, they are not to contain fuel oil having a flashpoint of less than 60°C.

Note 1: Machinery spaces of category A are defined in Ch 4, Sec 1.

d) The location of fuel oil tanks is to be in compliance with the requirements of Pt B, Ch 3, Sec 1, particularly as regards the installation of cofferdams, the separation between fuel oil tanks or bunkers and the other spaces of the unit, and the protection of these tanks and bunkers against any abnormal rise in temperature.

11.5.2 Use of free-standing fuel oil tanks

a) In general the use of free-standing fuel oil tanks may be permitted in category A spaces.

b) For the design and the installation of independent tanks, refer to Pt B, Ch 2, Sec 3, [2.7] and Pt B, Ch 3, Sec 3, [4.1.10].

11.5.3 Protection against oil pollution in the event of collision or grounding

a) Application

The provisions of [11.5.3] apply to all FPSOs and FSUs with an aggregate oil fuel capacity of 600 m^3 and above. They apply to all oil fuel tanks except small oil fuel tanks with a maximum individual capacity not exceeding 30 m^3, provided that the aggregate capacity of such excluded tanks is not greater than 600 m^3.

Note 1: For the purpose of application of this requirement, oil fuel means any oil used as fuel oil in connection with the machinery of the unit in which such oil is carried.

Note 2: The provisions of this requirement apply to oil fuel overflow tanks except if they are provided with an alarm for detection of oil and kept empty according to the operational procedures.

b) Maximum capacity of oil fuel tanks

Individual oil fuel tanks are not to have a capacity of over 2500 m^3.

c) Oil fuel tank protection

For units having an aggregate oil fuel capacity of 600 m^3 and above, oil fuel tanks are to be located at a sufficient distance from the bottom shell plating and from the side shell plating in accordance with the relevant provisions of MARPOL 73/78, Annex I, Regulation 12A.

Note 3: For units whose double bottom oil fuel tanks are kept empty when undertaking any voyage away from the operating station for whatever purpose, the requirement for the minimum distance between such tanks and the bottom shell plating may not be applied.

d) Suction wells

Suction wells in oil fuel tanks may protube in the double bottom provided that the conditions stated in MARPOL73/78, Annex I, Regulation 12A.10 are satisfied.

e) Valves

Lines of fuel oil piping located at a distance from the unit's bottom or from the unit's side less than those referred to in item c) are to be fitted with valves or similar closing devices within, or immediately adjacent to the oil fuel tank. These valves are to be capable of being brought into operation from a readily accessible enclosed space the location of which is accessible from the machinery control position without traversing exposed freeboard or superstructure decks. The valves are to be closed in case of remote control system failure and at sea at any time when the tank contains oil fuel, except during oil fuel transfer operations.

11.6 Design of fuel oil tanks and bunkers

11.6.1 General

Tanks such as collector tanks, de-aerator tanks etc. are to be considered as fuel oil tanks for the purpose of application of this sub-article, and in particular regarding the valve requirements.

Tanks with a volume lower than 500 l will be given special consideration by the Society.

11.6.2 Scantlings

a) The scantlings of fuel oil tanks and bunkers forming part of the unit's structure are to comply with the requirements stated in Part B, Chapter 3.

b) Scantlings of fuel oil tanks and bunkers which are not part of the unit's structure are to comply with Part B, Chapter 3. For cases which are not contained in the Tables of that appendix, scantlings will be given special consideration by the Society.

11.6.3 Filling and suction pipes

a) All suction pipes from fuel oil tanks and bunkers, including those in the double bottom, are to be provided with valves.

b) For storage tanks, filling pipes may also be used for suction purposes.

c) For fuel oil tanks which are situated higher than the double bottom tanks, the filling pipes which are connected to the tank at a point lower than the outlet of the overflow pipe, or below the top of tanks without an overflow pipe, are to be fitted with shut-off non-return valves, unless they are fitted with valves arranged in accordance with the requirements stated in [11.6.4]. For filling lines entering at the top of a tank and with inside extension towards the bottom, airholes shall be drilled in the pipe near the penetration in order to avoid the siphoning effect.

d) For oil piping which is led through engine room bulkheads, shut-off valves are to be fitted in the engine room on the bulkhead, or close to.

e) The valves requested in a), c) and d) are to be located on the tank or bulkhead itself. However, short distance pieces of rigid construction may be accepted, the length of which is not to exceed about 1,5 D of the pipe.

11.6.4 Remote control of valves

a) Every fuel oil pipe which, if damaged, would allow oil to escape from a storage, settling or daily service tank having a capacity of 500 l and above situated above the double bottom, is to be fitted with a cock or valve directly on the tank capable of being closed from a safe position outside the space in which such tanks are situated in the event of a fire occurring in such space.

Note 1: For the location of the remote controls, refer to [11.11.3], item c).

b) Such valves and cocks are also to include local control. Indicators are to be provided on the remote and local controls to show whether they are open or shut (see [2.8.3]). Where quick-closing valves are used, the indicators for remote controls may be omitted.

c) Where fuel oil tanks are situated outside boiler and machinery spaces, the remote control required in item a) may be transferred to a valve located inside the boiler or machinery spaces on the suction pipes from these tanks.

d) In the special case of deep tanks situated in any shaft or pipe tunnel or similar space, valves are to be fitted on the tank but control in the event of fire may be effected by means of an additional valve on the pipe or pipes outside the tunnel or similar space. If such additional valve is fitted in the machinery space it is to be operated from a position outside this space.

Note 2: For non-propelled units where the fuel oil transfer installation is designed for manual operation, suction valves from fuel oil tanks and bunkers, with the exception of daily service tanks, need not be arranged with remote controls provided they are maintained closed except during transfer operations. Such valves are, however, to be readily accessible and instruction plates are to be fitted in their vicinity specifying that they are to be kept closed except during transfer operations.

11.6.5 Drain pipes

Where fitted, drain pipes are to be provided with self-closing valves or cocks.

11.6.6 Air and overflow pipes

Air and overflow pipes are to comply with [9.1] and [9.3].

11.6.7 Sounding pipes and level gauges

a) Safe and efficient means of ascertaining the amount of fuel oil contained in any fuel oil tank are to be provided.

b) Sounding pipes of fuel oil tanks are to comply with the provisions of [9.2].

c) Oil-level gauges complying with [2.10.2] may be used in place of sounding pipes.

d) Gauge cocks for ascertaining the level in the tanks are not to be used.

11.7 Design of fuel oil heating systems

11.7.1 General

a) Where heavy fuel oil is used, a suitable heating system is to be provided for storage tanks, settling tanks and service tanks in order to ensure that the fuel oil has the correct fluidity and the fuel pumps operate efficiently.

b) Where necessary for pumping purposes, storage tanks containing heavy fuel oil are to be provided with heating systems.

c) Where necessary, pumps, filters, pipes and fittings are to be provided with heat tracing systems.

d) Where main or auxiliary engines are supplied with fuel oil which needs to be heated, arrangements are to be made so that the engines can still operate if one oil heating system or the heating power source is out of action. Such arrangements may consist of an alternative supply of the engines in accordance with [11.9.2].

11.7.2 Tank heating systems

a) Oil fuel in storage tanks are not to be heated to temperatures within 10°C below the flashpoint of the fuel oil, except that, where oil fuel in service tanks, settling tanks and any other tanks in supply system is heated, the following arrangements are to be provided:
   - the length of the vent pipes from such tanks and/or a cooling device is sufficient for cooling the vapours to below 60°C, or the outlet of the vent pipes is located 3 m away from a source of ignition
   - the vent pipes are fitted with flame screens
   - there are no openings from the vapour space of the fuel tanks into machinery spaces (bolted manholes are acceptable)
   - enclosed spaces are not to be located directly over such fuel tanks, except for vented cofferdams
   - electrical equipment is not to be fitted in the vapour space of the tanks, unless it is certified to be intrinsically safe.

b) The temperature of the heating medium is not to exceed 220°C.

c) Automatic control sensors are to be provided for each heated tank to maintain the temperature of the fuel oil below the limits prescribed in item a).

   For storage tanks, the manual control may be accepted subject to special consideration by the Society in each case.

d) Heated tanks are to be provided with temperature measuring systems.

e) The heating coils inlet and outlet connections at the tank are to be fitted with suitable means for closing. For steam heating coils, additional means are to be provided between tank outlet and closing device to enable testing the condensate for presence of oil.

   Heating pipes and coils inside the tanks are to be of material suitable for the heated fluid.

   For steel pipes, the thickness is not to be less than the values given in column 4, with footnote (4), of Tab 6.

   The heating coils within the tanks are to have welded connections and are to be supported in such a way that they are not subject to non permissible stress due to vibration or thermal extension.

11.7.3 Fuel oil heaters

a) Where steam heaters or heaters using other heating media are provided in fuel oil systems, they are to be fitted with at least a high temperature alarm or a low flow alarm in addition to a temperature control, except where temperatures dangerous for the ignition of the fuel oil cannot be reached.

b) Electric heating of fuel oil is to be avoided as far as practicable.

c) However, when electric heaters are fitted, means are to be provided to ensure that heating elements are permanently submerged during operation. In all cases a safety temperature switch is to be fitted in order to avoid a surface temperature of 220°C and above. It is to be:
   - independent from the automatic control sensor
   - designed to cut off the electrical power supply in the event of excessive temperature
   - provided with manual reset.

d) Fuel oil heaters are to be fitted with relief valves leading back to the pump suction concerned or to any other place deemed satisfactory.

11.8 Design of fuel oil treatment systems

11.8.1 General

a) Heavy fuel oils used in diesel engines are to be purified and filtered according to the engine manufacturer's requirements.

b) Provisions are to be made to avoid inadvertent entry of non-purified heavy fuel into the daily service tanks, in particular through the overflow system.

11.8.2 Drains

a) Settling tanks or, where settling tanks are not provided, daily service tanks, are to be provided with drains permitting the evacuation of water and impurities likely to accumulate in the lower part of such tanks.

b) Efficient means are to be provided for draining oily water escaping from the drains.

11.8.3 Purifiers

a) Where fuel oil needs to be purified, at least two purifiers are to be installed on board, each capable of efficiently purifying the amount of fuel oil necessary for the normal operation of the engines.

Note 1: On units operating in restricted zones, one purifier only may be accepted.

b) Subject to special consideration by the Society, the capacity of the standby purifier may be less than that required in a), depending on the arrangements made for the fuel oil service tanks to satisfy the requirement in [11.9.2].

c) The standby purifier may also be used for other services.

d) Each purifier is to be provided with an alarm in case of failures likely to affect the quality of the purified fuel oil.

e) Fuel oil purifiers are to be installed as required in Part C, Chapter 4.

11.9 Design of fuel supply systems

11.9.1 General

a) In units where heavy fuel oil and marine diesel oil are used, a change-over system from one fuel to the other is to be provided. This system is to be so designed as to avoid:

- overheating of marine diesel oil
- inadvertent ingress of heavy fuel oil into marine diesel oil tanks.

b) When necessary, arrangements are to be made for cooling the marine diesel oil from engine return lines.

11.9.2 Fuel oil service tanks

a) The oil fuel service tank is an oil fuel tank which contains only the required quality of fuel ready for immediate use.

b) In general, two fuel oil service tanks for each type of fuel used on board necessary for propulsion and vital systems, or equivalent arrangements, are to be provided. Each tank is to have a capacity of at least 8 h at maximum continuous rating of the propulsion plant and normal operating load at sea of the generator plant.

c) For “one fuel ship”, where main and auxiliary engines and boiler(s) are operated with Heavy Fuel Oil (HFO), the arrangements complying with this regulation or acceptable “equivalent arrangements” shall be provided.

The arrangements complying with this regulation shall comprise at least the following tanks:

- two (2) HFO service tanks, each of a capacity sufficient for at least 8 h operation of main engine(s), auxiliary engines and auxiliary boiler(s), and
- one (1) Marine Diesel Oil (MDO) service tank for initial cold starting or repair work of engines or boilers.

Acceptable “equivalent arrangements” shall comprise at least:

- one (1) HFO service tank with a capacity sufficient for at least 8 h operation of main engine(s), auxiliary engines and auxiliary boiler(s), and
- one (1) MDO service tank with a capacity sufficient for at least 8 h operation of main engine(s), auxiliary engines and auxiliary boiler(s), and
- for pilot burners of auxiliary boilers, if provided, an additional MDO service tank for 8 h may be required.

This arrangement only applies where main and auxiliary engines can operate with HFO under all load conditions and, in the case of main engines, during manoeuvring.

d) Where main engines and auxiliary boiler(s) are operated with Heavy Fuel Oil (HFO) and auxiliary engines are operating with Marine Diesel Oil (MDO), the arrangements complying with this regulation or acceptable “equivalent arrangements” shall be provided.

The arrangements complying with this regulation shall comprise at least the following tanks:

- two (2) HFO service tanks, each of a capacity sufficient for at least 8 h operation of main engine(s) and auxiliary boiler(s), and
- two (2) MDO service tanks each of a capacity sufficient for at least 8 h operation of auxiliary engines.

Acceptable “equivalent arrangements” shall comprise at least:

- one (1) HFO service tank with a capacity sufficient for at least 8 h operation of main engine(s) and auxiliary boiler(s), and
- two (2) MDO service tanks, each of a capacity sufficient for:
  - 4 h operation of main engine(s), auxiliary engines and auxiliary boiler(s), or
  - 8 h operation of auxiliary engines and auxiliary boiler(s).

e) The “equivalent arrangements” in items c) and d) apply, provided the propulsion and vital systems using two types of fuel support rapid fuel change over and are capable of operating in all normal operating conditions at sea with both types of fuel (MDO and HFO).

f) The arrangement of oil fuel service tanks is to be such that one tank can continue to supply oil fuel when the other is being cleaned or opened up for repair.

g) The use of a setting tank with or without purifiers, or purifiers alone, and one service tank is not acceptable as an “equivalent arrangement” to two service tanks.

Note 1: This requirement [11.9.2] need not be applied to small units operating in restricted zones or non-propelled units.

11.9.3 Fuel oil supply to boilers

a) In units where boilers burning oil under pressure are installed to supply steam to the machinery serving essential services, the fuel oil supply system is to include at least the following equipment:

- Two independently driven fuel oil service pumps, each one of a capacity sufficient to supply the boilers at their rated output. The pumps are to be arranged such that one may be overhauled while the other is in service.
- Filters or strainers fitted on the suction lines and so arranged that they can be cleaned without interrupting the fuel supply. For that purpose, two filters or strainers fitted in parallel, or one duplex type with a change over facility, may be accepted.
- Two heaters in the case that fuel oil heating is required, each one of a capacity sufficient to supply heated fuel oil to the boilers at their normal operating capacity. The heaters are to be arranged such that one may be overhauled while the other is in service.

b) The fuel oil supply system is to be capable of supplying the fuel oil necessary to generate enough steam for the essential services of the unit with one pump, one heater or one filter out of action.

c) A quick-closing valve is to be provided on the fuel supply to the burners of each boiler, arranged to be easily operated in case of emergency, either directly or by remote control.

d) The fuel supply to the burners is to be capable of being automatically cut off when required under Ch 1, Sec 3, [5.1.8].

e) Burners are to comply with Ch 1, Sec 3, [2.2.5].

f) Where burners are provided with fuel oil flow-back to the pump suctions or other parts under pressure, non-return devices are to be provided to prevent fuel oil from flowing back to the burners when the oil supply is cut off.

g) For the starting-up of boilers, an auxiliary fuel oil unit not requiring power from shore is to be provided.

h) Where fuel oil is supplied to the burners by gravity, a double filter satisfying the provisions of item a) is to be provided in the supply line.

i) Fuel oil supply systems are to be entirely separate from feed, bilge, ballast and other piping systems.

11.9.4 Fuel oil supply to internal combustion engines

a) The suctions of engine fuel pumps are to be so arranged as to prevent the pumping of water and sludge likely to accumulate after decanting at the lower part of service tanks.

b) Single internal combustion engines intended for essential services are to be fitted with at least two filters, or similar devices, so arranged that one of the filters can be overhauled while the other is in use.

Note 1: Where the engine has an output not exceeding 375 kW, the second filter may be replaced by a readily accessible and easily replaceable spare filter.

c) Oil filters fitted in parallel are to be so arranged as to minimise the possibility of a filter under pressure being opened by mistake.

Filter chambers are to be provided with suitable means for:

- ventilating when put into operation
- de-pressurising before being opened.

Valves or cocks used for this purpose are to be fitted with drain pipes led to a safe location.

d) Oil filters are to be so located that in the event of a leakage the fuel oil cannot be pulverised onto the exhaust manifold.

e) Where the engine fuel oil supply system is arranged with booster pumps, a standby pump connected ready for immediate use is to be provided.

The standby pump may be replaced by a complete spare pump of appropriate capacity ready to be connected, in the following cases:

- where two or more engines are fitted, each with its own booster pump
- where the engine output does not exceed 375 kW.

f) Where fuel oils require pre-heating in order to have the appropriate viscosity when being injected in the engine, the following equipment is to be provided in the fuel oil line:

- one viscosity control and monitoring system
- two pre-heaters, one serving as a standby for the other.

g) Excess fuel oil from pumps or injectors is to be led back to the service or settling tanks, or to other tanks intended for this purpose.

h) De-aeration tanks fitted in pressurised fuel oil return lines are to be equipped with at least:

- an automatic venting valve or equivalent device discharging to the daily service tank or to other safe place deemed satisfactorily having a device for flow detection.
- a non-return valve in the return line from the engines.

i) For high pressure fuel oil pipes and other components which may be built-in or attached to the engine, see Ch 1, Sec 2, [2.5].

Anyhow, the components of a diesel engine fuel oil system are to be designed considering the maximum peak pressure which will be experienced in service, including any high pressure pulses which are generated and transmitted back into the fuel supply and spill lines by the action of fuel injection pumps.

j) Connections within the fuel supply and spill lines are to be constructed having regard to their ability to prevent pressurised fuel oil leaks while in service and after maintenance.

k) In multi-engine installations which are supplied from the same fuel source, means of isolating the fuel supply and spill piping to individual engines are to be provided. The means of isolation shall not affect the operation of the other engines and shall be operable from a position not rendered inaccessible by a fire on any of the engines.

11.10 Helicopter refuelling facilities

11.10.1 Storage area

a) A designated area is to be provided for the storage of fuel tanks which are to be:
  - as remote as practicable from accommodation spaces, escape routes and embarkation stations, and
  - isolated from areas containing a source of vapour ignition, and
  - permanently marked.

b) The fuel storage area is to be provided with arrangements whereby fuel spillage may be collected and drained to a safe location.

c) Vent heads of an approved type with flame arresters are to be fitted to vent pipes arranged in the storage area.

11.10.2 Fuel tanks

a) Tanks and associated equipment are to be protected against physical damage and from a fire in an adjacent space or area.

b) Where portable fuel storage tanks are used, special attention is to be given to:
  1) design of the tank for its intended purpose
  2) mounting and securing arrangements
  3) electric bonding, and
  4) inspection procedures.

11.10.3 Fuel pumping

a) Storage tank fuel pumps are to be provided with means which permit shutdown from a safe remote location in the event of a fire. Where a gravity fuelling system is installed, equivalent closing arrangements are to be provided to isolate the fuel source.

b) The fuel pumping unit is to be connected to one tank at a time. The piping between the tank and the pumping unit is to be of steel or equivalent material, as short as possible, and protected against damage.

c) Electrical fuel pumping units and associated control equipment shall be of a type suitable for the location and potential hazards

d) Fuel pumping units shall incorporate a device which will prevent over-pressurization of the delivery or filling hose.

11.10.4 Refuelling equipment

Equipment used in refuelling operations is to be electrically bonded.

11.11 Control and monitoring

11.11.1 Monitoring

Alarms and safeguards are to be provided for fuel oil systems in accordance with Tab 29.

Note 1: Some departures from Tab 29 may be accepted by the Society in the case of units operating in restricted zones.

11.11.2 Automatic controls

Automatic temperature control is to be provided for:

- steam heaters or heaters using other media
- electric heaters.

11.11.3 Remote controls

a) The remote control arrangement of valves fitted on fuel oil tanks is to comply with [11.6.4].

b) The power supply to:
  - fuel oil burning pumps
  - transfer pumps and other pumps of the fuel oil system, and
  - fuel oil purifiers,

  is to be capable of being stopped from a position within the space containing the pumps and from another position located outside such space and always accessible in the event of fire within the space.

c) Remote control of the valve fitted to the emergency generator fuel tank is to be in a separate location from that of other valves fitted to tanks in the engine room.

d) The positions of the remote controls are also to comply with Part C, Chapter 3.

Table 29 : Fuel oil systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Fuel oil overflow tank level	H(**1**)						
Air pipe water trap level on fuel oil tanks	H(**2**)						
Fuel oil temperature after heaters	H(**3**)	local		X(**4**)			
Sludge tank level		local					
Fuel oil settling tank and service tank temperature	H(**2**)	local					
Fuel oil level in daily service tank	L+H(**1**)	local					
Fuel oil daily service tank temperature	H(**2**)	local					

(1) Or sightglasses on the over flow pipe.
(2) Applicable where heating arrangements are provided.
(3) Or low flow alarm in addition to temperature control when heated by steam or other media.
(4) Cut off of electrical power supply when electrically heated.

11.12 Construction of fuel oil piping systems

11.12.1 Materials

a) Fuel oil pipes and their valves are to be of steel or other approved material as mentioned in Tab 5.

Flexible pipes may be accepted provided they comply with [2.7.4].

b) Internal galvanisation of fuel oil pipes and tank or bunker walls is to be avoided.

11.12.2 Pipe thickness

The thickness of pipes conveying heated fuel oil, as well as their flanges, is to be calculated for a design pressure determined in accordance with Tab 4.

11.12.3 Pipe connections

a) Connections and fittings of pipes containing fuel oil are to be suitable for a design pressure according to Tab 3 and Tab 4.

b) Connections of pipes conveying heated fuel oil are to be made by means of close-fitting flanges, with joints made of a material impervious to oil heated to 160°C and as thin as possible.

11.13 Arrangement of fuel oil piping systems

11.13.1 Passage of fuel oil pipes through tanks

a) Fuel pipes are not to pass through tanks containing boiler feed water, fresh water or flammable oil, unless they are contained within tunnels.

b) Transfer pipes passing through ballast tanks are to have a reinforced thickness complying with Tab 6.

11.13.2 Passage of pipes through fuel oil tanks

Boiler feed water, fresh water or flammable oil pipes are not to pass through fuel oil tanks, unless such pipes are contained within tunnels.

11.13.3 Segregation of fuel oil purifiers

Purifiers for heated fuel oil are to be in accordance with Ch 4, Sec 6, [5.1.2].

12 Lubricating oil systems

12.1 Application

12.1.1 This Article applies to lubricating oil systems serving diesel engines, steam and gas turbines, reduction gears, clutches and controllable pitch propellers, for lubrication or control purposes.

12.2 Principle

12.2.1 General

a) Lubricating oil systems are to be so designed as to ensure reliable lubrication of the engines, turbines and other equipment, including electric motors, intended for propulsion:

- over the whole speed range, including starting, stopping and, where applicable, manoeuvring
- for all the inclinations angles stated in Ch 1, Sec 1.

b) Lubricating oil systems are to be so designed as to ensure sufficient heat transfer and appropriate filtration of the oil.

c) Lubricating oil systems are to be so designed as to prevent oil from entering into contact with sources of ignition.

12.2.2 Availability

a) Lubricating oil systems are to be so designed that, in the event that any one pump is inoperative, the lubrication of the engine and other equipment is maintained. Partial reduction of the operating capability of the engine or equipment may be accepted, however, when it is demonstrated that the safe operation of the unit is not impaired.

b) An emergency lubricating system, such as a gravity system, is to be provided to ensure sufficient lubrication of equipment which may be damaged due to a failure of the pump supply.

12.3 General

12.3.1 Arrangement of lubricating oil systems

a) The arrangements for the storage, distribution and utilisation of oil used in pressure lubrication systems are to be such as to ensure the safety of the unit and persons on board.

b) The provisions of [5.11] are to be complied with, where applicable.

12.3.2 Filtration

a) In forced lubrication systems, a device is to be fitted which efficiently filters the lubricating oil in the circuit.

b) The filters provided for this purpose for essential machinery are to be so arranged that they can be easily cleaned without stopping the lubrication of the machines.

c) The fineness of the filter mesh is to comply with the requirements of the engine or turbine manufacturers.

d) Where filters are fitted on the discharge side of lubricating oil pumps, a relief valve leading back to the suction or to any other convenient place is to be provided on the discharge of the pumps.

12.3.3 Purification

Where provided, lubricating oil purifiers are to comply with [11.8.3].

12.3.4 Heat transfer

Lubricating oil heaters are to comply with [11.7.3].

12.4 Design of engine lubricating oil systems

12.4.1 Lubrication of engines

a) Engines intended for essential services are to be provided with at least two power lubricating pumps, of such a capacity as to maintain normal lubrication with any one pump out of action.

b) In the case of installations comprising:

- more than one engine, each with its own lubricating pump, or
- one engine with an output not exceeding 375 kW,

one of the pumps mentioned in a) may be a spare pump ready to be connected to the lubricating oil system, provided disassembling and reassembling operations can be carried out on board in a short time.

12.4.2 Lubrication of engines intended for non-essential services

For engines intended for non-essential services, a single lubricating pump is acceptable.

12.5 Design of steam turbine lubrication systems

12.5.1 General

An alarm device is to be provided giving audible warning in the event of damage or of an appreciable reduction of the oil pressure.

12.5.2 Lubrication of propulsive turbines and turbogenerators

a) Turbines intended for essential services are to be provided with:

- one main lubricating pump, and
- one independently driven standby pump of at least the same capacity.

b) The standby pump is to be capable of supplying satisfactory lubrication to the turbines during starting and stopping operations.

c) Lubricating systems serving turbines intended for essential services are to be provided with a device which stops the steam supply to the turbines (see [12.7.1]).

12.5.3 Emergency lubrication of turbines intended for essential services

a) Turbines intended for essential services are to be provided with an emergency lubricating system arranged for automatic start (see [12.7.1]).

b) When a gravity system is provided for the purpose of item a), it is to ensure an adequate lubrication for not less than 6 minutes and, in the case of turbogenerators, for a period at least equal to the stopping period after unloading.

c) When the emergency supply is fulfilled by means of an emergency pump, it is to be so arranged that its operation is not affected by a failure of the power supply.

d) Suitable arrangements for cooling the bearings after stopping may also be required.

12.5.4 Lubrication of auxiliary turbines intended for essential services

a) Auxiliary turbines intended for essential services are to be provided with:

- one main lubricating pump, and
- one independently driven standby pump of at least the same capacity.

b) The standby pump is to be capable of supplying satisfactory lubrication to the turbines during starting and stopping operations.

12.6 Design of lubricating oil tanks

12.6.1 Remote control of valves

Lubricating oil tanks with a capacity of 500 litres and above are to be fitted with remote controlled valves in accordance with the provisions of [11.6.4].

The remote controlled valves need not be arranged for storage tanks on which valves are normally closed except during transfer operation, or where it is determined that an unintended operation of a quick closing valve on the oil lubricating tank would endanger the safe operation of the main propulsion and essential auxiliary machinery.

12.6.2 Filling and suction pipes

Filling and suction pipes are to comply with the provisions of [11.6.3].

12.6.3 Air and overflow pipes

Air and overflow pipes are to comply with the provisions of [9.1] and [9.3].

12.6.4 Sounding pipes and level gauges

a) Safe and efficient means of ascertaining the amount of lubricating oil contained in the tanks are to be provided.

b) Sounding pipes are to comply with the provisions of [9.2].

c) Oil-level gauges complying with [2.10.2] may be used in place of sounding pipes.

d) Gauge cocks for ascertaining the level in the tanks are not to be used.

12.6.5 Oil collecting tanks for engines

a) In surface units required to be fitted with a double bottom, wells for lubricating oil under main engines may be permitted by the Society provided it is satisfied that the arrangements give protection equivalent to that afforded by a double bottom complying with Pt D, Ch 1, Sec 3, [10].

b) Where, in surface units required to be fitted with a double bottom, oil collecting tanks extend to the outer bottom, a valve is to be fitted on the oil drain pipe, located between the engine sump and the oil drain tank. This valve is to be capable of being closed from a readily accessible position located above the working platform.

Alternative arrangements will be given special consideration.

c) Oil collecting pipes from the engine sump to the oil collecting tank are to be submerged at their outlet ends.

12.7 Control and monitoring

12.7.1 In addition to the requirements in:

- Ch 1, Sec 2 for diesel engines
- Ch 1, Sec 4 for steam turbines
- Ch 1, Sec 5 for gas turbines, and
- Ch 1, Sec 6 for gears,

alarms are to be provided for lubricating oil systems in accordance with Tab 30.

Note 1: Some departures from Tab 30 may be accepted by the Society in the case of units operating in restricted zones.

Table 30 : Lubricating oil systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Air pipe water trap level of lubricating oil tank **(1)**	H						
Sludge tank level		local					
(1) See [9.1.7].							

12.8 Construction of lubricating oil piping systems

12.8.1 Materials

Materials used for oil piping system in machinery spaces are to comply with the provisions of [11.12.1].

12.8.2 Sight-flow glasses

The sight-flow glasses may be used in lubricating oil systems, provided that they are shown by testing to have a suitable degree of fire resistance and so designed that the oil does not impinge on the glass – see [9.3.4], item d).

12.8.3 Air and overflow pipes

Air and overflow pipes are to comply with [9.1] and [9.3], including [5.11], as applicable.

12.8.4 Sounding pipes and level gauges

a) Safe and efficient means of ascertaining the amount of oil contained in any lubricating oil tank are to be provided.

b) Sounding pipes of lubricating oil tanks are to comply with the provisions of [9.2].

c) Oil-level gauges complying with [2.10.2] may be used in place of sounding pipes.

d) Gauge cocks for ascertaining the level in the tanks are not to be used.

13 Thermal oil systems

13.1 Application

13.1.1 This Article applies to all thermal oil systems involving organic liquids heated below their initial boiling temperature at atmospheric pressure by means of:

- oil fired heaters
- exhaust gas heaters, or
- electric heaters.

13.2 Principle

13.2.1 General

Thermal oil systems are to be so designed as to:

- avoid overheating of the thermal oil and contact with air
- take into account the compatibility of the thermal oil with the heated products in case of contact due to leakage of coils or heater tubes
- prevent oil from coming into contact with sources of ignition.

13.2.2 Availability

Thermal oil systems are to be so designed that, in the event that any one essential auxiliary is inoperative, the thermal oil supply to essential services can be maintained. Partial reduction of the operating capability may be accepted, however, when it is demonstrated that the safe operation of the unit is not impaired.

13.3 General

13.3.1 Limitations on use of thermal oil

a) The oil is to be used in the temperature ranges specified by the producer. The delivery temperature is, however, to be kept 50°C below the oil distillation point.

b) Thermal oil is not to be used for the direct heating of:

- accommodation
- fresh drinking water
- liquid cargoes with flashpoints below 60°C, except where permitted in Pt D, Ch 1, Sec 18, [6.4].

13.3.2 Location of thermal oil system components

Thermal oil heaters are normally to be located in spaces separated from main and auxiliary machinery spaces.

However, thermal oil heaters located in machinery spaces and protected by adequate screening may be accepted, subject to special consideration by the Society.

Note 1: For the purpose of application of Part C, Chapter 4, spaces where thermal oil heaters are located are to be considered as machinery spaces of category A.

13.3.3 Provision for quick drainage and alternative arrangements

a) Inlet and outlet valves of oil fired and exhaust fired heaters are to be arranged for remote closing from outside the compartment where they are situated.

As an alternative, thermal oil systems are to be arranged for quick gravity drainage of the thermal oil contained in the system into a draining tank.

b) The expansion tank is to be arranged for quick gravity drainage into a draining tank.

However, where the expansion tank is located in a low fire risk space, the quick drainage system may be replaced by a remote controlled closing device for isolating the expansion tank.

The quick drainage system and the alternative closing device are to be capable of being controlled from inside and outside the space containing the expansion tank.

13.3.4 Ventilation

a) Spaces containing thermal oil heaters are to be suitably mechanically ventilated.

b) Ventilation is to be capable of being stopped from outside these spaces.

13.4 Design of thermal oil heaters and heat exchangers

13.4.1 Thermal oil heaters

Oil fired and exhaust-fired thermal oil heaters are to be designed, equipped and controlled in accordance with the requirements specified in Ch 1, Sec 3.

13.4.2 Heat exchangers

Heat exchangers are to be designed and equipped in accordance with the requirements specified in Ch 1, Sec 3.

13.5 Design of storage, expansion and draining tanks

13.5.1 Storage and draining tanks

a) The capacity of the storage tank is to be sufficient to compensate the losses expected in service.

b) The capacity of the draining tank is to be sufficient to collect the quantity of thermal oil contained in the system, including the expansion tank.

c) Storage and draining tanks may be combined.

13.5.2 Expansion tanks

a) The capacity of the expansion tank is to be sufficient to allow volume variations, due to temperature changes, of all the circulating oil.

b) The expansion tank is to be so designed, installed and connected to the circuit as to ensure that the temperature inside the tank remains below 50°C.

13.5.3 Drain pipes

Where provided, drains pipes of thermal oil tanks are to be fitted with self-closing valves or cocks.

13.5.4 Air pipes

a) Air pipes fitted to the expansion and drainage tanks are to be suitably sized to allow the quick gravity drainage referred to in [13.3.3].

b) The applicable requirements of [9.1] are to be complied with.

13.5.5 Overflow pipes

a) The expansion tank is to be fitted with an overflow pipe led to the drainage tank. This overflow pipe may be combined with the quick draining line provided for in [13.3.3], item b).

b) The applicable requirements of [9.3] are to be complied with.

13.5.6 Sounding pipes and level gauges

a) Sounding pipes are to comply with the provisions of [9.2].

b) Level gauges are to comply with the provisions of [2.10.2].

13.6 Design of circulation and heat exchange systems

13.6.1 Circulating pumps

At least two circulating pumps are to be provided, of such a capacity as to maintain a sufficient flow in the heaters with any one pump out of action.

However, for circulating systems supplying non-essential services, one circulating pump only may be accepted.

13.6.2 Filters

A device which efficiently filters the thermal oil is to be provided in the circuit.

In the case of essential services, the filters provided for this purpose are to be so arranged that they can be easily cleaned without stopping the thermal oil supply.

The fineness of the filter mesh is to comply with the requirements of the thermal oil heating installation manufacturer.

13.7 Control and monitoring

13.7.1 Monitoring

In addition to the requirements specified in Ch 1, Sec 3, [3.3.2] for thermal heaters and heat exchangers, alarms and safeguards for thermal oil systems are to be provided in accordance with Ch 1, Sec 3, Tab 22.

Note 1: Some departures from Ch 1, Sec 3, Tab 22 may be accepted by the Society in the case units operating in restricted zones.

13.7.2 Remote control

a) Remote control is to be arranged for:
   - shut-off of circulating pumps
   - quick drainage of the thermal oil system and expansion tank, or shut-off of the alternative devices (see [13.3.3])
   - shut-off of the fuel supply to the oil fired heaters or of the exhaust gas supply to the exhaust gas heaters (see Ch 1, Sec 3, [5.3]).

   The shut-off of the exhaust gas supply may be ensured either by the engine shut down or by an exhaust gas by-pass.

b) Such control is to be possible from the space containing the thermal oil heaters and from another position located outside such space.

13.8 Construction of thermal oil piping systems

13.8.1 Materials

a) Materials are to comply with the provisions of [11.12.1].

b) Casings of pumps, valves and fittings are to be made of steel or other ductile material.

13.8.2 Pipe connections

a) Pipe connections are to comply with Article [2.5] and to be suitable for the design temperature of the thermal oil system.

b) Screw couplings of a type approved by the Society may be accepted for pipes of an outside diameter not exceeding 15 mm provided they are fitted with cutting rings or equivalent arrangements.

c) The materials of the joints are to be impervious to thermal oil.

13.9 Thermal oil piping arrangements

13.9.1 Passage of thermal oil pipes through certain spaces

a) Thermal oil pipes are not to pass through accommodation or public spaces or control stations.

b) Thermal oil pipes passing through main and auxiliary machinery spaces are to be restricted as far as possible.

13.9.2 Discharge of relief valves

Relief valves are to discharge to the drain tank.

13.9.3 Provision for de-aerating

Provisions are to be made for automatic evacuation of air, steam and gases from the thermal oil system to a safe location.

14 Hydraulic systems

14.1 Application

14.1.1 Hydraulic installations intended for essential services

Unless otherwise specified, this Article applies to all hydraulic power installations intended for essential services.

14.1.2 Hydraulic installations located in spaces containing sources of ignition

Hydraulic power installations not serving essential services but located in spaces where sources of ignition are present are to comply with the provisions of [14.3.2], [14.3.3], [14.4.4] and [14.4.5].

14.1.3 Low pressure or low power hydraulic installations

Hydraulic power installations with a design pressure of less than 2,5 MPa and hydraulic power packs of less than 5 kW will be given special consideration by the Society.

14.1.4 Very high pressure hydraulic installations

Hydraulic power installations with a design pressure exceeding 35 MPa will be given special consideration by the Society.

14.2 General design

14.2.1 Design requirements

As far as practicable, hydraulic systems are to be so designed as to:

- avoid any overload of the system
- maintain the actuated equipment in the requested position (or the driven equipment at the requested speed)
- avoid overheating of the hydraulic oil
- prevent hydraulic oil from coming into contact with sources of ignition.

14.2.2 Availability

a) As a rule, hydraulic systems are to be so designed that, in the event that any one essential component becomes inoperative, the hydraulic power supply to essential services can be maintained. Partial reduction of the operating capability of the hydraulic system may be accepted, however, when it is demonstrated that the safe operation of the unit is not impaired.

b) When a hydraulic power system is simultaneously serving one essential system and other systems, it is to be ensured that:
   - operation of such other systems, or
   - a single failure in the installation external to the essential system,

   is not detrimental to the operation of the essential system.

c) Provision b) applies in particular to steering gear.

d) Hydraulic systems serving lifting or hoisting appliances, including platforms, ramps, hatch covers, lifts, etc., are to be so designed that a single failure of any component of the system may not result in a sudden undue displacement of the load or in any other situation detrimental to the safety of the unit and persons on board.

14.3 General

14.3.1 Definitions

a) A power unit is the assembly formed by the hydraulic pump and its driving motor.

b) An actuator is a component which directly converts hydraulic pressure into mechanical action.

14.3.2 Limitations of use of hydraulic oils

a) Oils used for hydraulic power installations are to have a flashpoint not lower than 150°C and be suitable for the entire service temperature range.

b) The hydraulic oil is to be replaced in accordance with the specification of the installation manufacturer.

14.3.3 Location of hydraulic power units

a) Whenever practicable, hydraulic power units are to be located outside main engine or boiler rooms.

b) Where this requirement is not complied with, shields or similar devices are to be provided around the units in order to avoid an accidental oil spray or jet on heated surfaces which may ignite oil.

14.4 Design of hydraulic pumps and accessories

14.4.1 Power units

a) Hydraulic power installations are to include at least two power units so designed that the services supplied by the hydraulic power installation can operate simultaneously with one power unit out of service. A reduction of the performance may be accepted.

b) Low power hydraulic installations not supplying essential services may be fitted with a single power unit, provided that alternative means, such as a hand pump, are available on board.

14.4.2 Pressure reduction units

Pressure reduction units used in hydraulic power installations are to be duplicated.

14.4.3 Filtering equipment

a) A device is to be fitted which efficiently filters the hydraulic oil in the circuit.

b) Where filters are fitted on the discharge side of hydraulic pumps, a relief valve leading back to the suction or to any other convenient place is to be provided on the discharge of the pumps.

14.4.4 Provision for cooling

Where necessary, appropriate cooling devices are to be provided.

14.4.5 Provision against overpressure

a) Safety valves of sufficient capacity are to be provided at the high pressure side of the installation.

b) Safety valves are to discharge to the low pressure side of the installation or to the service tank.

14.4.6 Provision for venting

Cocks are to be provided in suitable positions to vent the air from the circuit.

14.4.7 Provision for drainage

Provisions are to be made to allow the drainage of the hydraulic oil contained in the installation to a suitable collecting tank.

14.5 Design of hydraulic tanks and other components

14.5.1 Hydraulic oil service tanks

a) Service tanks intended for hydraulic power installations supplying essential services are to be provided with at least:

- a level gauge complying with [2.10.2]
- a temperature indicator
- a level switch complying with [14.6.2].

b) The free volume in the service tank is to be at least 10% of the tank capacity.

14.5.2 Hydraulic oil storage tanks

a) Hydraulic power installations supplying essential services are to include a storage tank of sufficient capacity to refill the whole installation should the need arise case of necessity.

b) For hydraulic power installations of less than 5 kW, the storage means may consist of sealed drums or tins stored in satisfactory conditions.

14.5.3 Hydraulic accumulators

The hydraulic side of the accumulators which can be isolated is to be provided with a relief valve or another device offering equivalent protection in case of overpressure.

14.6 Control and monitoring

14.6.1 Indicators

Arrangements are to be made for connecting a pressure gauge where necessary in the piping system.

14.6.2 Monitoring

Alarms and safeguards for hydraulic power installations intended for essential services, except steering gear, for which the provisions of Ch 1, Sec 11 apply, are to be provided in accordance with Tab 31.

Note 1: Some departures from Tab 31 may be accepted by the Society in the case of small units, units operating in restricted zones or platforms installed in sheltered coastal areas.

Note 2: Tab 31 does not apply to steering gear.

Table 31 : Hydraulic oil systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Pump pressure	L						
Service tank level	L**(1)(2)**						X**(2)**

(1) The low level alarm is to be activated before the quantity of lost oil reaches 100 litres or 70% of the normal volume in the tank, whichever is the less.

(2) For hydraulics cranes where no electrical system has been provided, the requirement may be waived if the level gauge, the pressure gauge and the temperature gauge indicators are always visible by the crane operator. In addition, a warning label shall be placed on the tank reminding that, prior to start any operation of the crane, the oil level is to be checked.

15 Steam systems

15.1 Application

15.1.1 Scope

This Article applies to all steam systems intended for essential and non-essential services.

Steam systems with a design pressure of 10 MPa or more will be given special consideration.

15.2 Principle

15.2.1 Availability

a) Where a single boiler is installed, the steam system may supply only non-essential services.

b) Where more than one boiler is installed, the steam piping system is to be so designed that, in the event that any one boiler is out of action, the steam supply to essential services can be maintained.

15.3 Design of steam lines

15.3.1 General

a) Every steam pipe and every connected fitting through which steam may pass is to be designed, constructed and installed such as to withstand the maximum working stresses to which it may be subjected.

b) When the design temperature of the steam piping system exceeds 400°C, calculations of thermal stresses are to be submitted to the Society as specified in [2.4].

c) Steam connections on boilers and safety valves are to comply with the applicable requirements of Ch 1, Sec 3.

15.3.2 Provision against overpressure

a) If a steam pipe or fitting may receive steam from any source at a higher pressure than that for which it is designed, a suitable reducing valve, relief valve and pressure gauge are to be fitted.

b) When, for auxiliary turbines, the inlet steam pressure exceeds the pressure for which the exhaust casing and associated piping up to the exhaust valves are designed, means to relieve the excess pressure are to be provided.

15.3.3 Provision for dumping

In order to avoid overpressure in steam lines due to excessive steam production, in particular in systems where the steam production cannot be adjusted, provisions are to be made to allow the excess steam to be discharged to the condenser by means of an appropriate dump valve.

15.3.4 Provision for draining

Means are to be provided for draining every steam pipe in which dangerous water hammer action might otherwise occur.

15.3.5 Steam heating pipes

a) When heating coils are fitted in compartments likely to contain either fuel oil or liquid or dry cargoes, arrangements such as blind flanges are to be provided in order to disconnect such coils in the event of carriage of dry or liquid cargoes which are not to be heated.

b) The number of joints on heating coils is to be reduced to the minimum consistent with dismantling requirements.

15.3.6 Steam lines in accommodation spaces

Steam lines are not to pass through accommodation spaces, unless they are intended for heating purposes.

15.3.7 Turbine connections

a) A sentinel valve or equivalent is to be provided at the exhaust end of all turbines. The valve discharge outlets are to be visible and suitably guarded if necessary.

b) Bled steam connections are to be fitted with non-return valves or other approved means to prevent steam and water returning to the turbines.

15.3.8 Strainers

a) Efficient steam strainers are to be provided close to the inlets to ahead and astern high pressure turbines or, alternatively, at the inlets to manoeuvring valves.

b) Where required by the manufacturer of the auxiliaries, steam strainers are also to be fitted in the steam lines supplying these auxiliaries.

16 Boiler feed water and condensate systems

16.1 Application

16.1.1 This Article applies to:

- feed water systems of oil fired and exhaust gas boilers
- steam drain and condensate systems.

16.2 Principle

16.2.1 General

Boiler feed water and condensate systems are to be so designed that:

- reserve feed water is available in sufficient quantity to compensate for losses
- feed water is free from contamination by oils or chlorides
- feed water for propulsion systems is suitably de-aerated.

16.2.2 Availability

a) Feed water systems are to be so designed that, in the event of failure of any one component, the steam supply to essential services can be maintained or restored.

b) Condensate systems are to be so designed that, in the event of failure of:

  - one condensate pump, or
  - the arrangements to maintain vacuum in the condenser,

  the steam supply to essential services can be maintained. Partial reduction of the propulsion capability may be accepted.

16.3 Design of boiler feed water systems

16.3.1 Number of feed water systems

a) Every steam generating system which supplies essential services is to be provided with not less than two separate feed water systems from and including the feed pumps, noting that a single penetration of the steam drum is acceptable.

b) The requirement stated in item a) may be dispensed with for boilers heated exclusively by engine exhaust gases or by steam for which one feed system is considered as sufficient, provided an alternative supply of steam is available on board.

c) Each boiler is to be provided with feed regulators as specified in Ch 1, Sec 3, [5].

16.3.2 Feed pumps

a) The following pumps are to be provided:

  - at least one main feed pump of sufficient capacity to supply the boilers under nominal conditions, and
  - one standby feed pump.

b) The capacity of the standby pump may be less than that of the main feed pumps provided it is demonstrated that, taking into account the reduction of the steam plant capacity, the unit remains safely operable.

c) Main feed pumps may be either independent or driven by the main turbines. The standby feed pump is to be independent.

d) Independent feed pumps for main boilers are to be fitted with a delivery control and regulating system.

e) Unless overpressure is prevented by the feed pump characteristics, means are to be provided which will prevent overpressure in the feed water system.

f) The pressure head of feed pumps is to take into account the maximum service pressure in the boiler as well as the pressure losses in the discharge piping. The suction head of feed pumps is to be such as to prevent cavitation as far as possible.

g) Feed pumps and pipes are to be provided with valves so arranged that any one pump can be overhauled while the boilers are operating at full load.

16.3.3 Feed water tanks

a) All units fitted with boilers supplying essential services are to be provided with reserve feed water tanks.

b) Boilers are to be provided with means to supervise and control the quality of the feed water. Suitable arrangements are to be provided to preclude, as far as practicable, the entry of oil or other contaminants which may adversely affect the boiler.

c) Feed water tanks are not to be located adjacent to fuel oil tanks. Fuel oil pipes are not to pass through feed water tanks.

d) For boilers supplying essential services, one or more evaporators are to be provided, the capacity of which is to compensate for the losses of feed water due to the operation of the machines, in particular where the fuel supplied to the boilers is atomised by means of steam.

16.3.4 Provision for de-aerating feed water

A de-aerator is to be provided to ensure the de-aeration of the feed water intended for main boilers before it enters such boilers.

16.4 Design of condensate systems

16.4.1 Condensers

a) Appropriate arrangements, such as air ejectors, are to be provided to maintain vacuum in the main condenser or restore it to the required value.

b) Cooling of the main condenser is to comply with the provisions of [10.3.4].

16.4.2 Condensate pumps

a) Condensate pumps are to include at least:
   - one main condensate pump of sufficient capacity to transfer the maximum amount of condensate produced under nominal conditions, and
   - one independently driven standby condensate pump.

b) The standby condensate pump may be used for other purposes.

16.4.3 Condensate observation tanks

Any condensate from the steam heating pipes provided for fuel oil tanks and bunkers, fuel oil or lubricating oil heaters, production and processing facilities is to be led to an observation tank or some other device of similar efficiency located in a well-lighted and readily accessible position.

16.5 Control and monitoring

16.5.1 General

The provisions of this sub-article apply only to feed water and condensate systems intended for propulsion.

16.5.2 Monitoring

Alarms and safeguards are to be provided for feed water and condensate systems in accordance with Tab 32.

Note 1: Some departures from Tab 32 may be accepted by the Society in the case of units operating in restricted zones.

Table 32 : Boiler feed and condensate system

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Sea water flow or equivalent	L						
Condenser pressure	H	local					
	HH			X			
Water level in condenser (unless justified)	H	local					
Feed water salinity	H	local					
Feed water pump delivery pressure	L	local					
						X	
Feed water tank level	L						

16.5.3 Automatic controls

Automatic level control is to be provided for:

- de-aerators,
- condensers.

16.6 Arrangement of feed water and condensate piping

16.6.1 Feed water pipes are not to pass through fuel oil or lubricating oil tanks.

Pipes connected to feed water tanks are to be so arranged as to prevent the contamination of feed water by fuel oil, lubricating oil or chlorides.

Arrangements are to be made to avoid any flammable or toxic vapours from being released in the boiler feed water system through contaminated condensates.

17 Compressed air systems

17.1 Application

17.1.1 This Article applies to compressed air systems intended for essential services, and in particular to:

- starting of engines
- control and monitoring.

17.2 Principle

17.2.1 General

a) As a rule, compressed air systems are to be so designed that the compressed air delivered to the consumers:
   - is free from oil and water, as necessary
   - does not have an excessive temperature.

b) Compressed air systems are to be so designed as to prevent overpressure in any part of the systems.

17.2.2 Availability

a) Compressed air systems are to be so designed that, in the event of failure of one air compressor or one air receiver intended for starting, control purposes or other essential services, the air supply to such services can be maintained. The filling connections of the compressed air receivers shall be fitted with a non-return valve.

b) The compressed air system for starting engines intended for essential services is to be arranged so that the necessary initial charge of starting air can be developed on board the unit without external aid. If, for this purpose, an emergency air compressor or an electric generator is required, these units are to be powered by a hand-starting oil engine or a hand-operated compressor.

c) Where the compressed air is necessary for the air whistle or other safety services, it is to be available from two compressed air receivers. A separate connection, dedicated for this purpose, is to be provided directly from the compressed air main.

17.3 Design of starting air systems

17.3.1 Air supply for starting engines intended for essential services

a) The capacity of starting air systems is to allow at least 3 consecutive starts for each engine intended for essential services.

b) The capacity of starting air systems serving propulsion plants is to comply with the requirements given in Pt C, Ch 1, Sec 10, [17] of the Ship Rules.

17.3.2 Number and capacity of air compressors

a) Where engines intended for essential services are arranged for starting by compressed air, two or more air compressors are to be fitted with a total capacity sufficient to supply within one hour the quantity of air needed to satisfy the provisions of [17.3.1] charging the receivers from atmospheric pressure. This capacity is to be approximately equally divided between the number of compressors fitted, excluding the emergency compressor fitted in pursuance of item c) below.

b) At least one of the compressors is to be independent of the engines for which starting air is supplied and is to have a capacity of not less than 50% of the total required in item a).

c) Where, for the purpose of [17.2.2], an emergency air compressor is fitted, this unit is to be power driven by internal combustion engine, electric motor or steam engine.

   Suitable hand starting arrangement or independent electrical starting batteries may be accepted. In the case of small installations, a hand-operated compressor of approved capacity may be accepted.

17.3.3 Number and capacity of air receivers

a) Where engines intended for essential services are arranged for starting by compressed air, at least two air receivers are to be fitted of approximately equal capacity and capable of being used independently.

b) The total capacity of air receivers is to be sufficient to provide without replenishment the number of starts required in [17.3.1]. When other users such as control systems, whistle, etc. are connected to the starting air receivers, their air consumption is also to be taken into account.

Compressed air receivers are to comply with the requirements of Ch 1, Sec 3.

17.3.4 Air supply for starting the emergency generating set

Where the emergency generating set is arranged for starting by compressed air, the following provisions are to be complied with:

a) The starting air arrangement is to include a compressed air vessel, storing the energy dedicated only for starting of the emergency generator. The capacity of the compressed air available for starting purpose is to be sufficient to provide, without replenishment, at least three consecutive starts.

b) The compressed air starting systems may be maintained by the compressed air receivers supplying the engines intended for essential services, through a non-return valve fitted in the emergency generator space, or by an emergency air compressor which, if electrically driven, is to be supplied from the emergency switchboard.

c) All of these starting, charging and energy storing devices are to be located in the emergency generator space and are not to be used for any purpose other than the operation of the emergency generating set.

17.4 Design of control and monitoring air systems

17.4.1 Air supply

a) The control and monitoring air supply to essential services is to be available from two sources of a sufficient capacity to allow normal operation with one source out of service.

b) At least one air vessel fitted with a non-return valve is to be provided for control and monitoring purposes.

c) Pressure reduction units used in control and monitoring air systems intended for essential services are to be duplicated, unless an alternative air supply is provided.

d) Failure of the control air supply is not to cause any sudden change of the controlled equipment which may be detrimental to the safety of the unit.

17.4.2 Pressure control

Arrangements are to be made to maintain the air pressure at a suitable value in order to ensure satisfactory operation of the installation.

17.4.3 Air treatment

In addition to the provisions of [17.8.3], arrangements are to be made to ensure cooling, filtering and drying of the air prior to its introduction in the monitoring and control circuits.

17.5 Design of air compressors

17.5.1 Prevention of excessive temperature of discharged air

Air compressors are to be so designed that the temperature of discharged air cannot exceed 95°C. For this purpose, the air compressors are to provided where necessary with:

- suitable cooling means
- fusible plugs or alarm devices set at a temperature not exceeding 120°C.

17.5.2 Prevention of overpressure

a) Air compressors are to be fitted with a relief valve complying with [2.6.3].

b) Means are to be provided to prevent overpressure wherever water jackets or casings of air compressors may be subjected to dangerous overpressure due to leakage from air pressure parts.

c) Water space casings of intermediate coolers of air compressors are to be protected against any overpressure which might occur in the event of rupture of air cooler tubes.

17.5.3 Crankcase relief valves

Air compressors having a crankcase volume of at least 0,6 m^3 are to be fitted with crankcases explosion relief valves satisfying the provisions of Ch 1, Sec 2, [2.3.4].

17.5.4 Provision for draining

Air compressors are to be fitted with a drain valve.

17.6 Control and monitoring of compressed air systems

17.6.1 Monitoring

Alarms and safeguards are to be provided for compressed air systems in accordance with Tab 33.

Note 1: Some departures from Tab 33 may be accepted by the Society in the case of units operating in restricted zones.

Table 33 : Compressed air systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Compressor lubricating oil pressure (except where splash lubrication)	L						
Air pressure after reducing valves	L + H	local					
Starting air pressure before main shut-off valve	L	local + R**(1)**					
Air vessel pressure	L						

(1) Remote indication is required if starting of air compressor are remote controlled, from wheelhouse for example

17.6.2 Automatic controls

Automatic pressure control is to be provided for maintaining the air pressure in the air receivers within the required limits.

17.7 Materials

17.7.1 Pipes and valve bodies in control and monitoring air systems and in other air systems intended for non-essential services may be made of plastic in accordance with the provisions of Ch 1, App 1.

17.8 Arrangement of compressed air piping systems

17.8.1 Prevention of overpressure

Suitable pressure relief arrangements are to be provided for all systems.

17.8.2 Air supply to compressors

a) Provisions are to be made to reduce to a minimum the entry of oil into air pressure systems.

b) Air compressors are to be located in spaces provided with sufficient ventilation.

17.8.3 Air treatment and draining

a) Provisions are be made to drain air pressure systems.

b) Efficient oil and water separators, or filters, are to be provided on the discharge of compressors, and drains are to be installed on compressed air pipes wherever deemed necessary.

17.8.4 Lines between compressors, receivers and engines

All discharge pipes from starting air compressors are to be lead directly to the starting air receivers, and all starting pipes from the air receivers to engines are to be entirely separate from the compressor discharge pipe system.

17.8.5 Protective devices for starting air mains

Non-return valves and other safety devices are to be provided on the starting air mains of each engine in accordance with the provisions of Ch 1, Sec 2, [3.1.1].

18 Exhaust gas systems

18.1 General

18.1.1 Application

This Article applies to:

- exhaust gas pipes from engines and gas turbines
- smoke ducts from boilers and incinerators.

18.1.2 Principle

Exhaust gas systems are to be so designed as to:

- limit the risk of fire
- prevent gases from entering manned spaces
- prevent water from entering engines.

18.2 Design of exhaust systems

18.2.1 General

Exhaust systems are to be so arranged as to minimise the intake of exhaust gases into manned spaces, air conditioning systems and engine intakes.

18.2.2 Limitation of exhaust line surface temperature

a) Exhaust gas pipes and silencers are to be either water cooled or efficiently insulated where:
  - their surface temperature may exceed 220°C, or
  - they pass through spaces of the unit where a temperature rise may be dangerous.

b) The insulation of exhaust systems is to comply with the provisions of Ch 1, Sec 1, [3.4.1].

18.2.3 Limitation of pressure losses

Exhaust gas systems are to be so designed that pressure losses in the exhaust lines do not exceed the maximum values permitted by the engine or boiler manufacturers.

18.2.4 Intercommunication of engine exhaust gas lines or boiler smoke ducts

a) Exhaust gas from different engines is not to be led to a common exhaust main, exhaust gas boiler or economiser, unless each exhaust pipe is provided with a suitable isolating device complying with [18.2.6].

b) Smoke ducts from boilers discharging to a common funnel are to be separated to a height sufficient to prevent smoke passing from a boiler which is operating to a boiler out of action.

18.2.5 Boilers designed for alternative oil firing and exhaust gas operation

Where boilers are designed for alternative oil firing and exhaust gas operation, the exhaust gas pipe from the engine is to be fitted with an isolating device complying with [18.2.6].

18.2.6 Isolating devices

Where isolating devices are fitted on engine exhaust ducts or boiler smoke ducts, safety devices are to be provided to prevent the starting of the engine or boiler fuel burning installation if the isolating device is not in the open position. An indicator is also to be provided on the manoeuvring gear of the isolating device to show whether it is open or closed.

18.2.7 Exhaust gas pipe terminations

a) Exhaust outlets of internal combustion engines are to be fitted with efficient spark arresting devices and are to discharge outside the hazardous areas. Exhaust outlets of fired boilers are to discharge outside hazardous areas.

b) Where exhaust pipes are led overboard close to the load waterline, means are to be provided to prevent water from entering the engine or the unit.

c) Where exhaust pipes are water cooled, they are to be so arranged as to be self-draining overboard.

18.2.8 Control and monitoring

A high temperature alarm is to be provided in the exhaust gas manifolds of thermal oil heaters to detect any outbreak of fire.

18.3 Materials

18.3.1 General

Materials of exhaust gas pipes and fittings are to be resistant to exhaust gases and suitable for the maximum temperature expected.

18.3.2 Use of plastics

The use of non-metallic materials may be accepted in water cooled systems in accordance with the provisions of Ch 1, App 1.

18.4 Arrangement of exhaust piping systems

18.4.1 Provision for thermal expansion

a) Exhaust pipes and smoke ducts are to be so designed that any expansion or contraction does not cause abnormal stresses in the piping system, and in particular in the connection with engine turboblowers.

b) The devices used for supporting the pipes are to allow their expansion or contraction.

18.4.2 Provision for draining

a) Drains are to be provided where necessary in exhaust systems, and in particular in exhaust ducting below exhaust gas boilers, in order to prevent water flowing into the engine.

b) Where exhaust pipes are water cooled, they are to be so arranged as to be self-draining overboard.

18.4.3 Passage through spaces

Exhaust gas pipes and silencers which pass through spaces of the unit where a temperature rise might be dangerous are to be efficiently cooled or lagged.

18.4.4 Flexible hoses

The use of flexible hoses in water cooled exhaust systems will be given special consideration by the Society.

18.4.5 Silencers

Engine silencers are to be so arranged as to provide easy access for cleaning and overhaul.

18.4.6 Exhaust pipe termination

Exhaust pipes are to terminate in a place where the safety of helicopter operations is not impaired.

18.5 Additional requirements for exhaust gas treatment systems

18.5.1 General

Exhaust gas treatment systems are to be designed, arranged

and installed in accordance with the following requirements.

18.5.2 Design

Attention is drawn on IMO Guidelines regarding environmental performance of equipment such as Exhaust gas cleaning systems (ECGS) and Selective catalytic reduction (SCR) systems.

18.5.3 Availability

Availability of the machinery served by the exhaust gas treatment system is to be substantiated by a risk analysis.

The exhaust gas treatment equipment is to be so arranged that, in the case of failure of such equipment, propulsion power and auxiliary power supplying essential functions are not affected. Where necessary, a bypass is to be installed.

In case of black out, automatic starting of engines, if provided, is to remain effective as if no exhaust gas treatment system were installed and not detrimental to the exhaust gas treatment installation.

18.5.4 Arrangement

a) Exhaust systems connections

   As mentioned in [18.2.4], no interconnection is permitted between different exhaust piping systems for engines. In case of one exhaust gas treatment system used for several installations, interconnections may be acceptable with additional devices installed as follows:

   1) Forced ventilation is installed at the outlet of common exhaust pipe, preventing any back flow of exhaust gases in individual exhaust ducts in any possible working conditions.
   2) Individual isolating devices for exhaust pipes are to be provided on each individual exhaust pipes.

b) By-pass

   When exhaust gas treatment system may be by-passed, proper means are to be installed providing double barrier upstream from the exhaust gas treatment system, in order to enable safe inspection in exhaust gas treatment equipment in any working configuration of combustion units.

c) Use of substances mentioned in IMDG Code

   In case substances mentioned in IMDG Code are used in exhaust gas treatment systems, drainage and/or bilge pumping of compartments where such systems are located is to be separated from ship bilge system. Retention of potential leakages using coaming devices associated to spill kits is to be implemented. Drainage directly to the sea is to be avoided as far as possible.

   Treatment products tanks are not to be contiguous with tanks containing sea water, fresh water, fuel, lubricating tanks. A ventilated cofferdam between treatment product tanks and above mentioned tanks is an acceptable solution. Necessity of ventilation is to be considered on case by case basis, with relevant risk analysis.

   Treatment products tanks are not to be located in category A machinery spaces unless a specific risk analysis is submitted to the Society for approval.

   Treatment products tanks when located adjacent to or within a compartment used for other purposes are to be surrounded by coamings delimiting space fitted with a high level alarm. Bilge system of this compartment may be connected to ship bilge system. In this case, arrangements are to be made to isolate remotely this bilge suction and an alternative fixed pumping system, remotely controlled, is to be installed in order to pump liquid contained in compartment bilge and inside area delimited by coamings to chemical substance to bunkering station.

   For compartment containing treatment products tanks a risk analysis is to be provided, taking into account normal or abnormal operating conditions (failure, fluid leakage, fire) regarding human health and damage to essential equipment contained in compartment.

   Toxic or flammable product pipes, which, if damaged, would allow the product to escape from a tank, are to be fitted with a quick closing valve directly on the tank, capable of being closed from a safe position outside the compartment involved.

   Overflow pipes of product tanks are to be led to a specific tank dedicated for one kind of product. If several treatment tanks exist for a same product, overflow tank may be common.

   Sounding pipes and air pipes are to end in an open space above freeboard deck. Means in order to prevent water entry through these pipe ends in any circumstances are to be provided.

Filling systems for treatment products are to be located in places where no interference with other ship activities would happen. In case interference is unavoidable, risk analysis is to be provided in order to evaluate occurrence and level of danger for crew and passengers if any.

Filling systems are to fulfil same requirements as in [11.4.2]. Drainage of coamings if any and outlet of safety valves are to be led to a tank designed for that purpose.

In case substances covered by IEC standards 60092-502 or -506 are used, requirements regarding electric installations, dangerous areas and ventilation mentioned in these standards are to be applied and a specific risk analysis is to submitted.

Piping systems involved in process are not to pass through accommodations, control stations and service spaces.

Ventilation of compartments where treatment substances are stored or used somehow is to be separated from any ventilation systems. It has to be provided with mechanical means of ventilation. Acceptance of common ventilation with other compartments may be accepted on case by case basis subject to risk analysis.

d) Materials

Materials used for equipment and piping systems are to be suitable with fluids conveyed, not leading to early corrosion or creating hazardous gases, when in contact with treatment liquid or vapours. This requirement is also valid for coamings, save-alls, fans and ducts being part of exhaust gas treatment system.

Aluminium is to be avoided for equipment and piping systems in contact with fluids like caustic soda.

Copper is to be avoided for equipment and piping systems in contact with fluids containing ammonia.

e) Control and monitoring

Alarms and indications are to be provided in accordance with Tab 34.

Information related to exhaust gas treatment device and wash water discharge measurements is to be made available in a control station.

Table 34 : Control and monitoring for exhaust gas treatment systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Failure of exhaust fans (each fan)	X						
Exhaust temperature before entering in plastic parts, or Cooling medium flow	H L	local local					
Product tank level	H **(1)**	local**(1)**					
(1) High level alarm is to be independent from the tank level indicator.							

19 Oxyacetylene welding systems

19.1 Application

19.1.1 This Article applies to centralised fixed plants for oxyacetylene welding installed on units. It may also be applied, at the discretion of the Society, to other plants using liquefied gas, such as propane.

19.2 Definitions

19.2.1 Centralised plants for oxyacetylene welding

A centralised plant for oxyacetylene welding is a fixed plant consisting of a gas bottle room, distribution stations and distribution piping, where the total number of acetylene and oxygen bottles exceeds 4.

19.2.2 Gas bottle rooms

A gas bottle room is a room containing acetylene and oxygen bottles, where distribution headers, non-return and stop valves, pressure reducing devices and outlets of supply lines to distribution stations are also installed.

19.2.3 Distribution stations

Distribution stations are adequately protected areas or cabinets equipped with stop valves, pressure regulating devices, pressure gauges, non-return valves and oxygen as well as acetylene hose connections for the welding torch.

19.3 Design of oxyacetylene welding systems

19.3.1 General

No more than two distribution stations are normally permitted.

19.3.2 Acetylene and oxygen bottles

a) The bottles are to be tested under attendance of the Society or by a body recognised by the Society.

b) Bottles with a capacity exceeding 50 litres are not permitted.

c) Bottles supplying the plant and spare bottles are to be installed in the gas bottle room. Installation within accommodation spaces, service spaces, control stations and machinery spaces is not permitted.

d) Bottles are to be installed in a vertical position and are to be safely secured. The securing system is to be such as to allow the ready and easy removal of the bottles.

19.3.3 Piping systems

a) In general, the acetylene and oxygen piping systems are to comply with the following provisions:
- all valves and fittings as well as welding torches and associated supply hoses are to be adapted to this specific service and suitable for the conditions expected in the different parts of the system
- acetylene piping is to be of stainless steel and seamless drawn
- oxygen piping is to be of copper or stainless steel and seamless drawn
- the connections between the various pipe sections are to be carried out by means of butt welding. Other types of connections including threaded connections and flange connections are not permitted
- only a minimum number of unavoidable connections are permitted provided they are located in a clearly visible position.

b) High pressure lines (i.e. lines between bottles and pressure reducing devices) are to be installed inside the gas bottle room and are to comply with the following provisions:
- acetylene and oxygen piping and associated fittings are to be suitable for a design pressure of 29,5 MPa
- a non-return valve is to be installed on the connection of each acetylene and oxygen bottle to the header
- stop valves are to be provided on the bottles and kept shut when distribution stations are not working.

c) Low pressure lines (i.e. lines between pressure reducing devices and distribution stations) are to comply with the following provisions:
- for low pressure lines, black steel pipes seamless drawn could be also acceptable provided that:
    - a thickness is not less than 2,5 mm when installed in the open air
    - a thickness is not less than 2,0 mm when installed indoor
- supply lines to each distribution station are to include, at the station inlet:
    - a stop valve to be kept shut when the station is not working
    - devices to protect the supply lines from back flow of gas or flame passage.

d) Safety valves are to be provided on the low pressure side of the pressure reducing devices and led to the open air at least 3 m above the deck in a safe location where no source of ignition is present.

19.4 Arrangement of oxyacetylene welding systems

19.4.1 Gas bottle rooms

a) The gas bottle room is to be located in an independent space over the highest continuous deck and provided with direct access from outside. The limiting bulkheads and decks are to be gas-tight and made of steel.

b) When the total number of gas bottles, including possible spare bottles which are not connected to the plant, does not exceed 8, acetylene and oxygen bottles may be installed in the same room. Otherwise, acetylene and oxygen bottles are to be separated by a gas-tight bulkhead.

c) The bottle room is to be adequately insulated and ventilated so that the temperature inside does not exceed 40°C. If the temperature cannot be controlled by means of natural ventilation, mechanical and independent ventilation is to be provided. Air outlets are to be led at least 3 m away from ignition sources and ventilation intakes and are to be equipped with flameproof wire gauze.

d) The gas bottle room is not to be used for other services on board. Flammable oil or gas piping, except that related to the oxyacetylene welding plant, is not to be led through this room.

Note 1: On small units, gas bottles may be installed on open deck in a safe position to the satisfaction of the Society. In such case, appropriate protection is to be provided:
- for gas bottles, against sunrays and atmospheric agents, by means of watertight covers
- for the associated valves, piping and fittings, by means of steel covers, metal grids or similar devices.

Such means of protection are to be easily removable to allow bottle removal, when necessary.

When the total number of bottles exceeds 8, acetylene bottles are to be separated from oxygen bottles.

19.4.2 Distribution stations

Distribution stations are to be located in the engine room or in the workshop, in a well-ventilated position and protected against possible mechanical damage.

Note 1: On small units, distribution stations may also be installed in the open air, enclosed in a cabinet with a locked door, or in controlled access areas, to the satisfaction of the Society.

19.4.3 Piping

a) Piping is not to be led through accommodation or service spaces.

b) Piping is to be protected against any possible mechanical damage.

c) In way of deck or bulkhead penetrations, piping is to be suitably enclosed in sleeves so arranged as to prevent any fretting of the pipe with the sleeve.

19.4.4 Signboards

Signboards are to be posted on board the unit in accordance with Tab 35.

Table 35 : Signboards

Location of the signboard	Signboard to be posted
in the gas bottle room	diagram of the oxyacetylene plant
	"no smoking"
in way of: • bottle stop valves • distribution station stop valves	"to be kept shut when distribution stations are not working"
in way of the pressure reducing devices	indication of the maximum allowable pressure at the pressure reducing device outlet
in way of the safety valve discharge outlet	"no smoking"

20 Certification, inspection and testing of piping systems

20.1 Application

20.1.1 This Article defines the certification and workshop inspection and testing programme to be performed on:

- the various components of piping systems
- the materials used for their manufacture.

On board testing is dealt with in Ch 1, Sec 11.

20.2 Type tests of flexible hoses and expansion joints

20.2.1 General

a) Prototype test programmes are to be submitted by the manufacturer and are to be sufficiently detailed to demonstrate performance in accordance with the specified standards.

b) Prototype test programmes are to be made in accordance with recognised standards which are suitable for the intended service of the flexible hose or of an expansion joint.

c) Tests are to take into consideration the maximum anticipated in-service pressures, vibration frequencies and forces due to the installation.

d) All flexible hose assemblies or expansion joints are to be satisfactorily prototype burst tested to an international standard (see Note 1) to demonstrate that they are able to withstand a pressure not less than 4 times their design pressure without indication of failure or leakage.

Note 1: The international standards (e.g. EN or SAE standards) for burst testing of non-metallic hoses require the pressure to be increased until burst without any holding period. Burst is to occur at a pressure greater than 4 times the maximum working pressure.

20.2.2 Flexible hoses

a) For flexible hoses which are to comply with [2.7], prototype tests are to be carried out for each size of hose assembly.

However, for ranges with more than 3 different diameters, the prototype tests are to be carried out for at least:

- the smallest diameter
- the largest diameter
- intermediate diameters selected based on the principle that prototype tests carried out for a hose assembly with a diameter D are considered valid only for the diameters ranging between 0,5 D and 2 D.

For fire resistance tests the specimens are to be selected in accordance with ISO 15540:2016.

b) The flexible hoses subjected to the tests are to be fitted with their connections.

c) Type approval tests are to be carried out in accordance with the prototype test programmes required in [2.7.4], including, but not limited to, the scope of testing specified in Tab 36 for metallic flexible hoses and in Tab 40 for non-metallic flexible hoses.

Table 36 : Type tests and procedures for metallic flexible hoses depending on the application

	Burst	Pliability (bending)	Cycle test: U bend (Hoses up to 100 DN)	Cycle test: Cantilever bend (Hoses above DN 100)	Pressure and elongation	Impulse	Vibration
	ISO 10380:2012 **(1)**					**(2)**	Ch 3, Sec 6, Tab 1 **(1)**
Fuel Oil	X	X	X	X	X	**(3)**	**(4)**
Lubricating Oil	X	X	X	X	X	**(3)**	**(4)**
Hydraulic Oil	X	X	X	X	X	**(3)**	**(4)**
Thermal Oil	X	X	X	X	X	**(3)**	**(4)**
Fresh water	X	X	X	X	X	**(3)**	**(4)**
Sea water	X	X	X	X	X	**(3)**	**(4)**
Compressed air	X	X	X	X	X	**(3)**	**(4)**
Bilge	X	X	X	X	X	**(3)**	**(4)**
Exhaust Gas	X	X	X	X	X	**(3)**	**(4)**

(1) Other recognized standards may be accepted where agreed by the Society.
(2) Impulse pressure is to be raised from 0 to 1,5 times the design pressure with a frequency equal to 30-100 cycles per minute for at least 150 000 cycles.
(3) For piping systems subject to pressure pulsation.
(4) Where fitted to engines, pumps, compressors or other sources of high vibrations.

Table 37 : Type tests and procedures for non-metallic flexible hoses depending on the application

	Burst	Fire resistance	Visual inspection and dimensional check	Change in length	Resistance against liquid	Cover adhesion	Ozone resistance **(2)**	Impulse	Vibration	Vacuum	Cold flexibility
	EN ISO 1402:2021 **(1)**	EN ISO 15540:2016 / EN ISO 15541:2016 **(1)**	EN ISO 4671:2022 **(1)**	EN ISO 1402:2021 **(1)**	ISO 1817:2022 **(1)**	EN ISO 8033:2016 **(1)**	ISO 7326:2016 **(1)**	EN ISO 6802:2018 / EN ISO 6803:2017 **(1)**	Ch 3, Sec 6, Tab 1 **(1)**	EN ISO 7233:2016 **(1)**	EN ISO 10619-2:2021 **(1)**
Fuel Oil	X	X	X	X	X	X	X	**(3)**	**(4)**	**(5)**	**(6)**
Lubricating Oil	X	X	X	X	X	X	X	**(3)**	**(4)**	**(5)**	**(6)**
Hydraulic Oil	X	X	X	X	X	X	X	**(3)**	**(4)**	**(5)**	**(6)**
Thermal Oil	X	X	X	X	X	X	X	**(3)**	**(4)**	**(5)**	**(6)**
Fresh water	X		X	X		X	X	**(3)**	**(4)**	**(5)**	**(6)**
Sea water	X	X	X	X		X	X	**(3)**	**(4)**	**(5)**	**(6)**
Compressed air	X		X	X		X	X	**(3)**	**(4)**	**(5)**	**(6)**
Bilge	X		X	X		X	X	**(3)**	**(4)**	**(5)**	**(6)**
Exhaust Gas	X		X	X		X	X	**(3)**	**(4)**	**(5)**	**(6)**

(1) Other recognized standards may be accepted where agreed by the Society.
(2) For rubber hoses only.
(3) For piping systems subject to pressure pulsation.
(4) Where fitted to engines, pumps, compressors or other sources of high vibrations.
(5) For suction hoses only.
(6) For piping systems subject to low temperature (< 0°C).

20.2.3 Expansion joints

a) For the expansion joints which are to comply with [2.7], relevant type approval tests are to be carried out on a representative sampling on each type and for each pressure range.

b) The expansion joints subjected to the tests are to be fitted with their connections.

c) Type approval tests are to be carried out in accordance with the prototype test programmes required in [2.7.4], including, but not limited to, the scope of testing specified in Tab 38 for metallic expansion joints and in Tab 39 for non-metallic expansion joints.

d) Exemptions from prototype burst test may be granted for expansion joints of large diameter used on sea water lines and to large diameter expansion joints used on exhaust gas lines, except for those which are fitted directly on engines. Testing may be limited to pressure test.

20.3 Type tests of air pipe closing appliances

20.3.1 Type approval tests are to be carried out on each type and size of air pipe closing device, in accordance with Tab 40.

Table 38 : Type tests and procedures to be performed for metallic expansion joints

	Burst	Hydrostatic	Cyclic expansion **(1)**	Vibration
	see [20.2.1], item d) **(2)**	see [20.5.6]**(2)**	EJMA Code **(3)(2)**	Ch 3, Sec 6, Tab 1**(2)**
Fuel Oil	X		X	**(4)**
Lubricating Oil	X		X	**(4)**
Hydraulic Oil	X		X	**(4)**
Thermal Oil	X		X	**(4)**
Fresh water	X		X	**(4)**
Sea water	X		X	**(4)**
Compressed air	X		X	**(4)**
Bilge	X		X	**(4)**
Exhaust Gas		X	X	**(4)**

(1) For piping systems subject to expansion cycles.
(2) Other recognized standards may be accepted where agreed by the Society.
(3) Type test is an alternative. A test procedure is to be submitted to the Society for approval.
(4) Where fitted to engines, pumps, compressors or other sources of high vibrations.

Table 39 : Type tests and procedures for non-metallic expansion joints

	Burst	Fire resistance	Resistance against liquid	Cyclic expansion **(1)**	Ozone resistance	Impulse	Vibration
	[20.2.1], item d) **(2)**	EN ISO 15540:2016 / EN ISO 15541:2016 **(2)**	ISO 1817:2022 **(2)**	**(2) (3)**	ISO 7326:2016 **(2)**	EN ISO 6802:2018 / EN ISO 6803:2017 **(2)**	Ch 3, Sec 6, Tab 1 **(2)**
Fuel Oil	X	X	X	X	**(4)**	**(5)**	**(6)**
Lubricating Oil	X	X	X	X	**(4)**	**(5)**	**(6)**
Hydraulic Oil	X	X	X	X	**(4)**	**(5)**	**(6)**
Thermal Oil	X	X	X	X	**(4)**	**(5)**	**(6)**
Fresh water	X			X	**(4)**	**(5)**	**(6)**
Sea water	X	X		X	**(4)**	**(5)**	**(6)**
Compressed air	X			X	**(4)**	**(5)**	**(6)**
Bilge	X			X	**(4)**	**(5)**	**(6)**

(1) For piping systems subject to expansion cycles.
(2) Other recognized standards may be accepted where agreed by the Society.
(3) Test procedure is to be submitted to the Society for approval
(4) For rubber expansion joints only.
(5) For piping systems subject to pressure pulsation.
(6) Where fitted to engines, pumps, compressors or other sources of high vibrations

Table 40 : Type tests to be performed for air pipe closing appliances

Test to be performed	Type of air closing appliance	
	Float type	Other types
Tightness test **(1)**	X	X
Flow characteristic determination **(2)**	X	X
Impact test of floats	X	
Pressure loading test of floats	X **(3)**	

(1) The tightness test is to be carried out during immerging/emerging in water, in the normal position and at an inclination of 40 degrees.

(2) Pressure drop is to be measured versus flow rate using water.

(3) Only for non-metallic floats.

Note 1: X = required

20.4 Testing of materials

20.4.1 General

a) Detailed specifications for material tests are given in NR216.

b) Requirements for the inspection of welded joints are given in NR216.

c) The requirements of this Article do not apply to piping systems subjected to low temperatures.

20.4.2 Tests for materials

a) Where required in Tab 41, materials used for pipes, valves and other accessories are to be subjected to the following tests:
- tensile test at ambient temperature
- flattening test or bend test, as applicable
- tensile test at the design temperature, except if one of the following conditions is met:
  - the design temperature is below 200°C
  - the mechanical properties of the material at high temperature have been approved
  - the scantling of the pipes is based on reduced values of the permissible stress.

b) Plastic materials are to be subjected to the tests specified in Ch 1, App 1.

20.5 Hydrostatic testing of piping systems and their components

20.5.1 General

Pneumatic tests are to be avoided wherever possible. Where such testing is absolutely necessary in lieu of the hydraulic pressure test, the relevant procedure is to be submitted to the Society for acceptance prior to testing.

20.5.2 Hydrostatic pressure tests of piping

a) Hydrostatic pressure tests are to be carried out to the Surveyor’s satisfaction for:
- all class I and II pipes and their integral fittings
- all steam pipes, feed water pipes, compressed air pipes, and fuel oil and other flammable oil pipes with a design pressure greater than 0,35 MPa and their associated integral fittings.

b) These tests are to be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating.

Note 1: Classes of pipes are defined in [1.5.2].

c) Pressure testing of small bore pipes (less than 15 mm) may be waived at the discretion of the Surveyor, depending on the application.

d) Where the design temperature does not exceed 300°C, the test pressure is to be equal to 1,5 p.

e) Where the design temperature exceeds 300°C, the test pressure is to be as follows:
- for carbon and carbon-manganese steel pipes, the test pressure is to be equal to 2 p
- for alloy steel pipes, the test pressure P_H is to be determined by the following formula, but need not exceed 2 p:

$$p_H = 1{,}5\frac{K_{100}}{K_T}p$$

where:

K_{100} : Permissible stress for 100°C, as stated in Tab 11

K_T : Permissible stress for the design temperature, as stated in Tab 11.

Note 2: Where alloy steels not included in Tab 11 are used, the permissible stresses will be given special consideration.

f) Where it is necessary to avoid excessive stress in way of bends, branches, etc., the Society may give special consideration to the reduction of the test pressure to a value not less than 1,5 p. The membrane stress is in no case to exceed 90% of the yield stress at the testing temperature.

g) While satisfying the condition stated in b), the test pressure of pipes located on the discharge side of centrifugal pumps driven by steam turbines is not to be less than the maximum pressure liable to be developed by such pumps with closed discharge at the operating speed of their overspeed device.

h) Hydrostatic testing may be carried out after assembly on board of the piping sections under the conditions stated in Ch 1, Sec 11.

20.5.3 Hydrostatic tests of valves, fittings and heat exchangers

a) Valves and fittings non-integral with the piping system and intended for class I and II pipes are to be subjected to hydrostatic tests in accordance with standards recognised by the Society, at a pressure not less than 1,5 times the design pressure P defined in [1.3.2].

b) Valves and distance pieces intended to be fitted on the unit's side below the load waterline are to be subjected to hydrostatic tests under a pressure not less than 0,5 MPa.

c) The shells of appliances such as heaters, coolers and heat exchangers which may be considered as pressure vessels are to be tested under the conditions specified in Ch 1, Sec 3.

d) The nests of tubes or coils of heaters, coolers and heat exchangers are to be submitted to a hydraulic test under the same pressure as the fluid lines they serve.

e) For coolers of internal combustion engines, see Ch 1, Sec 2.

20.5.4 Hydrostatic tests of fuel oil bunkers and tanks not forming part of the unit's structure

Fuel oil bunkers and tanks not forming part of the unit's structure are to be subjected to a hydrostatic test under a pressure corresponding to the maximum liquid level in such spaces or in the air or overflow pipes, with a minimum of 2,40 m above the top. The minimum height is to be 3,60 m for tanks intended to contain fuel oil with a flashpoint below 60°C.

20.5.5 Hydrostatic tests of pumps and compressors

a) Cylinders, covers and casings of pumps and compressors are to be subjected to a hydrostatic test under a pressure at least equal to the test pressure p_H, in MPa, determined by the following formulae:

- $p_H = 1,5\ p$ where $p \le 4$
- $p_H = 1,4\ p + 0,4$ where $4 < p \le 25$
- $p_H = p + 10,4$ where $p > 25$

where:

p : Design pressure, in MPa, as defined in [1.3.2].

p_H is not to be less than 0,4 MPa.

b) While satisfying the condition stated in a), the test pressure for centrifugal pumps driven by steam turbines is not to be less than 1,05 times the maximum pressure likely to be recorded with closed discharge at the operating speed of the overspeed device.

c) Intermediate coolers of compressors are to undergo a hydrostatic test under a pressure at least equal to the pressure p_H defined in a). When determining p_H, the pressure p to be considered is that which may result from accidental communication between the cooler and the adjoining stage of higher pressure, allowance being made for any safety device fitted on the cooler.

d) The test pressure for water spaces of compressors and their intermediate coolers is not to be less than 1,5 times the design pressure in the space concerned, subject to a minimum of 0,2 MPa.

e) For air compressors and pumps driven by internal combustion engines, see Ch 1, Sec 2.

20.5.6 Hydrostatic test of flexible hoses and expansion joints

a) Each flexible hose or expansion joint, together with its connections, is to undergo a hydrostatic test under a pressure at least equal to twice the maximum service pressure, subject to a minimum of 1 MPa. For the expansion joints, or flexible hose used on exhaust gas lines, see [2.7.5], item d).

b) During the test, the flexible hose or expansion joint is to be repeatedly deformed from its geometrical axis.

20.6 Testing of piping system components during manufacturing

20.6.1 Pumps

a) Bilge and fire pumps are to undergo a performance test.

b) Rotors of centrifugal feed pumps for main boilers are to undergo a balancing test.

20.6.2 Centrifugal separators

Centrifugal separators used for fuel oil and lubricating oil are to undergo a running test, normally with a fuel water mixture.

20.7 Inspection and testing of piping systems

20.7.1 The inspections and tests required for piping systems and their components are summarised in Tab 41.

Table 41 : Inspection and testing at works for piping systems and their components

Item**(5)**		Tests for the materials **(1)**		Inspections and tests for the product **(1)**		
		Tests required **(7)**	Type of material certificate**(2)**	During manufacturing (NDT)	After completion	Type of product certificate**(2)**
Raw pipes	class I, ND ≥ 50 class II, ND ≥ 100	[20.4.2]	C**(3)**	[3.6.2], [3.6.3] **(4)**	[20.5.3]	C**(3)**
	class I, ND < 50 class II, ND < 100		W			W **(3)**
Valves and fittings	class I, ND ≥ 50 class II, ND ≥ 100	[20.4.2]	C	[3.6.2], [3.6.3] **(4)**	[20.5.3]	C**(3)**
	class I, ND < 50 class II, ND < 100		W			C**(3)**
Pipes, valves and fittings connected to: • the ship side • the collision bulkhead • fuel oil and lubricating oil tanks and under static pressure	ND ≥ 100	[20.4.2]	C**(3)**	[3.6.2], [3.6.3] **(4)**	[20.4.3], b)	C**(3)**
	ND < 100		W			
Flexible hoses and expansion joints		[20.4.2]	W		[20.5.6]	C**(3)**
Pumps and compressors within piping systems covered by Sections of Part C, Chapter 1**(9)**	when belonging to a class I piping system	[20.4.2]	C**(3)**		[20.5.5]	C**(3)**
	when belonging to a class II piping system	[20.4.2]	W		[20.5.5]	C**(3)**
	bilge and fire pump	[20.4.2]	W		[20.5.5] [20.6.1] a)	C**(3)**
	feed pumps for main boilers	[20.4.2]	C**(3)**	[3.6.2], [3.6.3] **(4)** **(8)**	[20.5.5] [20.6.1] b)	C**(3)**
	forced circulation pumps for main boilers	[20.4.2]	C**(3)**		[20.5.5]	C**(3)**
	when belonging to one of the following class III piping systems if design pressure exceeds 0,35 MP: • boiler feed water or forced circulating • fuel oil or other flammable oil • compressed air	[20.4.2]	W		[20.5.5]	C**(3)**
	when belonging to other class III piping systems				[20.5.5]	W
Centrifugal separators					[20.6.2]	C**(3)**

Item**(5)**		Tests for the materials **(1)**		Inspections and tests for the product **(1)**		
		Tests required **(7)**	Type of material certificate**(2)**	During manufacturing (NDT)	After completion	Type of product certificate**(2)**
Prefabricated pipeline	classes I and II with ND ≥ 65 or t ≥ 10			[3.6.2], [3.6.3] **(6)**	[20.5.2]	C**(3)**
	classes I and II with ND < 65 and t < 10			[3.6.2], [3.6.3] **(6)**	[20.5.2]	W
	class III where design pressure exceeds 0,35 MP, as follows: • steam pipes and feed water pipes • compressed air pipes • fuel oil or other flammable oil pipes				[20.5.2]	W

(1) [x.y.z] = test required, as per referent regulation. In general, the material are to comply with [2.1.2]

(2) C = class certificate; W = works' certificate.

(3) or alternative type of certificate, depending on the Survey Scheme. See Part A.

(4) if of welded construction.

(5) ND = Nominal diameter of the pipe, valve or fitting, in mm.
Class of pipping systems is to be determined in accordance with [1.5.2].

(6) for welded connections.

(7) where required by the table, material tests are to be carried out for the components subject to pressure, such as valve body, pump and compressor casings, etc. They are also to be carried out for the assembling bolts of feed water pumps and forced circulating pumps serving main boilers. Requirements for material testing are detailed in NR216, Chapter 4.

(8) for main parts, before assembling.

(9) for other pumps and compressors, see additional Rules relevant for related system.

Section 8 Thrusters

1 General

1.1 Application

1.1.1 Thrusters developing power equal to 110 kW or more

The requirements of this Section apply to the following types of thrusters developing power equal to 110 kW or more:

- transverse thrusters intended for manoeuvring
- thrusters intended for propulsion and steering.

For azimuth thrusters intended for dynamic positioning, refer to Part F, Chapter 4 of the Ship Rules.

1.1.2 Thrusters developing power less than 110 kW

Thrusters of less than 110 kW are to be built in accordance with sound marine practice and tested as required in [3.2] to the satisfaction of the Surveyor.

1.2 Definitions

1.2.1 Thruster

A thruster is a propeller installed in a revolving nozzle or in a special transverse tunnel in the ship, or a water-jet. A thruster may be intended for propulsion, manoeuvring and steering or any combination thereof. Propulsion propellers in fixed nozzles are not considered thrusters.

1.2.2 Transverse thruster

A transverse thruster is an athwartship thruster developing a thrust in a transverse direction for manoeuvring purposes.

1.2.3 Azimuth thruster

An azimuth thruster is a thruster which has the capability to rotate through 360° in order to develop thrust in any direction.

1.2.4 Continuous duty thruster

A continuous duty thruster is a thruster which is designed for continuous operation, such as a propulsion thruster.

1.2.5 Intermittent duty thruster

An intermittent duty thruster is a thruster designed for operation at full power for a period not exceeding 1 hour, followed by operation at reduced rating for a limited period of time not exceeding a certain percentage of the hours in a day and a certain (lesser) percentage of the hours in a year. In general, athwartship thrusters are intermittent duty thrusters.

1.3 Thrusters intended for propulsion

1.3.1 In general, at least two azimuth thrusters are to be fitted in ships where these are the sole means of propulsion. Single azimuth thruster installations will be specially considered by the Society on a case by case basis.

1.4 Documentation to be submitted

1.4.1 Plans to be submitted for transverse thrusters and azimuth thrusters

For thrusters developing power equal to 110 kW or more, the plans listed in Tab 1 are to be submitted.

1.4.2 Additional data to be submitted

The data and documents listed in Tab 2 are to be submitted by the manufacturer together with the plans.

Table 1 : Plans to be submitted for transverse thrusters and azimuth thrusters

No.	A/I **(1)**	ITEM
General requirements for all thrusters		
1	I	General arrangement of the thruster
2	A	Propeller, including the applicable details mentioned in Pt C, Ch 1, Sec 8 of the Ship Rules
3	A	Bearing details
4	A	Propeller and intermediate shafts
5	A	Gears, including the applicable details mentioned in Ch 1, Sec 6
Specific requirements for transverse thrusters		
6	A	Structure of the tunnel showing the materials and their thickness
7	A	Structural equipment or other connecting devices which transmit the thrust from the propeller to the tunnel
8	A	Sealing devices (propeller shaft gland and thruster-tunnel connection)
9	A	For the adjustable pitch propellers: pitch control device and corresponding monitoring system
Specific requirements for rotating and azimuth thrusters		
10	A	Structural items (nozzle, bracing, etc.)
11	A	Structural connection to hull
12	A	Rotating mechanism of the thruster
13	A	Thruster control system
14	A	Piping systems connected to thruster
(1) A = To be submitted for approval ; I = To be submitted for information		

Table 2 : Data and documents to be submitted for transverse thrusters and azimuth thrusters

No.	A/I **(1)**	ITEM
1	I	Rated power and revolutions
2	I	Rated thrust
3	A	Material specifications of the major parts, including their physical, chemical and mechanical properties
4	A	Where parts of thrusters are of welded construction, all particulars on the design of welded joints, welding procedures, heat treatments and non-destructive examinations after welding
5	I	Where applicable, background information on previous operating experience in similar applications
(1) A = To be submitted for approval ; I = To be submitted for information		

2 Design and construction

2.1 Materials

2.1.1 Propellers

For requirements relative to material intended for propellers, see Pt C, Ch 1, Sec 8, [2.1.1] of the Ship Rules.

2.1.2 Other thruster components

For the requirements relative to materials intended for other parts of the thrusters, such as gears, shaft, couplings, etc., refer to the applicable parts of the Rules.

2.2 Transverse thrusters and azimuth thrusters

2.2.1 Prime movers

a) Diesel engines intended for driving thrusters are to comply with the applicable requirements of Ch 1, Sec 2.

b) Electric motors intended for driving thrusters and their feeding systems are to comply with the requirements of Ch 2, Sec 4. In particular:

- provisions are to be made to prevent starting of the motors whenever there are insufficient generators in operation
- intermittent duty thrusters will be the subject of special consideration by the Society.

2.2.2 Propellers

a) For propellers of thrusters intended for propulsion, the requirements of Pt C, Ch 1, Sec 8, [2.5] of the Ship Rules apply.

b) For propellers of thrusters intended for manoeuvring only, the requirements of Pt C, Ch 1, Sec 8, [2.5] of the Ship Rules also apply, although the increase in thickness of 10% does not need to be applied.

2.2.3 Shafts

a) For propeller shafts of thrusters intended for propulsion, the requirements of Pt C, Ch 1, Sec 7, [2.2.3] of the Ship Rules apply.

b) For propellers of thrusters intended for manoeuvring only, the minimum diameter d_S of the shaft, in mm, is not to be less than the value obtained by the following formula:

$$d_S = [(C \cdot M_T)^2 + (D \cdot M)^2]^{1/6} \cdot \left(\frac{1}{1 - Q^4}\right)^{1/3}$$

where:

M_T : Maximum transmitted torque, in N·m; where not indicated, M_T may be assumed as 9550 (P/N)

with:

P : Maximum power of the thruster prime mover, in kW

N : Rotational speed of the propeller, in rev/min.

M : Bending moment, in N·m, at the shaft section under consideration

C : Coefficient equal to:

$$C = 10{,}2 + \frac{28000}{R_{S,MIN}}$$

D : Coefficient equal to:

$$D = \frac{170000}{412 + R_{S,MIN}}$$

with:

$R_{S,MIN}$: Minimum yield strength of the shaft material, in N/mm^2

Q :
- for solid shafts: $Q = 0$
- for hollow shafts: Q = the ratio between the diameter of the hole and the external diameter of the shaft. If $Q \leq 0{,}3$, Q may be assumed equal to 0.

d_S is to be increased by 10% in the case of keyed connection to the propeller in way of key.

2.2.4 Gears

a) Gears of thrusters intended for propulsion are to be in accordance with the applicable requirements of Ch 1, Sec 6, applying the safety factors for propulsion gears.

b) Gears of thrusters intended for manoeuvring only are to be in accordance with the applicable requirements of Ch 1, Sec 6, applying the safety factors for auxiliary gears.

2.2.5 Nozzles and connections to hull for azimuth thrusters

The scantlings of the nozzle connection to the hull and the welding type and size will be specially considered by the Society, which reserves the right to require detailed stress analysis in the case of certain high power installations.

2.2.6 Transverse thruster tunnel

a) The thickness of the tunnel is not to be less than the adjacent part of the hull.

b) Special consideration will be given by the Society to tunnels connected to the hull by connecting devices other than welding.

2.2.7 Electrical supply for steerable thrusters

The generating and distribution system is to be designed in such a way that the steering capability of the thruster can be maintained or regained within a period of 45 seconds, in the event of single failure of the system, and that the effectiveness of the steering capability is not reduced by more than 50% under such conditions. Details of the means provided for this purpose are to be submitted to the Society.

2.3 Alarm, monitoring and control systems

2.3.1 Steering thruster controls

a) Controls for steering are to be provided from the navigating bridge, the machinery control station and locally.

b) Means are to be provided to stop any running thruster at each of the control stations.

c) A thruster angle indicator is to be provided at each steering control station. The angle indicator is to be independent of the control system.

2.3.2 Alarm and monitoring equipment

Tab 3 summarises the minimum alarm and monitoring requirements for propulsion and steering thrusters.

Table 3 : Azimuth thrusters

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Thruster			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Steering oil pressure	L						
Oil tank level	L						

3 Testing and certification

3.1 Material tests

3.1.1 Propulsion and steering thrusters

All materials intended for parts transmitting torque and for propeller/impeller blades are to be tested in accordance with the requirements of Pt C, Ch 1, Sec 8, [4.1] of the Ship Rules, in the presence of a Surveyor.

3.1.2 Transverse thrusters

Material testing for parts of athwartship thrusters does not need to be witnessed by a Surveyor, provided full test reports are made available to him.

3.2 Testing and inspection

3.2.1 Thrusters

Thrusters are to be inspected as per the applicable requirements of Pt C, Ch 1, Sec 8, [4.2] of the Ship Rules.

3.2.2 Prime movers

Prime movers are to be tested in accordance with the requirements applicable to the type of mover used.

3.3 Certification

3.3.1 Certification of thrusters

Thrusters are to be individually tested and certified by the Society.

3.3.2 Mass produced thrusters

Mass produced thrusters may be accepted within the framework of the type approval program of the Society.

Section 9 Refrigerating Installations

1 General

1.1 Application

1.1.1 Refrigerating installations on all ships

The minimum safety requirements addressed in this Section are to be complied with for any refrigerating plant installed on board a ship to be classed by the Society. These requirements do not cover any operation or availability aspect of the plants, which are not the subject of class requirements, unless an additional notation is requested.

2 Minimum design requirements

2.1 Refrigerating installation components

2.1.1 General

In general, the specific requirements stated in Part C of the Rules for various machinery and equipment are also applicable to refrigerating installation components.

2.1.2 Pressure vessels and heat exchangers

a) Pressure vessels of refrigerating plants are to comply with the relevant requirements of Ch 1, Sec 3.

b) Vessels intended to contain ammonia or toxic substances are to be considered as class 1 pressure vessels as indicated in Ch 1, Sec 3, [1.4].

c) The materials used for pressure vessels are to be appropriate to the fluid that they contain. Where ammonia is the refrigerant, copper, bronze, brass and other copper alloys are not to be used.

d) Notch toughness of steels used in low temperature plants is to be suitable for the thickness and the lowest design temperature. A check of the notch toughness properties may be required where the working temperature is below minus 40°C.

2.1.3 Piping systems

a) Refrigerant pipes are generally to be regarded as pressure pipes.

b) Refrigerant, brine and sea water pipes are to satisfy the requirements of Ch 1, Sec 7 as applicable.

c) Refrigerant pipes are to be considered as belonging to the following classes:

- class I: where they are intended for ammonia or toxic substances
- class II: for other refrigerants
- class III: for brine.

d) In general, the pipes conveying the cooling medium are not to come into direct contact with the unit's structure; they are to be carefully insulated on their run outside the refrigerated spaces, and more particularly when passing through bulkheads and decks.

e) The materials used for the pipes are to be appropriate to the fluids that they convey. Copper, brass, bronze and other copper alloys are not to be used for pipes likely to convey ammonia. Methods proposed for joining such pipes are to be submitted to the Society for consideration.

f) Notch toughness of the steels used is to be suitable for the application concerned.

g) Where necessary, cooling medium pipes within refrigerated spaces or embedded in insulation are to be externally protected against corrosion; for steel pipes, this protection is to be ensured by galvanisation or equivalent. All useful precautions are to be taken to protect the joints of such pipes against corrosion.

h) The use of plastic pipes will be considered by the Society on a case by case basis.

2.2 Refrigerants

2.2.1 Prohibited refrigerants

The use of the following refrigerants is not allowed for shipboard installations:

- Methyl chloride
- R11 - Trichloromonofluoromethane ($C Cl_3 F$)
- Ethane
- Ethylene
- Ozone depleting substances
- Other substances with lower explosion limit in air of more than 3,5%.

2.2.2 Statutory requirements

Particular attention is to be paid to any limitation on the use of refrigerants imposed by the Administration of the State whose flag the unit is flying.

2.2.3 Toxic or flammable refrigerants

The arrangement of refrigerating machinery spaces of plants using toxic or flammable refrigerants will be the subject of special consideration by the Society.

For specific requirements on spaces intended for plants using ammonia as a refrigerant, see [2.3].

2.3 Special requirements for ammonia (R717)

2.3.1 Refrigerating machinery compartment

a) The refrigerating machinery compartment and the compartments where ammonia bottles are stored are to be separated by gastight bulkheads from the accommodation spaces, the engine room (including the shaft tunnel) and other machinery spaces intended for essential services. This requirement does not apply to plants using less than 25 kg of ammonia.

b) The space is to be arranged with a ventilation system, distinct from that of other spaces, having a capacity of at least 30 changes per hour. Provision is to be made for starting and stopping the ventilation fans from outside the refrigerated space.

c) A fire-extinguishing water spray system is to be provided for any ammonia machinery space, in particular in way of the access doors. The actuating device is to be fitted closed to the entrance outside the protected space.

d) At least two access doors are to be provided. One of these doors is to be used for emergency and is to lead directly to an open space. The doors are to open outwards and are to be self-closing.

e) Where the access to a refrigerating machinery space is through an accommodation or machinery space, the ventilation of the former is to be such as to keep it under negative pressure with respect to the adjacent space, or, alternatively, the access is to be provided with an air lock.

f) An independent bilge system is to be provided for the refrigerating machinery space.

g) At least two sets of breathing apparatus and protective clothing are to be available outside and in the vicinity of the ammonia machinery space.

h) All electrical equipment and apparatus in the space is to be arranged such that it may be shut off by a central switch located outside the space. This switch is not to control the ventilation system.

2.3.2 Ammonia in machinery spaces

When installation of ammonia is allowed in the machinery space in accordance with the provision of [2.3.1] item a), the area where ammonia machinery is installed is to be served by a hood with a negative ventilation system, having a capacity of not less than 30 changes per hour, independent from any other ventilation system of the unit, so as to prevent any leakage of ammonia from dissipating into other areas.

The periphery of the hood is to be fitted with a drenching water system operable locally and from the outside of the machinery space.

2.3.3 Unattended machinery spaces

Where the refrigerating machinery spaces are not permanently attended, a gas detection system with an audible and visual alarm is to be arranged in a suitable location. This system is also to stop the compressor when a flammable gas concentration is reached.

2.3.4 Segregation

Ammonia piping is not to pass through accommodation spaces.

Section 10 Self Elevating Systems

1 General

1.1

1.1.1 For self elevating systems, reference is made to NR534 Classification of Self-Elevating Units.

Section 11 Tests on Board

1 General

1.1 Application

1.1.1 This Section covers the tests to be carried out on board the unit, both at the moorings and during sea trials. Such tests are additional to the workshop tests required in the other Sections of this Chapter.

1.1.2 For self-propelled units, refer to Pt C, Ch 1, Sec 15 of the Ship Rules, in particular as regards:
- navigation and manoeuvring
- tests of electric propulsion systems
- tests of propulsion engines, turbines, and gears
- tests of propulsion shafting and propellers
- tests of steering gears.

1.2 Purpose of the tests on board the unit

1.2.1 On board tests are intended to demonstrate that the essential machinery and associated systems are functioning properly, in respect of the criteria imposed by the Rules. The tests are to be witnessed by a Surveyor.

1.3 Documentation to be submitted

1.3.1 A comprehensive list of the tests intended to be carried out by the shipyard is to be submitted to the Society.

For each test, the following information is to be provided:
- scope of the test
- parameters to be recorded.

2 General requirements for on board tests

2.1 Trials at the moorings

2.1.1 Trials at the moorings are to demonstrate the following:
- satisfactory operation of the machinery
- quick and easy response to operational commands
- protection of the various installations, as regards:
  - the protection of mechanical parts
  - the safeguards for personnel
- accessibility for cleaning, inspection and maintenance.

Where the above features are not deemed satisfactory and require repairs or alterations, the Society reserves the right to require the repetition of the trials at the moorings, either wholly or in part, after such repairs or alterations have been carried out.

2.2 Sea trials

2.2.1 Scope of the tests

Sea trials are to be conducted after the trials at the moorings and are to include the following:
- demonstration of the proper operation of the main and auxiliary machinery, including monitoring, alarm and safety systems, under realistic service conditions
- for propelled units, check of the propulsion capability when one of the essential auxiliaries becomes inoperative
- detection of dangerous vibrations by taking the necessary readings when required.

3 On board tests for machinery

3.1 Tests of boilers

3.1.1 General

The satisfactory operation of the main and auxiliary boilers supplying essential services is to be ascertained in all operating conditions during the trials at the moorings and the sea trials.

3.1.2 Tests to be performed

After installation on board, the following tests are to be carried out in the presence of the Surveyor:

- Test in the hot condition of boilers and superheaters
- Accumulation tests and setting of safety valves of boilers and superheaters
  - safety valves are to be set to lift at a pressure not exceeding 103% of the design pressure
  - for boilers fitted with superheaters, the safety valves of the latter are to be set to lift before or, at the latest, at the same time as the valves of the saturated steam chest.
- Verification that, at the maximum steaming rate, the boiler pressure does not exceed 110% of the design pressure when the stop valves of the boiler, except those which must remain open for the burning operation, are closed. The boiler is to be fed so that the water level remains normal throughout the test. The test is to last:
  - 15 minutes for fire tube boilers
  - 7 minutes for water tube boilers.
- Test and simulation of all safety devices, alarms, shut-off and automatic starting of standby equipment.

3.1.3 Alternative requirement

a) When it is recognised, for certain types of boilers, that accumulation tests might endanger the superheaters, the omission of such tests may be considered.

b) Such omission can be permitted, however, only if the drawings and the size of safety valves have been reviewed by the Society, and provided that the safety valves are of a type whose relieving capacity has been established by a test carried out in the presence of the Surveyor, or in other conditions deemed equivalent to those of the actual boiler.

c) When the Society does not agree to proceed with an accumulation test, the valve manufacturer is to supply, for each safety valve, a certificate specifying its relieving capacity for the working conditions of the boiler. In addition, the boiler manufacturer is to supply a certificate specifying the maximum steam capacity of the boiler.

3.2 Tests of diesel engines

3.2.1 Objectives

The purpose of the shipboard testing is to verify compatibility with power transmission and driven machinery in the system, control systems and auxiliary systems necessary for the engine and integration of engine / shipboard control systems, as well as other items that had not been dealt with in the FAT (Factory Acceptance Testing).

3.2.2 Starting capacity

Starting manoeuvres are to be carried out in order to verify that the capacity of the starting media satisfies the required number of start attempts.

3.2.3 Monitoring and alarm system

The monitoring and alarm systems are to be checked to the full extent for all engines, except items already verified during the works trials.

3.2.4 Test loads

a) Test loads for various engine applications are given below. In addition, the scope of the trials may be expanded depending on the engine application, service experience, or other relevant reasons.

b) The suitability of the engine to operate on fuels intended for use is to be demonstrated.

c) Tests other than those listed below may be required by statutory instruments (e.g. EEDI verification).

d) Propulsion engines driving fixed pitch propeller or impeller.

- At rated engine speed n_0: at least 4 hours.
- At engine speed 1,032 n_0 (if engine adjustment permits): 30 min.
- At approved intermittent overload (if applicable): testing for duration as agreed with the manufacturer.
- Minimum engine speed to be determined.
- The ability of reversible engines to be operated in reverse direction is to be demonstrated.

Note 1: During stopping tests according to IMO Resolution MSC.137 (76), see [3.2.5] for additional requirements in the case of a barred speed range.

e) Propulsion engines driving controllable pitch propellers.

- At rated engine speed n0 with a propeller pitch leading to rated engine power (or to the maximum achievable power if 100% cannot be reached): at least 4 hours.
- At approved intermittent overload (if applicable): testing for duration as agreed with the manufacturer.
- With reverse pitch suitable for manoeuvring, see [3.2.5] for additional requirements in the case of a barred speed range.

f) Engine(s) driving generator(s) for electrical propulsion and/or main power supply

- At 100% power (rated electrical power of generator): at least 60 min.
- At 110% power (rated electrical power of generator): at least 10 min.

Note 2: Each engine is to be tested 100% electrical power for at least 60 min and 110% of rated electrical power of the generator for at least 10 min. This may, if possible, be done during the electrical propulsion plant test, which is required to be tested with 100% propulsion power (i.e. total electric motor capacity for propulsion) by distributing the power on as few generators as possible. The duration of this test is to be sufficient to reach stable operating temperatures of all rotating machines or for at least 4 hours. When some of the gen. set(s) cannot be tested due to insufficient time during the propulsion system test mentioned above, those required tests are to be carried out separately.

- Demonstration of the generator prime movers' and governors' ability to handle load steps as described in Ch 1, Sec 2, [2.7].

g) Propulsion engines also driving power take off (PTO) generator.

- 100% engine power (MCR) at corresponding speed n_0: at least 4 hours.
- 100% propeller branch power at engine speed n_0 (unless covered in previous bullet point): 2 hours.
- 100% PTO branch power at engine speed n0: at least 1 hour.

h) Engines driving auxiliaries.

- 100% power (MCR) at corresponding speed n_0: at least 30 min.
- Approved intermittent overload: testing for duration as approved.

3.2.5 Torsional vibration - barred speed range

Where a barred speed range (bsr) is required, passages through this bsr, both accelerating and decelerating, are to be demonstrated. The times taken are to be recorded and are to be equal to or below those times stipulated in the approved documentation, if any. This also includes when passing through the bsr in reverse rotational direction, especially during the stopping test.

Note 1: Applies both for manual and automatic passing-through systems.

The ship's draft and speed during all these demonstrations is to be recorded. In the case of a controllable pitch propeller, the pitch is also to be recorded.

The engine is to be checked for stable running (steady fuel index) at both upper and lower borders of the bsr. Steady fuel index means an oscillation range less than 5% of the effective stroke (idle to full index).

3.3 Tests of steam turbines

3.3.1 Turbines driving electric generators or auxiliary machines are to be run for at least 4 hours at their rated power and for 30 minutes at 110% of rated power.

During the trials all safety, alarm, shut-off and control systems associated to the turbine are to be tested or properly simulated.

3.4 Tests of gas turbines

3.4.1 Turbines driving electric generators or auxiliary machines are to be run for at least 4 hours at their rated power and for 30 minutes at 110% of rated power.

During the trials all safety, alarm, shut-off and control systems associated to the turbine are to be tested or properly simulated.

3.5 Tests of gears

3.5.1 Tests during sea trials

During the sea trials, the performance of reverse and/or reduction gearing is to be verified, both when running ahead and astern.

In addition, the following checks are to be carried out:

- check of the bearing and oil temperature
- detection of possible gear hammering
- test of the monitoring, alarm and safety systems.

3.5.2 Check of the tooth contact

- Prior to the sea trials, the tooth surfaces of the pinions and wheels are to be coated with a thin layer of suitable coloured compound.

  Upon completion of the trials, the tooth contact is to be inspected. The contact marking is to appear uniformly distributed without hard bearing at the ends of the teeth and without preferential contact lines.

  The tooth contact is to comply with Tab 1.
- The verification of tooth contact at sea trials by methods other than that described above will be given special consideration by the Society.
- In the case of reverse and/or reduction gearing with several gear trains mounted on roller bearings, manufactured with a high standard of accuracy and having an input torque not exceeding 20000 N·m, the check of the tooth contact may be reduced at the Society's discretion.

  Such a reduction may also be granted for gearing which has undergone long workshop testing at full load and for which the tooth contact has been checked positively.

  In any case, the teeth of the gears are to be examined by the Surveyor after the sea trials. Subject to the results, additional inspections or re-examinations after a specified period of service may be required.

Table 1 : Tooth contact for gears

Heat treatment and machining	Percentage of tooth contact	
	across the whole face width	of the tooth working depth
quenched and tempered, cut	70	40
• quenched and tempered, shaved or ground • surface-hardener	90	40

3.6 Tests of piping systems

3.6.1 Hydrostatic tests of piping after assembly on board

- When the hydrostatic tests of piping referred to in Ch 1, Sec 7, [20.5.2] are carried out on board, they may be carried out in conjunction with the leak tests required in [3.6.2].
- Low pressure pipes, such as bilge or ballast pipes are to be tested, after fitting on board, under a pressure at least equal to the maximum pressure to which they can be subjected in service. Moreover, the parts of such pipes which pass, outside pipe tunnels, through compartments for ballast water, fresh water, fuel or liquid cargo, are to be fitted before the hydraulic test of the corresponding compartments.
- Heating coils in oil fuel tanks or in liquid cargo tanks and fuel pipes are to be subjected, after fitting on board, to a hydraulic test under a pressure not less than 1,5 times the design pressure, with a minimum of 4 bars.

3.6.2 Leak tests

Except otherwise permitted by the Society, all piping systems are to be leak tested under operational conditions after completion on board.

3.6.3 Functional tests

During the sea trials, piping systems serving propulsion and auxiliary machinery, including the associated monitoring and control devices, are to be subjected to functional tests at the nominal power of the machinery. Operating parameters (pressure, temperature, consumption) are to comply with the values recommended by the equipment manufacturer.

3.6.4 Performance tests

The Society reserves the right to require performance tests, such as flow rate measurements, should doubts arise from the functional tests.

4 Inspection of machinery after sea trials

4.1 General

4.1.1 For all types of essential machinery, those parts which have not operated satisfactorily in the course of the sea trials, or which have caused doubts to be expressed as to their proper operation, are to be disassembled or opened for inspection.

Machinery or parts which are opened up or disassembled for other reasons are to be similarly inspected.

Should the inspection reveal defects or damage of some importance, the Society may require other similar machinery or parts to be opened up for inspection.

An exhaustive inspection report is to be submitted to the Society for information.

4.2 Diesel engines

4.2.1 In general, for all diesel engines, the following items are to be verified:

- the deflection of the crankshafts
- the cleanliness of the lubricating oil filters.

In the case of engines for which power tests have not been carried out in the workshop, some parts, agreed upon by the interested parties, are to be disassembled for inspection after the sea trials.

Appendix 1 Plastic Pipes

1 General

1.1 Application

1.1.1 These requirements are applicable to pipes / piping systems made of plastic or made predominantly of other material than metal.

1.1.2 The requirements are not applicable to mechanical and flexible couplings used in metallic piping systems.

1.1.3 Piping systems made of thermoplastic materials, such as polyethylene (PE), polypropylene (PP), polybutylene (PB) and intended for non-essential services are to meet the requirements of recognized standards and of Articles [3] and [4] of this Appendix.

1.2 Use of plastic pipes

1.2.1 Plastic may be used in piping systems in accordance with the provisions of Ch 1, Sec 7, [2.1.3], provided the following requirements are complied with.

1.2.2 Plastic pipes are to be type approved by the Society.

1.3 Definitions

1.3.1 Plastic

Plastic includes both thermoplastic and thermosetting plastic materials with or without reinforcement, such as PVC and FRP (reinforced plastics pipes). Plastic includes synthetic rubber and materials of similar thermo/mechanical properties.

1.3.2 Piping systems

In this Appendix, pipes/piping systems means those made of plastic(s) and includes the pipes, fittings, system joints, method of joining and any internal or external liners, coverings and coatings required to comply with the performance criteria.

1.3.3 Joints

Joints include all pipe assembling devices or methods, such as adhesive bonding, laminating, welding, etc.

1.3.4 Fittings

Fittings include bends, elbows, fabricated branch pieces, etc. made of plastic materials.

1.3.5 Nominal pressure

Nominal pressure is the maximum permissible working pressure which is to be determined in accordance with [2.2.3].

1.3.6 Fire endurance

Fire endurance is the capability of the piping system to perform its intended function, i.e. maintain its strength and integrity, for some predicted period of time while exposed to fire.

1.4 Recognised standards

1.4.1 The following standard is recognised by the Society for design, manufacture, installation and qualification of plastic pipe systems:

- ISO 14692:2002: Petroleum and natural gas industries - Glass-reinforced plastics (GRP) piping.

Alternative standards may also be considered subject to the Society approval.

2 Design of plastic piping systems

2.1 General

2.1.1 Specification

The specification of the plastic piping is to be submitted in accordance with the provisions of Ch 1, Sec 7, [1.2.2]. It is to comply with a recognised national or international standard approved by the Society. In addition, the requirements stated below are to be complied with.

2.1.2 Marking

Plastic pipes and fittings are to be permanently marked with identification, including:

- pressure ratings
- the design standards that the pipe or fitting is manufactured in accordance with
- the material of which the pipe or fitting is made.

2.2 Strength

2.2.1 General

a) The piping is to have sufficient strength to take account of the most severe concomitant conditions of pressure, temperature, the weight of the piping itself and any static and dynamic loads imposed by the design or environment.

b) The strength of the pipes is to be determined at the maximum possible working temperature by the tests mentioned in [4.1.2].

2.2.2 Pipe thickness

Plastic pipes thickness is to be calculated using a maximum allowable stress not higher than 1/7 of the ultimate tensile strength of the material at the service temperature.

Minimum pipe thickness is to be in accordance with a recognised standard as defined in [1.4].

2.2.3 Permissible pressure

Piping systems are to be designed for a nominal pressure determined from the following conditions:

a) Internal pressure

The nominal internal pressure is not to exceed the smaller of:

- $P_{sth} / 4$
- $P_{lth} / 2,5$

where:

P_{sth} : Short-term hydrostatic test failure pressure, in MPa

P_{lth} : Long-term hydrostatic test failure pressure (>100 000 hours), in MPa.

b) External pressure (to be considered for any installation subject to vacuum conditions inside the pipe or a head of liquid acting on the outside of the pipe)

The nominal external pressure is not to exceed $P_{col} / 3$, where:

P_{col} : Collapse pressure.

Note 1: The external pressure is the sum of the vacuum inside the pipe and the static pressure head outside the pipe.

c) The collapse pressure is not to be less than 0,3 MPa.

2.2.4 Permissible temperature

a) In general, plastic pipes are not to be used for media with a temperature above 60°C or below 0°C, unless satisfactory justification is provided to the Society.

b) The permissible working temperature range depends on the working pressure and is to be justified by appropriate tests.

c) The maximum permissible working temperature is to be at least 20°C lower than the minimum heat distortion temperature of the pipe material, determined according to ISO 75 method A or equivalent.

d) The minimum heat distortion temperature is not to be less than 80°C.

2.2.5 Axial strength

a) The sum of the longitudinal stresses due to pressure, weight and other loads is not to exceed the allowable stress in the longitudinal direction.

b) In the case of fibre reinforced plastic pipes, the sum of the longitudinal stresses is not to exceed half of the nominal circumferential stress derived from the nominal internal pressure condition (see [2.2.3]).

2.2.6 Impact resistance

Plastic pipes and joints are to have a minimum resistance to impact in accordance with a recognised national or international standard.

2.3 Requirements depending on service and/or location

2.3.1 Fire endurance

The requirements for fire endurance of plastic pipes and their associated fittings are given in Tab 1 for the various systems and locations where the pipes are used.

Specifically:

- A 60 min. fire endurance test in dry conditions is to be carried out according to Appendix 1 of IMO Resolution A.753(18), where indicated “L1” in Tab 1.

  Level “L1W” refers to piping systems similar to “L1” systems except these systems do not carry flammable fluid or any gas and a maximum 5% flow loss in the system after exposure is acceptable.
- A 30 min. fire endurance test in dry conditions is to be carried out according to Appendix 1 of IMO Resolution A.753(18), where indicated “L2” in Tab 1.

  Level “L2W” refers to piping systems similar to “L2” systems except a maximum 5% flow loss in the system after exposure is acceptable.
- A 30 min. fire endurance test in wet conditions is to be carried out according to Appendix 1 of IMO Resolution A.753(18), where indicated “L3” in Tab 1.
- No fire endurance test is required, where indicated “0” in Tab 1.
- A metallic material with a melting point greater than 925°C is to be used, where indicated “X” in Tab 1.

Note 1: “NA” means “not applicable”.

Table 1 : Fire endurance of piping systems

PIPING SYSTEM		LOCATION								
		Machinery spaces of category A **(10)**	Other machinery spaces and pump rooms **(11)**	Cargo pump rooms **(12)**	Cargo tanks **(13)**	Fuel oil tanks **(14)**	Ballast water tanks **(15)**	Cofferdams, void spaces, pipe tunnels and ducts **(16)**	Accommodation, service and control spaces **(17)**	Open decks **(18)(19)**
CARGO (FLAMMABLE CARGOES WITH FLASH POINT ≤ 60°C)										
Cargo lines		NA	NA	L1	0	NA	0 **(9)**	0	NA	L1 **(2)**
Crude oil washing lines		NA	NA	L1	0	NA	0 **(9)**	0	NA	L1 **(2)**
Vent lines		NA	NA	NA	0	NA	0 **(9)**	0	NA	X
INERT GAS										
Water seal effluent line		NA	NA	0 **(1)**	0 **(1)**	0 **(1)**	0 **(1)**	0 **(1)**	NA	0
Scrubber effluent line		0 **(1)**	0 **(1)**	NA	NA	NA	0 **(1)**	0 **(1)**	NA	0
Main line		0	0	L1	NA	NA	NA	0	NA	L1 **(6)**
Distribution line		NA	NA	L1	0	NA	NA	0	NA	L1 **(2)**
FLAMMABLE LIQUIDS (FLASH POINT > 60°C)										
Cargo lines		X	X	L1	NA **(3)**	0	0 **(9)**	0	NA	L1
Fuel oil		X	X	L1	NA **(3)**	0	0	0	L1	L1
Lubricating oil		X	X	L1	NA	NA	NA	0	L1	L1
Hydraulic oil		X	X	L1	0	0	0	0	L1	L1
SEA WATER**(1)**										
Bilge main and branches		L1	L1	L1	NA	0	0	0	NA	L1
Fire main and water spray	dry	L1	L1	L1	NA	NA	0	0	X	L1
	wet	L1	L1	L1	NA	NA	0	0	X	L3
Foam system		L1W	L1W	L1W	NA	NA	NA	0	L1W	L1W
Sprinkler system		L1W	L1W	L3	NA	NA	0	0	L3	L3
Ballast		L3	L3	L3	0 **(9)**	0	0	0	L2	L2W
Cooling water, essential services		L3	L3	NA	NA	NA	0	0	NA	L2W
Tank cleaning services, fixed machines		NA	NA	L3	0	NA	0	0	NA	L3 **(2)**
Non-essential systems		0	0	0	NA	0	0	0	0	0
FRESH WATER										
Cooling water, essential services		L3	L3	NA	NA	0	0	0	L3	L3
Condensate return		L3	L3	L3	NA	NA	NA	0	0	0
Non-essential systems		0	0	0	NA	0	0	0	0	0

PIPING SYSTEM	LOCATION								
	Machinery spaces of category A **(10)**	Other machinery spaces and pump rooms **(11)**	Cargo pump rooms **(12)**	Cargo tanks **(13)**	Fuel oil tanks **(14)**	Ballast water tanks **(15)**	Cofferdams, void spaces, pipe tunnels and ducts **(16)**	Accommodation, service and control spaces **(17)**	Open decks **(18)(19)**
SANITARY, DRAINS, SCUPPERS									
Deck drains (internal)	L1W **(4)**	L1W **(4)**	NA	NA	0	0	0	0	0
Sanitary drains (internal)	0	0	NA	NA	0	0	0	0	0
Scuppers and discharges (over-board)	0 **(1) (7)**	0 **(1) (7)**	0 **(1) (7)**	0	0	0	0	0 **(1) (7)**	0
SOUNDING, AIR									
Water tanks, dry spaces	0	0	0	0 **(9)**	0	0	0	0	0
Oil tanks (flash point > 60°C)	X	X	X	X **(3)**	0	0 **(9)**	0	X	X
MISCELLANEOUS									
Control air	L1 **(5)**	L1 **(5)**	L1 **(5)**	NA	0	0	0	L1 **(5)**	L1 **(5)**
Service air (non-essential)	0	0	0	NA	0	0	0	0	0
Brine	0	0	NA	NA	NA	NA	0	0	0
Auxiliary low steam pressure (≤ 0,7 MPa)	L2	L2	0 **(8)**	0	0	0	0	0 **(8)**	0 **(8)**

(1) Where non-metallic piping is used, remote controlled valves to be provided at the shell (valve is to be controlled from outside space).

(2) Remote closing valves to be provided at the cargo tanks.

(3) When cargo tanks contain flammable liquids with flash point > 60 °C, "0" may replace "NA" or "X".

(4) For drains serving only the space concerned, "0" may replace "L1".

(5) When controlling functions are not required by the Rules, "0" may replace "L1".

(6) For pipes between machinery space and deck water seal, "0" may replace "L1".

(7) Scuppers serving open decks in positions 1 and 2, as defined in Pt B, Ch 1, Sec 2, are to be "X" throughout unless fitted at the upper end with a means of closing capable of being operated from a position above the freeboard deck in order to prevent downflooding.

(8) For essential services, such as fuel oil tank heating and unit's whistle, "X" is to replace "0".

(9) For floating production storage and offloading units, "NA" is to replace "0".

(10) Machinery spaces of category A are defined in Ch 1, Sec 1, [1.3.1].

(11) Spaces, other than category A machinery spaces and cargo pumps rooms, containing propulsion machinery, boilers, steam and internal combustion engines, generators and major electrical machinery, pumps, oil filling stations, refrigerating, stabilising, ventilation and air-conditioning machinery, and similar spaces, and trunks to such spaces.

(12) Spaces containing cargo pumps, and entrances and trunks to such spaces.

(13) All spaces used for liquid cargo and trunks to such spaces.

(14) All spaces used for fuel oil (excluding cargo tanks) and trunks to such spaces.

(15) All spaces used for ballast water and trunks to such spaces.

(16) Empty spaces between two bulkheads separating two adjacent compartments.

(17) Accommodation spaces, service spaces and control stations are defined in Ch 4, Sec 1, [3].

(18) Open decks are defined in SOLAS Chapter II-2 Regulation 9, 2.4.2.2 (10).

(19) Level of fire endurance of plastic pipes on hull deck of Offshore Units (when there is significant fire risk) should comply with the results of the Fire Risk Analysis Study & Report, unless agreement of the National Authority is provided.
(For Fire water system, reference is made to US Coast Guard's PFM 1-98: Policy File Memorandum on the Fire Performance Requirements for Plastic Pipe per IMO Resolution A.753(18)).

Note 1: For definitions of "L1", "L1W", "L2", "L2W", "L3", "0", "X" and "NA", refer to [2.3.1].

2.3.2 Flame spread

a) All pipes, except those fitted on open decks and within tanks, cofferdams, pipe tunnels and ducts, are to have low spread characteristics not exceeding average values listed in IMO Resolution A.653(16). Other recognised national standards may also be referred to.

b) Surface flame characteristics are to be determined using the procedure given in IMO Res. A.653(16) with regard to the modifications due to the curvilinear pipe surfaces as listed in Appendix 3 of Res. A.753(18).

2.3.3 Fire protection coating

Where a fire protective coating of pipes and fittings is necessary for achieving the fire endurance level required, it is to meet the following requirements:

- The pipes are generally to be delivered from the manufacturer with the protective coating on.
- The fire protection properties of the coating are not to be diminished when exposed to salt water, oil or bilge slops. It is to be demonstrated that the coating is resistant to products likely to come into contact with the piping.
- In considering fire protection coatings, such characteristics as thermal expansion, resistance against vibrations and elasticity are to be taken into account.
- The fire protection coatings are to have sufficient resistance to impact to retain their integrity.

2.3.4 Electrical conductivity

a) Piping systems conveying fluids with a conductivity less than 1000 pS/m (1pS/m = 10^{-9} siemens per meter), such as refined products and distillates, are to be made of conductive pipes.

b) Regardless of the fluid to be conveyed, plastic pipes passing through hazardous areas are to be electrically conductive.

c) Where electrical conductivity is to be ensured, the resistance of the pipes and fittings is not to exceed:

1×10^5 Ω/m.

d) Where pipes and fittings are not homogeneously conductive, conductive layers are to be provided, suitably protected against the possibility of spark damage to the pipe wall.

2.4 Pipe and fitting connections

2.4.1 General

a) The strength of connections is not to be less than that of the piping system in which they are installed.

b) Pipes and fittings may be assembled using adhesive-bonded, welded, flanged or other joints.

c) When used for joint assembly, adhesives are to be suitable for providing a permanent seal between the pipes and fittings throughout the temperature and pressure range of the intended application.

d) Tightening of joints, where required, is to be performed in accordance with the manufacturer's instructions.

e) Procedures adopted for pipe and fitting connections are to be submitted to the Society for approval, prior to commencing the work.

2.4.2 Bonding of pipes and fittings

a) The procedure for making bonds is to be submitted to the Society for qualification. It is to include the following:
  - materials used
  - tools and fixtures
  - joint preparation requirements
  - cure temperature
  - dimensional requirements and tolerances
  - acceptance criteria for the test of the completed assembly.

b) When a change in the bonding procedure may affect the physical and mechanical properties of the joints, the procedure is to be requalified.

3 Arrangement and installation of plastic pipes

3.1 General

3.1.1 Plastic pipes and fittings are to be installed by the Shipyard in accordance with the Manufacturer's guidelines and taking account of the following provisions, as deemed necessary.

3.2 Supporting of the pipes

3.2.1

a) Selection and spacing of pipe supports in shipboard systems are to be determined as a function of allowable stresses and maximum deflection criteria.

b) The selection and spacing of pipe supports are to take into account the following data:
  - pipe dimensions
  - mechanical and physical properties of the pipe material
  - mass of pipe and contained fluid
  - external pressure
  - operating temperature

- thermal expansion effects
- load due to external forces
- thrust forces
- water hammer
- vibrations
- maximum accelerations to which the system may be subjected.

Combinations of loads are also to be considered.

c) Support spacing is not to be greater than the pipe manufacturer's recommended spacing.

3.2.2 Each support is to evenly distribute the load of the pipe and its content over the full width of the support. Measures are to be taken to minimise wear of the pipes where they are in contact with the supports.

3.2.3 Heavy components in the piping system such as valves and expansion joints are to be independently supported.

3.3 Provision for expansion

3.3.1 Suitable provision is to be made in each pipeline to allow for relative movement between pipes made of plastic and the steel structure, having due regard to:

- the high difference in the coefficients of thermal expansion
- deformations of the ship's structure.

3.3.2 Calculations of the thermal expansions are to take into account the system working temperature and the temperature at which the assembly is performed.

3.4 External loads

3.4.1 When installing the piping, allowance is to be made for temporary point loads, where applicable. Such allowance is to include at least the force exerted by a load (person) of 100 kg at mid-span on any pipe of more than 100 mm nominal outside diameter.

3.4.2 Pipes are to be protected from mechanical damage where necessary.

3.5 Earthing

3.5.1 Where, in pursuance of [2.3.4], pipes are required to be electrically conductive, the resistance to earth from any point in the piping system is not to exceed $1 \times 10^6 \ \Omega$.

3.5.2 Where provided, earthing wires are to be accessible for inspection.

3.6 Penetration of fire divisions and watertight bulkheads or decks

3.6.1 Where plastic pipes pass through "A" or "B" class divisions, arrangements are to be made to ensure that fire endurance is not impaired. These arrangements are to be tested in accordance with 'Recommendations for Fire Test Procedures for "A", "B" and "F" Bulkheads' (IMO Resolution A754 (18) as amended).

3.6.2 When plastic pipes pass through watertight bulkheads or decks, the watertight integrity of the bulkhead or deck is to be maintained. If the bulkhead or deck is also a fire division and destruction by fire of plastic pipes may cause the inflow of liquid from tanks, a metallic shut-off valve operable from above the freeboard deck is to be fitted at the bulkhead or deck.

3.7 Systems connected to the hull

3.7.1 Bilge and sea water systems

a) Where, in pursuance of [2.3.1], plastic pipes are permitted in bilge and sea water systems, the ship side valves required in Ch 1, Sec 7, [2.9] and, where provided, the connecting pipes to the shell are to be made of metal in accordance with Ch 1, Sec 7, [2.1].

b) Ship side valves are to be provided with remote control from outside the space concerned. See Tab 1, footnote **(1)**.

3.7.2 Scuppers and sanitary discharges

a) Where, in pursuance of [2.3.1], plastic pipes are permitted in scuppers and sanitary discharge systems connected to the shell, their upper end is to be fitted with closing means operated from a position above the freeboard deck in order to prevent downflooding. See Tab 1, footnotes **(1)** and **(7)**.

b) Discharge valves are to be provided with remote control from outside the space concerned.

3.8 Application of fire protection coatings

3.8.1 Where necessary for the required fire endurance as stated in [2.3.3], fire protection coatings are to be applied on the joints, after performing hydrostatic pressure tests of the piping system.

3.8.2 The fire protection coatings are to be applied in accordance with the manufacturer's recommendations, using a procedure approved in each case.

4 Certification, inspection and testing of plastic piping

4.1 Certification

4.1.1 Type approval

Plastic pipes and fittings are to be of a type approved by the Society for the intended use. For this purpose, the material tests required in [4.1.2] and, where applicable, the bonding qualification test detailed in [4.1.3] are to be performed.

4.1.2 Material tests

a) Tests are to be performed according to a procedure approved by the Society to determine, for each type of pipe and fitting, the following characteristics:
   - ultimate tensile strength
   - short-term and long-term design strength
   - collapse
   - impact resistance
   - fire endurance
   - low flame spread characteristics
   - electrical resistance (for electrically conductive pipes).

   For the above tests, representative samples of pipes and fittings are to be selected to the satisfaction of the Society.

b) The ultimate tensile strength is to be determined by means of a hydrostatic test on pipe samples subjected to increasing pressure up to failure, the pressure being increased at such a rate that failure occurs in not less than 5 minutes. Such test is to be carried out under the standard conditions: atmospheric pressure equal to 100 kPa, relative humidity 30%, environmental and carried fluid temperature 298 K (25°C).

   The ultimate tensile strength is to be determined using the tangential stress based on the initial diameter of the pipe. Small deformations of the pipe sample during the test may be accepted.

c) Alternatively, hydrostatic test failure pressure and collapse pressure may be determined by a combination of tests and calculations, subject to the agreement of the Society.

d) After the impact resistance test, the specimen is to be subjected to hydrostatic pressure equal to 2,5 times the design pressure for at least 1 hour.

4.1.3 Bonding qualification test

a) A test assembly is to be fabricated in accordance with the procedure to be qualified. It is to consist of at least one pipe-to-pipe joint and one pipe-to-fitting joint.

b) When the test assembly has been cured, it is to be subjected to a hydrostatic test pressure at a safety factor of 2,5 times the design pressure of the test assembly, for not less than one hour. No leakage or separation of joints is allowed. The test is to be conducted so that the joint is loaded in both longitudinal and circumferential directions.

c) Selection of the pipes used for the test assembly is to be in accordance with the following:
   - when the largest size to be joined is 200 mm nominal outside diameter or smaller, the test assembly is to be the largest piping size to be joined
   - when the largest size to be joined is greater than 200 mm nominal outside diameter, the size of the test assembly is to be either 200 mm or 25% of the largest piping size to be joined, whichever is the greater.

4.1.4 Personnel qualification

All pipes, fittings and related items are to be installed by qualified GRP pipe fitters approved by a qualified GRP piping inspector. GRP pipe fitters and GRP piping inspectors are to be qualified in compliance with a recognized standard as defined in [1.4].

GRP fitters approved by the manufacturer of the bonding product may be accepted provided the approval procedure is accepted by the Society.

4.2 Quality control during manufacture

4.2.1 The Manufacturer is to have quality system that meets ISO 9000 series standards or equivalent. The quality system is to consist of elements necessary to ensure that pipes and fittings are produced with consistent and uniform mechanical and physical properties.

In case the Manufacturer does not have an approved quality system complying with ISO 9000 series or equivalent, pipes and fittings are to be tested in accordance with this Appendix to the satisfaction of the Classification Society's surveyors for every batch of pipes.

4.2.2 Each pipe and fitting is to be tested by the Manufacturer at a hydrostatic pressure not less than 1,5 times the nominal pressure. Alternatively, for pipes and fittings not employing hand lay up techniques, the hydrostatic pressure test may be carried out in accordance with the hydrostatic testing requirements stipulated in the recognised national or international standard to which the pipe or fittings are manufactured, provided that there is an effective quality system in place.

Depending upon the intended application, the Society may require the pressure testing of each pipe and/or fitting.

4.3 Testing after installation on board

4.3.1 Hydrostatic testing

a) Piping systems for essential systems are to be subjected to a test pressure of not less than 1,5 times the design pressure or 0,4 MPa, whichever is the greater.

b) Piping systems for non-essential services are to be checked for leakage under operational conditions.

The pressure rise in the pipe systems and the duration of the hydrostatic testing are to be in compliance with a recognised standard as defined in [1.4].

4.3.2 Earthing test

For piping required to be electrically conductive, earthing is to be checked and random resistance testing is to be performed.

4.4 Test specification for plastic pipes

4.4.1 Scope

This sub-article contains requirements for the type approval of plastic pipes. Unless otherwise specified, it is applicable to rigid pipes, pipe joints and fittings.

4.4.2 Documentation

The following information for the plastic pipes, fittings and joints is to be submitted for consideration and approval:

a) General information
    - pipe and fitting dimensions
    - maximum internal and external working pressure
    - working temperature range
    - intended services and installation locations
    - the level of fire endurance
    - electrically conductive
    - intended fluids
    - limits on flow rates
    - serviceable life
    - installation instructions
    - details of marking.

b) Drawings and supporting documentation
    - certificates and reports for relevant tests previously carried out
    - details of relevant standards
    - all relevant design drawings, catalogues, data sheets, calculations and functional descriptions
    - fully detailed sectional assembly drawings showing pipe, fittings and pipe connections.

c) Materials
    - resin type
    - catalyst and accelerator types, and concentration employed in the case of reinforced polyester resin pipes or hardeners where epoxide resins are employed
    - statement of all reinforcements employed where the reference number does not identify the mass per unit area or the tex number of a roving used in a filament winding process, these are to be detailed
    - full information regarding the type of gel-coat or thermoplastic liner employed during construction, as appropriate
    - cure/post-cure conditions. The cure and post-cure temperatures and times employ resin/reinforcement ratio
    - winding angle and orientation.

4.4.3 Testing

Testing is to demonstrate compliance of the pipes, fittings and joints for which type approval is sought with the present Appendix.

Pipes, joints and fittings are to be tested for compliance with the requirements of recognized standards acceptable to the Society. In that order, recommended standards are given in Tab 2 and Tab 3.

Table 2 : Typical requirements for all systems

No.	Test	Typical standard	Notes
1	Internal pressure **(1)**	Requirement [2.2.3], item a) ASTM D 1599 ASTM D 2992 ISO 15493 or equivalent	Top, middle, bottom (of range) Tests are to be carried out on pipe spools made of different pipe sizes, fittings and pipe connections
2	External pressure **(1)**	Requirement [2.2.3], item b) ISO 15493 or equivalent	As above, for straight pipes only
3	Axial strength	Requirement [2.2.5]	As above
4	Load deformation	ASTM D 2412 or equivalent	Top, middle, bottom (of each pressure range)
5	Temperature limitations	ISO 75 method A GRP piping system: HDT test on each type of resin according to ISO 75 method A Thermoplastic piping systems: ISO 75 method A ISO 306 - Thermoplastic materials - Determination of Vicat softening temperature (VST) VICAT test according to ISO 2507 Polyesters with an HDT below 80°C should not be used	Each type of resin
6	Impact resistance	ISO 9854: 1994, ISO 9653: 1991, ISO 15493, ASTM D 2444, or equivalent	Representative samples of each type of construction
7	Ageing	Manufacturer's standard ISO 9142: 1990	Each type of construction
8	Fatigue	Manufacturer's standard or service experience	Each type of construction
9	Fluid absorption	ISO 8361: 1991	
10	Material compatibility **(2)**	ASTM C581 Manufacturer's standard	

(1) Test to be witnessed by a Surveyor of the Society.
(2) If applicable.

Table 3 : Typical additional requirements depending on service and/or locations of piping

No.	Test	Typical standard	Notes
1	Fire endurance **(1) (2) (3)**	IMO Res. A753(18), Appendix 1, 2	Representative samples of each type of construction and type of pipe connection
2	Flame spread **(1) (2) (3)**	Requirement [2.3.2]	Representative samples of each type of construction
3	Smoke generation **(2)**	IMO Fire Test Procedures Code	Representative samples of each type of construction
4	Toxicity **(2)**	IMO Fire Test Procedures Code	Representative samples of each type of construction
5	Electrical conductivity **(1) (2) (3)**	ASTM F1173-95 or ASTM D 257, NS 6126 § 11.2 or equivalent	Representative samples of each type of construction

(1) Test to be witnessed by a Surveyor of the Society.
(2) If applicable.
(3) Optional. However, if the test is carried out, the range of approved applications for the pipes is to be limited accordingly.

Appendix 2 Type Testing Procedure for Crankcase Explosion Relief Valves

1 General

1.1 Scope

1.1.1 This appendix specifies type tests and identifies standard test conditions using methane gas and air mixture to demonstrate the Society requirements are satisfied for crankcase explosion relief valves intended to be fitted to engines and gear cases.

1.1.2 This test procedure is only applicable to explosion relief valves fitted with flame arresters.

Note 1: Where internal oil wetting of a flame arrester is a design feature of an explosion relief valve, alternative testing arrangements that demonstrate compliance with this appendix may be proposed by the manufacturer. The alternative testing arrangements are to be agreed by the Society.

1.2 Recognised standards

1.2.1 The following standards are considered as recognised standards:

- ISO 16852:2016
- ISO/IEC 17025:2017
- ISO 12100:2010
- VDI 3673-1:2002
- IMO Circular MSC/Circ.677 as amended by IMO Circular MSC/Circ.1009 and IMO Circular MSC.1/Circ.1324.

1.3 Purpose

1.3.1 The purpose of type testing crankcase explosion relief valves is fourfold:

- to verify the effectiveness of the flame arrester
- to verify that the valve closes after an explosion
- to verify that the valve is gas/air tight after an explosion
- to establish the level of over pressure protection provided by the valve.

1.4 Approval

1.4.1 The approval of explosion relief valves is at the discretion of the Society based on the appraisal of plans and particulars and the test facility’s report of the results of type testing.

2 Type testing procedure

2.1 Test facilities

2.1.1 Test houses carrying out type testing of crankcase explosion relief valves are to meet the following requirements:

a) The test houses where testing is carried out are to be accredited to a National or International Standard, e.g. ISO/IEC 17025:2017, and are to be acceptable to the Society.

b) The test facilities are to be equipped so that they can perform and record explosion testing in accordance with this procedure.

c) The test facilities are to have equipment for controlling and measuring a methane gas in air concentration within a test vessel to an accuracy of ± 0,1%.

d) The test facilities are to be capable of effective point-located ignition of a methane gas in air mixture.

e) The pressure measuring equipment is to be capable of measuring the pressure in the test vessel in at least two positions, one at the valve and the other at the test vessel centre. The measuring arrangements are to be capable of measuring and recording the pressure changes throughout an explosion test at a frequency recognising the speed of events during an explosion. The result of each test is to be documented by video recording and by recording with a heat sensitive camera.

f) The test vessel for explosion testing is to have documented dimensions. The dimensions are to be such that the vessel is not “pipe like” with the distance between dished ends being not more than 2,5 times its diameter. The internal volume of the test vessel is to include any standpipe arrangements.

g) The test vessel is to be provided with a flange, located centrally at one end perpendicular to the vessel longitudinal axis, for mounting the explosion relief valve.

The test vessel is to be arranged in an orientation consistent with how the valve will be installed in service, i.e., in the vertical plane or the horizontal plane.

h) A circular plate is to be provided for fitting between the pressure vessel flange and valve to be tested with the following dimensions:

  1) outside diameter of 2 times the outer diameter of the valve top cover

  2) internal bore having the same internal diameter as the valve to be tested.

i) The test vessel is to have connections for measuring the methane in air mixture at the top and bottom.

j) The test vessel is to be provided with a means of fitting an ignition source at a position specified in [2.2.3].

k) The test vessel volume is to be as far as practicable, related to the size and capability of the relief valve to be tested. In general, the volume is to correspond to the requirement in Ch 1, Sec 2, [2.3.4], d) for the free area of explosion relief valve to be not less than 115 cm^2/m^3 of crankcase gross volume.

Note 1: This means that the testing of a valve having 1150 cm^2 of free area, would require a test vessel with a volume of 10 m^3.

Note 2: Where the free area of relief valves is greater than 115 cm^2/m^3 of the crankcase gross volume, the volume of the test vessel is to be consistent with the design ratio.

Note 3: In no case is the volume of the test vessel to vary by more than ±15% from the design cm^2/m^3 volume ratio.

2.2 Explosion test process

2.2.1 All explosion tests to verify the functionality of crankcase explosion relief valves are to be carried out using an air and methane mixture with a volumetric methane concentration of 9,5% ±0,5%. The pressure in the test vessel is to be not less than atmospheric and is not to exceed the opening pressure of the relief valve.

2.2.2 The concentration of methane in the test vessel is to be measured at the top and bottom of the vessel and these concentrations are not to differ by more than 0,5%.

2.2.3 The ignition of the methane and air mixture is to be made at the centreline of the test vessel at a position approximately one third of the height or length of the test vessel opposite to where the valve is mounted.

2.2.4 The ignition is to be made using a maximum 100 J explosive charge.

2.3 Valves to be tested

2.3.1 The valves used for type testing (including testing specified in [2.3.3] are to be selected from the manufacturer's normal production line for such valves by the classification society witnessing the tests.

2.3.2 For approval of a specific valve size, three valves are to be tested in accordance with [2.3.3] and [2.4]. For a series of valves see [2.6].

2.3.3 The valves selected for type testing are to have been previously tested at the manufacturer's works to demonstrate that the opening pressure is in accordance with the specification within a tolerance of ± 20% and that the valve is air tight at a pressure below the opening pressure for at least 30 seconds.

Note 1: This test is to verify that the valve is air tight following assembly at the manufacturer's works and that the valve begins to open at the required pressure demonstrating that the correct spring has been fitted.

2.3.4 The type testing of valves is to recognise the orientation in which they are intended to be installed on the engine or gear case. Three valves of each size are to be tested for each intended installation orientation, i.e. in the vertical and/or horizontal positions.

2.4 Method

2.4.1 The following requirements are to be satisfied at explosion testing:

a) The explosion testing is to be witnessed by a classification society surveyor

b) Where valves are to be installed on an engine or gear case with shielding arrangements to deflect the emission of explosion combustion products, the valves are to be tested with the shielding arrangements fitted

c) Successive explosion testing to establish a valve's functionality is to be carried out as quickly as possible during stable weather conditions

d) The pressure rise and decay during all explosion testing is to be recorded

e) The external condition of the valves is to be monitored during each test for indication of any flame release by video and heat sensitive camera.

2.4.2 The explosion testing is to be in three stages for each valve that is required to be approved as being type tested.

a) Stage 1:

Two explosion tests are to be carried out in the test vessel with the circular plate described in [2.1.1], item h) fitted and the opening in the plate covered by a 0,05 mm thick polythene film

Note 1: These tests establish a reference pressure level for determination of the capability of a relief valve in terms of pressure rise in the test vessel, see [2.5.1], item f).

b) Stage 2:

1) Two explosion tests are to be carried out on three different valves of the same size. Each valve is to be mounted in the orientation for which approval is sought i.e., in the vertical or horizontal position with the circular plate described in [2.1.1], item h) located between the valve and pressure vessel mounting flange.

2) The first of the two tests on each valve is to be carried out with a 0,05mm thick polythene bag, having a minimum diameter of three times the diameter of the circular plate and volume not less than 30% of the test vessel, enclosing the valve and circular plate. Before carrying out the explosion test the polythene bag is to be empty of air. The polythene bag is required to provide a readily visible means of assessing whether there is flame transmission through the relief valve following an explosion consistent with the requirements of the standards identified in [1.2].

Note 2: During the test, the explosion pressure will open the valve and some unburned methane/air mixture will be collected in the polythene bag. When the flame reaches the flame arrester and if there is flame transmission through the flame arrester, the methane/air mixture in the bag will be ignited and this will be visible.

3) Provided that the first explosion test successfully demonstrated that there was no indication of combustion outside the flame arrester and there are no visible signs of damage to the flame arrester or valve, a second explosion test without the polythene bag arrangement is to be carried out as quickly as possible after the first test. During the second explosion test, the valve is to be visually monitored for any indication of combustion outside the flame arrester and video records are to be kept for subsequent analysis. The second test is required to demonstrate that the valve can still function in the event of a secondary crankcase explosion.

4) After each explosion, the test vessel is to be maintained in the closed condition for at least 10 seconds to enable the tightness of the valve to be ascertained. The tightness of the valve can be verified during the test from the pressure/time records or by a separate test after completing the second explosion test.

c) Stage 3:

Carry out two further explosion tests as described in Stage 1. These further tests are required to provide an average baseline value for assessment of pressure rise, recognising that the test vessel ambient conditions may have changed during the testing of the explosion relief valves in Stage 2.

2.5 Assessment and records

2.5.1 For the purposes of verifying compliance with the requirements of this Section, the assessment and records of the valves used for explosion testing is to address the following:

a) The valves to be tested are to have evidence of design appraisal/approval by the classification society witnessing tests.

b) The designation, dimensions and characteristics of the valves to be tested are to be recorded. This is to include the free area of the valve and of the flame arrester and the amount of valve lift at 0,2 bar.

c) The test vessel volume is to be determined and recorded.

d) For acceptance of the functioning of the flame arrester there is not to be any indication of flame or combustion outside the valve during an explosion test. This should be confirmed by the test laboratory taking into account measurements from the heat sensitive camera.

e) The pressure rise and decay during an explosion is to be recorded, with indication of the pressure variation showing the maximum overpressure and steady underpressure in the test vessel during testing. The pressure variation is to be recorded at two points in the pressure vessel.

f) The effect of an explosion relief valve in terms of pressure rise following an explosion is ascertained from maximum pressures recorded at the centre of the test vessel during the three stages. The pressure rise within the test vessel due to the installation of a relief valve is the difference between average pressure of the four explosions from Stages 1 and 3 and the average of the first tests on the three valves in Stage 2. The pressure rise is not to exceed the limit specified by the manufacturer.

g) The valve tightness is to be ascertained by verifying from the records at the time of testing that an underpressure of at least 0,3 bar is held by the test vessel for at least 10 seconds following an explosion. This test is to verify that the valve has effectively closed and is reasonably gas-tight following dynamic operation during an explosion.

h) After each explosion test in Stage 2, the external condition of the flame arrester is to be examined for signs of serious damage and/or deformation that may affect the operation of the valve.

i) After completing the explosion tests, the valves are to be dismantled and the condition of all components ascertained and documented. In particular, any indication of valve sticking or uneven opening that may affect operation of the valve is to be noted. Photographic records of the valve condition are to be taken and included in the report.

2.6 Design series qualification

2.6.1 The qualification of quenching devices to prevent the passage of flame can be evaluated for other similar devices of identical type where one device has been tested and found satisfactory.

2.6.2 The quenching ability of a flame arrester depends on the total mass of quenching lamellas/mesh. Provided the materials, thickness of materials, depth of lamellas/thickness of mesh layer and the quenching gaps are the same, then the same quenching ability can be qualified for different sizes of flame arresters satisfying:

$$\frac{n_1}{n_2} = \sqrt{\frac{S_1}{S_2}}$$

and

$$\frac{A_1}{A_2} = \frac{S_1}{S_2}$$

where:

n_1 : Total depth of flame arrester corresponding to the number of lamellas of size 1 quenching device for a valve with a relief area equal to S_1

n_2 : Total depth of flame arrester corresponding to the number of lamellas of size 2 quenching device for a valve with a relief area equal to S_2

A_1 : Free area of quenching device for a valve with a relief area equal to S_1

A_2 : Free area of quenching device for a valve with a relief area equal to S_2.

2.6.3 The qualification of explosion relief valves of larger sizes than that which has been previously satisfactorily tested in accordance with [2.4] and [2.5] can be evaluated where valves are of identical type and have identical features of construction subject to the following:

a) The free area of a larger valve does not exceed three times + 5% that of the valve that has been satisfactorily tested.

b) One valve of the largest size, see a), requiring qualification is subject to satisfactory testing required by [2.3.3] and [2.4.2], item b) except that a single valve will be accepted in [2.4.2], item b), 1) and the volume of the test vessel is not to be less than one third of the volume required by [2.1.1], item k).

c) The assessment and records are to be in accordance with [2.5] noting that [2.5.1], item f) will only be applicable to Stage 2 (see [2.4.2] for a single valve).

2.6.4 The qualification of explosion relief valves of smaller sizes than that which has been previously satisfactorily tested in accordance with [2.4] and [2.5] can be evaluated where valves are of identical type and have identical features of construction subject to the following:

a) The free area of a smaller valve is not less than one third of the valve that has been satisfactorily tested.

b) One valve of the smallest size, subject to item a), requiring qualification is subject to satisfactory testing required by [2.3.3] and [2.4.2], item b) except that a single valve will be accepted in [2.4.2], item b), 1) and the volume of the test vessel is not to be more than the volume required by [2.1.1], item k).

c) The assessment and records are to be in accordance with article [2.5] noting that [2.5.1], item f) will only be applicable to Stage 2 for a single valve.

2.7 Report

2.7.1 The test facility is to deliver a full report that includes the following information and documents:

- test specification
- details of test pressure vessel and valves tested
- the orientation in which the valve was tested (vertical or horizontal position)
- methane in air concentration for each test
- ignition source
- pressure curves for each test
- video recordings of each valve test
- the assessment and records stated in [2.5].

Appendix 3 Type Approval of Mechanical Joints

1 General

1.1 Scope

1.1.1 This specification describes the type testing condition for type approval of mechanical joints intended for use in marine piping systems. Conditions outlined in these requirements are to be fulfilled before Type Approval Certificates are issued.

1.1.2 The Society may accept alternative testing in accordance with national or international standards where applicable to the intended use and application.

1.1.3 This specification is applicable to mechanical joints defined in Ch 1, Sec 7, [2.5.5] including compression couplings and slip-on joints of different types for marine use.

1.2 Documentation

1.2.1 Following documents and information are to be submitted by Manufacturer for assessment and/or approval:

- product quality assurance system implemented
- complete description of the product
- typical sectional drawings with all dimensions necessary for evaluation of joint design
- complete specification of materials used for all components of the assembly
- proposed test procedure as required in Article [2] and corresponding test reports or other previous relevant tests
- initial information:
  - maximum design pressures (pressure and vacuum)
  - maximum and minimum design temperatures
  - conveyed media
  - intended services
  - maximum axial, lateral and angular deviation, allowed by manufacturer
  - installation details.

1.3 Materials

1.3.1 The materials used for mechanical joints are to comply with the requirements of Ch 1, Sec 7, [2.5.5].

The manufacturer has to submit evidence to substantiate that all components are adequately resistant to working the media at design pressure and temperature specified.

2 Testing, procedures and requirements

2.1 Aim of the tests

2.1.1 The aim of tests is to demonstrate ability of the pipe joints to operate satisfactory under intended service conditions. The scope and type of tests to be conducted e.g. applicable tests, sequence of testing, and the number of specimen, is subject to approval and will depend on joint design and its intended service in accordance with the requirements of Ch 1, Sec 7.

2.2 Test fluid

2.2.1 Unless otherwise specified, the water or oil as test fluid is to be used.

2.3 Test program

2.3.1 Testing requirements for mechanical joints are to be as indicated in Tab 1.

2.4 Selection of test specimen

2.4.1 Test specimens are to be selected from production line or at random from stock.

Where there are various sizes from type of joints requiring approval, minimum of three separate sizes representative of the range, from each type of joints are to be subject to the tests listed in Tab 1.

Table 1 : Tests for mechanical joints

Tests		Type of mechanical joint			Notes and references
		Compression couplings and pipes unions	Slip on joints		
			Grid type and machine grooved type	Slip type	
1	Tightness test	+	+	+	[2.7.1]
2	Vibration (fatigue) test	+	+	–	[2.7.2]
3	Pressure pulsation test**(1)**	+	+	–	[2.7.3]
4	Burst pressure test	+	+	+	[2.7.4]
5	Pull-out test	+	+	–	[2.7.5]
6	Fire endurance test	+	+	+	[2.7.6] if required by Ch 1, Sec 7, Tab 18
7	Vacuum test	+ **(2)**	+	+	[2.7.7] for suction line only
8	Repeated assembly test	+ **(3)**	+	–	[2.7.8]

\+ : Test is required
– : Test is not required.
(1) for use in those systems where pressure pulsation other than water hammer is expected.
(2) except joints with metal-to-metal tightening surfaces.
(3) except press type.

2.5 Mechanical joint assembly

2.5.1 Assembly of mechanical joints is to consist of components selected in accordance with [2.4.1] and the pipe sizes appropriate to the design of the joints.

2.5.2 Where pipe material would effect the performance of mechanical joints, the selection of joints for testing is to take the pipe material into consideration.

2.5.3 Where not specified, the length of pipes to be connected by means of the joint to be tested is to be at least five times the pipe diameter. Before assembling the joint, conformity of components to the design requirements is to be verified. In all cases the assembly of the joint is to be carried out only according to the manufacturer’s instructions. No adjustment operations on the joint assembly, other than that specified by the manufacturer, are permitted during the test.

2.6 Test results acceptance criteria

2.6.1 Where a mechanical joint assembly does not pass all or any part of the tests in Tab 1, two assemblies of the same size and type that failed are to be tested and only those tests which mechanical joint assembly failed in the first instance, are to be repeated. In the event where one of the assemblies fails the second test, that size and type of assembly is to be considered unacceptable.

2.6.2 The methods and results of each test are to be recorded and reproduced as and when required.

2.7 Methods of tests

2.7.1 Tightness test

In order to ensure correct assembly and tightness of the joints, all mechanical joints are to be subjected to a tightness test, as follows:

a) Mechanical joint assembly test specimen is to be connected to the pipe or tubing in accordance with the requirements of [2.5] and the manufacturers instructions, filled with test fluid and de-aerated.

Mechanical joints assemblies intended for use in rigid connections of pipe lengths, are not to be longitudinally restrained.

Pressure inside the joint assembly is to be slowly increased to 1,5 times of design pressure. This test pressure is to be retained for a minimum period of 5 minutes.

In the event where there is a drop in pressure or there is visual indication of leakage, the test (including fire test) is to be repeated for two test pieces.

If during the repeat test one test piece fails, the testing is regarded as having failed.

Other alternative tightness test procedure, such as pneumatic test, may be accepted.

b) For compression couplings a static gas pressure test is to be carried out to demonstrate the integrity of the mechanical joints assembly for tightness under the influence of gaseous media. The pressure is to be raised to maximum pressure or 70 bar whichever is less.

c) Where the tightness test is carried out using gaseous media as permitted in a) above, then the static pressure test mentioned in b) above need not be carried out.

2.7.2 Vibration (fatigue) test

In order to establish the capability of the mechanical joint assembly to withstand fatigue, which is likely to occur due to vibrations under service conditions, mechanical joints assembly is to be subject to the following vibration test.

Conclusions of the vibration tests should show no leakage or damage, which could subsequently lead to a failure.

a) Testing of compression couplings and pipe unions

Compression couplings, pipe unions or other similar joints intended for use in rigid connections of pipe are to be tested in accordance with this method described as follows. Rigid connections are joints, connecting pipe length without free angular or axial movement.

Two lengths of pipe are to be connected by means of the joint to be tested. One end of the pipe is to be rigidly fixed while the other end is to be fitted to the vibration rig. The test rig and the joint assembly specimen being tested are to be arranged as shown in Fig 1.

The joint assembly is to be filled with test fluid, de-aerated and pressurised to the design pressure of the joint.

Pressure during the test is to be monitored. In the event of drop in the pressure and visual signs of leakage the test is to be repeated as described in [2.6].

Visual examination of the joint assembly is to be carried out for signs of damage which may eventually lead to joint leakage.

Re-tightening may be accepted once during the first 1000 cycles.

Vibration amplitude is to be within 5% of the value calculated from the following formula:

$$A = \frac{2SL^2}{3ED}$$

where:

A : Single amplitude, in mm

L : Length of the pipe, in mm

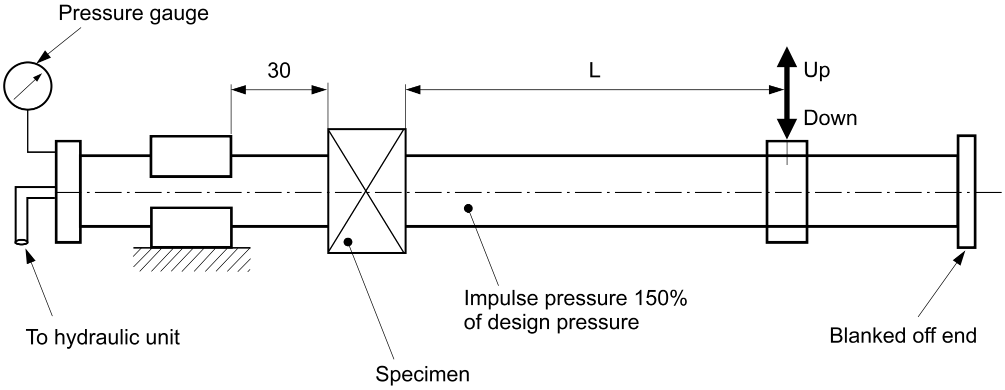
S : Allowable bending stress, in N/mm^2, based on 0,25 of the yield stress

E : Modulus of elasticity of tube material (for mild steel, E = 210 kN/mm^2)

D : Outside diameter of tube, in mm.

Test specimen is to withstand not less than 10^7 cycles with frequency 20 - 50 Hz without leakage or damage.

Figure 1 : Testing of compression couplings and pipe unions



b) Grip type and machine grooved type joints

Grip type joints and other similar joints containing elastic elements are to be tested in accordance with the following method.

A test rig of cantilever type used for testing fatigue strength of components may be used. The test specimen being tested is to be arranged in the test rig as shown in Fig 2.

Two lengths of pipes are to be connected by means of joint assembly specimen to be tested. One end of the pipe is to be rigidly fixed while the other end is to be fitted to the vibrating element on the rig. The length of pipe connected to the fixed end should be kept as short as possible and in no case exceed 200 mm.

Mechanical joint assemblies are not to be longitudinally restrained.

The assembly is to be filled with test fluid, de-aerated and pressurized to the design pressure of the joint. Preliminary angle of deflection of pipe axis is to be equal to the maximum angle of deflection, recommended by the manufacturer. The amplitude is to be measured at 1m distance from the centre line of the joint assembly at free pipe end connected to the rotating element of the rig (see Fig 2).

Parameters of testing are to be as indicated as per Tab 2 and to be carried out on the same assembly.

Pressure during the test is to be monitored. In the event of a drop in the pressure and visual signs of leakage the test is to be repeated as described in [2.6]. Visual examination of the joint assembly is to be carried out for signs of damage which may eventually cause leakage.

Figure 2 : Grip type and machine grooved type joints

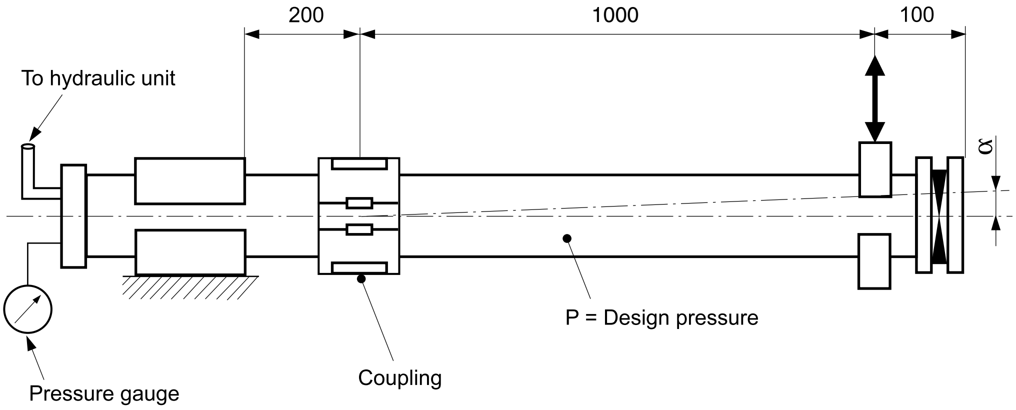


Table 2 : Parameters of testing

Number of cycles	Amplitude (mm)	Frequency (Hz)
$3 \cdot 10^6$	± 0,06	100
$3 \cdot 10^6$	± 0,50	45
$3 \cdot 10^6$	± 1,50	10

2.7.3 Pressure pulsation test

In order to determine capability of mechanical joint assembly to withstand pressure pulsation likely to occur during working conditions, joint assemblies intended for use in rigid connections of pipe lengths, are to be tested in accordance with the following method.

The mechanical joint test specimen for carrying out this test may be the same as that used in the test in [2.7.1], item a), provided it passed that test.

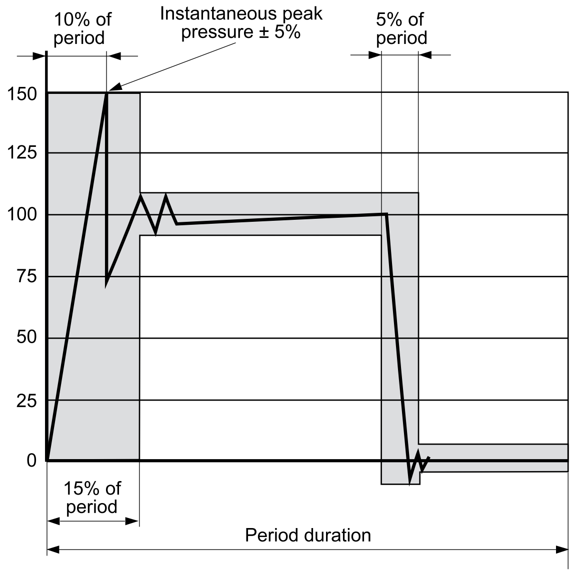
The vibration test in [2.7.2] and the pressure pulsation test are to be carried out simultaneously for compression couplings and pipe unions.

The mechanical joint test specimen is to be connected to a pressure source capable of generating pressure pulses of magnitude as shown in Fig 3.

Impulse pressure is to be raised from 0 to 1,5 times the design pressure of the joint with a frequency equal to 30-100 cycles per minute. The number of cycles is not to be less than 5 x 10^5.

The mechanical joint is to be examined visually for sign of leakage or damage during the test.

Figure 3 : Impulse pressure diagram



2.7.4 Burst pressure test

In order to determine the capability of the mechanical joint assembly to withstand a pressure as stated by Ch 1, Sec 7, [2.5.5], item e), the following burst test is to be carried out.

Mechanical joint test specimen is to be connected to the pipe or tubing in accordance with the requirements of [2.5], filled with test fluid, de-aerated and pressurized to test pressure with an increasing rate of 10% per minute of test pressure. The mechanical joint assembly intended for use in rigid connections of pipe lengths is not to be longitudinally restrained.

Duration of this test is not to be less than 5 minutes at the maximum pressure. This pressure value will be annotated.

Where consider convenient, the mechanical joint test specimen used in tightness test in [2.7.1], same specimen may be used for the burst test provided it passed the tightness test.

The specimen may have small deformation whilst under test pressure, but no leakage or visible cracks are permitted.

2.7.5 Pull-out test

In order to determine ability of a mechanical joint assembly to withstand axial load likely to be encountered in service without the connecting pipe from becoming detached, following pullout test is to be carried out.

Pipe length of suitable size is to be fitted to each end of the mechanical joints assembly test specimen. The test specimen is to be pressurized to design pressure such that the axial loads imposed are of a value calculated by the following formula:

$$L = \frac{\pi}{4}D^2p$$

where:

D : Pipe outside diameter, in mm

p : Design pressure, in N/mm^2

L : Applied axial load, in N.

This axial load is to be maintained for a period of 5 minutes.

During the test, pressure is to be monitored and relative movement between the joint assembly and the pipe measured.

The mechanical joint assembly is to be visually examined for drop in pressure and signs of leakage or damage.

There are to be no movement between mechanical joint assembly and the connecting pipes.

2.7.6 Fire endurance test

In order to establish capability of the mechanical joints to withstand effects of fire which may be encountered in service, mechanical joints are to be subjected to a fire endurance test. The fire endurance test is to be conducted on the selected test specimens as per the following standards:

- ISO 19921: 2005(E): Ships and marine technology – Fire resistance of metallic pipe components with resilient and elastomeric seals – Test methods.
- ISO 19922: 2005(E): Ships and marine technology – Fire resistance of metallic pipe components with resilient and elastomeric seals – Requirements imposed on the test bench.

Clarifications to the standard requirements:

a) If the fire test is conducted with circulating water at a pressure different from the design pressure of the joint (however of at least 5 bar) the subsequent pressure test is to be carried out to twice the design pressure.

b) A selection of representative nominal bores may be tested in order to evaluate the fire resistance of a series or range of mechanical joints of the same design. When a mechanical joint of a given nominal bore (D_n) is so tested then other mechanical joints falling in the range D_n to $2 \cdot D_n$ (both inclusive) are considered accepted.

2.7.7 Vacuum test

In order to establish capability of mechanical joint assembly to withstand internal pressures below atmosphere, similar to the conditions likely to be encountered under service conditions, following vacuum test is to be carried out.

Mechanical joint assembly is to be connected to a vacuum pump and subjected to a pressure 170 mbar absolute. Once this pressure is stabilized the mechanical joint assembly test specimen under test are to be isolated from the vacuum pump and this pressure is to be retained for a period of 5 minutes.

Pressure is to be monitored during the test.

No internal pressure rise is permitted.

2.7.8 Repeated assembly test

Mechanical joint test specimen are to be dismantled and reassembled 10 times in accordance with manufacturers instructions and then subjected to a tightness test as defined in [2.7.1].

Appendix 4 Dual Fuel Engines supplied with Low Pressure Gas and Dual Fuel Gas Turbines

1 General

1.1 Scope

1.1.1 This Appendix covers the specific features of Dual Fuel (DF) diesel engines and Dual Fuel (DF) gas turbines.

The requirements of:

- Ch 1, Sec 2, for diesel engines
- Ch 1, Sec 5 for gas turbines

are also to be complied with.

1.1.2 This Appendix applies to 4-stroke dual fuel engines supplied with gas at a pressure not exceeding 10 bar. The acceptance of 2-stroke dual fuel engines may be considered on a case by case basis.

1.2 Design principles

1.2.1 DF diesel engines and DF gas turbines are to be type-approved by the Society. The type tests are to be carried out according to an approved program.

1.2.2 DF diesel engines and DF gas turbines are to be designed so as to operate safely with any gas composition within the ship specification range, taking into account the possible variations of the gas composition during the voyage. Tests are to be carried out to demonstrate their ability in this respect.

1.2.3 Arrangements are to be made to ensure that under no circumstances introduction of liquid gas in the DF diesel engine or DF gas turbine may occur.

1.2.4 The fuel supply is to be capable of being switched over from gas fuel to oil fuel while the engine or turbine is running, without significant fluctuation of the engine or turbine output nor of the rotational speed.

1.2.5 Prior to a normal stop, the engine or turbine is to be switched over from gas fuel to oil fuel.

1.2.6 After each gas operation of the engine or turbine not followed by an oil fuel operation, the engine or turbine including the exhaust system is to be purged during a sufficient time in order to discharge the gas which may be present.

1.2.7 DF engines and DF gas turbines are to be fitted with a control system allowing a steady running with stable combustion, with any kind of gas as mentioned in [1.2.2] above, throughout the operating speed range of the engine or turbine. Automatic switch over to oil fuel may however be accepted at low loads.

1.2.8 Gas fuel and oil fuel supply systems pertaining to DF engines and DF gas turbines are to be so designed and controlled as to avoid any excessive gas delivery to the engine or gas turbine, which may result in the engine overspeed, in particular while the engine or gas turbine is running with gas fuel and oil fuel at the same time.

2 Additional requirements for dual fuel engines

2.1 Air inlet manifolds

2.1.1 Air inlet manifolds are to be provided with relief valves or other approved devices, the size, number and distribution of which are to be justified.

Note 1: The relief valves or equivalent devices may be omitted in the following cases, subject to satisfactory justifications:

- the strength of the air inlet manifold is sufficient to withstand the pressure build-up due to the worst-case explosion, or
- the maximum gas concentration expected in the air inlet manifold in case of malfunction of a gas admission valve, leakage of an air inlet valve, etc. cannot reach dangerous levels.

2.1.2 Where provided, explosion relief valves or equivalent devices are to be so arranged and located as to minimize the consequences of a flame emission.

2.1.3 Any electric equipment located in the inlet air manifold is to be of the intrinsically safe type.

2.2 Gas supply to the cylinders

2.2.1 Gas is normally to be introduced directly in or as close as possible to the cylinders heads.

2.2.2 Gas may also be introduced in the air manifold provided that:

- the gas concentration of the gas/air mixture in the air manifold may under no circumstances exceed 60% of the lower flammable limit. A gas detector is to be provided for that purpose
- gas may not pass from the air manifold to the exhaust system
- excessive gas supply to the engine likely to result in overspeed is precluded.

Note 1: The following failures are to be considered in the risk analysis:

- malfunction of the gas admission valve
- leaking cylinder inlet/exhaust valves.

2.2.3 The gas manifold is to be fitted with a flame arrester at the engine inlet, unless it is demonstrated that the gas supply system is so designed as to prevent the passage of flame into the gas piping.

2.3 Gas Ignition in the cylinders

2.3.1 In order to initiate the gas combustion, each cylinder is to be fitted with a pilot injection system supplied with liquid fuel and continuously operated. Other systems, such as spark ignition, will be subject to a special examination.

2.4 Exhaust manifold

2.4.1 Exhaust manifolds are to be of reinforced construction and provided with safety valves or other approved devices, the size, number and distribution of which are to be justified.

Note 1: Where the strength of the exhaust manifold is sufficient to withstand the pressure build-up due to the worst-case explosion, the relief valves or equivalent devices may be omitted.

2.4.2 In the case where an analysis showing that the gas concentration within the exhaust manifold cannot reach dangerous levels is submitted to the Society, the provisions of [2.4.1] may be waived. This analysis is to cover at least the malfunction of a cylinder (misfiring) and an exhaust valve leakage.

2.5 Crankcase

2.5.1 The crankcase is to be equipped with a sensor to detect an overpressure due to a piston ring failure (blow-by).

2.5.2 Owing to the continuous presence of gas in the crankcase due to the operating principle of the engine (compression of a gas/air mixture), a temperature monitoring system approved by the Society is to be provided for each part of the engine subjected to friction in order to detect any abnormal temperature rise likely to result in the gas ignition.

The temperature monitoring system is to be provided in particular for the cylinder liners, main bearings and connecting rod big end bearings. In case of abnormal temperature rise, this system is to activate the immediate shut-down of the engine.

The temperature sensors and other components of the temperature monitoring system located within the crankcase are to be of the safe type, suitable for use in explosive atmosphere.

Note 1: Arrangements other than direct temperature measurements, such as:

- hot spot detection systems based on other principles, or
- justifications submitted by the engine manufacturer and showing that the engine components subjected to friction are under no circumstances likely to be brought to dangerous temperatures which may result in crankcase gas ignition

may be taken into consideration if, in the opinion of the Society, they present an equivalent safety level. Oil mist detection systems, which are required to be fitted on ships having an automation notation, will normally not be accepted for this purpose.

2.5.3 Crankcase vent lines are to be fitted with a sampling line allowing the measurement of the gas concentration in the crankcase by means of a portable measuring device.

2.5.4 Arrangements are to be made to allow the inerting of the crankcase before servicing of the engine.

2.6 Instrumentation and safeties

2.6.1 The engine control system as well as the related systems are to be of a type approved by the Society.

2.6.2 The alarm and safety systems are to be provided in accordance with Tab 1.

2.6.3 Gas admission valves are to be fitted with a device allowing the immediate detection of a malfunction (such as locking in open position).

2.6.4 The combustion in each cylinder is to be monitored for the detection of possible misfiring or knocking.

Note 1: When the gas is introduced in the air inlet manifold in accordance with [2.2.2], only one cylinder needs to be monitored for knocking detection.

Table 1 : Dual fuel diesel engine alarm and safety systems

Parameter	Alarms	Automatic safety actions			
		Activation of the block-and-bleed valves	Activation of the master gas valve	Switch over to oil fuel mode	Engine shut down
Gas supply - pressure	L+H	X		X	
Gas supply - temperature	L+H	X		X	
Gas admission valve(s) - failure	X	X		X	
Pilot injection system - failure	X	X		X	
Air inlet manifold - gas concentration reaching 60% LFL **(1)**	H	X		X	
Exhaust gas at each cylinder outlet - temperature	H	X		X	
Exhaust gas at each cylinder outlet - temperature deviation from average	H	X		X	
Combustion in each cylinder - misfiring	X	X		X	
Combustion in each cylinder - knocking	X	X		X	
Crankcase - pressure	H	X			X
Crankcase - temperature **(2)**	H	X			X
Crankcase - oil mist concentration	H	X			X
Engine stop from any cause	X	X			

(1) Required only when gas is introduced directly in the gas manifold in accordance with [2.2.2].
(2) High temperature of cylinder liners or bearings. See [2.5.2].
Note 1: Symbol convention: H = High, L = Low, X = function is required

3 Additional requirements for dual fuel gas turbines

3.1 General

3.1.1 The turbine and associated gas treatment and gas supply systems as well as their control system are to be so designed and arranged as to allow the proper operation of the turbine taking into account the expected variations of the gas characteristics, in particular:

- Lower heating value
- Specific gravity
- Gas temperature
- Ambient temperature.

3.2 Protection against liquid presence in the gas supply

3.2.1 Arrangements are to be made to avoid the condensation of heavy hydrocarbons or water in the turbine gas inlet system. Where this is achieved by heating the gas fuel, a superheat of at least 28°C above the dew point is to be observed to ensure that no liquid may appear in the gas system downstream of the heater.

3.2.2 Where necessary, the gas piping system is to be heat traced to avoid any condensation, in particular during the turbine start-up.

3.3 Instrumentation and safeties

3.3.1 The turbine control system as well as the related systems are to be of a type approved by the Society.

3.3.2 The alarm and safety systems are to be provided in accordance with Tab 2.

Table 2 : Dual fuel gas turbine alarm and safety systems

Parameter	Alarms	Automatic safety actions			
		Activation of the block-and-bleed valves	Activation of the master gas valve	Switch over to oil fuel mode	Engine shut down
Gas supply - abnormal pressure	L+H	X		X	
Gas supply - abnormal temperature	L+H	X		X	
Gas admission valve - failure	X	X		X	
Turbine stop from any cause	X	X			

Note 1: Symbol convention: H = High, L = Low, X = function is required

Part C
Facilities

CHAPTER 2
ELECTRICAL INSTALLATIONS

Section 1	General
Section 2	General Design Requirements
Section 3	System Design
Section 4	Rotating Machines
Section 5	Transformers
Section 6	Semiconductor Converters
Section 7	Storage Batteries and Chargers
Section 8	Switchgear and Controlgear Assemblies
Section 9	Cables
Section 10	Miscellaneous Equipment
Section 11	Location
Section 12	Installation
Section 13	High Voltage Installations
Section 14	Communications, Safeties and Alarms
Section 15	Specific Requirements for Electrical Installations in Hazardous Areas
Section 16	Propulsion Plant
Section 17	Testing
Appendix 1	Indirect Test Method for Synchronous Machines
Appendix 2	Indirect Test Method for Induction Machines (Static Torque Method)

Section 1 General

1 Application

1.1 General

1.1.1 The requirements of this Chapter apply to electrical installations on all units, except express notifications, where indicated. In particular, they apply to the components of electrical installations for:

- essential services to be maintained under various emergency conditions
- safety of crew, contractors, visitors and unit
- essential services for special purposes connected with units specifically intended for such purposes (e.g. propulsion on mobile units, ballast system on semi-submersible units...)
- services for habitability
- SOLAS requirements, as far as practicable.

The other parts of the installation are to be so designed as not to introduce any risks or malfunctions to the above services.

1.2 Propelled units

1.2.1 For propelled units, reference is to be made to the Ship Rules, for the installation related to propulsion plant and steering, where the requirements of these installations, and corresponding essential services, are applicable. This includes power plant, machinery and the associated additional notations, where required.

1.3 References to other regulations and standards

1.3.1 The Society may refer to other regulations and standards when deemed necessary. These include the IEC publications, notably the IEC 60092 series "Electrical installations of ships and of mobile and fixed offshore units" and IEC61892 series "Mobile and fixed offshore units - electrical installations".

1.3.2 When referred to by the Society, publications by the International Electrotechnical Commission (IEC) or other internationally recognised standards defined in this chapter, are in principle those currently in force at the date of the contract for construction.

Note 1: The use of previous versions of these standards will be considered on the case by case basis.

2 National Authorities requirements

2.1 International Regulations

2.1.1 Attention is directed to the International Regulations the electrical systems of the unit or installation may have to comply with such as:

- IMO Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU code), in particular for drilling units.
- International Convention for the Safety of Life at Sea (SOLAS), in particular for self-propelled units.

2.2 National Authorities requirements

2.2.1 Attention is drawn to special legal provisions enacted by National Authorities which units or installations may have to comply with according to their flag, type, size, operational site and intended service, as well as other particulars and details.

2.3 Statutory requirements

2.3.1 Compliance with statutory requirements mentioned in [2.1] and [2.2] is not included in the classification scope but, in case of conflict between the Rules and these requirements, the latter ones are to take precedence over the requirements of the present Rules, as stated in the Ship Rules.

3 Documentation to be submitted

3.1

3.1.1 The documents listed in Tab 1 are to be submitted.

Table 1 : Documents to be submitted

No.	I/A **(1)**	Documents to be submitted
1	A	General arrangement of electrical installation
2	A	Single line diagram of main and emergency power and lighting systems
3	A	Electrical generation system philosophy
4	I	Electrical power balance (main and emergency supply)
5	A	Calculation of short-circuit currents for each installation in which the sum of rated power of the energy sources which may be connected contemporaneously to the network is greater than 500 kVA (kW)
6	A	List of circuits including, for each supply and distribution circuit, data concerning the nominal current, the cable type, length and cross-section, nominal and setting values of the protective and control devices
7	A	Single line diagram and detailed diagram of the main switchboard
8	A	Single line diagram and detailed diagram of the emergency switchboard
9	A	Diagram of the most important section boards and motor control centres (above 100 kW)
10	A	Diagram of the supply for monitoring and control systems of generator prime movers
11	A	Diagram of the general emergency alarm system, of the public address system and other intercommunication systems
12	A	Detailed diagram of the navigation-light switchboard (where required)
13	A	Diagram of the remote stop system (ventilation, fuel pump, fuel valves, etc.)
14	A	List of batteries including type and manufacturer, voltage and capacity, location and equipment and/or system(s) served (when used for essential and emergency services)
15	A	General arrangement of electrical equipment with regards to hazardous areas
16	A	Justification of safety character of electrical equipment located in hazardous areas
17	I	Principal cable routing diagram
18	A	Selectivity and coordination of electrical protections (for high voltage installations)
19	A	Diagram of jackup control system (for self-elevating units)
20	A	Diagram of ballast control system (for column stabilized units)
(1) A = To be submitted for approval ; I = To be submitted for information		

4 Definitions

4.1 General

4.1.1 Unless otherwise stated, the terms used in this Chapter have the definitions laid down by the IEC standards.

The definitions given in the following requirements also apply.

4.2 Essential services

4.2.1 Essential services are defined in Pt A, Ch 1, Sec 1, [1.2.1].

Examples of equipment for essential services are given in Tab 2. This list is not exhaustive and other services may be defined by the party applying for classification.

4.2.2 Complementary primary and secondary essential services specific for propelled units are defined in Pt C, Ch 2, Sec 1 of the Ship Rules.

4.3 Services for habitability

4.3.1 Services for habitability are those intended for minimum comfort conditions for people on board.

Some examples of equipment for maintaining conditions of habitability are listed in Tab 3.

Table 2 : Essential services

Item	Description of service
1	Electric generators and associated power sources
2	Auxiliary services supplying the above equipment (fuel oil supply pumps, lubricating oil pumps and cooling water pumps...)
3	Sea water pumps
4	Forced draught fans, feed water pumps, water circulating pumps, condensate pumps, oil burning installations, for auxiliary boilers on units where steam is used for equipment supplying primary essential services
5	Control, monitoring and safety devices/systems for primary essential services
6	Starting equipment of diesel engines and gas turbines
7	The main lighting system for those parts of the unit normally accessible to and used by personnel
8	Ventilation of hazardous areas and those areas maintained at an overpressure to exclude the ingress of dangerous gases
9	Fuel oil transfer pumps and fuel oil treatment equipment
10	Lubrication oil transfer pumps and lubrication oil treatment equipment
11	Preheaters and viscosity control equipment for heavy fuel oil
12	Bilge, ballast and heeling pump
13	Fire pumps and other fire-extinguishing medium pumps
14	Ventilation fans for engine and boiler rooms
15	Navigation lights, aids and sound signals
16	Internal safety communication equipment
17	Fire and gas detection and alarm systems as required in Part C, Chapter 4
18	Electrical equipment for watertight closing appliances
19	Control, monitoring and safety devices/systems for equipment for secondary essential services
20	Emergency shutdown systems having an impact on essential services
21	Cooling system of environmentally controlled spaces
22	Blow out preventer **(1)**
23	Services considered as necessary to maintain dangerous cargo in a safe condition (e.g. inert gas plant) **(4)**
24	Jacking systems **(2)**
25	Ballast control system **(3)**
26	Crude oil offloading pumps **(4)**
27	Mooring system **(5)**

(1) Drilling units and also units granted with notation **HIPS**.
(2) Self-elevating units.
(3) Column stabilized units.
(4) Storage and offloading units.
(5) Units granted with **POSA** notation.

Table 3 : Services for maintaining habitability conditions

Item	Description of service
1	Cooking
2	Heating
3	Domestic refrigeration
4	Mechanical ventilation
5	Sanitary and fresh water
6	Electric generators and associated power sources supplying the above equipment

4.4 Emergency services

4.4.1 The emergency services are the services essential for safety which need to be operable during emergencies. The services listed in Tab 4 are to be considered as emergency ones.

Table 4 : Emergency services

Item	Description of emergency services
1	Emergency lighting
2	Indoor and outdoor communication systems required in emergency conditions
3	Signalling lights and sound signals required for the marking of offshore structures, including helicopter perimeter lights
4	Navigation lights and sound signals
5	Fire and gas detection and alarm systems required in Part C, Chapter 4
6	Fire fighting systems
7	Diving equipment
8	All power-operated watertight doors systems
9	General alarm and public address system
10	Emergency shutdown systems having an impact on emergency services
11	Ventilation of hazardous areas and those areas maintained at an overpressure to exclude the ingress of dangerous gases
12	Equipment, operating on electric power, at life-saving stations serving platform disembarkation
13	Ballast system and assorted control system **(1)**
14	Blow-out preventer and well disconnection systems, if any **(2)**

(1) Column stabilized units.
(2) Drilling units.

4.5 Safety voltage

4.5.1 A voltage which does not exceed 50 V a.c. r.m.s. between conductors, or between any conductor and earth, in a circuit isolated from the supply by means such as a safety isolating transformer.

4.5.2 A voltage which does not exceed 50 V d.c. between conductors or between any conductor and earth in a circuit isolated from higher voltage circuits.

4.6 Low-voltage systems

4.6.1 Alternating current systems with rated voltages greater than 50 V r.m.s. up to 1000 V r.m.s. inclusive and direct current systems with a maximum instantaneous value of the voltage under rated operating conditions greater than 50 V up to 1500 V inclusive.

4.7 High-voltage systems

4.7.1 Alternating current systems with rated voltages greater than 1000 V r.m.s. and direct current systems with a maximum instantaneous value of the voltage under rated operating conditions greater than 1500 V, up to 35000 V included.

4.8 Basic insulation

4.8.1 Insulation applied to live parts to provide basic protection against electric shock.

Note 1: Basic insulation does not necessarily include insulation used exclusively for functional purposes.

4.9 Supplementary insulation

4.9.1 Independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation.

4.10 Double insulation

4.10.1 Insulation comprising both basic insulation and supplementary insulation.

4.11 Reinforced insulation

4.11.1 A single insulation system applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation.

Note 1: The term “insulation system” does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

4.12 Earthing

4.12.1 The earth connection to the general mass of the hull of the ship in such a manner as will ensure at all times an immediate discharge of electrical energy without danger.

4.13 Normal operational and habitable condition

4.13.1 *A condition under which the unit as a whole, its machinery, services, means and aids ensuring safe navigation when under way, safety when in the industrial mode, fire and flooding safety, internal and external communications and signals, means of escape and winches for rescue boats, as well as the means of ensuring the minimum comfortable conditions of habitability, are in working order and functioning normally, and drilling operations.*

4.14 Emergency condition

4.14.1 *A condition under which any services needed for normal operational and habitable conditions are not in working order due to failure of the main source of electrical power.*

4.15 Main source of electrical power

4.15.1 *A source intended to supply electrical power to the main switchboard for distribution to all services necessary for maintaining the unit in normal operational and habitable condition.*

4.16 Black start condition

4.16.1 The condition under which the services essential to maintain the habitability and the safety of the unit are not in operation due to the absence of power.

Note 1: Black start condition is the condition under which entire machinery installation, including the main power supply, is not in operation and auxiliary means for bringing the main power supply and the essential services into operation, such as compressed air and starting current from batteries, are not available, but assuming that means are available to start the emergency generator at all times.

4.17 Main generating station

4.17.1 *The space in which the main source of electrical power is situated.*

4.18 Main switchboard

4.18.1 *A switchboard which is directly supplied by the main source of electrical power and is intended to distribute electrical energy to the unit's services.*

4.19 Emergency switchboard

4.19.1 *A switchboard which, in the event of failure of the main system of electrical power supply is directly supplied by the emergency source of electrical power and/or the transitional source of emergency power and is intended to distribute electrical energy to the emergency services.*

4.20 Emergency source of electrical power

4.20.1 *A source of electrical power, intended to supply the necessary services in the event of failure of the supply from the main source of electrical power.*

4.21 Section boards

4.21.1 A switchgear and controlgear assembly which is supplied by another assembly and arranged for the distribution of electrical energy to other section boards or distribution boards.

4.22 Distribution board

4.22.1 A switchgear and controlgear assembly arranged for the distribution of electrical energy to final sub-circuits.

4.23 Final sub-circuit

4.23.1 That portion of a wiring system extending beyond the final required overcurrent protective device of a board.

4.24 Hazardous areas

4.24.1 Areas in which an explosive atmosphere is present, or may be expected to be present due to the presence of vapours, gases, flammable dusts or explosives in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

Note 1: An explosive gas atmosphere is a mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour or mist, in which, after ignition, combustion spreads throughout the unconsumed mixture.

4.24.2 Hazardous areas definitions and considerations for electrical equipment and installations are defined in Ch 2, Sec 15.

4.25 High fire risk areas

4.25.1 The high fire risk areas are defined as follows:

a) machinery spaces as defined in Ch 4, Sec 1, [3.2.1]

b) spaces containing fuel treatment equipment and other highly inflammable substances

c) galleys and pantries containing cooking appliances

d) laundry with drying equipment

e) enclosed or semi-enclosed hazardous spaces, in which certified safe type electric equipment is required.

4.26 Certified safe-type equipment

4.26.1 Certified safe-type equipment is electrical equipment of a type for which a national or other appropriate authority has carried out the type verifications and tests necessary to certify the safety of the equipment with regard to explosion hazard when used in an explosive gas atmosphere.

4.27 Voltage and frequency transient

4.27.1 Voltage transient

Sudden change in voltage (excluding spikes) which goes outside the nominal voltage tolerance limits and returns to and remains inside these limits within a specified recovery time after the initiation of the disturbance (time range: seconds).

4.27.2 Frequency transient

Sudden change in frequency which goes outside the frequency tolerance limits and returns to and remains inside these limits within a specified recovery time after initiation of the disturbance (time range: seconds).

4.28 Environmental categories

4.28.1 Electrical equipment is classified into environmental categories according to the temperature range, vibration levels, and resistance to chemically active substances and to humidity and to EMC required for installation in bridge and deck zone.

The designation of the environmental categories is indicated by the EC Code in Tab 5.

The first characteristic numeral indicates the temperature range in which the electrical equipment operates satisfactorily, as specified in Tab 6.

The second characteristic numeral indicates the vibration level in which the electrical equipment operates satisfactorily, as specified in Tab 7.

4.28.2 The tests for verifying the additional and supplementary letters and the characteristic numeral of the environmental categories are defined in Ch 3, Sec 6.

Table 5 : EC Code

Code letter	First characteristic numeral	Second characteristic numeral	Additional letter
EC	(numerals 1 to 4)	(numerals 1 to 3)	S **(1)** C **(2)** B **(3)**

(1) The additional letter S indicates the resistance to salt mist (exposed decks, masts) of the electrical equipment.

(2) The additional letter C indicates the relative humidity up to 80% (air conditioned areas) in which the electrical equipment operates satisfactorily.

(3) The additional letter B indicates the compliance for installing on the bridge and deck zone or in the vicinity of the bridge, with regards to EMC requirements specified in IEC 60533.

Table 6 : First characteristic numeral

First characteristic numeral	Brief description of location	Temperature range °C	
1	Air conditioned areas	+ 5	+ 40
2	Enclosed spaces	+ 5	+ 45
3	Inside consoles or close to combustion engines and similar	+ 5	+ 55
4	Exposed decks, masts	– 25	+ 45

Table 7 : Second characteristic numeral

Second characteristic numeral	Brief description of location	Frequency range, in Hz	Displacement amplitude, in mm	Acceleration amplitude, in g
1	Machinery spaces, command and control stations, accommodation spaces, exposed decks, cargo spaces	from 2,0 to 13,2	1,0	–
		from 13,2 to 100	–	0,7
2	Masts	from 2,0 to 13,2	3,0	–
		from 13,2 to 50	–	2,1
3	On air compressors, on diesel engines and similar	from 2,0 to 25,0	1,6	–
		from 25,0 to 100	–	4,0

Section 2 General Design Requirements

1 Environmental conditions

1.1 General

1.1.1 The electrical components of installations are to be designed and constructed to operate satisfactorily under the environmental conditions on board.

In particular, the conditions shown in the tables in this Article are to be taken into account.

Note 1: The environmental conditions are characterised by:

- one set of variables including climatic conditions (e.g. ambient air temperature and humidity), conditions dependent upon chemically active substances (e.g. salt mist) or mechanically active substances (e.g. dust or oil), mechanical conditions (e.g. vibrations or inclinations) and conditions dependent upon electromagnetic noise and interference, and
- another set of variables dependent mainly upon location on units, operational patterns and transient conditions.

1.2 Ambient air temperatures

1.2.1 The ambient air temperature ranges shown in Tab 1 are applicable in relation to the various locations of installation.

1.2.2 For units classed for service in specific zones, the Society may accept different ranges for the ambient air temperature (e.g. for units operating outside the tropical belt, the maximum ambient air temperature may be assumed as equal to +40°C instead of +45°C).

Table 1 : Ambient air temperature

Location	Temperature range (°C)	
Enclosed spaces	+5	+45
Inside consoles or fitted on combustion engines and similar	+5	+55
Air conditioned areas **(1)**	+5	+35 to +45
Exposed decks	–25	+45
(1) For environmentally controlled spaces, refer to Ch 2, Sec 12, [1.4]		

1.3 Humidity

1.3.1 The humidity ranges shown in Tab 2 are applicable in relation to the various locations of installation.

Table 2 : Humidity

Location	Humidity
General	95% up to 45°C 70% above 45°C
Air conditioned areas	Different values may be considered on a case by case basis

1.4 Sea water temperatures

1.4.1 The temperatures shown in Tab 3 are applicable to units classed for unrestricted service.

Table 3 : Water temperature

Coolant	Temperature range (°C)	
Sea water	0	+32

1.4.2 For units classed for service in specific zones, the Society may accept different values for the sea water temperature (e.g. for units operating outside the tropical belt, the maximum sea water temperature may be assumed as equal to +25°C instead of +32°C).

1.5 Salt mist

1.5.1 The applicable salt mist content in the air is to be 1mg/m^3.

1.6 Cold climate precautions

1.6.1 For units operating in cold climate areas, specific precaution may be found in IEC 61892-1, Annex B.

Particular requirements are specified for electrical installation for cold weather conditions, when additional class notation **COLD** is applied (refer to Pt A, Ch 1, Sec 2, [6.14.12] of the Ship Rules).

1.7 Inclinations

1.7.1 The inclinations applicable to electrical and electronic equipment are those indicated in Ch 1, Sec 1, Tab 1 and Ch 1, Sec 1, Tab 2 and Ch 1, Sec 1, Tab 3.

The Society may consider deviations from these angles of inclination taking into consideration the type, size and service conditions of the units.

1.8 Vibrations

1.8.1 In relation to the location of the electrical components, the vibration levels given in Tab 4 are to be assumed.

1.8.2 The natural frequencies of the equipment, their suspensions and their supports are to be outside the frequency ranges specified.

Where this is not possible using a suitable constructional technique, the equipment vibrations are to be dumped so as to avoid unacceptable amplifications.

Table 4 : Vibration levels

Location	Frequency range, in Hz	Displacement amplitude, in mm	Acceleration amplitude, in g
Machinery spaces, command and control stations, accommodation spaces, exposed decks, cargo spaces	from 2,0 to 13,2	1,0	–
	from 13,2 to 100	–	0,7
On air compressors, on diesel engines and similar	from 2,0 to 28,0	1,6	–
	from 28,0 to 100	–	4,0
Masts	from 2,0 to 13,2	3,0	–
	from 13,2 to 50	–	2,1

2 Quality of power supply

2.1 General

2.1.1 All electrical components are to be so designed and manufactured that they are capable of operating satisfactorily under the variations of voltage, frequency and harmonic distortion of the power supply specified from [2.2] to [2.4].

2.2 a.c. distribution systems

2.2.1 For alternating current components the voltage and frequency variations of power supply shown in Tab 5 are to be assumed.

Table 5 : Voltage and frequency variations of power supply in a.c.

Variation	Parameter	
	Voltage	Frequency
Continuous	+ 6% – 10%	± 5%
Unbalanced	7%	–
Cyclic	2%	0,5%
Transient	± 20% (recovery time: 1,5 s)	± 10% (recovery time: 5 s)
Note 1: For alternating current components supplied by emergency generating sets, different variations may be considered.		

2.3 d.c. distribution systems

2.3.1 For direct current components the power supply variations shown in Tab 6 are to be assumed.

Table 6 : Voltage variations in d.c.

Parameters	Variations
Voltage tolerance (continuous)	± 10%
Voltage cyclic variation	5%
Voltage ripple (a.c. r.m.s. over steady d.c. voltage)	10%

2.3.2 For direct current components supplied by electrical battery the following voltage variations are to be assumed:

- +30% to –25% for components connected to the battery during charging (see Note 1)
- +20% to –25% for components not connected to the battery during charging.

Note 1: Different voltage variations as determined by the charging/discharging characteristics, including ripple voltage from the charging device, may be considered.

2.4 Harmonic distortions

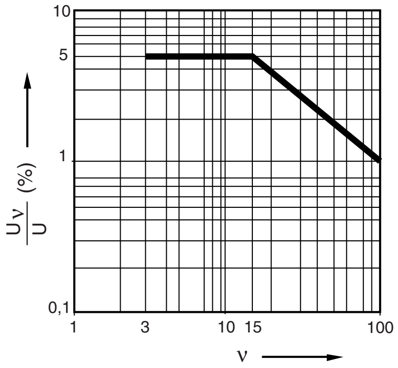
2.4.1 For components intended for systems without substantially static converter loads and supplied by synchronous generators, it is assumed that the total voltage harmonic distortion does not exceed 5%, and the single harmonic does not exceed 3% of the nominal voltage.

2.4.2 For components intended for systems fed by static converters, and/or systems in which the static converter load predominates, it is assumed that:

- the single harmonics do not exceed 5% of the nominal voltage up to the 15th harmonic of the nominal frequency, decreasing to 1% at the 100th harmonic (see Fig 1), and
- the total harmonic distortion does not exceed 8%.

2.4.3 Higher values for the harmonic content (e.g. in electric propulsion plant systems) may be accepted on the basis of correct operation of all electrical devices.

Figure 1 : Harmonics



3 Electromagnetic susceptibility

3.1

3.1.1 For electronic type components such as sensors, alarm panels, automatic and remote control equipment, protective devices and speed regulators, the conducted and radiated disturbance levels to be assumed are those given in Part C, Chapter 3.

Note 1: See also IEC Publication 60533 - “Electromagnetic Compatibility of Electrical and Electronic Installations in ships and of Mobile and Fixed Offshore Units”.

3.1.2 Electrical and electronic equipment on the bridge and in the vicinity of the bridge, not required neither by classification rules nor by International Conventions and liable to cause electromagnetic disturbance, shall be of type which fulfil the test requirements of test specification Ch 3, Sec 6, Tab 1, tests 19 and 20.

4 Materials

4.1 General

4.1.1 In general, and unless it is adequately protected, all electrical equipment is to be constructed of durable, flame-retardant, moisture-resistant materials which are not subject to deterioration in the atmosphere and at the temperatures to which they are likely to be exposed. Particular consideration is to be given to sea air and oil vapour contamination.

Note 1: The flame-retardant and moisture-resistant characteristics may be verified by means of the tests cited in IEC Publication 60092-101 or in other recognised standards.

4.1.2 Where the use of incombustible materials or lining with such materials is required, the incombustibility characteristics may be verified by means of the test cited in IEC Publication 60092-101 or in other recognised standards.

4.2 Insulating materials for windings

4.2.1 Insulated windings are to be resistant to moisture, sea air and oil vapour unless special precautions are taken to protect insulants against such agents.

4.2.2 The insulation classes given in Tab 7 may be used in accordance with IEC Publication 60085.

Table 7 : Insulation classes

Class	Maximum continuous operating temperature (°C)
A	105
E	120
B	130
F	155
H	180

4.3 Insulating materials for cables

4.3.1 See Ch 2, Sec 9, [2.3.1].

5 Construction

5.1 General

5.1.1 All electrical apparatus is to be so constructed as not to cause injury when handled or touched in the normal manner.

5.1.2 The design of electrical equipment is to allow accessibility to each part that needs inspection or adjustment, also taking into account its arrangement on board.

5.1.3 Enclosures are to be of adequate mechanical strength and rigidity.

5.1.4 Enclosures for electrical equipment are generally to be of metal; other materials may be accepted for accessories such as connection boxes, socket-outlets, switches and luminaires. Other exemptions for enclosures or parts of enclosures not made of metal are to be specially considered by the Society.

5.1.5 Cable entrance are not to impair the degree of protection of the relevant enclosure (see Ch 2, Sec 3, Tab 3).

5.1.6 All nuts and screws used in connection with current-carrying parts and working parts are to be effectively locked.

5.1.7 All equipment is generally to be provided with suitable, fixed terminal connectors in an accessible position for convenient connection of the external cables.

5.2 Degree of protection of enclosures

5.2.1 Electrical equipment is to be protected against the ingress of foreign bodies and water.

The minimum required degree of protection, in relation to the place of installation, is generally that specified in Ch 2, Sec 3, Tab 3.

5.2.2 The degrees of protection are to be in accordance with:

- IEC Publication No. 60529 for equipment in general
- IEC Publication No. 60034-5 for rotating machines.

5.2.3 For cable entries, see [5.1.5].

6 Protection against explosion hazard

6.1 Protection against explosive gas or vapour atmosphere hazard

6.1.1 Electrical equipment intended for use in areas where explosive gas or vapour atmospheres may occur (e.g. drilling area, cargo tanks, main deck above cargo tanks, process area, etc.), is to be of a “safe type” suitable for the relevant flammable atmosphere and for use on board. Specific requirements for electrical installations located in hazardous area are indicated in Ch 2, Sec 15.

Section 3 System Design

1 Distribution systems

1.1 Supply systems

1.1.1 The following parallel distribution systems with constant voltage may be used:

a) on d.c. installations:
- two-wire insulated (IT system)
- two-wire with one pole earthed (TN system)
- three-wire with middle wire earthed (TN system)

b) on a.c. installations (primary distribution systems):
- three-phase three-wire with insulated or impedance earthed (IT system)
- three-phase four-wire with neutral directly earthed (TN system)

c) on a.c. installations (secondary distribution systems):
- three-phase three-wire with insulated or impedance earthed (IT system)
- three-phase four-wire with neutral directly earthed (TN system)
- single-phase two-wire insulated (IT system)
- single-phase two-wire with one pole earthed (TN system)
- single-phase two-wire with mid-point of system earthed for supplying lighting and socket outlets (TN system)
- single-phase three-wire with mid-point earthed (TN system).

1.1.2 Where phase to neutral loads are to be served, systems are to be directly earthed (TN system).

Note 1: The neutral is defined for a polyphase only.

1.1.3 Hull return distribution systems are not permitted with the following exceptions:

a) impressed current cathodic protective systems

b) limited and locally earthed systems, such as starting and ignition systems of internal combustion engines, provided that any possible resulting current does not flow directly through any hazardous area

c) insulation level monitoring devices, provided that the circulation current of the device does not exceed 30 mA under the most unfavourable conditions.

1.1.4 For emergency power systems, consideration is to be given to the need for continuous operation of the consumers supplied from the emergency power system. An insulated neutral system is to be normally used to supply the emergency consumers.

1.1.5 For electrical installation located in gas dangerous area, requirements specified in Ch 2, Sec 15 apply with.

1.1.6 Distribution systems other than those listed in [1.1.1] will be considered by the Society on a case by case basis.

1.2 Maximum voltages

1.2.1 The maximum voltages for both alternating current and direct current low-voltage systems of supply for the ship's services are given in Tab 1.

1.2.2 Voltages exceeding those shown will be specially considered in the case of specific systems.

1.2.3 For high voltage systems see Ch 2, Sec 13.

Table 1 : Maximum voltages for various ship services

For:	Use	Maximum voltage (V)
Permanently installed and connected to fixed wiring	Power equipment	1000
	Cooking equipment	500
	Lighting	250
	Space heaters in accommodation spaces	250
	Control **(1)**, communication (including signal lamps) and instrumentation equipment	250
Permanently installed and connected by flexible cable	Power and heating equipment, where such connection is necessary because of the application (e.g. for moveable cranes or other hoisting gear)	1000
Socket-outlets supplying	Portable appliances which are not hand-held during operation (e.g. refrigerated containers) by flexible cables	1000
	Portable appliances and other consumers by flexible cables	250
	Equipment requiring extra precaution against electric shock where an isolating transformer is used to supply one appliance **(2) (3)**	250
	Equipment requiring extra precaution against electric shock with or without a safety transformer **(2) (3)**	50

(1) For control equipment which is part of a power and heating installation (e.g. pressure or temperature switches for starting/stopping motors), the same maximum voltage as allowed for the power and heating equipment may be used provided that all components are constructed for such voltage. However, the control voltage to external equipment is not to exceed 500 V.
(2) Both conductors in such systems are to be insulated from earth.
(3) Equipment located in narrow and wet spaces such as machinery spaces provided with bilge spaces.

2 Sources of electrical power

2.1 Main source of electrical power

2.1.1 A main source of electrical power is to be provided, of sufficient capability to supply all electrical auxiliary services necessary for maintaining the unit in normal operational and habitable conditions without recourse to the emergency source of electrical power (see list of services in Ch 2, Sec 1, [4.2] and Ch 2, Sec 1, [4.3]).

2.1.2 The main source of electrical power is to consist of at least two generating sets.

The capacity of these generating sets is to be such that in the event of any one generating set being stopped it is still be possible to supply those services necessary to provide:

a) normal operational conditions and safety (see [2.1.5])

b) minimum comfortable conditions of habitability (see Ch 2, Sec 1, [4.3.1])

c) preservation of the cargo, i. e. all the equipment which are needed for refrigerated cargo or operation of any safety device, such as inert gas generator.

Such capacity is, in addition, to be sufficient to start the largest motor without causing any other motor to stop or having any adverse effect on other equipment in operation.

2.1.3 For fixed units, other sources of electrical power supply arrangements may be acceptable subject to approval by the Society (e.g. supply from shore by fixed cables).

2.1.4 When renewable source of electrical power are used as a main source of power, specific arrangement may be found in IEC 61892-2, [4.6].

2.1.5 Those services necessary to provide normal operational conditions and safety include primary and secondary essential services.

For the purpose of calculating the capacity necessary for such services, it is essential to consider which of them can be expected to be in use simultaneously.

For a duplicated service, one being supplied electrically and the other non-electrically (e.g. driven by the main engine), the electrical capacity is not included in the above calculation.

2.1.6 The services mentioned in [2.1.5] do not include:

- cargo handling gear
- refrigerators for air-conditioning systems.

2.1.7 Where the electrical power is normally supplied by one generator, provision is to be made, upon loss of power, for automatic starting and connecting to the main switchboard of stand-by generator(s) of sufficient capacity to ensure the safety of the unit, with automatic restarting of the essential auxiliaries, in sequential operation if required. Starting and connection to the main switchboard of one generator are to be as rapid as possible, preferably within 30 seconds, but in any case not more than 45 seconds after loss of power.

Where prime movers with longer starting time are used, this starting and connection time may be exceeded upon approval from the Society.

2.1.8 Where the electrical power is normally supplied by more than one generator set simultaneously in parallel operation, provision of protection, including automatic disconnection of sufficient non-essential services and, if necessary, secondary essential services and those provided for habitability, are to be made to ensure that, in case of loss of any of these generating sets, the remaining ones are kept in operation to maintain primary essential services and to ensure safety.

2.1.9 Load shedding or other equivalent arrangements should be provided to protect the generators required in the present Article against sustained overload.

The load shedding should be automatic.

The non-essential services, services for habitability and, if necessary, the secondary essential services may be shed in order to make sure that the connected generator set(s) is/are not overloaded.

2.1.10 The emergency source of electrical power may be used for the purpose of starting from a dead ship condition if its capability either alone or combined with that of any other source of electrical power is sufficient to supply at the same time the services providing safety of all unit and a minimum of habitability conditions.

2.1.11 Where transformers, converters or similar appliances constitute an essential part of the electrical supply system, the system is to be so arranged as to ensure the same continuity of supply as stated in this sub-article.

This may be achieved by arranging at least two three-phase or three single-phase transformers supplied, protected and installed as indicated in Fig 1, so that with any one transformer not in operation, the remaining transformer(s) is/are sufficient to ensure the supply to the services stated in [2.1.2].

Each transformer required is to be located as a separate unit with separate enclosure or equivalent, and is to be served by separate circuits on the primary and secondary sides. Each of the primary and secondary circuits is to be provided with switchgears and protection devices in each phase.

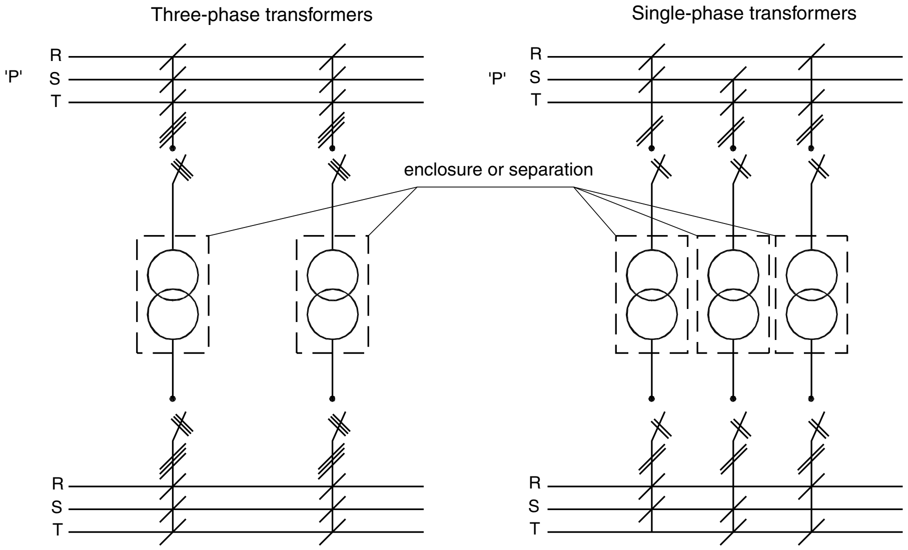
Suitable interlocks or a warning label are to be provided in order to prevent maintenance or repair of one single-phase transformer unless both switchgears are opened on their primary and secondary sides.

2.1.12 Where single phase transformers are used, only one spare element is required if special precautions are taken to rapidly replace the faulty one.

2.1.13 For starting arrangements of main generating sets, see Ch 1, Sec 2, [3.1].

2.1.14 For units intended for operation with periodically unattended machinery spaces, see additional notation **AUTO** in Ch 3, Sec 7.

Figure 1 : Installation and protection of transformers



3 Emergency power sources and circuits

3.1 Emergency power source

3.1.1 A self-contained emergency source of electrical power is to be provided.

3.1.2 *Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator may be used, exceptionally, and for short periods, to supply non-emergency circuits.*

Exceptionally is understood to mean conditions, while the unit is at sea, such as:

a) blackout situation

b) dead ship situation

c) routine use for testing

d) short-term parallel operation with the main source of electrical power for the purpose of load transfer.

3.1.3 *The electrical power available shall be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously.*

3.1.4 *The emergency source of electrical power shall be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the services stated in* Tab 2 *for the period specified, if they depend upon an electrical source for their operation.*

3.1.5 *An indicator shall be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power referred to in* [3.1.14] *and* [3.2.1] *are being discharged.*

3.1.6 If the services which are to be supplied by the transitional source receive power from an accumulator battery by means of semiconductor converters, means are to be provided for supplying such services also in the event of failure of the converter (e.g. providing a bypass feeder or a duplication of converter).

3.1.7 Where the emergency source of power is necessary to restore the main source of electrical power, provisions are to be made to allow a manual restart of a main generating set in case of failure of the emergency source.

3.1.8 Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements. If running unattended during tests, normal prime mover and generator protections are to be provided.

3.1.9 For starting arrangements for emergency generating sets, see Ch 1, Sec 2, [3.1].

3.1.10 *The emergency source of electrical power may be either a generator or an accumulator battery which shall comply with the requirements of* [3.1.11] *or* [3.1.14]*, respectively.*

3.1.11 *Where the emergency source of electrical power is a generator, it shall be:*

a) *driven by a suitable prime mover with an independent supply of fuel, having a flashpoint (closed cup test) of not less than 43°C*

b) *started automatically upon failure of the main source of electrical power supply* to the emergency switchboard *unless a transitional source of emergency electrical power in accordance with* item c) *below is provided; where the emergency generator is automatically started, it shall be automatically connected to the emergency switchboard; those services referred to in* [3.2.1] *shall then be connected automatically to the emergency generator;* see also Ch 1, Sec 2, [3.1.3]

c) *provided with a transitional source of emergency electrical power as specified in* [3.2.1] *unless an emergency generator is provided capable both of supplying the services mentioned in that paragraph and of being automatically started and supplying the required load as quickly as is safe and practicable subject to a maximum of 45 s.*

3.1.12 *The emergency generator and its prime mover and any emergency accumulator battery should be designed to function at full rated power when upright and when inclined up to the maximum angle of heel in the intact and damaged condition, as determined in accordance with* Part B, Chapter 1. In no case need the equipment be designed to operate when inclined more than the values indicated in Ch 1, Sec 1, Tab 1 to Ch 1, Sec 1, Tab 3.

3.1.13 The availability of the emergency generator is to be maintained as far as possible. Shutdown or inhibition of emergency generator starting may be accepted for ultimate safety reasons, such as confirmed gas detection at air entrance of emergency generator room or fire detection inside emergency generator room.

3.1.14 *Where the emergency source of electrical power is an accumulator battery it shall be capable of:*

a) *carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage*

b) *automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and*

c) *immediately supplying at least those services specified in* [3.2.2].

Table 2 : Duration services and duration of services to be supplied by an emergency and a transitional source

Service	Emergency power consumers	Duration, in hours, of:	
		emergency power	transitional power
All units			
Emergency lighting	At every muster and embarkation station on deck and over sides	18	0,5 **(1)**
	In all service and accommodation alleyways, stairways and exits, personnel lift cars and personnel lift trunks	18	0,5 **(1)**
	In the machinery spaces and main generating stations including their control positions	18	0,5 **(1)**
	In all control stations, machinery control rooms, and at each main and emergency switchboard	18	0,5 **(1)**
	At the stowage positions for firemen's outfits	18	0,5 **(1)**
	At the steering gear, as applicable		0,5 **(1)**
	At the fire pump, at the sprinkler pump, if any, at the emergency bilge pump, if any, and at the starting positions of their motors	18	0,5 **(1)**
	On helideck, including landing area perimeter and obstacle lighting	18	0,5 **(1)**
Machinery and safety equipment	Fans and other equipment deemed necessary to avoid accumulation of dangerous or explosive gases	18	
	One of the fire pumps required by the Society’s Rules for Classification applicable to the unit or installation considered if dependent upon the emergency generator for its source of power	18	
	Automatic sprinkler pump (if any)	18	
	The fire and gas detection and their alarm systems	18	0,5 **(2)**
Structure marking	Any signalling lights or sound signals which may be required for marking of offshore structures	96	
Navigation lights	Navigation lights and other lights required by the International Regulations for the Prevention of Collisions at Sea in force	18	0,5 **(1)**
Communications	All internal communication equipment required in an emergency	18	0,5 **(2)**
	Safety telecommunication systems	18	0,5
Doors and hatches	Power to operate watertight doors, remote controlled doors and hatch covers, together with corresponding alarms and controls, but not necessarily all of them simultaneously, unless an independent temporary source of stored energy is provided	18	
Radio installation	• According to regulations of national authorities • MODU Ch 11 and SOLAS Ch IV, where applicable	18	0,5
Miscellaneous	Permanently installed diving equipment, if dependent upon electrical power of the unit or installation	18	
Additional requirements for mobile units			
Navigation aids	Where applicable on mobile units, the navigation aids as required by Chap V Reg 19 of SOLAS 2002; where such a provision is unreasonable or impracticable, special consideration is to be given by the Society for units of less than 5000 tons gross tonnage, where applicable	18	0,5
Additional requirements for column stabilized units			
Ballast system	Control and indicating systems required by the Society’s Rules for Classification applicable to the unit or installation considered	18	
	Any of the ballast pumps required by the Society’s Rules for Classification applicable to the unit or installation considered	18	
Watertight doors	Power to operate the watertight doors (not necessarily all of them simultaneously)	0,5	
	Power to operate the controls and indicators	0,5	
Additional requirements for drilling units			
Emergency lighting	In all spaces from which control of the drilling process is performed and where controls of machinery essential for the performance of this process, or devices for emergency switching-off of the power plant are located	18	
Well blow out preventer	Capability of closing the blow-out preventer and of disconnecting the unit from the well-head arrangement, if electrically controlled	18	0,5 **(2)**

(1) The required emergency lighting, in respect of the machinery space and accommodation and service areas, may be provided by permanently fixed, individual accumulator lamps which are automatically charged and operated.

(2) Transitional source required unless these services have an independent supply from an accumulator battery suitably located for use in an emergency and sufficient for the period specified.

3.1.15 *For units* and installations *where the main source of electrical power is located in two or more spaces which have their own systems, including power distribution and control systems, completely independent of the systems in other spaces and so arranged that a fire or other casualty in any one of the spaces will not affect the power distribution from the others, or to the services required in* Tab 2 *and other services that may be required by the Society's Rules for Classification applicable to the unit or installation considered, the requirements of* [3.1.1] *may be considered satisfied without an additional emergency source of electrical power, provided that:*

a) *there are at least two generating sets, meeting the requirements of* [3.1.12] *and each of sufficient capacity to meet the requirements indicated in* Tab 2, *in each of at least two spaces*

b) *the arrangements required by* item a) *in each such space are equivalent to those required by* [3.1.11], Ch 2, Sec 11, [3.3], Ch 2, Sec 11, [3.5.1], as well as [3.1.5], [5.4.1], [5.4.2] and Ch 1, Sec 2, [3.1] *so that a source of electrical power is available at all times to the services required in* Tab 2

c) *the location of each of the spaces referred to in* item a) *is in compliance with* Ch 2, Sec 11, [3.1.1] *and the boundaries meet the requirements of* Ch 2, Sec 11, [3.2.1] *except that contiguous boundaries should consist of an "A-60" bulkhead and a cofferdam, or a steel bulkhead insulated to class "A-60" on both sides.*

3.2 Transitional source

3.2.1 *The transitional source of emergency electrical power where required by* [3.1.11] item c), *shall consist of an accumulator battery which shall operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage and be so arranged as to supply automatically in the event of failure of either the main or the emergency source of electrical power for half an hour at least the services in* [3.2.2] *if they depend upon an electrical source for their operation.*

3.2.2 The transitional source of emergency electrical power, where required, is to supply the services listed in Tab 2, when a duration of transitional power is indicated.

3.2.3 Where the emergency and/or transitional emergency loads are supplied from a battery via an electronic converter or inverter, the maximum permitted d.c. voltage variations are to be taken as those on the load side of the converter or inverter.

Where the d.c. is converted into a.c. the maximum variations are not exceed those given in Ch 2, Sec 2, Tab 5.

3.3 Services to be supplied by the emergency source

3.3.1 The emergency source of electrical power is to be capable of supplying simultaneously at least the services listed in Tab 2 for the periods specified, if they depend upon an electrical source for their operation.

3.4 Services to be operable after emergency shutdown

3.4.1 Electrical power is to be provided, in case of emergency shutdown causing loss of both main and emergency power so that services listed below remain available during half an hour, in order to allow the personnel on board to escape safely from the installation and to maintain contact with the external emergency services:

a) emergency lighting:
   - at every muster and embarkation station on deck and over sides
   - in all service and accommodation alleyways, stairways and exits, personnel lift cars and personnel lift trunks
   - in the machinery spaces and main generating stations including their control positions
   - in all control stations, machinery control rooms, and at each main and emergency switchboard

b) navigation aids

c) blow-out preventer control system

d) general alarm system

e) public address system

f) battery-supplied radiocommunication installations.

3.4.2 Electrical equipment required to be operable for services listed in [3.4.1] are to be compliant with dispositions relative to installation of electrical equipment in hazardous areas described in Ch 2, Sec 15.

4 System earthing

4.1 General requirements

4.1.1 Neutral earthing is to be in accordance with one of the methods specified in [1.1.1].

4.1.2 The magnitude and duration of a potential earth fault current are not to exceed the design capacity of any part of the electrical power supply system.

4.1.3 The requirements applicable for high voltage installations are detailed in Ch 2, Sec 13.

4.1.4 Additional requirements apply for the electrical power systems located in hazardous areas. See Ch 2, Sec 15, [2.2].

4.2 Earthed distribution systems

4.2.1 The neutral point is to be connected to earth directly. The earth loop impedance is to be low enough to permit the passage of a current at least three times the fuse rating for fuse protected circuits or one and a half times the tripping current of any excess current circuit breaker used to protect the circuit.

4.2.2 System earthing is to be effected by means independent of any earthing arrangements of the non-current-carrying parts.

4.2.3 Means of disconnection are to be fitted in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance or insulation resistance measurements.

4.2.4 Generator neutrals may be connected in common, provided that the third harmonic content of the voltage wave form of each generator does not exceed 5%.

4.2.5 Where a switchboard is split into sections operated independently or where there are separate switchboards, neutral earthing is to be provided for each section or for each switchboard. Means are to be provided to ensure that the earth connection is not removed when generators are isolated.

4.2.6 Where for final sub-circuits it is necessary to locally connect a pole (or phase) of the sub-circuits to earth after the protective devices (e.g. in automation systems or to avoid electromagnetic disturbances), provision (e.g. d.c./d.c. converters or transformers) is to be made such that current unbalances do not occur in the individual poles or phases.

4.3 Insulated distribution systems

4.3.1 Every insulated distribution system, whether primary or secondary for power, heating or lighting, is to be provided with a device capable of continuously monitoring the insulation level to earth (i.e. the values of electrical insulation to earth) and of giving at a manned control centre an audible and visual indication of abnormally low insulation values Ch 2, Sec 17.

Note 1: A primary system is one supplied directly by generators. Secondary systems are those supplied by transformers or converters.

4.4 Impedance earthed distribution system

4.4.1 In the case of impedance earthing, the impedance should be such that the earth fault current is slightly higher than the capacitive current of system. The maximum earth fault should however be limited to:

- 100 A per generator
- 100 A per transformer.

4.4.2 Earth leakage monitoring and an alarm or automatic disconnection via earth leakage protection devices are to be provided.

4.5 Cross-sectional area of earthing connections

4.5.1 The cross-sectional areas of earthing connections are to be calculated according to the characteristics of the generators or transformers and of the protective devices.

5 Distribution

5.1 General requirements for distribution systems

5.1.1 *The distribution system is to be such that the failure of any single circuit will not endanger or impair primary essential services and will not render secondary essential services inoperative for longer periods.*

5.1.2 No common switchgear (e.g. contactors for emergency stop) is to be used between the switchboard's busbars and two primary non-duplicated essential services.

5.2 Distribution systems with hull return

5.2.1 *Where the hull return system is used,* if permitted*, all final sub-circuits, i.e. all circuits fitted after the last protective device, are to be two-wire.*

The hull return is to be achieved by connecting to the hull one of the busbars of the distribution board from which the final sub-circuits originate.

5.3 Main distribution of electrical power

5.3.1 The main busbar is to be divided into at least two parts which are normally to be connected by circuit breakers or other approved means such as circuit breakers without tripping mechanisms or switches by means of which busbars can be split safely and easily.

The connection of generating sets and associated auxiliaries and other duplicated equipment is to be equally divided between the parts as far as practicable, so that in the event of damage to one section of the switchboard the remaining parts are still supplied.

5.3.2 Two or more units serving the same consumer (e.g. main and standby lubricating oil pumps) are to be supplied by individual separate circuits without the use of common feeders, protective devices or control circuits.

This requirement is satisfied when such units are supplied by separate cables from the main switchboard or from two independent section boards.

5.3.3 *A main electric lighting system which shall provide illumination throughout those parts of the unit normally accessible to and used by crew shall be supplied from the main source of electrical power.*

5.4 Emergency distribution of electrical power

5.4.1 *The emergency switchboard shall be supplied during normal operation from the main switchboard by an interconnector feeder which shall be adequately protected at the main switchboard against overload and short-circuit and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power.*

Where the system is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard at least against short-circuit.

5.4.2 *In order to ensure ready availability of the emergency source of electrical power, arrangements shall be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that power shall be available to the emergency circuits.*

5.5 Shore supply

5.5.1 Where arrangements are made for supplying the electrical installation from a source on shore or elsewhere, a suitable connection box is to be installed on the unit in a convenient location to receive the flexible cable from the external source.

5.5.2 Permanently fixed cables of adequate rating are to be provided for connecting the box to the main switchboard.

5.5.3 Where necessary for systems with earthed neutrals, the box is to be provided with an earthed terminal for connection between the shore's and unit's neutrals or for connection of a protective conductor.

5.5.4 The connection box is to contain a circuit-breaker or a switch-disconnector and fuses.

The shore connection is to be protected against short-circuit and overload; however, the overload protection may be omitted in the connection box if provided on the main switchboard.

5.5.5 Means are to be provided for checking the phase sequence of the incoming supply in relation to the unit's system.

5.5.6 The cable connection to the box is to be provided with at least one switch-disconnector on the main switchboard.

5.5.7 The shore connection is to be provided with an indicator at the main switchboard in order to show when the cable is energised.

5.5.8 At the connection box a notice is to be provided giving full information on the nominal voltage and frequency of the installation and the procedure for carrying out the connection.

5.5.9 The switch-disconnector on the main switchboard is to be interlocked with the main generator circuit-breakers in order to prevent its closure when any generator is supplying the main switchboard.

5.5.10 Adequate means are to be provided to equalise the potential between the hull and the shore when the electrical installation of the unit is supplied from shore.

5.5.11 Provisions are to be made for securing the trailing cables to the framework so that mechanical stress is not applied to the electrical terminals.

5.6 Supply of motors

5.6.1 A separate final sub-circuit is to be provided for every motor required for an essential service (and for every motor rated at 1 kW or more).

5.6.2 Each motor is to be provided with controlgear ensuring its satisfactory starting.

Direct on line starters are accepted if the voltage drop does not exceed 15% of the network voltage.

5.6.3 Efficient means are to be provided for the isolation of the motor and its associated control gear from all live poles of the supply.

Where the control gear is mounted on or adjacent to a switchboard, a disconnecting switch in the switchboard may be used for this purpose.

Otherwise, a disconnecting switch within the control gear enclosure or a separate enclosed disconnecting switch is to be provided.

5.6.4 Where the starter or any other apparatus for disconnecting the motor is remote from the motor itself, one of the following is to be arranged:

a) provision for locking the circuit disconnecting switch in the OFF position

b) an additional disconnecting switch fitted near the motor

c) provision such that the fuses in each live pole or phase can be readily removed and retained by persons authorised to have access to the motor.

5.6.5 Unless automatic restarting is required, motor control circuits are to be designed so as to prevent any motor from unintentional automatic restarting after a stoppage due to over-current tripping or a fall in or loss of voltage, if such starting is liable to cause danger. Where reverse-current braking of a motor is provided, provision is to be made for the avoidance of reversal of the direction of rotation at the end of braking, if such reversal may cause danger.

5.7 Specific requirements for special power services

5.7.1 For the supply and characteristics of the distribution of the following services see the requirements listed:

- electrical starting of diesel engines for main and emergency generators: Ch 1, Sec 2, [3.1]
- fire-extinguishing and detecting systems: Ch 4, Sec 11
- permanently installed submersible bilge pump: Ch 1, Sec 7, [6.5.7]
- ventilation fans: Ch 4, Sec 3, [5] and Ch 4, Sec 4, [5]
- fuel pumps: Ch 1, Sec 7
- pumps discharging overboard above the lightest water line and in way of the area of lifeboat and liferaft launching: Ch 1, Sec 7, [5.3.4].
- ballast pumps for column stabilized units: NR571
- heaters: Ch 2, Sec 10, [6.2.1].

5.7.2 All power circuits terminating in a bunker or cargo space are to be provided with a multiple-pole switch outside the space for disconnecting such circuits.

5.8 Power supply to the speed control systems of generator sets

5.8.1 Each electrically operated control and/or speed control system of generator sets is to be provided with a separate supply from the main source of electric power and from an accumulator battery for at least 15 minutes or from a similar supply source.

5.8.2 The speed control systems of generator sets are to be supplied from the main switchboard or from independent section boards.

Where the main busbars are divided into two sections, the governors are, as far as practicable, to be supplied from the sections to which the relevant generators are connected.

5.9 Power supply to lighting installations

5.9.1 Final sub-circuits for lighting supplying more than one lighting point and for socket-outlets are to be fitted with protective devices having a current rating not exceeding 16 A.

5.9.2 Final circuits for lighting are not to supply appliances for heating and power except that small galley equipment (e.g. toasters, mixers, coffee makers) and small miscellaneous motors (e.g. desk and cabin fans, refrigerators) and wardrobe heaters and similar items may be supplied.

5.9.3 Discharge lamp luminaires or installations of voltages above 250 V are to be provided with a multipole disconnecting switch in an accessible location.

Such a switch is to be clearly marked and a warning note is to be placed nearby.

Switches or other current-interrupting devices are not to be installed in the secondary circuit of transformers.

5.10 Special lighting services

5.10.1 In spaces such as:

- main and large machinery spaces
- large galleys
- passageways
- stairways leading to boat-decks
- public spaces,

there is to be more than one final sub-circuit for lighting, one of which is to be supplied from the emergency switchboard, in such a way that failure of any one circuit does not reduce the lighting to an insufficient level.

5.10.2 All lighting circuits terminating in a bunker or cargo space are to be provided with a multiple-pole switch outside the space for disconnecting such circuits.

5.10.3 The number of lighting points (lamps) supplied by a final sub-circuit having a current rating not exceeding 16 A is not to exceed the following maxima:

- 10 lamps for voltage up to 55 V
- 14 lamps for voltage from 56 V up to 120 V
- 24 lamps for voltage from 121 V to 250 V.

5.10.4 Final sub-circuits for lighting in accommodation spaces may include socket-outlets. In that case, each socket-outlet counts for two lighting points.

5.11 Navigation lights

5.11.1 The following requirements [5.11.2] to [5.11.6] are applicable to fixed navigation lights installed on mobile units, where required by National Authorities.

5.11.2 Navigation lights are to be connected separately to a distribution board specially reserved for this purpose.

5.11.3 The distribution board in [5.11.2] is to be supplied from two alternative circuits, one from the main source of power and one from the emergency source of power; see also [5.4].

The transfer of supply is to be practicable from the bridge, or the central control position, as appropriate, for example by means of a switch.

5.11.4 Each navigation light is to be controlled and protected in each insulated pole by a double-pole switch and a fuse or, alternatively, by a double-pole circuit-breaker, fitted on the distribution board referred to in [5.11.2].

5.11.5 Where there are double navigation lights, i.e. lights with two lamps or where for every navigation light a spare is also fitted, the connections to such lights may run in a single cable provided that means are foreseen in the distribution board to ensure that only one lamp or light may be supplied at any one time.

5.11.6 Each navigation light is to be provided with an automatic indicator giving audible and/or visual warning in the event of failure of the light. If an audible device alone is fitted, it is to be connected to a separate source of supply from that of the navigation lights, for example an accumulator (storage) battery.

If a visual signal is used connected in series with the navigation light, means are to be provided to prevent the extinction of the navigation light due to the failure of the visual signal.

A minimum level of visibility is to be assured in the case of use of dimmer devices.

5.12 Offshore structure marking

5.12.1 Marking lights and sound signals are to be fitted on offshore structures, following IALA recommendations and national authorities regulations, where applicable, and supplied for the period defined in Tab 2.

5.13 Installation of water-based local application fire-fighting systems (FWBLAFFS)

5.13.1 The system is to be capable of manual release.

5.13.2 The activation of the fire-fighting system is not to result in loss of electrical power.

6 Degrees of protection of the enclosures

6.1 General

6.1.1 The minimum required degree of protection for electrical equipment, in relation to the place of installation, is generally that specified in Tab 3.

Table 3 : Minimum required degrees of protection

Condition in location	Example of location	Switchboard, control gear, motor starters	Generators	Motors	Transformers	Luminaires	Heating appliances	Cooking appliances	Socket outlets	Accessories (e.g. switches, connection boxes)
Danger of touching live parts only	Dry accommodation spaces, dry control rooms	IP 20	X **(1)**	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20
Danger of dripping liquid and/or moderate mechanical damage	Control rooms, wheel-house, radio room	IP 22	X	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22
	Engine and boiler rooms above floor	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 44	IP 44
	Steering gear rooms	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	X	IP 44	IP 44
	Emergency machinery rooms	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	X	IP 44	IP 44
	General storerooms	IP 22	X	IP 22	IP 22	IP 22	IP 22	X	IP 22	IP 44
	Pantries	IP 22	X	IP 22	IP 22	IP 22	IP 22	IP 22	IP 44	IP 44
	Provision rooms	IP 22	X	IP 22	IP 22	IP 22	IP 22	X	IP 44	IP 44
	Ventilation ducts	X	X	IP 22	X	X	X	X	X	X
Increased danger of liquid and/or mechanical damage	Bathrooms and/or showers	X	X	X	X	IP 34	IP 44	X	IP 55	IP 55
	Engine and boiler rooms below floor	X	X	IP 44	X	IP 34	IP 44	X	X	IP 55
	Closed fuel oil separator rooms	IP 44	X	IP 44	IP 44	IP 34	IP 44	X	X	IP 55
	Closed lubricating oil separator rooms	IP 44	X	IP 44	IP 44	IP 34	IP 44	X	X	IP 55
	Enclosed spaces on Topsides and drilling areas	IP 44	IP 44	IP 44	IP 44	IP 34	IP 44	X	IP 55	IP 55
Increased danger of liquid and mechanical damage	Ballast pump rooms	IP 44	X	IP 44	IP 44	IP 34	IP 44	X	IP 55	IP 55
	Refrigerated rooms	X	X	IP 44	X	IP 34	IP 44	X	IP 55	IP 55
	Galleys and laundries	IP 44	X	IP 44	IP 44	IP 34	IP 44	IP 44	IP 44	IP 44
	Public bathrooms and shower	X	X	IP 44	IP 44	IP 34	IP 44	X	IP 44	IP 44
Danger of liquid spraying, presence of cargo dust, serious mechanical damage, aggressive fumes	Shaft or pipe tunnels in double bottom	IP 55	X	IP 55	IP 55	IP 55	IP 55	X	IP 56	IP 56
	Holds for general cargo	X	X	IP 55	X	IP 55	IP 55	X	IP 56	IP 56
	Ventilation trunks	X	X	IP 55	X	X	X	X	X	X
Danger of liquid in massive quantities	Open decks	IP 56	X	IP 56	X	IP 55	IP 56	X	IP 56	IP 56
	Topsides and drilling areas	IP 56	IP 56	IP 56	IP 56	IP 55	IP 56	X	IP 56	IP 56

(1) The symbol "X" denotes equipment which it is not advised to install.

6.1.2 Equipment supplied at nominal voltages in excess of 500 V and accessible to non-authorised personnel (e.g. equipment not located in machinery spaces or in locked compartments under the responsibility of the unit's masters) is to have a degree of protection against touching live parts of at least IP 4X.

6.1.3 In addition to the requirements of this paragraph, equipment installed in spaces with an explosion hazard is also subject to the provisions of Ch 2, Sec 15.

6.1.4 The enclosures of electrical equipment for the monitoring and control of watertight doors which are situated below the bulkhead deck are to provide suitable protection against the ingress of water.

In particular, the minimum required degree of protection is to be:

- IP X7 for electric motors, associated circuits and control components
- IP X8 for door position indicators and associated circuit components
- IP X6 for door movement warning signals.

Note 1: The water pressure testing of the enclosures protected to IP X8 is to be based on the pressure that may occur at the location of the component during flooding for a period of 36 hours.

6.2 Installation of electrical and electronic equipment in engine rooms protected by fixed water-based local application fire-fighting systems (FWBLAFFS)

6.2.1 Unless it is essential for safety or operational purposes, electrical and electronic equipment is not to be located within areas protected by FWBLAFFS and in adjacent areas where water may extend.

The electrical and electronic equipment located within areas protected by FWBLAFFS and those within adjacent exposed to direct spray are to have a degree of protection not less than IP 44, except where evidence of suitability is submitted to and approved by the Society.

Electrical and electronic equipment within adjacent areas not exposed to direct spray may have a lower degree of protection provided evidence of suitability for use in these areas is submitted taking into account the design and equipment layout, e.g. position of inlet ventilation openings, filters, baffles, etc. to prevent or restrict the ingress mist/spray into the equipment. The cooling airflow for the equipment is to be assured.

Note 1: Definitions (see Fig 2):

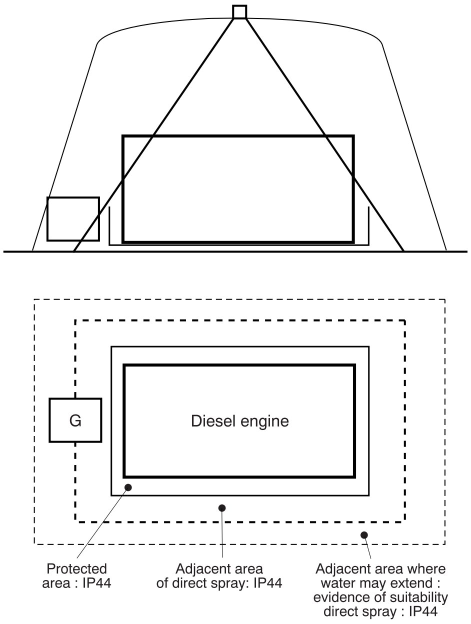
- protected space: machinery space where a FWBLAFFS is installed
- protected areas: areas within a protected space which is required to be protected by FWBLAFFS
- adjacent areas:
  - areas other those protected areas, exposed
  - areas other those defined above, where water may extend.

Note 2: Additional precautions may be required to be taken in respect of:

- tracking as the result of water entering the equipment
- potential damage as the result of residual salts from sea water systems
- high voltage installations
- personnel protection against electric shock.

Equipment may require maintenance after being subjected to water mist/spray.

Figure 2 : Definitions of areas



7 Diversity (demand) factors

7.1 General

7.1.1 The cables and protective devices of final sub-circuits are to be rated in accordance with their connected load.

7.1.2 Circuits supplying two or more final sub-circuits are to be rated in accordance with the total connected load subject, where justifiable, to the application of a diversity (demand) factor.

7.1.3 A diversity (demand) factor may be applied provided the known or anticipated operating conditions in a particular part of an installation are suitable for the application of diversity.

8 Environmental categories of the equipment

8.1 Environmental categories

8.1.1 The environmental categories of the electrical equipment, in relation to the place of installation, are generally to be those specified in Tab 4.

8.1.2 For units operating outside the tropical belt, the maximum ambient air temperature may be assumed as equal to +40°C instead of +45°C, so that the first characteristic numeral changes from 1 to 3.

Table 4 : Required environmental categories - Location within main area

Main areas on board	General	Inside cubicles, desks, etc.	On machinery such as internal combustion engines, compressors	Masts
Machinery spaces, steering gear	EC21	EC31	EC23	X **(1)**
Control room, accommodation	EC21 EC11C	EC31	X	X
Bridge	EC21B EC11BC	EC31B	X	X
Pump room, holds, rooms without heating	EC41	X	X	X
Exposed decks	EC41S EC41BS	X	X	EC42S EC42BS

(1) The symbol "X" denotes locations which are generally not applicable.

9 Electrical protection

9.1 General requirements for overcurrent protection

9.1.1 Electrical installations are to be protected against accidental overcurrents including short-circuit.

The choice, arrangement and performance of the various protective devices are to provide complete and coordinated automatic protection in order to ensure as far as possible:

- continuity of service in the event of a fault, through coordinated and discriminative action of the protective devices
- elimination of the effects of faults to reduce damage to the system and the hazard of fire as far as possible.

Note 1: An overcurrent is a current exceeding the nominal current.

Note 2: A short-circuit is the accidental connection by a relatively low resistance or impedance of two or more points in a circuit which are normally at different voltages.

9.1.2 Devices provided for overcurrent protection are to be chosen according to the requirements, especially with regard to overload and short-circuit.

Note 1: Overload is an operating condition in an electrically undamaged circuit which causes an overcurrent.

9.1.3 Systems are to be such as to withstand the thermal and electrodynamic stresses caused by the possible overcurrent, including short-circuit, for the admissible duration.

9.2 Short-circuit currents

9.2.1 In calculating the maximum prospective short-circuit current, the source of current is to include the most powerful configuration of generators which can be simultaneously connected (as far as permitted by any interlocking arrangements), and the maximum number of motors which are normally simultaneously connected in the system.

The maximum number of generators or transformers is to be evaluated without taking into consideration short-term parallel operation (e.g. for load transfer) provided that suitable interlock is foreseen.

9.2.2 Short-circuit current calculations are to be performed in accordance with a method recognised by the Society, such as that given in IEC Publication 61363-1, 60909 series, as appropriate to the installation.

9.2.3 In the absence of precise data concerning the characteristics of generators, accumulator batteries and motors, the maximum short-circuit currents on the main busbars may be calculated as follows:

- for alternating current systems:

  $I_{ac} = 10\ I_{TG} + 3{,}5\ I_{TM}$

  $I_{pk} = 2{,}4\ I_{ac}$

- for direct current systems supplied by batteries:

  $I_p = K\ C_{10} + 6\ I_{TM}$

where:

I_p : Maximum short-circuit current

I_{ac} : r.m.s. value of the symmetrical component (at the instant T/2)

I_{pk} : Maximum peak value

I_{TG} : Rated current of all generators which can be connected simultaneously

C_{10} : Battery capacity, in A·h, for a discharge duration of 10 hours

K : Ratio of the short-circuit current of the batteries to C_{10} (see Note 1)

I_{TM} : Rated current of all motors which are normally simultaneously connected in the system.

Note 1: For stationary batteries the following values may be assumed for guidance:

- vented lead-acid batteries: K = 8
- vented alkaline type batteries intended for discharge at low rates corresponding to a battery duration exceeding three hours: K = 15
- sealed lead-acid batteries having a capacity of 100 A·h or more or alkaline type batteries intended for discharge at high rates corresponding to a battery duration not exceeding three hours: K = 30.

9.3 Selection of equipment

9.3.1 Circuit-breakers of withdrawable type are required where they are not suitable for isolation.

9.3.2 Equipment is to be chosen on the basis of its rated current and its making/breaking capacity.

9.3.3 In the selection of circuit-breakers with intentional short-time delay for short-circuit release, those of utilisation category B are to be used and they are to be selected also taking into account their rated short-time withstand current capacity (I_{cw}).

For circuit-breakers without intentional short-time delay for short-circuit release, circuit breakers of utilisation category A may be used and they are to be selected according to their rated service short-circuit breaking capacity (I_{cs}).

Note 1: For the purpose of these Rules, utilisation categories A and B are defined as follows:

- utilisation category A: circuit-breakers not specifically intended for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, i.e. without an intentional short-time delay provided for selectivity under short-circuit conditions
- utilisation category B: circuit-breakers specifically intended for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, i.e. with an intentional short-time delay (which may be adjustable) provided for selectivity under short-circuit conditions.

9.3.4 For duplicated essential services and non-essential services, circuit-breakers may be selected according to their ultimate short-circuit breaking capacity (I_{cu}).

9.3.5 For switches, the making/breaking capacity is to be in accordance with utilisation category AC-22 A or DC-22 A (in compliance with IEC Publication 60947-3).

9.3.6 For fuse-switch disconnectors or switch-disconnector fuse units, the making/breaking capacity is to be in accordance with utilisation categories AC-23 A or DC-23 A (in compliance with IEC Publication 60947-3).

9.4 Protection against short-circuit

9.4.1 Protection against short-circuit currents is to be provided by circuit- breakers or fuses.

9.4.2 The rated short-circuit breaking capacity of every protective device is to be not less than the maximum prospective value of the short-circuit current at the point of installation at the instant of contact separation.

9.4.3 The rated short-circuit making capacity of every mechanical switching device intended to be capable of being closed on short-circuit is to be not less than the maximum value of the short-circuit current at the point of installation. On alternating current this maximum value corresponds to the peak value allowing for maximum asymmetry.

9.4.4 Every protective device or contactor not intended for short-circuit interruption is to be adequate for the maximum short-circuit current liable to occur at the point of installation having regard to the time required for the short-circuit to be removed.

9.4.5 The use of a protective device not having a short-circuit breaking or making capacity at least equal to the maximum prospective short-circuit current at the point where it is installed is permitted, provided that it is backed up on the generator side by a fuse or by a circuit-breaker having at least the necessary short-circuit rating and not being the generator circuit-breaker.

9.4.6 The same fuse or circuit-breaker may back up more than one circuit-breaker where the circuits concerned do not involve essential services.

9.4.7 The short-circuit performance of the back-up arrangement is to be equal to the requirements of IEC Publication 60947-2 for a single circuit-breaker having the same short-circuit performance category as the backed-up circuit-breaker and rated for the maximum prospective short-circuit level at the supply terminals of the arrangement.

9.4.8 Circuit-breakers with fuses connected to the load side may be used, provided the back-up fuses and the circuit-breakers are of coordinated design, in order to ensure that the operation of the fuses takes place in due time so as to prevent arcing between poles or against metal parts of the circuit-breakers when they are submitted to overcurrents involving the operation of the fuse.

9.4.9 When determining the performance requirements for the above-mentioned back-up protection arrangement, it is permissible to take into account the impedance of the various circuit elements of the arrangement, such as the impedance of a cable connection when the backed-up circuit-breaker is located away from the back-up breaker or fuse.

9.5 Continuity of supply and continuity of service

9.5.1 The protection of circuits is to be such that a fault in one service does not cause the loss of any essential services.

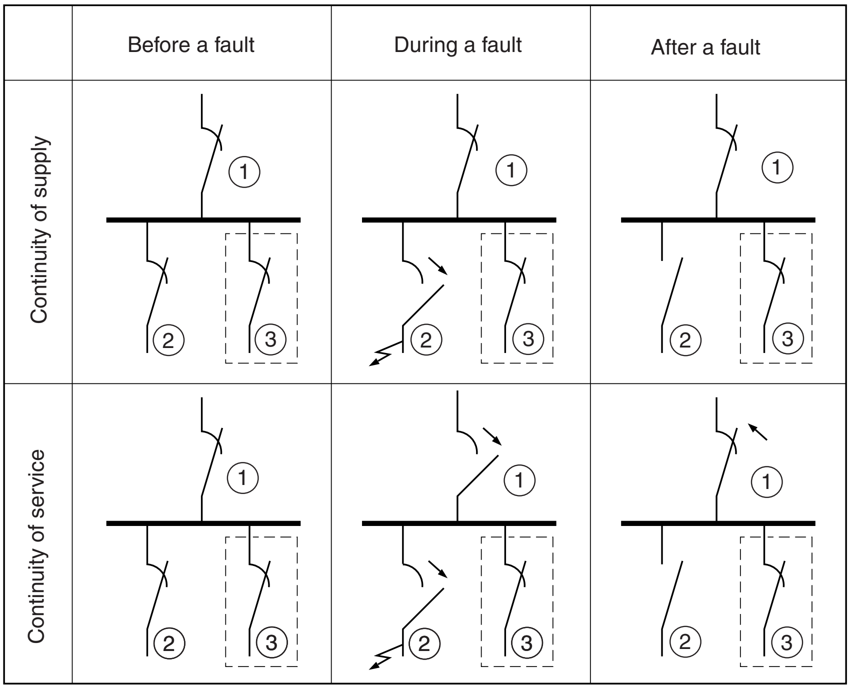
9.5.2 The protection of the emergency circuit is to be such that a failure in one circuit does not cause a loss of other emergency services.

Note 1: The continuity of supply for the primary essential services and the continuity of service for the secondary essential services are to be ensured.

The continuity of supply is the condition for which during and after a fault in a circuit, the supply to the healthy circuits (see circuit 3 in Fig 3) is permanently ensured.

The continuity of service is the condition for which after a fault in a circuit has been cleared, the supply to the healthy circuits (see circuit 3 in Fig 3) is re-established.

Figure 3 : Continuity of supply and continuity of service



9.6 Protection against overload

9.6.1 Devices provided for overload protection are to have a tripping characteristic (overcurrent-trip time) adequate for the overload ability of the elements of the system to be protected and for any discrimination requirements.

9.6.2 The use of fuses up to 320 A for overload protection is permitted.

9.7 Localisation of overcurrent protection

9.7.1 Short-circuit protection is to be provided for every non-earthed conductor.

9.7.2 Overload protection is to be provided for every non-earthed conductor; nevertheless, in insulated single-phase circuits or insulated three-phase circuits having substantially balanced loads, the overload protection may be omitted on one conductor.

9.7.3 Short-circuit and overload protective devices are not to interrupt earthed conductors, except in the case of multiple disconnection devices which simultaneously interrupt all the conductors, whether earthed or not.

9.7.4 Electrical protection is to be located as close as possible to the origin of the protected circuit.

9.8 Protection of generators

9.8.1 Generators are to be protected against short-circuits and overloads by multipole circuit-breakers.

For generators not arranged to operate in parallel with a rated output equal to or less than 50 kVA, a multipole switch with a fuse in each insulated phase on the generator side may be accepted.

9.8.2 When multipole switch and fuses are used, the fuse rating is to be maximum 110% of the generator rated current.

9.8.3 Where a circuit-breaker is used:

a) The overload protection is to trip the generator circuit-breaker at an overload between 10% and 50%; for an overload of 50% of the rated current of the generator the time delay is not to exceed 2 minutes; however, the figure of 50% or the time delay of 2 minutes may be exceeded if the construction of the generator permits this.

b) The setting of the short-circuit protection is to instantaneously trip the generator circuit-breaker at an overcurrent less than the steady short-circuit current of the generator. Short time delays (e.g. from 0,5 s to 1 s) may be introduced for discrimination requirements in “instantaneous” tripping devices.

9.8.4 For emergency generators the overload protection may, instead of disconnecting the generator automatically, give a visual and audible alarm in a permanently attended space.

9.8.5 After disconnection of a generator due to overload, the circuit-breaker is to be ready for immediate reclosure.

9.8.6 Generator circuit-breakers are to be provided with a reclosing inhibitor which prevents their automatic reclosure after tripping due to a short-circuit.

9.8.7 Generators having a capacity of 1500 kVA or above are to be equipped with a suitable protective device or system which, in the event of a short-circuit in the generator or in the supply cable between the generator and its circuit-breaker, will de-excite the generator and open the circuit-breaker (e.g. by means of differential protection).

9.8.8 Arrangements are to be made to disconnect or reduce automatically the excess load when the generators are overloaded in such a way as to prevent a sustained loss of speed and/or voltage (see Ch 2, Sec 2, Tab 5). The operation of such device is to activate a visual and audible alarm. A time delay of 5-20 s is considered acceptable.

9.8.9 When an overload is detected the load shedding system is to disconnect automatically, after an appropriate time delay, the circuits supplying the non-essential services and, if necessary, the secondary essential services in a second stage.

9.8.10 Alternating current generators arranged to operate in parallel are to be provided with reverse-power protection.

The protection is to be selected in accordance with the characteristics of the prime mover.

The following values are recommended:

- 2-6% of the rated power for turbogenerators
- 8-15% of the rated power for diesel generators.

The reverse-power protection may be replaced by other devices ensuring adequate protection of the prime movers.

9.8.11 Generators are to be provided with an undervoltage protection which trips the breaker if the voltage falls to 70%-35% of the rated voltage.

The undervoltage release also prevents the closing of the circuit-breaker if the generator voltage does not reach a minimum of 85% of the rated voltage.

The operation of the undervoltage release is to be instantaneous when preventing closure of the breaker, but it is to be delayed for selectivity purposes when tripping the breaker.

9.8.12 Generators are to be provided with overvoltage protection to avoid damage to the connected equipment.

9.9 Protection of circuits

9.9.1 *Each separate circuit shall be protected against short-circuit and against overload, unless otherwise specified in these Rules or where the Society may exceptionally otherwise permit.*

9.9.2 Each circuit is to be protected by a multipole circuit-breaker or switch and fuses against overloads and short-circuits.

9.9.3 Circuits for lighting are to be disconnected on both non-earthed conductors; single-pole disconnection of final sub-circuits with both poles insulated is permitted only in accommodation spaces, when a differential protection is provided.

9.9.4 The protective devices of the circuits supplying motors are to allow excess current to pass during transient starting of motors.

9.9.5 Final sub-circuits which supply one consumer with its own overload protection (for example motors), or consumers which cannot be overloaded (for example permanently wired heating circuits and lighting circuits), may be provided with short-circuit protection only.

9.10 Protection of motors

9.10.1 Motors of rating exceeding 1 kW and all motors for essential services are to be protected individually against overload and short-circuit. The short-circuit protection may be provided by the same protective device for the motor and its supply cable (see [9.9.5]).

9.10.2 For motors intended for essential services, the overload protection may be replaced by an overload alarm.

9.10.3 The protective devices are to be designed so as to allow excess current to pass during the normal accelerating period of motors according to the conditions corresponding to normal use.

If the current/time characteristic of the overload protection device does not correspond to the starting conditions of a motor (e.g. for motors with extra-long starting period), provision may be made to suppress operation of the device during the acceleration period on condition that the short-circuit protection remains operational and the suppression of overload protection is only temporary.

9.10.4 For continuous duty motors the protective gear is to have a time delay characteristic which ensures reliable thermal protection against overload.

9.10.5 The protective devices are to be adjusted so as to limit the maximum continuous current to a value within the range 105% - 120% of the motor’s rated full load current.

9.10.6 For intermittent duty motors the current setting and the delay (as a function of time) of the protective devices are to be chosen in relation to the actual service conditions of the motor.

9.10.7 Where fuses are used to protect polyphase motor circuits, means are to be provided to protect the motor against unacceptable overload in the case of single phasing.

9.10.8 Motors rated above 1 kW are to be provided with:

- undervoltage protection, operating on the reduction or failure of voltage, to cause and maintain the interruption of power in the circuit until the motor is deliberately restarted or
- undervoltage release, operating on the reduction or failure of voltage, so arranged that the motor restarts automatically when power is restored after a power failure.

9.10.9 The automatic restart of a motor is not to produce a starting current such as to cause excessive voltage drop.

In the case of several motors required to restart automatically, the total starting current is not to cause an excessive voltage drop or sudden surge current; to this end, it may be necessary to achieve a sequence start.

9.10.10 The undervoltage protective devices are to allow the motor to be started when the voltage exceeds 85% of the rated voltage and are to intervene without fail when the voltage drops to less than approximately 20% of the rated voltage, at the rated frequency and with a time delay as necessary.

9.11 Protection of storage batteries

9.11.1 Batteries are to be protected against overload and short-circuit by means of fuses or multipole circuit-breakers at a position adjacent to the battery compartment.

Note 1: Overcurrent protection may be omitted for the circuit to the starter motors when the current drawn is so large that is impracticable to obtain short-circuit protection.

Note 2: For starting systems, when conductors from the batteries are not protected against short-circuiting and overload, they are to be installed so as to be adequately protected against short-circuits and earth faults and as short as possible.

9.11.2 Emergency batteries supplying essential services are to have short-circuit protection only.

9.12 Protection of shore power connection

9.12.1 Permanently fixed cables connecting the shore connection box to the main switchboard are to be protected by fuses or circuit-breakers (see [5.5.4]).

9.13 Protection of measuring instruments, pilot lamps and control circuits

9.13.1 Measuring circuits and devices (voltage transformers, voltmeters, voltage coils of measuring instruments, insulation monitoring devices etc.) and pilot lamps are to be protected against short-circuit by means of multipole circuit-breakers or fuses.

The protective devices are to be placed as near as possible to the tapping from the supply.

The secondary side of current transformers is not to be protected.

9.13.2 Control circuits and control transformers are to be protected against overload and short-circuit by means of multipole circuit-breakers or fuses on each pole not connected to earth.

Overload protection may be omitted for transformers with a rated current of less than 2 A on the secondary side.

The short-circuit protection on the secondary side may be omitted if the transformer is designed to sustain permanent short-circuit current.

9.13.3 Where a fault in a pilot lamp would impair the operation of essential services, such lamps are to be protected separately from other circuits such as control circuits.

Note 1: Pilot lamps connected via short-circuit-proof transformers may be protected in common with control circuits.

9.13.4 Circuits whose failure could endanger operation, such as steering gear control feeder circuits, are to be protected only against short-circuit.

9.13.5 The protection is to be adequate for the minimum cross-section of the protected circuits.

9.14 Protection of transformers

9.14.1 The primary winding side of power transformers is to be protected against short-circuit and overload by means of multipole circuit-breakers or switches and fuses.

Overload protection on the primary side may be dispensed with where it is provided on the secondary side or when the total possible load cannot reach the rated power of the transformer.

9.14.2 The protection against short-circuit is to be such as to ensure the selectivity between the circuits supplied by the secondary side of the transformer and the feeder circuit of the transformer.

9.14.3 When transformers are arranged to operate in parallel, means are to be provided so as to trip the switch on the secondary winding side when the corresponding switch on the primary side is open.

10 System components

10.1 General

10.1.1 The components of the electrical system are to be dimensioned such as to withstand the currents that can pass through them during normal service without their rating being exceeded.

10.1.2 The components of the electrical system are to be designed and constructed so as to withstand for the admissible duration the thermal and electrodynamic stresses caused by possible overcurrents, including short-circuit.

11 Electrical cables

11.1 General

11.1.1 *All electrical cables and wiring external to equipment shall be at least of a flame-retardant type,* in accordance with IEC Publication 60332-1.

11.1.2 In addition to the provisions of [11.1.1], when cables are laid in bunches, cable types are to be chosen in compliance with IEC Publication 60332-3 Category A, or other means (see Ch 2, Sec 12) are to be provided such as not to impair their original flame-retarding properties.

11.1.3 Where necessary for specific applications such as radio frequency or digital communication systems, which require the use of particular types of cables, the Society may permit the use of cables which do not comply with the provisions of [11.1.1] and [11.1.2].

11.1.4 Cables which are required to have fire-resisting characteristics are to comply with the requirements stipulated in IEC Publication 60331.

11.2 Choice of insulation

11.2.1 The maximum rated operating temperature of the insulating material is to be at least 10°C higher than the maximum ambient temperature liable to occur or to be produced in the space where the cable is installed.

11.2.2 The maximum rated conductor temperature for normal and short-circuit operation, for the type of insulating compounds normally used for cables onboard, is not to exceed the values stated in Tab 5. Special consideration is to be given to other insulating materials.

11.2.3 PVC-ST2 insulated cables are not to be used either in refrigerated spaces, or on decks exposed to the weather of units classed for unrestricted service.

11.2.4 Mineral insulated cables is to be considered on a case by case basis.

Table 5 : Maximum rated conductor temperature

Type of insulating compound	Abbreviated designation	Maximum rated conductor temperature (°C)	
		Normal operation	Short-circuit
a) Thermoplastic:			
- based upon polyvinyl chloride or copolymer of vinyl chloride and vinyl acetate	PVC/A	70	150
b) Elastomeric or thermosetting:			
- based upon ethylene-propylene rubber or similar (EPM or EPDM)	EPR	90	250
- based upon high modulus or hardgrade ethylene propylene rubber	HEPR	90	250
- based upon cross-linked polyethylene	XLPE	90	250
- based upon rubber silicon	S 95	95	350**(1)**
- based upon ethylene-propylene rubber or similar (EPM or EPDM) halogen free	HF EPR	90	250
- based upon high modulus or hardgrade halogen free ethylene propylene rubber	HF HEPR	90	250
- based upon cross-linked polyethylene halogen free	HF XLPE	90	250
- based upon rubber silicon halogen free	HF S 95	95	350**(1)**
- based upon cross-linked polyolefin material for halogen free cable	HF 90	90	250

(1) This temperature is applicable only to power cables and not appropriate for tinned copper conductors

11.3 Choice of protective covering

11.3.1 The conductor insulating materials are to be enclosed in an impervious sheath of material appropriate to the expected ambient conditions where cables are installed in the following locations:

- on decks exposed to the weather
- in damp or wet spaces (e.g. in bathrooms)
- in refrigerated spaces
- in machinery spaces and, in general
- where condensation water or harmful vapour may be present.

11.3.2 Where cables are provided with armour or metallic braid (e.g. for cables installed in hazardous areas), an overall impervious sheath or other means to protect the metallic elements against corrosion is to be provided; see Ch 2, Sec 9, [2.5].

11.3.3 An impervious sheath is not required for single-core cables installed in tubes or ducts inside accommodation spaces, in circuits with maximum system voltage 250 V.

11.3.4 In choosing different types of protective coverings, due consideration is to be given to the mechanical action to which each cable may be subjected during installation and in service.

If the mechanical strength of the protective covering is considered insufficient, the cables are to be mechanically protected (e.g. by an armour or by installation inside pipes or conduits).

11.3.5 Single-core cables for a.c. circuits with rated current exceeding 20 A are to be either non-armoured or armoured with non-magnetic material.

11.4 Cables in refrigerated spaces

11.4.1 Cables installed in refrigerated spaces are to have a watertight or impervious sheath and are to be protected against mechanical damage. If an armour is applied on the sheath, the armour is to be protected against corrosion by a further moisture-resisting covering.

11.5 Cables in areas with a risk of explosion

11.5.1 For cables in areas with a risk of explosion, see Ch 2, Sec 15, [5.1].

11.6 Cables in circuits required to be operable under fire condition

11.6.1 Electrical services required to be operable under fire conditions are as follows:

- control and power systems to power-operated fire doors and status indication for all fire doors
- control and power systems to power-operated watertight doors and their status indication
- emergency fire pump
- emergency lighting
- fire and general alarms
- fire detection systems
- fire-extinguishing systems and fire-extinguishing media release alarms
- low location lighting
- public address systems
- remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and/or explosion.

11.6.2 Where cables for services specified in [11.6.1] including their power supplies pass through high fire risk areas, they are to be so arranged that a fire in any of these areas does not affect the operation of the service in any other area. This may be achieved by either of the following measures:

a) Cables being of a fire resistant type complying with Ch 2, Sec 9, [2.1.8] are to be installed and run continuous to keep the fire integrity within the high fire risk area (see Fig 4).

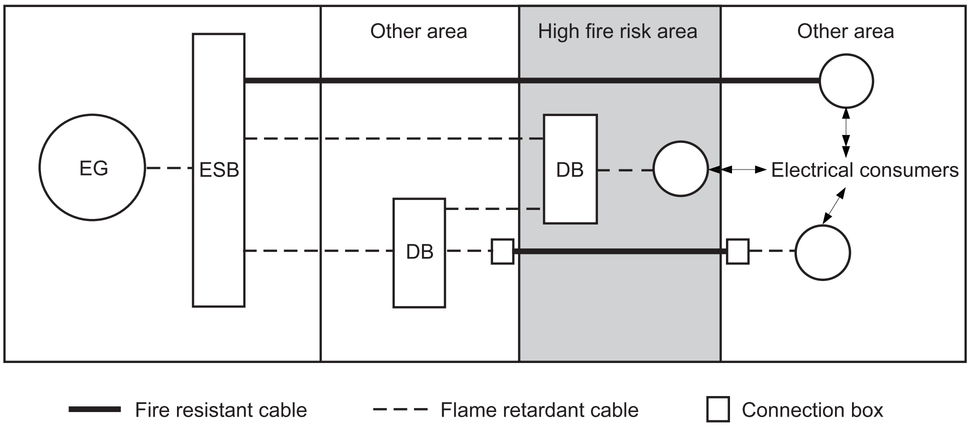
b) At least two-loops/radial distributions run as widely apart as is practicable and so arranged that in the event of damage by fire at least one of the loops/radial distributions remains operational.

Systems that are self monitoring, fail safe or duplicated with cable runs as widely separated as is practicable may be exempted.

11.6.3 Cables for services required to be operable under fire conditions, including their power supplies, are to be run as directly as is practicable.

11.6.4 *Cables connecting fire pumps to the emergency switchboard shall be of a fire-resistant type where they pass through high fire risk areas.*

Figure 4 : Routing of cables in high fire risk area



11.7 Cables for submerged bilge pumps

11.7.1 Cables and their connections to such pumps are to be capable of operating under a head of water equal to their distance below the bulkhead deck. The cable is to be impervious-sheathed and armoured, is to be installed in continuous lengths from above the bulkhead to the motor terminals and is to enter the air bell from the bottom.

11.8 Internal wiring of switchboards and other enclosures for equipment

11.8.1 For installation in switchboards and other enclosures for equipment, single-core cables may be used without further protection (sheath).

Other types of flame-retardant switchboard wiring may be accepted at the discretion of the Society.

11.9 Current carrying capacity of cables

11.9.1 Current carrying capacity of cables are depending of installation conditions, according to requirements of IEC publication 60092-352. The present Rules show values extracted from the method "B", based on limited experimental data, easily applicable. Therefore, if the method "A" is used, all cables installation conditions are to be clearly detailed and submitted, for all cable laying considerations.

11.9.2 The current carrying capacity for continuous service of cables given in Tab 7 to Tab 10 is based on the maximum permissible service temperature of the conductor also indicated therein and on an ambient temperature of 45°C.

11.9.3 The current carrying capacity given in [11.9.2] is applicable, with rough approximation, to all types of protective covering (e.g. both armoured and non-armoured cables).

11.9.4 Values other than those shown in Tab 7 to Tab 10 may be accepted provided they are determined on the basis of calculation methods or experimental values approved by the Society.

11.9.5 When the actual ambient temperature obviously differs from 45°C, the correction factors shown in Tab 11 may be applied to the current carrying capacity in Tab 7 to Tab 10.

11.9.6 Where more than six cables are bunched together in such a way that there is an absence of free air circulating around them, and the cables can be expected to be under full load simultaneously, a correction factor of 0,85 is to be applied.

11.9.7 Where a cable is intended to supply a short-time load for 1/2-hour or 1-hour service, the current carrying capacity obtained from Tab 7 to Tab 10 may be increased by applying the corresponding correction factors given in Tab 12.

In no case is a period shorter than 1/2-hour to be used, whatever the effective period of operation.

11.9.8 For supply cables to single services for intermittent loads (e.g. cargo winches or machinery space cranes), the current carrying capacity obtained from Tab 7 to Tab 10 may be increased by applying the correction factors given in Tab 13.

The correction factors are calculated with rough approximation for periods of 10 minutes, of which 4 minutes with a constant load and 6 minutes without load.

Table 6 : Current carrying capacity, in A, in continuous service for cables based on maximum conductor operating temperature of 70°C (ambient temperature 45°C)

Nominal section (mm^2)	Number of conductors					
	1		2		3 or 4	
1,5	15		13		11	
2,5	21		18		15	
4	29		25		20	
6	37		31		26	
10	51		43		36	
16	68		58		48	
25	90		77		63	
35	111		94		78	
50	138		117		97	
70	171		145		120	
95	207		176		145	
120	239		203		167	
150	275		234		193	
185	313		266		219	
240	369		314		258	
300	424		360		297	
	d.c.	a.c.	d.c.	a.c.	d.c.	a.c.
400	500	490	425	417	350	343
500	580	550	493	468	406	385
630	670	610	570	519	469	427

Table 7 : Current carrying capacity, in A, in continuous service for cables based on maximum conductor operating temperature of 60°C (ambient temperature 45°C)

Nominal section (mm^2)	Number of conductors					
	1		2		3 or 4	
1,5	10		9		7	
2,5	17		14		12	
4	23		20		16	
6	29		25		20	
10	40		34		28	
16	54		46		38	
25	71		60		50	
35	88		75		62	
50	110		94		77	
70	135		115		95	
95	164		139		115	
120	189		161		132	
150	218		185		153	
185	248		211		174	
240	292		248		204	
300	336		286		235	
	d.c.	a.c.	d.c.	a.c.	d.c.	a.c.
400	390	380	332	323	273	266
500	450	430	383	366	315	301
630	520	470	442	400	364	329

Table 8 : Current carrying capacity, in A, in continuous service for cables based on maximum conductor operating temperature of 85°C (ambient temperature 45°C)

Nominal section (mm^2)	Number of conductors					
	1		2		3 or 4	
1,5	21		18		15	
2,5	28		24		20	
4	38		32		27	
6	49		42		34	
10	67		57		47	
16	91		77		64	
25	120		102		84	
35	148		126		104	
50	184		156		129	
70	228		194		160	
95	276		235		193	
120	319		271		223	
150	367		312		257	
185	418		355		293	
240	492		418		344	
300	565		480		396	
	d.c.	a.c.	d.c.	a.c.	d.c.	a.c.
400	650	630	553	536	455	441
500	740	680	629	578	518	476
630	840	740	714	629	588	518

Table 9 : Current carrying capacity, in A, in continuous service for cables based on maximum conductor operating temperature of 90°C (ambient temperature 45°C)

Nominal section (mm^2)	Number of conductors					
	1		2		3 or 4	
1,5	23		20		16	
2,5	30		26		21	
4	40		34		28	
6	52		44		36	
10	72		61		50	
16	96		82		67	
25	127		108		89	
35	157		133		110	
50	196		167		137	
70	242		206		169	
95	293		249		205	
120	339		288		237	
150	389		331		272	
185	444		377		311	
240	522		444		365	
300	601		511		421	
	d.c.	a.c.	d.c.	a.c.	d.c.	a.c.
400	690	670	587	570	483	469
500	780	720	663	612	546	504
630	890	780	757	663	623	546

Table 10 : Current carrying capacity, in A, in continuous service for cables based on maximum conductor operating temperature of 95°C (ambient temperature 45°C)

Nominal section (mm^2)	Number of conductors					
	1		2		3 or 4	
1,5	26		22		18	
2,5	32		27		22	
4	43		37		30	
6	55		47		39	
10	76		65		53	
16	102		87		71	
25	135		115		95	
35	166		141		116	
50	208		177		146	
70	256		218		179	
95	310		264		217	
120	359		305		251	
150	412		350		288	
185	470		400		329	
240	553		470		387	
300	636		541		445	
	d.c.	a.c.	d.c.	a.c.	d.c.	a.c.
400	760	725	646	616	532	508
500	875	810	744	689	612	567
630	1010	900	859	765	707	630

Table 11 : Correction factors for various ambient air temperatures

Maximum conductor temperature (°C)	Correction factors for ambient air temperature of:										
	35°C	40°C	45°C	50°C	55°C	60°C	65°C	70°C	75°C	80°C	85°C
60	1,29	1,15	1,00	0,82	–	–	–	–	–	–	–
65	1,22	1,12	1,00	0,87	0,71	–	–	–	–	–	–
70	1,18	1,10	1,00	0,89	0,77	0,63	–	–	–	–	–
75	1,15	1,08	1,00	0,91	0,82	0,71	0,58	–	–	–	–
80	1,13	1,07	1,00	0,93	0,85	0,76	0,65	0,53	–	–	–
85	1,12	1,06	1,00	0,94	0,87	0,79	0,71	0,61	0,50	–	–
90	1,10	1,05	1,00	0,94	0,88	0,82	0,74	0,67	0,58	0,47	–
95	1,10	1,05	1,00	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45

Table 12 : Correction factors for short-time loads

Sum of nominal cross-sectional areas of all conductors, in mm^2				Correction factor
1/2-hour service		1-hour service		
Cables with metallic sheath and armoured cables	Cables with non-metallic sheath and non-armoured cables	Cables with metallic sheath and armoured cables	Cables with non-metallic sheath and non-armoured cables	
up to 20	up to 75	up to 80	up to 230	1,06
21 - 41	76 - 125	81 - 170	231 - 400	1,10
41 - 65	126 - 180	171 - 250	401 - 600	1,15
66 - 95	181 - 250	251 - 430	601 - 800	1,20
96 - 135	251 - 320	431 - 600	–	1,25
136 - 180	321 - 400	601 - 800	–	1,30
181 - 235	401 - 500	–	–	1,35
236 - 285	501 - 600	–	–	1,40
286 - 350	–	–	–	1,45

11.9.9 Parallel connection of cables

The current carrying capacity of cables connected in parallel is the sum of the current ratings of all parallel conductors but the cables must have equal impedance, equal cross-section, equal maximum permissible conductor temperatures and follow substantially identical routing or be installed in close proximity. Connections in parallel are only permitted for cross-sections of 10 mm^2 or above. When equal impedance can not be assured, a correction factor of 0,9 is to be applied to the current carrying capacity.

11.10 Minimum nominal cross-sectional area of conductors

11.10.1 In general the minimum allowable conductor cross-sectional areas are those given in Tab 14.

11.10.2 The nominal cross-sectional area of the neutral conductor in three-phase distribution systems is to be equal to at least 50% of the cross-sectional area of the phases, unless the latter is less than or equal to 16 mm^2. In such case the cross-sectional area of the neutral conductor is to be equal to that of the phase.

Table 13 : Correction factors for intermittent service

Sum of nominal cross-sectional areas of all conductors, in mm^2		Correction factor
Cables with metallic sheath and armoured cables	Cables without metallic sheath and non-armoured cables	
	$S \leq 5$	1,10
	$5 < S \leq 8$	1,15
	$8 < S \leq 16$	1,20
$S \leq 4$	$16 < S \leq 25$	1,25
$4 < S \leq 7$	$25 < S \leq 42$	1,30
$7 < S \leq 17$	$42 < S \leq 72$	1,35
$17 < S \leq 42$	$72 < S \leq 140$	1,40
$42 < S \leq 110$	$140 < S$	1,45
$110 < S$	–	1,50

Table 14 : Minimum nominal cross-sectional areas

Service	Nominal cross-sectional areas (mm^2)	
	External wiring	Internal wiring
Power, heating and lighting system	1,0	1,0
Control circuits for power plant	1,0	1,0
Control circuits other than those for power plant	0,75	0,5
Control circuits for telecommunications, measurements, alarms	0,5	0,2
Telephone and bell equipment, not required for the safety of the unit or crew calls	0,2	0,1
Bus and data cables	0,2	0,1

11.10.3 For the nominal cross-sectional area of:

- earthing conductors, see Ch 2, Sec 12, [2.3]
- earthing connections for distribution systems, see Ch 2, Sec 12, [2.5]
- neutral connections for three-phase systems, see Ch 2, Sec 8, [1.2.4].

11.11 Choice of cables

11.11.1 The rated voltage of any cable is to be not lower than the nominal voltage of the circuit for which it is used.

11.11.2 The nominal cross-sectional area of each cable is to be sufficient to satisfy the following conditions with reference to the maximum anticipated ambient temperature:

- the current carrying capacity is to be not less than the highest continuous load carried by the cable
- the voltage drop in the circuit, by full load on this circuit, is not to exceed the specified limits
- the cross-sectional area calculated on the basis of the above is to be such that the temperature increases which may be caused by overcurrents or starting transients do not damage the insulation.

11.11.3 The highest continuous load carried by a cable is to be calculated on the basis of the power requirements and of the diversity factor of the loads and machines supplied through that cable.

11.11.4 When the conductors are carrying the maximum nominal service current, the voltage drop from the main or emergency switchboard busbars to any point in the installation is not to exceed 6% of the nominal voltage.

For battery circuits with supply voltage less than 55 V, this value may be increased to 10%.

For the circuits of navigation lights, the voltage drop is not to exceed 5% of the rated voltage under normal conditions.

Section 4 Rotating Machines

1 Constructional requirements for generators and motors

1.1 Mechanical construction

1.1.1 Materials and construction of electrical machines are to conform to the relevant requirements of Ch 2, Sec 2, [4] and Ch 2, Sec 2, [5].

1.1.2 Shafts are to be made of material complying with the provisions of NR216, Chapter 5 or, where rolled products are allowed in place of forgings, with those of NR216, Chapter 3.

1.1.3 Where welded parts are foreseen on shafts and rotors, the provisions of NR216, Chapter 12 apply.

1.1.4 Sleeve bearings are to be efficiently and automatically lubricated at all running speeds.

Provision is to be made for preventing the lubricant from gaining access to windings or other insulated or bare current carrying parts.

1.1.5 Each self-lubricated sleeve bearing shall be fitted with an inspection lid and means for the visual indication of oil level or the use of an oil-gauge. This requirement does not apply to machines under 100 kW (d.c.) or 100 kVA (a.c.).

1.1.6 Means are to be provided to prevent bearings from being damaged by the flow of currents circulating between them and the shaft. According to the manufacturer’s requirements, electrical insulation of at least one bearing is to be considered.

1.1.7 For surface-cooled machines with an external fan installed on the open deck, adequate protection of the fan against icing is to be provided.

1.1.8 When liquid cooling is used, the coolers are to be so arranged as to avoid entry of water into the machine, whether by leakage or condensation in the heat exchanger, and provision is to be made for the detection of leakage.

1.1.9 Rotating machines whose ventilation or lubrication system efficiency depends on the direction of rotation are to be provided with a warning plate.

1.2 Sliprings, commutators and brushes

1.2.1 Sliprings and commutators with their brushgear are to be so constructed that undue arcing is avoided under all normal load conditions.

1.2.2 The working position of brushgear is to be clearly and permanently marked.

1.2.3 Sliprings, commutators and brushgear are to be readily accessible for inspection, repairs and maintenance.

1.3 Terminal connectors

1.3.1 Suitable, fixed terminal connectors are to be provided in an accessible position for connection of the external cables.

1.3.2 All terminal connectors are to be clearly identified with reference to a diagram.

1.3.3 The degree of protection of terminal boxes is to be adequate to that of the machine.

1.4 Electrical insulation

1.4.1 Insulating materials for windings and other current carrying parts are to comply with the requirements of Ch 2, Sec 2, [4.2] and Ch 2, Sec 2, [4.3].

2 Special requirements for generators

2.1 Prime movers, speed governors and overspeed protection

2.1.1 Prime movers for generators are to comply with the relevant requirements of Ch 1, Sec 2, [2.7.5] or Ch 1, Sec 5, [2.5.2].

2.1.2 When generators are to operate in parallel, the characteristics of speed governors are to comply with the provisions of [2.2].

2.2 A.c. generators

2.2.1 Alternators are to be so constructed that, when started up, they take up the voltage without the aid of an external electrical power source.

Where these provisions are not complied with, the external electrical power source is to be constituted by a battery installation in accordance with the requirements for electrical starting systems of auxiliary machinery (see Ch 1, Sec 2, [3.1.2]).

2.2.2 The voltage wave form is to be approximately sinusoidal, with a maximum deviation from the sinusoidal fundamental curve of 5% of the peak value.

2.2.3 Each alternator is to be provided with automatic means of voltage regulation.

2.2.4 When a.c. generators are operated in parallel, the reactive loads of the individual generating sets are not to differ from their proportionate share of the total reactive load by more than 10% of the rated reactive power of the largest machine, or 25% of that of the smallest machine, whichever is the lesser.

3 Testing of rotating machines

3.1 General

3.1.1 All machines are to be tested by the manufacturers.

3.1.2 The manufacturer is to issue a test report giving, inter alia, information concerning the construction, type, serial number, insulation class and all other technical data relevant to the machine, as well as the results of the tests required.

Such test reports are to be provided to the Society, for machines for essential services. For other machines, these test reports are to be made available upon request of the Society.

3.1.3 All tests are to be carried out according to IEC Publication 60092-301.

3.1.4 All machines of 100 KW and over, intended for essential services are to be surveyed by the Society during testing and, if appropriate, during manufacturing.

Note 1: An alternative inspection scheme may be agreed by the Society with the manufacturer whereby the attendance of the Surveyor will not be required as indicated above.

3.2 Shaft material

3.2.1 Shaft material for electric propulsion motors and for main engine driven generators where the shaft is part of the propulsion shafting is to be certified by the Society.

3.2.2 Shaft material for other machines is to be in accordance with recognised international or national standard.

3.3 Tests

3.3.1 Type test are to be carried out on a prototype machine or on the first batch of machines, and routine tests carried out on subsequent machines in accordance with Tab 1.

3.3.2 Where the test procedure is not specified, the requirements of IEC 60034-1 apply.

Table 1 : Tests to be carried out on electrical rotating machines

No.	Tests	A.c. generators		Motors	
		Type test **(1)**	Routine test **(2)**	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection	X	X	X	X
2	Insulation resistance measurement	X	X	X	X
3	Winding resistance measurement	X	X	X	X
4	Verification of the voltage regulation system	X	X **(3)**		
5	Rated load test and temperature rise measurement	X		X	
6	Overcurrent test	X			
7	Overtorque test			X	

(1) Type test on prototype machine or test on at least the first batch of machines.

(2) The reports of machines routine tested are to contain the manufacturer's serial number of the machine which has been type tested and the test result.

(3) Only functional test of the voltage regulator system.

(4) Verification of steady short-circuit condition applies to synchronous machines only.

No.	Tests	A.c. generators		Motors	
		Type test **(1)**	Routine test **(2)**	Type test **(1)**	Routine test **(2)**
8	Verification of steady short-circuit conditions **(4)**	X			
9	Overspeed test	X	X	X	
10	Dielectric strength test	X	X	X	X
11	No load test	X	X	X	X
12	Verification of degree of protection	X		X	
13	Verification of bearings	X	X	X	X

(1) Type test on prototype machine or test on at least the first batch of machines.
(2) The reports of machines routine tested are to contain the manufacturer's serial number of the machine which has been type tested and the test result.
(3) Only functional test of the voltage regulator system.
(4) Verification of steady short-circuit condition applies to synchronous machines only.

4 Description of test

4.1 Technical documentation and visual inspection

4.1.1 Technical documentation of machines rated at 100 kW (kVA) and over are to be available for examination by the Surveyor.

4.1.2 A visual inspection of the machine is to be made to ensure, as far as practicable, that it complies with the technical documentation.

4.2 Insulation resistance measurement

4.2.1 Immediately after the high voltage tests the insulation resistances are to be measured using a direct current insulation tester between:

a) all current carrying parts connected together and earth

b) all current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

The minimum values of test voltages and corresponding insulation resistances are given in Tab 2. The insulation resistance is to be measured close to the operating temperature, or an appropriate method of calculation is to be used.

Table 2 : Minimum insulation resistance

Rated voltage Un V	Minimum test voltage V	Minimum insulation resistance MΩ
Un = 250	2 Un	1
250 < Un ≤ 1000	500	1
1000 < Un ≤ 7200	1000	Un/1000 + 1
7200 < Un ≤ 15000	5000	Un/1000 + 1

4.3 Winding resistance measurement

4.3.1 The resistances of the machine windings are to be measured and recorded using an appropriate bridge method or voltage and current method.

4.4 Verification of the voltage regulation

4.4.1 The alternating current generator, together with its voltage regulation system, is to be verified in such a way that, at all loads from no load running to full load, the rated voltage at the rated power factor is maintained under steady conditions within ± 2,5%. These limits may be increased to ± 3,5% for emergency sets.

4.4.2 When the generator is driven at rated speed, giving its rated voltage, and is subjected to a sudden change of symmetrical load within the limits of specified current and power factor, the voltage is not to fall below 85% nor exceed 120% of the rated voltage.

4.4.3 The voltage of the generator is then to be restored to within plus or minus 3% of the rated voltage for the main generator sets in not more than 1,5 s. For emergency sets, these values may be increased to plus or minus 4% in not more than 5 s, respectively.

4.4.4 In the absence of precise information concerning the maximum values of the sudden loads, the following conditions may be assumed: 60% of the rated current with a power factor of between 0,4 lagging and zero to be suddenly switched on with the generator running at no load, and then switched off after steady - state conditions have been reached.

4.5 Rated load test and temperature rise measurements

4.5.1 The temperature rises are to be measured at the rated out-put, voltage and frequency and for the duty for which the machine is rated and marked in accordance with the testing methods specified in IEC Publication 60034-1, or by means of a combination of other tests (see indirect methods in Ch 2, App 1 for synchronous machines and in Ch 2, App 2 for induction machines).

4.5.2 The limits of temperature rise above ambient air temperature of 45°C for air-cooled machines are those given in Tab 3.

Table 3 : Temperature rise limits for air-cooled machines based on an ambient temperature of 45°C

No.	Part of machines	Method of measurement of temperature **(1)**	Temperature rise °C by class of insulation				
			A	E	B	F	H
1	a) a.c. windings of machines having outputs of 5000 kW (or kVA) or more	R ETD	55 60	– –	75 80	95 100	120 125
	b) a.c. windings of machines having outputs of less than 5000 kW (or kVA)	R ETD	55 60	70 –	75 85	100 105	120 125
2	Windings of armatures with commutators	T R	45 55	60 70	65 75	80 100	100 120
3	Field windings of a.c. and d.c machines having d.c. excitation other than those in item 4	T R	45 55	60 70	65 75	80 100	100 120
4	a) Field windings of synchronous machines with cylindrical rotors having d.c. excitation	R	–	–	85	105	130
	b) Stationary field windings of d.c. machines having more than one layer	T R ETD	45 55 –	60 70 –	65 75 85	80 100 105	100 120 130
	c) Low resistance field windings of more than one layer, and compensating windings	T, R **(2)**	55	70	75	95	120
	d) Single-layer windings with exposed bare surfaces	T, R **(2)**	60	75	85	105	130
5	Permanently short-circuited, insulated windings	T	55	70	75	95	120
6	Permanently short-circuited uninsulated windings	The temperature rise of these parts is in no case to reach such a value that there is a risk of damage to any insulating or other material on adjacent parts					
7	Magnetic core and other parts not in contact with windings						
8	Magnetic core and other parts in contact with windings	T	55	70	75	95	120
9	Commutators and sliprings, open or enclosed **(3)**	T	55	65	75	85	95

(1) T : Measurement by the thermometer method
R : Measurement by the resistance method
ETD : Measurement by embedded temperature detectors.

(2) Temperature rise measurement is to use the resistance method R whenever practicable.

(3) If commutators and sliprings are adjacent to windings with a lower insulation class, the temperature rises for this class apply.

4.6 Overcurrent test - Overtorque test

4.6.1 Overcurrent test is to be carried out as a type test for generators, as required in IEC Publication 60034-1. The overcurrent test is the proof of current capability of the windings, wires, connections etc. of each machine.

AC generators are to be capable of withstanding a current equal to 1,5 times the rated current for not less than 30 s.

Note 1: This test may be performed in conjunction with the short-circuit testing, provided the electrical input energy to the machine is not less than that required for the above overload capability.

4.6.2 Overtorque test is to be carried out as a type test for motors, as required in IEC Publication 60034-1. The overtorque test is a proof of momentary excess torque capability of the machine.

General purpose rotating machines are to be designed considering the following excess torque:

- AC induction motors and DC motors: 60% in excess of the torque that corresponds to the rating, for 15 s, without stalling or abrupt change in speed (under gradual increase of torque), the voltage and frequency being maintained at their rated value
- AC synchronous motors with salient poles: 50% in excess of the torque that corresponds to the rating, for 15 s, without falling out of synchronism, the voltage, frequency and excitation current being maintained at their rated values
- AC synchronous motors with wound (induction) or cylindrical rotors: 35% in excess of the torque that corresponds to the rating, for 15 s, without losing synchronism, the voltage and frequency being maintained at their rated value.

Note 1: The overtorque test can be replaced at a routine test by an overcurrent test.

Note 2: The overtorque test may be omitted for electrical propulsion motor supplied by converter if an overload protection / limitation is provided inside the converter. Justifications are to be transmitted by the converter manufacturer.

4.6.3 In the case of machines for special uses (e.g. for windlasses), overload values other than the above may be considered.

4.7 Verification of the steady short circuit current

4.7.1 It is to be verified that under steady state short-circuit conditions, the generator with its voltage regulating system is capable of maintaining, without sustaining any damage, a current of at least three times the rated current for a duration of at least 2 s or, where precise data is available, for a duration of any time delay which may be fitted in a tripping device for discrimination purposes.

4.8 Overspeed test

4.8.1 Machines are to withstand the overspeed test as specified in IEC Publication 60034-1.

4.9 Dielectric strength test

4.9.1 New and completed rotating machines are to withstand a dielectric test as specified in IEC Publication 60034-1.

4.9.2 For high voltage machines an impulse test is to be carried out on the coils according to Ch 2, Sec 13.

4.9.3 When it is necessary to perform an additional high voltage test, this is to be carried out after any further drying, with a test voltage of 80% of that specified in IEC Publication 60034-1.

4.9.4 Completely rewound windings of used machines are to be tested with the full test voltage applied in the case of new machines.

4.9.5 Partially rewound windings are to be tested at 75% of the test voltage required for new machines. Prior to the test, the old part of the winding is to be carefully cleaned and dried.

4.9.6 Following cleaning and drying, overhauled machines are to be subjected to a test at a voltage equal to 1,5 times the rated voltage, with a minimum of 500 V if the rated voltage is less than 100 V, and with a minimum of 1000 V if the rated voltage is equal to or greater than 100 V.

4.9.7 A repetition of the high voltage test for groups of machines and apparatus is to be avoided if possible, but if a test on an assembled group of several pieces of new apparatus, each of which has previously passed its high voltage test, is per-formed, the test voltage to be applied to such assembled group is 80% of the lowest test voltage appropriate for any part of the group.

Note 1: For windings of one or more machines connected together electrically, the voltage to be considered is the maximum voltage that occurs in relation to earth.

4.10 No load test

4.10.1 Machines are to be operated at no load and rated speed whilst being supplied at rated voltage and frequency as a motor while generators are to be driven by a suitable means and excited to give rated terminal voltage.

During the running test, the vibration of the machine and operation of the bearing lubrication system, if appropriate, are to be checked.

4.11 Verification of degree of protection

4.11.1 As specified in IEC Publication 60034-5.

4.12 Verification of bearings

4.12.1 Upon completion of the above tests, machines which have sleeve bearings are to be opened upon request for examination by the Surveyor, to establish that the shaft is correctly seated in the bearing shells.

Section 5 Transformers

1 Constructional requirements

1.1 General

1.1.1 The provisions of this clause are applicable to all transformers used for power, lighting and static converters and, where appropriate, to starting transformers, static balancers, saturable reactors and transductors for use in offshore units, including single-phase transformers rated at less than 1 kVA, and three-phase transformers rated at less than 5 kVA, unless special requirements are specified. All equipment referred is to comply with the relevant requirements of IEC 60076 series, as well as with the additional requirements given in these Rules.

Transformers for use with converters, invertors, variable speed drives, etc., are to be so designed as to be suitable for use on non-sinusoidal supplies and/or variable frequency supplies, and shall comply with IEC 60146-1-3.

1.2 Construction

1.2.1 When installed indoors, transformers are preferably to be of the dry, air-cooled type.

Note 1: In some countries oil-filled equipment is not permitted on offshore units.

1.2.2 Transformers, except those for motor starting, are to be double wound (two or more separate windings).

1.2.3 Where forced cooling is used, it shall be possible to operate at reduced power on failure of a pump or a fan. Consideration is to be given to the provision of suitable indicating and alarm facilities.

1.2.4 Liquid-immersed type transformers may be used provided that:

- The liquid is non-toxic and of a type which does not readily support combustion.
- They are preferably be hermetically sealed. If of the conservator type, they are to be so designed that they operate without risk of spilling liquid under all conditions, with the offshore units inclined from the normal as specified in Ch 1, Sec 1, Tab 1 and Ch 1, Sec 1, Tab 2 and Ch 1, Sec 1, Tab 3. If provision is made for breathing, a suitable dehydrator is to be provided.
- Over-temperature alarm and gas-actuated protection devices are installed.
- Drip trays or other suitable arrangements for collecting the liquid from leakages are provided.
- A liquid gauge indicating the normal liquid level range is fitted.

1.2.5 Transformers are to have enclosures with a degree of protection in accordance with Ch 2, Sec 3, Tab 3.

1.3 Terminals

1.3.1 Suitable fixed terminal connections are to be provided in an accessible position with sufficient space for convenient connection of the external cables.

1.3.2 Terminals are to be clearly identified.

1.4 Voltage variation, short-circuit conditions and parallel operation

1.4.1 Under resistive load ($\cos \Phi = 1$), the voltage drop from no load to full load is not to exceed 2,5%.

For transformers with a power lower than 5 kVA per phase, this voltage drop is not to exceed 5%.

An exception is made for special transformers, such as starting and instrument transformers, for which a different voltage variation may be considered.

1.4.2 In determining the voltage ratio and the impedance voltage of transformers, account is to be taken of the total permitted voltage drop from the main switchboard’s busbars to the consumers (see Ch 2, Sec 2).

1.4.3 Transformers are to be constructed to withstand, without damage, the thermal and mechanical effects of a secondary terminal short-circuit for 2 s, with rated primary voltage and frequency.

For transformers of 1 MVA and over, this is to be justified with appropriate tests or documentation.

1.4.4 When transformers are so arranged that their secondary windings may be connected in parallel, their winding connections are to be compatible, their rated voltage ratios are to be equal (with tolerances allowed) and their short-circuit impedance values, expressed as a percentage, are to have a ratio within 0,9 to 1,1.

When transformers are intended for operation in parallel, the rated power of the smallest transformer in the group is to be not less than half of the rated power of the largest transformer in the group.

1.5 Electrical insulation and temperature rise

1.5.1 Insulating materials for windings and other current carrying parts are to comply with the requirements of Ch 2, Sec 2.

1.5.2 All windings of air-cooled transformers are to be suitably treated to resist moisture, air salt mist and oil vapours.

1.5.3 The permissible limits of temperature rise with an ambient air temperature of 45°C for (natural or forced) air-cooled transformers are given in Tab 1. The temperature rises shown for windings refer to measurement by the resistance method while those for the core refer to the thermometer method.

1.5.4 For dry-type transformers cooled with an external liquid cooling system, the permissible limits of temperature rise with a sea water temperature of 32°C are 13°C higher than those specified in Tab 1.

1.5.5 For liquid-cooled transformers, the following temperature rises measured by the resistance method apply:

- 55°C where the fluid is cooled by air
- 68°C where the fluid is cooled by water.

Table 1 : Temperature rise limits for transformers

No.	Part of machine	Temperature rise by class of insulation °C				
		A	E	B	F	H
1	Windings	55	70	75	95	120
2	Cores and other parts: a) in contact with the windings b) not in contact with the windings	a) the same values as for the windings b) in no case is the temperature to reach values such as to damage either the core itself or other adjacent parts or materials				

2 Testing

2.1 General

2.1.1 Transformers intended for essential services are to be subject to the tests stated in [2.2].

2.1.2 The manufacturer is to issue a test report giving, inter alia, information concerning the construction, type, serial number, insulation class and all other technical data relevant to the transformer, as well as the results of the tests required.

Such test reports are to be made available to the Society.

2.1.3 In the case of transformers which are completely identical in rating and in all other constructional details, it will be acceptable for the temperature rise test to be performed on only one transformer.

The results of this test and the serial number of the tested transformer are to be inserted in the test reports for the other transformers.

2.1.4 Where the test procedure is not specified, the requirements of IEC 60076-1 apply.

2.1.5 The tests and, if appropriate, manufacture of transformers of 100 kVA and over (60 kVA when single phase) intended for essential services are to be attended by a Surveyor of the Society.

Transformers of 5 kVA up to the limit specified above are approved on a case by case basis, at the discretion of the Society, subject to the submission of adequate documentation and routine tests.

2.2 Tests on transformers

2.2.1 Tests to be carried out on transformers are specified in Tab 2.

2.3 Insulation tests

2.3.1 Transformers are to be subjected to a high voltage test in accordance with the requirements of IEC 60076-3.

2.3.2 The test voltage is to be applied between each winding under test and the other windings not under test, core and enclosure all connected together.

Single-phase transformers for use in a polyphase group are to be tested in accordance with the requirements applicable to that group.

2.3.3 The r.m.s. value of the test voltage is to be equal to 2 U + 1000 V, with a minimum of 2500 V, where U is the rated voltage of the winding. The full voltage is to be maintained for 1 minute.

2.3.4 Partially rewound windings are to be tested at 80% of the test voltage required for new machines.

2.3.5 The insulation resistance of a new, clean and dry transformer, measured after the temperature rise test has been carried out (at or near operating temperature) at a voltage equal to 500 V d.c., is to be not less than 5 MΩ.

2.3.6 Transformers are to be subjected to an induced voltage insulation test by applying to the terminals of the winding under test a voltage equal to twice the rated voltage. The duration of the test is to be 60 s for any test frequency fp up to and including twice the rated frequency fn.

If the test frequency exceeds twice the rated frequency, the test time in seconds is to be:

120 fn / fp with a minimum of 15 s.

Table 2 : Tests to be carried out on transformers

No.	Tests	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection **(3)**	X	X
2	Insulation resistance measurement	X	X
3	Measurement of winding resistance	X	X
4	Measurement of voltage ratio and check of phase displacement	X	X
5	Measurement of short-circuit impedance and load loss	X	X
6	Measurement of no-load loss and no load current	X	X
7	High voltage test	X	X
8	Induced voltage test	X	X
9	Temperature-rise measurement	X	

(1) Type test on prototype transformer or test on at least the first batch of transformers.

(2) The certificates of transformers routine tested are to contain the manufacturer's serial number of the transformer which has been type tested and the test result.

(3) A visual examination of the transformer is to be made to ensure, as far as practicable, that it complies with technical documentation: inspection of enclosure, terminations, instrumentation or protection.

Section 6 Semiconductor Converters

1 Constructional requirements

1.1 Construction

1.1.1 Semiconductor converters are generally to comply with the requirements for switchgear assemblies (see Ch 2, Sec 8).

1.1.2 The design of semi-conductor converters is to comply with the requirements of IEC Publication 60146-1-1 with applicable requirements modified to suit marine installations like e.g. environmental requirements stated in Ch 2, Sec 2.

1.1.3 The design of semi-conductor converters for power supply is to comply with the requirements of IEC 62040 series (see Article [2]).

1.1.4 The design of semi-conductor converters for motor drives is to comply with the requirements of IEC 61800 series.

1.1.5 The monitoring and control circuits are generally to comply with the requirements of Part C, Chapter 3.

1.1.6 For liquid-cooled converters the following provisions are to be satisfied:

- liquid is to be non-toxic and of low flammability
- drip trays or other suitable means are to be provided to contain any liquid leakages
- the resistivity of the cooling fluid in direct contact with semiconductor or other current carrying parts is to be monitored and an alarm initiated if the resistivity is outside the specified limits.

1.1.7 Where forced cooling is used, the temperature of the heated cooling medium is to be monitored.

If the temperature exceeds a preset value an alarm is to be given and the shutdown of the converter is to be activated.

1.1.8 Where forced (air or liquid) cooling is provided, it is to be so arranged that the converter cannot be or remain loaded unless effective cooling is maintained.

Alternatively, other effective means of protection against overtemperature may be provided.

1.1.9 Stacks of semiconductor elements, and other equipment such as fuses, or control and firing circuit boards etc., are to be so arranged that they can be removed from equipment without dismantling the complete unit.

1.1.10 Semiconductor converters are to be rated for the required duty having regard to the peak loads, system transient and overvoltage and to be dimensioned so as to withstand the maximum short-circuit currents foreseen at the point of installation for the time necessary to trip the protection of the circuits they supply.

1.2 Protection

1.2.1 Semiconductor elements are to be protected against short-circuit by means of devices suitable for the point of installation in the network.

1.2.2 Overcurrent or overvoltage protection is to be installed to protect the converter. When the semiconductor converter is designed to work as an inverter supplying the network in transient periods, precautions necessary to limit the current are to be taken.

1.2.3 Semiconductor converters are not to cause distortion in the voltage wave form of the power supply at levels exceeding the voltage wave form tolerances at the other user input terminals (see Ch 2, Sec 2, [2.4]).

1.2.4 An alarm is to be provided for tripping of protective devices against overvoltages and overcurrents in electric propulsion converters and for converters for the emergency source of power.

1.3 Parallel operation with other power sources

1.3.1 For converters arranged to operate in parallel with other power sources, load sharing is to be such that under normal operating conditions overloading of any unit does not occur and the combination of paralleled equipment is stable.

1.4 Temperature rise

1.4.1 The permissible limit of temperature rise of the enclosure of the semiconductors is to be assessed on the basis of an ambient air temperature of 45°C or sea water temperature of 32°C for water-cooled elements, taking into account its specified maximum permissible temperature value.

1.4.2 The value of the maximum permissible temperature of the elements at the point where this can be measured (point of reference) is to be stated by the manufacturer.

1.4.3 The value of the mean rated current of the semiconductor element is to be stated by the manufacturer.

1.5 Insulation test

1.5.1 The test procedure is that specified in IEC Publication 60146.

1.5.2 The effective value of the test voltage for the insulation test is to be as shown in Tab 1.

Table 1 : Test voltages for high voltage test on static converters

$\frac{U_m}{\sqrt{2}} = U$ in V **(1)**	Test voltage, in V
$U \le 60$	600
$60 < U \le 90$	900
$90 < U$	2 U + 1000 (at least 2000)
(1) U_m : Highest crest value to be expected between any pair of terminals.	

2 Requirements for uninterruptible power system (UPS) units as alternative and/or transitional power

2.1 Definitions

2.1.1 Uninterruptible power system (UPS)

Combination of converters, switches and energy storage means, for example batteries, constituting a power system for maintaining continuity of load power in case of input power failure (see IEC Publication 62040).

2.1.2 Off line UPS unit

A UPS unit where under normal operation the output load is powered from the bypass line (raw mains) and only transferred to the inverter if the bypass supply fails or goes outside preset limits. This transition will invariably result in a brief (typically 2 to 10 ms) break in the load supply.

2.1.3 Line interactive UPS unit

An off-line UPS unit where the bypass line switch to stored energy power when the input power goes outside the preset voltage and frequency limits.

2.1.4 On line UPS unit

A UPS unit where under normal operation the output load is powered from the inverter, and will therefore continue to operate without break in the event of the supply input failing or going outside preset limits.

2.2 Design and construction

2.2.1 UPS units are to be constructed in accordance with IEC 62040, or an acceptable and relevant national or international standard.

2.2.2 The operation of the UPS is not to depend upon external services.

2.2.3 The type of UPS unit employed, whether off-line, line interactive or on-line, is to be appropriate to the power supply requirements of the connected load equipment.

2.2.4 An external bypass is to be provided.

2.2.5 The UPS unit is to be monitored and audible and visual alarm is to be given in a normally attended location for:

- power supply failure (voltage and frequency) to the connected load
- earth fault
- operation of battery protective device
- when the battery is being discharged
- when the bypass is in operation for on-line UPS units.

2.3 Location

2.3.1 The UPS unit is to be suitably located for use in an emergency.

2.3.2 UPS units utilising valve regulated sealed batteries may be located in compartments with normal electrical equipment, provided the ventilation arrangements are in accordance with the requirements of IEC 62040 or an acceptable and relevant national or international standard.

2.4 Performance

2.4.1 The output power is to be maintained for the duration required for the connected equipment as stated in Ch 2, Sec 3, Tab 2.

2.4.2 No additional circuits are to be connected to the UPS unit without verification that the UPS unit has adequate capacity.

2.4.3 The UPS battery capacity is, at all times, to be capable of supplying the designated loads for the time specified in the regulations.

2.4.4 On restoration of the input power, the rating of the charge unit shall be sufficient to recharge the batteries while maintaining the output supply to the load equipment.

3 Testing

3.1 General

3.1.1 Converters intended for essential services are to be subjected to the tests stated in [3.2].

3.1.2 The manufacturer is to issue a test report giving information on the construction, type, serial number and all technical data relevant to the converter, as well as the results of the tests required.

3.1.3 In the case of converters which are completely identical in rating and in all other constructional details, it will be acceptable for the rated current test and temperature rise measurement stipulated in [3.2] not to be repeated.

3.1.4 The tests and, if appropriate, manufacture of converters of 50 kVA and over intended for essential services are to be attended by a Surveyor of the Society.

3.2 Tests on converters

3.2.1 Converters are to be subjected to tests in accordance with Tab 2.

Type tests are the tests to be carried out on a prototype converter or the first of a batch of converters, and routine tests are the tests to be carried out on subsequent converters of a particular type.

3.2.2 The tests listed in Tab 2 are to be performed in accordance with IEC 60146-1-1. The relevant requirements of IEC 61800-5-1 and of IEC 62040-3 based on the equipment type also apply.

3.2.3 The electronic components of the converters are to be constructed to withstand the tests required in Ch 3, Sec 6.

3.2.4 Final approval of converters is to include complete function tests after installation on board, performed with all unit's systems in operation and in all characteristic load conditions.

Table 2 : Tests to be carried out on static converters

No.	Tests	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection **(3)** including check of earth continuity	X	X
2	Light load function test to verify all basic and auxiliary functions	X	X
3	Rated current test	X	
4	Temperature rise measurement	X	
5	Insulation test (dielectric strength test and insulation resistance measurement)	X	X
6	Protection of the converters in case of failure of forced cooling system	X	X

(1) Type test on prototype converter or test on at least the first batch of converters.
(2) The certificates of converters routine tested are to contain the manufacturer's serial number of the converter which has been type tested and the test result.
(3) A visual examination of the converter is to be made to ensure, as far as practicable, that it complies with technical documentation.

3.3 Additional testing and survey for uninterruptible power system (UPS) units as alternative and/or transitional power

3.3.1 UPS units of 50 kVA and over are to be surveyed by the Society during manufacturing and testing.

3.3.2 Appropriate testing is to be carried out to demonstrate that the UPS unit is suitable for its intended environment. This is expected to include as a minimum the following tests:

- functionality, including operation of alarms
- ventilation rate
- battery capacity.

3.3.3 Where the supply is to be maintained without a break following a power input failure, this is to be verified after installation by practical test.

Section 7 Storage Batteries and Chargers

1 Constructional requirements for batteries

1.1 General

1.1.1 The requirements of this Section apply to permanently installed storage batteries (not to portable batteries).

1.1.2 Storage batteries may be of the lead-acid or nickel-alkaline type, due consideration being given to the suitability for any specific application.

Other types of storage batteries of satisfactorily proven design (e.g. silver/zinc) may be accepted provided they are suitable for shipboard use to the satisfaction of the Society.

1.1.3 Cells are to be assembled in suitable crates or trays equipped with handles for convenient lifting.

1.2 Vented batteries

1.2.1 Vented batteries are those in which the electrolyte can be replaced and freely releases gas during periods of charge and overcharge.

1.2.2 Vented batteries are to be constructed to withstand the movement of the unit and the atmosphere (salt mist, oil etc.) to which they may be exposed.

1.2.3 Battery cells are to be so constructed as to prevent spilling of electrolyte at any inclination of the battery up to 40° from the vertical.

1.2.4 It is to be possible to check the electrolyte level and the ph.

1.3 Valve-regulated sealed batteries

1.3.1 Valve-regulated sealed batteries are batteries whose cells are closed under normal conditions but which have an arrangement which allows the escape of gas if the internal pressure exceeds a predetermined value. The cells cannot normally receive addition to the electrolyte.

Note 1: The cells of batteries which are marketed as “sealed” or “maintenance free” are fitted with a pressure relief valve as a safety precaution to enable uncombined gas to be vented to the atmosphere; they should more properly be referred to as valve-regulated sealed batteries. In some circumstances the quantity of gas vented can be up to 25% of the equivalent vented design. The design is to take into consideration provision for proper ventilation.

1.3.2 Cell design is to minimise risks of release of gas under normal and abnormal conditions.

1.4 Tests on batteries

1.4.1 The battery autonomy is to be verified on board in accordance with the operating conditions.

1.5 Battery maintenance

1.5.1 Where batteries are fitted for use for essential and emergency services, a schedule of such batteries is to be compiled and maintained. The schedule, which is to be reviewed by the Society, is to include at least the following information regarding the battery(ies):

- maintenance/replacement cycle dates
- date(s) of last maintenance and/or replacement
- for replacement batteries in storage, the date of manufacture and shelf life.

Note 1: Shelf life is the duration of storage under specified conditions at the end of which a battery retains the ability to give a specified performance.

1.5.2 Procedures are to be put in place to ensure that, where batteries are replaced, they are of an equivalent performance type.

1.5.3 Where vented type batteries replace valve-regulated sealed types, it is to be ensured that there is adequate ventilation and that the Society's requirements relevant to the location and installation of vented types batteries are complied with.

1.5.4 Details of the schedule and of the procedures are to be included in the unit's safety management system and be integrated into the unit's operational maintenance routine, as appropriate, to be verified by the Society's surveyor.

2 Constructional requirements for chargers

2.1 Characteristics

2.1.1 Chargers are to be adequate for the batteries for which they are intended and provided with a voltage regulator.

2.1.2 In the absence of indications regarding its operation, the battery charger is to be such that the completely discharged battery can be recharged to 80% capacity within a period of 10 hours without exceeding the maximum permissible charging current. A charging rate other than the above (e.g. fully charged within 6 hours for batteries for starting of motors) may be required in relation to the use of the battery.

2.1.3 For floating service or for any other condition where the load is connected to the battery while it is on charge, the maximum battery voltage is not to exceed the safe value of any connected apparatus.

Note 1: Consideration is to be given to the temperature variation of the batteries.

2.1.4 The battery charger is to be designed so that the charging current is set within the maximum current allowed by the manufacturer when the battery is discharged and the floating current to keep the battery fully charged.

2.1.5 Trickle charging to neutralise internal losses is to be provided. An indication is to be provided to indicate a charging voltage being present at the charging unit.

2.1.6 Protection against reversal of the charging current is to be provided.

2.1.7 Battery chargers are to be constructed to simplify maintenance operation. Indications are to be provided to visualise the proper operation of the charger and for troubleshooting.

2.2 Tests on chargers

2.2.1 Battery chargers are to be subjected to tests in accordance with Tab 1.

Type tests are the tests to be carried out on a prototype charger or the first of a batch of chargers, and routine tests are the tests to be carried out on subsequent chargers of a particular type.

2.2.2 The electronic components of the battery chargers are to be constructed to withstand the tests required in Ch 3, Sec 6.

2.2.3 The tests of battery chargers of 5 kW and over intended for essential services are to be attended by a Surveyor of the Society.

Table 1 : Tests to be carried out on battery chargers

No.	Tests	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection **(3)** including check of earth continuity	X	X
2	Functional tests (current and voltage regulation, quick, slow, floating charge, alarms)	X	X
3	Temperature rise measurement	X	
4	Insulation test (dielectric strength test and insulation resistance measurement)	X	X

(1) Type test on prototype battery charger or test on at least the first batch of battery chargers.

(2) The certificates of battery chargers routine tested are to contain the manufacturer’s serial number of the battery charger which has been type tested and the test result.

(3) A visual examination of the battery charger is to be made to ensure, as far as practicable, that it complies with technical documentation.

Section 8 Switchgear and Controlgear Assemblies

1 Constructional requirements for main and emergency switchboards

1.1 Construction

1.1.1 Construction is to be in accordance with IEC Publication 60092-302.

1.1.2 Where the framework, panels and doors of the enclosure are of steel, suitable measures are to be taken to prevent overheating due to the possible circulation of eddy currents.

1.1.3 Insulating material for panels and other elements of the switchboard is at least to be moisture-resistant and flame-retardant.

1.1.4 Switchboards are to be of dead front type, with enclosure protection according to Ch 2, Sec 3, Tab 3.

1.1.5 Switchboards are to be provided with insulated handrails or handles fitted in an appropriate position at the front of the switchboard. Where access to the rear is necessary for operational or maintenance purposes, an insulated handrail or insulated handles are to be fitted.

1.1.6 Where the aggregate capacity of generators connected to the main busbars exceeds 100 kVA, a separate cubicle for each generator is to be arranged with flame-retardant partitions between the different cubicles. Similar partitions are to be provided between the generator cubicles and outgoing circuits.

1.1.7 Instruments, handles or push-buttons for switchgear operation are to be placed on the front of the switchboard. All other parts which require operation are to be accessible and so placed that the risk of accidental touching of live parts, or accidental making of short-circuits and earthings, is reduced as far as practicable.

1.1.8 Where it is necessary to make provision for the opening of the doors of the switchboard, this is to be in accordance with one of the following requirements:

a) Opening is to necessitate the use of a key or tool (e.g. when it is necessary to replace a lamp or a fuse-link).

b) All live parts which can be accidentally touched after the door has been opened are to be disconnected before the door can be opened.

c) The switchboard is to include an internal barrier or shutter with a degree of protection not less than IP2X shielding all live parts such that they cannot accidentally be touched when the door is open. It is not to be possible to remove this barrier or shutter except by the use of a key or tool.

1.1.9 All parts of the switchboard are to be readily accessible for maintenance, repair or replacement. In particular, fuses are to be able to be safely inserted and withdrawn from their fuse-bases.

1.1.10 Hinged doors which are to be opened for operation of equipment on the door or inside are to be provided with fixing devices for keeping them in open position.

1.1.11 Means of isolation of the circuit-breakers of generators and other important parts of the installation are to be provided so as to permit safe maintenance while the main busbars are alive.

1.1.12 Where components with voltage exceeding the safety voltage are mounted on hinged doors, the latter are to be electrically connected to the switchboard by means of a separate, flexible protective conductor.

1.1.13 All measuring instruments and all monitoring and control devices are to be clearly identified with indelible labels of durable, flame-retardant material.

1.1.14 The rating of each circuit, together with the rating of the fuse or the appropriate setting of the overload protective device (circuit-breaker, thermal relay etc.) for each circuit is to be permanently indicated at the location of the fuse or protective device.

1.2 Busbars and bare conductors

1.2.1 Busbars are to be of copper or of copper-surrounded aluminium alloy if suitable for use in the marine environment and if precautions are taken to avoid galvanic corrosion.

1.2.2 All connections are to be so made as to inhibit corrosion.

1.2.3 Busbars are to be dimensioned in accordance with IEC Publication 60092-302.

The mean temperature rise of busbars is not to exceed 45°C under rated current condition with an ambient air temperature of 45°C (see Ch 2, Sec 2, [1.2.2]) and is not to have any harmful effect on adjacent components. Higher values of temperature rise may be accepted to the satisfaction of the Society.

1.2.4 The cross-section of neutral connection on an a.c. three-phase, four-wire system is to be at least 50% of the cross-section for the corresponding phases.

1.2.5 Bare main busbars, excluding the conductors between the main busbars and the supply side of outgoing units, are to have the minimum clearances and creepage distances given in Tab 1. The values shown apply to clearances and creepage distances between live parts as well as between live parts and exposed conductive parts.

Note 1: Clearance is the distance between two conductive parts along a string stretched the shortest way between such parts. Creepage distance is the shortest distance along the surface of an insulating material between two conductive parts.

Table 1 : Clearance and creepage distances

Rated insulation voltage a.c. r.m.s. or d.c. (V)	Minimum clearance (mm)	Minimum creepage distance (mm)
≤ 250	15	20
> 250 to ≤ 690	20	25
> 690	25	35

1.2.6 Reduced values as specified in IEC Publication 60092-302 may be accepted for type tested and partially type tested assemblies.

The reference values for the evaluation of the minimum clearances and creepage distances for these assemblies are based on the following:

- pollution degree 3 (conductive pollution occurs, or dry non-conductive pollution occurs which becomes conductive due to condensation which is expected)
- overvoltage category III (distribution circuit level)
- inhomogenous field conditions (case A)
- rated operational voltage 1000 V a.c., 1500 V d.c.
- group of insulating material IIIa.

Special consideration is to be given to equipment located in spaces where a pollution degree higher than 3 is applicable, e.g. in diesel engine rooms.

1.2.7 Busbars and other bare conductors with their supports are to be mechanically dimensioned and fixed such that they can withstand the stresses caused by short-circuits.

Where maximum symmetrical short-circuit currents are expected to exceed 50 kA, calculation is to be submitted to the Society.

1.2.8 Busbars and bare conductors are to be protected, where necessary, against falling objects (e.g. tools, fuses or other objects).

1.3 Internal wiring

1.3.1 Insulated conductors for internal wiring of auxiliary circuits of switchboards are to be constructed in accordance with Ch 2, Sec 9, [2.1.1].

1.3.2 All insulated conductors provided for in [1.3.1] are to be of flexible construction and of the stranded type.

1.3.3 Connections from busbars to protective devices are to be as short as possible. They are to be laid and secured in such a way to minimise the risk of a short-circuit.

1.3.4 All conductors are to be secured to prevent vibration and are to be kept away from sharp edges.

1.3.5 Connections leading to indicating and control instruments or apparatus mounted in doors are to be installed such that they cannot be mechanically damaged due to movement of the doors.

1.3.6 Non-metallic trays for internal wiring of switchboards are to be of flame-retardant material.

1.3.7 Control circuits are to be installed and protected such that they cannot be damaged by arcs from the protective devices.

1.3.8 Where foreseen, fixed terminal connectors for connection of the external cables are to be arranged in readily accessible positions.

1.4 Switchgear and controlgear

1.4.1 Switchgear and controlgear are to comply with IEC Publication 60947 series and to be chosen from among that type approved by the Society.

1.4.2 The characteristics of switchgear, controlgear and protective devices for the various consumers are to be in compliance with Ch 2, Sec 3, [9].

1.5 Auxiliary circuits

1.5.1 Auxiliary circuits are to be designed in such a manner that, as far as practicable, faults in such circuits do not impair the safety of the system. In particular, control circuits are to be designed so as to limit the dangers resulting from a fault between the control circuit and earth (e.g. inadvertent operation or malfunction of a component in the installation), also taking account of the earthing system of their supply.

1.5.2 Auxiliary circuits of essential systems are to be independent of other auxiliary circuits.

1.5.3 Common auxiliary circuits for groups of consumers are permitted only when the failure of one consumer jeopardises the operation of the entire system to which it belongs.

1.5.4 Auxiliary circuits are to be branched off from the main circuit in which the relevant switchgear is used.

1.5.5 The supply of auxiliary circuits by specifically arranged control distribution systems will be specially considered by the Society.

1.5.6 Means are to be provided for isolating the auxiliary circuits as well when the main circuit is isolated (e.g. for maintenance purposes).

1.5.7 For the protection of auxiliary circuits, see Ch 2, Sec 3, [9.13].

1.6 Instruments

1.6.1 The upper limit of the scale of every voltmeter is to be not less than 120% of the rated voltage of the circuit in which it is installed.

1.6.2 The upper limit of the scale of every ammeter is to be not less than 130% of the normal rating of the circuit in which it is installed.

1.6.3 The upper limit of the scale of every wattmeter is to be not less than 120% of the rated voltage of the circuit in which it is installed.

1.6.4 Ammeters or wattmeters for use with a.c. generators which may be operated in parallel are to be capable of indicating 15% reverse-current or reverse power, respectively.

1.6.5 For wattmeters using one current circuit only, the measurement of the current of all generators is to be made in the same phase.

1.6.6 The rated value of the measure read, at full load, is to be clearly indicated on the scales of instruments.

1.6.7 Frequency meters are to have a scale at least ± 5% of the nominal frequency.

1.6.8 The secondary windings of instrument transformers are to be earthed.

1.6.9 Each a.c. generator not operated in parallel is to be provided with:

- 1 voltmeter
- 1 frequency meter
- 1 ammeter in each phase or 1 ammeter with a selector switch to enable the current in each phase to be read
- 1 three-phase wattmeter in the case of generators rated more than 50 kVA.

1.6.10 Each a.c. generator operated in parallel is to be provided with:

- 1 three-phase wattmeter
- 1 ammeter in each phase or 1 ammeter with a selector switch to enable the current in each phase to be read.

1.6.11 For paralleling purposes the following are to be provided:

- 2 voltmeters (voltage measurements of each alternator and busbar)
- 2 frequency meters (frequency measurements of each alternator and busbar).

Note 1: As an alternative, a switch may be provided to enable one voltmeter and one frequency meter to be connected to each generator before the latter is connected to the busbars.

The other voltmeter and frequency meter are to be permanently connected to the busbars.

Note 2: Voltmeter and frequencymeter with dual display may be considered.

1.6.12 Each secondary distribution system is to be provided with one voltmeter.

1.6.13 Switchboards are to be fitted with means for monitoring the insulation level of insulated distribution systems as stipulated in Ch 2, Sec 3, [5.5.1].

1.6.14 The main switchboard is to be fitted with a voltmeter or signal lamp indicating that the cable between the shore-connection box and the main switchboard is energised (see Ch 2, Sec 3, [5.5.7]).

1.6.15 For each d.c. power source (e.g. converters, rectifiers and batteries), one voltmeter and one ammeter are to be provided, except for d.c. power sources for starting devices (e.g. starting motor for emergency generator).

1.7 Synchronisation of generators

1.7.1 It is to be possible to synchronise each generator intended for parallel operation with two independent synchronizing devices. At least one of these synchronizing devices is to be manual.

1.7.2 Provisions are to be made for manual speed control of the prime mover and manual voltage control of the generators at the place where the manual synchronization is carried out.

2 Constructional requirements for section boards and distribution boards

2.1 Construction

2.1.1 Section boards and distribution boards are to be constructed, insofar as applicable, as specified for main and emergency switchboards.

2.1.2 All parts which require operation in normal use are to be placed on the front.

2.1.3 Insulated handrails or handles required in [1.1.5] may be omitted for section boards and distribution boards not requiring prolonged manual operations.

2.1.4 Distribution switchboards which are provided with two or more supply circuits arranged for automatic standby connection are to be provided with positive indication of which of the circuits is feeding the switchboard.

2.1.5 Where switchboard supplying essential services is provided with a forced air cooling system, the air temperature is to be monitored. An alarm is to be activated when temperature exceeds a preset value.

3 Testing

3.1 General

3.1.1 Switchboards are to be subjected to the tests specified from [3.2] to [3.4].

3.1.2 The manufacturer is to issue the relative test reports providing information concerning the construction, serial number and technical data relevant to the switchboard, as well as the results of the tests required.

3.1.3 The tests are to be carried out prior to installation on board.

3.1.4 The test procedures are as specified in IEC Publication 60092-302.

3.1.5 The tests of main switchboards, emergency switchboards or switchboards rated above 100 kW are to be attended by a surveyor of the Society.

3.2 Inspection of equipment, check of wiring and electrical operation test

3.2.1 It is to be verified that the switchboard:

- complies with the approved drawings
- maintains the prescribed degree of protection
- is constructed in accordance with the relevant constructional requirements, in particular as regards creepage and clearance distances.

3.2.2 The connections, especially screwed or bolted connections, are to be checked for adequate contact, possibly by random tests.

3.2.3 Depending on the complexity of the switchboard it may be necessary to carry out an electrical functioning test. The test procedure and the number of tests depend on whether or not the switchboard includes complicated interlocks, sequence control facilities, etc. In some cases it may be necessary to conduct or repeat this test following installation on board.

3.3 High voltage test

3.3.1 The test is to be performed with alternating voltage at a frequency between 25 and 100 Hz of approximately sinusoidal form.

3.3.2 The test voltage is to be applied:

- between all live parts connected together and earth
- between each polarity and all the other polarities connected to earth for the test.

During the high voltage test, measuring instruments, ancillary apparatus and electronic devices may be disconnected and tested separately in accordance with the appropriate requirements.

3.3.3 The test voltage at the moment of application is not to exceed half of the prescribed value. It is then to be increased steadily within a few seconds to its full value. The prescribed test voltage is to be maintained for 1 minute.

3.3.4 The value of the test voltage for main and auxiliary circuits is given in Tab 2 and Tab 3.

Table 2 : Test voltages for main circuits

Rated insulation voltage Ui (V)	Test voltage a.c. (r.m.s.) (V)
Ui ≤ 60	1000
60 < Ui ≤ 300	2000
300 < Ui ≤ 660	2500
660 < Ui ≤ 800	3000
800 < Ui ≤ 1000	3500

Table 3 : Test voltage for auxiliary circuits

Rated insulation voltage Ui (V)	Test voltage a.c. (r.m.s.) (V)
Ui ≤ 12	250
12 < Ui ≤ 60	500
Ui > 60	2 Ui + 1000 (at least 1500)

3.4 Measurement of insulation resistance

3.4.1 Immediately after the high voltage test, the insulation resistance is to be measured using a device with a direct current voltage of at least 500 V.

3.4.2 The insulation resistance between all current carrying parts and earth (and between each polarity and the other polarities) is to be at least equal to 1 MΩ..

Section 9 Cables

1 General

1.1 Type approval

1.1.1 Cables are to be of a type approved by the Society.

2 Constructional requirements

2.1 Construction

2.1.1 Cables and insulated wiring are generally to be constructed in accordance with the relevant recommendations of IEC 60092-350, 60092-352, 60092-353, 60092-354, 60092-360, 60092-370 and 60092-376, as well as with the provisions of this Chapter.

2.1.2 Mineral-insulated cables are to be constructed according to IEC 60702.

2.1.3 Optical fibre cables are to be constructed in accordance with IEC 60794.

2.1.4 Flexible cables constructed according to national standards are to be specially considered by the Society.

2.1.5 Cables and insulated wires manufactured and tested in accordance to standards other than those specified in [2.1.1] may be accepted provided they are in accordance with an acceptable and relevant international or national standard and are of an equivalent or higher safety level than those listed in [2.1.1].

However, cables such as flexible cable, fibre-optic cable, etc. used for special purposes may be accepted provided they are manufactured and tested in accordance with relevant standards accepted by the Society.

2.1.6 Insulated wiring for auxiliary circuits of switchboards may be constituted by cables with a single conductor of the stranded type for all sections, PVC-ST2 or rubber-insulated in accordance with the standards cited in [2.1.1] and without further protection.

2.1.7 The insulated wiring is to be at least of the flame-retardant type according to IEC 60332-1-2. Switchboard wires, of an equivalent flame-retardant type, will be specially considered by the Society.

2.1.8 Fire resistant cables are to be designed and tested in accordance with the relevant IEC 60092 series standards.

They are to comply with the requirements of:

- IEC 60331-1 for cables with an overall diameter exceeding 20 mm, or
- IEC 60331-2 for cables with an overall diameter not exceeding 20 mm,
- otherwise IEC 60331-21.

The minimum flame application time is to be at least 90 minutes.

Fire resistant type cables are to be easily distinguishable.

Note 1: For installation methods refer to those specified in Ch 2, Sec 12, [7.1.4].

Note 2: For special cables, requirements in the following standards may be used:

- IEC 60331-23: Procedures and requirements - Electric data cables
- IEC 60331-25: Procedures and requirements - Optical fibre cables.

2.2 Conductors

2.2.1 Conductors are to be of annealed electrolytic copper with a resistivity not exceeding 17.241 Ω mm^2/km at 20°C according to IEC 60228.

2.2.2 Individual conductor wires of rubber-insulated cables are to be tinned or coated with a suitable alloy.

2.2.3 All conductors are to be stranded, except for cables of nominal cross-sectional area 2,5 mm^2 and less (provided that adequate flexibility of the finished cable is assured).

2.2.4 For the minimum nominal cross-sectional areas permitted, see Ch 2, Sec 3, [11.10].

2.3 Insulating materials

2.3.1 The materials used for insulation are to comply with IEC 60092-360 and to have the thicknesses specified for each type of cable in the relevant standard. The maximum permissible rated temperature is specified for the various materials.

2.3.2 Materials and thicknesses other than those in [2.3.1] are to be specially considered by the Society.

2.4 Inner covering, fillers and binders

2.4.1 The cores of a multicore cable are to be laid up. The spaces between the cores are to be filled so as to obtain an assembly having an essentially circular cross-section. The filling may be omitted in multicore cables having a conductor cross-sectional area not exceeding 4 mm^2.

When a non-metallic sheath is applied directly over the inner covering or the fillers, it may substitute partially for the inner covering or fillers.

2.4.2 The materials used, the binders and the thicknesses of the inner coverings are generally to be in accordance with IEC Publications of the series 60092-3., in relation to the type of cable.

2.5 Protective coverings (armour and sheath)

2.5.1 Metallic armour, if not otherwise protected against corrosion, is to be protected by means of a coating of protective paint (see Ch 2, Sec 3, [11.3]).

2.5.2 The paint is to be non-flammable and of adequate viscosity. When dry, it is not to flake off.

2.5.3 The materials and construction used for (metal) armour are to be in accordance with IEC Publication 60092-350 and their dimensions are to be those specified for each type of cable in the relevant standard.

2.5.4 The materials used for sheaths are to be in accordance with IEC Publication 60092-360 and are to have the thicknesses specified for each type of cable in the relevant standard.

The quality of the materials is to be adequate to the service temperature of the cable.

2.5.5 Materials other than those in [2.5.3] and [2.5.4] are to be specially considered by the Society.

2.6 Identification

2.6.1 Each cable is to have clear means of identification so that the manufacturer can be determined.

2.6.2 Fire non propagating cables are to be clearly labelled with indication of the standard according to which this characteristic has been verified and, if applicable, of the category to which they correspond.

3 Testing

3.1 Type tests

3.1.1 Type tests are to be in accordance with the relevant IEC 60092-3.. Series and IEC 60332-1, IEC 60332-3 Category A, and IEC 60331 where applicable.

3.2 Routine tests

3.2.1 Every length of finished cable is to be subjected to the tests specified in [3.2.2].

3.2.2 The following routine tests are to be carried out:

a) visual inspection

b) check of conductor cross-sectional area by measuring electrical resistance

c) high voltage test

d) insulation resistance measurement

e) dimensional checks (as necessary).

3.2.3 The manufacturer is to issue a statement providing information on the type and characteristics of the cable, as well as the results of the tests required and the Type Approval Certificates.

3.2.4 The test procedure is as specified in IEC Publication 60092-350.

3.2.5 Where an alternative scheme, e.g. a certified quality assurance system, is recognised by the Society, attendance of the Surveyor may not be required.

Section 10 Miscellaneous Equipment

1 Switchgear and controlgear, protective devices

1.1 General

1.1.1 Switchgear and controlgear are to comply with IEC Publication 60947 series.

1.1.2 The protection devices are normally to be type approved by the Society on the basis of the IEC Standards specified in [1.1.1].

Equipment in accordance with national regulations and having at least equivalent characteristics may also be used; necessary justification may be required.

The Society may require, in addition, justification of the characteristics of switchgears, by means of tests for instance.

1.1.3 For materials and construction see Ch 2, Sec 2, [4] and Ch 2, Sec 2, [5].

1.2 Circuit-breakers

1.2.1 Power-driven circuit-breakers are to be equipped with an additional separate drive operated by hand.

1.2.2 Power circuit-breakers with a making capacity exceeding 10 kA are to be equipped with a drive which performs the make operation independently of the actuating force and speed.

1.2.3 Where the conditions for closing the circuit-breaker are not satisfied (e.g. if the undervoltage trip is not energised), the closing mechanism is not to cause the closing of the contacts.

1.2.4 All circuit-breakers rated more than 16 A are to be of the trip-free type, i.e. the breaking action initiated by overcurrent or undervoltage releases is to be fulfilled independently of the position of the manual handle or other closing devices.

1.3 Protection devices

1.3.1 Short-circuit releases are generally to be independent of energy supplied from circuits other than that to be protected. Tripping due to short-circuit is to be reliable even in the event of a total loss of voltage in the protected circuit.

1.3.2 Short-circuit releases for generators are to be equipped with reclosing inhibitors and are to be delayed for selective tripping.

1.3.3 Overload releases or relays are to operate reliably at any voltage variation of the supply voltage in the protected circuit.

1.3.4 Undervoltage relays or releases are to cause the circuit-breaker to open if the voltage drops to 70% - 35% of the rated voltage.

1.3.5 Shunt releases are to ensure the disconnection of the circuit-breaker even when the supply voltage of the release drops to 85% of the rated supply voltage.

1.3.6 The reverse power protection device is to respond to the active power regardless of the power factor, and is to operate only in the event of reverse power.

1.3.7 Single-phase failure devices in three-phase circuits are to operate without a time lag.

1.3.8 Insulation monitoring devices are to continuously monitor the insulation resistance to earth and trigger an alarm should the insulation resistance fall below a predetermined value.

The measuring current of such devices is not to exceed 30 mA in the event of a total short to earth.

2 Electrical slip ring assemblies

2.1 Applicable requirements

2.1.1 Electrical slip rings are to be designed and manufactured according to the applicable requirements of this Section.

2.1.2 Where relevant, electrical slip rings are to be suitable for operation in gas dangerous area in which they are located.

2.2 Construction

2.2.1 The purpose of an electrical slip ring is to form a continuous electrical connection between cables that are fixed to a stationary structure and cables fixed to a rotating structure.

2.2.2 Enclosure and connections are to be made of corrosion resistant materials.

2.2.3 If an oil production pipe passes through the central annulus of the electrical slip ring, it is to be verified that the ambient temperature in the slip ring enclosure does not exceed 45°C. Otherwise special precautions are to be considered.

2.3 Testing

2.3.1 General

Electric slip rings intended for essential services are to be subjected to the tests stated in Tab 1.

Type tests are to be carried out, unless the manufacturer can produce evidence based on previous experience indicating the satisfactory performance of such equipment onboard offshore units or ships.

The manufacturer is to issue the relative test reports providing information concerning the construction, type, serial number and all other technical data relevant to the slip ring, as well as the results of the tests required.

Such test reports are to be made available to the Society.

Tests procedure is to be submitted to the Society for approval.

Tests of electric slip ring intended for essential services are to be attended by a Surveyor of the Society.

Table 1 : Tests to be carried out on electrical slip rings

No.	Tests	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection **(3)** including check of protection index, clearances and creepage distances	X	X
2	Torque measurement test	X	X
3	Insulation resistance measurement	X	X
4	Dielectric strength test	X	X
5	Continuity test	X	X
6	Resistance test (or attenuation test for optical fibre slip rings)	X	X
7	Rotational test	X	X
8	Environmental type test (cold, dry head, damp heat, salt mist, vibration)	X	

(1) Type test on prototype slip ring or test on at least the first batch of slip rings.

(2) The certificates of slip rings routine tested are to contain the manufacturer's serial number of the slip ring which has been type tested and the test result.

(3) A visual examination is to be made of the converter to ensure, as far as practicable, that it complies with technical documentation.

2.4 Description of tests

2.4.1 Visual inspection

It is to be verified that the electrical slip ring assembly:

- complies with the approved drawings
- maintains the prescribed degree of protection
- is constructed in accordance with the relevant constructional requirements, in particular as regards creepage and clearance distances.

2.4.2 Insulation resistance measurement

Immediately after the high voltage tests the insulation resistances are to be measured using a direct current insulation tester between:

a) all current carrying parts connected together and earth

b) all current carrying parts of different polarity or phase.

The minimum values of test voltages and corresponding insulation resistances are given in Tab 2.

Table 2 : Minimum insulation resistance

Rated voltage Un (V)	Minimum test voltage (V)	Minimum insulation resistance (MΩ)
Un = 250	2 Un	1
250 < Un ≤ 1000	500	1
1000 < Un ≤ 7200	1000	Un/1000 + 1
7200 < Un ≤ 15000	5000	Un/1000 + 1

2.4.3 Dielectric strength test

Slip ring assemblies are to be subjected to a high voltage test between the polarities and between live parts and the enclosure.The test voltage is to be as given in Tab 3 and Tab 4. The test voltage is to be applied for 1 minute at any frequency between 25 and 100 Hz of approximately sinusoidal form.

No break down should occur during the test.

Table 3 : Test voltages for main circuits

Rated insulation voltage Ui (V)	Test voltage a.c. (r.m.s.) (V)
Ui ≤ 60	1000
60 < Ui ≤ 300	2000
300 < Ui ≤ 660	2500
660 < Ui ≤ 800	3000
800 < Ui ≤ 1000	3500
1000 < Ui ≤ 3600	10.000
3600 < Ui ≤ 7200	20.000
7200 < Ui ≤ 12000	28.000

Table 4 : Test voltage for auxiliary circuits

Rated insulation voltage Ui (V)	Test voltage a.c. (r.m.s.) (V)
Ui ≤ 12	250
12 < Ui ≤ 60	500
Ui > 60	2 Ui + 1000 (at least 1500)

2.4.4 Torque measurement test

The purpose of this test is to measure and record the running and break-out torque of the electrical slip ring assembly. Test is to be carried out on the full 360° in both clockwise and anti-clockwise directions. Measured values are not to exceed data given by manufacturer.

2.4.5 Continuity test

The purpose of this test is to ensure the continuous connection of each passes while the slip ring is rotating in both directions. No transitional discontinuity is to be detected.

2.4.6 Resistance or attenuation test

The purpose of this test is to measure the maximum resistance or the maximum attenuation of each pass while slip ring is rotating. Test is to be carried out between the inlet and outlet connection of the slip ring assembly on the full 360° in both clockwise and anti-clockwise directions. Values are not to exceed data given by manufacturer.

2.4.7 Rotational test

A rotational test at rated voltage and rated current is to be carried out. Number of rotations is to be evaluated taking into consideration the intended purpose of the slip ring. An endurance test is to be performed following manufacturer recommendations.

3 Lighting fittings

3.1 Applicable requirements

3.1.1 Lighting fittings are to comply with IEC Publications 60598 and 60092-306.

Lighting fittings complying with other standards are to be specially considered by the Society.

3.2 Construction

3.2.1 The temperature of terminals for connection of supplying cables is not to exceed the maximum conductor temperature permitted for the cable (see Ch 2, Sec 3, [11.9]).

Where necessary, luminaires are to be fitted with terminal boxes which are thermally insulated from the light source.

3.2.2 Wires used for internal connections are to be of a temperature class which corresponds to the maximum temperature within the luminaire.

3.2.3 The temperature rise of parts of luminaires which are in contact with the support is not to exceed 50°C. The rise is not to exceed 40°C for parts in contact with flammable materials.

3.2.4 The temperature rise of surface parts which can easily be touched in service is not to exceed 15°C.

3.2.5 High-power lights with higher surface temperatures than those in [3.2.2] and [3.2.3] are to be adequately protected against accidental contact.

4 Accessories

4.1 Applicable requirements

4.1.1 Accessories are to be constructed in accordance with the relevant IEC Publications, and in particular with Publication 60092-306.

4.2 Construction

4.2.1 Enclosures of accessories are to be of metal having characteristics suitable for the intended use on board, or of flame-retardant insulating material.

4.2.2 Terminals are to be suitable for the connection of stranded conductors, except in the case of rigid conductors for mineral-insulated cables.

5 Plug-and-socket connections

5.1 Applicable requirements

5.1.1 Plug-and-socket connections are to comply with IEC Publication 60092-306 and with the following additional standards in relation to their use:

- in accommodation spaces, day rooms and service rooms (up to 16 A, 250 V a.c.): IEC Publication 60083 or 60320, as applicable
- for power circuits (up to 250 A, 690 V a.c.): IEC Publication 60309
- for electronic switchgear: IEC Publications, e.g. 60512 and 60603
- for refrigerated containers: ISO 1496-2.

6 Heating and cooking appliances

6.1 Applicable requirements

6.1.1 Heating and cooking appliances are to comply with the relevant IEC Publications (e.g. those of series 60335), with particular attention to IEC 60092-307.

6.2 General

6.2.1 Power supply

Each heater rated more than 16 A is to be connected to a separate final circuit.

6.2.2 Heating elements are to be enclosed and protected with metal or refractory material.

6.2.3 The terminals of the power supply cable are not to be subjected to a higher temperature than that permitted for the conductor of the connection cable.

6.2.4 The temperature of parts which are to be handled in service (switch knobs, operating handles and the like) is not to exceed the following values:

- 55°C for metal parts
- 65°C for vitreous or moulded material.

6.3 Space heaters

6.3.1 The casing or enclosure of heaters is to be so designed that clothing or other flammable material cannot be placed on them.

6.3.2 The temperature of the external surface of space heaters is not to exceed 60°C.

6.3.3 Space heaters are to be provided with a temperature limiting device without automatic reconnection which automatically trips all poles or phases not connected to earth when the temperature exceeds the maximum permissible value.

6.4 Cooking appliances

6.4.1 Live parts of cooking appliances are to be protected such that any foods or liquids which boil over or spill do not cause short-circuits or loss of insulation.

6.5 Fuel oil and lube oil heaters

6.5.1 In continuous-flow fuel oil and lube oil heaters, the maximum temperature of the heating elements is to be below the boiling point of the oil.

6.5.2 Each oil heater is to be provided with a thermostat maintaining the oil temperature at the correct level.

6.5.3 In addition to the thermostat in [6.5.2], each oil heater is to be provided with a temperature limiting device without automatic reconnection, and with the sensing device installed as close as possible to the heating elements and permanently submerged in the liquid.

6.6 Water heaters

6.6.1 Water heaters are to be provided with a thermostat and safety temperature limiter.

Section 11 Location

1 General

1.1 Location

1.1.1 The degree of protection of the enclosures and the environmental categories of the equipment are to be appropriate to the spaces or areas in which they are located; see Ch 2, Sec 3, Tab 3, Ch 2, Sec 3, Tab 4 and Ch 2, Sec 2, [5.2.2].

1.2 Areas with a risk of explosion

1.2.1 Except where the installation of equipment for explosive gas atmosphere is provided for by the Rules, electrical equipment is not to be installed where flammable gases or vapours are liable to accumulate; see Ch 2, Sec 15.

2 Main electrical system

2.1 Location in relation to the emergency system

2.1.1 The arrangement of the emergency electrical system is to be such that a fire or other casualty in spaces containing the emergency source of electrical power, associated converting equipment, if any, the emergency switchboard and the emergency lighting switchboard will not render inoperative the main electric lighting system and the other primary essential services.

2.2 Main switchboard

2.2.1 The main switchboard shall be so placed relative to one main generating station that, as far as is practicable, the integrity of the normal electrical supply may be affected only by a fire or other casualty in one space.

2.2.2 An environmental enclosure for the main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the space, is not to be considered as separating switchboards from generators.

2.2.3 The main generating station is to be situated within the machinery space, i.e. within the extreme main transverse watertight bulkheads.

2.2.4 Any bulkhead between the extreme main transverse watertight bulkheads is not regarded as separating the equipment in the main generating station provided that there is access between the spaces.

2.2.5 The main switchboard is to be located as close as practicable to the main generating station, within the same machinery space and the same vertical and horizontal A60 fire boundaries.

2.2.6 A non-required subdivision bulkhead, with sufficient access, located between the switchboard and generators, or between two or more generators, is not to be considered as separating the equipment.

3 Emergency electrical system

3.1 Spaces for the emergency source

3.1.1 The emergency source of electrical power, associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard are to be located in a non-hazardous space, on or above the uppermost continuous deck, above the worst damage waterline and inboard of the relevant damage conditions of the unit. They are to be readily accessible from the open deck.

They shall not be located forward of the collision bulkhead.

3.1.2 The spaces containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard are not to be contiguous to the boundaries of machinery spaces of Category A or those spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard.

Where this is not practicable, the contiguous boundaries are to be Class A60.

3.2 Location in relation to the main electrical system

3.2.1 The location of the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency power, the emergency switchboard and the emergency lighting switchboard in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard shall be such as to ensure to the satisfaction of the Society that a fire or other casualty in the space containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard or in any machinery space of Category A will not interfere with the supply, control and distribution of emergency electrical power.

3.2.2 The arrangement of the main electrical system is to be such that a fire or other casualty in spaces containing the main source of electrical power, associated converting equipment, if any, the main switchboard and the main lighting switchboard will not render inoperative the emergency electric lighting system and the other emergency services other than those located within the spaces where the fire or casualty has occurred.

3.3 Emergency switchboard

3.3.1 The emergency switchboard shall be installed as near as is practicable to the emergency source of electrical power.

3.3.2 Where the emergency source of electrical power is a generator, the emergency switchboard shall be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

3.4 Alternative arrangement of emergency source installation

3.4.1 For units where the main source of electrical power is located in two or more spaces which have their own systems, including power distribution and control systems, completely independent of the systems in the other spaces and such that a fire or other casualty in any one of the spaces will not affect the power distribution from the others, or to the services listed in Ch 2, Sec 3, [3.1.14], the provisions of Ch 2, Sec 3, [3.1.1] may be considered satisfied without an additional emergency source of electrical power, provided the Society is satisfied that:

a) there are at least two generating sets, meeting the provisions of Ch 1, Sec 1, [2.6] and each of sufficient capacity to meet the provisions of Ch 2, Sec 3, [3.1.14], in each of at least two spaces

b) the arrangements in [3.4.1], item a) in each such space are equivalent to those in Ch 2, Sec 3, [3.1.11], [3.3], [3.5.1], Ch 2, Sec 3, [5.4.2] and Ch 1, Sec 2, [3.1.3] so that a source of electrical power is available at all times to the services listed in Ch 2, Sec 3, [3.1.15]

c) the location of each of the spaces referred to in [3.4.1], item a), is in compliance with [3.1.1] and the boundaries meet the provisions of [3.1.2] and [3.2.1], except that contiguous boundaries should consist of an A-60 bulkhead and a cofferdam, or a steel bulkhead insulated to class A-60 on both sides.

3.5 Emergency battery

3.5.1 No accumulator battery fitted in accordance with the provisions of Ch 2, Sec 3, [3.1] is to be installed in the same space as the emergency switchboard.

3.5.2 For units not subject to SOLAS, accumulator batteries fitted in accordance with the provisions of Ch 2, Sec 3, [3] and connected to a charging device of power of 2 kW or less may be accepted in the same space as the emergency switchboard but outside the emergency switchboard to the satisfaction of the Society.

4 Distribution boards

4.1 Distribution boards for cargo spaces and similar spaces

4.1.1 Distribution boards containing multipole switches for the control of power and lighting circuits in bunkers and cargo spaces are to be situated outside such spaces.

4.2 Distribution board for navigation lights

4.2.1 The distribution board for navigation lights is to be placed in an accessible position on the bridge or at the central control position.

5 Cable runs

5.1 General

5.1.1 Cable runs are to be selected so as to be as far as practicable accessible, with the exception of single cables, situated behind walls or ceilings constructed of incombustible materials, supplying lighting fittings and socket-outlets in accommodation spaces, or cables enclosed in pipes or conduits for installation purposes.

5.1.2 Cable runs are to be selected so as to avoid action from condensed moisture and from dripping of liquids.

5.1.3 Connection and draw boxes are to be accessible.

5.1.4 Cables are generally not to be installed across expansion joints.

Where this is unavoidable, however, a loop of cable of length proportional to the expansion of the joint is to be provided (see Ch 2, Sec 12, [7.2.2]).

5.2 Location of cables in relation to the risk of fire and overheating

5.2.1 Cables and wiring serving essential or emergency power, lighting, internal communications or signals are, so far as is practicable, to be routed clear of galleys, laundries, machinery spaces of Category A and their casings and other high fire risk areas, except for supplying equipment in those spaces.

5.2.2 When it is essential that a circuit functions for some time during a fire and it is unavoidable to carry the cable for such a circuit through a high fire risk area (e.g. cables connecting fire pumps to the emergency switchboard), the cable is to be of a fire-resistant type or adequately protected against direct exposure to fire.

5.2.3 The electrical cables to the emergency fire pump are not to pass through the machinery spaces containing the main fire pumps and their source(s) of power and prime mover(s).

They are to be of a fire resistant type, in accordance with Ch 2, Sec 9, [2.1.8], where they pass through other high fire risk areas.

5.2.4 Main cable runs (see Note 1) and cables for the supply and control of essential services are, as far as is practicable, to be kept away from machinery parts having an increased fire risk (see Note 2) unless:

- the cables have to be connected to the subject equipment
- the cables are protected by a steel bulkhead or deck, or
- the cables in that area are of the fire-resisting type.

Note 1: Main cable runs are for example:

- cable runs from generators and propulsion motors to main and emergency switchboards
- cable runs directly above or below main and emergency switchboards, centralised motor starter panels, section boards and centralised control panels for propulsion and essential auxiliaries.

Note 2: Machinery, machinery parts or equipment handling combustibles are considered to present an increased fire risk.

5.2.5 Cables and wiring serving essential or emergency power, lighting, internal communications or signals are to be arranged, as far as practicable, in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

5.2.6 Cables are to be arranged as remote as possible from sources of heat such as hot pipes, resistors, etc. Where installation of cables near heat sources cannot be avoided, and where there is consequently a risk of damage to the cables by heat, suitable shields are to be installed, or other precautions to avoid overheating are to be taken, for example use of ventilation, heat insulation materials or special heat-resisting cables.

5.3 Location of cables in relation to electromagnetic interference

5.3.1 For the installation of cables in the vicinity of radio equipment or of cables belonging to electronic control and monitoring systems, steps are to be taken in order to limit the effects of unwanted electromagnetic interference (see Ch 3, Sec 5).

5.4 Services with a duplicate feeder

5.4.1 In the case of essential services requiring a duplicate supply, the supply and associated control cables are to follow different routes which are to be as far apart as practicable, separated both vertically and horizontally.

5.5 Emergency circuits

5.5.1 Cables supplying emergency circuits are not to run through spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard, except for cables supplying emergency equipment located within such spaces (see [3.2.2]).

6 Storage batteries

6.1 General

6.1.1 Batteries are to be located where they are not exposed to excessive heat, extreme cold, spray, steam or other conditions which would impair performance or accelerate deterioration. They are to be installed in such a way that no damage may be caused to surrounding appliances by the vapours generated.

6.1.2 Storage batteries are to be suitably housed, and compartments (rooms, lockers or boxes) used primarily for their accommodation are to be properly constructed and efficiently ventilated so as to prevent accumulation of flammable gas.

6.1.3 Starter batteries are to be located as close as practicable to the engine or engines served.

6.1.4 Accumulator batteries, except for batteries of self-contained battery-operated lights, should not be located in sleeping quarters. The Society may grant exemptions from or equivalencies to this provision where hermetically sealed batteries are installed.

6.1.5 Lead-acid batteries and alkaline batteries are not to be installed in the same compartment (room, locker, box), unless of valve-regulated sealed type.

6.2 Large vented batteries

6.2.1 Batteries connected to a charging device of power exceeding 2 kW, calculated from the maximum obtainable charging current and the nominal voltage of the battery (hereafter referred to as “large batteries”) are to be installed in a room assigned to batteries only.

Where this is not possible, they may be arranged in a suitable locker on deck.

6.2.2 Rooms assigned to large batteries are to be provided with mechanical exhaust ventilation.

Natural ventilation may be employed for boxes located on open deck.

6.2.3 The provisions of [6.2.1] and [6.2.2] also apply to several batteries connected to charging devices of total power exceeding 2 kW calculated for each one as stated in [6.2.1].

6.3 Moderate vented batteries

6.3.1 Batteries connected to a charging device of power between 0,2 kW and 2 kW calculated as stated in [6.2.1] (hereafter referred to as “moderate batteries”) are to be arranged in the same manner as large batteries or placed in a box or locker in suitable locations such as machinery spaces, storerooms or similar spaces. In machinery spaces and similar well-ventilated compartments, these batteries may be installed without a box or locker provided they are protected from falling objects, dripping water and condensation where necessary.

6.3.2 Rooms, lockers or boxes assigned to moderate batteries are to be provided with natural ventilation or mechanical exhaust ventilation, except for batteries installed without a box or locker (located open) in well-ventilated spaces.

6.3.3 The provisions of [6.3.1] and [6.3.2] also apply to several batteries connected to charging devices of total power between 0,2 kW and 2 kW calculated for each one as stated in [6.2.1].

6.4 Small vented batteries

6.4.1 Batteries connected to a charging device of power less than 0,2 kW calculated as stated in [6.2.1] (hereafter referred to as “small batteries”) are to be arranged in the same manner as moderate or large batteries, or without a box or locker, provided they are protected from falling objects, or in a box in a ventilated area.

6.4.2 Boxes for small batteries may be ventilated only by means of openings near the top to permit escape of gas.

6.5 Valve regulated sealed batteries

6.5.1 The valve regulated sealed batteries are to be installed in ventilated spaces, following conditions indicated in [6.6.3]. Installation of electrical equipment in spaces where valve regulated sealed batteries are located are indicated in Ch 2, Sec 15, [6.1.3].

6.5.2 Valve regulated sealed batteries of power exceeding 4 kW are considered as large vented batteries for their location.

6.5.3 Valve regulated sealed batteries of power less than 4 kW are considered as moderated vented batteries for their location.

6.6 Ventilation

6.6.1 The ventilation of battery compartments is to be independent of ventilation systems for other spaces.

6.6.2 The quantity of air expelled (by natural or forced ventilation) for compartments containing vented type batteries is to be at least equal to:

$Q = 110\, I\, n$

where:

Q : Quantity of air expelled, in litres per hour

I : Maximum current delivered by the charging equipment during gas formation, but not less than one quarter of the maximum obtainable charging current, in amperes

n : Number of cells in series.

6.6.3 The quantity of air expelled (by natural or forced ventilation) for compartments containing valve-regulated sealed batteries is to be at least 25% of that given in [6.6.2].

6.6.4 Ducts are to be made of a corrosion-resisting material or their interior surfaces are to be painted with corrosion-resistant paint.

6.6.5 Adequate air inlets (whether connected to ducts or not) are to be provided near the floor of battery rooms or the bottom of lockers or boxes (except for that of small batteries).

Air inlet may be from the open air or from another space (for example from machinery spaces).

6.6.6 Exhaust ducts of natural ventilation systems are:

a) to be run directly from the top of the compartment to the open air above (they may terminate in the open or in well-ventilated spaces)

b) to terminate not less than 90 cm above the top of the battery compartment

c) to have no part more than 45° from the vertical

d) not to contain appliances (for example for barring flames) which may impede the free passage of air or gas mixtures.

Where natural ventilation is impracticable or insufficient, mechanical exhaust ventilation is to be provided.

6.6.7 In mechanical exhaust ventilation systems:

a) electric motors are to be outside the exhaust ducts and battery compartment and are to be of safe type if installed within 3 m from the exhaust of the ventilation duct

b) fans are to be so constructed and of a material such as to render sparking impossible in the event of the impeller touching the fan casing

c) steel or aluminium impellers are not to be used

d) the system is to be interlocked with the charging device so that the battery cannot be charged without ventilation (trickle charge may be maintained)

e) a temperature sensor is to be located in the battery compartment to monitor the correct behaviour of the battery in cases where the battery element is sensitive to temperature.

6.6.8 For natural ventilation systems for deck boxes:

a) holes for air inlet are to be provided on at least two opposite sides of the box

b) the exhaust duct is to be of ample dimensions

c) the duct is to terminate at least 1,25 m above the box in a goose-neck or mushroom-head or the equivalent

d) the degree of protection is to be in accordance with Ch 2, Sec 3, Tab 3.

Section 12 Installation

1 General

1.1 Protection against injury or damage caused by electrical equipment

1.1.1 All electrical equipment is to be so installed as not to cause injury when handled or touched in the normal manner.

1.1.2 All electrical equipment is to be installed in such a way that live parts cannot be inadvertently touched, unless supplied at a safety voltage.

1.1.3 For protective earthing as a precaution against indirect contact, see Article [2].

1.1.4 Equipment is to be installed so as not to cause, or at least so as to reduce to a minimum, electromagnetic interference.

1.2 Protection against damage to electrical equipment

1.2.1 Electrical equipment is to be so placed that as far as practicable it is not exposed to risk of damage from water, steam, oil or oil vapours.

1.2.2 The air supply for internal ventilation of electrical equipment is to be as clean and dry as practicable; cooling air for internal ventilation is not to be drawn from below the floor plates in engine and/or boiler rooms.

1.2.3 Equipment is to be so mounted that its enclosing arrangements and the functioning of the built-in equipment will not be affected by distortions, vibrations and movements of the unit's structure or by other damage liable to occur.

1.2.4 If electrical fittings, not of aluminium, are attached to aluminium, suitable provision is to be made to prevent galvanic corrosion.

1.3 Accessibility

1.3.1 Equipment is to be so installed that sufficient space is available for inspection and maintenance as required for all its parts (see [6.1.3]).

1.4 Electrical equipment in environmentally controlled spaces

1.4.1 Where electrical equipment is installed within environmentally controlled space the ambient temperature for which the equipment is to be suitable may be reduced from 45°C and maintained at a value not less than 35°C provided:

a) the equipment is not for use for emergency services and is located outside of the machinery space(s)

b) temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, for any reason, the remaining unit(s) is capable of satisfactorily maintaining the design temperature

c) the equipment is able to be initially set to work safety within a 45°C ambient temperature until such a time that the lesser ambient temperature may be achieved; the cooling equipment is to be rated for a 45°C ambient temperature

d) audible and visual alarms are provided, at a continually manned control station, to indicate any malfunction of the cooling units.

1.4.2 In accepting a lesser ambient temperature than 45°C, it is to be ensured that electrical cables for their entire length are adequately rated for the maximum ambient temperature to which they are exposed along their length.

2 Earthing of non-current carrying parts

2.1 Parts which are to be earthed

2.1.1 Exposed metal parts of both fixed and portable electrical machines or equipment which are not intended to be live but which are liable under fault conditions to become live and similar metal parts inside non-metallic enclosures are to be earthed unless the machines or equipment are:

a) supplied at a voltage not exceeding 50 V direct current or 50 V, root mean square between conductors, achieved without the use of auto-transformers (safety voltage); or

b) supplied at a voltage not exceeding 250 V by safety isolating transformers supplying one consuming device only; or

c) constructed in accordance with the principle of double insulation.

2.1.2 To minimise shock from high frequency voltage induced by the radio transmitter, handles, handrails and other metal elements on the bridge or upper decks are to be in electrical connection with the hull or superstructures.

2.2 Methods of earthing

2.2.1 Metal frames or enclosures of apparatus and electrical machinery may be fixed to, and in metallic contact with, the unit's structure, provided that the surfaces in contact are clean and free from rust, scale or paint when installed and are firmly bolted together.

2.2.2 For metal frames or enclosures which are not earthed as specified in [2.2.1], earthing connections complying with [2.3] and [2.4] are to be used.

2.2.3 For requirements regarding the earthing of coverings of cables and the mechanical protection of cables, see [7.11] and [7.12].

2.3 Earthing connections

2.3.1 Every earthing connection is to be of copper or other corrosion-resistant material and is to be securely installed and protected, where necessary, against damage and electrolytic corrosion.

2.3.2 The nominal cross-sectional area of each copper earthing connection is to be not less than that required in Tab 1.

Earthing connections of other metals are to have conductance at least equal to that specified for a copper earthing connection.

2.3.3 Metal parts of portable appliances are to be earthed, where required (see [2.1.1]), by means of an earth-continuity conductor in the flexible supply cable or cord, which has the cross-sectional area specified in Tab 1 and which is earthed, for example, through the associated plug and socket.

2.3.4 In no circumstances is the lead sheathing or armour of cables to be relied upon as the sole means of earthing.

2.4 Connection to the unit's structure

2.4.1 Every connection of an earth-continuity conductor or earthing lead to the unit's structure is to be secured by means of a screw of brass or other corrosion-resistant material of diameter not less than 6 mm.

2.4.2 Such earthing connection is not to be used for other purposes.

2.4.3 The connection described in [2.4.1] is to be located in an accessible position where it may readily be checked.

2.5 Earthed distribution systems

2.5.1 The system earthing of earthed distribution systems is to be effected by means independent of any earthing arrangements of non-current carrying parts and is to be connected to the hull at one point only.

2.5.2 In an earthed distribution system in which the earthing connection does not normally carry current, this connection is to conform with the requirements of [2.3], except that the lower limit of 70 mm^2 (see Tab 1) does not apply.

2.5.3 In a distribution system with hull return, the system earthing connection is to have at least the same cross-sectional area as the feeder lines.

2.5.4 The earthing connection is to be in an accessible position where it may readily be inspected and disconnected for insulation testing.

2.6 Aluminium superstructures

2.6.1 When aluminium superstructures are insulated from the steel hull to prevent electrolytic corrosion, they are to be secured to the hull by means of a separate bonding connection.

2.6.2 The connections are to be adequately close together and are to have a resistance less than 0,1 Ω.

2.6.3 The connections are to be located where they may readily be inspected.

Table 1 : Cross-sectional area of earth-continuity conductors and earthing connections

<table>
<tr><th colspan="2">Type of earthing connection</th><th>Cross-sectional area of associated current carrying conductor</th><th colspan="2">Minimum cross-sectional area of copper earthing connection</th></tr>
<tr><td>1</td><td>Earth-continuity conductor in flexible cable or flexible cord</td><td>any</td><td colspan="2">Same as current carrying conductor up to and including 16 mm^2 and one half above 16 mm^2 but at least 16 mm^2</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Earth-continuity conductor incorporated in fixed cable</td><td rowspan="3">any</td><td colspan="2">a) for cables having an insulated earth-continuity conductor
• a cross-section equal to the main conductors up to and including 16 mm^2, but minimum 1,5 mm^2
• a cross-section not less than 50% of the cross-section of the main conductor when the latter is more than 16 mm^2, but at least 16 mm^2
b) for cables with a bare earth wire in direct contact with the lead sheath</td></tr>
<tr><td>Cross-section of main conductor (mm^2)</td><td>Earthing connection (mm^2)</td></tr>
<tr><td>1 ÷ 2,5
4 ÷ 6</td><td>1
1,5</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">Separate fixed earthing conductor</td><td>≤ 2,5 mm^2</td><td colspan="2">Same as current carrying conductor subject to minimum of
• 1,5 mm^2 for stranded earthing connection, or
• 2,5 mm^2 for unstranded earthing connection</td></tr>
<tr><td>> 2,5 mm^2 but ≤ 120 mm^2</td><td colspan="2">One half the cross-sectional area of the current carrying conductor, subjected to a minimum of 4 mm^2</td></tr>
<tr><td>> 120 mm^2</td><td colspan="2">70 mm^2</td></tr>
</table>

3 Rotating machines

3.1

3.1.1 Every rotating machine is preferably to be installed with the shaft in the fore-and-aft direction. Where a rotating machine of 100 kW and over is installed athwartship, or vertically, it is to be ensured that the design of the bearings and the arrangements for lubrication are satisfactory to withstand the rolling specified in Ch 1, Sec 1, [2.6].

4 Semiconductor converters

4.1 Semiconductor power converters

4.1.1 Naturally air-cooled semiconductor converters are to be installed such that the circulation of air to and from the stacks or enclosures is not impeded and that the temperature of the cooling inlet air to converter stacks does not exceed the ambient temperature for which the stacks are specified.

5 Vented type storage batteries

5.1 General

5.1.1 Batteries are to be arranged so that each cell or crate of cells is accessible from the top and at least one side to permit replacement and periodical maintenance.

5.1.2 Cells or crates are to be carried on insulating supports of material non-absorbent to the electrolyte (e.g. treated wood).

5.1.3 Cells are to be securely chocked by means of insulating material non-absorbent to the electrolyte, e.g. strips of treated wood. Special mechanical precautions are to be taken to prevent the emergency battery from being damaged by the shock due to a collision.

5.1.4 Provision is to be made for the free circulation of air.

5.2 Protection against corrosion

5.2.1 The interior of battery compartments (rooms, lockers, boxes) including all metal parts subject to the electrolyte is to be protected against the deteriorating effect of the latter by electrolyte-resistant coating or other equivalent means, unless corrosion-resistant materials are used.

5.2.2 Interior surfaces of metal shelves for battery cells, whether or not grouped in crates or trays, are to be protected by a lining of electrolyte-resistant material, watertight and carried up to at least 75 mm on all sides. In particular, linings are to have a minimum thickness of 1,5 mm, if of lead sheet for lead-acid batteries, and of 0,8 mm, if of steel for alkaline batteries.

Alternatively, the floor of the room or locker is to be lined as specified above to a height of at least 150 mm.

5.2.3 Battery boxes are to be lined in accordance with [5.2.2] to a height of at least 75 mm.

6 Switchgear and controlgear assemblies

6.1 Main switchboard

6.1.1 The main switchboard is to be so arranged as to give easy access as may be needed to apparatus and equipment, without danger to personnel.

6.1.2 An unobstructed space is to be left in front of the switchboard wide enough to allow access for operation; such width is generally about 1 metre.

When withdrawable equipment is contained in the switchboard, the width of the space is to be not less than 0,5 m when the equipment is fully withdrawn.

Reduced widths may be considered for small units.

6.1.3 Where necessary, an unobstructed space is to be provided at the rear of the switchboard ample to permit maintenance; in general, the width of this passage is to be not less than 0,6 m, except that this may be reduced to 0,5 m in way of stiffeners and frames, and the height sufficient for the operation foreseen.

6.1.4 Where the switchboard is open at the rear, the rear space in [6.1.3] is to form a locked space provided at each end with an access door. The required IP protection for the corresponding location is to be fulfilled.

6.1.5 If necessary, the clear height above the switchboard specified by the manufacturer is to be maintained for pressure relief in the event of a short-circuit.

6.1.6 When the voltage exceeds the safety voltage, non-conducting mats or gratings are to be provided at the front and rear of the switchboard as necessary.

If an assembly contains withdrawable equipment, the insulating mat or grating is to be provided in front of and on both sides of the equipment in its fully withdrawn position.

This requirement does not apply when the floor is made of an insulating layer.

6.1.7 Piping and conduits are not to be installed directly above or in the vicinity of switchboards.

Where this is unavoidable, pipes and conduits are to have welded joints only or to be provided with protection against spray from steam or pressurised liquids or dripping.

6.2 Emergency switchboard

6.2.1 For the installation of the emergency switchboard, the same requirements apply as given in [6.1] for the installation of the main switchboard.

6.3 Section boards and distribution boards

6.3.1 For the installation of section and distribution boards, the same requirements apply, as far as applicable, as given in [6.1] for the installation of the main switchboard.

Note 1: Removable mats for use only during repair and maintenance may be considered to satisfy [6.1.6].

6.3.2 In accommodation spaces, where open type assemblies are surrounded by combustible material, a fire barrier of incombustible material is to be provided.

7 Cables

7.1 General

7.1.1 Cables having insulating materials with different maximum permissible conductor temperatures are not to be bunched together.

Where this is not practicable, the cables are to be so installed that no cable reaches a temperature higher than its rating.

7.1.2 Cables having a protective covering which may damage the covering of more vulnerable cables are not to be bunched with the latter.

7.1.3 Cables having a bare metallic sheath (e.g. of copper) or braid or armour are to be installed in such a way that galvanic corrosion by contact with other metals is prevented.

7.1.4 All cables and wiring external to equipment are to be so installed as not to impair their original flame-retarding properties.

To this end, the following methods may be used:

a) the use of cables which have been tested in accordance with IEC 60332-3-22 Category A or an equivalent test procedure for cables installed in bunches, or

b) the use of fire stops having at least B0 penetrations fitted as follows (see Fig 1, Fig 2, Fig 3 and Fig 4):
  - cable entries at the main and emergency switchboard
  - where cables enter engine control rooms
  - cable entries at centralised control panels for propulsion machinery and essential auxiliaries
  - at each end of totally enclosed cable trunks
  - at every second deck or approximately 6 metres for verticals runs and every 14 metres for horizontal runs in enclosed and semi-enclosed spaces
  - at the boundaries of the spaces in cargo areas.

c) the use of fire protection coating applied to at least 1 metre in every 14 metres on horizontal cable runs and over the entire length of vertical cable runs for cables installed in enclosed and semi-enclosed spaces.

The cable penetrations are to be installed in steel plates of at least 3 mm thickness extending all around to twice the largest dimension of the cable run for vertical runs and once for horizontal runs, but need not extend through ceilings, decks, bulkheads or solid sides of trunks. These precautions apply in particular to bunches of 5 or more cables in areas with a high fire risk (such as Category A machinery spaces, galleys etc.) and to bunches of more than 10 cables in other areas.

7.1.5 Cables for high voltage, low voltage, control and instrumentation are not to be installed on the same cable ladders or trays. Where insufficient space makes this impossible, cables for low voltage, control and instrumentation may be installed on the same tray, but not in the same cable bunch.

7.2 Radius of bend

7.2.1 The internal radius of bend for the installation of cables is to be chosen according to the type of cable as recommended by the manufacturer.

Its value is generally to be not less than the values given in Tab 2.

7.2.2 Where the installation of cables across expansion joints is unavoidable, the minimum internal radius of the loop at the end of the travel of the expansion joint is to be not less than 12 times the external diameter of the cable.

Table 2 : Bending radii

Cable construction		Overall diameter of cable (D)	Minimum internal radius of bend
Insulation	Outer covering		
Thermoplastic or thermosetting with circular copper conductors	Unarmoured or unbraided	≤ 25 mm	4 D
		> 25 mm	6 D
	Metal braid screened or armoured	any	6 D
	Metal wire armoured Metal tape armoured or metal-sheathed	any	6 D
	Composite polyester/metal laminate tape screened units or collective tape screening	any	8 D
Thermoplastic or thermosetting with shaped copper conductors	any	any	8 D

Figure 1 : Totally enclosed trunks

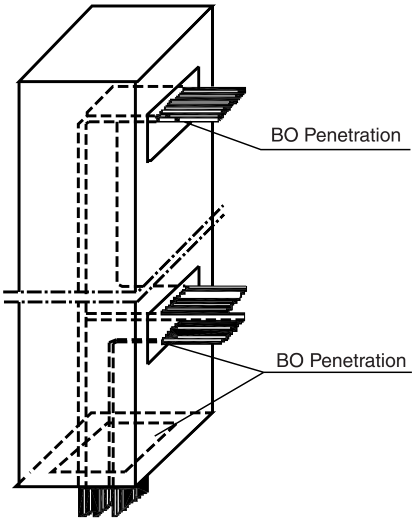


Figure 2 : Non-totally enclosed trunks, vertical

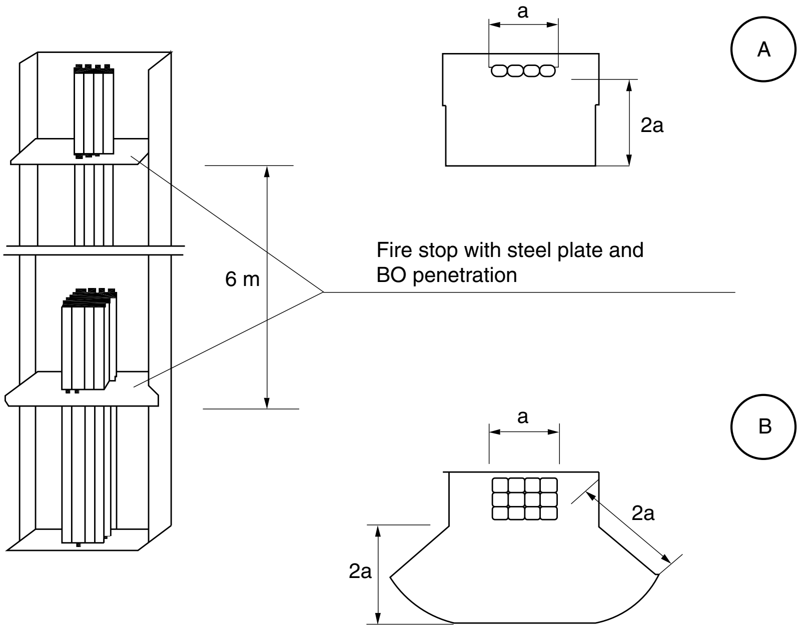


Figure 3 : Non-totally enclosed trunks, horizontal

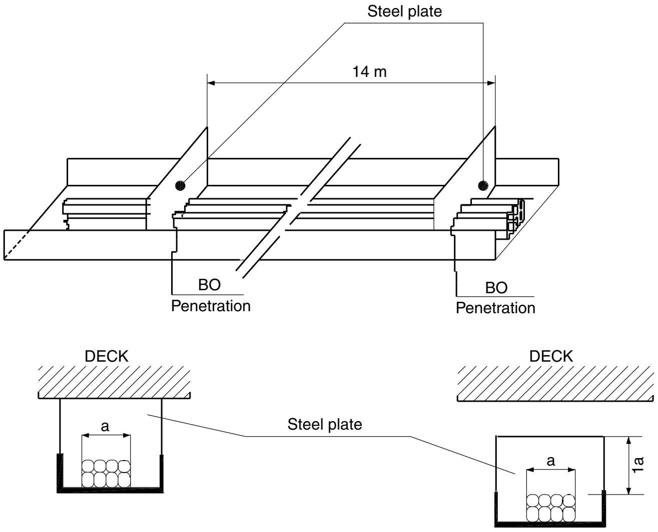
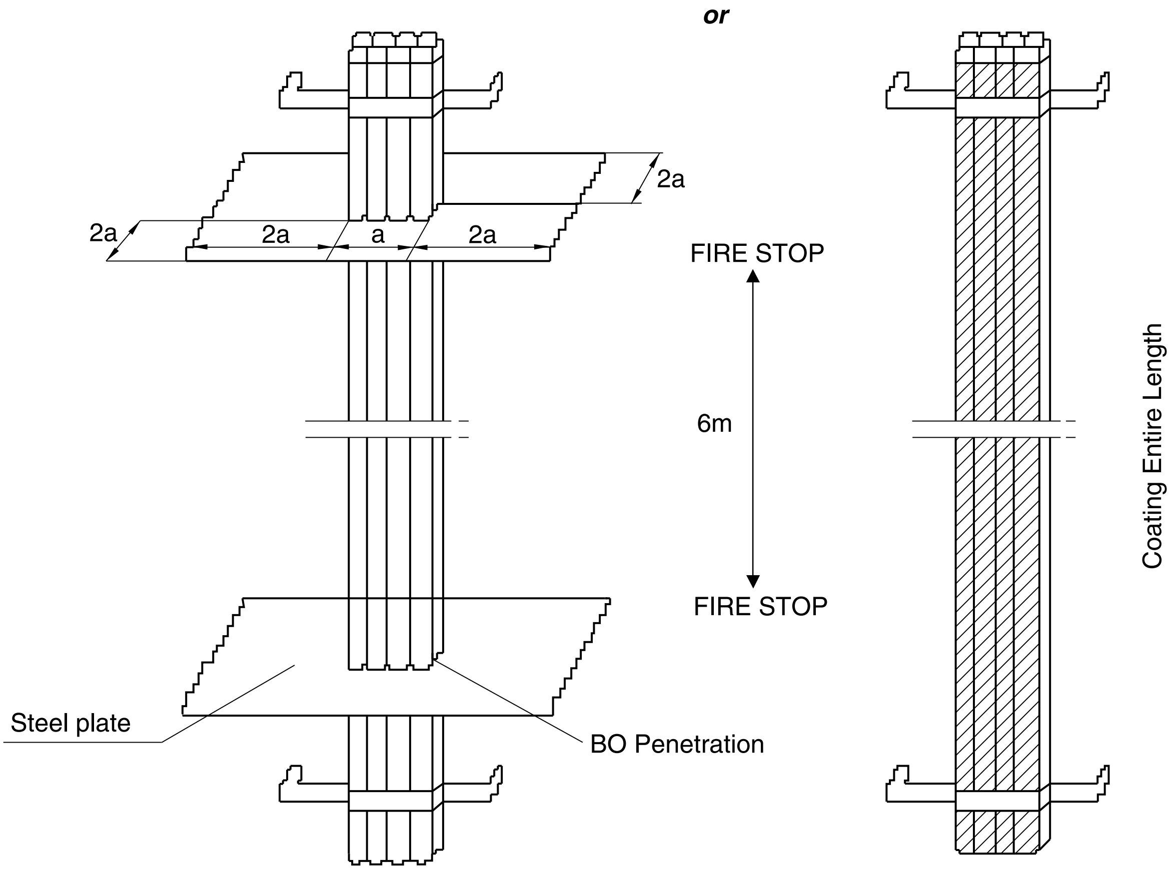
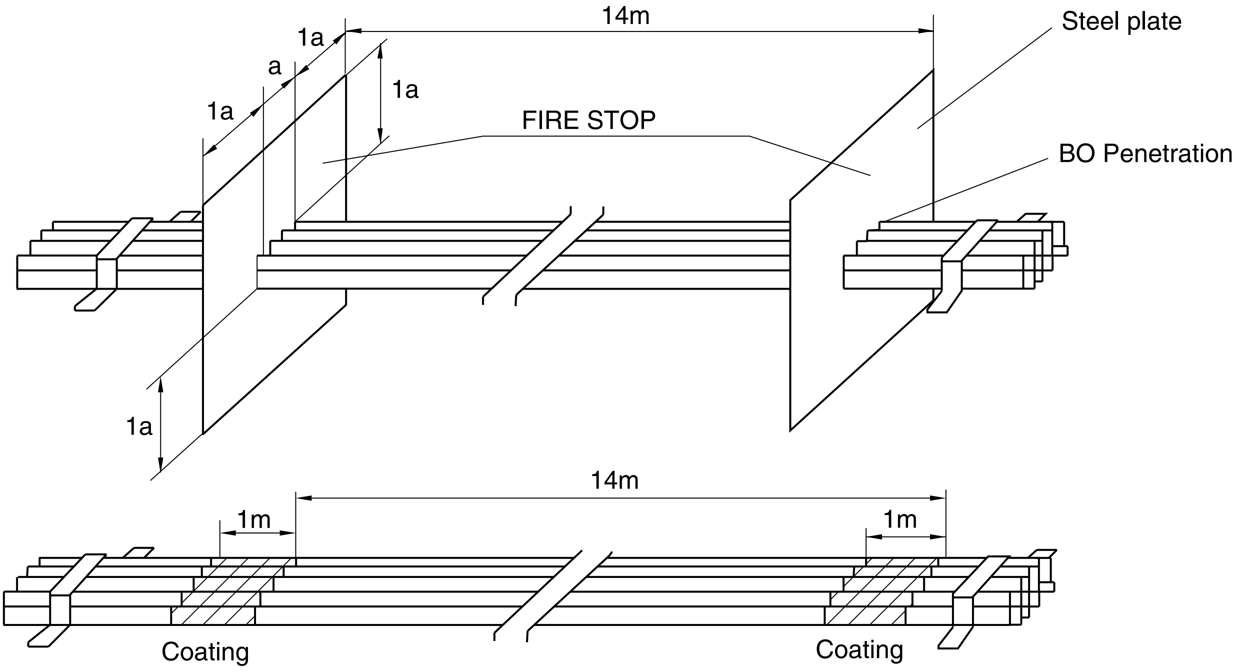


Figure 4 : Open cables runs

Vertical



Horizontal



7.3 Fixing of cables

7.3.1 Cables shall be installed and supported in such a manner as to avoid chafing or other damage.

7.3.2 The supports (tray plates, separate support brackets or hanger ladders) and the corresponding accessories are to be of robust construction and of corrosion-resistant material or suitably treated before erection to resist corrosion.

When cables are installed directly on aluminium structures, fixing devices of aluminium or suitably treated steel are to be used.

For mineral-insulated cables with copper sheath, fixing devices in contact with the sheath are to be of copper alloy.

7.3.3 With the exception of cables installed in pipes, conduits, trunkings or special casings, cables are to be fixed by means of clips, saddles or straps of suitable material, in order to tighten the cables without their coverings being damaged.

7.3.4 Cable clips or straps made from a material other than metal are to be manufactured of a flame-retardant material.

7.3.5 The distances between fastenings and between supports are to be suitably chosen according to the type and number of cables and the probability of vibration.

7.3.6 When cables are fixed by means of clips or straps made from a material other than metal and these cables are not laid on top of horizontal cable supports (e.g. in the case of vertical installation), suitable metal clips or saddles spaced not more than 1 metre apart are to be used in addition in order to prevent the release of cables during a fire.

7.3.7 Suspended cables of fire-resisting type are to be fixed by means of steel straps spaced not more than 500 mm apart.

7.4 Mechanical protection

7.4.1 Cables exposed to risk of mechanical damage are to be protected by metal casing, profiles or grids or enclosed in metal pipes or conduits, unless the cable covering (e.g. armour or sheath) provides adequate mechanical protection.

7.4.2 In situations where there would be an exceptional risk of mechanical damage, e.g. in holds, storage spaces, cargo spaces, etc., cables are to be protected by metal casing, trunkings or conduits, even when armoured, if the unit’s structure or attached parts do not afford sufficient protection for the cables.

7.4.3 For the protection of cables passing through decks, see [7.5.3].

7.4.4 Metal casing used for mechanical protection of cables is to be effectively protected against corrosion.

7.5 Penetrations of bulkheads and decks

7.5.1 If cables have to pass without adequate support through non-watertight bulkheads and generally through holes drilled in sheets of structural steel, these holes are to be fitted with glands or bushings of suitable material.

7.5.2 If cables have to pass through a watertight bulkhead or deck, the penetration is to be effected in a watertight manner.

Either suitable individual watertight glands for single cables or boxes containing several cables and filled with a flame-retardant packing may be used for this purpose.

Whichever type of penetration is used, the watertight integrity of the bulkheads or deck is to be maintained.

7.5.3 Cables passing through decks and continuing vertically are to be protected against mechanical damage to a height of about 200 mm above the deck.

7.5.4 Where cables pass through bulkheads or decks separating areas with a risk of explosion, arrangements are to be such that hazardous gas or dust cannot penetrate through openings for the passage of cables into other areas.

7.5.5 Where cables pass through a bulkhead or deck which is required to have some degree of fire integrity, penetration is to be so effected as to ensure that the required degree of fire integrity is not impaired.

7.6 Expansion joints

7.6.1 If there is reason to fear that a tray plate, pipe or conduit may break because of the motion of the unit, different load conditions and temperature variations, appropriate expansion joints are to be provided.

This may apply in particular in the case of cable runs on the weather deck.

7.7 Cables in closed pipes or conduits

7.7.1 Closed pipes or conduits are to have such internal dimensions and radius of bend as will permit the easy drawing in and out of the cables which they are to contain; the internal radius of bend is to be not less than that permitted for cables and, for pipes exceeding 63 mm external diameter, not less than twice the external diameter of the pipe where this value is greater.

7.7.2 Closed pipes and conduits are to be suitably smooth on the interior and are to have their ends shaped or bushed in such a way as not to damage the cable covering.

7.7.3 The space factor (ratio of the sum of the cross-sectional areas corresponding to the external diameters of the cables to the internal cross-sectional areas of the pipe or conduit) is to be not greater than 0,4.

7.7.4 If necessary, openings are to be provided at the highest and lowest points so as to permit air circulation and ensure that the heat from the cables can be dissipated, and to obviate the possibility of water accumulating at any part of the pipe or conduit.

7.7.5 Vertical trunking for electrical cables is to be so constructed as not to jeopardise the required passive fire protection between the spaces.

7.7.6 Metal pipes or conduits are to be protected against corrosion.

7.7.7 Non-metallic pipes or conduits are to be flame-retardant.

7.8 Cables in casings or trunking and conduits with removable covers

7.8.1 Covers are to be removable and when they are open, cables are to be accessible.

7.8.2 Materials used are to comply with [7.7.6] and [7.7.7].

7.8.3 If the fixing of covers is by means of screws, the latter are to be of non-rusting material and arranged so as not to damage the cables.

7.8.4 Means are to be provided to ensure that the heat from the cables can be dissipated and water accumulation is avoided (see [7.7.4]).

7.9 Cable ends

7.9.1 Terminations in all conductors are to be so made as to retain the original electrical, mechanical, flame-retarding properties of the cable.

7.9.2 Where mechanical clamps are not used, the ends of all conductors having a cross-sectional area greater than 4 mm^2 are to be fitted with soldering sockets or compression-type sockets of sufficient size to contain all the strands of the conductor.

7.9.3 Cables not having a moisture-resistant insulation (e.g. mineral-insulated) are to have their ends effectively sealed against ingress of moisture.

7.10 Joints and tappings (branch circuit)

7.10.1 Cable runs are normally not to include joints. Where absolutely necessary, cable joints are to be carried out by a junction method with rebuilding of the insulation and protective coverings.

7.10.2 Joints in all conductors are to be so made as to retain the original electrical (continuity and isolation), mechanical (strength and protection), flame-retarding and, where necessary, fire-resisting properties of the cable.

7.10.3 Tappings (branch circuits) are to be made via suitable connections or in suitable boxes of such design that the conductors remain adequately insulated and protected from atmospheric action and are fitted with terminals or busbars of dimensions appropriate to the current rating.

7.10.4 Cables for safety voltages are not to terminate in the same connection boxes as cable for higher voltages unless separated by suitable means.

7.11 Earthing and continuity of metal coverings of cables

7.11.1 All metal coverings of cables are to be electrically connected to the metal hull of the unit.

7.11.2 Metal coverings are generally to be earthed at both ends of the cable, except for [7.11.3] and [7.11.4].

7.11.3 Single-point earthing is admitted for final sub-circuits (at the supply end), except for those circuits located in areas with a risk of explosion.

7.11.4 Earthing is to be at one end only in those installations (mineral-insulated cables, intrinsically safe circuits, control circuits (see Ch 3, Sec 5), etc.) where it is required for technical or safety reasons.

7.11.5 Metal coverings of single-core a.c. cables and special d.c. cables with high “ripple” content (e.g. for thyristor equipment) are to be earthed at one point only (e.g. at the mid-point).

7.11.6 The electrical continuity of all metal coverings of cables throughout the length of the latter, particularly at joints and tappings, is to be ensured.

7.11.7 The metal covering of cables may be earthed by means of glands intended for the purpose and so designed as to ensure an effective earth connection.

The glands are to be firmly attached to, and in effective electrical contact with, a metal structure earthed in accordance with these requirements.

7.11.8 The metal covering of cables may also be earthed by means of clamps or clips of corrosion-resistant material making effective contact with the covering and earthed metal.

7.12 Earthing and continuity of metal pipes, conduits and trunking or casings

7.12.1 Metal casings, pipes, conduits and trunking are to be effectively earthed.

7.12.2 Pipes or conduits may be earthed by being screwed into a metal enclosure, or by nuts on both sides of the wall of a metallic enclosure, provided the surfaces in contact are clean and free from rust, scale or paint and that the enclosure is in accordance with these requirements on earthing.

The connection is to be painted immediately after assembly in order to inhibit corrosion.

7.12.3 Pipes and conduits may be earthed by means of clamps or clips of corrosion-resistant metal making effective contact with the earthed metal.

7.12.4 Pipes, conduits or trunking together with connection boxes of metallic material are to be electrically continuous.

7.12.5 All joints in metal pipes and conduits used for earth continuity are to be soundly made and protected, where necessary, against corrosion.

7.12.6 Individual short lengths of pipes or conduits need not be earthed.

7.13 Precautions for single-core cables for a.c.

7.13.1 For the earthing of metal coverings see [7.11.5].

7.13.2 Where it is necessary to use single-core cables for alternating current circuits rated in excess of 20 A, the requirements of [7.13.3] to [7.13.7] are to be complied with.

7.13.3 Conductors belonging to the same circuit are to be contained within the same pipe, conduit or trunking, unless this is of non-magnetic material.

7.13.4 Cable clips are to include cables of all phases of a circuit unless the clips are of non-magnetic material.

7.13.5 In the installation of two, three or four single-core cables forming respectively single-phase circuits, three-phase circuits, or three-phase and neutral circuits, the cables are to be in contact with one another, as far as possible. In any event, the distance between the external covering of two adjacent cables is to be not greater than one diameter.

7.13.6 When single-core cables having a current rating greater than 250 A are installed near a steel bulkhead, the clearance between the cables and the bulkhead is to be at least 50 mm, unless the cables belonging to the same circuit are installed in trefoil twisted formation.

7.13.7 Magnetic material is not to be used between single-core cables of a group. Where cables pass through steel plates, all the conductors of the same circuit are to pass through a plate or gland, so made that there is no magnetic material between the cables, and the clearance between the cables and the magnetic material is to be no less than 75 mm, unless the cables belonging to the same circuit are installed in trefoil twisted formation.

7.14 Cables in refrigerated spaces

7.14.1 For the types of cables permitted in refrigerated spaces, see Ch 2, Sec 3, [11.4].

7.14.2 Power cables installed in refrigerated spaces are not to be covered by thermal insulation. Moreover, such cables are not to be placed directly on the face of the refrigerated space unless they have a thermoplastic or elastomeric extruded sheath.

7.14.3 Power cables entering a refrigerated space are to pass through the walls and thermal insulation at right angles, in tubes sealed at each end and protected against oxidation.

7.15 Cables in areas with a risk of explosion

7.15.1 For the types of cables permitted in areas with a risk of explosion, see Ch 2, Sec 15.

7.15.2 For penetration of bulkheads or decks separating areas with a risk of explosion, see [7.5.4].

7.15.3 Cables of intrinsically safe circuits are to be separated from the cables of all other circuits (minimum 50 mm).

7.16 Cables and apparatus for services required to be operable under fire conditions

7.16.1 Cables and apparatus for services required to be operable under fire conditions including their power supplies are to be so arranged that the loss of these services is minimized due to a localized fire at any one area or zone listed in Ch 2, Sec 1, [4.25].

7.17 Cables in the vicinity of radio equipment

7.17.1 All cables between antennas and transmitters are to be routed separately of any other cable.

7.17.2 Where it is necessary to use single-core cables, the arrangement of conductors is to be such as to avoid complete or partial loops.

7.18 Cable trays/protective casings made of plastics materials

7.18.1 Cable trays or protective casings made of plastics materials (thermoplastic or thermosetting plastic material) are to be type-approved or case-by-case approved.

7.18.2 Cable trays/protective casings are to be supplemented by metallic fixing and straps such that in the event of a fire they, and the cables affixed, are prevented from falling and causing injury to personnel and/or an obstruction to any escape route.

When used on open deck, they are to be protected against U.V. light.

7.18.3 The load on the cable trays/ protective casings is to be within the Safe Working Load (SWL). The support spacing is not to be greater than the manufacturer recommendations nor in excess of spacing at SWL test. In general, the spacing is not to exceed 2 meters.

7.18.4 The selection and spacing of cable tray/protective casing supports are to take into account:
- cable trays/protective casings' dimensions
- mechanical and physical properties of their material
- mass of cable trays/protective casings
- loads due weight of cables, external forces, thrust forces and vibrations
- maximum accelerations to which the system may be subjected
- combination of loads.

7.18.5 The sum of the cables total cross-sectional area, based on the cables external diameter is not to exceed 40% of the protective casing internal cross-sectional area. This does not apply to a single cable in a protective casing.

8 Various appliances

8.1 Lighting fittings

8.1.1 Lighting fittings are to be so arranged as to prevent temperature rises which could damage the cables and wiring.

Note 1: Where the temperature of terminals of lighting fittings exceeds the maximum conductor temperature permitted for the supplied cable (see Ch 2, Sec 3, [11.9]), special installation arrangements, such as terminal boxes thermally insulated from the light source, are to be provided.

8.1.2 Lighting fittings are to be so arranged as to prevent surrounding material from becoming excessively hot.

8.1.3 Lighting fittings are to be secured in place such that they cannot be displaced by the motion of the vessel.

8.1.4 Emergency lights are to be marked for easy identification.

8.2 Heating appliances

8.2.1 Space heaters are to be so installed that clothing, bedding and other flammable material cannot come in contact with them in such a manner as to cause risk of fire.

Note 1: To this end, for example, hooks or other devices for hanging garments are not to be fitted above space heaters or, where appropriate, a perforated plate of incombustible material is to be mounted above each heater, slanted to prevent hanging anything on the heater itself.

8.2.2 Space heaters are to be so installed that there is no risk of excessive heating of the bulkheads or decks on which or next to which they are mounted.

8.2.3 Combustible materials in the vicinity of space heaters are to be protected by suitable incombustible and thermal-insulating materials.

8.3 Heating cables and tapes or other heating elements

8.3.1 Heating cables and tapes or other heating elements are not to be installed in contact with combustible materials.

Where they are installed close to such materials, they are to be separated by means of a non-flammable material.

Section 13 High Voltage Installations

1 General

1.1 Field of application

1.1.1 The following requirements apply to a.c. three-phase systems with nominal voltage exceeding 1 kV, the nominal voltage being the voltage between phases.

If not otherwise stated herein, construction and installation applicable to low voltage equipment stated in Part C, Chapter 2 generally apply to high voltage equipment.

1.2 Nominal system voltage

1.2.1 The nominal system voltage is not to exceed 35 kV. The standardised high voltages for equipment are given in Tab 1.

1.3 High-voltage, low-voltage segregation

1.3.1 Equipment with voltage above about 1 kV is not to be installed in the same enclosure as low voltage equipment, unless segregation or other suitable measures are taken to ensure that access to low voltage equipment is obtained without danger.

Table 1 : AC tree-phase systems having a nominal voltage above 1 kV and not exceeding 35 kV and related equipment

Series I			Series II	
Highest voltage for equipment (kV)	Nominal system voltage (kV)		Highest voltage for equipment (kV)	Nominal system voltage (kV)
3,6	3,3	3,0	4,40	4,16
7,2	6,6	6,0	–	–
12,0	11,0	10,0	–	–
–	–	–	13,20**(1)**	12,47**(1)**
–	–	–	13,97**(1)**	13,20**(1)**
–	–	–	14,52	13,80
(17,5)	–	(15,0)	–	–
24,0	22,0	20,0	–	–
–	–	–	26,40**(1)**	24,94**(1)**
36,0**(2)**	33,0**(2)**	–	–	–
–	–	–	36,50**(1)**	34,50**(1)**
40,5**(2)**	–	35,0**(2)**	–	–

(1) These systems are generally four-wire systems.

(2) The unification of these values is under consideration.

Note 1: It is recommended that in any one country the ratio between two adjacent nominal voltages should be not less than two.

Note 2: In a normal system of Series I, the highest voltage and the lowest voltage do not differ by more than approximately ±10% from the nominal voltage of the system. In a normal system of Series II, the highest voltage does not differ by more than +5% and the lowest voltage by more than ±10% φρομ τηε νομιναλ ϖολταγε οφ τηε σψστεμ.

Note 3: These systems are generally three-wire systems unless otherwise indicated. The values indicated are voltages between phases.

Note 4: The values indicated in parentheses should be considered as non-preferred values. It is recommended that these values should not be used for new systems to be constructed in the future.

2 System design

2.1 Distribution

2.1.1 It is to be possible to split the main switchboard into at least two independent sections, by means of at least one circuit breaker or other suitable disconnecting devices, each supplied by at least one generator. If two separate switchboards are provided and interconnected with cables, a circuit breaker is to be provided at each end of the cable.

Services which are duplicated are to be divided between the sections.

2.1.2 It is to be assured that at least one source neutral to ground connection is available whenever the system is in the energised mode. Electrical equipment in neutral earthed systems is to withstand the current due to a single phase fault against earth for the time necessary to trip the protection device.

2.1.3 Means of disconnection are to be fitted in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance and for insulation resistance measurement.

2.1.4 All earthing impedances are to be connected to the hull. The connection to the hull is to be so arranged that any circulating currents in the earth connections do not interfere with radio, radar, communication and control equipment circuits.

2.1.5 Alternators running in parallel may have a common neutral connection to earth provided they are suitably designed to avoid excessive circulating currents.

This is particularly important if the alternators are of different size and make. Alternators in which the third harmonic content does not exceed 5% may be considered adequate.

Note 1: This would mostly occur with a neutral bus with a single grounding resistor with the associated neutral switching. Where individual resistors are used, circulation of the third harmonic currents between paralleled alternators is minimised.

2.1.6 In systems with earthed neutral, resistors or other current-limiting devices for the connection of the neutrals to the hull are to be provided for each section in which the systems are split [2.1.2].

2.2 Degrees of protection

2.2.1 Each part of the electrical installation is to be provided with a degree of protection appropriate to the location, as a minimum the requirements of IEC Publication 61892-2.

2.2.2 The degree of protection of enclosures of rotating electrical machines is to be at least IP 23.

The degree of protection of terminals is to be at least IP 44.

For motors installed in spaces accessible to unqualified personnel, a degree of protection against approaching or contact with live or moving parts of at least IP 4X is required.

2.2.3 The degree of protection of enclosures of transformers is to be at least IP 23.

For transformers installed in spaces accessible to unqualified personnel, a degree of protection of at least IP 4X is required.

For transformers not contained in enclosures, see [7.1].

2.2.4 The degree of protection of metal enclosed switchgear, controlgear assemblies and static converters is to be at least IP 32. For switchgear, control gear assemblies and static converters installed in spaces accessible to unqualified personnel, a degree of protection of at least IP 4X is required.

2.3 Insulation

2.3.1 In general, for non-type tested equipment phase-to-phase air clearances and phase-to-earth air clearances between non-insulated parts are to be not less than those specified in Tab 2.

Intermediate values may be accepted for nominal voltages, provided that the next higher air clearance is observed.

In the case of smaller distances, an appropriate voltage impulse test is to be applied.

Table 2 : Minimum clearances

Rated voltage (kV)	Minimum clearance (mm)
3,0 - 3,3	55
6,0 - 6,6	90
10,0 - 11,0	120

2.3.2 Creepage distances between live parts and between live parts and earthed metal parts are to be in accordance with IEC 60092-503 for the nominal voltage of the system, the nature of the insulation material and the transient overvoltage developed by switch and fault conditions.

2.4 Neutral earthing system

2.4.1 Directly earthed neutral system is not to be used for high voltage installations.

2.4.2 Earthed neutral systems are admitted provided that the earth fault current is limited to an acceptable level, either by inserting an impedance in the neutral connection to earth or by an earthing transformer.

2.4.3 The earthing impedance is to be designed in order that:

a) the resistive current is higher than the network capacitive current in the event of an earth fault, and

b) the maximum earth fault current is limited to a value that the generators and transformers can withstand for a prolonged time without damage to the core (see Note 1), and

c) the prospective earth fault current is at least three times the values of current required to operate any earth fault protective devices.

Note 1: The maximum earthing current is to be discussed with the equipment manufacturer. In the absence of precise values, the values specified in Tab 3 may be taken for guidance.

Table 3 : Recommended maximum earth fault currents

Rated voltage	Generator	Transformer
6,6 kV	20 A per generator	20 A per transformer
11,0 kV	20 A per generator	20 A per transformer

2.4.4 Efficient means are to be provided for detecting defects in the insulation of the system. For systems where the earth fault current exceeds 5 A, automatic tripping devices are to be provided. Where the earth fault current does not exceed 5 A, an indicator may be provided as an alternative to an automatic tripping.

2.4.5 In insulated earth system, any earth fault in the system is to be indicated by means of a visual and audible alarm.

2.4.6 In installations where outgoing feeders are not disconnected in case of an earth fault, the insulation of the equipment is to be designed for the phase-to-phase voltage.

2.5 Protection

2.5.1 Protective devices are to be provided against phase-to-phase faults in the cables connecting the generators to the main switchboard and against interwinding faults within the generators. The protective devices are to trip the generator circuit breaker and to automatically de-excite the generator.

In distribution systems with a neutral earthed, phase-to-earth faults are also to be treated as above.

2.5.2 Power transformers are to be provided with overload and short circuit protection.

When transformers are connected in parallel, tripping of the protective devices on the primary side is to automatically trip the switch connected on the secondary side.

2.5.3 Voltage transformers are to be provided with overload and short circuit protection on the secondary side.

2.5.4 Fuses are not to be used for overload protection.

2.5.5 Lower voltage systems supplied through transformers from high voltage systems are to be protected against overvoltages. This may be achieved by:

a) direct earthing of the lower voltage system

b) appropriate neutral voltage limiters

c) earthed screen between the primary and secondary windings of transformers.

3 Rotating machinery

3.1 Stator windings of generators

3.1.1 Generator stator windings are to have all phase ends brought out for the installation of the differential protection.

3.2 Temperature detectors

3.2.1 Rotating machinery is to be provided with temperature detectors in its stator windings to actuate a visual and audible alarm in a normally attended position whenever the temperature exceeds the permissible limit.

If embedded temperature detectors are used, means are to be provided to protect the circuit against overvoltage.

3.3 Tests

3.3.1 In addition to the tests normally required for rotating machinery, a high voltage test in accordance with IEC Publication 60034-15 is to be carried out on the individual coils in order to demonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surges.

4 Power transformers

4.1 General

4.1.1 Dry type transformers are to comply with IEC Publication 60076-11.

Liquid cooled transformers are to comply with IEC Publication 60076.

Oil immersed transformers are to be provided with the following alarms and protection:

- liquid level (Low) - alarm
- liquid temperature (High) - alarm
- liquid level (Low) - trip or load reduction
- liquid temperature (High) - trip or load reduction
- gas pressure relay (High) - trip.

5 Cables

5.1 General

5.1.1 Cables are to be constructed in accordance with IEC Publication 60092-353 and 60092-354 or other equivalent Standard.

6 Switchgear and controlgear assemblies

6.1 General

6.1.1 Switchgear and controlgear assemblies are to be constructed in accordance with IEC Publication 62271-200 and the following additional requirements.

6.2 Construction

6.2.1 Switchgear is to be of metal-enclosed type in accordance with IEC Publication 62271-200 or of the insulation-enclosed type in accordance with IEC Publication 62271-201.

6.2.2 Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities in both service and disconnected positions. For maintenance purposes, key locking of withdrawable circuit breakers and switches and fixed disconnectors is to be possible.

Withdrawable circuit breakers are to be located in the service position so that there is no relative motion between fixed and moving portions.

6.2.3 The fixed contacts of withdrawable circuit breakers and switches are to be so arranged that in the withdrawable position the live contacts are automatically covered.

Shutters are to be clearly marked for incoming and outgoing circuits. This may be achieved with the used of colours or labels.

6.2.4 For maintenance purposes an adequate number of earthing and short-circuiting devices is to be provided to enable circuits to be worked on in safety.

6.2.5 Switchgear and controlgear assemblies are to be internal arc classified (IAC).

Where swichgear and controlgear are accessible by authorized personnel only, Accessibility Type A is sufficient (IEC 62271-200 Annex AA 2.2). Accessibility Type B is required if accessible by non-authorised personnel.

Installation and location of the switchgear and controlgear is to correspond with its internal arc classification and classified sides (F, L and R).

6.3 Auxiliary systems

6.3.1 If electrical energy and/or physical energy is required for the operation of circuit-breakers and switches, a store supply of such energy is to be provided for at least two operations of all the components.

However, the tripping due to overload or short-circuit, and under-voltage is to be independent of any stored electrical energy sources. This does not preclude shunt tripping provided that alarms are activated upon lack of continuity in the release circuits and power supply failures.

6.3.2 When external source of supply is necessary for auxiliary circuits, at least two external sources of supply are to be provided and so arranged that a failure or loss of one source will not cause the loss of more than one generator set and/or a main switchboard section as described in [2.1.1] and/or set of essential services.

Where necessary one source of supply is to be from the emergency source of electrical power for the start up from dead ship condition.

6.4 High voltage test

6.4.1 A power-frequency voltage test is to be carried out on any switchgear and controlgear assemblies. The test procedure and voltages are to be according to IEC Publication 62271-200, Section 7, Routine tests.

7 Installation

7.1 Electrical equipment

7.1.1 Where equipment is not contained in an enclosure but a room forms the enclosure of the equipment, the access doors are to be so interlocked that they cannot be opened until the supply is isolated and the equipment earthed down.

At the entrance to spaces where high-voltage electrical equipment is installed, a suitable marking is to be placed indicating danger of high voltage. As regards high-voltage electrical equipment installed outside the aforementioned spaces, similar marking is to be provided.

An adequate, unobstructed working space is to be left in the vicinity of high voltage equipment for preventing potential severe injuries to personnel performing maintenance activities. In addition, the clearance between the switchboard and the ceiling / deckhead above is to be meet the requirements of the Internal Arc Classification according to IEC 62271-200. See [6.2.5].

7.2 Cables

7.2.1 In accommodation spaces, high voltage cables are to be run in enclosed cable transit systems.

7.2.2 High voltage cables are to be segregated from cables operating at different voltage ratings; in particular, they are not to be run in the same cable bunch, in the same ducts or pipes, or in the same box.

Where high voltage cables of different voltage ratings are installed on the same cable tray, the air clearance between cables is not to be less than the minimum air clearance for the higher voltage side in [2.3.1]. However, high voltage cables are not to be installed on the same cable tray for cables operating at the nominal system voltage of 1 kV and less.

7.2.3 High voltage cables are generally to be installed on cable trays when they are provided with a continuous metallic sheath or armour which is effectively bonded to earth; otherwise, they are to be installed for their entire length in metallic castings effectively bonded to earth.

7.2.4 Terminations in all conductors of high voltage cables are, as far as practicable, to be effectively covered with suitable insulating material. In terminal boxes, if conductors are not insulated, phases are to be separated from earth and from each other by substantial barriers of suitable insulating materials.

High voltage cables of the radial field type, i.e. having a conductive layer to control the electric field within the insulation, are to have terminations which provide electric stress control.

Terminations are to be of a type compatible with the insulation and jacket material of the cable and are to be provided with means to ground all metallic shielding components (i.e. tapes, wires, etc.).

7.2.5 High voltage cables are to be readily identifiable by suitable marking.

7.2.6 Before a new high voltage cable installation, or an addition to an existing installation, is put into service, a voltage withstand test is to be satisfactorily carried out on each completed cable and its accessories.

The test is to be carried out after an insulation resistance test.

For cables with rated voltage (Uo/U) above 1,8/3 kV (Um = 3,6 kV) an a.c. voltage withstand test may be carried out upon advice from high voltage cable manufacturer. One of the following test is to be used:

- test for 5 minutes with the phase to phase voltage of the system applied between the conductor and the metallic screen/sheath
- test for 24 hours with the normal operating voltage of the system. Alternatively, a d.c. test voltage equal to 4 Uo may be applied for 15 minutes.

For cables with rated voltage (Uo/U) up to 1,8/3 kV (Um = 3,6 kV) an d.c. voltage equal to 4 Uo is to be applied for 15 minutes.

7.2.7 After completion of the test, the conductors are to be connected to earth for a sufficient period in order to remove any trapped electric charge.

An insulation resistance test is then repeated.

Section 14 Communications, Safeties and Alarms

1 General

1.1

1.1.1 Equipment, systems and installation designed on computer based architectures are to comply with requirements of Ch 3, Sec 3.

2 General emergency alarm system

2.1 General

2.1.1 Each unit is to be provided with a general alarm system so installed as to be clearly perceptible in all parts of the unit, including open decks.

Alarm signal devices are to be provided which will produce a distinctive and strong note.

The signals used should be limited to: general emergency, toxic gas (hydrogen sulphide), combustible gas, fire alarm, and abandon unit signals. These signals should be described in the muster list and operations manual.

Control stations for activating the alarm should be installed to the satisfaction of the Society.

2.1.2 The general alarm is to be capable of being operated at least from the following spaces:

- main control station
- drilling console
- navigating bridge (if any), and
- fire control station (if any).

2.1.3 An electrically operated bell or klaxon or other equivalent warning system installed in addition to the ship's whistle or siren, for sounding the general emergency alarm signal, is to comply with the requirements of this sub-article.

2.1.4 The general emergency alarm system is to be supplemented by either instructions over the public address system complying with the requirements in [3.1] or other suitable means of communication.

2.1.5 Entertainment sound system is to be automatically turned off when the general alarm system is activated.

2.1.6 The system is to be continuously powered and is to have an automatic change-over to a standby power supply in case of loss of normal power supply.

An alarm is to be given in the event of failure of the normal power supply.

2.1.7 The system is to be powered by means of two circuits, one from the unit's main supply and the other from the emergency source of electrical power required by Ch 2, Sec 3, [3.1] and Ch 2, Sec 3, [5.4].

2.1.8 The system is to be capable of operation from the central control room, the navigation bridge (if provided) and, except for the unit's whistle, also from other strategic points.

Note 1: Other strategic points are taken to mean those locations, other than the navigation bridge and/or the central control room, from where emergency situations are intended to be controlled and the general alarm system can be activated. A fire control station or a cargo control station should normally be regarded as strategic points.

2.1.9 The alarm is to continue to function after it has been triggered until it is manually turned off or is temporarily interrupted by a message on the public address system.

2.1.10 The alarm system is to be audible throughout all the accommodation and normal crew working spaces.

2.1.11 The minimum sound pressure level for the emergency alarm tone in interior and exterior spaces is to be 80 dB (A) and at least 10 dB (A) above ambient noise levels occurring during normal equipment operation with the ship underway in moderate weather.

2.1.12 In cabins without a loudspeaker installation, an electronic alarm transducer, e.g. a buzzer or similar, is to be installed.

2.1.13 The sound pressure level at the sleeping position in cabins and in cabin bathrooms is to be at least 75 dB (A) and at least 10 dB (A) above ambient noise levels.

2.1.14 For cables used for the general emergency alarm system, see Ch 2, Sec 3, [11.6].

2.1.15 Areas with a noise level above 85 dB (A) shall also be covered with visual indication of the announcement.

3 Public address system

3.1 General

3.1.1 A public address system is to be provided supplementing general alarm system.

The public address system is to have the priority on the general alarm system.

3.1.2 The public address system is to be a loudspeaker installation enabling the broadcast of messages into all spaces where personnel are normally present and muster stations.

3.1.3 The system is to allow for the broadcast of messages from the following locations (if provided): navigation bridge, central control room, emergency response centre, engine control room, ballast control station, jacking control station and drilling console.

3.1.4 The system is to be protected against unauthorised use.

3.1.5 The system is to be installed with regard to acoustically marginal conditions and not require any action from the addressee.

3.1.6 The minimum sound pressure levels for broadcasting emergency announcements are to be:

a) in interior spaces: 75 dB (A) and at least 20 dB (A) above the speech interference level

b) in exterior spaces: 80 dB (A) and at least 15 dB (A) above the speech interference level.

With respect to cabin/state rooms, the sound pressure level is to be attained as required inside such spaces during sea trials.

3.1.7 Audible alarm signals shall not exceed 120 dB (A).

3.1.8 In spaces such as under deck passageways, bosun’s locker, hospital and pump rooms, the public address system is/may not be required.

3.1.9 Where the public address system is used to supplement the general emergency alarm system as per [2.1.4], it is to be continuously powered from the emergency source of electrical power required by Ch 2, Sec 3, [3.1] and Ch 2, Sec 3, [5.4].

3.1.10 Where an individual loudspeaker has a device for local silencing, an override arrangement from the control station(s), including the navigating bridge, is to be in place.

4 Combined general emergency alarm-public address system

4.1 General

4.1.1 Where the public address system is the only means for sounding the general emergency alarm signal and the fire alarm, in addition to the requirements of [2.1] and [3.1], the following are to be satisfied:

- the system automatically overrides any other non emergency input system when an emergency alarm is required
- the system automatically overrides any volume control provided to give the required output for the emergency mode when an emergency alarm is required
- the system is arranged to prevent feedback or other interference
- the system is arranged to minimise the effect of a single failure so that the alarm signal is still audible (above ambient noise levels) also in the case of failure of any one circuit or component, by means of the use of:
  - multiple amplifiers
  - segregated cable routes to public rooms, alleyways, stairways and control stations
  - more than one device for generating electronic sound signal
  - electrical protection for individual loudspeakers against short-circuits.

5 Fire alarm and gas detection systems

5.1 Fire alarm system

5.1.1 Fire alarm system, equipment and power supplies are defined in Ch 4, Sec 5, [3].

5.2 Gas detection system

5.2.1 Gas detection system requirements are defined in Ch 4, Sec 5, [4].

6 Internal communications

6.1 General

6.1.1 All types of units are to be fitted with efficient means of communication between the central control room, the navigation bridge (if provided) and all spaces where action may be necessary in case of emergency.

6.1.2 An engineers' alarm is to be provided to be operated from the engine control room or at the manoeuvring platform, as appropriate, and clearly audible in the engineers' accommodation. Alternative means, such as internal communication system may be accepted, at the satisfaction of the Society.

7 Helicopter communications

7.1 General

7.1.1 In order to ensure communication with helicopters, units serviced by helicopters should carry an aeromobile VHF radiotelephone station complying with the relevant requirements of ICAO.

Section 15 Specific Requirements for Electrical Installations in Hazardous Areas

1 Application

1.1 General

1.1.1 The present Section is applicable to electrical systems of units and installations including hazardous areas, as defined by the Society's Rules for Classification applicable to the unit or installation considered, in addition to other applicable requirements of the present Rules.

1.1.2 Where reference is made to “certified safe type equipment”, it means electrical equipment for which satisfactory guarantees are furnished to the appropriate authorities concerning the safety of its operation in the flammable atmosphere(s) concerned.

Such guarantees shall be supplied in the form of test certificates, certificates of conformity or equivalent documentation issued by independent and competent authority and established on a basis at least equivalent to that IEC 60079 series publications.

1.2 References to other regulations and standards

1.2.1 The Society may refer to other regulations and standards when deemed necessary. These include the IEC publications, notably the IEC 61892-7 and IEC 60079.

2 Electrical systems

2.1 General

2.1.1 Electrical equipment and wiring are not to be installed in hazardous areas unless essential for operational purposes or safety enhancement. Where necessary, they are to comply with the requirements specified in this Section.

2.1.2 Where electrical equipment is permitted in hazardous areas, all switches and protective devices are to interrupt all poles or phases and, where practicable, to be located in a non-hazardous area unless specifically permitted otherwise.

Such switches and equipment located in hazardous areas are to be suitably labelled for identification purposes.

2.2 Distribution systems and protection

2.2.1 If a power system with directly earthed neutral is used, it is to be of type TN-S with separate neutral and protective conductor. The neutral and the protective conductor are not to be connected together, or combined in a single conductor in a hazardous area.

Power system of type TN-C, having combined neutral and protective functions in a single conductor throughout the system, is not allowed in hazardous areas.

2.2.2 The electrical circuits and apparatus in hazardous areas, except intrinsically safe circuits and apparatus, are to be provided with means to ensure disconnection in the shortest practical time in the event of overload or short-circuit.

2.2.3 The electrical systems located in hazardous areas are to be further protected against earth fault as follows:

a) IT system: alarm or automatic disconnection

b) IT system with impedance earthed neutral: automatic disconnection in the shortest practical time

c) TN-S system: automatic disconnection in the shortest practical time.

2.2.4 For installation in Zone 0, the following precautions are to be considered:

a) earth fault currents in magnitude and duration is to be limited

b) installation is to be disconnected instantaneously in case of the first fault, either by the insulation monitoring device or by a residual current device.

2.2.5 In insulated distribution systems, no current carrying part is to be earthed, other than:

a) through an insulation level monitoring device

b) through components used for the suppression of interference in radio circuits.

3 Emergency conditions

3.1 General

3.1.1 In view of exceptional conditions in which the explosion hazard may extend outside the zones specified in Ch 4, Sec 3, special arrangements are to be provided to facilitate the selective disconnection or shutdown of the:

- ventilation systems
- all electrical equipment outside Zone 1 areas, except where of a certified safe type for Zone 1 applications
- main electrical generator and prime movers
- emergency equipment except those items listed in Ch 2, Sec 3, [3.4.1]
- emergency generators

3.1.2 Disconnection or shutdown is to be possible from at least two strategic locations, one of which is to be outside the hazardous areas.

3.1.3 Shutdown system provided in accordance with [3.1.1] is to be so designed that the risk of unintentional stoppages caused by malfunction in a shutdown system and the risk of inadvertent operation of shutdown are minimized.

3.1.4 Initiation of the foregoing shutdown of facilities will be the operator’s responsibility. The initiated action may vary according to the nature of the emergency. A recommended sequence of shutdowns should be included in the Operating Booklet.

3.1.5 Equipment to remain operational after emergency shutdown

Equipment which is located in spaces other than enclosed spaces and arranged to be operated after complete shutdown as given [3.1.1] is to be suitable for installation in Zone 2 locations. Such equipment, when located in enclosed spaces, is to be suitable for its intended application to the satisfaction of the Society.

The equipment which is to be operable after an emergency shutdown is listed in Ch 2, Sec 3, [3.4.1].

4 Selection of electrical equipment

4.1 General

4.1.1 Electrical equipment installed in hazardous area should satisfied the following requirements:

- to be of a type which will not ignite the mixture concerned
- to be appropriate to the space concerned, and
- to be of an appropriate certified safe type for operation in the vapours or gases likely to be encountered.

4.1.2 Selection of certified safe type equipment is to be made with due consideration given to:

- classification of the hazardous area (see Ch 4, Sec 3, [2])
- temperature class
- explosion group.

Note 1: For some type of protection, for example increased safety, pressurization, oil-immersion and sand-filling, only the area classification and ignition temperature are required.

4.1.3 Flammable gases and vapours are classified in explosion group IIA, IIB or IIC, and in six temperature classes, from T1 to T6, according to the international classification of the International Electrotechnical Commission.

4.1.4 The explosion group and temperature class of electrical equipment of a certified safe type are to be at least IIA and T3.

Note 1: The certification ratings specified by this requirement are valid only for gases emanating from hydrocarbon products.

4.2 Selection according to zones

4.2.1 For electrical equipment installed in Zone 0 hazardous areas, only the following types are permitted:

- certified intrinsically-safe apparatus Ex(ia)
- simple electrical apparatus and components (e.g. thermocouples, photocells, strain gauges, junction boxes, switching devices), included in intrinsically-safe circuits of category “ia” not capable of storing or generating electrical power or energy in excess of limits stated in the relevant Rules
- equipment specifically designed and certified by the appropriate Authority for use in Zone 0.

4.2.2 For electrical equipment installed in Zone 1 hazardous areas, only the following types are permitted:

- any type that may be considered for Zone 0
- certified intrinsically-safe apparatus Ex(ib)
- simple electrical apparatus and components (e.g. thermocouples, photocells, strain gauges, junction boxes, switching devices), included in intrinsically-safe circuits of category "ib" not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules)
- certified flameproof Ex(d)
- certified pressurised Ex(p)
- certified increased safety Ex(e)
- certified encapsulated Ex(m)
- certified sand filled Ex(q)
- certified oil immersion Ex(o)
- through runs of cables.

Note 1: A simple apparatus is a device whose electrical parameters, according to the manufacturer's specification, do not exceed any of the values 1.2 V, 0.1 A, 20 or 25 mW. It is considered intrinsically safe as it is not capable of igniting an explosive atmosphere and does need not to be certified or marked. It is subject however to the requirements of the different parts of IEC 60079 if it is connected to a device which contains a source of energy (mains supply, battery or accumulator) which could cause the circuit to exceed these values.

Note 2: The use of Ex(o) is to be limited for fixed apparatuses and is not to be used for portable apparatuses.

4.2.3 For electrical equipment installed in Zone 2 hazardous areas, only the following types are permitted:

- any type that may be considered for Zone 1
- tested specially for Zone 2 (e.g. type "n" protection)
- the type which ensures the absence of sparks and arcs and of "hot spots" during its normal operation, as specified in IEC61892-7
- special protection Ex(s) (apparatus not conforming with IEC 60079 may be considered safe by a national or other authorised body for use in potentially explosive atmosphere).

4.2.4 Where an apparatus incorporates a number of types of protection, it is to be ensured that all are suitable for use in the zone in which it is located.

5 Installation requirements

5.1 Electrical cables

5.1.1 All cables installed in hazardous areas are to be sheathed with a non-metallic impervious sheath in combination with braiding or other metallic covering for earth fault detection and mechanical protection.

Note 1: Braiding and other metallic covering may be excluded from cables installed in Zone 2.

5.1.2 Cables of intrinsically safe circuits are to have a metallic shielding with at least a non-metallic external impervious sheath.

5.1.3 The circuits of a category "ib" intrinsically safe system are not to be contained in a cable associated with a category "ia" intrinsically safe system required for a hazardous area in which only category "ia" systems are permitted.

5.1.4 Cables of intrinsically safe circuits are to be separated from the cables of all other circuits (minimum 50 mm).

5.1.5 In situations where there is an exceptional risk of mechanical damages, for example in storage cargo landing area, cables are to be protected by steel casing, trunking or conduits, even when armoured, if the unit's structure or attached parts do not afford sufficient protection for cables.

5.1.6 Cable runs in hazardous areas are, where practicable, to be uninterrupted. Where discontinuities cannot be avoided, the joint is to comply with the requirements specified in IEC61892-7.

5.1.7 The connection of cables and conduits to the electrical apparatuses are to be made in accordance with the requirements of the relevant type of protection.

5.1.8 Unused openings for cables or conduits entries in electrical apparatuses are to be closed with blanking elements suitable for the relevant type of protection and certified for the installation in the considered zone.

5.1.9 The hazardous area end of each unused core in multi-core cables is to be either connected to earth or adequately insulated by means of suitable terminations.

5.2 Earthing and bonding

5.2.1 All metallic protective coverings of power and lighting cables passing through a hazardous zone, or connected to apparatus in such zone, are to be earthed at least at their ends. The metallic covering of all other cables is to be earthed at least at one end.

5.2.2 To avoid dangerous sparking between metallic parts of structures, potential equalization is always required for installations in hazardous areas. All exposed and extraneous conductive parts are to be connected to the equipotential bonding system. The bonding system may include protective conductors, conduits, metal cable sheaths, steel wire armouring and metallic parts of structures, but is not to include neutral conductors. Connections are to be secured against self-loosening.

5.2.3 Exposed conductive parts need not be separately connected to the equipotential bonding system if they are firmly secured to and are in metallic contact with structural parts or piping which are connected to the equipotential bonding system. Extraneous conductive parts which are not part of the structure of the electrical installation need not be connected to the equipotential bonding system, if there is no danger of voltage displacement, for example frames of doors or windows.

5.2.4 The hazard of an incentive discharge due to the build-up of static electricity resulting from the flow of liquid/ gases/vapours can be avoided if the resistance between the storage tanks/process plant/piping systems and the structure of the unit or installation is less than 10^6 Ω..

5.2.5 Bonding straps are required for cargo tanks/process plant/piping systems which are not permanently connected to the structure of the unit or installation; this may be omitted where storage tanks/process plant/piping systems are directly or via their supports, either welded or bolted to the structure of the unit or installation.

5.2.6 Bonding straps are to be visible and protected against mechanical damage as far as possible.

5.3 Electromagnetic radiation

5.3.1 The effects of strong electromagnetic radiation are to be considered. Precautions are to be taken to prevent electromagnetic waves radio-frequency transmitters, such as radio and radars, to induce electric currents and voltages in any conductive structure.

The siting of aerials and associated parts is to be selected in relation with the location of any gas and vapour outlets.

Note 1: IEC 60533 and CLC/TR 50426:2004 may be used for guidance.

6 Miscellaneous installations

6.1 Electrical installations in battery rooms

6.1.1 Only intrinsically safe equipment and lighting fittings may be installed in compartments assigned solely to large vented storage batteries; see Ch 2, Sec 11, [6.2].

The associated switches are to be installed outside such spaces.

Electric ventilator motors are to be outside ventilation ducts and, if within 3 m of the exhaust end of the duct, they are to be of an explosion-proof safe type. The impeller of the fan is to be of the non-sparking type.

Overcurrent protective devices are to be installed as close as possible to, but outside of, battery rooms.

Electrical cables other than those pertaining to the equipment arranged in battery rooms are not permitted.

6.1.2 Electrical equipment for use in battery rooms is to have minimum explosion group IIC and temperature class T1.

6.1.3 Standard marine electrical equipment may be installed in compartments assigned solely to valve-regulated sealed storage batteries.

6.2 Electrical installations in paint stores

6.2.1 General

Electrical equipment is to be installed in paint stores and in ventilation ducts serving such spaces only when it is essential for operational services.

Certified safe type equipment of the following type is acceptable:

- certified intrinsically-safe apparatus Ex(i)
- certified flameproof Ex(d)
- certified pressurised Ex(p)
- certified increased safety Ex(e)
- certified specially Ex(s).

Cables (through runs or termination cables) of armoured type or installed in metallic conduits are to be used.

6.2.2 In the areas on open deck within 1 m of inlet and exhaust ventilation openings of paint stores or within 3 m of exhaust mechanical ventilation outlets of such spaces, the following electrical equipment may be installed:

- electrical equipment with the type of protection as permitted in paint stores
- equipment of protection class Ex(n)
- appliances which do not generate arcs in service and whose surface does not reach unacceptably high temperature
- appliances with simplified pressurised enclosures or vapour-proof enclosures (minimum class of protection IP55) whose surface does not reach unacceptably high temperature or
- cables as specified in [6.2.1].

6.2.3 Minimum requirements

The minimum requirements for the certified safe type equipment are as follows:

- explosion group II B
- temperature class T3.

6.2.4 Switches, protective devices and motor control gear of electrical equipment installed in a paint store are to interrupt all poles or phases and are preferably to be located in a non-hazardous space.

6.3 Electrical installations in stores for welding gas (acetylene) bottles

6.3.1 The following equipment may be installed in stores for welding gas bottles provided that it is of a safe type appropriate for Zone 1 area installation:

- lighting fittings
- ventilator motors, where provided.

6.3.2 Electrical cables other than those pertaining to the equipment arranged in stores for welding gas bottles are not permitted.

6.3.3 Electrical equipment for use in stores for welding gas bottles is to have minimum explosion group IIC and temperature class T2.

7 Inspection and maintenance

7.1 Maintenance or modification of safety electrical apparatus

7.1.1 It is reminded that, in pursuance of Rules for Classification, checking, maintaining, or reconditioning of safety apparatus where necessary, are to be carried out at the care of users, in accordance with the requirements of the IEC Publication 60079-17.

7.1.2 Any modification is to be the subject of a new certification by an independent competent institution. It is to be reported with necessary documentation to the Society, in accordance with the requirements of the IEC Publication 60079-17.

Section 16 Propulsion Plant

1 Design requirements

1.1 General

1.1.1 Requirements for propulsion systems of mobile offshore units are given in the Ship Rules, Part C, Chapter 2 and Part C, Chapter 3, as far as electrical installations and control systems of propulsion engines, variable speed pitch propellers and steering gear systems are concerned, regarding the following items:

- main power supply
- emergency conditions: power supply and communications
- local and remote control
- essential services dedicated to propulsion and steering
- electrical propulsion systems.

Section 17 Testing

1 General

1.1 Rule application

1.1.1 Before a new installation, or any alteration or addition to an existing installation, is put into service, the electrical equipment is to be tested in accordance with [3], [4] and [5], to the satisfaction of the Surveyor in charge.

1.2 Insulation-testing instruments

1.2.1 Insulation resistance may be measured with an instrument applying a voltage of at least 500 V. The measurement will be taken when the deviation of the measuring device is stabilised.

Note 1: Any electronic devices present in the installation are to be disconnected prior to the test in order to prevent damage.

1.2.2 For high voltage installation, the measurement is to be taken with an instrument applying a voltage adapted to the rated value and agreed with the Society.

2 Type approved components

2.1

2.1.1 The following components are to be type approved or in accordance with [2.1.2]:

- electrical cables
- transformers
- rotating machines
- electrical converters for primary essential services
- switching devices (circuit-breakers, contactors, disconnectors, etc.) and overcurrent protective devices
- sensors, alarm panels, electronic protective devices, automatic and remote control equipment, actuators, safety devices for installations intended for essential services, electronic speed regulators for auxiliary engines
- computers used for tasks essential to safety
- cable trays or protective casings made of plastics materials (thermoplastic or thermosetting plastic materials)
- all components related to safety functions.

2.1.2 Case by case approval based on submission of adequate documentation and execution of tests may also be granted at the discretion of the Society.

3 Insulation resistance

3.1 Lighting and power circuits

3.1.1 The insulation resistance between all insulated poles (or phases) and earth and, where practicable, between poles (or phases), is to be at least 1 MΩ in ordinary conditions.

The installation may be subdivided to any desired extent and appliances may be disconnected if initial tests give results less than that indicated above.

3.2 Internal communication circuits

3.2.1 Circuits operating at a voltage of 50 V and above are to have an insulation resistance between conductors and between each conductor and earth of at least 1 MΩ.

3.2.2 Circuits operating at voltages below 50 V are to have an insulation resistance between conductors and between each conductor and earth of at least 0,33 MΩ.

3.2.3 If necessary, any or all appliances connected to the circuit may be disconnected while the test is being conducted.

3.3 Switchboards

3.3.1 The insulation resistance between each busbar and earth and between each insulated busbar and the busbar connected to the other poles (or phases) of each main switchboard, emergency switchboard, section board, etc. is to be not less than 1 MΩ.

3.3.2 The test is to be performed before the switchboard is put into service with all circuit-breakers and switches open, all fuse-links for pilot lamps, earth fault-indicating lamps, voltmeters, etc. removed and voltage coils temporarily disconnected where otherwise damage may result.

3.4 Generators and motors

3.4.1 The insulation resistance of generators and motors, in normal working condition and with all parts in place, is to be measured and recorded.

3.4.2 The test is to be carried out with the machine hot immediately after running with normal load.

3.4.3 The insulation resistance of generator and motor connection cables, field windings and starters is to be at least 1 MΩ.

4 Earth

4.1 Electrical constructions

4.1.1 Tests are to be carried out, by visual inspection or by means of a tester, to verify that all earth-continuity conductors and earthing leads are connected to the frames of apparatus and to the hull, and that in socket-outlets having earthing contacts, these are connected to earth.

4.2 Metal-sheathed cables, metal pipes or conduits

4.2.1 Tests are to be performed, by visual inspection or by means of a tester, to verify that the metal coverings of cables and associated metal pipes, conduits, trunking and casings are electrically continuous and effectively earthed.

5 Operational tests

5.1 Generating sets and their protective devices

5.1.1 Generating sets are to be run at full rated load to verify that the following are satisfactory:

- electrical characteristics
- commutation (if any)
- lubrication
- ventilation
- noise and vibration level.

5.1.2 Suitable load variations are to be applied to verify the satisfactory operation under steady state and transient conditions (see Ch 2, Sec 4, [2]) of:

- voltage regulators
- speed governors.

5.1.3 Generating sets intended to operate in parallel are to be tested over a range of loading up to full load to verify that the following are satisfactory:

- parallel operation
- sharing of the active load
- sharing of the reactive load (for a.c. generators).

Synchronising devices are also to be tested.

5.1.4 The satisfactory operation of the following protective devices is to be verified:

- overspeed protection
- overcurrent protection (see Note 1)
- load-shedding devices
- any other safety devices.

For sets intended to operate in parallel, the correct operation of the following is also to be verified:

- reverse-power protection for a.c. installations (or reverse-current protection for d.c. installations)
- minimum voltage protection.

Note 1: Simulated tests may be used to carry out this check where appropriate.

5.1.5 The satisfactory operation of the emergency source of power and of the transitional source of power, when required, is to be tested. In particular, the automatic starting and the automatic connection to the emergency switchboard, in case of failure of the main source of electrical power, are to be tested.

5.2 Switchgear

5.2.1 All switchgear is to be loaded and, when found necessary by the attending Surveyor, the operation of overcurrent protective devices is to be verified (see Note 1).

Note 1: The workshop test is generally considered sufficient to ensure that such apparatus will perform as required while in operation.

5.2.2 Short-circuit tests may also be required at the discretion of the Society in order to verify the selectivity characteristics of the installation.

5.3 Safety systems

5.3.1 Satisfactory operation of all functions of the following safety systems are to be verified:

- fire and gas detection system
- emergency shutdown system
- control and monitoring systems.

5.4 Consuming devices

5.4.1 Electrical equipment is to be operated under normal service conditions (though not necessarily at full load or simultaneously) to verify that it is suitable and satisfactory for its purpose.

5.4.2 Motors and their starters are to be tested under normal operating conditions to verify that the following are satisfactory:

- power
- operating characteristics
- commutation (if any)
- speed
- direction of rotation
- alignment.

5.4.3 The remote stops foreseen are to be tested.

5.4.4 Lighting fittings, heating appliances etc. are to be tested under operating conditions to verify that they are suitable and satisfactory for their purposes (with particular regard to the operation of emergency lighting).

5.5 Communication systems

5.5.1 Communication systems, under the condition stated in Ch 2, Sec 14 are to be tested to verify their suitability.

5.6 Installations in areas with a risk of explosion

5.6.1 Installations and the relevant safety certification are to be examined to ensure that they are of a type permitted in the various areas and that the integrity of the protection concept has not been impaired.

5.7 Voltage drop

5.7.1 Where it is deemed necessary by the attending Surveyor, the voltage drop is to be measured to verify that the permissible limits are not exceeded (see Ch 2, Sec 3, [11.11.4]).

Appendix 1 Indirect Test Method for Synchronous Machines

1 General

1.1 Test method

1.1.1 The machine is to be subject to the three separate running tests specified below (see Fig 1) when it is complete (with covers, heat exchangers, all control devices and sensors), the exciter circuit is connected to its normal supply or to a separate supply having the same characteristics, and the supply is fitted with the necessary measuring instruments:

- Test No. 1: No load test at rated voltage and current on rotor, stator winding in open circuit. The temperature rise of the stator winding depends, in such case, on the magnetic circuit losses and mechanical losses due to ventilation, where:
  - Δts1 is the stator temperature rise
  - Δtr1 is the rotor temperature rise.
- Test No. 2: Rated stator winding current with the terminals short-circuited. The temperature of the stator winding depends on the thermal Joule losses and mechanical losses, as above, where:
  - Δts2 is the stator temperature rise
  - Δtr2 is the rotor temperature rise, which for test No. 2 is negligible.
- Test No. 3: Zero excitation. The temperature of all windings depends on the mechanical losses due to friction and ventilation, where:
  - Δts3 is the stator temperature rise
  - Δtr3 is the rotor temperature rise.

Note 1: The synchronous electric motor is supplied at its rated speed by a driving motor. The temperature balance will be considered as being obtained, when the temperature rise does not vary by more than 2°C per hour.

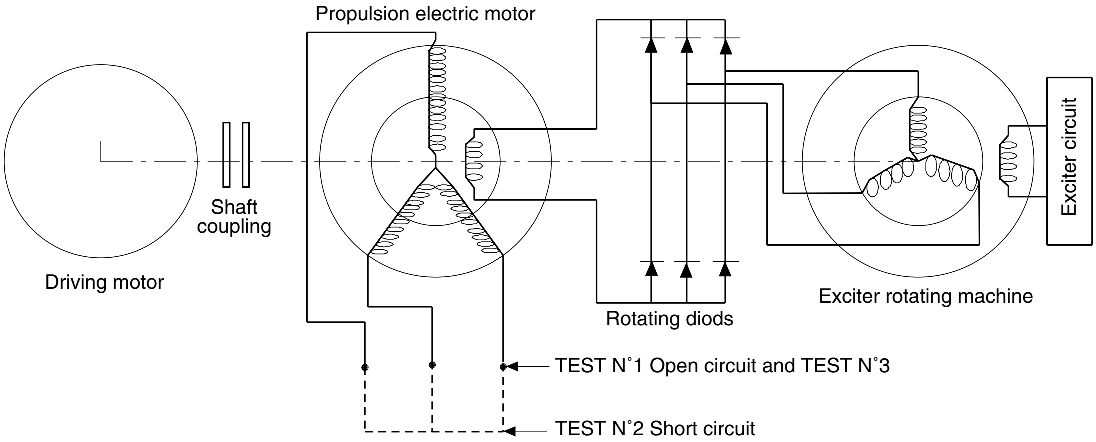
1.1.2 Temperature measurements of the stator winding can be based on the use of embedded temperature sensors or measurement of winding resistance. When using the resistance method for calculation of the temperature rise, the resistance measurement is to be carried out as soon as the machine is shut down.

The rotor temperature rise is obtained by calculation of rotor resistance, Rrotor = U/Ir , where U and I are the voltage and current in the magnetic field winding.

The following parameters are recorded, every 1/2 hour:

- temperature sensors as well as the stator current and voltage
- the main field voltage and current
- the bearing temperatures (embedded sensor or thermometer), and the condition of cooling of the bearings, which are to be compared to those expected on board.

Figure 1 : Schematic diagram used for the test



1.1.3 The tests described above allow the determination of the final temperature rise of stator and rotor windings with an acceptable degree of accuracy.

- The temperature rise of the stator winding is estimated as follows:

  Δt stator = $\Delta ts1 + \Delta ts2 - \Delta ts3$

  Δt stator winding is to be corrected by the supplementary temperature rise due to current harmonics evaluated by the manufacturer
- Considering that in test No. 1 the magnetic field winding current Irt is different from the manufacturer's estimated value Ir (due to the fact that the cos φ in operation is not equal to 1), the temperature rise of the rotor is to be corrected as follows:

  Δt rotor = $(\Delta tr1 - \Delta tr3) \times (\text{rated loading conditions Ir/ test loading conditions Irt})^2 + \Delta tr3$

1.1.4 In the indirect method, a possible mutual influence of the temperature rise between the stator and the rotor is not taken into consideration. The test results may be representative of the temperature rise on board ship, but a margin of 10 to 15°C is advisable compared with the permitted temperature of the Rules and the measure obtained during tests.

Appendix 2 Indirect Test Method for Induction Machines (Static Torque Method)

1 General

1.1 Test method

1.1.1 The induction machine is to be subject to the three separate tests specified in Tab 1 when it is completely assembled (with covers, heat exchangers, all control devices and sensors).

1.1.2 Temperature measurements of the stator winding is based on the use of embedded temperature sensors. The stator temperature taken into account for the temperature rise is the average of all sensors values.

The following parameters are recorded, every 1/2 hour:

- temperature sensors as well as the stator current and voltage
- bearing temperatures (embedded sensor or thermometer), and the condition of cooling of the bearings, which are to be compared to those expected on board.

1.1.3 The tests described in Tab 1 allow the determination of the final temperature rise of stator windings with an acceptable degree of accuracy.

The stator temperature rise Δt_{stator} is the average of embedded temperature sensors values minus cooling element temperature:

$\Delta t_{stator} = \Delta\theta_1 - \Delta\theta_2 + \Delta\theta_3$

where:

$\Delta\theta_1$: Stator temperature rise of Test 1 defined in Tab 1

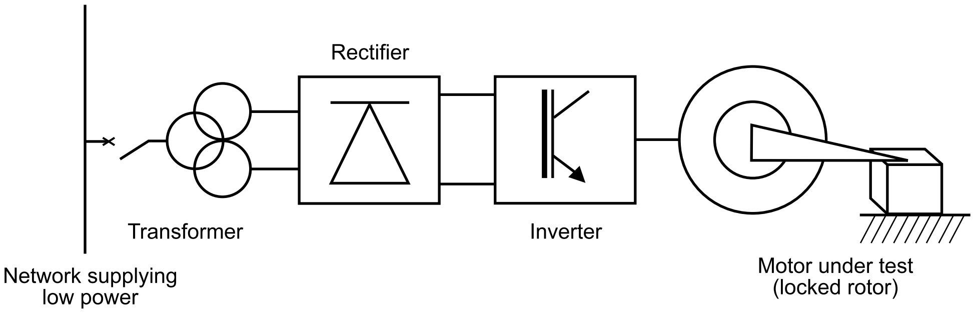
$\Delta\theta_2$: Stator temperature rise of Test 2 defined in Tab 1

$\Delta\theta_3$: Stator temperature rise of Test 3 defined in Tab 1.

Table 1 : Tests for induction machines

Test 1	Test 2	Test 3
Rotor locked (see Fig 1), machine ventilated in normal condition with stator supplied by rated current at reduced voltage and frequency	Rotor running at no-load with stator supplied at the same voltage and frequency as Test 1	Rotor running at no-load at rated speed with stator supplied at rated voltage and rated frequency

Figure 1 : Heating Test 1



CHAPTER 3
CONTROL SYSTEMS AND AUTOMATION

Section 1	General Requirements
Section 2	Design Requirements
Section 3	Computer Based Systems
Section 4	Constructional Requirements
Section 5	Installation Requirements
Section 6	Testing
Section 7	Unattended Machinery Spaces (AUTO)

Section 1 General Requirements

1 General

1.1 Field of application

1.1.1 The following requirements apply to automation systems, installed on all units, intended for essential services as defined in Ch 2, Sec 1. They also apply to systems required in Part C, Chapter 1 and Part C, Chapter 2, installed on all units.

1.1.2 This chapter is intended to avoid that failures or malfunctions of automation systems associated with essential and non-essential services cause danger to other essential services.

1.1.3 Requirements for unattended machinery spaces and for additional notations **AUTO** are specified in Ch 3, Sec 7.

1.2 Regulations and standards

1.2.1 The regulations and standards applicable are those defined in Ch 2, Sec 1.

1.3 Definitions

1.3.1 Unless otherwise stated, the terms used in this Chapter have the definitions laid down in Ch 2, Sec 1 or in the IEC standards. The following definitions also apply:

- Alarm indicator:

  Indicator which gives a visible and/or audible warning upon the appearance of one or more faults to advise the operator that his attention is required.
- Alarm system:

  System intended to give a signal in the event of abnormal running condition.
- Application software:

  Software performing tasks specific to the actual configuration of the computer based system and supported by the basic software.
- Automatic control:

  Control of an operation without direct or indirect human intervention, in response to the occurrence of predetermined conditions.
- Automation systems:

  Systems including control systems and monitoring systems.
- Basic software:

  The minimum software, including firmware and middleware, required to support the application software.
- Cold standby system:

  Duplicated system with a manual commutation or manual replacement of cards which are live and non-operational. The duplicated system is to be able to achieve the operation of the main system with identical performance, and be operational within 10 minutes.
- Computer based system:

  System of one or more computers, associated software, peripherals and interfaces, and the computer network with its protocol.
- Control station:

  Group of control and monitoring devices by means of which an operator can control and verify the performance of equipment.
- Centralized control:

  Control of all operations of a controlled system from one central control position.
- Control system:

  System by which an intentional action is exerted on an apparatus to attain given purposes.
- Data communication links include local area networks, instrument networks and other means which share a communication medium.
- Expert system:

  Intelligent knowledge-based system that is designed to solve a problem with information that has been compiled using some form of human expertise.

- Fail safe:

  Design property of an item in which the specified failure mode is predominantly in a safe direction with regard to the safety of the unit, as a primary concern.
- Full redundant:

  Used to describe an automation system comprising two (identical or non-identical) independent systems which perform the same function and operate simultaneously.
- Hot standby system:

  Used to describe an automation system comprising two (identical or non-identical) independent systems which perform the same function, one of which is in operation while the other is on standby with an automatic change-over switch.
- Instrumentation:

  Sensor or monitoring element.
- Integrated system:

  System consisting of two or more subsystems having independent functions connected by a data transmission network and operated from one or more workstations.
- Local control:

  Control of an operation at a point on or adjacent to the controlled switching device.
- Monitoring system:

  System designed to observe the correct operation of the equipment by detecting incorrect functioning (measure of variables compared with specified value).
- Safety system:

  System intended to limit the consequence of failure and activated automatically when an abnormal condition appears.
- Software:

  Program, procedures and associated documentation pertaining to the operation of the computer system.
- Redundancy:

  Existence of more than one means for performing a required function.
- Remote control:

  Control from a distance of apparatus by means of an electrical or other link.
- Quality plan for software:

  A plan for software lifecycle activities is to be produced which defines relevant procedures, responsibilities and system documentation, including configuration management.
- Inspection of components (only hardware) from sub-suppliers:

  Proof that components and/or sub-assemblies conform to specification.
- Quality control in production:

  Evidence of quality assurance measures on production.
- Final test reports:

  Reports from testing of the finished product and documentation of the test results.
- Traceability of software:

  Modification of program contents and data as well as change of version are to be carried out in accordance with a procedure and are to be documented.
- Software description: Software is to be described, e.g.:
  - description of the basic and communication software installed in each hardware unit
  - description of application software (not program listings)
  - description of functions, performance, constraints and dependencies between modules or other components.
- Hardware description:
  - system block diagram, showing the arrangement, input and output devices and interconnections
  - connection diagrams
  - details of input and output devices
  - details of power supplies.
- Failure analysis for safety related functions only (e.g. FMEA):

  The analysis is to be carried out using appropriate means, e.g.:
  - fault tree analysis
  - risk analysis
  - FMEA or FMECA

  The purpose is to demonstrate that for single failures, systems will fail to safety and that systems in operation will not be lost or degraded beyond acceptable performance criteria when specified by the Society.

1.4 General

1.4.1 The automation systems and components, as indicated in Ch 2, Sec 17, [2], are to be of types approved according to the applicable requirements of these Rules and in particular those stated in this Chapter.

Case-by-case approval may also be granted at the discretion of the Society, based on submission of adequate documentation and subject to the satisfactory outcome of any required tests.

1.4.2 Main and auxiliary machinery essential for the propulsion, control and safety of the unit are to be provided with effective means for its operation and control.

1.4.3 Control, alarm and safety systems are to be based on the fail-to-safety principle.

1.4.4 Failure of automation systems is to generate an alarm.

1.4.5 Detailed indication, alarm and safety requirements regarding automation systems for individual machinery and installations are to be found in Tables located in Part C, Chapter 1 and in Ch 3, Sec 7.

Each row of these tables is to correspond to one independent sensor.

2 Documentation

2.1 General

2.1.1 Before the actual construction is commenced, the Manufacturer, Designer or Shipbuilder is to submit to the Society the documents (plans, diagrams, specifications and calculations) requested in this Section.

2.2 Documents to be submitted

2.2.1 The documents listed in Tab 1 are to be submitted.

2.3 Documents for computer based system

2.3.1 General

For computer based systems, the documents listed in Tab 2 are to be submitted.

2.3.2 System description, computer software

This documentation is to contain:

- a list of all main software modules installed per hardware unit with names and version numbers
- a description of all main software which is to include at least:
  - a description of basic software installed per hardware unit, including communication software, when applicable
  - a description of application software.

Table 1 : Documentation to be submitted

No.	I/A **(1)**	Documentation
1	I	The general specification for the automation of the unit
2	A	The detailed specification of the essential service systems
3	A	The list of components used in the automation circuits, and references (Manufacturer, type, etc.)
4	I	Instruction manuals
5	I	Test procedures for control, alarm and safety systems
6	A	A general diagram showing the monitoring and/or control positions for the various installations, with an indication of the means of access and the means of communication between the positions as well as with the engineers
7	A	The diagrams of the supply circuits of automation systems, identifying the power source
8	A	The list of monitored parameters for alarm/monitoring and safety systems
9	A	Diagram of the engineers' alarm system
(1) A = To be submitted for approval ; I = To be submitted for information.		

Table 2 : Computer based system documentation

No.	I/A **(1)**	Documentation **(2)**
1	I	System description, computer software [2.3.2]
2	A	System description, computer hardware [2.3.3]
3	I	System reliability analysis [2.3.4]
4	I	User interface description [2.3.5]
5	I	Test programs [2.3.6]
6	I	Method of tests and required tests results **(3)**
7	A	For wireless data communication: a) details of manufacturers recommended installation and maintenance practices b) network plan with arrangement and type of antennas and identification of location c) specification of wireless communication system protocols and management functions; see Ch 3, Sec 3, [4.6.3] d) details of radio frequency and power levels e) evidence of type testing in accordance with Ch 3, Sec 6 f) on-board test schedule; see Ch 3, Sec 6, [4].

(1) A = To be submitted for approval ; I = To be submitted for information.
(2) For the evaluation computer based systems of categories II and III.
(3) For systems of category III.

2.3.3 Description of computer hardware

The documentation to be submitted is to include:

- hardware information of importance for the application and a list of documents that apply to the system
- the supply circuit diagram
- a description of hardware and software tools for equipment configuration
- the information to activate the system
- general information for trouble shooting and repair when the system is in operation.

2.3.4 System reliability analysis

The documentation to be submitted is to demonstrate the reliability of the system by means of appropriate analysis such as:

- A failure mode analysis describing the effects due to failures leading to the destruction of the automation system. In addition, this documentation is to show the consequences on other systems, if any. This analysis is appraised in accordance with the IEC Publication 60812, or a recognised standard.
- Test report /life test.
- MTBF calculation.
- Any other documentation demonstrating the reliability of the system.

2.3.5 User interface description

The documentation is to contain:

- a description of the functions allocated to each operator interface (keyboard/screen or equivalent)
- a description of individual screen views (schematics, colour photos, etc.)
- a description of how menus are operated (tree presentation)
- an operator manual providing necessary information for installation and use.

2.3.6 Test programs

The following test programs are to be submitted:

- software module/unit test
- software integration test
- system validation test
- on-board test.

Each test program is to include:

- a description of each test item
- a description of the acceptance criteria for each test.

2.4 Documents for type approval of equipment

2.4.1 Documents to be submitted for type approval of equipment are listed hereafter:

- a request for type approval from the manufacturer or his authorized representative
- the technical specification and drawings depicting the system, its components, characteristics, working principle, installation and conditions of use and, when there is a computer based system, the documents listed in Tab 2
- any test reports previously prepared by specialised laboratories.

2.4.2 Modifications

Modifications are to be documented by the manufacturer. Subsequent significant modifications to the software and hardware for systems of categories II and III are to be submitted for approval.

Note 1: A significant modification is a modification which influences the functionality and/or the safety of the system.

3 Environmental and supply conditions

3.1 General

3.1.1 General

The automation system is to operate correctly when the power supply is within the range specified in Ch 3, Sec 2.

3.1.2 Environmental conditions

The automation system is to be designed to operate satisfactorily in the environment in which it is located. The environmental conditions are described in Ch 2, Sec 2.

3.1.3 Failure behaviour

The automation system is to have non-critical behaviour in the event of power supply failure, faults or restoration of operating condition following a fault. If a redundant power supply is used, it must be taken from an independent source.

3.2 Power supply conditions

3.2.1 Electrical power supply

The conditions of power supply to be considered are defined in Ch 2, Sec 2.

3.2.2 Pneumatic power supply

For pneumatic equipment, the operational characteristics are to be maintained under permanent supply pressure variations of ± 20% of the rated pressure.

Detailed requirements are given in Ch 1, Sec 7.

3.2.3 Hydraulic power supply

For hydraulic equipment, the operational characteristics are to be maintained under permanent supply pressure variations of ± 20% of the rated pressure.

Detailed requirements are given in Ch 1, Sec 7.

4 Materials and construction

4.1 General

4.1.1 The choice of materials and components is to be made according to the environmental and operating conditions in order to maintain the proper function of the equipment.

4.1.2 The design and construction of the automation equipment is to take into account the environmental and operating conditions in order to maintain the proper function of the equipment.

4.2 Type approved components

4.2.1 See Ch 2, Sec 17, [2].

Section 2 Design Requirements

1 General

1.1

1.1.1 All control systems essential for the control and safety of the unit shall be independent or designed such that failure of one system does not degrade the performance of another system.

1.1.2 Controlled systems are to have manual operation.

Failure of any part of such systems shall not prevent the use of the manual override.

1.1.3 Automation systems are to have constant performance.

1.1.4 Safety functions are to be independent of control and monitoring functions.

1.1.5 Control, monitoring and safety systems are to have self-check facilities. In the event of failure, an alarm is to be activated.

In particular, failure of the power supply of the automation system is to generate an alarm.

1.1.6 When a computer based system is used for control, alarm or safety systems, it is to comply with the requirements of Ch 3, Sec 3.

1.1.7 The automatic change-over switch is to operate independently of both systems. When change-over occurs, no stop of the installation is necessary and the latter is not to enter undefined or critical states.

1.1.8 Emergency stops are to be hardwired and independent of any computer based system.

Note 1: Computerized systems may be admitted if evidence is given demonstrating they provide a safety level equivalent to a hardwired system (see Ch 3, Sec 3, [1.7.3]).

2 Power supply of automation systems

2.1 General

2.1.1 Automation systems are to be arranged with an automatic change-over to a continuously available stand-by power supply in case of loss of normal power source.

2.1.2 During changeover from the main source of electrical power to the stand-by source of electrical power, an uninterruptible power supply (UPS) system is to ensure uninterrupted duty for consumers which require continuous power supply, and for consumers which may malfunction upon voltage transients.

2.1.3 The capacity of the stand-by power supply is to be sufficient to allow the normal operation of the automation systems for at least half an hour.

2.1.4 Failure of any power supply to an automation system is to generate an audible and visual alarm.

2.1.5 Power supplies are to be protected against short circuit and overload for each independent automation system.

Power supplies are to be isolated.

3 Control systems

3.1 General

3.1.1 In the case of failure, the control systems used for essential services are to remain in their last position they had before the failure.

3.2 Local control

3.2.1 Each system is to be able to be operated manually from a position located so as to enable visual control of operation. For detailed instrumentation for each system, refer to Part C, Chapter 1 and Part C, Chapter 2.

It shall also be possible to control the auxiliary machinery, essential for the safety of the unit, at or near the machinery concerned.

3.3 Remote control systems

3.3.1 When several control stations are provided, control of machinery is to be possible at one station at a time.

3.3.2 Remote control is to be provided with the necessary instrumentation, in each control station, to allow effective control (correct function of the system, indication of control station in operation, alarm display).

3.3.3 When transferring the control location, no significant alteration of the controlled equipment is to occur. Transfer of control is to be protected by an audible warning and acknowledged by the receiving control location. The main control location is to be able to take control without acknowledgement.

3.4 Automatic control systems

3.4.1 *Automatic starting, operational and control systems shall include provisions for manually overriding the automatic controls.*

3.4.2 Automatic control is to be stable in the range of the controller in normal working conditions.

3.4.3 Automatic control is to have instrumentation to verify the correct function of the system.

4 Remote control of valves

4.1

4.1.1 The following requirements are applicable to valves whose failure could impair essential services.

4.1.2 Failure of the power supply is not to permit a valve to move to an unsafe condition.

4.1.3 An indication is to be provided at the remote control station showing the actual position of the valve or whether the valve is fully open or fully closed.

4.1.4 When valves are remote controlled, a secondary means of operating them is to be provided which may be manual control.

5 Alarm system

5.1 General requirements

5.1.1 Alarms are to be visual and audible and are to be clearly distinguishable, in the ambient noise and lighting in the normal position of the personnel, from any other signals.

5.1.2 Sufficient information is to be provided for proper handling of alarms.

5.1.3 The alarm system is to be of the self-check type; failure within the alarm system, including the outside connection, is to activate an alarm. The alarm circuits are to be independent from each other. All alarm circuits are to be protected so as not to endanger each other.

5.2 Alarm functions

5.2.1 Alarm activation

Alarms are to be activated when abnormal conditions appear in the machinery, which need the intervention of personnel on duty, and on the automatic change-over, when standby machines are installed.

An existing alarm is not to prevent the indication of any further fault.

5.2.2 Acknowledgement of alarm

The acknowledgment of an alarm consists in manually silencing the audible signal and additional visual signals (e.g. rotating light signals) while leaving the visual signal on the active control station. Acknowledged alarms are to be clearly distinguishable from unacknowledged alarms. Acknowledgement should not prevent the audible signal to operate for new alarm.

Alarms shall be maintained until they are accepted and visual indications of individual alarms shall remain until the fault has been corrected, when the alarm system shall automatically reset to the normal operating condition.

Acknowledgement of alarms is only to be possible at the active control station.

Alarms, including the detection of transient faults, are to be maintained until acknowledgement of the visual indication.

Acknowledgement of visual signals is to be separate for each signal or common to a limited group of signals. Acknowledgement is only to be possible when the user has visual information on the alarm condition for the signal or all signals in a group.

5.2.3 Inhibition of alarms

Manual inhibition of separate alarms may be accepted when this is clearly indicated.

Inhibition of alarm and safety functions in certain operating modes (e.g. during start-up or trimming) is to be automatically disabled in other modes.

5.2.4 Time delay of alarms

It is to be possible to delay alarm activation in order to avoid false alarms due to normal transient conditions (e.g. during start-up or trimming).

5.2.5 Transfer of responsibility

Where several alarm control stations located in different spaces are provided, responsibility for alarms is not to be transferred before being acknowledged by the receiving location. Transfer of responsibility is to give an audible warning. At each control station it is to be indicated which location is in charge.

6 Safety system

6.1 Design

6.1.1 System failures

A safety system is to be designed so as to limit the consequence of failures. It is to be constructed on the fail-to-safety principle.

The safety system is to be of the self-check type; as a rule, failure within the safety system, including the outside connection, is to activate an alarm.

6.2 Function

6.2.1 Safety activation

The safety system is to be activated automatically in the event of identified conditions which could lead to damage of associated machinery or systems, such that:

- normal operating conditions are restored (e.g. by the starting of the standby unit), or
- the operation of the machinery is temporarily adjusted to the prevailing abnormal conditions (e.g. by reducing the output of the associated machinery), or
- the machinery is protected, as far as possible, from critical conditions by shutting off the fuel or power supply, thereby stopping the machinery (shutdown), or appropriate shutdown.

6.2.2 Safety indication

When the safety system has been activated, it is to be possible to trace the cause of the safety action. This is to be accomplished by means of a central or local indication.

When a safety system is made inoperative by a manual override, this is to be clearly indicated at corresponding control stations.

Override of safety functions in certain operating modes (e.g. during start-up or trimming) is to be automatically disabled in the other modes.

Automatic safety actions are to activate an alarm at predefined control stations.

6.3 Shutdown

6.3.1 For shutdown systems of machinery, when the system has stopped a machine, the latter is not to be restarted automatically before a manual reset of the safety system has been carried out.

6.4 Standby systems

6.4.1 For the automatic starting system of the standby units, the following requirements are to be applied:

- faults in the electrical or mechanical system of the running machinery are not to prevent the standby machinery from being automatically started
- when a machine is on standby, ready to be automatically started, this is to be clearly indicated at its control position
- the change-over to the standby unit is to be indicated by a visual and audible alarm
- means are to be provided close to the machine, to prevent undesired automatic or remote starting (e.g. when the machine is being repaired)
- automatic starting is to be prevented when conditions are present which could endanger the standby machine.

6.5 Testing

6.5.1 The safety systems are to be tested in accordance with the requirements in Ch 3, Sec 6.

Section 3 Computer Based Systems

1 General requirements

1.1 General

1.1.1 The characteristics of the system are to be compatible with the intended applications, under normal and abnormal process conditions. The response time for alarm function is to be less than 2 seconds.

1.1.2 When systems under control are required to be duplicated and in separate compartments, this is also to apply to control elements within computer based systems.

1.1.3 As a rule, computer based systems intended for essential services are to be type approved.

1.1.4 Programmable electronic systems are to fulfil the requirements of the system under control for all normally anticipated operating conditions, taking into account danger to persons, environmental impact, damage to unit as well as equipment, usability of programmable electronic systems and operability of non-computer-based devices and systems, etc.

1.1.5 When an alternative design or arrangement deviating from these requirements is proposed, an engineering analysis is required to be carried out in accordance with a relevant International or National Standard acceptable to the Society. See also SOLAS Ch II-1/F, Reg. 55.

Note 1: As a failure of a category III system may lead to an accident with catastrophic severity, the use of unconventional technology for such applications is only to be permitted exceptionally in cases where evidence is presented that demonstrates acceptable and reliable system performance to the satisfaction of the Society.

1.2 System type approval

1.2.1 The type approval is to cover the hardware and basic software of the system. The type approval requirements are detailed in Ch 3, Sec 6. A list of the documents to be submitted is provided in Ch 3, Sec 1.

1.3 System operation

1.3.1 The system is to be protected so that authorised personnel only can modify any setting which could alter the system.

1.3.2 Modification of the configuration, set points or parameters is to be possible without complex operations such as compilation or coded data insertion.

1.3.3 Program and data storage of the system is to be designed so as not to be altered by environmental conditions, as defined in Ch 2, Sec 2, [1], or loss of the power supply.

1.4 System reliability

1.4.1 System reliability is to be documented as required in Ch 3, Sec 1, [2.3.4].

1.4.2 When used for alarm, safety or control functions, the hardware system design is to be on the fail safe principle.

1.5 System failure

1.5.1 In the event of failure of part of the system, the remaining system is to be brought to a downgraded operable condition.

1.5.2 A self-monitoring device is to be implemented so as to check the proper function of hardware and software in the system. This is to include a self-check facility of input /output cards, as far as possible.

1.5.3 The failure and restarting of computer based systems should not cause processes to enter undefined or critical states.

1.6 System redundancy

1.6.1 If it is demonstrated that the failure of the system, which includes the computer based system, leads to a disruption of the essential services, a secondary independent means, of appropriate diversity, is to be available to restore the adequate functionality of the service.

1.7 System categories

1.7.1 Programmable electronic systems are to be assigned into three system categories as shown in Tab 1 according to the possible extent of the damage caused by a single failure within the programmable electronic systems.

Consideration is to be given to the extent of the damage directly caused by a failure, but not to any consequential damage.

Identical redundancy is not to be taken into account for the assignment of a system category.

1.7.2 The assignment of a programmable electronic system to the appropriate system category is to be made according to the greatest likely extent of direct damage. For examples, see Tab 2.

Note 1: Where independent effective backup or other means of averting danger is provided, the system category III may be decreased by one category.

1.7.3 For computer-based systems ensuring safety function and which are not backed-up by non-computer-based devices, a risk analysis which demonstrates the appropriate availability and reliability of the system, is to be carried out at the satisfaction of the Society.

Note 1: Guidance for highly reliable hardware and software can be found in IEC 61508 series and IEC 61511.

Table 1 : System categories

Category	Effect	System functionality
I	Those systems, failure of which will not lead to dangerous situations for human safety, safety of the unit and/or threat to the environment	• Monitoring function for informational/administrative tasks
II	Those systems, failure of which could eventually lead to dangerous situations for human safety, safety of the unit and/or threat to the environment	• Alarm and monitoring functions • Control functions which are necessary to maintain the unit in its normal operational and habitable conditions
III	Those systems, failure of which could immediately lead to dangerous situations for human safety, safety of the unit and/or threat to the environment	• Functions for maintaining the safety systems of the unit in normal and emergency conditions

Table 2 : Examples of assignment to system categories

Category	Effect
I	Maintenance support systems Information and diagnostic systems
II	Alarm and monitoring equipment Tank capacity measuring equipment Control systems for auxiliary machinery Fire detection systems Fire extinguishing systems Bilge systems Governors
III	Machinery protection systems / equipment Burner control systems Electronic fuel injection for diesel engines Control systems for essential services Synchronising units for switchboards
Note 1: The examples listed are not exhaustive.	

2 Hardware

2.1 General

2.1.1 The construction of systems is to comply with the requirements of Ch 3, Sec 4.

2.2 Housing

2.2.1 The housing of the system is to be designed to face the environmental conditions, as defined in Ch 2, Sec 2, [1], in which it will be installed. The design will be such as to protect the printed circuit board and associated components from external aggression. When required, the cooling system is to be monitored, and an alarm activated when the normal temperature is exceeded.

2.2.2 The mechanical construction is to be designed to withstand the vibration levels defined in Ch 2, Sec 2, depending on the applicable environmental condition.

3 Software

3.1 General

3.1.1 The basic software is to be developed in consistent and independent modules.

A self-checking function is to be provided to identify failure of software module.

When hardware (e.g. input /output devices, communication links, memory, etc.) is arranged to limit the consequences of failures, the corresponding software is also to be separated in different software modules ensuring the same degree of independence.

3.1.2 Basic software is to be type approved according to Ch 3, Sec 6, [2.3.1].

3.1.3 Application software is to be tested in accordance with Ch 3, Sec 6, [3.4].

3.1.4 Loading of software, when necessary, is to be performed in the aided conversational mode.

3.1.5 Software versions are to be solely identified by number, date or other appropriate means. Modifications are not to be made without also changing the version identifier. A record of changes is to be maintained and made available upon request of the Society.

3.2 Software development quality

3.2.1 Software development is to be carried out according to a quality plan defined by the builder and records are to be kept. The standard ISO 9000-1, or equivalent international standard, is to be taken as guidance for the quality procedure. The quality plan is to include the test procedure for software and the results of tests are to be documented.

4 Data transmission link

4.1 General

4.1.1 These requirements apply to system categories II and III using shared data communication links to transfer data between distributed programmable electronic equipment or systems.

4.1.2 The performance of the network transmission medium (transfer rate and time delay) is to be compatible with the intended application.

4.1.3 When the master /slave configuration is installed, the master terminal is to be indicated on the other terminals.

4.1.4 System self-checking capabilities are to be arranged to initiate transition to the least hazardous state for the complete installation in the event of data communication failure.

4.1.5 The characteristics of the data communication link are to be such as to transmit that all necessary information in adequate time and overloading is prevented.

4.2 Hardware support

4.2.1 Loss of a data communication link is not to affect the ability to operate essential services by alternative means.

4.2.2 The data communication link is to be self-checking, detecting failures on the link itself and data communication failures on nodes connected to the link. Detected failures are to initiate an alarm.

The data communication link is to be automatically started when power is turned on, or restarted after loss of power.

4.2.3 Where a single component failure results in loss of data communication, means are to be provided to automatically restore data communication.

4.2.4 The choice of transmission cable is to be made according to the environmental conditions. Particular attention is to be given to the level characteristics required for electromagnetic interferences.

4.2.5 The installation of transmission cables is to comply with the requirements stated in Ch 2, Sec 11. In addition, the routing of transmission cables is to be chosen so as to be in less exposed zones regarding mechanical, chemical or EMI damage. As far as possible, the routing of each cable is to be independent of any other cable. These cables are not normally allowed to be routed in bunches with other cables on the cable tray.

4.2.6 The coupling devices are to be designed, as far as practicable, so that in the event of a single fault, they do not alter the network function. When a failure occurs, an alarm is to be activated.

Addition of coupling devices is not to alter the network function.

Hardware connecting devices are to be chosen, when possible, in accordance with international standards.

When a computer based system is used with a non-essential system and connected to a network used for essential systems, the coupling device is to be of an approved type.

4.3 Transmission software

4.3.1 The transmission software is to be so designed that alarm or control data have priority over any other data, and overloading is prevented. For control data, the transmission time is not to jeopardise efficiency of the functions.

4.3.2 The transmission protocol is preferably to be chosen among international standards.

4.3.3 A means of transmission control is to be provided and designed so as to verify the completion of the data transmitted (CRC or equivalent acceptable method). When corrupted data is detected, the number of retries is to be limited so as to keep an acceptable global response time. The duration of the message is to be such that it does not block the transmission of other stations.

4.4 Transmission operation

4.4.1 When a hardware or software transmission failure occurs, an alarm is to be activated. A means is to be provided to verify the activity of transmission and its proper function (positive information).

4.5 Redundant network

4.5.1 Where two or more essential functions are using the same network, redundant networks are required according to the conditions mentioned in [1.6.1].

4.5.2 Switching of redundant networks from one to the other is to be achieved without alteration of the performance.

4.5.3 When not in operation, the redundant network is to be permanently monitored, so that any failure of either network may be readily detected. When a failure occurs in one network, an alarm is to be activated.

4.5.4 In redundant networks, the two networks are to be mutually independent. Failure of any common components is not to result in any degradation in performance.

4.5.5 When redundant data communication links are required, they are to be routed separately, as far as practicable.

4.6 Additional requirements for wireless data links

4.6.1 These requirements are in addition to the requirements of [4.1] to [4.4] and apply to system category II using wireless data communication links to transfer data between distributed programmable electronic equipment or systems.

Wireless data communication links are not allowed for systems category III.

4.6.2 Functions that are required to operate continuously to provide essential services dependant on wireless data communication links are to have an alternative means of control that can be brought in action within an acceptable period of time.

4.6.3 Wireless data communication is to employ recognised international wireless communication system protocols that incorporate the following:

a) Message integrity: fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message.

b) Configuration and device authentication: shall only permit connection of devices that are included in the system design.

c) Message encryption: protection of the confidentiality and or criticality the data content.

d) Security management: protection of network assets, prevention of unauthorised access to network assets.

4.6.4 The wireless system is to comply with the radio frequency and power level requirements of International Telecommunications Union and flag state requirements.

Note 1: Consideration should be given to system operation in the event of port state and local regulations that pertain to the use of radio-frequency transmission prohibiting the operation of a wireless data communication link due to frequency and power level restrictions.

4.7 Protection against modifications

4.7.1 Programmable electronic systems of categories II and III are to be protected against program modification by the user.

4.7.2 For systems of category III, modifications of parameters by the manufacturer are to be approved by the Society.

4.7.3 Any modifications made after performance of the tests witnessed by the Society as per item No. 6. of Ch 3, Sec 6, Tab 2 are to be documented and traceable.

5 Man-machine interface

5.1 General

5.1.1 The design of the operator interface is to follow ergonomic principles. The standard IEC 60447 Man-machine interface or equivalent recognised standard may be used.

5.2 System functional indication

5.2.1 A means is to be provided to verify the activity of the system, or subsystem, and its proper function.

5.2.2 A visual and audible alarm is to be activated in the event of malfunction of the system, or subsystem. This alarm is to be such that identification of the failure is simplified.

5.3 Input devices

5.3.1 Input devices are to be positioned such that the operator has a clear view of the related display.

The operation of input devices, when installed, is to be logical and correspond to the direction of action of the controlled equipment.

The user is to be provided with positive confirmation of action.

Control of essential functions is only to be available at one control station at any time. Failing this, conflicting control commands are to be prevented by means of interlocks and /or warnings.

5.3.2 When keys are used for common/important controls, and several functions are assigned to such keys, the active function is to be recognisable.

If use of a key may have unwanted consequences, provision is to be made to prevent an instruction from being executed by a single action (e.g. simultaneous use of two keys, repeated use of a key, etc.).

Means are to be provided to check validity of the manual input data into the system (e.g. checking the number of characters, range value, etc.).

5.3.3 If use of a push button may have unwanted consequences, provision is to be made to prevent an instruction from being executed by a single action (e.g. simultaneous use of two push buttons, repeated use of push buttons, etc.). Alternatively, this push button is to be protected against accidental activation by a suitable cover, or use of a pull button, if applicable.

5.4 Output devices

5.4.1 VDU's (video display units) and other output devices are to be suitably lighted and dimmable when installed in the wheelhouse. The adjustment of brightness and colour of VDU's is to be limited to a minimum discernable level.

When VDU's are used for alarm purposes, the alarm signal, required by the Rules, is to be displayed whatever the other information on the screen. The alarms are to be displayed according to the sequence of occurrence.

When alarms are displayed on a colour VDU, it is to be possible to distinguish alarm in the event of failure of a primary colour.

The position of the VDU is to be such as to be easily readable from the normal position of the personnel on watch. The size of the screen and characters is to be chosen accordingly.

When several control stations are provided in different spaces, an indication of the station in control is to be displayed at each control station. Transfer of control is to be effected smoothly and without interruption to the service.

5.5 Workstations

5.5.1 The number of workstations at control stations is to be sufficient to ensure that all functions may be provided with any one unit out of operation, taking into account any functions which are required to be continuously available.

5.5.2 Multifunction workstations for control and display are to be redundant and interchangeable.

5.5.3 The choice of colour, graphic symbols, etc. is to be consistent in all systems on board.

5.6 Computer dialogue

5.6.1 The computer dialogue is to be as simple and self-explanatory as possible.

The screen content is to be logically structured and show only what is relevant to the user.

Menus are to be organised so as to have rapid access to the most frequently used functions.

5.6.2 A means to go back to a safe state is always to be accessible.

5.6.3 A clear warning is to be displayed when using functions such as alteration of control condition, or change of data or programs in the memory of the system.

5.6.4 A 'wait' indication is to warn the operator when the system is executing an operation.

6 Integrated systems

6.1 General

6.1.1 Operation with an integrated system is to be at least as effective as it would be with individual, stand alone equipment.

6.1.2 Failure of one part (individual module, equipment or subsystem) of the integrated system is not to affect the functionality of other parts, except for those functions directly dependant on information from the defective part.

6.1.3 A failure in connection between parts, cards connections or cable connections is not to affect the independent functionality of each connected part.

6.1.4 Alarm messages for essential functions are to have priority over any other information presented on the display.

7 Expert system

7.1

7.1.1 The expert system software is not to be implemented on a computer linked with essential functions.

7.1.2 Expert system software is not to be used for direct control or operation, and needs human validation by personnel on watch.

8 System testing

8.1

8.1.1 The system tests are to be carried out according to Ch 3, Sec 6.

8.1.2 All alterations of a system (hardware and software) are to be tested and the results of tests documented.

9 System maintenance

9.1

9.1.1 System maintenance is to be planned and documented. Changes in configuration, hardware and software are to be documented. The relevant documents and back-ups are to be prepared when the system is delivered.

Section 4 Constructional Requirements

1 General

1.1 General

1.1.1 Automation systems are to be so constructed as:

- to withstand the environmental conditions, as defined in Ch 2, Sec 2, [1], in which they operate
- to have necessary facilities for maintenance work.

1.2 Materials

1.2.1 Materials are generally to be of the flame-retardant type.

1.2.2 Connectors are to be able to withstand standard vibrations, mechanical constraints and corrosion conditions as given in Ch 3, Sec 6.

1.3 Component design

1.3.1 Automation components are to be designed to simplify maintenance operations. They are to be so constructed as to have:

- easy identification of failures
- easy access to replaceable parts
- easy installation and safe handling in the event of replacement of parts (plug and play principle) without impairing the operational capability of the system, as far as practicable
- facility for adjustment of set points or calibration
- test point facilities, to verify the proper operation of components.

1.4 Environmental and supply conditions

1.4.1 The environmental and supply conditions are specified in Ch 3, Sec 1. Specific environmental conditions are to be considered for air temperature and humidity, vibrations, corrosion from chemicals and mechanical or biological attacks.

2 Electrical and/or electronic systems

2.1 General

2.1.1 Electrical and electronic equipment is to comply with the requirements of Part C, Chapter 2 and Part C, Chapter 3.

2.1.2 A separation is to be done between any electrical components and liquids, if they are in a same enclosure. Necessary drainage will be provided where liquids are likely to leak.

2.1.3 When plug-in connectors or plug-in elements are used, their contacts are not to be exposed to excessive mechanical loads. They are to be provided with a locking device.

2.1.4 All replaceable parts are to be so arranged that it is not possible to connect them incorrectly or to use incorrect replacements. Where this not practicable, the replacement parts as well as the associated connecting devices are to be clearly identified. In particular, all connection terminals are to be properly tagged. When replacement cannot be carried out with the system on, a warning sign is to be provided.

2.1.5 Forced cooling systems are to be avoided. Where forced cooling is installed, an alarm is to be provided in the event of failure of the cooling system.

2.1.6 The interface connection is to be so designed to receive the cables required. The cables are to be chosen according to Ch 2, Sec 3.

2.2 Electronic system

2.2.1 Printed circuit boards are to be so designed that they are properly protected against the normal aggression expected in their environment.

2.2.2 Electronic systems are to be constructed taking account of electromagnetic interferences.

Special precautions are to be taken for:

- measuring elements such as the analogue amplifier or analog/digital converter; and
- connecting different systems having different ground references.

2.2.3 The components of electronic systems (printed circuit board, electronic components) are to be clearly identifiable with reference to the relevant documentation.

2.2.4 Where adjustable set points are available, they are to be readily identifiable and suitable means are to be provided to protect them against changes due to vibrations and uncontrolled access.

2.2.5 The choice of electronic components is to be made according to the normal environmental conditions, in particular the temperature rating.

2.2.6 All stages of fabrication of printed circuit boards are to be subjected to quality control. Evidence of this control is to be documented.

2.2.7 Burn-in tests or equivalent tests are to be performed.

2.2.8 The programmable components are to be clearly tagged with the program date and reference.

Components are to be protected against outside alteration when loaded.

2.3 Electrical system

2.3.1 Cables and insulated conductors used for internal wiring are to be at least of the flame-retardant type, and are to comply with the requirements in Part C, Chapter 2.

2.3.2 If specific products (e.g. oil) are likely to come into contact with wire insulation, the latter is to be resistant to such products or properly shielded from them, and to comply with the requirements in Part C, Chapter 2.

3 Pneumatic systems

3.1

3.1.1 Pneumatic automation systems are to comply with Ch 1, Sec 7, [17].

3.1.2 Pneumatic circuits of automation systems are to be independent of any other pneumatic circuit on board.

4 Hydraulic systems

4.1

4.1.1 Hydraulic automation systems are to comply with Ch 1, Sec 7, [14].

4.1.2 Suitable filtering devices are to be incorporated into the hydraulic circuits.

4.1.3 Hydraulic circuits of automation systems are to be independent of any other hydraulic circuit on board.

5 Automation consoles

5.1 General

5.1.1 Automation consoles are to be designed on ergonomic principles. Handrails are to be fitted for safe operation of the console.

5.2 Indicating instruments

5.2.1 The operator is to receive feed back information on the effects of his orders.

5.2.2 Indicating instruments and controls are to be arranged according to the logic of the system in control. In addition, the operating movement and the resulting movement of the indicating instrument are to be consistent with each other.

5.2.3 The instruments are to be clearly labelled. When installed in the wheelhouse, all lighted instruments of consoles are to be dimmable, where necessary.

5.3 VDU’s and keyboards

5.3.1 VDU’s in consoles are to be located so as to be easily readable from the normal position of the operator. The environmental lighting is not to create any reflection which makes reading difficult.

5.3.2 The keyboard is to be located to give easy access from the normal position of the operator. Special precautions are to be taken to avoid inadvertent operation of the keyboard.

Section 5 Installation Requirements

1 General

1.1

1.1.1 Automation systems are to be installed taking into account:

- the maintenance requirements (test and replacement of systems or components)
- the influence of EMI. The IEC 60533 standard is to be taken as guidance
- the environmental conditions corresponding to the location in accordance with Ch 2, Sec 1 and Ch 2, Sec 3, [8].

1.1.2 Control stations are to be arranged for the convenience of the operator.

1.1.3 Automation components are to be properly fitted. Screws and nuts are to be locked, where necessary.

2 Sensors and components

2.1 General

2.1.1 The location and selection of the sensor is to be done so as to measure the actual value of the parameter. Temperature, vibration and EMI levels are to be taken into account. When this is not possible, the sensor is to be designed to withstand the local environment.

2.1.2 The enclosure of the sensor and the cable entry are to be appropriate to the space in which they are located.

2.1.3 Means are to be provided for testing, calibration and replacement of automation components. Such means are to be designed, as far as practicable, so as to avoid perturbation of the normal operation of the system.

2.1.4 A tag number is to identify automation components and is to be clearly marked and attached to the component. These tag numbers are to be collected on the instrument list mentioned in Ch 3, Sec 1, Tab 1.

2.1.5 Electrical connections are to be arranged for easy replacement and testing of sensors and components. They are to be clearly marked.

2.1.6 Low level signal sensors are to be avoided. When installed they are to be located as close as possible to amplifiers, so as to avoid external influences. Failing this, the wiring is to be provided with suitable EMI protection and temperature correction.

2.2 Temperature elements

2.2.1 Temperature sensors, thermostats or thermometers are to be installed in a thermowell of suitable material, to permit easy replacement and functional testing. The thermowell is not to significantly modify the response time of the whole element.

2.3 Pressure elements

2.3.1 Three-way valves or other suitable arrangements are to be installed to permit functional testing of pressure elements, such as pressure sensors, pressure switches, without stopping the installation.

2.3.2 In specific applications, where high pulsations of pressure are likely to occur, a damping element, such as a capillary tube or equivalent, is to be installed.

2.4 Level switches

2.4.1 Level switches fitted to flammable oil tanks, or similar installations, are to be installed so as to reduce the risk of fire.

3 Cables

3.1 Installation

3.1.1 Cables are to be installed according to the requirements in Ch 2, Sec 12, [7].

3.1.2 Suitable installation features such as screening and/or twisted pairs and/or separation between signal and other cables are to be provided in order to avoid possible interference on control and instrumentation cables.

3.1.3 Specific transmission cables (coaxial cables, twisted pairs, etc.) are to be routed in specific cable-ways and mechanically protected to avoid loss of any important transmitted data. Where there is a high risk of mechanical damage, the cables are to be protected with pipes or equivalent.

3.1.4 The cable bend radius is to be in accordance with the requirements of Ch 2, Sec 12, [7.2].

For mineral insulated cables, coaxial cables or fibre optic cables, whose characteristics may be modified, special precautions are to be taken according to the manufacturer's instructions.

3.2 Cable terminations

3.2.1 Cable terminations are to be arranged according to the requirements in Part C, Chapter 2. Particular attention is to be paid to the connections of cable shields. Shields are to be connected only at the sensor end when the sensor is earthed, and only at the processor end when the sensor is floating.

3.2.2 Cable terminations are to be able to withstand the identified environmental conditions (shocks, vibrations, salt mist, humidity, etc.).

3.2.3 Terminations of all special cables such as mineral insulated cables, coaxial cables or fibre optic cables are to be arranged according to the manufacturer's instructions.

4 Pipes

4.1

4.1.1 For installation of piping circuits used for automation purposes, see the requirements in Ch 1, Sec 7.

4.1.2 As far as practicable, piping containing liquids is not to be installed in or adjacent to electrical enclosures (see Ch 3, Sec 4, [2.1.2]).

4.1.3 Hydraulic and pneumatic piping for automation systems is to be marked to indicate its function.

5 Automation consoles

5.1 General

5.1.1 Consoles or control panels are to be located so as to enable a good view of the process under control, as far as practicable. Instruments are to be clearly readable in the ambient lighting.

5.1.2 The location is to be such as to allow easy access for maintenance operations.

Section 6 Testing

1 General

1.1 General

1.1.1 Automation systems are to be tested for type approval, at works and on board, when required. Tests are to be carried out under the supervision of a Surveyor of the Society.

1.1.2 The type testing conditions for electrical, control and instrumentation equipment, computers and peripherals are described in Article [2].

1.1.3 Automation systems are to be inspected at works, according to the requirements of [3], in order to check that the construction complies with the Rules.

1.1.4 Automation systems are to be tested when installed on board and prior to sea trials, to verify their performance and adaptation on site, according to Article [4].

2 Type approval

2.1 General

2.1.1 The following requirements are applicable, but not confined, to all electrical, electronic and programmable equipment which are intended to be type approved for control, monitoring, alarm and protection systems for use in offshore units.

2.1.2 The necessary documents to be submitted, prior to type testing, are listed in Ch 3, Sec 1, [2.4.1]. The type approval of automation systems refers to hardware type approval or software type approval, as applicable.

2.2 Hardware type approval

2.2.1 Hardware type approval of automation systems is obtained subject to the successful outcome of the tests described in Tab 1. These tests are to demonstrate the ability of the equipment to function as intended under the specified test conditions.

2.2.2 The extent of testing (i.e. selection and sequence of carrying out tests and number of pieces to be tested) is to be determined upon examination and evaluation of the equipment or component subject to testing, giving due regards to its intended usage.

Equipment is to be tested in its normal position if otherwise not specified in the test specification.

Vibration and salt mist testing may be performed on different specimens, where applicable.

Reset of the automation system is accepted between each test, where necessary.

Note 1: As used in this Section, and in contrast to a complete performance test, a functional test is a simplified test sufficient to verify that the equipment under test (EUT) has not suffered any deterioration caused by the individual environmental tests.

2.2.3 The following additional tests may be required, depending on particular manufacturing or operational conditions:

- mechanical endurance test
- temperature shock test (e.g. 12 shocks on exhaust gas temperature sensors from 20°C ± 5°C to maximum temperature of the range)
- immersion test
- oil resistance test
- shock test.

The test procedure is to be defined with the Society in each case.

2.3 Software type approval

2.3.1 Software of computer based systems are to be approved in accordance with the related system category, as defined in Ch 3, Sec 3, [1.7].

Type approval consists of an assessment of the development quality and verification of tests and evidence, according to Tab 2.

2.3.2 Software is to be approved in association with hardware. References of software and hardware are to be specified in the type approval certificate.

2.3.3 Basic software of standard type used as tools for operation of a computer based system may be accepted without type approval at the discretion of the Society.

Table 1 : Type tests

No.	Test	Procedure **(6)**	Test parameters	Other information
1	Visual inspection	–	–	• drawings, design data
2	Performance test	Manufacturer performance test programme based upon specification and relevant rule requirements When the EUT is required to comply with an international performance standard, e.g. protection relays, verification of requirements in the standard are to be part of the performance testing required in this initial test and subsequent performance tests after environmental testing where required as per [2.2].	• standard atmosphere conditions • temperature: 25°C ± 10°C • relative humidity: 60% ± 30% • air pressure: 96 KPa ± 10 KPa	• confirmation that operation is in accordance with the requirements specified for particular automatic systems or equipment • checking of self-monitoring features • checking of specified protection against an access to the memory • checking against effect of unerroneous use of control elements in the case of computer systems
3	Power supply failure	–	• 3 interruptions during 5 minutes • switching- off time 30 s each case	• verification of the specified action of the equipment on loss and restoration of supply in accordance with the system design • verification of possible corruption of programme or data held in programmable electronic systems, where applicable • the time of 5 minutes may be exceeded if the equipment under test needs a longer time for start up, e.g. booting sequence • for equipment which requires booting, one additional power supply interruption during booting to be performed
4a	Electric A.C. power supply variations	–	COMBINATION Voltage variation permanent – Frequency variation permanent + 6% – + 5% + 6% – – 5% – 10% – – 5% – 10% – + 5% voltage transient (1,5s) – frequency transient (5s) + 20% – + 10% – 20% – – 10%	
4b	Electric D.C. power supply variations	–	Voltage tolerance continuous: ± 10% Voltage cyclic variation: 5% Voltage ripple: 10% Electric battery supply: • +30% to –25% for equipment connected to charging battery or as determined by the charging/discharging characteristics, including ripple voltage from the charging device • +20% to –25% for equipment not connected to the battery during charging	
4c	Pneumatic and hydraulic power supply variations	–	Pressure: ± 20% Duration: 15 minutes	

No.	Test	Procedure **(6)**	Test parameters	Other information
5a	Dry heat **(1)**	IEC 60068-2-2 Test Bb for non-heat dissipating equipment	• Temperature: 55°C ± 2°C Duration: 16 hours, or • Temperature: 70°C ± 2°C Duration: 16 hours	• equipment operating during conditioning and testing • functional test **(9)** during the last hour at the test temperature • for equipment specified for increased temperature the dry heat test is to be conducted at the agreed test temperature and duration
5b	Dry heat **(1)**	IEC 60068-2-2 Test Be for heat dissipating equipment	• Temperature: 55°C ± 2°C Duration: 16 hours, or • Temperature: 70°C ± 2°C Duration: 16 hours	• equipment operating during conditioning and testing with cooling system on if provided • functional test **(9)** during the last hour at the test temperature • for equipment specified for increased temperature the dry heat test is to be conducted at the agreed test temperature and duration.
6	Damp heat	IEC 60068-2-30 Test Db	Temperature: 55°C Humidity: 95% Duration: 2 cycles (12 + 12 hours)	• measurement of insulation resistance before test • the test shall start with 25°C ± 3°C and at least 95% humidity • equipment operating during the complete first cycle and switched off during second cycle except for functional test • functional test during the first 2 hours of the first cycle at the test temperature and during the last 2 hours of the second cycle at the test temperature; Duration of the second cycle can be extended due to more convenient handling of the functional test • recovery at standard atmosphere conditions • insulation resistance measurements and performance test
7	Vibration	IEC 60068-2-6 Test Fc	• 2 Hz ± 3/0 Hz to 13,2 Hz amplitude: ± 1mm • 13,2 Hz to 100 Hz acceleration: ± 0,7 g For severe vibration conditions such as, e. g., on diesel engines, air compressors, etc.: • 2,0 Hz to 25 Hz amplitude: ± 1,6 mm • 25 Hz to 100 Hz acceleration: ± 4,0 g Note: More severe conditions may exist for example on exhaust manifolds or fuel oil injection systems of diesel engines. For equipment specified for increased vibration levels the vibration test is to be conducted at the agreed vibration level, frequency range and duration. Values may be required to be in these cases: • 40 Hz to 2000 Hz • acceleration: ± 10,0 g at 600°C	• duration 90 minutes at 30 Hz in case of no resonance condition • duration 90 minutes at each resonance frequency at which Q ≥ 2 is recorded • during the vibration test, functional tests are to be carried out • tests to be carried out in three mutually perpendicular planes • it is recommended as a guidance that Q does not exceed 5 • duration 120 minutes where sweep test is to be carried out instead of discrete frequency test and a number of resonant frequencies is detected close to each other. Sweep over a restricted frequency range between 0.8 and 1.2 times the critical frequencies can be used where appropriate. Note: Critical frequency is a frequency at which the equipment being tested may exhibit: • malfunction and/or performance deterioration • mechanical resonances and/or other response effects occur, e.g. chatter

<table>
<tr><th>No.</th><th>Test</th><th colspan="2">Procedure **(6)**</th><th colspan="2">Test parameters</th><th>Other information</th></tr>
<tr><td rowspan="2">8</td><td rowspan="2">Inclination</td><td colspan="2" rowspan="2">IEC 60092-504</td><td colspan="2">Static 22,5°</td><td>a) inclined to the vertical at an angle of at least 22,5°
b) inclined to at least 22,5° on the other side of the vertical and in the same plane as in a)
c) inclined to the vertical at an angle of at least 22,5° in plane at right angles to that used in a)
d) inclined to at least 22,5° on the other side of the vertical and in the same plane as in c)
Note: The period of testing in each position should be sufficient to fully evaluate the behaviour of the equipment</td></tr>
<tr><td colspan="2">Dynamic 22,5°</td><td>Using the directions defined in a) to d) above, the equipment is to be rolled to an angle of 22,5° each side of the vertical with a period of 10 seconds
The test in each direction is to be carried out for not less than 15 minutes
Note: These inclination tests are normally not required for equipment with no moving parts.</td></tr>
<tr><td rowspan="4">9</td><td rowspan="4">Insulation resistance</td><td rowspan="2">Rated supply voltage</td><td rowspan="2">Test voltage (D.C. voltage) (V)</td><td colspan="2">Minimum insulation resistance</td><td rowspan="4">• insulation resistance test is to be carried out before and after: damp heat test, cold test, salt mist test and high voltage test
• between all phases and earth, and where appropriate between the phases
Note: Certain components, e. g. for EMC protection, may be required to be disconnected for this test</td></tr>
<tr><td>before</td><td>after</td></tr>
<tr><td>Un ≤ 65 V</td><td>2 x Un min. 24 V</td><td>10 Mohms</td><td>1,0 Mohms</td></tr>
<tr><td>Un > 65V</td><td>500 V</td><td>100 Mohms</td><td>10 Mohms</td></tr>
<tr><td rowspan="5">10</td><td rowspan="5">High voltage</td><td colspan="2">Rated voltage Un</td><td colspan="2">Test voltage (A.C. voltage 50 or 60 Hz)</td><td rowspan="5">• separate circuits are to be tested against each other and all circuits connected with each other tested against earth
• printed circuits with electronic components may be removed during the test
• period of application of the test voltage: 1 minute
Note: Certain components, e. g. printed circuits with electronic components, may be required to be disconnected for this test</td></tr>
<tr><td colspan="2">Up to 65 V</td><td colspan="2">2 x Un + 500 V</td></tr>
<tr><td colspan="2">66 V to 250 V</td><td colspan="2">1500 V</td></tr>
<tr><td colspan="2">251 V to 500 V</td><td colspan="2">2000 V</td></tr>
<tr><td colspan="2">501 V to 690 V</td><td colspan="2">2500 V</td></tr>
<tr><td>11</td><td>Cold</td><td colspan="2">IEC 60068-2-1</td><td colspan="2">• Temperature: +5°C ± 3°C Duration: 2 hours, or
• Temperature: –25°C ± 3°C Duration: 2 hours (see **(2)**)</td><td>• initial measurement of insulation resistance
• equipment not operating during conditioning and testing except for functional test
• functional test during the last hour at the test temperature
• insulation resistance measurement and the functional test after recovery</td></tr>
<tr><td>12</td><td>Salt mist</td><td colspan="2">IEC 60068-2-52
Test Kb</td><td colspan="2">Four spraying periods with a storage of seven days after each</td><td>• initial measurement of insulation resistance and initial functional test
• equipment not operating during conditioning
• functional test on the 7th day of each storage period
• insulation resistance measurement and performance test 4 to 6h after recovery (see **(3)**)
• on completion of exposure, the equipment shall be examined to verify that deterioration or corrosion (if any) is superficial in nature</td></tr>
</table>

No.	Test	Procedure **(6)**	Test parameters	Other information
13	Electrostatic discharge	IEC 61000-4-2	Contact discharge: 6 kV Air discharge: 2 kV, 4 kV, 8 kV Interval between single discharges: 1 sec. No. of pulses: 10 per polarity According to test level 3	• to simulate electrostatic discharge as may occur when persons touch the appliance • the test is to be confined to the points and surfaces that can normally be reached by the operator • performance criterion B (see **(4)**)
14	Electromagnetic field	IEC 61000-4-3	Frequency range: 80 MHz to 2 GHz Modulation**: 80% AM at 1000Hz Field strength: 10V/m Frequency sweep rate: $\leq 1,5.10^{-3}$ decades/s (or 1% / 3 sec) According to test level 3	• to simulate electromagnetic fields radiated by different transmitters • the test is to be confined to the appliances exposed to direct radiation by transmitters at their place of installation • performance criterion A (see **(5)**) • if an equipment is intended to receive radio signals for the purpose of radio communication (e.g. wifi router, remote radio controller), then the immunity limits at its communication frequency do not apply, subject to the provisions in Ch 3, Sec 3, [4.6] ** If, for tests of equipment, an input signal with a modulation frequency of 1000 Hz is necessary, a modulation frequency of 400 Hz should be chosen
15	Conducted low Frequency		A.C.: • Frequency range: rated frequency to 200th harmonic • Test voltage (rms): 10% of supply to 15th harmonic reducing to 1% at 100th harmonic and maintain this level to the 200th harmonic, min 3 V r.m.s, max. 2 W D.C.: • Frequency range: 50 Hz - 10 kHz • Test voltage (rms): 10% of supply, max. 2 W	• to simulate distortions in the power supply system generated, for instance, by electronic consumers and coupled in as harmonics • performance criterion A (see **(5)**) • see figure "Test set-up" (see **(8)**) • for keeping max. 2W, the voltage of the test signal may be lower
16	Conducted Radio Frequency	IEC 61000-4-6	AC, DC, I/O ports and signal/ control lines Frequency range: 150 kHz - 80 MHz Amplitude: 3 V rms (see **(7)**) Modulation***: 80% AM at 1000 Hz Frequency sweep range: $\leq 1,5.10^{-3}$ decades/s (or 1% / 3sec.) According to test level 2	• to simulate electromagnetic fields coupled as high frequency into the test specimen via the connecting lines • performance criterion A (see**(5)**) *** If, for tests of equipment, an input signal with a modulation frequency of 1000 Hz is necessary, a modulation frequency of 400 Hz should be chosen
17	Electrical Fast Transients / Burst	IEC 61000-4-4	Single pulse time: 5ns (between 10% and 90% value) Single pulse width: 50 ns (50% value) Amplitude (peak): 2 kV line on power supply port/earth; 1 kV on I/O data control and communication ports (coupling clamp) Pulse period: 300 ms Burst duration: 15 ms Duration/polarity: 5 min According to test level 3	• arcs generated when actuating electrical contacts • interface effect occurring on the power supply, as well as at the external wiring of the test specimen • performance criterion B (see**(4)**)

<table>
<tr><th>No.</th><th>Test</th><th>Procedure (6)</th><th>Test parameters</th><th>Other information</th></tr>
<tr><td>18</td><td>Surge</td><td>IEC 61000-4-5</td><td>Test applicable to AC and DC power ports.
Open-circuit voltage:
Pulse rise time: 1,2 μs (front time)
Pulse width: 50 μs (time of half value)
Amplitude (peak): 1 kV line/ earth; 0,5kV line/line
Short circuit current:
Pulse rise time: 8 μs (front time)
Pulse width: 20 μs (time of half value)
Repetition rate: ≥ 1 pulse/min
No of pulses: 5 per polarity
Application: continuous
According to test level 2</td><td>to simulate interference generated, for instance, by switching “ON” or “OFF” high power inductive consumers
test procedure in accordance with figure 10 of the standard for equipment where power and signal lines are identical
performance criterion B (see(4))</td></tr>
<tr><td rowspan="2">19</td><td rowspan="2">Radiated Emission</td><td rowspan="2">CISPR 16-2-3
IEC 60945 for 156-165 MHz</td><td>Limits below 1000 MHz:
For equipment installed in the bridge and deck zone:
<table><tr><th>Frequency range (MHz):</th><th>Quasi peak limits (dBμV/m):</th></tr><tr><td>0,15 - 0,30</td><td>80- 52</td></tr><tr><td>0,30 - 30</td><td>52- 34</td></tr><tr><td>30 - 1000</td><td>54</td></tr><tr><td>except for:</td><td></td></tr><tr><td>156 - 165</td><td>24</td></tr></table>
For equipment installed in the general power distribution zone:
<table><tr><th>Frequency range (MHz):</th><th>Quasi peak limits (dBμV/m):</th></tr><tr><td>0,15 - 30</td><td>80 - 50</td></tr><tr><td>30 - 100</td><td>60 - 54</td></tr><tr><td>100 - 1000</td><td>54</td></tr><tr><td>except for:</td><td></td></tr><tr><td>156 - 165</td><td>24</td></tr></table></td><td>procedure in accordance with the standard but distance 3 m between equipment and antenna
for the frequency band 156 MHz to 165 MHz the measurement is to be repeated with a receiver bandwidth of 9 kHz (as per IEC 60945)
alternatively the radiation limit at a distance of 3 m from the enclosure port over the frequency 156 MHz to 165 MHz shall be 30 dB micro-V/m peak (as per IEC 60945)</td></tr>
<tr><td>Limit above 1000 MHz:<table><tr><th>Frequency range (MHz):</th><th>Average limit (dBμV/m):</th></tr><tr><td>1000 - 6000</td><td>54</td></tr></table></td><td>procedure in accordance with the standard (distance 3 m between equipment and antenna). Equipment intended to transmit radio signals for the purpose of radio communication (e.g. wifi router, remote radio controller) may be exempted from limit, within its communication frequency range, subject to the provisions in Ch 3, Sec 3, [4.6]</td></tr>
</table>

No.	Test	Procedure **(6)**	Test parameters	Other information
20	Conducted Emission	CISPR 16-2-1	Test applicable to AC and DC power ports • For equipment installed in the bridge and deck zone: Frequency range: – Limits: (dBµV) 10 - 150 kHz – 96 - 50 150 - 350 kHz – 60 - 50 0,35 - 30 MHz – 50 • For equipment installed in the general power distribution zone: Frequency range: – Limits: (dBµV) 10 - 150 kHz – 120 - 69 150 - 500 kHz – 79 0,50 - 30 MHz – 73	
21	Flame retardant	IEC 60092-101 or IEC 60695-11-5	Flame application: 5 times 15 s each Interval between each application: 15 s or 1 time 30 s	• the burnt out or damaged part of the specimen by not more than 60mm long • no flame, no incandescence or in the event of a flame or incandescence being present, it shall extinguish itself within 30 s of the removal of the needle flame without full combustion of the test specimen • any dripping material shall extinguish itself in such a way as not to ignite a wrapping tissue. The drip height is 200 mm ± 5 mm

(1) Dry heat at 70 °C is to be carried out to automation, control and instrumentation equipment subject to high degree of heat, for example mounted in consoles, housings, etc. together with other heat dissipating power equipment.

(2) For equipment installed in non-weather protected locations or cold locations, test is to be carried out at –25°C.

(3) Salt mist test is to be carried out for equipment installed in weather exposed areas.

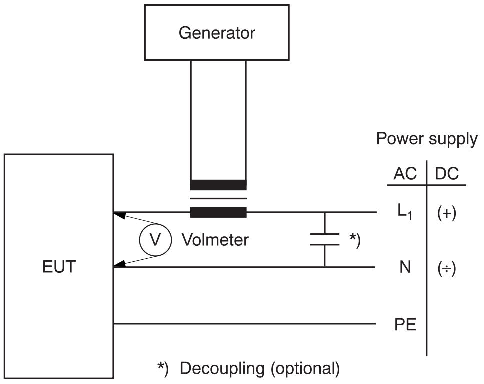
(4) Performance criterion B: (for transient phenomena): The Equipment Under Test shall continue to operate as intended after the tests. No degradation of performance or loss of function is allowed as defined in the technical specification published by the Manufacturer. During the test, degradation or loss of function or performance which is self recoverable is however allowed but no change of actual operating state or stored data is allowed.

(5) Performance criterion A (for continuous phenomena): The EUT shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed as defined in relevant equipment standard and the technical specification published by the Manufacturer.

(6) Column 3 indicates the testing procedure which is normally to be applied. However, equivalent testing procedure may be accepted by the Society provided that what is required in the other columns is fulfilled.

(7) For equipment installed on the bridge and deck zone, the test levels shall be increased to 10V rms for spot frequencies in accordance with IEC 60945 at 2,3,4,6.2, 8.2, 12.6, 16.5, 18.8, 22, 25 MHz.

(8) Figure - Test set-up for Conducted Low Frequency - Refer to IEC 60945 (1996).



(9) See [2.2.2], Note 1.

2.3.4 In case of separate approval of software, an assessment certificate may be issued, at the request of the manufacturer, based on the requirements of the appropriate system category.

2.4 Loading instruments

2.4.1 Loading instrument approval consists of:

- approval of hardware according to [2.2], unless two computers are available on board for loading calculations only
- approval of basic software according to [2.3]
- approval of application software, consisting in data verification which results in the Endorsed Test Condition according to Part B
- installation testing according to Article [4].

2.5 Oil mist detection system

2.5.1 Type test of oil mist detection system are to be carried out according to Ship rules Pt C, Ch 3, App 1.

3 Acceptance testing

3.1 General

3.1.1 Acceptance tests are generally to be carried out at the manufacturer’s facilities before the shipment of the equipment, when requested.

Acceptance tests refer to hardware and software tests as applicable.

3.2 Tests and evidence

3.2.1 Tests and evidence are to be in accordance with Tab 2. Definitions and notes relating to Tab 2 are given in Ch 3, Sec 1, [1.3.1].

Table 2 : Tests and evidence according to the system category

No.	Tests and evidence		System category **(1)**		
			I	II	III
1.	Evidence of quality system	Quality plan for software		M	M
		Inspection of components (only hardware) from sub-suppliers		M	M
		Quality control in production		M	M
		Final test reports	M	M	S
		Traceability of software	M	M	S
2.	Hardware and software description	Software description		M	S
		Hardware description		M	S
		Failure analysis for safety related functions only			S
3.	Evidence of software testing	Evidence of software testing according to quality plan		M	S
		Analysis regarding existence and fulfilment of programming procedures for safety related functions			S
4.	Hardware tests	Tests according to Tab 1	M	S/W	S/W
5.	Software tests	Module tests		M	S
		Subsystem tests		M	S
		System test		M	S
6.	Performance tests	Integration test		M	W
		Fault simulation		W	W
		Factory Acceptance Test (FAT)	M	W	W
7.	On board tests	Complete system test	M	W	W
		Integration test		W	W
		Operation of wireless equipment to demonstrate electromagnetic compatibility		W	W*
8.	Modifications	Tests after modifications	M	S/W	S/W

(1) M : Evidence kept by manufacturer and submitted on request
S : Evidence checked by the Society
W : To be witnessed by the Society
* : The level of witnessing is to be determined during the assessment required by Ch 3, Sec 3, [1.1.5].

3.3 Hardware testing

3.3.1 Final acceptance will be granted subject to:

- the results of the tests listed in [3.3.2]
- the type test report or type approval certificate.

3.3.2 Hardware acceptance tests include, where applicable:

- visual inspection
- operational tests and, in particular:
  - tests of all alarm and safety functions
  - verification of the required performance (range, calibration, repeatability, etc.) for analogue sensors
  - verification of the required performance (range, set points, etc.) for on/off sensors
  - verification of the required performance (range, response time, etc.) for actuators
  - verification of the required performance (full scale, etc.) for indicating instruments
- endurance test (burn-in test or equivalent)
- high voltage test
- hydrostatic tests.

Additional tests may be required by the Society.

3.4 Software testing

3.4.1 Software acceptance tests of computer based systems are to be carried out to verify their adaptation to their use on board, and concern mainly the application software.

3.4.2 The software modules of the application software are to be tested individually and subsequently subjected to an integration test. The test results are to be documented and to be part of the final file. It is to be checked that:

- the development work has been carried out in accordance with the plan
- the documentation includes the method of testing, the test programs producing, the simulation, the acceptance criteria and the result.

Software module tests are to provide evidence that each module performs its intended function and does not perform unintended functions.

Subsystem testing is to verify that modules interact correctly to perform the intended functions and do not perform unintended functions.

System testing is to verify that subsystems interact correctly to perform the functions in accordance with specified requirements and do not perform unintended functions.

Repetition tests may be required to verify the consistency of test results.

3.4.3 Analysis regarding existence and fulfilment of programming procedures for safety related functions

Specific assurance methods are to be planned for verification and validation of satisfaction of requirements, e.g.:

- diverse programs
- program analysis and testing to detect formal errors and discrepancies to the description
- simple structure.

3.4.4 The Society may ask for additional tests of systems which are part of safety systems or which integrate several functions.

3.4.5 Integration tests

Programmable electronic system integration testing is to be carried out using satisfactorily tested system software and, as far as practicable, intended system components.

3.4.6 Fault simulation

Faults are to be simulated as realistically as possible to demonstrate appropriate system fault detection and system response. The results of any required failure analysis are to be observed.

3.4.7 Factory Acceptance Test (FAT)

Factory acceptance testing is be carried out in accordance with a test program accepted by the Society. Testing is to be based on demonstrating that the system fulfils the requirements specified by the Society.

3.4.8 Modifications

Modifications to approved systems are to be notified in advance and carried out to the Society’s satisfaction. Refer to Ch 3, Sec 1, [2.4.2].

4 On board tests

4.1 General

4.1.1 Testing is to be performed on the completed system comprising actual hardware components with the final application software, in accordance with an approved test program.

4.1.2 On board tests are to be carried out on automation systems associated with essential services to verify their compliance with the Rules, by means of visual inspection and the performance and functionality according to Tab 3.

On board testing is to verify that correct functionality has been achieved with all systems integrated.

When completed, automation systems are to be such that a single failure, for example loss of power supply, is not to result in a major degradation of the services essential to the safety of the unit. In addition, a blackout test is to be carried out to show that automation systems are continuously supplied.

Upon completion of on board tests, test reports are to be made available to the Surveyor.

4.1.3 For wireless data communication equipment, tests during harbour and sea trials are to be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not itself fail as a result of electromagnetic interference during expected operating conditions.

Note 1: Where electromagnetic interference caused by wireless data communication equipment is found to be causing failure of equipment required for Category II or III systems, the layout and/or equipment are/is to be changed to prevent further failures occurring.

Table 3 : On board tests

Equipment	Nature of tests
Electronic equipment	Main hardware and software functionalities with all systems integrated
Analogue sensors	Signal calibration, trip set point adjustment
On/off sensors	Simulation of parameter to verify and record the set points
Actuators	Checking of operation in whole range and performance (response time, pumping)
Reading instruments	Checking of calibration, full scale and standard reference value

Section 7 Unattended Machinery Spaces (AUTO)

1 General

1.1 Application

1.1.1 The additional class notation **AUTO** is assigned in accordance with Pt A, Ch 1, Sec 2, [8.3.14] to units fitted with automated installations enabling periodically unattended operation of machinery spaces, and complying with the requirements of this Section.

Note 1: Machinery spaces are defined in Ch 1, Sec 1, [1.3.2].

1.1.2 For propelled units, requirements relative to propulsion, detailed in additional notation **AUT-UMS** in the Ship Rules, are applicable.

1.1.3 *The arrangements provided shall be such as to ensure that the safety of the unit in all operating conditions, including manoeuvring and sailing, is equivalent to that of a unit having the machinery spaces manned.*

1.1.4 Automation of process and drilling systems, if any, are outside the scope of the present Section.

1.2 Communication system

1.2.1 *A reliable means of vocal communication shall be provided between the main machinery control room and the engineer officers' accommodation.*

This means of communication is to be foreseen in collective or individual accommodation of engineer officers.

1.2.2 Means of communication are to be capable of being operated even in the event of failure of supply from the main source of electrical power.

2 Documentation

2.1 Documents to be submitted

2.1.1 In addition to those mentioned in Ch 3, Sec 1, Tab 1, the documents in Tab 1 are required.

Table 1 : Documents to be submitted

No.	I/A **(1)**	Document
1	A	Means of communication diagram
2	A	Technical description of automatic engineer's alarm and connection of alarms to accommodation, when applicable
3	A	System of protection against flooding
4	A	Fire detection system: diagram, location and cabling
(1) A = To be submitted for approval ; I = To be submitted for information		

3 Fire and flooding precautions

3.1 Fire prevention

3.1.1 *Where daily service oil tanks are filled automatically, or by remote control, means shall be provided to prevent overflow spillages.*

3.1.2 The requirements regarding piping and arrangements of fuel oil and lubricating oil systems given in Ch 1, Sec 8, Ch 1, Sec 2 and Ch 1, Sec 7 are applicable.

3.1.3 Fuel oil and lubricating oil purifiers and the auxiliary equipment and its fittings containing hot fuel oil are to be grouped in a special room or in locations ventilated by extraction; nevertheless, transfer pumps may be located outside this room.

3.1.4 Where heating is necessary, it is to be arranged with automatic control. A high temperature alarm is to be fitted and the possibility of adjusting its threshold according to the fuel quality is to be provided. Such alarm may be omitted if it is demonstrated that the temperature in the tank cannot exceed the flashpoint under the following conditions: volume of liquid corresponding to the low level alarm and maximum continuous heating power during 24 hours.

3.1.5 For arrangement of remote stops, the requirements in Ch 4, Sec 4, [5.5.5] and in Pt D, Ch 1, Sec 18 are applicable. The operation is to be possible from a permanently manned control station.

3.2 Fire detection

3.2.1 For fire detection, the requirements given in Ch 4, Sec 5 are applicable.

3.2.2 *Means are to be provided to detect and give alarms at an early stage in case of fires:*

- *in boiler air supply casing and exhausts (uptakes),*

unless the Society considers this to be unnecessary in a particular case.

3.2.3 An automatic fire detection system is to be fitted in machinery spaces as defined in Ch 1, Sec 1, [1.3.1] intended to be unattended.

3.2.4 The fire detection system is to be designed with self-monitoring properties. Power or system failures are to initiate an audible alarm distinguishable from the fire alarm.

3.2.5 The fire detection indicating panel is to be located in a permanently manned control station or other accessible place where a fire in the machinery space will not render it inoperative.

3.2.6 The fire detection indicating panel is to indicate the place of the detected fire in accordance with the arranged fire zones by means of a visual signal. Audible signals clearly distinguishable in character from any other signals are to be audible throughout a permanently manned control station and the accommodation area of the personnel responsible for the operation of the machinery space.

3.2.7 Fire detectors are to be of such type and so located that they will rapidly detect the onset of fire in conditions normally present in the machinery space. Consideration is to be given to avoiding false alarms. The type and location of detectors are to be approved by the Society and a combination of detector types is recommended in order to enable the system to react to more than one type of fire symptom.

3.2.8 Except in spaces of restricted height and where their use is specially appropriate, detection systems using thermal detectors only are not permitted. Flame detectors may be installed, although they are to be considered as complementary and are not to replace the main installation.

3.2.9 Fire detector zones are to be arranged in a manner that will enable the operating staff to locate the seat of the fire. The arrangement and the number of loops and the location of detector heads are to be approved in each case. Air currents created by the machinery are not to render the detection system ineffective.

3.2.10 When fire detectors are provided with the means to adjust their sensitivity, necessary arrangements are to be allowed to fix and identify the set point.

3.2.11 When it is intended that a particular loop or detector is to be temporarily switched off, this state is to be clearly indicated. Reactivation of the loop or detector is to be performed automatically after a preset time.

3.2.12 The fire detection indicating panel is to be provided with facilities for functional testing.

3.2.13 The fire detecting system is to be fed automatically from the emergency source of power by a separate feeder if the main source of power fails.

3.2.14 Facilities are to be provided in the fire detecting system to manually release the fire alarm from the following places:

- passageways having entrances to engine and boiler rooms
- the control station in the engine room.

3.2.15 The detection equipment is to be so designed as to signal in less than 3 minutes a conventional seat of fire resulting from the combustion of 500 g textile waste impregnated with 25 cl of diesel oil in a square gutterway 30 cm wide x 15 cm high. Alternative means of testing may be accepted at the discretion of the Society.

3.3 Fire fighting

3.3.1 Unless otherwise stated, pressurisation of the fire main at a suitable pressure by starting a main fire pump and carrying out the other necessary operations is to be possible from the permanently manned control station. Alternatively, the fire main system may be permanently under pressure.

3.3.2 In addition to the fire-extinguishing arrangements mentioned in Part C, Chapter 4, periodically unattended spaces containing steam turbines (whose power is at least 375 kW) are to be provided with one of the fixed fire-extinguishing systems required in the same chapter for machinery spaces of category A containing oil fired boilers or fuel oil units.

3.3.3 Local application fire extinguishing systems provided in machinery spaces of category A are to have an automatic release capability in addition to the manual release.

3.4 Protection against flooding

3.4.1 Bilge wells or machinery spaces bilge levels are to be monitored in such a way that the accumulation of liquid is detected in normal angles of trim and heel, and are to be large enough to accommodate easily the normal drainage during the unattended period.

3.4.2 *Where the bilge pumps are capable of being started automatically, means shall be provided to indicate when the influx of liquid is greater than the pump capacity or when the pump is operating more frequently than would normally be expected.*

3.4.3 *The location of the controls of any valve serving a sea inlet, a discharge below the waterline or a bilge injection system shall be so sited as to allow adequate time for operation in case of influx of water to the space, having regard to the time likely to be required in order to reach and operate such controls. If the level to which the space could become flooded with the unit in the fully loaded condition so requires, arrangements shall be made to operate the controls from a position above such level.*

A calculation is to be carried out to show that the time taken from alarm activation plus the time to reach and fully close manually operated or powered valves is less than the time taken for the influx of water to reach the control without submergence of the platform on which the person is operating the valves. If necessary a remote control device is to be fitted above the level.

Note 1: The time it takes for the influx of water to reach the control of valves should be based on a breach in the largest diameter seawater line in the lowest location in the engine room when the unit is fully loaded.

Note 2: The time it takes to reach the sea valves should be determined based on the distance between the navigation bridge and the platform from where the valves associated with the aforementioned seawater line are manually operated (or the actuator for valves controlled by stored mechanical energy).

Note 3: In the event calculations are not available, 10 minutes shall be regarded as adequate time for operation unless other requirements are specified by the flag Administration.

3.4.4 Bilge level alarms are to be given at the main control station.

3.4.5 Alarm is to be given to the a permanently manned control station in case of flooding into the machinery space situated below the load line.

4 Control of machinery

4.1 General

4.1.1 All manual operations or services expected to be carried out with a periodicity of less than 24 h are to be eliminated or automated, particularly for: lubrication, topping up of make up tanks and filling tanks, filter cleaning, cleaning of centrifugal purifiers, drainage, load sharing on main engines and various adjustments. Nevertheless, the transfer of operation mode may be effected manually.

4.1.2 *A centralised control position shall be arranged with the necessary alarm panels and instrumentation indicating any alarm.*

4.1.3 Parameters for essential services which need to be adjusted to a preset value are to be automatically controlled.

4.1.4 *The control system shall be such that the services needed for the operation of the essential services are ensured through the necessary automatic arrangements.*

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

4.2 Auxiliary system

4.2.1 *Where standby machines are required for essential services, automatic changeover devices shall be provided.*

Change-over restart is to be provided for the following systems:

- cylinder cooling of diesel generating sets (where the circuit is common to several sets)
- diesel generating sets fuel supply (where the circuit is common to several sets)
- sea water to main condenser (main turbines)
- thermal fluid systems (thermal fluid heaters).

4.2.2 When a standby machine is automatically started, an alarm is to be activated.

4.2.3 *Where daily service fuel oil tanks are filled automatically, or by remote control, means shall be provided to prevent overflow spillages.*

4.2.4 Arrangements are to be provided to prevent overflow spillages coming from equipment treating flammable liquids.

4.2.5 *Where daily service fuel oil tanks 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.*

4.2.6 For auxiliary systems, the following parameters, according to Tab 2 to Tab 13 are to be monitored or controlled.

Table 2 : Incinerators

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required	Monitoring	Automatic control				
		Incinerator			Auxiliary	
Identification of system parameter	Alarm	Slow-down	Shut-down	Control	Standby Start	Stop
Combustion air pressure	L		X			
Flame failure	X		X			
Furnace temperature	H		X			
Exhaust gas temperature	H					
Fuel oil pressure	L					
Fuel oil temperature or viscosity, where heavy fuel is used	H + L					

Table 3 : Auxiliary boilers

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required	Monitoring	Automatic control				
		Boiler			Auxiliary	
Identification of system parameter	Alarm	Slow-down	Shut-down	Control	Standby Start	Stop
Water level	L + H		X	X		
Fuel oil temperature or viscosity, where heavy fuel is used	L + H		X	X		
Flame failure	X					
			X			
Combustion air supply fan low pressure			X			
Temperature in boiler casing (fire)	H					
Steam pressure	H **(1)**		X	X		
Steam temperature			X **(2)**			

(1) When the automatic control does not cover the entire load range from zero load.
(2) For superheated steam over 330°C.

Table 4 : Fuel oil system

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required,	Monitoring	Automatic control				
		System			Auxiliary	
Identification of system parameter	Alarm	Slow-down	Shut-down	Control	Standby Start	Stop
Fuel oil tank level, overflow	H **(1)**					
Air pipe water trap level on fuel oil tanks	H **(2)**					
Heater outlet fuel oil temperature				X		
	H **(4)**		X **(5)**			
Sludge tank level	H					
Fuel oil settling tank level	H **(1)**					
Fuel oil settling tank temperature **(3)**	H			X		
Fuel oil centrifugal purifier overflow	H		X **(6)**			
Fuel oil in daily service tank level	L					
Fuel oil daily service tank temperature **(3)**	H			X		
Fuel oil in daily service tank level (to be provided if no suitable overflow arrangement)	H **(1)**					

(1) Or sight-glasses on the overflow pipe.
(2) Or alternative arrangement as per Ch 1, Sec 7, [9.1.7].
(3) Applicable where heating arrangements are provided.
(4) Or low flow alarm in addition to temperature control when heated by steam or other media.
(5) Cut off of electrical power supply when electrically heated.
(6) Shutdown of the fuel oil supply.

Table 5 : Lubricating oil system

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required	Monitoring	Automatic control				
		System			Auxiliary	
Identification of system parameter	Alarm	Slow-down	Shut-down	Control	Standby Start	Stop
Air pipe water trap level of lubricating oil tank see Ch 1, Sec 7, [9.1.7]	H					
Sludge tank level	H					
Lubricating oil centrifugal purifier overflow	H		X **(1)**			
(1) Shutdown of the lubricating oil supply.						

Table 6 : Thermal oil system

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required	Monitoring	Automatic control				
		System			Auxiliary	
Identification of system parameter	Alarm	Slow-down	Shut-down	Control	Standby Start	Stop
Thermal fluid temperature heater outlet	H					
	HH		X **(1)**			
Thermal fluid pressure pump discharge **(4)**	H		X			
Thermal fluid flow through heating element	L				X	
	LL		X **(1)**			
Expansion tank level	L					
	LL		X **(2)**			
Expansion tank temperature	H					
Combustion air pressure	L		X			
Fuel oil pressure	L					
Fuel oil temperature or viscosity **(3)**	H + L					
Burner flame failure	X		X			
Flue gas temperature heater outlet	H					
	HH		X **(2)**			
(1) Shut-off of heat input only. **(2)** Shut-off of heat input and delayed stop of fluid flow. **(3)** Where heavy fuel is used. **(4)** Not applicable to centrifugal pumps.						

Table 7 : Hydraulic oil system

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required	Monitoring	Automatic control				
		System			Auxiliary	
Identification of system parameter	Alarm	Slow-down	Shut-down	Control	Standby Start	Stop
Pump pressure	H					
Service tank level	L					X **(1)**
(1) The automatic stop of the hydraulic pumps is to be operated in the same circumstances, except where this stop can lead to propulsion stop.						

Table 8 : Boiler feed and condensate system for auxiliary boiler

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required	Monitoring	Automatic control				
		System			Auxiliary	
Identification of system parameter	Alarm	Slow-down	Shut-down	Control	Standby Start	Stop
Sea water flow in condenser or equivalent	L				X	
Vacuum in condenser **(2)**	L					
	LL		X			
Water level in main condenser (unless justified)	H + L					
				X		
	HH		X			
Salinity of condensate	H					
Feed water pump delivery pressure	L				X	
Feed water tank level	L					
Deaerator inside temperature or pressure **(2)**	L + H **(1)**					
Water level in deaerator **(2)**	L + H					
Extraction pump pressure **(2)**	L					
Drain tank level	L + H					

(1) In the case of forced circulation boiler.
(2) When installed.

Table 9 : Compressed air system

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required	Monitoring	Automatic control				
		System			Auxiliary	
Identification of system parameter	Alarm	Slow-down	Shut-down	Control	Standby Start	Stop
Air temperature at compressor outlet	H					
Compressor lubricating oil pressure (except where splash lubrication)	LL		X			
Control air pressure **(3)**	L					
				X		
Starting air pressure before main shut-off valve	L **(1)(2)**					
				X		
	X				X	
Safety air pressure **(3)**	L					
				X		

(1) Local indication. Remote indication is required if starting of air compressor is remote controlled, from wheelhouse for example.
(2) For starting air, the alarm minimum pressure set point is to be so adjusted as to enable at least three starts per engine.
(3) When supplied through reducing valve, see Ch 1, Sec 7, [2.6.4].

Table 10 : Cooling system

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required	Monitoring	Automatic control				
		System			Auxiliary	
Identification of system parameter	Alarm	Slow-down	Shut-down	Control	Standby Start	Stop
Sea water pump pressure or flow	X				X	
	L					
Fresh water pump pressure or flow	X				X	
	L					
Level in cooling water expansion tank	L					

Table 11 : Control and monitoring of auxiliary electrical systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required	Monitoring	Automatic control				
		Main engine			Auxiliary	
Identification of system parameter	Alarm	Slow-down	Shut-down	Control	Standby Start	Stop
Electric circuit, blackout	X					
Power supply failure of control, alarm and safety system	X					

Table 12 : Auxiliary reciprocating I.C. engines driving generators

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required	Monitoring	Automatic control				
		Engine			Auxiliary	
Identification of system parameter	Alarm	Slow-down	Shut-down	Control	Standby Start	Stop
Fuel oil viscosity or temperature before injection (for engine running on heavy fuel)	L + H					
				X		
Common rail fuel oil pressure	L					
Fuel oil leakage from pressure pipes	H					
Lubricating oil temperature	H					
Lubricating oil pressure	L				X **(5)**	
	LL		X **(1)**			
Oil mist concentration in crankcase **(2)**	H		X			
Crankcase oil mist detector failure	X					
Exhaust gas temperature after each cylinder **(3)**	H	X				
Turbocharger lubricating oil inlet pressure **(3)(4)**	L					
Common rail servo oil pressure	L					
Pressure or flow of cooling system, if not connected to main system	L					
Temperature of cooling medium	H					
Level in cooling water expansion tank, if not connected to main system	L					
Engine speed				X		
	H		X **(6)**			
Fault in the electronic governor system	X					

(1) Not applicable to emergency generator set.
(2) For engines having a power of more than 2250 kW or a cylinder bore of more than 300 mm.
(3) For engine power > 500 kW/cyl.
(4) If without integrated self contained oil lubricating system.
(5) When a stand by pump is required.
(6) Not applicable to emergency generator set of less than 220 kW.

Table 13 : Auxiliary gas turbine driving generators

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required	Monitoring	Automatic control				
		Turbine			Auxiliary	
Identification of system parameter	Alarm	Slow-down	Shut-down	Control	Standby Start	Stop
Lubricating oil system						
• Turbine supply pressure	L	X			X	
	LL		X			
• Differential pressure across lubricating oil filter	H					
• Bearing or lubricating oil (discharge) temperature	H					
Mechanical monitoring of gas turbine						
• Speed				X		
	H		X			
• Vibration	H					
	HH		X			
• Rotor axial displacement (not applicable to roller bearing)	H					
	HH		X			
• Number of cycles performed by rotating parts	H					
Gas generator monitoring system						
• Flame and ignition failure			X			
• Fuel oil supply pressure	L					
• Fuel oil supply temperature	H + L					
				X		
• Cooling medium temperature	H					
• Exhaust gas temperature or gas temperature in specific locations of flow gas path (alarm before shutdown)	H					
	HH		X			
• Pressure at compressor inlet (alarm before shutdown)	L					
Miscellaneous						
• Control system failure	X					
• Automatic starting failure	X					

4.3 Control of electrical installation

4.3.1 *Where the electrical power can normally be supplied by one generator, suitable load shedding arrangement shall be provided to ensure the integrity of supplies to services required for the safety of the unit.*

4.3.2 Following a blackout, automatic connection of the standby generating set is to be followed by an automatic restart of the essential electrical services which are essential to ensure the safety of the unit. If necessary, time delay sequential steps are to be provided to allow satisfactory operation.

4.3.3 Monitored parameters for which alarms are required to identify machinery faults and associated safeguards are listed in Tab 11 and Tab 12. These alarms are to be indicated at the control location for machinery as individual alarms; where the alarm panel with all individual alarms is installed on the engine or in the vicinity, a common alarm in the control location for machinery is required. For communication of alarms from the machinery space to permanently manned control station area and accommodation for engineering personnel, detailed requirements are contained in Article [5].

5 Alarm system

5.1 General

5.1.1 A system of alarm displays and controls is to be provided which readily allows identification of faults in the machinery and satisfactory supervision of related equipment. This may be arranged at a main control station or, alternatively, at subsidiary control stations. In the latter case, a master alarm display is to be provided at the main control station showing which of the subsidiary control stations is indicating a fault condition.

5.1.2 Unless otherwise justified, separation of monitoring and control systems is to be provided.

5.2 Alarm system design

5.2.1 The alarm system is to be designed to function independently of control and safety systems, so that a failure or malfunction of these systems will not to prevent the alarm system from operating. Common sensors for alarms and automatic slowdown functions are acceptable as specified in each specific table.

5.2.2 The alarm system should be able to indicate at the same time more than one fault and the acceptance of any alarm should not inhibit another alarm.

5.2.3 The alarm system and associated sensors are to be capable of being tested during normal machinery operation.

5.2.4 Insulation faults on any circuit of the alarm system are to generate an alarm, when an insulated earth distribution system is used.

5.2.5 The alarm system is to have a connection to the engineers' public rooms and to each of the engineers' cabins through a selector switch, to ensure connection to at least one of those cabins.

5.2.6 An engineers' alarm is to be activated when the machinery alarm has not been accepted in the machinery spaces or control room within 5 minutes.

5.2.7 Requirements [5.2.5] and [5.2.6] may be omitted for units where machinery installation are under continuous supervision from the centralized control position. Means to check the operator alertness is to be provided, when alone.

5.3 Machinery alarm system

5.3.1 The local silencing of the alarms in accommodation spaces is not to stop the audible machinery space alarm.

5.3.2 Machinery faults are to be indicated at the control locations for machinery.

6 Safety systems

6.1 General

6.1.1 Safety systems of different units of the machinery plant are to be independent. Failure in the safety system of one part of the plant is not to interfere with the operation of the safety system in another part of the plant.

6.1.2 In order to avoid undesirable interruption in the operation of machinery, the system is to intervene sequentially after the operation of the alarm system by:

- starting of standby auxiliaries
- load reduction or shutdown, such that the least drastic action is taken first.

6.1.3 The arrangement for overriding the shutdown of the machinery systems is to be such as to preclude inadvertent operation.

7 Testing

7.1 General

7.1.1 Tests of automated installations are to be carried out according to Ch 3, Sec 6 to determine their operating conditions. The details of these tests are defined, in each case, after having studied the concept of the automated installations and their construction. A complete test program is to be submitted for approval.

7.1.2 The tests of equipment carried out alongside the quay under normal conditions of use include, for instance:

- the electrical power generating set
- the auxiliary steam generator
- the automatic bilge draining system
- automatic centrifugal separators or similar purifying apparatus
- automatic change-over of service auxiliaries
- detection of high pressure fuel leaks from diesel generating sets or from flexible boiler burner pipes.

7.1.3 Sea trials are used to demonstrate the proper operation of the automated machinery and systems. For this purpose, for instance, the following tests are to be carried out:

- Test of the operating conditions of the electrical production:
  - automatic starting of the generating set in the event of a blackout
  - automatic restarting of auxiliaries in the event of a blackout
  - load-shedding in the event of generating set overload
  - automatic starting of a generating set in the event of generating set overload.
- Test of fire and flooding system:
  - test of normal operation of the fire detection system (detection, system faults)
  - test of detection in the scavenging air belt and boiler air duct
  - test of the fire alarm system
  - test of protection against flooding.
- Test of operating conditions, including manoeuvring, of the whole machinery in an unattended situation for 6 h.

Part C
Facilities

CHAPTER 4
SAFETY FEATURES

Section 1	General
Section 2	Arrangement of Unit or Installation
Section 3	Hazardous Areas
Section 4	Structural Fire Protection
Section 5	Detection, Controls, Communications and Alarms
Section 6	Suppression of Fire: Fire Fighting
Section 7	Suppression of Fire: Structural Integrity
Section 8	Escape
Section 9	Fire Plan
Section 10	Helicopter Facilities
Section 11	Fire Safety Systems
Section 12	Additional Class Notation LSA

Section 1 General

1 Scope - Classification requirements

1.1 General

1.1.1 Safety features of offshore units intended to be classed by Bureau Veritas are to be designed in compliance with the applicable requirements of the present Chapter, or, subject to a preliminary agreement, in accordance with other particular specifications based on the same principles or applicable National or International Regulations.

Note 1: The attention of the Designer is drawn upon the fact that the present Chapter is intended to be used as specified by a set of Rules for Classification.

Indeed, the present Chapter contains only requirements applicable to a wide range of units and installations, specific requirements being excluded from its scope, as well as references to specific requirements contained in other Rule Notes or Rules.

Using the present Chapter without the support of Rules for Classification applicable to the type and service of unit or installation concerned might therefore lead to a complete misreading of applicable requirements.

1.1.2 The Society may, after special examination, allow alterations or additions to requirements of the present Chapter in certain particular cases relating for instance to small units, units operating in restricted zones or platforms installed in sheltered coastal areas.

1.2 Requirements applicable to piping

1.2.1 Piping and accessories are to comply with the applicable requirements of Part C, Chapter 1 in addition to those given in the present Chapter.

1.3 Surveys and tests

1.3.1 Systems and equipment dealt with in the present Chapter are to be constructed and assembled to the Surveyor's satisfaction, upon application of the Builder, under conditions specified by the applicable Rules for Classification.

1.3.2 Tests of systems and equipment dealt with in the present Chapter are to be carried out as specified in Part C, Chapter 1, as applicable. Refer also to NR266 Survey of Materials and Equipment at Works.

1.3.3 During the trial of the unit or the commissioning of the installation, the Surveyor will check the normal operation of system and equipment dealt with by the present Chapter in order to assess the compliance with rule requirements.

1.3.4 Attention of the Owner and Operator is drawn on the fact that it is their responsibility to maintain the installations and systems mentioned in the present Rules in safe and good working conditions.

2 Statutory requirements

2.1 International Regulations

2.1.1 Attention is directed to the International Regulations the unit or installation may have to comply with, such as, for mobile units:

- IMO Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU code)
- International Convention for the Safety of Life at Sea (SOLAS)
- International Convention for Prevention of Pollution (MARPOL)
- IMO Code for Fire Safety Systems (FSS Code)
- IMO Code for Application or Fire Test Procedures (FTP Code).

Attention is also draw to the fact that Owners may require compliance to these regulations or parts of them.

2.2 National Authorities requirements

2.2.1 The attention of Owners, designers, builders and other interested parties is drawn to special legal provisions enacted by National Authorities which units or installations may have to comply with according to their flag, type, size, operational site and intended service, as well as other particulars and details.

2.2.2 Classification and statutory requirements

Statutory requirements mentioned in [2.1.1] and in [2.2.1] are to take precedence over the requirements of the present Chapter, as stated in Pt A, Ch 1, Sec 1, [2] and, in case of conflict between this chapter and these requirements, are to be brought to the attention of the Society by the party applying for classification.

In such instances the Society reserves the right to call for the necessary adaptation to preserve the intent of the rule requirements or to refuse or to withdraw the classification of the unit or installation not complying with applicable requirements of the rules.

3 Definitions

3.1 General

3.1.1 Definitions used in the present Chapter are, as a general rule, the ones of MODU Code and SOLAS Convention.

3.2 Machinery spaces, working spaces, hazardous areas

3.2.1 “Machinery spaces of category A” are those spaces and trunks to such spaces which contain either:

- internal combustion machinery used for main propulsion
- internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW, or
- any oil-fired boiler or oil fuel unit, or any oil-fired equipment other than boilers, such as inert gas generators, incinerators, etc.

Note 1: For the purpose of the present requirement and of [3.2.2], an oil fuel unit, according to SOLAS, is defined as an equipment used for the preparation of oil fuel for delivery to an oil-fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 1,8 bar.

Separate spaces provided for the installation of incinerators burning other residues than oil residues are to be considered as machinery spaces of category A.

3.2.2 “Machinery spaces” are machinery spaces of category A and all other spaces containing propelling machinery, boilers and other fired processes, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilising, ventilation and air-conditioning machinery and similar spaces, and trunks to such spaces.

3.2.3 “Working spaces” are those open or enclosed spaces containing equipment and processes associated with the operation of the unit, which are not included in spaces defined in [3.2.2] or [3.2.4].

3.2.4 “Hazardous areas” are all those areas where, due to the possible presence of a flammable atmosphere, the use without proper consideration of machinery or electrical equipment may lead to fire hazard or explosion. Hazardous areas are further defined in Ch 4, Sec 3.

3.3 Service spaces

3.3.1 “Service spaces (low risk)” are lockers, store-rooms and working spaces in which flammable materials are not stored, drying rooms and laundries.

3.3.2 “Service spaces (high risk)” are lockers, store-rooms and working spaces in which flammable materials are stored, galleys, pantries containing cooking appliances, paint rooms and workshops other than those forming part of the machinery space.

3.3.3

a) Main pantries and pantries containing cooking appliances may contain:
   - toasters, microwave ovens, induction heaters and similar appliances each of them with a power of more than 5 kW; and
   - electrically heated cooking plates and hot plates for keeping food warm each of them with a maximum power of 5 kW.

   These pantries may also contain coffee machines, dish washers and water boilers regardless of their power.

b) Spaces containing any electrically heated cooking plate or hot plate for keeping food warm with a power of more than 5 kW should be regarded as galleys.

3.4 Control stations, central control room

3.4.1 “Control stations” are those spaces in which the unit's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment or the dynamic positioning control system is centralised or where a fire-extinguishing system serving various locations is situated. In the case of column stabilized units, a centralised ballast station is a “control station”.

3.4.2 “Central control room” is the space where all control, indicator and monitoring functions of the various systems and processes of the unit installations are centralized. The central control room is to be continuously manned.

On mobile units, the central control room is the navigation bridge.

3.5 Accommodation and corridors

3.5.1 "Accommodation spaces" are those used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, pantries containing no cooking appliances and similar spaces. Public spaces are those portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

3.5.2 Pantries or isolated pantries containing no cooking appliances may contain:

- toasters, microwave ovens, induction heaters and similar appliances each of them with a maximum power of 5 kW; and
- electrically heated cooking plates and hot plates for keeping food warm each of them with a maximum power of 2 kW and a surface temperature not above 150°C.

These pantries may also contain coffee machines, dish washers and water boilers with no exposed hot surfaces regardless of their power.

A dining room containing such appliances should not be regarded as a pantry.

3.6 Deck and bulkhead fire ratings and fire materials

3.6.1 "Non-combustible material" is a material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined in accordance with the Fire Test Procedures Code. Any other material is a combustible material.

In general, products made only of glass, concrete, ceramic products, natural stone, masonry units, common metals and metal alloys are considered as being non-combustible and may be installed without testing and approval.

3.6.2 "Low flame-spread" means that the surface thus described is to adequately restrict the spread of flame, this being determined in accordance with the Fire Test Procedures Code.

3.6.3 "Standard fire test" means a test in which specimens of the relevant bulkheads or decks are exposed in a test furnace to temperatures corresponding approximately to the standard time-departure curve in accordance with the test method specified in the Fire Test Procedures Code.

3.6.4 "A class divisions" are those divisions formed by bulkheads and decks which comply with the following criteria:

a) they are constructed of steel or other equivalent material

b) they are suitably stiffened

c) they are insulated with approved non-combustible materials such that the average temperature of the unexposed side is not to rise more than 140°C above the original temperature, nor is the temperature, at any one point, including any joint, to rise more than 180°C above the original temperature, within the time listed below:
   - class "A-60": 60 min
   - class "A-30": 30 min
   - class "A-15": 15 min
   - class "A-0": 0 min.

d) they are so constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test, and

e) the Society required a test of a prototype bulkhead or deck in accordance with the Fire Test Procedures Code to ensure that it meets the above requirements for integrity and temperature rise.

3.6.5 "B class divisions" are those divisions formed by bulkheads, decks, ceilings or linings which comply with the following criteria:

a) they are constructed of approved non-combustible materials and all materials used in the construction and erection of "B" class divisions are non-combustible, with the exception that combustible veneers may be permitted provided they meet other appropriate requirements of the present Chapter

b) they have an insulation value such that the average temperature of the unexposed side is not to rise more than 140°C above the original temperature, nor is the temperature at any one point, including any joint, to rise more than 225°C above the original temperature, within the time listed below:
   - class "B-15": 15 min.
   - class "B-0": 0 min.

c) they are so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test, and

d) the Society required a test of a prototype division in accordance with the Fire Test Procedures Code to ensure that it meets the above requirements for integrity and temperature rise.

3.6.6 "C class divisions" are divisions constructed of approved non-combustible materials. They need meet neither requirements relative to the passage of smoke and flame nor limitation relative to the temperature rise. Combustible veneers are permitted provided they meet the requirements of the present Chapter.

3.6.7 "H class divisions" are those divisions formed by bulkheads and decks which comply with the construction and integrity requirements a) and b) for "A" class divisions, and with the following:

a) They are to be so constructed as to be capable of preventing the passage of smoke and flame up to the end of the two hours hydrocarbon fire test

b) They are to be insulated with approved non-combustible materials such that the average temperature, on the unexposed side, when exposed to a hydrocarbon fire test, is not to rise more than 140°C above the original temperature, nor is the temperature at any one point, including any joint to rise more than 180°C above the original temperature within the time listed below:

  - class "H-120": 120 min.
  - class "H-60": 60 min.
  - class "H-0": 0 min.

c) A test of a prototype bulkhead or deck may be required to ensure that it meets the above requirements for integrity and temperature rise.

A "hydrocarbon fire test" is one in which the specimens defined for a standard fire test are exposed in a test furnace to temperatures corresponding approximately to a time temperature relating to, and defined by, a smooth curve drawn through the following temperature points measured above the initial furnace temperature:

- at the end of the first 3 minutes: 880°C
- at the end of the first 5 minutes: 945°C
- at the end of the first 10 minutes: 1032°C
- at the end of the first 15 minutes: 1071°C
- at the end of the first 30 minutes: 1098°C
- at the end of the first 60 minutes: 1100°C.

3.6.8 "Steel or other equivalent material" means steel or any non-combustible material which, by itself or due to insulation provided, has structural and integrity properties equivalent to steel at the end of the applicable fire exposure to the standard fire test (e.g. aluminium alloy with appropriate insulation).

3.6.9 A fan is considered as a "non-sparking fan" if in either normal or abnormal conditions it is unlikely to produce sparks. For this purpose, the following criteria are to be met:

a) Design criteria

  1) The air gap between the impeller and the casing is to be not less than 1/10 of the shaft diameter in way of the impeller bearing and in any case not less than 2 mm, but need not exceed 13 mm.

  2) Protective screens with square mesh of not more than 13 mm are to be fitted to the inlet and outlet of ventilation ducts to prevent objects entering the fan housing.

b) Materials

  1) The impeller and the housing in way of the impeller are to be made of spark-proof materials which are recognised as such by means of an appropriate test to the satisfaction of the Society.

  2) Electrostatic charges, both in the rotating body and the casing, are to be prevented by the use of antistatic materials. Furthermore, the installation on board of ventilation units is to be such as to ensure their safe bonding to the hull.

  3) Tests may not be required for fans having the following material combinations:

    - impellers and/or housings of non-metallic material, due regard being paid to the elimination of static electricity
    - impellers and housings of non-ferrous materials
    - impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous material is fitted in way of the impeller
    - any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm design tip clearance.

  4) The following impeller and housing combinations are considered as sparking and therefore are not permitted:

    - impellers of an aluminium alloy or a magnesium alloy and a ferrous housing, regardless of tip clearance
    - housings made of an aluminium alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance
    - any combination of ferrous impeller and housing with less than 13 mm design tip clearance.

  5) Complete fans are to be type-tested in accordance with either the Society's requirements or national or international standards accepted by the Society.

3.7 Fire Test Procedures Code

3.7.1 Fire Test Procedures Code means the "International Code for Application of Fire Test Procedures, 2010" (2010 FTP Code), as adopted by the Maritime Safety Committee of the IMO by Resolution MSC.307 (88), as may be amended by the IMO.

3.8 Fire damper

3.8.1 *Fire damper is, for the purpose of implementing requirements of Ch 4, Sec 4, [5], a device installed in a ventilation duct, which under normal conditions remains open allowing flow in the duct, and is closed during a fire, preventing the flow in the duct to restrict the passage of fire. In using the above definition the following terms may be associated:*

a) automatic fire damper is a fire damper that closes independently in response to exposure to fire products

b) manual fire damper is a fire damper that is intended to be opened or closed by the crew by hand at the damper itself; and

c) remotely operated fire damper is a fire damper that is closed by the crew through a control located at a distance away from the controlled damper.

4 Type approved products

4.1 General

4.1.1 The following materials, equipment, systems or products in general used for fire protection are to be of a type approved by the Society, except for special cases for which the acceptance may be given for individual units on the basis of suitable documentation or ad hoc tests:

a) H, A, B class fire divisions (bulkheads or decks) and associated openings

b) C-class divisions

c) materials for pipes penetrating H, A or B class divisions (where they are not of steel or other equivalent material)

d) bulkhead or deck penetrations for electrical cables passing through H, A or B class divisions

e) fire dampers

f) prefabricated sanitary units

g) prefabricated window casings

h) fire door control systems

i) flexible pipes and expansion bellows of non-conventional material for any type of fluid

j) materials with low flame spread characteristic including paints, varnishes and similar, when they are required to have such characteristic

k) non-combustible materials

l) non-readily igniting materials for primary deck coverings

m) fixed foam fire-extinguishing systems and associated foam-forming liquids

n) fixed powder fire-extinguishing systems, including the powder

o) equivalent water-mist fire-extinguishing systems

p) equivalent fixed gas fire-extinguishing systems

q) fixed water-based local application fire-extinguishing systems

r) equivalent water-mist automatic sprinkler systems

s) fixed fire-extinguishing systems for protection of galley cooking equipment

t) portable fire-extinguishers

u) non-portable and transportable fire-extinguishers

v) fire hoses

w) portable foam applicators

x) water and foam monitors

y) foam proportioner/inductor

z) sprinkler heads for automatic sprinkler systems

aa) nozzles for fixed pressure water-spraying fire-extinguishing systems for machinery spaces, boiler rooms, deep-fat cooking equipment fire-extinguishing systems, and spaces intended for the carriage of vehicles and for hangars

ab) sensing heads for automatic fire alarm and fire detection systems

ac) fixed fire detection and fire alarm systems

ad) flammable gas detection systems

ae) explosive mixture detecting systems

af) portable explosive mixture detecting apparatus

ag) fixed instruments for measuring the oxygen content for inert gas systems serving cargo tanks

ah) portable instruments for measuring the oxygen content for inert gas systems serving cargo tanks.

As regards the granting of type approval, the requirements of Part A apply.

The Society may request type approval for other materials, equipment, systems or products required by the applicable provisions for units or installations of special types.

5 Fire safety

5.1 General

5.1.1 The provisions and requirements regarding fire safety are defined in the following Sections:

- Structural fire protection: Ch 4, Sec 4
- Detection, controls, communications and alarms: Ch 4, Sec 5
- Suppression of fire: Fire fighting: Ch 4, Sec 6
- Suppression of fire: Structural integrity: Ch 4, Sec 7
- Means of escape: Ch 4, Sec 8
- Fire plan: Ch 4, Sec 9
- Fire safety provisions for helicopter facilities: Ch 4, Sec 10
- Fire safety systems: Ch 4, Sec 11.

5.2 Alternative design and arrangement

5.2.1 When fire safety design or arrangements deviate from the prescriptive provisions of the Sections referred to in [5.1.1], engineering analysis, evaluation and approval of the alternative design and arrangements should be carried out in accordance with SOLAS regulation II-2/17.

Section 2 Arrangement of Unit or Installation

1 General

1.1 Principles of design

1.1.1 The layout of the unit or installation is to be designed giving due consideration to safety of personnel, prevention of pollution and protection of industrial properties.

1.1.2 The principle of risk segregation is to be applied and potential sources of fuel are to be separated as far as practicable from potential sources of ignition.

1.1.3 The unit or installation is to be so arranged as to minimise the risk of occurrence of accidents, the risk of escalation, to protect the accommodation from the consequences of accidents affecting other areas and to allow a safe evacuation when necessary.

1.2 Risk analyses - Safety level

1.2.1 If deemed necessary by the Society, risk analysis is to be performed to validate the arrangement and to determine the accidental loads equipment and systems are to be capable to withstand. Reference is made in this respect to Recommended Practice API RP 14J for design and hazard analysis for offshore production facilities.

1.2.2 A suitable safety level is to be maintained and verified throughout the life of the unit or installation.

1.2.3 Access is to be provided for maintenance and inspection of hazardous equipment, safety equipment and load bearing structures.

1.2.4 Possible future modifications are to be taken into account as practicable.

2 Location and arrangement of areas

2.1 Relative location and separation of areas

2.1.1 A risk grading principle is to be used: areas with low risk are to be located between areas with high risk and living quarter and control stations.

2.1.2 The different areas are to be separated by a suitable distance or by adequately rated fire and blast bulkheading.

2.2 Location and arrangement of accommodation and control stations

2.2.1 Accommodation and control stations are to be located outside hazardous areas.

2.2.2 Accommodation and control stations are not to be located above wellhead, processing or storage areas.

2.2.3 The accommodation is to have a direct access to the helideck and/or to the boat landing.

2.2.4 Ventilation intakes are to be located so as to minimise the risk of ingress of gas or smoke.

2.3 Arrangement of wellhead area

2.3.1 Wellhead and Christmas tree area is to be protected against mechanical, fire or explosion loads from adjacent areas.

2.4 Location and arrangement of helideck area

2.4.1 As a rule, the helideck is to be located under the prevailing wind of the unit or installation.

2.4.2 Exhaust from turbines, fired equipment engines, flare or vents are to be located so as not to disturb the operation of the helideck.

2.5 Location and arrangement of cranes and lay down areas

2.5.1 Cranes and lay down areas are to be located so as to minimise load lifting over wellhead and process areas.

2.6 General orientation of the unit or installation

2.6.1 The general orientation of the unit or installation is to be as far as practicable such as the living quarter is not located under the prevailing wind of drilling, wellhead, process area, flare or cold vent.

2.6.2 The hazardous areas are not to be as far as practicable under the prevailing wind of the flare.

2.6.3 The general orientation with regard to current is to be as far as practicable such as liquid hydrocarbons leaks will not be pushed towards accommodation.

Section 3 Hazardous Areas

1 Definitions

1.1 Hazardous areas

1.1.1 Hazardous areas are all those areas where, due to the possible presence of a flammable atmosphere, the use without proper consideration of machinery or electrical equipment may lead to fire hazard or explosion.

1.1.2 Under normal operating conditions, a hazardous zone or space may arise from the presence of any of the following:

a) Spaces or tanks containing any of the following:
   1) flammable liquid having a flash point not exceeding 60°C closed-cup test
   2) flammable liquid having a flash point above 60°C closed-cup test, heated or raised by ambient conditions to a temperature within 15°C of its flash point
   3) flammable gas.

b) Piping systems or equipment containing fluid defined in a) and having flanged joints, glands or other fittings through which leakage of fluid may occur.

c) Piping systems or equipment containing flammable liquid not defined in above a) and having flanged joints, glands or other fittings through which leakage of fluid in the form of a fine spray or mist may occur.

d) Equipment associated with processes such as battery charging or electrochlorination which generate flammable gas as a by-product, and having vents or other openings from which gas may be released.

e) Equipment associated with drilling operations.

1.2 Zones

1.2.1 Hazardous areas as defined in [1.1], are divided into zones as follows:

Zone 0 : Zone in which ignitable concentrations of flammable gases or vapours are continuously present or present for long periods

Zone 1 : Zone in which ignitable concentrations of flammable gases or vapours are likely to occur in normal operation

Zone 2 : Zone in which ignitable concentrations of flammable gases or vapours are not likely to occur, or in which such a mixture, if it does occur, will only exist for a short time.

Non-hazardous areas are those which are not classified as hazardous according to the above definitions.

Indication of the frequency of the occurrence and duration may be taken from recognised international codes and standards. Guidance on duration for each “grade of release” (see [1.6]) may be taken from IP Code Part 15 (see [3]), paragraphs 1.5.5.2 and 1.5.4 for a continuously operated plant in open air:

- Zone 0 : Typical for continuous grade source present for more than 1000 hours a year or that occurs frequently for short periods
- Zone 1 : Typical for primary grade source present between 10 and 1000 hours a year
- Zone 2 : Typical for secondary grade source present for less than 10 hours per year and for short periods only.

Conditions of ventilation may change the zone definition for each grade of release. Also, the likehood of detecting the leak may influence the zone.

1.3 Enclosed spaces

1.3.1 Enclosed spaces are spaces delineated by floors, bulkheads and/or decks which may have doors or windows, such that in the absence of artificial ventilation, the ventilation will be limited and any flammable atmosphere will not be dispersed naturally.

1.4 Semi-enclosed spaces

1.4.1 Semi-enclosed locations are locations where natural conditions of ventilation are notably different from those on open decks due to the presence of structures such as roofs, windbreaks or bulkheads, and which are so arranged that dispersion of gas may not occur.

1.5 Open spaces

1.5.1 Open spaces are spaces in open air situation without stagnant areas where vapours are rapidly dispersed by wind and natural convection. Typical air velocities should rarely be less than 0,5 m/s and should frequently be above 2 m/s.

Note 1: If necessary, the Society may refer to Institute of Petroleum publications such as IP 15 § 6 for the relationship between the ventilation and the classification into enclosed, semi-enclosed and open spaces as defined in [1.3] to [1.5].

1.6 Sources of release

1.6.1 Release of explosive gas-air mixtures may be categorized into continuous, primary and secondary grades:

a) Continuous grades of release include the following:
   1) surface of a flammable liquid in a closed tank or pipe
   2) vent or other opening which releases flammable gases or vapours frequently, continuously or for long periods.

b) Primary grades of release include the following:
   1) pumps and compressors with standard seals, and valves, flanges and fittings containing flammable fluids if release of fluid to atmosphere during normal operation may be expected
   2) sample points and process equipment drains which may release flammable fluid to atmosphere during normal operation
   3) pig launcher and receiver doors which are opened frequently
   4) vents which frequently release small quantities, or occasionally release larger quantities, of flammable gases to atmosphere
   5) tanks or openings of the active mud circulating system between the well and the final degasser discharge which may release gas during normal operation
   6) drilling operations in enclosed or semi-enclosed spaces.

c) Secondary grades of release include the following:
   1) pumps and compressors with high integrity seals, and valves, flanges and fittings containing flammable fluids
   2) vents which release flammable gases intermittently to atmosphere
   3) tanks or openings of the mud circulating system from the final degasser discharge to the mud pump connection at the mud pit
   4) drilling, workover and wirelining operations in open spaces.

2 Classification of hazardous areas

2.1

2.1.1 General

a) For the purpose of machinery and electrical installations, hazardous areas are classified as follows. Hazardous areas not covered (such as, but not limited to, well test equipment areas, helicopter fuel storage areas, acetylene cylinder storage areas, battery rooms, paint lockers, flammable gas or vapour vents and diverter line outlets) in the present Article are to be classified in accordance with [1.2].

b) The hazardous areas as specified may be extended or reduced depending on the actual arrangements in each case, by use of windshields, special ventilation arrangements, structural arrangements (e.g. low deck head), etc.

c) Hazardous area classification of offshore mobile drilling units is to comply with the provisions of [2.1.2] to [2.1.4].

2.1.2 Hazardous areas Zone 0

a) The internal spaces of closed tanks and piping for containing active non-degassed drilling mud, oil that has a closed-cup flashpoint below 60°C or flammable gas and vapour, as well as produced oil and gas in which an oil/gas/air mixture is continuously present or present for long periods.

b) Unventilated spaces separated by a single bulkhead or deck from a tank containing flammable liquid or gas.

c) In open spaces, the area within 3 m radius from continuous grades of release.

d) Based on above definitions, Zone 0 includes for example:
   - areas within process apparatus developing gas or vapours
   - areas within enclosed pressure vessels or storage tanks containing oil and gas products
   - areas within 3m radius around vent pipes (releasing flammable gases or vapours) which discharges continuously or for long periods
   - areas over/near surface of flammable liquids in general.

2.1.3 Hazardous areas Zone 1

a) Adequately ventilated closed or semi-enclosed spaces containing primary grades of release. See [1.6], item b).

b) Mechanically ventilated closed spaces separated by a single bulkhead or deck from a tank intended for the storage in bulk of flammable liquid or gas.

c) In open spaces, the area within 3 m radius from primary grades of release and from any ventilation outlet from a Zone 1 space.

d) In open spaces, the area within 3 m from pig launcher and receiver doors. This may be reduced to 1,5 m if the equipment is washed through with nitrogen or water washed before opening.

e) In open or semi-enclosed spaces, the area within 1,5 m of the boundaries of any access to Zone 1.

f) The paint stores and supply and exhaust ventilation ducts serving such spaces.

g) Semi-enclosed spaces, such as inadequately ventilated pits, ducts or similar structure situated in locations which should otherwise be a Zone 2, but where their arrangement is such that gas dispersion cannot easily occur.

h) In open spaces, the area below the drill floor and within a radius of 1,5 m from a possible source of release such as the top of a drilling nipple.

i) Following hazardous area classifications are to be complied with as applicable (generally for mobile offshore drilling units):
   1) enclosed spaces containing any part of the mud-circulating system that has an opening into the spaces and is between the well and the final degassing discharge
   2) enclosed spaces or semi-enclosed locations that are below the drill floor and contain a possible source of release such as the top of a drilling nipple
   3) enclosed spaces that are on the drill floor and which are not separated by a solid floor from the space in item i) 2)
   4) in open or semi-enclosed spaces except as provided for in item i) 2), the area within 1,5 m of the boundaries of any openings to apparatus which is part of the mud system as specified in item i) 1) or any access to Zone 1 spaces and the area within 3 m of any ventilation outlets of Zone 1 spaces.

j) Based on above definitions, Zone 1 includes for example:
   - area above roof and outside sides of storage tanks
   - areas with a 3 m radius around the outlet vent pipes, pipelines and safety lines
   - rooms without ventilation with direct access from a Zone 1 or a Zone 2
   - rooms or parts of rooms containing secondary sources of release, be where internal outlets indicate Zone 2, but where efficient dilution of an explosive atmosphere cannot be expected because of a lack of ventilation
   - areas around ventilation opening from a Zone 1 area
   - area around flexible pipelines and hoses
   - area around sample tacking points (valves, etc.)
   - areas around seals of pumps, compressors, and similar apparatus, if primary source of release.

2.1.4 Hazardous areas Zone 2

a) Adequately ventilated closed or semi-enclosed spaces containing secondary grades of release (see [1.6] item c)).

b) In open spaces, the area within a radius of 3 m from secondary grades of release, any ventilation outlet from a Zone 2 space or from a space ventilated as per [1.5.1] and containing primary grades of release.

c) The area within 1,5 m from flange joints, glands or other fittings or openings as defined in [1.1.2] items c) and d).

d) The area within a 3 m radius from bunds or barriers intended to contain spillage of liquids defined in [1.1.2], item a).

e) In open spaces, the area below the drill floor and within a radius 1,5 m beyond the Zone 1 area.

f) The areas 1,5 m beyond the Zone 1 areas specified in [2.1.3].

g) Areas on open deck within 1 m of inlet and exhaust ventilation openings of paint stores or within 3 m of exhaust mechanical ventilation outlets of such spaces.

h) Open spaces or semi-enclosed spaces within 1,5 m of the boundaries of any access to a Zone 2 space unless [4.1.1] is applicable.

i) Air locks between Zone 1 and a non-hazardous area.

j) Following hazardous area classifications are to be complied with as applicable (generally for mobile offshore drilling units):
   1) enclosed spaces which contain open sections of the mud circulating system from the final degassing discharge to the mud pump suction connection at the mud pit
   2) open locations within the boundaries of the drilling derrick up to a height of 3 m above the drill floor
   3) semi-enclosed locations below and contiguous with the drill floor and to the boundaries of the derrick or to the extent of any enclosure which is liable to trap gases
   4) Outdoor locations below the drill floor, within a radius of 1,5 m area beyond the Zone 1 area as specified in [2.1.3], item h)
   5) the areas 1,5 m beyond the semi-enclosed locations specified in [2.1.3] items i) 2) and i) 4)
   6) semi-enclosed derricks to the extent of their enclosures above the drill floor or to a height of 3 m above the drill floor, whichever is greater.

k) Based on above definitions, Zone 2 includes for example:
  - area around flanges, connections, valves, etc.
  - areas outside of Zone 1, around the outlet of vent pipes, pipelines and safety valves
  - areas around vent openings from Zone 2 area.

2.2 Provisions regarding mobile and fixed offshore units

2.2.1 Pipelines without flanges, connections, valves or other similar fittings are not to be regarded as a source of release.

2.2.2 Certain areas and rooms are to be, if so indicated by the circumstances, classified as more hazardous zones than set out in these examples.

2.2.3 Certain areas and rooms may under certain circumstances and/or when special precautions are taken, be classified as a less hazardous zone than indicated by these examples. Such special circumstances may be, shielding or reinforced ventilation arrangements.

2.2.4 Enclosed rooms, without ventilation, with openings to an area with explosion risks, are to be designed as the same, or as a more hazardous zone than such an area.

2.3 Extension of hazardous areas due to emergency conditions

2.3.1 In view of extension of hazardous areas due to emergency conditions, requirements of Ch 2, Sec 15, [3] are to be considered.

3 Recognised codes

3.1

3.1.1 In addition to the general provisions of this Section, the Society may refer to the following recognised codes and standards:
- API RP 505 “Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities”
- EI Code of safe practice, Part 15 “Area Classification Code for installations handling flammable fluids”
- IEC 60079-10 “Electrical apparatus for explosive gas atmospheres - Part 10: Classification of hazardous areas”
- IEC 60092-502 “Electrical installations in ships - Part 502: Tankers - Special features”
- IEC 61892-7 “Mobile and fixed offshore units - Electrical installations - Part 7: Hazardous area”
- IMO MODU Code.

4 Openings, access, ventilation, piping conditions affecting the extent of hazardous areas

4.1 Openings, access and ventilation

4.1.1 Except for operational reasons access doors or other openings are not to be provided between:
- a non-hazardous space and a hazardous area
- a Zone 2 space and a Zone 1 space.

Where such access doors or other openings are provided, any enclosed space not referred to in [2.1.3] or [2.1.4] or [2.1.3] item h) or [2.1.4] item i) and having a direct access to any Zone 1 location or Zone 2 location becomes the same zone as the location except that:

a) An enclosed space with direct access to any Zone 1 location can be considered as Zone 2 if:
  - the access is fitted with a self-closing gas-tight door opening into the Zone 2 space, and
  - ventilation is such that the air flow with the door open is from the Zone 2 space into the Zone 1 location, and
  - loss of ventilation is alarmed at a manned control station.

b) An enclosed space with direct access to any Zone 2 location is not considered hazardous if:
  - the access is fitted with a self-closing gas-tight door that opens into the non-hazardous location, and
  - ventilation is such that the air flow with the door open is from the non-hazardous space into the Zone 2 location, and
  - loss of ventilation is alarmed at a manned control station.

c) An enclosed space with direct access to any Zone 1 location is not considered hazardous if:
- the access is fitted with gas-tight self-closing doors forming an air lock, and
- the space has ventilation overpressure in relation to the hazardous space, and
- loss of ventilation overpressure is alarmed at a manned control station.

Where ventilation arrangements of the intended safe space are considered sufficient by the Society to prevent any ingress of gas from the Zone 1 location, the two self-closing doors forming an air lock may be replaced by a single self-closing gas-tight door which opens into the non-hazardous location and has no hold-back device.

d) Enclosed spaces giving access to paint stores may be considered as non-hazardous, provided that:
- the door to the paint store is a gastight door with self-closing devices without holding-back arrangements. A watertight door may be considered as being gastight
- the paint store is provided with an acceptable, independent, natural ventilation system ventilated from a safe area, and
- warning notices are fitted adjacent to the paint store entrance stating that the store contains flammable liquids.

e) Notices warning that the doors are to be kept closed are to be fitted whenever any of the above arrangement were adopted.

4.1.2 Hold back devices are not to be used on self-closing gastight doors forming hazardous areas boundaries.

4.2 Pipings

4.2.1 Piping systems are to be designed to preclude direct communication between hazardous areas of different classifications and between hazardous and non-hazardous areas.

5 Ventilation

5.1 General

5.1.1 Attention is to be given to ventilation inlet and outlet location and airflow in order to minimize the possibility of cross contamination. Inlets are to be located in non-hazardous areas as high and as far away from any hazardous area as practicable. Ventilation systems for hazardous areas are to be completely separate from those used for non-hazardous areas.

5.1.2 Hazardous enclosed spaces are to be ventilated to reduce the accumulation of explosive gas. Where possible, it shall eliminate the hazardous area or lessen the area classification, (for example from Zone 0 where an explosive atmosphere is present continuously or for long period, to Zone 1 where it is likely to occur in normal operation). Where mechanical ventilation is applied it is to be such that the hazardous enclosed spaces are maintained with underpressure in relation to the less hazardous spaces or areas and non-hazardous enclosed spaces are maintained in overpressure in relation to adjacent hazardous locations (at a minimum of 0,25 mbar).

5.2 Air inlets and discharges

5.2.1 The arrangement of ventilation inlet and outlet openings in the space is to be such that the entire space is efficiently ventilated, giving special consideration to location of equipment which may release gas, and to spaces where gas may accumulate.

5.2.2 The air inlets for the ventilation systems are to be located in a designated safe area and at least 3 m from any hazardous area.

Where the inlet duct passes through an hazardous area the inlet duct is to have overpressure in relation to this area.

5.2.3 Air intakes and openings into the accommodation spaces and all service and control station spaces are to be fitted with closing devices. For toxic gases, these devices are to be operable from inside the space.

5.2.4 The air inlets and discharges of the ventilation systems are to be situated so that recirculation of the vented vapours does not occur.

In particular, the discharges from ventilation systems which may contain hazardous vapours are to be located not less than 8 m from the nearest air intake or opening to accommodation, service and control station spaces or other safe spaces, and from all possible sources of ignition.

5.2.5 Each air outlet from hazardous spaces is to be located in an outdoor area which in the absence of the considered outlet is of the same or lesser hazard than the ventilated space.

5.2.6 The discharges from ventilation systems which may contain vapours that present a hazard due to reaction with each other are to be effectively segregated.

5.2.7 The outlet air from Zone 1 and Zone 2 spaces is to be led in separate ducts to outdoor locations. The internal spaces of such ducts belong to the same Zone as the inlet space. Air inlet ducts designed for constant relative underpressures are to be rigidly constructed to avoid air leaks. Non sparking fans are to be used.

Hazardous enclosed mud processing spaces are to be ventilated at a minimum rate of 12 air changes per hour.

5.2.8 Where the ventilation duct passes through a hazardous area of a higher level, the ventilation duct is to have overpressure in relation to this area; where the ventilation duct passes through a hazardous area of a lower level, the ventilation duct is to have underpressure in relation to this area.

5.3 Capacity of ventilation system to hazardous area spaces

5.3.1 Ventilation is regarded as adequate if it is sufficient to prevent accumulation of flammable gas.

5.3.2 The capacity of the ventilation systems is normally to be so that it allows not less than:

- 12 air changes per hour for enclosed spaces without stagnant areas, in particular those associated with hydrocarbon production and the mud processing areas.
- 8 air changes per hour for other enclosed spaces.

5.4 Open and semi-enclosed areas

5.4.1 Open and semi-enclosed areas without solid floor nor ceiling may be considered as adequately ventilated.

5.4.2 Open areas with natural ventilation are to have a sufficient air flow-through.

5.4.3 Sheltered or obstructed open areas with natural ventilation are to be provided with sufficient openings in decks, bulkheads or ceilings.

5.5 Gas safe compartments

5.5.1 Gas safe rooms or spaces located within an exterior hazardous atmosphere, including control rooms, are to be protected with an overpressure ventilation (maintaining an overpressure of 0,25 mbar minimum).

In particular, where it is impracticable to locate a plant service space or control station so that any access thereto is from a safe space, the service space or control station is to be maintained at an overpressure above the surrounding spaces. Details of the arrangements to ensure that this pressure differential is maintained are to be submitted.

5.6 Ventilation material and equipment

5.6.1 The number and capacity of fans are to be such that the minimum ventilation capacity required in each compartment is maintained at all times, with one unit out of service. If internal combustion engines are proposed, their fuel supply is to be kept separate from any other system. Electric motors are to be supplied by two alternative circuits each of which is capable of supplying all the motors which are normally connected to that circuit and which are operated simultaneously.

5.6.2 The ventilation system is to be capable of being controlled from a position outside the compartment being ventilated.

5.6.3 Each fan situated in an hazardous area is to be non-sparking.

5.7 Ventilation and operation of rooms or buildings protected by pressurization

5.7.1 Electrical apparatus liable to cause an ignition, may be used in a room or building located in a hazardous area, provided the ingress of the explosive atmosphere is prevented by maintaining inside it a protective gas at a higher pressure than that of the outside atmosphere.

5.7.2 During initial start-up or after shutdown, and whatever the classification of the hazardous area, it is necessary, before energizing any electrical apparatus in the room which is not suitably protected for the classification of the area to:

a) either ensure that the internal atmosphere is not hazardous (see Note 1), or proceed with prior purging of sufficient duration that the internal atmosphere may be considered as non-hazardous (see Note 2)

b) pressurize the room.

Note 1: An atmosphere is considered non-hazardous when, at all points in the room, the enclosures and associated ducts, the concentration of explosive gases or vapours is below 25% of the lower explosive limit. The place of measurement should be judiciously chosen to determine the highest concentration of gas.

Note 2: Generally, the volume of protective gas required for purging is estimated as at least 5 times the internal volume of the room and its associated ducts.

5.7.3 Fixed gas detectors are to be installed at the ventilation air intake; in the event of gas detection at 25% of LEL, visible and audible alarms are to be actuated in a location where they will immediately be perceived by the responsible personnel.

Note 1: Gas detectors which are not intrinsically safe are to be certified for the groups of gases they are operating in.

5.7.4 In the event of detection of an explosive gas concentration at 60% LEL, an automatic shut-down of process and apparatus which is not certified gas safe type, is to be initiated.

Note 1: It may well necessary, to avoid false indications and possible inadvertent shut-down, to apply a coincidence voting arrangement where monitoring is carried out employing 3 detectors, in which operation of any detector at low level will sound alarm and where coincidence operation of 2 out of 3 at high level will activate the shut-down.

5.8 Value of overpressure and of protective gas flow

5.8.1 The pressurization system as required in [5.6] and [5.7] are to be capable of ensuring a sufficient outward protective gas speed through the openings of the room when all these openings are open at the same time. The velocity is to be greater than of external air currents but shall not lead to so great a pressure in the room as to make it difficult to open and close the doors.

Note 1: When doors, windows and openings are provided with airlocks, these should be closed when checking this requirement.

5.8.2 A minimum overpressure of 25 Pa (0,25 mbar) with respect to the outer atmosphere is to be maintained at all points inside the room and its associated ducts at which leaks are liable to occurs, all doors and windows being closed.

Note 1: This overpressure value is to prevent the ingress of the external atmosphere for wind speed up to approximately 3,5 m/s.

5.8.3 If there is any air consuming apparatus inside the pressurized room, the flow through the pressurization system is to be capable of covering all needs; if not the extra air required is to be supplied by a separate system.

Note 1: The pressurization system may also include heating, ventilation and air-conditioning devices over and above the apparatus necessary to comply with the above requirements.

Note 2: The design of a pressurized room also needs to consider:

- the number of persons expected to stay in the room in order to ensure the necessary renewal of the air, and
- the type of apparatus to be installed in the room and their need for cooling air if any.

5.9 Failure of the pressurization

5.9.1 For monitoring the satisfactory functioning of the pressurization, either a pressure monitoring device or a flow monitoring device or both are to be used.

Note 1: Electrical interlock on the fan motors is not suitable to indicate failure of the pressurization. They do not give an indication in the event of, for example, the fan belt slipping, the fan becoming loose on the shaft or reserve rotation of the fan.

Note 2: Pressure monitoring devices should be certified for the group of gases they might be operating in.

5.9.2 Following loss of pressurization, visible and audible alarms are to be actuated; they are to be located where they will immediately alert the responsible personnel who will take the necessary action (see Tab 1).

Table 1 : Summary of protective measures to be taken in the event of failure of pressurization

Classification of the interior of the room**(1)**	Electrical apparatus installed		
	Apparatus suitable for Zone 1	Apparatus suitable for use in Zone 2	Apparatus not protected for any hazardous area
Zone 1	No action is required	Suitable alarm (visible or audible or both) Immediate action to restore pressurization Programmed disconnection of power supplies if the pressurization cannot be restored for an extended period or if the concentration of flammable gas is rising to a dangerous level	Suitable alarm (visible or audible or both) Immediate action to restore pressurization Automatic interruption of the power supplies as rapidly as practicable within a prescribed delay time having regard to the needs of a programmed shut-down
Zone 2	No action is required	No action is required	Suitable alarm (visible or audible or both) Immediate action to restore pressurization Programmed disconnection of power supplies if the pressurization cannot be restored for an extended period or if the concentration of flammable gas is rising to a dangerous level

(1) Classification in the event of absence of pressurization.

6 Machinery installation in hazardous areas

6.1 General

6.1.1 Mechanical equipment is to be limited to that necessary for operational purposes.

6.1.2 Mechanical equipment and machinery in hazardous areas are to be so constructed and installed as to reduce the risk of ignition form sparking due to the formation of static electricity or friction between moving parts and from high temperatures of exposed parts due to exhausts or other emissions.

6.1.3 The installation of internal combustion machinery may be permitted in zone 2 hazardous areas, provided the requirements of Ch 1, Sec 2, [5] are complied with.

6.1.4 Fired boilers are not to be installed in hazardous areas.

The installation of fired equipment may however be permitted in zone 2 hazardous areas provided that the Society is satisfied that sufficient precaution has been taken against the risk of dangerous ignition.

6.2 Compressors and pumps

6.2.1 In general, air compressors are not to be installed in hazardous areas. Where this is not practicable, alternative arrangements may be accepted, provided that the air inlets are trunked or ducted from a safe space and that such trunking/ducting is fitted with gas detectors arranged to give audible and visual alarms and to shut down the compressor in the event of flammable and/or toxic gas or vapour entering the air inlets.

6.2.2 Gas detectors

The gas detectors provided in application of [6.2.1] are to be capable of continuously sampling the air supply and are to be so arranged as to prevent cross-communication between hazardous and safe spaces.

6.2.3 Relief valves

Pumps for hydrocarbon oil/gas systems are to be provided with relief valves in close circuit. Alternate arrangements may be considered; details are to be submitted. The vent line from relief valves is to be self-draining.

6.2.4 Emergency stop

Pumps and compressors are to be fitted with remote emergency stop facilities.

Section 4 Structural Fire Protection

1 General requirements

1.1 General

1.1.1 Requirements of the present Article are principally formulated for units having their hull superstructures, structural bulkheads, decks and deckhouses constructed of steel.

1.1.2 Units constructed of other materials may be accepted, provided that, in the opinion of the Society, they provide an equivalent standard of safety.

1.1.3 The requirements of this Section do not apply to hazardous areas as defined in Ch 4, Sec 1, [3.2.4].

1.1.4 Structural fire protection details, materials and methods of construction should be in accordance with FTP Code, as applicable and SOLAS Convention as applied for cargo ships.

1.2 Fire integrity of bulkheads and decks

1.2.1 In addition to comply with the specific provisions for fire integrity of bulkheads and decks in the present Sub-article and in [4.1], the minimum fire integrity of bulkheads and decks is to be as prescribed in Tab 1 and Tab 2.

External boundaries of superstructures and deckhouses enclosing accommodation, including any overhanging decks which support such accommodation, are to be constructed at least to “A-60” standard for the whole of the portion which faces the process, the storage area or the drilling area and is within 30 m of the centre of the rotary table, if any. For units which have a movable substructure the 30 m are to be measured with the substructure at its closest drilling position to accommodation.

When facing a process or storage area, the “A-60” insulation is to extend on the outward side for a distance of at least 3 m, and as high as deemed necessary by the Society.

The Society may accept equivalent arrangements for existing units.

1.2.2 The following requirements govern application of the Tables:

a) Tab 1 and Tab 2 are applicable respectively to the bulkheads and decks separating adjacent spaces.

b) For determining the appropriate fire integrity standards to be applied to divisions between adjacent spaces, such spaces are classified according to their fire risk as shown in categories (1) to (11) below. Where the contents and use of a space are such that there is a doubt as to its classification for the purpose of the present Section, or where it is possible to assign two or more classifications to a space, it is to be treated as a space within the relevant category having the most stringent boundary requirements. Smaller, enclosed areas within a space that have less than 30 % communicating openings to that space are considered separate areas. The fire integrity of the boundary bulkheads and decks of such smaller spaces are to be as prescribed in Tab 1 and Tab 2.

The number between parentheses preceding each category refers to the applicable column or row in the Tables:

(1) : Control stations are spaces as defined in Ch 4, Sec 1, [3.4] and storage rooms of fire-extinguishing medium referred to in Ch 4, Sec 6, [4.3.1]

(2) : Corridors means corridors and lobbies

(3) : Accommodation spaces are spaces as defined in Ch 4, Sec 1, [3.5.1], excluding corridors, lavatories and pantries containing no cooking appliances

(4) : Stairways are interior stairways, lifts and escalators (other than those wholly contained within the machinery spaces) and enclosures thereto.

In this connection a stairway which is enclosed only at one level should be regarded as part of the space from which it is not separated by a fire door

(5) : Service spaces (low risk) are spaces as defined in Ch 4, Sec 1, [3.3.1]

(6) : Machinery spaces of category A are spaces as defined in Ch 4, Sec 1, [3.2.1]

(7) : Other machinery spaces are spaces defined in Ch 4, Sec 1, [3.2.2] other than machinery spaces of category A

(8) : Hazardous areas are areas as defined in Ch 4, Sec 1, [3.2.4]

(9) : Service spaces (high risk) are spaces as defined in Ch 4, Sec 1, [3.3.2]

(10) : Open decks are open deck spaces, excluding hazardous areas

(11) : Sanitary and similar spaces are communal sanitary facilities such as showers, baths, lavatories, etc., and isolated pantries containing no cooking appliances. Sanitary facilities which serve a space and with access only from that space are to be considered as a portion of the space in which they are located.

Table 1 : Fire integrity of bulkheads separating adjacent spaces

Spaces	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
Control stations **(1)**	A-0 [d]	A-0	A-60	A-0	A-15	A-60	A-15	A-60 [e]	A-60	*	A-0
Corridors **(2)**		C	B-0	B-0 A-0 [b]	B-0	A-60	A-0	A-0 [e]	A-0	*	B-0
Accommodation spaces **(3)**			C	B-0 A-0 [b]	B-0	A-60	A-0	A-0 [e]	A-0	*	C
Stairways **(4)**				B-0 A-0 [b]	B-0 A-0 [b]	A-60	A-0	A-0 [e]	A-0	*	B-0 A-0 [b]
Service spaces (low risk) **(5)**					C	A-60	A-0	A-0	A-0	*	B-0
Machinery spaces of category A **(6)**						* [a]	A-0 [a]	A-60	A-60	*	A-0
Other machinery spaces **(7)**							A-0 [a] [c]	A-0	A-0	*	A-0
Hazardous areas **(8)**									A-0	*	A-0
Service spaces (high risk) **(9)**									A-0 [c]	*	A-0
Open decks **(10)**											*
Sanitary and similar spaces **(11)**											C
Note 1: For the meaning of [a], [b], [c], [d], [e] and *, refer to Tab 2.											

Table 2 : Fire integrity of decks separating adjacent spaces

Space below	Space above										
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
Control stations **(1)**	A-0	A-0	A-0	A-0	A-0	A-60	A-0	A-0 [e]	A-0	*	A-0
Corridors **(2)**	A-0	*	*	A-0	*	A-60	A-0	A-0 [e]	A-0	*	*
Accommodation spaces **(3)**	A-60	A-0	*	A-0	*	A-60	A-0	A-0 [e]	A-0	*	*
Stairways **(4)**	A-0	A-0	A-0	*	A-0	A-60	A-0	A-0 [e]	A-0	*	A-0
Service spaces (low risk) **(5)**	A-15	A-0	A-0	A-0	*	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A **(6)**	A-60	A-60	A-60	A-60	A-60	* [a]	A-60	A-60	A-60	*	A-0
Other machinery spaces **(7)**	A-15	A-0	A-0	A-0	A-0	A-0 [a]	* [a]	A-0	A-0	*	A-0
Hazardous areas **(8)**	A-60 [e]	A-0 [e]	A-0 [e]	A-0 [e]	A-0	A-60	A-0	–	A-0	–	A-0
Service spaces (high risk) **(9)**	A-60	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0 [c]	*	A-0
Open decks **(10)**	*	*	*	*	*	*	*	–	*	–	*
Sanitary and similar spaces **(11)**	A-0	A-0	*	A-0	*	A-0	A-0	A-0	A-0	*	*

Note 1:

[a]	:	Where the space contains an emergency power source or components of an emergency power source adjoining a space containing a unit's service generator or the components of a unit's service generator, the boundary bulkhead or deck between those spaces should be an “A-60” class division
[b]	:	For clarification as to which the Note applies, refer to [4.1.3] and [4.1.5]
[c]	:	Where spaces are of the same numerical category and superscript (c) appears, a bulkhead or deck of the rating shown in the tables is only required when the adjacent spaces are for a different purpose e.g. in category (9). A galley next to a galley does not require a bulkhead but a galley next to a paint room requires an “A-0” bulkhead
[d]	:	Bulkheads separating the central control room, chartroom and radio room from each other may be “B-0” rating
[e]	:	An engineering evaluation is to be conducted in accordance with [4.1.1]. In no case the bulkhead or deck rating is to be less than the value indicated in the tables.
*	:	Where an asterisk appears in the tables the division is required to be of steel or equivalent material but not required to be of “A” class standard. However, where a deck is penetrated for the passage of electric cables, pipes and vent ducts, such penetrations are to be made tight to prevent the passage of flame and smoke.

1.2.3 Continuous B class ceilings or linings in association with the relevant decks or bulkheads may be accepted as contributing wholly or in part to the required insulation and integrity of a division.

1.2.4 In designing fire protection details, due consideration is to be given to the risk of heat transmission at intersections and terminal points of required thermal barriers.

The insulation of a deck or bulkhead is to be carried past the penetration, intersection or terminal point for a distance of at least 450 mm in the case of steel and aluminium structures. If a space is divided with a deck or a bulkhead of A class standard having insulation of different values, the insulation with the higher value is to continue on the deck or bulkhead with the insulation of the lesser value for a distance of at least 450 mm.

2 Penetrations in fire-resisting divisions

2.1 Penetrations in A class divisions

2.1.1 Where A class divisions are penetrated, such penetration are to be tested in accordance with the Fire Test Procedures Code. In the case of ventilation ducts, requirements [5.1.2], [5.3.1] and [5.3.2] apply. However, where a pipe penetration is made of steel or equivalent material having a thickness of 3 mm or greater and a length of not less than 900 mm (preferably 450 mm on each side of the division), and there are no openings, testing is not required. Such penetrations are to be suitably insulated by extension of the insulation at the same level of the division.

2.2 Penetrations in B class divisions

2.2.1 Where B class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for the fitting of ventilation terminals, lighting fixtures and similar devices, arrangements shall be made to ensure that the fire resistance is not impaired, subject to the provisions of [5.3.3]. Pipes other that steel or copper that penetrate B class divisions shall be protected by either:

- a fire-tested penetration device suitable for the fire resistance of the division pierced and the type of pipe used, or
- a steel sleeve, having a thickness of not less than 1,8 mm and a length of not less than 900 mm for pipe diameters of 150 mm or more and not less than 600 mm for pipe diameters of less than 150 mm (preferably equally divided to each side of the division). The pipe shall be connected to the ends of the sleeve by flanges or couplings; or the clearance between the sleeve and the pipe shall not exceed 2,5 mm; or any clearance between pipe and sleeve shall be made tight by means of non-combustible or other suitable material.

2.3 Pipes penetrating A or B class divisions

2.3.1 Uninsulated metallic pipes penetrating A or B class divisions shall be of materials having a melting temperature which exceeds 950°C for A-0 and 850°C for B-0 class divisions.

2.3.2 Where the Society may permit the conveying of oil and combustible liquids through accommodation and service spaces, the pipes conveying oil or combustible liquids are to be of a material approved by the Society having regard to the fire risk.

3 Protection of openings in fire-resisting divisions

3.1 Doors in fire-resisting divisions

3.1.1 The fire resistance of doors is to be equivalent to that of the division in which they are fitted, this being determined in accordance with the Fire Test Procedures Code. Doors and door frames in A class divisions are to be constructed of steel. Doors in B class divisions are to be non-combustible. External doors in superstructures and deckhouses should be constructed to at least A-0 class standard and be self-closing, where practicable. Doors fitted in boundary bulkheads of machinery spaces of category A are to be reasonably gas-tight and self-closing. However, if the machinery space is not protected by a fixed gas fire-extinguishing system, the doors needs not to be gas-tight.

Note 1: Where a door is fitted in an A class bulkhead which is also required to be watertight by the present Rules, this steel door need not to be fire tested nor insulated.

3.1.2 Self-closing doors in fire rated bulkheads are to not be fitted with hold-back hooks. However, hold-back arrangements fitted with remote release devices of the fail-safe type capable of being operated from a control station may be accepted.

3.1.3 In corridor bulkheads, ventilation openings may be permitted in and under the doors of cabins, public spaces, offices and sanitary spaces. The openings should be provided only in the lower half of the door. Where such an opening is in or under a door, the total net area of any such opening or openings is not to exceed 0,05 m^2. Where such an opening is in cut in a door it should be fitted with a grille made of non-combustible material. Such openings are not to be provided in a door in a division forming a stairway enclosure.

Note 1: Alternatively, a non-combustible air balance duct routed between the cabin and the corridor, and located below the sanitary unit, is permitted where the cross-sectional area of the duct does not exceed 0,05 m^2.

Note 2: Except as permitted above, balancing openings or ducts between two enclosed spaces are prohibited.

3.2 Windows and sidescuttles

3.2.1 For units other than drilling units, the party applying for classification is to specify, in order to enter this information in the Design Criteria Statement, windows and sidescuttles which may face the drilling floor and/or be included in hazardous areas due to the drilling unit or fixed platform for which the unit performs services and, if any, communicate all necessary information about the extent of these zones.

3.2.2 Windows and sidescuttles, with the exception of central control room windows, should be of the non-opening type. Navigating bridge windows may be of the opening type provided the design of such windows permits rapid closure. The Society may permit windows and sidescuttles outside hazardous areas to be of the opening type.

3.2.3 Windows and sidescuttles in boundaries which are required to meet an A-60 standard and which face the drill floor area of the unit, or of the unit or fixed platform for which the unit performs services, are to be:

- either constructed to an A-60 standard, or
- protected by a water-curtain, or
- fitted with shutters of steel or equivalent material.

3.3 Openings and access in machinery and working spaces

3.3.1 The number of skylights, doors, ventilators and openings in funnels to allow exhaust ventilation and other openings to machinery spaces is to be reduced to a minimum consistent with the needs of ventilation and the proper and safe operation of the unit.

3.3.2 Skylights are to be made of steel and are to include no glass panels. Suitable arrangements are to be made to allow the release of smoke in the event of a fire in the space to be protected.

3.3.3 Means of control are to be provided for closing power-operated doors or actuating release mechanisms on doors other than power-operated watertight doors. The controls are to be located outside the space concerned, where they will not be cut off in the event of fire in the space it serves.

3.3.4 Windows are not to be fitted in machinery space boundaries. However, this does not preclude the use of glass in control rooms within the machinery spaces.

4 Protection of accommodation spaces, service spaces and control stations

4.1

4.1.1 In general, accommodation spaces, service spaces and control stations are not to be located adjacent to hazardous areas. However, where this is not practicable, an engineering evaluation is to be performed to ensure that the level of fire protection and blast resistance of the bulkheads and decks separating these spaces from the hazardous areas are adequate for the likely hazard.

4.1.2 All bulkheads required to be A class divisions are to extend from deck to deck and to the deckhouse side or other boundaries.

4.1.3 All bulkheads required to be B class divisions are to extend from deck to deck and to the deckhouse side or other boundaries, unless continuous B class ceilings and/or linings are fitted on both sides of the bulkhead, in which case the bulkhead may terminate at the continuous ceiling or lining.

4.1.4 Stairs are to be constructed of steel or other equivalent material.

4.1.5 Stairways which penetrate only a single deck are to be protected at least at one level by A or B class divisions and self-closing doors so as to limit the rapid spread of fire from one deck to another. Personnel lift trunks are to be protected by A class divisions. Stairways and lift trunks which penetrate more than a single deck are to be surrounded by A class divisions and protected by self-closing doors at all levels.

4.1.6 Air spaces enclosed behind ceilings, panellings or linings are to be divided by close fitting draught stops spaced not more than 14 metres apart. In the vertical direction, such enclosed air spaces, including those behind linings of stairways, trunks, etc., are to be closed at each deck.

4.1.7 Except for insulation in refrigerated compartments, insulation material, pipe and vent duct lagging, ceilings, linings and bulkheads are to be of non-combustible material. Insulation of pipe fittings for cold service systems and vapour barriers and adhesives used in conjunction with insulation need not be non-combustible, but they are to be kept to a minimum and their exposed surfaces are to have low flame spread characteristics. In spaces where penetration of oil products is possible, the surfaces of the insulation are to be impervious to oil or oil vapours.

4.1.8 The framing, including grounds and the joint pieces of bulkheads, linings, ceilings and draught stops is to be of non-combustible material.

4.1.9 All exposed surfaces in corridors and stairway enclosures and surfaces in concealed or inaccessible spaces in accommodation and service spaces and control stations are to have low flame-spread characteristics. Exposed surfaces of ceilings in accommodation and service spaces and control stations are to have low flame-spread characteristics.

4.1.10 Bulkheads, linings and ceilings may have combustible veneers provided that the thickness of such veneers is not to exceed 2,5 mm within any space other than corridors, stairway enclosures and control stations where the thickness is not to exceed 1,5 mm. Combustible materials used on these surfaces are to have a calorific value not exceeding 45 MJ/m² of the area for the thickness used.

Note 1: For the calorific value, reference is made to ISO 1716 “Reaction to fire tests for building products - Determination of the heat of combustion”, as amended.

4.1.11 Primary deck coverings, if applied within accommodation and service spaces and control stations, are to be of type approved materials which do not readily ignite and materials which do not give rise to smoke or toxic or explosive hazards at elevated temperature, this being determined in accordance with FTP Code.

4.1.12 Paints, varnishes and other finishes used on exposed interior surfaces are not to offer an undue fire hazard in the judgement of the Society, and are not to be capable of producing excessive quantities of smoke or toxic products. They are to be type approved in accordance with FTP Code.

5 Ventilation systems

5.1 Ducts and dampers

5.1.1 Ventilation ducts are to be of non-combustible material. However, short ducts, not generally exceeding 2 m in length and with a free cross-sectional area not exceeding 0,02 m², need not be non-combustible, subject to the following conditions:

a) the ducts are made of a material which has low flame-spread characteristics
b) the ducts are only used at the end of the ventilation device, and
c) the ducts are not situated less than 600 mm, measured along the duct, from an opening in an A or B class division, including continuous B class ceiling.

Flexible bellows of combustible material may be used for connecting fans to the ducting in the air-conditioning room.

Combustible gaskets in flanged ventilation duct connections are not permitted within 600 mm of an opening in an A or B class division and in ducts required to be of A class construction.

Note 1: The term free cross-sectional area means, even in the case of a pre-insulated duct, the area calculated on the basis of the inner diameter of the duct.

5.1.2 The following arrangements are to be tested in accordance with the Fire Test Procedures Code.

a) fire dampers, including their relevant means of operation, and
b) duct penetrations through A class divisions. However, the test is not required where steel sleeves are directly joined to ventilation ducts by means of riveted or screwed flanges or by welding.

5.2 Arrangement of ducts

5.2.1 The ventilation system for machinery spaces of category A, galleys and hazardous areas are to be, in general, separated from each other and from the ventilation systems serving other spaces, except that the galley ventilation systems on units of less than 4000 gross tonnage need not be completely separated, but may be served by separate ducts from a ventilation unit serving other spaces. In any case, an automatic fire damper is to be fitted in the galley ventilation duct near the ventilation unit. Ducts provided for ventilation of machinery spaces of category A, galleys and hazardous areas are not to pass through accommodation and service spaces or control stations. However, the Society may permit relaxation from the present requirement, except for the ducts serving hazardous areas passing through accommodation spaces, control stations and galleys, provided that the ducts are:

a) Constructed of steel having a thickness of at least 3 mm for ducts of 300 mm in width or less and of at least 5 mm for ducts of 760 mm in width and over; in the case of ducts the width or diameter of which is between 300 mm and 760 mm, the thickness is to be obtained by interpolation.
b) Suitably supported and stiffened.
c) Fitted with automatic fire dampers close to the boundary penetrated.
d) Insulated to A-60 standard from the machinery spaces or galleys to a point at least 5 m beyond each fire damper.
e) Constructed of steel in accordance with a).
f) Insulated to A-60 standard throughout accommodation spaces, service spaces or control stations.

5.2.2 Ducts provided for the ventilation of accommodation spaces, service spaces or control stations are not to pass through machinery spaces of category A, galleys or hazardous areas. However, the Society may permit relaxation from the present requirement, except for the ducts passing through hazardous areas, provided that:

a) the ducts where they pass through a machinery space of category A or a galley are constructed of steel in accordance with [5.2.1] item a)

b) automatic fire dampers are fitted close to the boundaries penetrated

c) the integrity of the machinery space or galley boundaries is maintained at the penetrations

d) the ducts where they pass through a machinery space of category A or a galley are constructed of steel in accordance with [5.2.1] item a)

e) are insulated to A-60 standard within the machinery space or galley.

5.3 Details of duct penetrations

5.3.1 Where a thin plated duct with a free cross-sectional area equal to, or less than, 0,02 m² passes through A class bulkheads or decks, the opening is to be lined with a steel sheet sleeve having a thickness of at least 3 mm and a length of at least 200 mm, divided preferably into 100 mm on each side of the bulkhead or, in the case of the deck, wholly laid on the lower side of the deck pierced.

5.3.2 Where ventilation ducts with a cross-sectional area exceeding 0,02 m² pass through A class bulkheads or decks, the opening is to be lined with a steel sheet sleeve unless the ducts passing though the bulkheads or decks are of steel in the vicinity of penetrations through the deck or bulkhead; the ducts and sleeves at such places are to comply with the following:

a) The ducts or sleeves are to have a thickness of at least 3 mm and a length of at least 900 mm. When passing through bulkheads, this length is to be divided preferably into 450 mm on each side of the bulkhead. These ducts, or sleeve lining such ducts, are to be provided with fire insulation. The insulation is to have at least the same fire integrity as the bulkhead or deck through which the duct passes. Equivalent penetration protection may be provided to the satisfaction of the Society.

b) Ducts with a cross-sectional area exceeding 0,075 m², except those serving hazardous areas, are to be fitted with fire dampers in addition to meeting the requirements of item a) above.

   The fire dampers are to operate automatically but are also to be capable of being closed manually from both sides of the bulkhead or deck. The dampers are to be provided with indicators showing whether they are open or closed.

   Fire dampers are not required, however, where ducts pass through spaces surrounded by A class divisions, without serving those spaces, provided those ducts have the same fire integrity as the divisions which they pierce. The Society may, given special considerations, permit operation from one side of a division only.

5.3.3 Ventilation ducts with a cross-sectional area exceeding 0,02 m² passing through B class bulkheads are to be lined with steel sheet sleeves of 900 mm in length divided preferably into 450 mm on each side of the bulkhead unless the duct is of steel for this length.

5.4 Exhausts ducts from galley range

5.4.1 Where they pass through accommodation spaces or spaces containing combustible materials, the exhaust ducts from galley ranges are to be of equivalent fire integrity to A class divisions. Each such exhaust duct is to be fitted with:

- a grease trap readily removable for cleaning
- a fire damper located in the galley end of the duct which is automatically and remotely operated and, in addition a remotely operated fire damper located in the exhaust end of the duct
- arrangements, operable from within the galley, for shutting off the exhaust fans
- fixed means for extinguishing a fire within the duct.

5.5 Control of fire growth

5.5.1 The main inlets and outlets of all ventilation systems are to be capable of being closed from outside the spaces being ventilated.

5.5.2 Power ventilation of accommodation spaces, service spaces, control stations, machinery spaces and hazardous areas are to be capable of being stopped from an easily accessible position outside the space being served. The accessibility of this position in the event of a fire in the spaces served is to be specially considered. The means provided for stopping the power ventilation of the machinery spaces are to be entirely separate from the means provided for stopping ventilation of other spaces.

These requirements do not apply to closed recirculating systems within a single space.

5.5.3 The ventilation of the accommodation spaces and control stations is to be arranged in such a way as to prevent the ingress of flammable, toxic or noxious gases, or smoke from surrounding areas.

5.5.4 Means should be provided for stopping ventilating fans serving machinery and working spaces and for closing all doorways, ventilators, annular spaces around funnels and other openings to such spaces. These means should be capable of being operated from outside such spaces in case of fire.

5.5.5 Combustion air fans and compressors such as machinery driving forced and induced draught fans or electric motor pressurization fans and fuel pumps such as oil fuel transfer pumps or oil fuel unit pumps should be fitted with remote controls situated outside the space concerned so that they may be stopped in the event of a fire arising in the space in which they are located.

Section 5 Detection, Controls, Communications and Alarms

1 Alarms

1.1 General alarms

1.1.1 General alarms are to be provided in accordance with Ch 2, Sec 14, [2].

1.2 Ventilation alarms

1.2.1 Ventilation alarms are to be provided in accordance with Ch 4, Sec 3, [4.1] on units and installations where hazardous areas are present.

1.3 Mud systems level alarms

1.3.1 For mobile offshore drilling units, a suitable audible and visual alarm to indicate significant increase or decrease in the level of the contents of the mud pit is to be provided at the control station for drilling operations and at the mud pit. Equivalent means to indicate possible abnormal conditions in the drilling system may be considered by the Society.

2 Detection systems general design

2.1 General

2.1.1 Failure in an alarm detection panel and detector circuit is to activate failure alarm. The automatic alarm system is to be operational even during periods of main switchboard blackout.

2.1.2 Detection and alarm systems are to be designed in such a way they allow a satisfactory function testing without interrupting the operation of the unit.

2.1.3 The detection circuits are to be routed and protected so as to minimise the risks of failure.

3 Fixed fire detection and fire alarm systems

3.1 Definition

3.1.1 Section means a group of fire detectors and manually operated call points as reported in the indicating unit(s).

3.1.2 Section identification capability means a system with the capability of identifying the section in which a detector or manually operated call point has activated.

3.1.3 Individually identifiable means a system with the capability to identify the exact location and type of detector or manually activated call point which has activated, and which can differentiate the signal of that device from all others.

3.2 General

3.2.1 In principle, spaces having a fire risk should be provided with an automatic fire detection and alarm system.

3.2.2 In selecting the type of detectors, their following features should be taken into account:

a) capability to detect fire at the incipient stage

b) ability to avoid spurious alarm and trips; and

c) suitability to the located environment.

3.2.3 The fire detection main indicator board is to be at a manned control station and is to clearly indicate where fire has been detected.

3.2.4 Machinery spaces

Fixed fire detection and alarm systems are to be fitted in:

a) periodically unattended machinery spaces

b) machinery spaces where:
  - the installation of automatic and remote control system and equipment has been approved in lieu of continuous manning of the spaces, and
  - the main propulsion and associated machinery, including the main sources of electrical power, are provided with various degrees of automatic or remote control and are under continuous manned supervision from a control room and,

c) enclosed spaces containing incinerators.

Detection systems using only thermal detectors, in general, are not to be permitted.

Note 1: When additional classification notation **AUTO** is granted, the provisions of Ch 3, Sec 7 are to be complied with.

3.2.5 Accommodation and service spaces

An automatic fire detection and alarm system is to be provided in all accommodation and service spaces.

Accommodation space is to be fitted with smoke detectors.

Thermal detectors are to be fitted in galleys.

3.2.6 Electrical rooms and control stations

Smoke detectors are to be provided in all electrical rooms and control stations.

3.2.7 Drilling and mud processing areas

Flame or thermal detectors are to be installed in open drilling and/or mud processing areas.

Smoke detectors may be used in enclosed mud processing areas.

3.2.8 Manually operated alarm system

Sufficient manual fire alarm stations are to be installed throughout the accommodation spaces, service spaces and control stations. One manually operated call point is to be located at each exit. Manually operated call points are to be readily accessible in the corridors of each deck such that no part of the corridor is more than 20 m from a manually operated call point.

Measures are to be taken to prevent inadvertent operation of the manual call alarm system.

3.3 Engineering specifications

3.3.1 General requirements

a) Any required fixed fire detection and fire alarm system with manually operated call points shall be capable of immediate operation at all times (this does not require a backup control panel). Notwithstanding this, particular spaces may be disconnected, for example, workshops during hot work. The means for disconnecting the detectors shall be designed to automatically restore the system to normal surveillance after a predetermined time that is appropriate for the operation in question. The space shall be manned or provided with a fire patrol when detectors required by regulation are disconnected. Detectors in all other spaces shall remain operational.

b) The fire detection system shall be designed to:
  1) control and monitor input signals from all connected fire and smoke detectors and manual call points
  2) provide output signals to the navigation bridge, continuously manned central control station or onboard safety centre to notify the crew of fire and fault conditions
  3) monitor power supplies and circuits necessary for the operation of the system for loss of power and fault conditions; and
  4) the system may be arranged with output signals to other fire safety systems including:
    - paging systems, fire alarm or public address systems
    - fan stops
    - fire doors
    - fire dampers
    - sprinkler systems
    - smoke extraction systems
    - low-location lighting systems
    - fixed local application fire-extinguishing systems
    - closed circuit television (CCTV) systems, and
    - other fire safety systems.

Note 1: The ventilation fans and the fire dampers serving a machinery room equipped with internal combustion engines taking their combustion air directly inside the room are not to be automatically stopped or closed in case of fire detection, in order to prevent depressurization of the room

c) The fire detection system may be connected to a decision management system provided that:
   1) the decision management system is proven to be compatible with the fire detection system;
   2) the decision management system can be disconnected without losing any of the functions required by this chapter for the fire detection system; and
   3) any malfunction of the interfaced and connected equipment should not propagate under any circumstance to the fire detection system.

d) Detectors and manual call points shall be connected to dedicated sections of the fire detection system. Other fire safety functions, such as alarm signals from the sprinkler valves, may be permitted if in separate sections.

e) The system and equipment shall be suitably designed to withstand supply voltage variation and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in units. All electrical and electronic equipment on the bridge or in the vicinity of the bridge shall be tested for electromagnetic compatibility, taking into account the recommendations developed by the Organization.

Note 2: Refer to general requirements for electromagnetic compatibility for electrical and electronic equipment (Resolution A.813(19).

f) Fixed fire detection and fire alarm systems with individually identifiable fire detectors shall be so arranged that:
   1) means are provided to ensure that any fault (e.g. power break, short circuit, earth, etc.) occurring in the section will not prevent the continued individual identification of the remainder of the connected detectors in the section;
   2) all arrangements are made to enable the initial configuration of the system to be restored in the event of failure (e.g. electrical, electronic, informatics, etc.);
   3) the first initiated fire alarm will not prevent any other detector from initiating further fire alarms; and
   4) no section will pass through a space twice. When this is not practical (e.g. for large public spaces), the part of the section which by necessity passes through the space for a second time shall be installed at the maximum possible distance from the other parts of the section.

g) The fixed fire detection and fire alarm system shall, as a minimum, have section identification capability.

3.3.2 Sources of power supply

a) There shall be not less than two sources of power supply for the electrical equipment used in the operation of the fixed fire detection and fire alarm system, one of which shall be an emergency source of power. The supply shall be provided by separate feeders reserved solely for that purpose. Such feeders shall run to an automatic change-over switch situated in, or adjacent to, the control panel for the fire detection system. The change-over switch shall be arranged such that a fault will not result in the loss of both power supplies. The main (respective emergency) feeder shall run from the main (respective emergency) switchboard to the change-over switch without passing through any other distributing switchboard.

b) The operation of the automatic changeover switch or a failure of one of the power supplies shall not result in loss of fire detection capability. Where a momentary loss of power would cause degradation of the system, a battery of adequate capacity shall be provided to ensure continuous operation during change-over.

c) There shall be sufficient power to permit the continued operation of the system with all detectors activated, but not more than 100 if the total exceeds this figure.

d) The emergency source of power specified in item a) above may be supplied by accumulator batteries or from the emergency switchboard. The power source shall be sufficient to maintain the operation of the fire detection and fire alarm system for the periods required under Ch 2, Sec 3 and at the end of that period shall be capable of operating all connected visual and audible fire alarm signals for a period of at least 30 min.

e) Where the system is supplied from accumulator batteries, they shall be located in or adjacent to the control panel for the fire detection system, or in another location suitable for use in an emergency. The rating of the battery charge unit shall be sufficient to maintain the normal output power supply to the fire detection system while recharging the batteries from a fully discharged condition.

3.3.3 Component requirements

a) Detectors
   1) Detectors shall be operated by heat, smoke or other products of combustion, flame, or any combination of these factors. Detectors operated by other factors indicative of incipient fires may be considered by the Society provided that they are no less sensitive than such detectors.
   2) Smoke detectors required in all stairways, corridors and escape routes within accommodation spaces shall be certified to operate before the smoke density exceeds 12,5% obscuration per metre, but not until the smoke density exceeds 2% obscuration per metre, when tested according to standards EN 54:2001 and IEC 60092-504. Alternative testing standards may be used as determined by the Society. Smoke detectors to be installed in other spaces shall operate within sensitivity limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity.
   3) Heat detectors shall be certified to operate before the temperature exceeds 78°C but not until the temperature exceeds 54°C, when the temperature is raised to those limits at a rate less than 1°C per minute, when tested according to standards EN 54:2001 and IEC 60092-504. Alternative testing standards may be used as determined by the Society. At higher rates of temperature rise, the heat detector shall operate within temperature limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity.

4) The operation temperature of heat detectors in drying rooms and similar spaces of a normal high ambient temperature may be up to 130°C, and up to 140°C in saunas.

5) Flame detectors shall be tested according to standards EN 54-10:2001 and IEC 60092-504. Alternative testing standards may be used as determined by the Society.

6) All detectors shall be of a type such that they can be tested for correct operation and restored to normal surveillance without the renewal of any component.

7) Detectors fitted in hazardous areas shall be tested and approved for such service.

b) Control panel

The control panel for the fire detection system shall be tested according to standards EN 54-2:1997, EN 54-4:1997 and IEC 60092-504:2001. Alternative standards may be used as determined by the Society.

c) Cables

Cables used in the electrical circuits shall be flame retardant according to standard IEC 60332-1.

3.3.4 Installation requirements

a) Sections

1) Detectors and manually operated call points are to be grouped into sections.

2) A section of fire detectors which covers a control station, a service space or an accommodation space shall not include a machinery space of category A. For fixed fire detection systems with remotely and individually identifiable fire detectors, a section covering fire detectors in accommodation, service spaces and control stations shall not include fire detectors in machinery spaces of category A.

3) Where the fixed fire detection and fire alarm system does not include means of remotely identifying each detector individually, no section covering more than one deck within accommodation spaces, service spaces and control stations shall normally be permitted except a section which covers an enclosed stairway. In order to avoid delay in identifying the source of fire, the number of enclosed spaces included in each section shall be limited as determined by the Society. If the detection system is fitted with remotely and individually identifiable fire detectors, the sections may cover several decks and serve any number of enclosed spaces.

b) Position of detectors

1) Detectors are to be located for optimum performance. Positions near beams and ventilation ducts, or other positions where patterns of air flow could adversely affect performance, and positions where impact or physical damage is likely, shall be avoided. Detectors shall be located on the overhead at a minimum distance of 0,5 m away from bulkheads, except in corridors, lockers and stairways.

2) The maximum spacing of detectors is to be in accordance with Tab 1. The Society may require or permit other spacing based upon test data which demonstrate the characteristics of the detectors.

3) Detectors in stairways shall be located at least at the top level of the stair and at every second level beneath.

4) When fire detectors are installed in freezers, drying rooms, saunas, parts of galleys used to heat food, laundries and other spaces where steam and fumes are produced, heat detectors may be used.

5) Where a fixed fire detection and fire alarm system is required by Article [3], spaces having little or no fire risk need not be fitted with detectors. Such spaces include void spaces with no storage of combustibles, private bathrooms, public toilets, fire-extinguishing medium storage rooms and cleaning gear lockers (in which flammable liquids are not stowed).

c) Arrangement of cables

1) Cables which form part of the system shall be so arranged as to avoid galleys, machinery spaces of category A and other enclosed spaces of high fire risk except where it is necessary to provide for fire detection or fire alarms in such spaces or to connect to the appropriate power supply.

2) A section with individually identifiable capability shall be arranged so that it cannot be damaged at more than one point by a fire.

Table 1 : Spacing of detectors

Type of detector	Maximum floor area per detector	Maximum distance apart between centres	Maximum distance away from bulkheads
Heat	37 m^2	9 m	4,5 m
Smoke	74 m^2	11 m	5,5 m

3.3.5 System control requirements

a) Visual and audible fire signals

1) The activation of any detector or manually operated call point shall initiate a visual and audible fire detection alarm signal at the control panel and indicating units. If the signals have not been acknowledged within 2 minutes, an audible fire alarm shall be automatically sounded throughout the crew accommodation and service spaces, control stations and machinery spaces of category A. This alarm sounder system need not be an integral part of the detection system.

The alarm sounder system utilized by the fixed fire detection and fire alarm system should be powered from no less than two sources of power, one of which should be an emergency source of power.

In offshore units for which a transitional source of emergency electrical power is required by Ch 2, Sec 3, [3.1.11], the alarm sounder system should also be powered from this power source.

2) The control panel shall be located on the navigation bridge or in the fire control station.

3) In units with a cargo control room, an additional indicating unit shall be located in the cargo control room. An indicating unit shall be located on the navigation bridge if the control panel is located in the fire control station. Indicating units shall, as a minimum, denote the section in which a detector has been activated or manually operated call point has been operated.

A space in which a cargo control console is installed, but does not serve as a dedicated cargo control room (e.g. ship's office, machinery control room), should be regarded as a cargo control room for the purposes of this requirement and therefore be provided with an additional indicating unit.

4) Clear information is to be displayed on or adjacent to each indicating unit about the spaces covered and the location of the sections.

5) Power supplies and electric circuits necessary for the operation of the system shall be monitored for loss of power and fault conditions, as appropriate, including:

- a single open or power break fault caused by a broken wire;
- a single ground fault caused by the contact of a wiring conductor to a metal component; and
- a single wire to wire fault caused by the contact of two or more wiring conductors.

Occurrence of a fault condition shall initiate a visual and audible fault signal at the control panel which shall be distinct from a fire signal.

6) Means to manually acknowledge all alarm and fault signals shall be provided at the control panel. The audible alarm sounders on the control panel and indicating units may be manually silenced. The control panel shall clearly distinguish between normal, alarm, acknowledged alarm, fault and silenced conditions.

7) The system shall be arranged to automatically reset to the normal operating condition after alarm and fault conditions are cleared.

8) When the system is required to sound a local audible alarm within the cabins where the detectors are located, a means to silence the local audible alarms from the control panel shall not be permitted.

9) In general, audible alarm sound pressure levels at the sleeping positions in the cabins and 1 m from the source shall be at least 75 dB(A) and at least 10 dB(A) above ambient noise levels existing during normal equipment operation with the unit under way in moderate weather. The sound pressure level should be in the 1/3 octave band about the fundamental frequency. Audible alarm signals shall not exceed 120 dB(A).

b) Testing

Suitable instructions and component spares for testing and maintenance shall be provided. Detectors shall be periodically tested using equipment suitable for the types of fires to which the detector is designed to respond. Detectors installed within cold spaces such as refrigerated compartments shall be tested using procedures having due regard for such locations. Units with self-diagnostic systems that have in place a cleaning regime for areas where heads may be prone to contamination may carry out testing in accordance with the requirements of the Society.

4 Gas detection system

4.1 Combustible gas detection and alarm system

4.1.1 General

A fixed automatic gas detection and alarm system is to be provided to the satisfaction of the Society, so arranged as to monitor continuously all enclosed areas of the unit in which an accumulation of flammable gas may be expected to occur. The system should be capable of indicating at the central control room by audible and visual means the presence and location of an accumulation of flammable gas.

4.1.2 Areas for protection

Fixed automatic combustible gas detection and alarm systems are to be provided for the following areas:

a) cellar deck

b) drill floor

c) ventilation intake of positive pressure driller's cabin

d) mud pit area

e) shale shaker area

f) enclosed spaces containing the open components of mud circulation system from the bell nipple to the mud pits

g) ventilation intakes of accommodation spaces

h) ventilation intakes of enclosed machinery spaces contiguous to hazardous areas and containing internal combustion engines, boilers, or non-explosion proof electrical equipment

i) air intakes to all combustion engines or machinery, including internal combustion engines, boilers, compressors or turbines, located outside of an enclosed machinery space

j) at each access door to accommodation spaces

k) near other openings, including emergency egress, of accommodation spaces, regardless if these openings are fitted with self-closing and gastight closing appliances.

4.1.3 Areas where protection is not required

Fixed automatic combustible gas detection and alarm systems are not required:

- Near access doors to accommodation spaces where these form part of an airlock which is provided with a gas detection and alarm system between the two doors of the airlock.
- Near emergency egress doors which are fitted with a mechanism to prevent use other than in an emergency (e.g. doors fitted with security seals acting as a deterrent but easily breakable in a real emergency.).
- Near other openings which are provided with closing appliances of non-opening type, e.g. bolted closed maintenance ways etc.

4.1.4 Alarms

The gas detectors are to be connected to an audible and visual alarm system with indicators on the drill floor and in the main control station. The alarm system is to clearly indicate the location and concentration of the gas hazard. The combustible gas detectors are to alarm at not more than 25% and at 60% of the lower explosive limit (LEL).

4.1.5 Power supply

The detection system, where electrically supplied, is to be fed automatically from an emergency source of power by a separate feeder if the main source of power fails.

4.1.6 Ventilation air intakes

Requirement of Ch 4, Sec 3, [5.7.3] and Ch 4, Sec 3, [5.7.4] are to be complied with.

4.2 Hydrogen sulphide detection and alarm system

4.2.1 General

When deemed necessary, a fixed automatic hydrogen sulphide gas detection and alarm system is to be provided to the satisfaction of the Society.

4.2.2 Areas for protection

For mobile offshore drilling units, a fixed automatic hydrogen sulphide gas detection and alarm system are to be provided for the following areas:

a) drill area

b) mud processing area

c) well test area.

4.2.3 Alarms

The detectors are to be connected to an audible and visual alarm system with indicators in the main control room. The system is to clearly indicate where gas has been detected. Low level alarm set at 10 ppm and high level alarm set not higher than 300 ppm are to be designed. The high level alarm is to activate an evacuation alarm. If the alarm at the main control point is unanswered within 2 min, the toxic gas (hydrogen sulphide) alarm and the helideck status light is to be automatically activated.

4.2.4 Power supply

The detection system, where electrically supplied, is to be fed automatically from an emergency source of power by a separate feeder if the main source of power fails.

4.3 Portable gas monitoring devices

4.3.1 On drilling units or installations, or units and installations where hydrocarbons are processed or stored, at least two portable flammable gas monitoring devices and two portable hydrogen sulphide gas monitoring devices are to be provided, each capable of an accurate measurement of gas concentration. In addition, at least two portable oxygen analysers are to be provided.

4.3.2 The gas detectors are to be of a type approved by the Society.

4.4 Respiratory protection equipment for hydrogen sulphide

4.4.1 Respiratory protection equipment for hydrogen sulphide are to be provided on board according to either of the following:

- a Self-Contained Breathing Apparatus (SCBA) positive-pressure/pressure-demand breathing equipment with full-face piece and rated for a minimum of 30 minutes is to be provided for each person in working areas where hydrogen sulphide may be encountered, and each person in other areas is to be provided with SCBA rated for a minimum of 15 minutes, or
- a positive-pressure/pressure-demand air line breathing equipment coupled with a SCBA equipped low pressure warning alarm and rated for a minimum of 15 minutes is to be provided for each person on board the unit.

Breathing air supply line stations are to be provided at least in the following areas:

- living quarters
- muster/evacuation area
- drilling areas
- mud processing areas
- other working areas.

Section 6 Suppression of Fire: Fire Fighting

1 Application

1.1

1.1.1 When a fixed fire fighting installation is provided in addition to those required by the present Chapter, such an installation is to be installed and arranged to the satisfaction of the Society.

2 Fire fighting water supply

2.1 General

2.1.1 Units are to be provided with fire pumps, fire mains, hydrants and hoses complying with the applicable requirements of this Section.

2.1.2 If the unit is intended to operate in cold weather, the entire water fire fighting system is to be protected from freezing. This includes tanks used as intermediate storage tanks as defined in [2.4].

2.2 Fire pumps

2.2.1 At least two independently driven power pumps are to be provided, each arranged to draw directly from the sea and discharge into a fixed fire main. Particular arrangements are to satisfy the requirements of [2.4].

2.2.2 At least one of the required pumps is to be dedicated for fire-fighting duties and be available for such duties at all times.

2.2.3 Except as provided in [2.2.2], sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil.

2.2.4 The arrangement of the pumps, sea suctions, piping, valves and sources of power is to be such that a fire or flooding in any one space will not put all fire pumps out of action.

2.2.5 The capacity of the required pumps is to be appropriate to the fire-fighting services supplied from the fire main. Where more pumps than required are installed, their capacity are to be to the satisfaction of the Society.

2.2.6 For all units, the Society requires a calculation of the water demand.

2.2.7 Each pump is to be able to maintain a pressure of at least 350 kPa at any hydrant with two 19 mm nozzles in action.

In addition of the water demand from the two hydrants mentioned above, where a foam system is provided for protection of the helideck, the pump is also to be capable of maintaining a pressure of 700 kPa at the foam installation and the water consumption used for foam system is to be added to the pump capacity.

If the water consumption for any other fire protection or fire-fighting purpose should exceed the rate of the helideck foam installation, this consumption is to be the determining factor in calculating the required capacity of the fire pumps.

2.2.8 Where either of the required fire pumps is located in a space not normally manned and, in the opinion of the Society, is relatively far removed from working areas, suitable provisions are to be made for remote start-up of that pump and remote operation of associated suction and discharge valves.

2.2.9 Every centrifugal pump which is connected to the fire main is to be fitted with a non-return valve.

2.2.10 Relief valves are to be provided in conjunction with all pumps connected to the fire main if the pumps are capable of developing a pressure exceeding the design pressure of the fire main, hydrant and hoses. Such valves are to be so placed and adjusted as to prevent excessive pressure in the fire main system.

2.3 Fire mains and hydrants

2.3.1 Material

Materials rendered ineffective by heat are not to be used for fire mains and hydrants unless adequately protected. The pipes and hydrants are to be so placed that the fire hoses can be easily coupled to them.

Note 1: For plastic pipes, the level of the fire endurance test (L1, L2, L3) requirements are given in Ch 1, App 1.

Suitable drainage provisions are to be provided for fire main piping.

2.3.2 Diameter of fire mains

The diameter of the fire main and water service pipes are to be sufficient for the effective distribution of the maximum required discharge from the required fire pumps operating simultaneously.

2.3.3 Pressure of the fire main

With the required fire pumps operating simultaneously, the pressure maintained in the fire mains should be to the satisfaction of the Society and adequate for the safe and efficient operation of all equipment supplied therefrom.

2.3.4 Routing of the fire main

Where practicable, the fire main is to be routed clear of hazardous areas and be arranged in such a manner as to make maximum use of any thermal shielding or physical protection afforded by the structure of the unit.

2.3.5 Isolating valves

a) The fire main is to be provided with isolating valves located so as to permit optimum utilization in the event of physical damage to any part of the fire main.

Note 1: For floating storage oil units, isolation valves are to be fitted in the fire main at the accommodation block fronts in a protected position and on the tank deck at intervals of not more than 40 m to preserve the integrity of the fire main system in case of fire or explosion of on the cargo area.

b) The fire main is not to have connections other than those necessary for fire-fighting purposes.

2.3.6 Hydrants, hoses and nozzles

a) A cock or a valve is to be fitted to serve each fire hydrant so that any fire hose may be removed while the fire pumps are operating.

b) The number and position of the hydrants is to be such that at least two jets of water, not emanating from the same hydrant, one of which should be from a single length of fire hose, may reach any part of the unit normally accessible to those on board while the unit is operating. A hose is to be provided for every hydrant.

c) Fire hoses are to be of non perishable material and of a type approved by the Society. They are to be of sufficient length to project a jet of water to any of the spaces in which they are required to be used. Each hose is to be provided with a dual-purpose nozzle and the necessary couplings. Hoses specified in this Chapter as “fire hoses” are, together with any necessary fittings and tools, to be kept ready for use in conspicuous positions near the water service hydrants or connections. Fire hoses are to have a length of at least 10 m, but not more than:
   - 15 m in machinery spaces
   - 20 m in other spaces and open decks
   - 25 m for open decks on units with a maximum breadth in excess of 30 m.

d) Dual purpose jet spray nozzles are to be fitted throughout the unit and are to comply with the following requirements:
   - Standard nozzle sizes are to be 12 mm, 16 mm and 19 mm or as near thereto as possible. Larger diameter nozzles may be permitted at the discretion of the Society.
   - For accommodation and service spaces, a minimum nozzle diameter of 12 mm is to be used.
   - For machinery spaces and exterior locations, the nozzle size is to be such as to obtain the maximum discharge possible from two jets of water at the pressure specified in [2.2.7] from the smallest pump, provided that a maximum nozzle size of 19 mm is used.

2.3.7 Shore connection

The surface unit is to be provided with at least one international shore connection complying with the requirements of Ch 4, Sec 11, [2].

Facilities are to be available enabling such a connection to be used on any side of the unit.

2.4 Particular arrangements

2.4.1 Supply

At least two water supply sources (sea chests, valves, strainers and pipes) are to be provided and so arranged that one supply source failure will not put all supply sources out of action.

For self-elevating units, the following additional fire water supply measures are to be provided:

a) Water is to be supplied from sea water main filled by at least two submersible pumping systems. One system failure will not put the other system(s) out of function, and

b) Water is to be supplied from drill water system while unit lifting or lowering. Water stored in the drill water tank(s) is not less than 40 m^3 plus engine cooling water consumptions before unit lifting or lowering. Alternatively, water may be supplied from buffer tank(s) in which sea water stored is not less the quantity as the above mentioned.

2.4.2 Fire mains permanently loaded with water

For particular units, the Society may consider a fire main permanently loaded with water by means of:

a) a pressure tank associated with a dedicated replenishment pump, or

b) a fire main arranged in loop and permanently pressurized by jockey pumps provided in sufficient number.

In that case, the ready availability of water supply is to be such that at least one effective jet of water is immediately available from any hydrant and so as to ensure the continuation of the output of water by the automatic starting of one of the required fire pump.

3 Portable fire-extinguishers

3.1 General

3.1.1 The Society may require tests to be carried out to verify the efficiency of the extinguishers provided on board the unit.

3.2 Type and design

3.2.1 Portable fire-extinguishers are to comply with the requirements of Ch 4, Sec 11.

3.3 Arrangement of fire extinguishers

3.3.1 Except for the supplemental arrangements provided in [3.3.2], portable fire extinguishers in accommodation spaces, service spaces, control stations, machinery spaces of category A, other machinery spaces, cargo spaces, weather deck and other spaces should be provided in number and arrangement in accordance with the guidance provided by the Organization and to the satisfaction of the Society.

Note 1: Refer to the Unified Interpretation of SOLAS chapter II-2 on the Number and Arrangement of Portable Fire Extinguishers on Board Ships (MSC.1/Circ.1275).

3.3.2 Machinery spaces, working spaces, cargos spaces, weather decks and other spaces are to be provided with portable fire-extinguishers in accordance with Tab 1. When the requirements of Tab 1 differ from the provisions of [3.3.1], the requirements of Tab 1 are to be followed.

In all cases, the selection of the fire-extinguishing medium is to be based on the fire hazard for the space protected.

Note 1: Refer to the IMO Res. A 951(23) Improved Guidelines for Marine Portable Fire Extinguishers.

Table 1 : Number and distribution of portable fire-extinguishers

Type of space	Minimum number of extinguishers**(1)**	Class(es) of extinguisher(s) **(3)**
Space containing the controls for the main source of electrical power	1 1 additional extinguisher suitable for electric fires when main switchboards are arranged in the space	A and/or C
Cranes - with electric motors / hydraulics	0	
Cranes - with internal combustion engine	2 (1 in cabin and 1 at exterior of engine compartment)	B
Drill floor	2 (1 at each exit)	C
Helidecks	In accordance with Ch 4, Sec 10	B
Machinery spaces of category A	In accordance with [5]	B
Machinery spaces of category A which are periodically unattended	At each entrance, in accordance with [5]**(2)**	B
Main switchboards	2 in the vicinity	C
Mud pits, mud processing areas	1 for each enclosed space **(4)**	B

(1) Minimum size should be in accordance with FSS Code, Ch 4.
(2) A portable extinguisher provided for that space may be located outside that space near the entrance. This extinguisher may also be considered as satisfying the provisions for the space in which it is located.
(3) Classes of portable extinguishers are only for reference. Refer to IMO Res. A951(23) Improved Guidelines for Marine Portable Fire Extinguishers.
(4) Travel distance to an extinguisher is not to exceed 10 m for open space.

3.3.3 One of the portable fire extinguishers intended for use in any space is to be stowed near the entrance to that space.

3.3.4 Instruction plates are to be fitted, either near the extinguishers or on the extinguishers themselves, stating that a non-recharged extinguisher is not to be put back into place.

3.3.5 Fire extinguishers are to be situated ready for use at easily places, which can be reached quickly and easily at any time in the event of a fire, and in such a way that their serviceability is not impaired by the weather, vibration or other external factors.

4 Fixed fire-extinguishing systems

4.1 Types of fixed fire-extinguishing systems

4.1.1 A fixed fire extinguishing system required by [5] may be any of the following systems:

a) a fixed gas fire-extinguishing system complying with the provisions of Ch 4, Sec 11

b) a fixed high-expansion foam fire-extinguishing system complying with the provisions of Ch 4, Sec 11, and

c) a fixed pressure water-spraying fire-extinguishing system complying with the provisions of Ch 4, Sec 11

d) any other fixed fire extinguishing system considered equivalent by the Society and of a type approved by the Society.

4.1.2 Where a fixed fire-extinguishing system not required by this Chapter is installed, it shall meet the relevant requirements of this Chapter.

4.1.3 Fire-extinguishing systems using Halon 1211, 1301, and 2402 and perfluorocarbons are to be prohibited.

4.1.4 In general, the Society does not permit the use of steam as a fire-extinguishing medium in fixed fire-extinguishing systems. Where the use of steam is permitted by the Society, it shall be used only in restricted areas as an addition to the required fire-extinguishing system and shall comply with the requirements of Ch 4, Sec 11.

4.2 Closing appliances for fixed gas fire-extinguishing systems

4.2.1 Where a fixed gas fire-extinguishing system is used, openings which may admit air to, or allow gas to escape from, a protected space shall be capable of being manually closed from outside the protected space.

4.3 Storage rooms of fire-extinguishing medium

4.3.1 When the fire-extinguishing medium is stored outside a protected space, it is to be stored in a room which is located behind the forward collision bulkhead, if any, and is used for no other purposes. Any entrance to such a storage room is to be preferably from the open deck and is to be independent of the protected space. If the storage space is located below deck, it is to be located no more than one deck below the open deck and is to be directly accessible by a stairway or ladder from the open deck. Spaces which are located below deck or spaces where access from the open deck is not provided are to be fitted with a mechanical ventilation system designed to take exhaust air from the bottom of the space and are to be sized to provide at least 6 air changes per hour. Access doors are to open outwards, and bulkheads and decks, including doors and other means of closing any opening therein, which form the boundaries between such rooms and adjacent enclosed spaces, are to be gastight. For the purpose of the application of Ch 4, Sec 4, [1.2], such storage rooms are to be treated as fire control stations.

4.4 Water pumps for other fire-extinguishing systems

4.4.1 Pumps, other than those serving the fire main, required for the provision of water for fire-extinguishing systems required by the present Chapter, their sources of power and their controls are to be installed outside the space or spaces protected by such systems and are to be so arranged that a fire in the space or spaces protected will not put any such system out of action.

5 Fire-extinguishing arrangements in machinery spaces

5.1 Machinery spaces arrangement

5.1.1 General

a) The arrangement of machinery spaces is to be such that safe storage and handling of flammable liquids is ensured.

b) All spaces where oil-consuming installations, settling tanks or daily service fuel tanks are located are to be easily accessible and well ventilated.

c) Where leakage of flammable liquids may occur during normal service or routine maintenance work, special arrangement is to be made to prevent these fluids from reaching other parts of the machinery where danger of ignition may arise.

d) Materials used in machinery spaces are not normally to have properties increasing the fire potential of these rooms. Neither combustible nor oil-absorbing materials are to be used as flooring, bulkhead lining, ceiling or deck in the control room, machinery spaces, shaft tunnel or rooms where oil tanks are located. Where penetration of oil products is possible, the surface of the insulation is to be impervious to oil or oil vapours.

5.1.2 Segregation of fuel oil purifiers and other systems for preparing flammable liquids

a) The system (such as purifiers) for preparing flammable liquids for use in boilers and machinery, and separate oil systems with working pressure above 1,5 MPa and which are not part of the main engines, auxiliary engines or boilers etc., are subject to the following additional requirements.

b) The main components in the systems as per a) are to be placed in a separate room, enclosed by steel bulkheads extending from deck to deck and provided with self-closing steel doors.

Transfer pumps may be placed outside this room.

Note 1: Lubricating oil systems part of the main machinery may be located in the main engine room in location ventilated by extraction.

c) Rooms in which flammable liquids are handled as specified in item a) are to be provided with:

- Independent mechanical ventilation or ventilation arrangements which can be isolated from the machinery space ventilation.
- A fire detecting system.
- A fixed fire-extinguishing installation. The extinguishing installation is to be capable of being activated from outside the room. The extinguishing system is to be separated from the room, but may be a part of the main fire-extinguishing system for the machinery space. Closing of ventilation openings is to be effected from a position close to where the extinguishing system is activated.

d) Where the size of the engine room makes it impracticable to locate the main components of such systems in a separate space, specific measures with regard to the location, containment of possible leakages and shielding of the components, and to ventilation, are to be provided to the satisfaction of the Society, such as:

- fitting of drip trays and shielding for leakage containment
- location close to ventilation exhaust so as to avoid flammable gas accumulation in vicinity
- fitting of dedicated hood above for ventilation exhaust.

A local fixed fire-extinguishing system is to be provided, capable of being activated automatically or activated manually from the machinery control position or from another suitable location. If automatic release is provided, additional manual release is to be arranged.

5.2 Machinery spaces containing oil-fired boilers or oil fuel units

5.2.1 Fixed fire-extinguishing systems

Machinery spaces of category A containing oil fired boilers or oil fuel units are to be provided with any one of the fixed fire-extinguishing systems in [4.1].

In each case, if the engine-room and boiler room are not entirely separate, or if fuel oil can drain from the boiler room into the engine-room, the combined engine and boiler rooms are to be considered as one compartment.

5.2.2 Additional fire-extinguishing arrangements

a) There is to be in each boiler room or at an entrance outside of the boiler room at least one portable foam applicator unit of a type approved by the Society.

Note 1: The portable foam applicator unit is to consist of a foam nozzle of an inductor type capable of being connected to the fire main by a fire hose, together with a portable tank containing at least 20 l of foam-forming liquid and one spare tank of foam making liquid. The nozzle is to be capable of producing effective foam suitable for extinguishing an oil fire, at the rate of at least 1,5 m^3/min.

b) There are to be at least two portable foam extinguishers or equivalent in each firing space in each boiler room and in each space in which a part of the oil fuel installation is situated. There are to be not less than one approved foam-type extinguisher of at least 135 l capacity or equivalent in each boiler room. These extinguishers are to be provided with hoses on reels suitable for reaching any part of the boiler room. In the case of domestic boilers of less than 175 kW an approved foam-type extinguisher of at least 135 l capacity is not required.

c) In each firing space there is to be a receptacle containing at least 0,1 m^3 sand, sawdust impregnated with soda, or other approved dry material, along with a suitable shovel for spreading the material. An approved portable extinguisher may be substituted as an alternative.

5.3 Machinery spaces of category A containing internal combustion machinery

5.3.1 Fixed fire-extinguishing systems

Machinery spaces of category A containing internal combustion machinery are to be provided with one of the fixed fire-extinguishing systems required in [4.1].

5.3.2 Additional fire-extinguishing arrangements

a) There is to be at least one portable foam applicator unit of a type approved by the Society.

Note 1: Refer to Note 1 in [5.2.2].

b) There are to be in each such space approved foam-type fire extinguishers, each of at least 45 l capacity or equivalent, sufficient in number to enable foam or its equivalent to be directed onto any part of the fuel and lubricating oil pressure systems, gearing and other fire hazards. In addition, there is to be provided a sufficient number of portable foam extinguishers or equivalent which are to be so located that no point in the space is more than 10 m walking distance from an extinguisher and that there are at least two such extinguishers in each such space. For smaller spaces of cargo units, the Society may consider relaxing this requirement.

c) In the case of machinery spaces containing both boilers and internal combustion engines, [5.2] and [5.3] apply, with the exception that one of the foam fire extinguishers of at least 45 l capacity or equivalent may be omitted provided that the 136 l extinguisher can efficiently and readily protect the area covered by the 45 l extinguishers.

5.4 Machinery spaces containing steam turbines or enclosed steam engines

5.4.1 Fixed fire-extinguishing systems

In spaces containing steam turbines or enclosed steam engines used for main propulsion or other purposes having in the aggregate a total output of not less than 375 kW, one of the fire-extinguishing systems specified in [4.1] is to be provided if such spaces are periodically unattended.

5.4.2 Additional fire-extinguishing arrangements

a) There are to be approved foam fire extinguishers, each of at least 45 l capacity or equivalent, sufficient in number to enable foam or its equivalent to be directed on to any part of the pressure lubrication system, on to any part of the casings enclosing pressure-lubricated parts of the turbines, engines or associated gearing, and any other fire hazards. However, such extinguishers are not to be required if protection, at least equivalent to that required by this item, is provided in such spaces by a fixed fire-extinguishing system fitted in compliance with [4.1].

b) There is to be a sufficient number of portable foam extinguishers or equivalent which are to be so located that no point in the space is more than 10 m walking distance from an extinguisher and that there are at least two such extinguishers in each such space, except that such extinguishers are not to be required in addition to any provided in compliance with item b) of [5.2.2].

c) There is to be at least one CO_2 or powder extinguisher in the proximity of any electric switchboard or section board having a power of 20 kW and upwards.

5.5 Other machinery spaces

5.5.1 Where, in the opinion of the Society, a fire hazard exists in any machinery space for which no specific provisions for fire-extinguishing appliances are prescribed in [5.2], [5.3] and [5.4], there is to be provided in or adjacent to that space, such a number of approved portable fire extinguishers or other means of fire extinction as the Society may deem sufficient.

5.6 Fixed local application fire-extinguishing systems

5.6.1 Machinery spaces of category A above 500 m^3 in volume shall, in addition to the fixed fire-extinguishing system required in [5.3.1], be protected by fixed water-based or equivalent local application fire-extinguishing system complying with the provisions of Ch 4, Sec 11. In the case of periodically unattended machinery spaces, the fire-extinguishing system shall have both automatic and manual release capabilities. In the case of continuously manned machinery spaces, the fire-extinguishing system is only required to have a manual release capability.

5.6.2 Fixed local application fire-extinguishing systems are to protect areas such as the following, without the necessity of engine shutdown, personnel evacuation, or sealing of the spaces:

- the fire hazard portions of internal combustion machinery
- the boiler fronts
- the fire hazard portions of incinerators
- the purifiers for heated fuel oil
- the oil fired equipment, such as inert gas generators and thermal oil heaters.

5.6.3 Activation of any local application system shall give a visual and distinct audible alarm in the protected space and at continuously manned stations. The alarm shall indicate the specific system activated. The system alarm requirements described within this requirement are in addition to, and not a substitute for, the detection and fire alarm system required elsewhere in this Chapter.

6 Fire-extinguishing arrangements in service spaces

6.1 Spaces containing flammable liquid

6.1.1 Paint lockers are to be protected by:

a) a carbon dioxide system, designed to give a minimum volume of free gas equal to 40% of the gross volume of the protected space

b) a dry powder system, designed for at least 0,5 kg powder/m^3

c) a water spraying or sprinkler system, designed for 5 l/min·m^2. Water spraying systems may be connected to the fire main of the unit, or

d) a system providing equivalent protection, as determined by the Society.

In all cases, the system is to operable from outside the protected space.

6.1.2 Flammable liquid lockers are to be protected by an appropriate fire-extinguishing arrangement approved by the Society.

6.1.3 For lockers of a deck area of less than 4 m^2, which do not give access to accommodation spaces, a portable carbon dioxide fire extinguisher sized to provide a minimum volume of free gas equal to 40% of the gross volume of the space may be accepted in lieu of a fixed system. A discharge port is to be arranged in the locker to allow the discharge of the extinguisher without having to enter into the protected space. The required portable fire extinguisher is to be stowed adjacent to the port. Alternatively, a port or hose connection may be provided to facilitate the use of fire main water.

6.2 Deep-fat cooking equipment

6.2.1 Deep-fat cooking equipment is to be fitted with the following:

a) an automatic or manual fire-extinguishing system tested to an international standard

b) a primary and backup thermostat with an alarm to alert the operator in the event of failure of either thermostat

c) arrangements for automatically shutting off the electrical power upon activation of the fire-extinguishing system

d) an alarm for indicating operation of the fire-extinguishing system in the galley where the equipment is installed, and

e) controls for manual operation of the fire-extinguishing system which are clearly labelled for ready use by the crew.

7 Additional fire-extinguishing arrangements on drilling units

7.1 Fixed fire-extinguishing systems on drilling and well test areas

7.1.1 In addition to the requirements of Articles [5] and Article [6]:

a) A fixed water-spray system is to be provided to protect drilling area. The minimum water application rate is to be not less than 20,4 l/min·m^2, or

b) At least two dual-purpose (jet/spray) fire monitors are to be installed to cover drilling and well test areas. The minimum capacity of each monitor is to be not less than 100 m^3/h. The monitors may be operated either remotely or locally. Monitors arranged for local operation are to be sited on an accessible protected position.

7.2 Fixed fire-extinguishing systems on mud processing area

7.2.1 A suitable fixed foam system is to be provided. The system is to be capable of delivering foam solution at a rate of not less than 6,5 l/min·m^2 (4,1 l/min·m^2 for Aqueous Film Forming Foam or Film-Forming Fluoroprotein Foam) for 15 minutes. Alternatively, a gas fixed fire-extinguishing system may be used for enclosed mud processing spaces.

Section 7 Suppression of Fire: Structural Integrity

1 Material of hull, superstructures, structural bulkheads, decks and deckhouses

1.1 General

1.1.1 The hull, superstructures, structural bulkheads, decks and deckhouses are to be constructed of steel or other equivalent material. For the purpose of applying the definition of steel or other equivalent material as given in Ch 4, Sec 1, [3.6.8], the “applicable fire exposure” is to be according to the integrity and insulation standards given in Ch 4, Sec 4, [1.2]. For example, where divisions such as decks or sides and ends of deckhouses are permitted to have B-0 fire integrity, the “applicable fire exposure” is to be half an hour.

2 Structure of aluminium alloy

2.1 General

2.1.1 Unless otherwise specified in [1.1.1], in cases where any part of the structure is of aluminium alloy, the following is to be applied:

a) the insulation of aluminium alloy components of A or B class divisions, except structure which, in the opinion of the Society, is non-load-bearing, is to be such that the temperature of the structural core does not rise more than 200°C above the ambient temperature at any time during the applicable fire exposure to the standard fire test, and

b) special attention is to be given to the insulation of aluminium alloy components of columns, stanchions and other structural members required to support lifeboat and liferaft stowage, launching and embarkation areas, and A and B class divisions to ensure that:

    1) for such members supporting lifeboat and liferaft areas and A class divisions, the temperature rise limitation specified in item a) shall apply at the end of one hour, and

    2) for such members required to support B class divisions, the temperature rise limitation specified in item a) shall apply at the end of half an hour.

3 Machinery spaces of category A

3.1 Crowns and casings

3.1.1 Crowns and casings of machinery spaces of category A are to be of steel construction and are to be insulated as required by Ch 4, Sec 4, [1.2] as appropriate.

3.2 Floor plating

3.2.1 The floor plating of normal passageways in machinery spaces of category A are to be made of steel.

4 Materials of overboard fittings

4.1 General

4.1.1 Materials readily rendered ineffective by heat are not to be used for overboard scuppers, sanitary discharges, and other outlets which are close to the waterline and where the failure of the material in the event of fire would give rise to danger of flooding.

Section 8 Escape

1 Notification of people on board

1.1 General emergency alarm system

1.1.1 A general emergency alarm system required in Ch 2 Sec 3 [7.14] is to be used for notifying personnel on board of a fire.

2 Means of escape

2.1 General requirements

2.1.1 Unless expressly provided otherwise in this Article, at least two widely separated and ready means of escape are to be provided from all spaces or groups of spaces.

Note 1: In case notation **PROC** is not granted to the unit, escape routes in the topsides modules are not covered by the present Section.

2.1.2 Lifts are not to be considered as forming one of the means of escape as required by this Section.

2.1.3 Embarkation areas are to be adequately protected to ensure safe access to the evacuation means during an accidental event and for a period of time sufficient for evacuation operations.

2.1.4 Every escape route should be readily accessible and unobstructed and all exit doors along the route should be readily operable.

2.1.5 For drilling units, consideration should be given by the Society to the sitting of superstructures and deckhouses such that in the event of fire at the drill floor at least one escape route to the embarkation position and survival craft is protected against radiation effects of that fire as far as practicable.

2.1.6 Stairways and corridors used as means of escape shall be not less than 700 mm in clear width and shall have a handrail on one side. Stairways and corridors with a clear width of 1800 mm and over shall have handrails on both sides. Clear width is considered the distance between the handrail and the bulkhead on the other side or between the handrails. The angle of inclination of stairways should be, in general, 45°, but not greater than 50°, and in machinery spaces and small spaces not more than 60°. Doorways which give access to a stairway shall be of the same size as the stairway.

2.2 Means of escape from control stations, accommodation spaces and service spaces

2.2.1 General requirements

a) Stairways should normally be used for means of vertical escape; however, a vertical ladder may be used for one of the means of escape when the installation of a stairway is shown to be impracticable.

b) In every general area which is likely to be regularly manned or in which personnel are accommodated at least two separate escape routes should be provided, situated as far apart as practicable, to allow ready means of escape to the open decks and embarkation stations.

c) All stairways in accommodation and service spaces and control stations are to be of steel frame construction except where the Society sanctions the use of other equivalent material.

d) Escape routes are to be of suitable size to enable quick and efficient movement of the maximum of personnel who may require to use them, and for easy manoeuvring of fire-fighting equipment and use of stretchers.

e) Doors in escape routes are, in general, to open in way of the direction of escape, except that:

   1) individual cabin doors may open into the cabins in order to avoid injury to persons in the corridor when the door is opened, and

   2) doors in vertical emergency escape trunks may open out of the trunk in order to permit the trunk to be used both for escape and for access.

f) At all levels of accommodation there are to be provided at least two widely separated means of escape from each restricted space or group of spaces.

g) In addition to the emergency lighting, the means of escape in accommodation areas, including stairways and exits, are to be marked by lighting or photoluminescent strip indicators placed not more than 300 mm above the deck at all points of the escape route, including angles and intersections. The marking is to enable personnel to identify the routes of escape and readily identify the escape exits. If electric illumination is used, it is to be supplied by the emergency source of power and it is to be so arranged that the failure of any single light or cut in a lighting strip will not result in the marking being ineffective.

Additionally, escape route signs and fire equipment location markings are to be of photoluminescent material or marked by lighting. Such lighting or photoluminescent equipment is to be evaluated, tested and applied in accordance with the FSS Code.

2.2.2 Escape from spaces below the lowest open deck

Below the lowest open deck the main means of escape is to be a stairway and the second escape may be a trunk or a stairway.

2.2.3 Escape from spaces above the lowest open deck

Above the lowest open deck the means of escape are to be stairways or doors to an open deck or a combination thereof.

2.2.4 Dead-end corridors

No dead-end corridors having a length of more than 7 m are to be accepted.

2.2.5 Continuity of escape routes

The number and continuity of escape routes are to be at the satisfaction of the Society.

2.2.6 Precautions against hazardous areas

The escape routes are to be routed, as far as practicable, outside hazardous areas and due consideration is to be given to protection of personnel from effects of gas, smoke and heat.

2.2.7 Dispensation from one of the two means of escape

Exceptionally, the Society may permit only one of the means of escape, due regard being paid to the nature and location of spaces and to the number of persons who might normally be accommodated or employed here.

2.2.8 Means of escape from the steering gear space

a) Steering gear spaces which do not contain the emergency steering position need only have one means of escape.

b) Steering gear spaces containing the emergency steering position can have one means of escape provided it leads directly onto the open deck. Otherwise, two means of escape are to be provided but they do not need to lead directly onto the open deck.

c) Direct access to the open deck

Escape routes that pass only through stairways and/or corridors that have fire integrity protection equivalent to steering gear spaces are considered as providing a “direct access to the open deck”.

2.3 Means of escape from machinery spaces

2.3.1 Means of escape from each machinery space are to comply with the following provisions:

a) Escape from machinery spaces of category A

Except as provided in the following item b), two means of escape are to be provided from each machinery space of category A. In particular, one of the following provisions is to be complied with:

1) two sets of steel ladders, as widely separated as possible, leading to doors in the upper part of the space, similarly separated and from which access is provided to the open deck. One of these ladders is to be located within a protected enclosure that satisfies Ch 4, Sec 4, [1.2.2], category (4), from the lower part of the space it serves to a safe position outside the space. Self-closing fire doors of the same integrity standards are to be fitted in the enclosure. The ladder is to be fixed in such a way that heat is not transferred into the enclosure through non-insulated fixing points. The enclosure is to have minimum internal dimensions of at least 800 mm x 800 mm and is to have emergency lighting provisions, or

2) one steel ladder leading to a door in the upper part of the space from which access is provided to the open deck and, additionally, in the lower part of the space and in a position well separated from the ladder referred to, a steel door capable of being operated from each side and which provides access to a safe escape route from the lower part of the space to the open deck.

b) Dispensation from two means of escape

Exceptionally, one means of escape may be permitted, due regard being paid to the nature and location of spaces and to the number of persons who might normally be employed there.

c) Escape from machinery spaces other than those of category A

From machinery spaces other than those of category A, two escape routes are to be provided except that a single escape route may be accepted for spaces that are entered only occasionally and for spaces where the maximum travel distance to the door is 5 m or less.

Note 1: In machinery spaces other than those of category A, which are not entered only occasionally, the travel distance shall be measured from any point normally accessible to the crew, taking into account machinery and equipment within the space.

d) Inclined ladders and stairways

Inclined ladders/stairways in machinery spaces being part of, or providing access to, escape routes but not located within a protected enclosure shall not have an inclination greater than 60° and shall not be less than 600 mm in clear width. Such requirement need not be applied to ladders/stairways not forming part of an escape route, only provided for access to equipment or components, or similar areas, from one of the main platforms or deck levels within such spaces.

e) Escape from machinery control rooms in machinery spaces of category “A”

Two means of escape shall be provided from the machinery control room located within a machinery space. At least one of these escape routes shall provide a continuous fire shelter to a safe position outside the machinery space.

f) Escape from main workshops in machinery spaces of category “A”

Two means of escape shall be provided from the main workshop within a machinery space. At least one of these escape routes shall provide a continuous fire shelter to a safe position outside the machinery space.

2.4 Fibre Reinforced Plastic (FRP) Gratings

2.4.1 FRP gratings may be used in locations where steel or an equivalent material is not specified by the rules.

FRP gratings are to:

- possess low flame spread characteristics
- generate not excessive quantities of smoke or toxic products as defined in the FTP Code
- have adequate structural fire integrity as defined in the USCG Marine Safety Manual Vol. II Para 5.C.6.f. Structural Fire Integrity Matrix or another recognized standard.

FRP grating are to undergo testing in accordance wit the above standards.

Section 9 Fire Plan

1 Fire control plans

1.1 Compilation of the fire control plans

1.1.1 Fire control plans are to be permanently exhibited for the guidance of the unit's officers.

1.1.2 Fire control plans are to be submitted for review and to clearly show:

a) locations of control stations

b) various fire sections enclosed by various classes of fire divisions

c) arrangement of fire detectors and manual fire alarm stations

d) arrangement of combustible gas detectors

e) arrangement of hydrogen sulphide gas detectors

f) locations of respiratory protection equipment for hydrogen sulphide

g) general alarm actuating positions

h) arrangement of various fire-extinguishing appliances

i) locations of fighter's outfits

j) location of helicopter crash kit

k) arrangement of water spray nozzles and sprinklers (if fitted)

l) locations of emergency shutdown (such as oil fuel source shutdown, engine shutdown, etc.) stations

m) the ventilating system including fire dampers positions, ventilating fans control positions with indication of identification numbers of ventilating fans serving each section

n) arrangement of fire/watertight doors and their remote control positions

o) blowout preventer control positions

p) escape route and means of access to different compartments, decks, etc.

q) locations of Emergency Escape Breathing Devices (EEBD)

r) arrangement of emergency muster stations and life-saving appliances.

1.1.3 Alternatively, at the discretion of the Society, the aforementioned details may be set out in a booklet, a copy of which is to be supplied to each officer, and one copy is to at all times be available on board in an accessible position. Plans and booklets are to be kept up to date; any alterations thereto are to be recorded as soon as practicable. Description in such plans and booklets is to be in the language or languages required by the Owner. If the language is neither English nor French, a translation into one of those languages is to be included.

In addition, instructions concerning the maintenance and operation of all the equipment and installations on board for the fighting and containment of fire are to be kept under one cover, readily available in an accessible position.

1.1.4 Special equipment provided for the carriage of dangerous goods, if fitted, is to be shown.

1.2 Location of the fire control plans

1.2.1 A duplicate set of fire control plans or a booklet containing such plans is to be permanently stored in a prominently marked weathertight enclosure outside the deckhouse for the assistance of shore-side fire-fighting personnel.

Section 10 Helicopter Facilities

Symbols

D-value : D-value means the largest dimension of the helicopter when the rotors are turning, measured from the most forward position of the main rotor tip path plane to the most rearward position of the tail rotor path plane or helicopter structure.

1 General

1.1 Application

1.1.1 In addition to complying with the requirements of the other Sections of this Chapter, as appropriate, units equipped with helicopter facilities are to comply with those of this Section.

Items e) and f) of [3.1.1] and Articles [5] and [6] do not contain requirements applicable for the purpose of classification; they have been reproduced for reference purposes only.

1.2 Contents

1.2.1 This Section includes the provisions of the MODU Code, Sec 9.16.

This section provides additional measures in order to address the fire safety objectives for units fitted with facilities for helicopters and meets the following functional provisions:

a) helideck structure is to be adequate to protect the unit from the fire hazards associated with helicopter operations

b) fire-fighting appliances is to be provided to adequately protect the unit from the fire hazards associated with helicopter operations

c) refuelling facilities and operations is to provide the necessary measures to protect the unit from the fire hazards associated with helicopter operations

d) helicopter facility operation manuals and training should be provided.

1.3 Definitions

1.3.1 Helideck

Helideck is a purpose-built helicopter landing area located on a unit including all structure, fire-fighting appliances and other equipment necessary for the safe operation of helicopters.

1.3.2 Helicopter facilities

Helicopter facility is a helideck including any refuelling and hangar facilities.

1.4 Recognised codes

1.4.1 Recognised code, as concerned with helicopter facilities, are:

- CAA CAP 437 “Civil Aviation Authority; Offshore Helicopter Landing Areas -Guidance on Standards”
- MODU code Ch 13

2 Structure

2.1 Construction of steel or other equivalent materials

2.1.1 The construction of the helidecks is to be of steel or other equivalent materials. If the helideck forms the deckhead of a deckhouse or superstructure, it is to be insulated to A-60 class standard.

2.2 Construction of aluminium or other low melting point metals

2.2.1 If the Society permits aluminium or other low melting point metal construction that is not made equivalent to steel and if the helideck is located above the unit’s deckhouse or similar structure, the following conditions are to be satisfied:

a) the deckhouse top and bulkheads under the helideck are to have no opening

b) windows under the helideck are to be provided with steel shutters.

2.3 Means of escape

2.3.1 A helideck is to be provided with both a main and an emergency means of escape and access for fire-fighting and rescue personnel. These are to be located as far apart from each other as is practicable and preferably on opposite sides of the helideck.

3 Fire-fighting appliances

3.1 General

3.1.1 Where areas of a unit are designated for helicopter facilities, the fire fighting equipment as given below are to be provided and so arranged as to adequately protect both the helicopter deck and fuel storage areas:

a) at least two dry powder extinguishers having a total capacity of not less than 45 kg but not less than 9 kg each

b) carbon dioxide extinguishers of a total capacity of not less than 18 kg or equivalent, one of these extinguishers being so equipped as to enable it to reach the engine area of any helicopter using the deck. The carbon dioxide extinguishers are to be located so that they would not be vulnerable to the same damage as the dry powder extinguishers

c) a suitable foam application system consisting of monitors or hose streams or both is to be installed.The system is to be capable of delivering foam solution to all parts of the helideck in all weather conditions in which the helideck is intended to be available for helicopter operations. The minimum capacity of the foam production system is to be dependent of the area to be protected, as defined below:
   - a minimum application rate of 6,0 $l/min\cdot m^2$ (4,1 $l/min\cdot m^2$ for Aqueous Film Forming Foam or Film-Forming Fluoroprotein Foam), within a circle having a diameter equal to the D-value
   - a minimum of 5 min discharge capability is to be provided
   - foam delivery at the minimum application rate is to start within 30 s of system activation.

   The Society may accept other fire-fighting systems which provide a fire-extinguishing capability at least as effective as the required foam application system

d) the principal agent is to meet the applicable performance standards of the International Civil Aviation Organization “Airport Services Manual, Part 1 - Rescue and Firefighting, Chapter 8 - Extinguishing Agent Characteristics, Paragraph 8.1.5 - Foam Specifications Table 8-1, Level “B” foam”, and be suitable for use with salt water

e) at least two dual-purpose nozzles (jet/spray) and hoses sufficient in length to reach any part of the helideck. The nozzles and hoses are to be of a type approved by the Society

f) two sets of fire-fighter’s outfits, and

g) at least the following equipment, stored in a manner that provides for immediate use and protection from the elements:
   - adjustable wrench
   - blanket, fire-resistant
   - cutters, bolt 60 cm
   - hook, grab or salving
   - hacksaw, heavy duty complete with 6 spare blades
   - ladder
   - lift line 5 mm diameter and 30 m in length
   - pliers, side-cutting
   - set of assorted screwdrivers, and
   - harness knife complete with sheath
   - crowbar

h) fire extinguishing arrangements for the protection of the fuel storage/fuel pumping are to be at the satisfaction of the Society.

3.1.2 Drainage facilities in way of helidecks are to be:

- constructed of steel or other arrangements providing equivalent fire safety
- lead directly overboard independent of any other system
- designed so that drainage does not fall onto any part of the unit.

4 Helicopter refuelling and hangar facilities

4.1 “No smoking” signs

4.1.1 “NO SMOKING” signs are to be displayed at appropriate locations.

4.2 Hangar, refuelling and maintenance facilities

4.2.1 Hangar, refuelling and maintenance facilities are to be treated as category A machinery spaces with regard to structural fire protection, fixed fire-extinguishing and detection system requirements.

4.3 Arrangement of spaces containing the refuelling installations

4.3.1 General

Where the unit has helicopter refuelling, the following provisions are to be complied with:

a) A designated area is to be provided for the storage of fuel tanks and is to be:
   - as remote as is practicable from accommodation spaces, escape routes and embarkation stations
   - isolated from areas containing a source of vapour ignition.

b) The fuel storage area is to be provided with arrangements whereby fuel spillage may be collected and drained to a safe location.

c) Tanks and associated equipment are to be protected against physical damage and from a fire in an adjacent space or area.

d) Where portable fuel storage tanks are used, special attention is to be given to:
   - design of the tank for its intended purpose
   - mounting and securing arrangements
   - electric bonding
   - inspection procedures.

e) Storage tank fuel pumps are to be provided with means which permit shutdown from a safe remote location in the event of a fire. Where a gravity-fuelling system is installed, equivalent closing arrangements is to be provided to isolate the fuel source.

f) The fuel pumping unit is to be connected to one tank at a time. The piping between the tank and the pumping unit is to be of steel or equivalent material, as short as possible, and protected against damage.

g) Electrical fuel pumping units and associated control equipment should be of a type suitable for the location and potential hazards.

h) Fuel pumping units are to incorporate a device which will prevent over-pressurization of the delivery or filling hose.

i) Equipment used in refuelling operations are to be electrically bonded.

4.3.2 Ventilation

Enclosed hangar facilities or enclosed spaces containing refuelling installations are to be provided with mechanical ventilation with the following features.

a) Capacity of ventilation systems

   There is to be provided an effective power ventilation system sufficient to give at least 6 air changes per hour.

   The Society may require an increased number of air changes when the refuelling unit installations are used.

b) Performance of ventilation systems

   1) Ventilation fans are to be normally run continuously whenever the refuelling unit installations are used. Where this is impracticable, they are to be operated for a limited period daily as weather permits. One or more portable combustible gas detecting instruments are to be carried for this purpose. The system is to be entirely separated from other ventilating systems. The system is to be capable of being controlled from a position outside such spaces.
   2) The ventilation system is to be such as to prevent air stratification and the formation of air pockets.
   3) Ventilation fans are to be of non-sparking type.

c) Indication of ventilation systems

   Means are to be provided on the central control room to indicate any loss of the required ventilating capacity.

d) Closing appliances and ducts

   Arrangements are to be provided to permit a rapid shut-down and effective closure of the ventilation system from outside of the space in case of fire, taking into account the weather and sea conditions.

e) Permanent openings

   Permanent openings in the side plating, the ends or deckhead of the space are to be so situated that a fire in the space containing the refuelling installations does not endanger stowage areas and embarkation stations for survival craft and accommodation spaces, service spaces and control stations in superstructures and deckhouses above the spaces containing the refuelling installations.

4.3.3 Electric equipment and wiring

Electric equipment and wiring in enclosed hangars or enclosed spaces containing refuelling installations are to comply with the following requirements:

a) Electrical equipment and wiring are to be of a type suitable for use in an explosive petrol and air mixture.

b) Electrical equipment and wiring, if installed in an exhaust ventilation duct, are to be of a type approved for use in explosive petrol and air mixtures and the outlet from any exhaust duct is to be sited in a safe position, having regard to other possible sources of ignition.

c) Other equipment which may constitute a source of ignition of flammable vapours is not to be permitted.

5 Occasional and emergency helicopter operations

5.1 General

5.1.1 Where helicopters land or conduct winching operations on an occasional or emergency basis on units without helidecks, fire-fighting equipment fitted in accordance with the requirements of Ch 4, Sec 1 may be used. This equipment is to be made readily available in close proximity to the landing or winching areas during helicopter operations.

6 Operations manual

6.1 General

6.1.1 Each helicopter facility is to have an operations manual, including a description and a checklist of safety precautions, procedures and equipment requirements. This manual may be part of the unit's emergency response procedures.

6.1.2 The procedures and precautions during refuelling operations are to be in accordance with industry recognised practice.

Section 11 Fire Safety Systems

1 General

1.1 Application

1.1.1 This Section applies to fire safety systems as referred to in the Rules.

1.1.2 Piping systems included in fire safety systems covered by this Section are to comply with the requirements of Ch 1, Sec 7, unless otherwise specified in the present Section

1.1.3 Pressure vessels included in fire safety systems covered by this Section are to comply with the requirements of Ch 1, Sec 3, unless otherwise specified in the present Section.

1.2 Statutory requirements

1.2.1 Fire safety systems are to be in accordance with the provision of the SOLAS Convention and the FSS Code, as applicable.

1.3 Use of toxic extinguishing media

1.3.1 The use of a fire-extinguishing medium which, in the opinion of the Society, either by itself or under expected conditions of use gives off toxic gases, liquids and other substances in such quantities as to endanger persons shall not be permitted.

2 International shore connections

2.1 Engineering specifications

2.1.1 Standard dimensions

Standard dimensions of flanges for the international shore connection are to be in accordance with Tab 1 (see also Fig 1).

Figure 1 : International shore connection

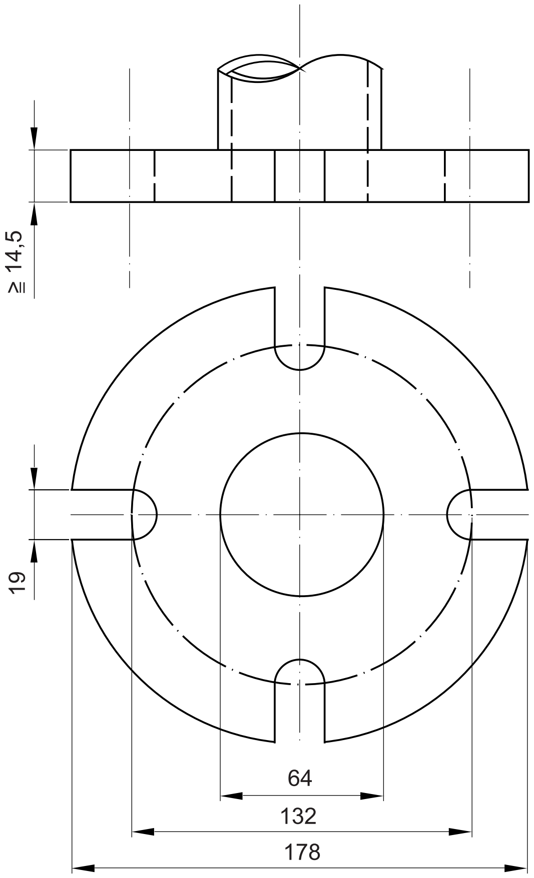


Table 1 : Standard dimensions

Description	Dimension
Outside diameter	178 mm
Inside diameter	64 mm
Bolt circle diameter	132 mm
Slots in flange	4 holes, 19 mm in diameter spaced equidistantly on a bolt circle of the above diameter, slotted to the flange periphery
Flange thickness	14,5 mm minimum
Bolts and nuts	4, each of 16 mm diameter, 50 mm in length

2.1.2 Materials and accessories

International shore connections are to be of steel or other equivalent material and are to be designed for 1,0 N/mm^2 services. The flange is to have a flat face on one side and, on the other side, to be permanently attached to a coupling that fitting the unit's hydrant and hose. The connection is to be kept aboard the unit together with a gasket of any material suitable for 1,0 N/mm^2 services, together with four bolts of 16 mm diameter and 50 mm in length, four 16 mm nuts and eight washers.

3 Fire extinguishers

3.1 Type approval

3.1.1 All fire extinguishers are to be of approved types and designs.

3.2 Engineering specifications

3.2.1 Fire extinguisher

a) Safety requirements

Fire extinguishers containing an extinguishing medium which, in the opinion of the Society, either by itself or under the expected conditions of use gives off toxic gases in such quantities as to endanger persons or which is an ozone depleting substance are not to be permitted.

b) Quantity of medium

1) Each powder or carbon dioxide extinguisher is to have a capacity of at least 5 kg and each foam extinguisher is to have a capacity of at least 9 l. The mass of all portable fire extinguishers is not to exceed 23 kg and they are to have a fire-extinguishing capability at least equivalent to that of a 9 l fluid extinguisher.

2) The Society determines the equivalents of fire extinguishers.

3.2.2 Portable foam applicator

a) A portable foam applicator unit shall consist of a foam nozzle/branch pipe, either of a self-inducing type or in combination with a separate inductor, capable of being connected to the fire main by a fire hose, together with a portable tank containing at least 20 l of foam concentrate and at least one spare tank of foam concentrate of the same capacity.

b) System performance

1) The nozzle/branch pipe and inductor shall be capable of producing effective foam suitable for extinguishing an oil fire, at a foam solution flow rate of at least 200 l/min at the nominal pressure in the fire main.

2) The foam concentrate shall be approved.

3) The values of the foam expansion and drainage time of the foam produced by the portable foam applicator unit shall not differ more than ± 10% of that determined in item 2).

4) The portable foam applicator unit shall be designed to withstand clogging, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered on units.

4 Fixed gas fire-extinguishing systems

4.1 Engineering specifications

4.1.1 General

a) Fire-extinguishing medium

1) Where the quantity of the fire-extinguishing medium is required to protect more than one space, the quantity of medium available need not be more than the largest quantity required for any one space so protected. The system is to be fitted with normally closed control valves arranged to direct the agent into the appropriate space.Adjacent spaces with independent ventilation systems not separated by at least A-0 class divisions should be considered as the same space.

2) The volume of starting air receivers, converted to free air volume, is to be added to the gross volume of the machinery space when calculating the necessary quantity of the fire-extinguishing medium. Alternatively, a discharge pipe from the safety valves may be fitted and led directly to the open air.

3) Means are to be provided for the crew to safely check the quantity of the fire-extinguishing medium in the containers.It shall not be necessary to move the containers completely from their fixing position for this purpose. For carbon dioxide systems, hanging bars for a weighing device above each bottle row, or other means shall be provided. For other types of extinguishing media, suitable surface indicators may be used.

4) Containers for the storage of fire-extinguishing medium, piping and associated pressure components shall be designed to pressure codes of practice to the satisfaction of the Society having regard to their locations and maximum ambient temperatures expected in service.

b) Installation requirements

1) The piping for the distribution of fire-extinguishing medium is to be arranged and discharge nozzles so positioned that a uniform distribution of the medium is obtained. System flow calculations is to be performed using a calculation technique acceptable to the Society.

In machinery spaces, the discharge nozzles are to be positioned in the upper and lower parts of these spaces.

2) Except as otherwise permitted by the Society, pressure containers required for the storage of the fire-extinguishing medium, other than steam, are to be located outside the protected spaces in accordance with Ch 4, Sec 6, [4.3].

3) The storage of the fire extinguishing medium is not permitted within spaces which may contain air/flammable gas mixtures.

4) In piping sections where valve arrangements introduce sections of closed piping, such sections are to be fitted with a pressure relief valve and the outlet of the valve is to be led to open deck.

5) All discharge piping, fittings and nozzles in the protected spaces are to be constructed of materials having a melting temperature which exceeds 925°C. The piping and associated equipment are to be adequately supported.

6) A fitting is to be installed in the discharge piping to permit the air testing as required in [4.1.3], item g) 4).

c) System control requirements

1) The necessary pipes for conveying fire-extinguishing medium into the protected spaces are to be provided with control valves so marked as to indicate clearly the space to which the pipes are led. Suitable provision is to be made to prevent inadvertent release of the medium into the space. The pipes may pass through accommodation areas provided that they are of substantial thickness and that their tightness is verified with a pressure test, after their installation, at a pressure head not less than 5 N/mm^2. In addition, pipes passing through accommodation areas are to be joined only by welding and are not to be fitted with drains or other openings within such spaces. The pipes are not to pass through refrigerated spaces.

Control valves are to be capable of local operation.

The open or closed position of control valves is to be indicated.

Means are to be provided in order to permit the blowing through each branch line of the piping system downstream of the master (control) valves.

2) Means are to be provided for automatically giving audible and visual warning of the release of fire-extinguishing medium into spaces in which personnel normally work or to which they have access. The audible alarms are to be located so as to be audible throughout the protected space with all machinery operating, and the alarms are to be distinguished from other audible alarms by adjustment of sound pressure or sound patterns. The pre-discharge alarm is to be automatically activated (e.g. by opening of the release cabinet door). The alarm is to operate for the length of time needed to evacuate the space, but in no case less than 20 seconds before the medium is released. Small spaces (such as compressor rooms, paint lockers, etc.) with only a local release need not be provided with such an alarm.

Where audible alarms are fitted to warn of the release of fire-extinguishing medium into pump rooms, they may be of the pneumatic or electrical type:

- pneumatically operated alarms

  Air operated alarms may be used provided the air supply is clean and dry.

- electrically operated alarms

  When electrically operated alarms are used, the arrangements are to be such that the electrical actuating mechanism is located outside the pump room except where the alarms are certified intrinsically safe.

Electrically operated alarms are to be supplied with power from the main and an emergency source of power. They are to differ from other signals transmitted to the protected space.

3) The means of control of any fixed gas fire-extinguishing system shall be readily accessible, simple to operate and shall be grouped together in as few locations as possible at positions not likely to be cut off by a fire in a protected space. At each location there shall be clear instructions relating to the operation of the system having regard to the safety of personnel.

4) Automatic release of fire-extinguishing medium is not to be permitted, except as permitted by the Society.

4.1.2 Carbon dioxide systems - General

a) Quantity of fire-extinguishing medium

1) For cargo spaces the quantity of carbon dioxide available shall, unless otherwise provided, be sufficient to give a minimum volume of free gas equal to 30% of the gross volume of the largest cargo space to be protected in the unit.

2) For machinery spaces the quantity of carbon dioxide carried is to be sufficient to give a minimum volume of free gas equal to the larger of the following volumes, either:

- 40% of the gross volume of the largest machinery space so protected, the volume to exclude that part of the casing above the level at which the horizontal area of the casing is 40% or less of the horizontal area of the space concerned taken midway between the tank top and the lowest part of the casing, or
- 35% of the gross volume of the largest machinery space protected, including the casing.

  In the calculation of 35% of the above-mentioned volume, the net volume of the funnel is to be considered up to a height equal to the whole casing height if the funnel space is in open connection with the machinery space without inter-position of closing means.

3) For the purpose of this item the volume of free carbon dioxide is to be calculated at 0,56 m^3/kg.

4) For machinery spaces, the fixed piping system is to be such that 85% of the gas can be discharged into the space within 2 minutes.

b) Controls

1) Carbon dioxide systems are to comply with the following requirements:

- two separate controls are to be provided for releasing carbon dioxide into a protected space and to ensure the activation of the alarm. One control is to be used for opening the valve of the piping which conveys the gas into the protected space and a second control is to be used to discharge the gas from its storage containers. Positive means (see Note 1) are to be provided so they can only be operated in that order, and
- the two controls are to be located inside a release box clearly identified for the particular space. If the box containing the controls is to be locked, a key to the box is to be in a break-glass-type enclosure conspicuously located adjacent to the box.

2) The pre-discharge alarm may be activated before the two separate system release controls are operated (e.g. by a micro-switch that activates the pre-discharge alarm upon opening the release cabinet door as per [4.1.1]. Therefore, the two separate controls for releasing carbon dioxide into the protected space (i.e. one control to open the valve of the piping which conveys the gas into the protected space and a second control used to discharge the gas from its storage containers) as per item b) 1) above can be independent of the control for activating the alarm.

A single control for activation of the alarm is sufficient.

Note 1: The “positive means”, referred to for the correct sequential operation of the controls, is to be achieved by a mechanical and/or electrical interlock that does not depend on any operational procedure to achieve the correct sequence of operation.

Note 2: The controls requirements detailed in item b) apply to the spaces identified in [4.1.1], item c) 2) to be provided with a pre-discharge alarm.

4.1.3 High-pressure carbon dioxide systems

a) The system is to be designed for an ambient temperature range of 0°C/55°C, as a rule.

b) Containers for the storage of the fire-extinguishing medium are to be designed and tested in accordance with the relevant requirements of Part C, Chapter 1.

c) The filling ratio of carbon dioxide bottles is to be normally 0,67 kg/l, or less, of the total internal volume; however, for bottles to be fitted in units which are to operate solely outside the tropical zone, the filling ratio may be 0,75 kg/l.

d) Piping and accessories are to generally satisfy the relevant requirements of Part C, Chapter 1.

e) For systems where carbon dioxide is stored at ambient temperature, the thickness of steel pipes is not to be less than the values given in Tab 2.

Slightly smaller thicknesses may be accepted provided they comply with national standards.

The thickness of threaded pipes is to be measured at the bottom of the thread.

f) Pipes are to be appropriately protected against corrosion. Steel pipes are to be, at least, zinc or paint coated, except those fitted in machinery spaces, with the reservation of the Society’s acceptance.

g) After mounting onboard, and in complement to tests and inspections at the Manufacturer's workshop, as per requirements of Part C, Chapter 1, carbon dioxide pipes and their accessories are to undergo the following tests:

   1) pipe lengths between bottles and master valves:

      a hydraulic test, at the workshop or on board, at 128 bar. When the hydraulic test is carried out at the workshop, at least test with inert gas or air, at 7 bar, is to be carried out on board

   2) pipe lengths between master valves and nozzles:

      a test on board with inert gas or air, at 7 bar

   3) master valves:

      a hydraulic test at 128 bar

   4) a test of the free air flow in all pipes and nozzles, and

   5) a functional test of the alarm equipment.

Table 2 : Minimum wall thickness for steel pipes for CO_2 fire-extinguishing systems

External diameter (mm)	Minimum wall thickness (mm)	
	Between bottles and master valves	Between master valves and nozzles
21,3 - 26,9	3,2	2,6
30,0 - 48,3	4,0	3,2
51,0 - 60,3	4,5	3,6
63,5 - 76,1	5,0	3,6
82,5 - 88,9	5,6	4,0
101,6	6,3	4,0
108,0 - 114,3	7,1	4,5
127,0	8,0	4,5
133,0 - 139,7	8,0	5,0
152,4 - 168,3	8,8	5,6

4.1.4 Low-pressure carbon dioxide systems

When carbon dioxide, instead of being contained in non-refrigerated high pressure bottles, is contained in refrigerated low pressure vessels, in addition to the requirements in [4.1.2] the following are to be complied with.

a) General

   Except where different requirements are given in this item, the requirements of [4.1.3] for systems with carbon dioxide contained in high pressure bottles are generally to be complied with.

b) Vessels and associated devices

   1) The system control devices and the refrigerating plants are to be located within the same room where the pressure vessels are stored.

   2) The rated amount of liquid carbon dioxide is to be stored in vessels under the working pressure in the range of 1,8 MPa to 2,2 MPa. The normal liquid charge in the container is to be limited to provide sufficient vapour space to allow for expansion of the liquid under the maximum storage temperatures that can be obtained corresponding to the setting of the pressure relief valves, but is not to exceed 95% of the volumetric capacity of the container.

   3) The vessels are to be designed, constructed and tested in accordance with the requirements of Ch 1, Sec 3. For this purpose the design pressure is to be taken not less than the relief valve setting. In addition, for each vessel, provision is to be made for:

      - a pressure gauge
      - a high pressure alarm: not more than the setting of the relief valve
      - a low pressure alarm: not less than 1,8 MPa
      - branch pipes with stop valves for filling the vessel
      - discharge pipes
      - a liquid CO_2 level indicator, fitted on the vessel
      - two safety relief valves arranged so that either valve can be shut off while the other is connected to the vessel. The setting of the relief valves is to be not less than 1,1 times the working pressure. The capacity of each valve is to be such that the vapours generated due to fire can be discharged with a pressure rise not more than 20% above the setting pressure. The discharge from the safety valves is to be led to the open.

   4) The vessels and outgoing pipes permanently filled with carbon dioxide are to have thermal insulation preventing the operation of the safety valve for 24 hours after de-energising the plant, at ambient temperature of 45°C and an initial pressure equal to the starting pressure of the refrigeration unit. The insulating materials and their liners are to be to the satisfaction of the Society, bearing in mind, in particular, their fire resistance and mechanical properties, as well as protection against penetration of water vapours.

c) Refrigerating plant

   1) The vessels are to be serviced by two automated completely independent refrigerating units solely intended for this purpose, each comprising a compressor and the associated prime mover, evaporator and condenser.

   2) The refrigerating plant is to comply with the relevant requirements of Ch 1, Sec 9. The refrigerating capacity and the automatic control of each unit are to be such as to maintain the required temperature under conditions of continuous operation for 24 hours at a sea temperature up to 32°C and ambient air temperature up to 45°C.

   3) In the event of failure of either one of the refrigerating units, the other is to be actuated automatically. Provision is to be made for local manual control of the refrigerating plant.

   4) Each electrical refrigerating unit is to be supplied from the main switchboard busbars by a separate feeder.

   5) The cooling water supply to the refrigerating plant (where required) is to be provided from at least two circulating pumps, one of which being used as a standby. The standby pump may be a pump used for other services so long as its use for cooling would not interfere with any other essential service of the ship. Cooling water is to be taken from not less than two sea connections, preferably one port and one starboard.

d) Pipes, valves and associated fittings

   1) The pipes, valves and fittings are to be in accordance with the requirements of Ch 1, Sec 7 for a design pressure not less than the design pressure of the CO_2 vessels.

   2) Safety relief devices are to be provided in each section of pipe that may be isolated by block valves and in which there could be a build up of pressure in excess of the design pressure of any of the components.

   3) The piping system is to be designed in such a way that the CO_2 pressure at the nozzles should not be less than 1 MPa.

e) Control of fire-extinguishing system operation

   The machinery alarm system is to be equipped with audible and visual alarms activated when:

   1) the pressure in the vessels reaches the low and the high values according to item b) 2) above

   2) any one of the refrigerating units fails to operate

   3) the lowest permissible level of the liquid in the vessels is reached.

f) Release control

   1) The release of CO_2 is to be initiated manually.

   2) If a device is provided which automatically regulates the discharge of the rated quantity of carbon dioxide into the protected spaces, it is also to be possible to regulate the discharge manually.

   3) If the system serves more than one space, means for control of discharge quantities of CO_2 are to be provided, e.g. automatic timer or accurate level indicators located at the control positions or positions.

g) Testing

   1) The pipes, valves and fittings and assembled system are to be tested to the satisfaction of the Society.

   2) The pipes from the vessels to the release valves on the distribution manifold are to be subjected to a pressure test to not less than 1,5 times the set pressure of the safety relief valves.

   3) The pipes from the release valves on the distribution manifold to the nozzles are to be tested for tightness and free flow of CO_2, after having been assembled on board.

   4) After having been fitted on board, the refrigerating plant is to be checked for its proper operation.

   5) If deemed necessary by the Society, a discharge test may be required to check the fulfilment of the requirements of item d) 3) above.

4.2 Equivalent fixed gas fire-extinguishing systems

4.2.1 Fixed gas fire-extinguishing systems equivalent to those specified in [4.1] are to be of a type approved by the Society.

4.3 Requirements of steam systems

4.3.1 The boiler or boilers available for supplying steam are to have an evaporation of at least 1 kg of steam per hour for each 0,75 m^3 of the gross volume of the largest space so protected. In addition to complying with the foregoing requirements, the systems in all respects are to be as determined by, and to the satisfaction of, the Society.

5 Fixed foam fire-extinguishing systems

5.1 General

5.1.1 Application

The Article [5] details the specifications for fixed foam fire-extinguishing systems for:

- the protection of machinery spaces in accordance with Ch 4, Sec 6, [5]
- cargo pump-rooms in accordance with Pt D, Ch 1, Sec 17, [7.4].

5.1.2 Definition

a) Design filling rate is at least the minimum nominal filling rate used during the approval tests.

b) Foam is the extinguishing medium produced when foam solution passes through a foam generator and is mixed with air.

c) Foam solution is a solution of foam concentrate and water.

d) Foam concentrate is a liquid which, when mixed with water in the appropriate concentration forms a foam solution.

e) Foam delivery ducts are supply ducts for introducing high-expansion foam into the protected space from foam generators located outside the protected space.

f) Foam mixing ratio is the percentage of foam concentrate mixed with water forming the foam solution.

g) Foam generators are discharge devices or assemblies through which high-expansion foam solution is aerated to form foam that is discharged into the protected space. Foam generators using inside air typically consist of a nozzle or set of nozzles and a casing. The casing is typically made of perforated steel/stainless steel plates shaped into a box that enclose the nozzle(s). Foam generators using outside air typically consist of nozzles enclosed within a casing that spray onto a screen. An electric, hydraulic or pneumatically driven fan is provided to aerate the solution.

h) High-expansion foam fire-extinguishing systems are fixed total flooding extinguishing systems that use either inside air or outside air for aeration of the foam solution. A high-expansion foam system consists of both the foam generators and the dedicated foam concentrate approved during the fire testing specified in [5.2.1], item c).

i) Inside air foam system is a fixed high-expansion foam fire-extinguishing system with foam generators located inside the protected space and drawing air from that space.

j) Nominal flow rate is the foam solution flow rate expressed in l/min.

k) Nominal application rate is the nominal flow rate per area expressed in l/min/m^2.

l) Nominal foam expansion ratio is the ratio of the volume of foam to the volume of foam solution from which it was made, under non-fire conditions, and at an ambient temperature of e.g. around 20ºC.

m) Nominal foam production is the volume of foam produced per time unit, i.e. nominal flow rate times nominal foam expansion ratio, expressed in m^3/min.

n) Nominal filling rate is the ratio of nominal foam production to the area, i.e. expressed in m/min.

o) Nominal filling time is the ratio of the height of the protected space to the nominal filling rate, i.e. expressed in minutes.

p) Outside air foam system is a fixed high-expansion foam system with foam generators installed outside the protected space that are directly supplied with fresh air.

5.2 Fixed high-expansion foam fire-extinguishing systems

5.2.1 Principal performance

a) The system shall be capable of manual release, and shall be designed to produce foam at the required application rate within 1 minute of release. Automatic release of the system shall not be permitted unless appropriate operational measures or interlocks are provided to prevent any local application systems required by Ch 4, Sec 6, [5.6], from interfering with the effectiveness of the system.

b) The foam concentrates shall be approved by the Society based on the guidelines developed by the Organization. Different foam concentrate types shall not be mixed in a high-expansion foam system.

c) The system shall be capable of fire extinction and manufactured and tested to the satisfaction of the Society based on the guidelines developed by the Organization.

d) The system and its components shall be suitably designed to withstand ambient temperature changes, vibration, humidity, shock, clogging and corrosion normally encountered on units. Piping, fittings and related components inside the protected spaces (except gaskets) shall be designed to withstand 925°C.

e) System piping, foam concentrate storage tanks, components and pipe fittings in contact with the foam concentrate shall be compatible with the foam concentrate and be constructed of corrosion resistant materials such as stainless steel, or equivalent. Other system piping and foam generators shall be full galvanized steel or equivalent. Distribution pipework shall have self-draining capability.

f) Means for testing the operation of the system and assuring the required pressure and flow shall be provided by pressure gauges at both inlets (water and foam concentrate supply) and at the outlet of the foam proportioner. A test valve shall be installed on the distribution piping downstream of the foam proportioner, along with orifices which reflect the calculated pressure drop of the system. All sections of piping shall be provided with connections for flushing, draining and purging with air. All nozzles shall be able to be removed for inspection in order to prove clear of debris.

g) Means shall be provided for the crew to safely check the quantity of foam concentrate and take periodic control samples for foam quality.

h) Operating instructions for the system shall be displayed at each operating position.

i) Spare parts shall be provided based on the manufacturer's instruction.

j) If an internal combustion engine is used as a prime mover for the seawater pump for the system, the fuel oil tank to the prime mover shall contain sufficient fuel to enable the pump to run on full load for at least 3 h and sufficient reserves of fuel shall be available outside the machinery space of category A to enable the pump to be run on full load for an additional 15 h. If the fuel tank serves other internal combustion engines simultaneously, the total fuel tank capacity shall be adequate for all connected engines.

k) The arrangement of foam generators and piping in the protected space shall not interfere with access to the installed machinery for routine maintenance activities.

l) The system source of power supply, foam concentrate supply and means of controlling the system shall be readily accessible and simple to operate, and shall be arranged at positions outside the protected space not likely to be cut off by a fire in the protected space. All electrical components directly connected to the foam generators shall have at least an IP 54 rating.

m) The piping system shall be sized in accordance with a hydraulic calculation technique to ensure availability of flows and pressures required for correct performance of the system.

Note 1: Where the Hazen-Williams method is used, the values of the friction factor C given in Tab 3 for different pipe types which may be considered should apply.

Table 3 : Friction factor C

Pipe type	C
Black or galvanized mild steel	100
Copper or copper alloys	150
Stainless steel	150

n) The arrangement of the protected spaces shall be such that they may be ventilated as the space is being filled with foam. Procedures shall be provided to ensure that upper level dampers, doors and other suitable openings are kept open in case of a fire. For inside air foam systems, spaces below 500 m^3 need not comply with this requirement.

o) Onboard procedures shall be established to require personnel re-entering the protected space after a system discharge to wear breathing apparatus to protect them from oxygen deficient air and products of combustion entrained in the foam blanket.

p) Installation plans and operating manuals shall be supplied to the ship and be readily available on board. A list or plan shall be displayed showing spaces covered and the location of the zone in respect of each section. Instructions for testing and maintenance shall be available on board.

q) All installation, operation and maintenance instructions/plans for the system shall be in the working language of the ship. If the working language of the ship is not English, French, nor Spanish, a translation into one of these languages shall be included.

r) The foam generator room shall be ventilated to protect against overpressure, and shall be heated to avoid the possibility of freezing.

s) The quantity of foam concentrate available shall be sufficient to produce a volume of foam equal to at least five times the volume of the largest protected space enclosed by steel bulkheads, at the nominal expansion ratio, or enough for 30 min of full operation for the largest protected space, whichever is greater.

t) Machinery spaces and cargo pump-rooms shall be provided with audible and visual alarms within the protected space warning of the release of the system. The alarms shall operate for the length of time needed to evacuate the space, but in no case less than 20 s.

5.2.2 Inside air foam systems

a) Systems for the protection of machinery spaces and cargo pump-rooms

  1) The system is to be supplied by both main and emergency sources of power. The emergency power supply shall be provided from outside the protected space.

  2) Sufficient foam-generating capacity is to be provided to ensure the minimum design filling rate for the system is met and in addition shall be adequate to completely fill the largest protected space within 10 min.

Where such a machinery space includes a casing (e.g. an engine casing in a machinery space of category A containing internal combustion machinery, and/or a boiler), the volume of such casing, above the level up to which foam shall be filled to protect the highest position of the fire risk objects within the machinery space, need not be included in the volume of the protected space.

The level up to which foam shall be filled to protect the highest positioned fire risk objects within the machinery space shall not be less than whichever is higher between 1 m above the highest point of any such object; and the lowest part of the casing.

Where such a machinery space does not include a casing, the volume of the largest protected space shall be that of the space in its entirety, irrespective of the location of any fire risk object therein.

Fire risk objects include, but may not be limited to, those listed in Ch 4, Sec 1, [3.2.1], although not referred to in this requirement, they may also include items having a similar fire risk such as exhaust gas boilers or oil fuel tanks.

3) The arrangement of foam generators shall in general be designed based on the approval test results. A minimum of two generators shall be installed in every space containing combustion engines, boilers, purifiers, and similar equipment. Small workshops and similar spaces may be covered with only one foam generator.

4) Foam generators is to be uniformly distributed under the uppermost ceiling in the protected spaces including the engine casing. The number and location of foam generators is to be adequate to ensure all high risk areas are protected in all parts and at all levels of the spaces. Extra foam generators may be required in obstructed locations. The foam generators is to be arranged with at least 1 m free space in front of the foam outlets, unless tested with less clearance. The generators is to be located behind main structures, and above and away from engines and boilers in positions where damage from an explosion is unlikely.

5.2.3 Outside air foam systems

a) Systems for the protection of machinery spaces and cargo pump-rooms

1) The system shall be supplied by both main and emergency sources of power. The emergency power supply shall be provided from outside the protected machinery space.

2) Sufficient foam-generating capacity shall be provided to ensure the minimum design filling rate for the system is met and in addition shall be adequate to completely fill the largest protected space within 10 min.

3) The arrangement of foam delivery ducts shall in general be designed based on the approval test results. The number of ducts may be different, but the minimum design filling rate determined during approval testing shall be provided by the system. A minimum of two ducts shall be installed in every space containing combustion engines, boilers, purifiers, and similar equipment. Small workshops and similar spaces may be covered with only one duct.

4) Foam delivery ducts shall be uniformly distributed under the uppermost ceiling in the protected spaces including the engine casing. The number and location of ducts shall be adequate to ensure all high risk areas are protected in all parts and at all levels of the spaces. Extra ducts may be required in obstructed locations. The ducts shall be arranged with at least 1 m free space in front of the foam delivery ducts, unless tested with less clearance. The ducts shall be located behind main structures, and above and away from engines and boilers in positions where damage from an explosion is unlikely.

5) The arrangement of the foam delivery ducts shall be such that a fire in the protected space will not affect the foam-generating equipment. If the foam generators are located adjacent to the protected space, foam delivery ducts shall be installed to allow at least 450 mm of separation between the generators and the protected space, and the separating divisions shall be class "A-60" rated. Foam delivery ducts shall be constructed of steel having a thickness of not less than 5 mm. In addition, stainless steel dampers (single or multi-bladed) with a thickness of not less than 3 mm shall be installed at the openings in the boundary bulkheads or decks between the foam generators and the protected space. The dampers shall be automatically operated (electrically, pneumatically or hydraulically) by means of remote control of the foam generator related to them, and arranged to remain closed until the foam generators begin operating.

6) The foam generators is to be located where an adequate fresh air supply can be arranged.

5.2.4 Installation testing requirements

a) After installation, the pipes, valves, fittings and assembled systems shall be tested to the satisfaction of the Society, including functional testing of the power and control systems, water pumps, foam pumps, valves, remote and local release stations and alarms. Flow at the required pressure shall be verified for the system using orifices fitted to the test line. In addition, all distribution piping shall be flushed with freshwater and blown through with air to ensure that the piping is free of obstructions.

b) Functional tests of all foam proportioners or other foam mixing devices shall be carried out to confirm that the mixing ratio tolerance is within +30 to -0% of the nominal mixing ratio defined by the system approval. For foam proportioners using foam concentrates of Newtonian type with kinematic viscosity equal to or less than 100 cSt at 0ºC and density equal to or less than 1,100 kg/m3, this test can be performed with water instead of foam concentrate. Other arrangements shall be tested with the actual foam concentrate.

5.2.5 Systems using outside air with generators installed inside the protected space

Systems using outside air but with generators located inside the protected space and supplied by fresh air ducts may be accepted by the Society provided that these systems have been shown to have performance and reliability equivalent to systems defined in [5.2.3]. For acceptance, the Society should consider the following minimum design features:

- lower and upper acceptable air pressure and flow rate in supply ducts;
- function and reliability of damper arrangements;
- arrangements and distribution of air delivery ducts including foam outlets; and
- separation of air delivery ducts from the protected space.

5.3 Fixed low-expansion foam fire-extinguishing systems

5.3.1 Quantity and foam concentrates

a) The foam concentrates of low-expansion foam fire-extinguishing systems is to be approved by the Society based on the guidelines adopted by IMO (MSC. Circ.1312). Different foam concentrate types shall not be mixed in a low-expansion foam system. Foam concentrates of the same type from different manufacturers shall not be mixed unless they are approved for compatibility.

b) The system is to be capable of discharging through fixed discharge outlets, in no more than 5 min, a quantity of foam sufficient to produce an effective foam blanket over the largest single area over which oil fuel is liable to spread.

5.3.2 Installation requirements

a) Means is to be provided for effective distribution of the foam through a permanent system of piping and control valves or cocks to suitable discharge outlets, and for the foam to be effectively directed by fixed sprayers onto other main fire hazards in the protected space. The means for effective distribution of the foam is to be proven acceptable to the Society through calculation or by testing.

b) The means of control of any such systems is to be readily accessible and simple to operate and shall be grouped together in as few locations as possible at positions not likely to be cut off by a fire in the protected space.

6 Fixed pressure water-spraying and water-mist fire-extinguishing systems

6.1 Engineering specifications

6.1.1 Fixed pressure water-spraying fire-extinguishing systems

a) Nozzles and pumps

  1) Any required fixed pressure water-spraying fire-extinguishing system in machinery spaces is to be provided with type approved spraying nozzles.

  2) The number and arrangement of the nozzles of any required fixed pressure water-spraying fire-extinguishing system in machinery spaces are to be to the satisfaction of the Society and are to be such as to ensure an effective average distribution of water of at least 5 l/m^2/minute in the spaces to be protected. Where increased application rates are considered necessary, these are to be to the satisfaction of the Society.

  3) Precautions shall be taken to prevent the nozzles from becoming clogged by impurities in the water or corrosion of piping, nozzles, valves and pump.

  4) In machinery spaces, the pump shall be capable of simultaneously supplying at the necessary pressure all sections of the system in any one compartment to be protected.

  5) The pump may be driven by independent internal combustion machinery, but, if it is dependent upon power being supplied from the emergency generator fitted in compliance with the provisions of Ch 1, Sec 2 or Part C, Chapter 2, as appropriate, the generator shall be so arranged as to start automatically in case of main power failure so that power for the pump required by item 4) above is immediately available. The independent internal combustion machinery for driving the pump shall be so situated that a fire in the protected space or spaces will not affect the air supply to the machinery.

b) Installation requirements

  1) The system may be divided into sections, the distribution valves of which are to be operated from easily accessible positions outside the spaces to be protected so as not to be readily cut off by a fire in the protected space.

  2) The pump and its controls are to be installed outside the space or spaces to be protected. It shall not be possible for a fire in the space or spaces protected by the water-spraying system to put the system out of action.

c) System control requirements

  The system is to be kept charged at the necessary pressure and the pump supplying the water for the system is to be put automatically into action by a pressure drop in the system.

d) Installation requirements for machinery spaces

  Nozzles are to be fitted above bilges, tank tops and other areas over which oil fuel is liable to spread and also above other specific fire hazards in the machinery spaces.

6.1.2 Equivalent water-mist fire-extinguishing systems

Water-mist fire-extinguishing systems for machinery spaces and cargo pump rooms are to be approved by the Society.

6.2 Particular requirements for wellhead, production and drilling areas

6.2.1 The system is to be such as to provide a water application of at least 12 l/m²/min and the entire area limited by the extremities of the unit, A or H class vertical division or both.

6.3 Fixed water-based local application fire-fighting systems

6.3.1 Fixed water-based local application fire-fighting systems are to be approved by the Society based on IMO Circular MSC.1/ Circ.1387 as corrected by MSC.1/Circ.1387/Corr.1.

7 Automatic sprinkler, fire detection and fire alarm systems

7.1 Engineering specifications

7.1.1 General

a) Type of sprinkler systems

Where required, the automatic sprinkler systems are to be of the wet pipe type, but small exposed sections may be of the dry pipe type where, in the opinion of the Society, this is a necessary precaution.

b) Automatic sprinkler systems equivalent to those specified in [7.1.2] to [7.1.4] are to be approved by the Society.

7.1.2 Sources of power supply

There are to be not less than two sources of power supply for the sea water pump and automatic alarm and detection system. If the pump is electrically driven, it shall be connected to the main source of electrical power, which shall be capable of being supplied by at least two generators. The feeders are to be so arranged as to avoid galleys, machinery spaces and other enclosed spaces of high fire risk except in so far as it is necessary to reach the appropriate switchboards. One of the sources of power supply for the alarm and detection system shall be an emergency source. Where one of the sources of power for the pump is an internal combustion engine, it shall, in addition to complying with the provisions of [7.1.4], item c), be so situated that a fire in any protected space will not affect the air supply to the machinery.

7.1.3 Component requirements

a) Sprinklers

1) The sprinklers shall be resistant to corrosion by the marine atmosphere. In accommodation and service spaces the sprinklers shall come into operation within the temperature range from 68°C to 79°C, except that in locations such as drying rooms, where high ambient temperatures might be expected, the operating temperature may be increased by not more than 30°C above the maximum deckhead temperature.

b) Pressure tanks

1) A pressure tank having a volume equal to at least twice that of the charge of water specified in this item is to be provided. The tank is to contain a standing charge of fresh water, equivalent to the amount of water which would be discharged in one minute by the pump referred to in item c) 2) below, and the arrangements are to be provided for maintaining an air pressure in the tank such as to ensure that where the standing charge of fresh water in the tank has been used the pressure will be not less than the working pressure of the sprinkler, plus the pressure exerted by a head of water measured from the bottom of the tank to the highest sprinkler in the system. Suitable means of replenishing the air under pressure and of replenishing the fresh water charge in the tank are to be provided. A glass gauge is to be provided to indicate the correct level of the water in the tank.

The tank is to be designed and built in compliance with the requirements for pressure vessels given in Ch 1, Sec 3.

2) Means are to be provided to prevent the passage of sea water into the tank.

c) Sprinkler pumps

1) An independent power pump shall be provided solely for the purpose of continuing automatically the discharge of water from the sprinklers. The pump shall be brought into action automatically by the pressure drop in the system before the standing fresh water charge in the pressure tank is completely exhausted.

2) The pump and the piping system are to be capable of maintaining the necessary pressure at the level of the highest sprinkler to ensure a continuous output of water sufficient for the simultaneous coverage of a minimum area of 280 m² at the application rate specified in [7.1.4], item d). The hydraulic capability of the system is to be confirmed by the review of hydraulic calculations, followed by a test of the system, if deemed necessary by the Society.

3) The pump is to have fitted on the delivery side a test valve with a short open-ended discharge pipe. The effective area through the valve and pipe is to be adequate to permit the release of the required pump output while maintaining the pressure in the system specified in item b) 1) above.

7.1.4 Installation requirements

a) General

- Any parts of the system which may be subjected to freezing temperatures in service are to be suitably protected against freezing.
- Means are to be provided for testing the automatic operation of the pumps on a reduction of pressure in the system.

b) Piping arrangements

1) Sprinklers are to be grouped into separate sections, each of which is to contain not more than 200 sprinklers. In accommodation units, any section of sprinklers is not to serve more than two decks. However, the Society may permit such a section of sprinklers to serve more than two decks, if it is satisfied that the protection of the unit against fire will not thereby be reduced.

2) Each section of sprinklers is to be capable of being isolated by one stop-valve only. The stop-valve in each section is to be readily accessible in a location outside of the associated section or in cabinets within stairway enclosures. The valve's location is to be clearly and permanently indicated. Means are to be provided to prevent the operation of the stop-valves by any unauthorized person.

3) A test valve is to be provided for testing the automatic alarm for each section of sprinklers by a discharge of water equivalent to the operation of one sprinkler. The test valve for each section is to be situated near the stop-valve for that section.

4) The sprinkler system is to have a connection from the unit’s fire main by way of a lockable screw-down non-return valve which is to prevent a backflow from the sprinkler system to the fire main.

   The automatic sprinkler fire detection and fire alarm system are to be an independent unit and therefore no other piping system is to be connected to it, except for the following:

   - connections for feeding the system from shoreside sources, fitted with adjacent stop valves and non-return valves
   - connection from the fire main as required above.

   The valves on the shore filling connection and on the fire main connection are to be fitted with clear and permanent labels indicating their service. These valves are to be capable of being locked in the “closed” position.

5) A gauge indicating the pressure in the system is to be provided at each section stop-valve and at a central station.

6) The sea inlet to the pump is to be, wherever possible, in the space containing the pump and is to be so arranged that when the unit is afloat it will not be necessary to shut off the supply of sea water to the pump for any purpose other than the inspection or repair of the pump.

c) Location of systems

The sprinkler pump and tank are to be situated in a position reasonably remote from any machinery space of category A and are not to be situated in any space required to be protected by the sprinkler system.

d) Sprinkler position

Sprinklers are to be placed in an overhead position and spaced in a suitable pattern to maintain an average application rate of not less than 5 l/m^2/minute over the nominal area covered by the sprinklers. For this purpose, nominal area shall be taken as the gross horizontal projection of the area to be covered. However, the Society may permit the use of sprinklers providing such an alternative amount of water suitably distributed as has been shown, to the satisfaction of the Society, to be not less effective.

7.1.5 System control requirements

a) Ready availability

1) Any required automatic sprinkler, fire detection and fire alarm system are to be capable of immediate operation at all times and no action by the crew shall be necessary to set it in operation.

2) The automatic sprinkler system is to be kept charged at the necessary pressure and is to have provision for a continuous supply of water as required in this Section.

b) Alarm and indication

1) Each section of sprinklers is to include means for giving a visual and audible alarm signal automatically at one or more indicating units whenever any sprinkler comes into operation. Such alarm systems are to be such as to indicate if any fault occurs in the system.

   - In accommodation units, means required above are to give an indication of any fire and its location in any space served by the system and are to be centralised on the central control room or in the main fire control station, which is to be so manned or equipped as to ensure that any alarm from the system is immediately received by a responsible member of the crew.
   - In mobile units other than accommodation units, means required above are to indicate in which section served by the system a fire has occurred. They are to be centralised on the central control room and in addition, visible and audible alarms are to be given in a position other than on the central control room, so as to ensure that the indication of fire is immediately received by the crew.

    - In fixed platforms, means required above are to give an indication of any fire and its location in any space served by the system and are to be centralised in the main fire control station, which is to be so manned or equipped as to ensure that any alarm from the system is immediately received by a responsible member of the crew.
  2) Switches are to be provided at one of the indicating positions referred to in the previous item 1) which will enable the alarm and the indicators for each section of sprinklers to be tested.
  3) A list or plan shall be displayed at each indicating unit showing the spaces covered and the location of the zone in respect of each section. Suitable instructions for testing and maintenance shall be available.

c) Testing

Means are to be provided for testing the automatic operation of the pump on reduction of pressure in the system.

8 Fire-fighters’ outfits

8.1

8.1.1 At least two fire-fighters’ outfits complying with the relevant requirements of the FSS Code should be provided, each with portable instruments for measuring oxygen and flammable vapour concentrations acceptable to the Administration.

8.1.2 Two spare charges should be provided for each required breathing apparatus. Units that are equipped with suitably located means for fully recharging the air cylinders free from contamination need carry only one spare charge for each required apparatus.

8.1.3 The fire-fighters’ outfits should be kept ready for use in an easily accessible location that is permanently and clearly marked. They should be stored in two or more widely separated locations.

9 Recharging of air cylinders

9.1

9.1.1 The apparatus for recharging air cylinders, if provided, should have its power supplied from the emergency supply or be independently diesel-powered, or be so constructed or equipped that the air cylinders may be used immediately after recharging.

9.1.2 The apparatus should be suitably located in a sheltered space above main deck level on the unit.

9.1.3 Intakes for air compressors should draw from a source of clean air.

9.1.4 The air should be filtered after compression to eliminate compressor oil contamination.

9.1.5 The recharging capacity should meet the requirements of SOLAS regulation II-2/10.10.2.6.

9.1.6 The equipment and its installation should be to the satisfaction of the Society.

Section 12 Additional Class Notation LSA

1 General

1.1 Definitions

1.1.1 International Life-Saving Appliance (LSA) Code (referred to as "the LSA Code" in the present Section) means the International Life-Saving Appliance (LSA) Code adopted by the Maritime Safety Committee of the IMO by Resolution MSC.48(66).

1.2 Classification requirements

1.2.1 It is reminded that life-saving appliances are outside the scope of classification, except for units and installations intended to be assigned the additional class notation **LSA**.

1.2.2 Units and installations intended to be assigned the additional class notation **LSA** are to fulfil the requirements of the present Section.

1.2.3 In addition, units and installations intended to receive the additional class notation **LSA** are to comply with additional requirements given by the applicable Rules for Classification according to their service notation and structural type notation.

1.3 National Authorities requirements

1.3.1 It is to be noted that, in all cases, the actual arrangement of life-saving appliances provided on board is always to be approved by National authorities, even if requirements of the present Section are complied with; it is the responsibility of the Owner or Operator to obtain this approval.

1.3.2 National Rules and Regulations always take precedence upon corresponding provisions of the present Section.

1.3.3 Alleviations from requirements of the present Section may be considered, if judged acceptable by the Society, in case of approval by National Authorities of less stringent arrangements than those provided for by these requirements.

1.4 Approval of appliances and equipment

1.4.1 Where the words "of an approved type" are indicated, the equipment is to meet the requirements of the IMO LSA Code and IMO Resolution MSC.81(70), as amended by Resolutions MSC.200(80), MSC.226(82), MSC.274(85), MSC.295(87), MSC.321(89), MSC.323(89), MSC.378(93) and MSC.472(101), and is to be approved by the Society. Existing type approval or certification (e.g. Directive 2014/90/EU) may be considered by the Society. Other recognized references covering design and testing found acceptable by the Society may be used for approval.

1.4.2 Unless expressly provided otherwise in this section, all life-saving appliances are to comply with the applicable requirements of the IMO LSA Code and MSC.81(70), as amended by Resolutions MSC.200(80), MSC.226(82), MSC.274(85), MSC.295(87), MSC.321(89), MSC.323(89), MSC.378(93) and MSC.472(101).

1.4.3 New and novel life-saving appliances should meet the applicable provisions of SOLAS chapter III, including those for servicing and maintenance.

1.4.4 All life-saving appliances should comply with the applicable SOLAS regulations.

1.4.5 All lifeboats should be fire-protected in accordance with the LSA Code.

1.5 Alternative design and arrangements

1.5.1 When alternative design or arrangements deviate from the prescriptive provisions of the present Section, an engineering analysis, evaluation and approval of the design and arrangements should be carried out in accordance with SOLAS regulation III/38.

Note 1: Refer to IMO Circular MSC.1/Circ.1212 "Guidelines on alternative design and arrangements for SOLAS chapters II-1 and III".

2 Survival crafts

2.1 Surface units

2.1.1 Each unit is to carry, on each side of the unit, one or more lifeboats of an approved type, complying with the requirements of the LSA Code, of such aggregate capacity as will accommodate the total number of persons on board. Alternatively, the Society may accept one or more free-fall lifeboats of an approved type, complying with the requirements of section 4.7 of the LSA Code, capable of being free-fall launched over the end of the unit of such aggregate capacity as will accommodate the total number of persons on board.

2.1.2 In addition to lifeboats prescribed in [2.1.1], liferafts of an approved type for the actual operating height, capable of being launched on either side of the unit are to be provided in sufficient number and size to accommodate all persons on board of the unit.

If the liferafts cannot be readily transferred for launching on either side of the unit, the total capacity available on each side is to be sufficient to accommodate all persons on board.

2.1.3 Where the survival crafts are stowed in a position which is more than 100 m from the stem or stern, each unit should carry in addition to the liferafts as provided in [2.1.2], a liferaft stowed as far forward or aft, or one as far forward and another as far aft, as is reasonable and practicable. Notwithstanding item f) of [2.3.3], such liferaft or liferafts may be securely fastened so as to permit manual release.

2.1.4 In any case, even in case of a very small number of persons on board, a minimum number of one lifeboat plus one liferaft, or two lifeboats are to be provided.

2.2 Other units or installations

2.2.1 Each unit or installation is to carry self-propelled lifeboats of an approved type, installed in at least two widely separate locations on different sides or ends. The arrangement of the lifeboats is to provide sufficient capacity to accommodate all persons on board (1,5 times for accommodation units) if:

- all the lifeboats in any one location are lost or rendered unusable, or
- all the lifeboats on any one side, any one end or any one corner of the unit or installation are lost or rendered unusable.

Note 1: In case of use of free fall launching systems, this requirement may be alleviated, subject to special examination by the Society.

2.2.2 In addition to lifeboats prescribed in [2.2.1], liferafts of an approved type for the actual operating height, are to be provided in sufficient number and size to accommodate all persons on board (1,5 times for accommodation units or installations).

2.2.3 In the case of a self-elevating unit where, due to its size or configuration, lifeboats cannot be located in widely separated locations to satisfy [2.2.1], the Society may permit the aggregate capacity of the lifeboats to accommodate only the total number of persons on board. However, the liferafts required in [2.2.2] should be served by launching appliances or marine evacuation system complying with the requirements of the LSA Code.

2.3 Survival craft stowage, launching stations, launching and recovery arrangements

2.3.1 Survival craft assembly and embarkation arrangements

a) Davit-launched survival craft assembly and embarkation stations should be so arranged as to enable stretcher cases to be placed in survival craft.

b) Survival craft embarkation arrangements should be so designed that:

  1) lifeboats can be boarded and launched directly from the stowed position

  2) davit-launched liferafts can be boarded and launched from a position immediately adjacent to the stowed position or from a position to which the liferaft is transferred prior to launching in compliance with item e) of [2.3.3], and

  3) where necessary, means should be provided for bringing the davit-launched liferaft against the unit’s side and holding it alongside so that persons can be safely embarked.

2.3.2 Stowage craft launching stations

Launching stations should be in such positions as to ensure safe launching having particular regard to clearance from any exposed propeller or steeply overhanging portions of the hull. As far as possible, launching stations should be located so that survival craft can be launched down a straight side of the unit, except for:

a) survival craft specially designed for free-fall launching; and

b) survival craft mounted on structures intended to provide clearance from lower structures.

2.3.3 Stowage of survival craft

a) Each survival craft should be stowed:

1) so that neither the survival craft nor its stowage arrangement will interfere with the operation of any other survival craft or rescue boat at any other launching station

2) as near the water surface as is safe and practicable

3) in a state of continuous readiness, so that two crew members can carry out preparations for embarkation and launching in less than 5 min.

4) fully equipped as required by the LSA Code; however, in the case of units operating in areas such that, in the opinion of the Society, certain items of equipment are unnecessary, the Society may allow these items to be dispensed with

5) as far as practicable, in a secure and sheltered position and protected from damage by fire and explosion.

b) A survival craft or davit-launched liferaft should be so positioned that the survival craft or raft is upon embarkation at least 2 m above the waterline when the unit is in the limiting damaged condition determined in accordance with Part B, Chapter 1

c) Where appropriate, the unit should be so arranged that lifeboats, in their stowed positions, are protected from damage by heavy seas.

d) Lifeboats should be stowed attached to launching appliances.

e) Liferafts should be stowed as to permit manual release of one raft or container at a time from their securing arrangements.

f) Davit-launched liferafts should be stowed within reach of the lifting hooks, unless some means of transfer is provided which is not rendered inoperable within the limits of trim and list prescribed in Part B, Chapter 1 for any damaged condition or by unit motion or power failure.

g) Every liferaft other than those mentioned in [2.1.2] should be stowed with the weak link of its painter permanently attached to the unit and with a float-free arrangement complying with the requirements of paragraph 4.1.6 of the LSA Code so that the liferaft floats free of any structure and, if inflatable, inflates automatically when the unit sinks.

2.3.4 Survival craft launching and recovery arrangements

a) Launching appliances complying with the requirements of the LSA Code, as applicable, should be provided for all lifeboats and davit-launched liferafts.

b) Automatic launching and inflating devices are to be provided for inflatable liferafts.

c) Launching and recovery arrangements should be such that the appliance operator on the unit is able to observe the survival craft at all times during launching and lifeboats during recovery.

d) In the case of floating units, launching of lifeboats and rigid liferafts is to be possible by one single man from their board, even when the unit is in its most severe damage condition.

e) Only one type of release mechanism should be used for similar survival craft carried on board the unit.

f) Preparation and handling of survival craft at any one launching station should not interfere with the prompt preparation and handling of any other survival craft or rescue boat at any other station.

g) Falls, where used, should be long enough for the survival craft to reach the water with the unit under unfavourable conditions, such as maximum air-gap, lightest transit or operational condition or any damaged condition, as described in Part B, Chapter 1.

h) During preparation and launching, the survival craft, its launching appliance and the area of water into which it is to be launched, should be adequately illuminated by emergency lighting.

i) Means should be available to prevent any discharge of fluids on to survival craft during abandonment.

j) All lifeboats required for abandonment by the total number of persons permitted on board, should be capable of being launched with their full complement of persons and equipment within 10 min. from the time the signal to abandon the unit is given.

k) Manual brakes should be so arranged that the brake is always applied unless the operator, or a mechanism activated by the operator, holds the brake control in the “off” position.

l) Each survival craft should be so arranged as to clear each leg, column, footing, brace, mat and each similar structure below the hull of a self-elevating unit and below the upper hull of a column-stabilized unit with the unit in an intact condition. The Society may allow a reduction in the total number of survival craft meeting the requirement when the unit is in the transit mode and the number of personnel on board has been reduced. In such cases, sufficient survival craft to meet the requirements of this Section should be available for use by those personnel remaining on board.

m) In any case of damage specified in Part B, Chapter 1, lifeboats with an aggregate capacity of not less than 100% of persons on board should, in addition to meeting all other requirements of launching and stowage contained in this Section, be capable of being launched clear of any obstruction.

n) Consideration should be given to the location and orientation of the survival craft with reference to unit design such that clearance of the unit is achieved in an efficient and safe manner having due regard to the capabilities of the survival craft.

o) Notwithstanding the requirements of paragraph 6.1.2.8 of the LSA Code, the speed of lowering need not be greater than 1 m/s.

2.3.5 Arrangements for remotely located survival craft

a) Liferafts required by [2.1.3] are to be regarded as "remotely located survival craft" with regard to [6.1.1].

b) The area where these remotely located survival craft are stowed shall be provided with:

   1) a minimum number of 2 lifejackets and 2 immersion suits

   2) adequate means of illumination complying with [2.3.4], either fixed or portable, which shall be capable of illuminating the liferaft stowage position as well as the area of water into which the liferaft should be launched. Portable lights, when used, shall have brackets to permit their positioning on both sides of the vessel

   3) an embarkation ladder or other means of embarkation enabling descent to the water in a controlled manner, and

Note 1: Controlled manner: a knotted rope is not acceptable for this purpose.

   4) self-contained battery-powered lamps (i.e. luminaires) may be accepted as means of illumination for complying with [2.3.4]. Such lamps shall be capable of being recharged from the ship's main and emergency source of electrical power, and shall be stowed close to the liferaft and embarkation ladder they are intended to serve, under charge. When disconnected from the ship's power, the lamp shall give a minimum duration of 3 hours of undiminished performance. The lamps shall comply with the requirements of the LSA Code. The lamps (i.e. luminaires) should meet the requirements of IP 55. The batteries for the subject lamps should comply with IACS UR E18 requirements irrespective of whether the expiry date is marked by the manufacturer or not.

c) With regard to the distance between the embarkation station and stowage location of the liferaft as required by [2.1.3] (remotely located survival craft), the embarkation station shall be so arranged that the requirements of [2.2.3] can be satisfied.

d) Exceptionally, the embarkation station and stowage position of the liferaft (remotely located survival craft) may be located on different decks provided that the liferaft can be launched from the stowage deck using the attached painter to relocate it to the embarkation ladder positioned on the other deck (traversing a stairway between different decks with the liferaft carried by crew members is not acceptable).

e) Notwithstanding item b), where the exceptional cases mentioned in item d) exist, the following provisions shall be applied:

   1) the lifejackets and the immersion suits required by item b) 1) may be stowed at the embarkation station

   2) adequate means of illumination complying with item b) 2), shall also illuminate liferaft stowage position, embarkation station and the area of water where the liferaft is to be embarked

   3) the embarkation ladder or other means of embarkation as required by item b) 3) may be stowed at the embarkation station

   4) notwithstanding the requirements in LSA Code, the painter is to be long enough to reach the relevant embarkation station.

f) The length of the embarkation ladder used to board this liferaft (remotely located survival craft) is calculated by applying an adverse list of 20 degrees, to the loading condition taken from the approved loading manual which gives the lightest draft at the embarkation station.

3 Rescue boat

3.1 General

3.1.1 Each unit should carry at least one rescue boat of an approved type complying with the requirements of the LSA Code. A lifeboat may be accepted as a rescue boat, provided that it and its launching and recovery arrangements also comply with the requirements for a rescue boat.

3.2 Stowage of rescue boats

3.2.1 Rescue boats should be stowed:

a) in a state of continuous readiness for launching in not more than 5 min.

b) if of an inflated type, in a fully inflated condition at all times

c) in a position suitable for launching and recovery

d) so that neither the rescue boats nor their stowage arrangements will interfere with the operation of any survival craft at any other launching station

e) in compliance with [2.3.3], if they are also lifeboats.

3.3 Rescue boat embarkation, launching and recovery arrangements

3.3.1 The rescue boat embarkation and launching arrangements should be such that the rescue boat can be boarded and launched in the shortest possible time.

3.3.2 Launching arrangements should comply with [2.3.4].

3.3.3 Rapid recovery of the rescue boat should be possible when loaded with its full complement of persons and equipment. If the rescue boat is also a lifeboat, rapid recovery should be possible when loaded with its lifeboat equipment and the approved rescue boat complement of at least six persons.

3.3.4 Rescue boat embarkation and recovery arrangements should allow for safe and efficient handling of a stretcher case. Foul weather recovery strops should be provided for safety if heavy fall blocks constitute a danger.

4 Lifebuoys

4.1 Total number

4.1.1 At least eight buoys of an approved type, located as per [6.3], are to be fitted. For surface units of 100 m length or more, this number is to be increased up to the values given in Tab 1.

Table 1 : Lifebuoys

Length of unit (m)	Minimum number of lifebuoys
Under 100	8
$100 \le L < 150$	10
$150 \le L < 200$	12
$200 \le L$	14

4.2 Types

4.2.1 At least one-half of the total number of lifebuoys should be provided with self-igniting lights of an approved electric battery type complying with the requirements of the LSA Code. Not less than two of these should also be provided with self-activating smoke signals complying with the requirements of the LSA Code and be capable of quick release from the central control station, or a location readily available to operating personnel. Lifebuoys with lights and those with lights and smoke signals should be equally distributed on both sides of the unit and should not be the lifebuoys provided with lifelines in compliance with the requirements of [4.2.2].

Lifebuoys fitted with self-igniting lights or self-activating smoke signals should be located outside hazardous areas.

4.2.2 At least two lifebuoys in widely separated locations should each be fitted with a buoyant lifeline, the length of which should be at least one-and-half times the distance from the deck of stowage to the waterline at light draught or 30 m whichever is greater. For self-elevating drilling units, consideration should be taken of the maximum height above the waterline, and for other drilling units the lightest operating condition. The lifeline should be so stowed that it can easily run out.

4.2.3 Each lifebuoy should be marked in block capitals of the Roman alphabet with the name and port of registry of the unit on which it is carried.

5 Lifejackets, immersion suits, visual signals and other life-saving appliances

5.1 Lifejackets

5.1.1 Lifejackets of an approved type are to be provided for at least 1,2 times the number of persons on board.

5.1.2 Each lifejacket should be fitted with a light complying with the requirements of the LSA Code.

5.2 Immersion suits

5.2.1 Immersion suits of an approved type according to the LSA Code are to be provided for at least 1,2 times the number of persons on board. Immersion suits are to be of an appropriate size for each person on board.

5.2.2 In lieu of an immersion suit, an anti-exposure suit complying with the LSA Code, of an appropriate size, should be provided for every person assigned to crew the rescue boat or assigned to a marine evacuation system party.

5.2.3 Immersion suits and anti-exposure suits need not be carried if the unit is constantly in operation in warm climates where, in the opinion of the Flag Authority, they are unnecessary.

5.3 Visual signals

5.3.1 Not less than twelve rocket parachute flares, complying with the requirements of section 3.1 of the LSA Code, are to be carried and stowed on or near the central control room.

5.4 Line-throwing appliances

5.4.1 A line-throwing appliance complying with the requirements of section 7.1 of the LSA Code is to be provided.

6 Distribution of life-saving equipment

6.1 Lifejackets

6.1.1 A sufficient number of lifejackets are to be stowed in suitable locations for those persons who may be on duty in locations where their lifejackets are not readily accessible. In addition, sufficient lifejackets should be available for use at remotely located survival craft positions to the satisfaction of the Society.

6.2 Immersion suits

6.2.1 When required by [5.2], immersion suits are to be distributed the same way as lifejackets (refer to [6.1]).

6.3 Buoys

6.3.1 Buoys provided as per Article [4] are to be located in places where risks of fall outboard are particularly important.

The number and placement of lifebuoys should be such that a lifebuoy is accessible from exposed locations.

6.4 Assembly and embarkation places

6.4.1 If separate, assembly stations are to be provided close to the embarkation stations.

6.4.2 Assembly and embarkation places are to comply with the following requirements:

- easy access of assembly station, or of embarkation place if they are not separated, from accommodation and work areas by two different ways (deck surface, ladders or stairs); access ways are to be chosen in such a way that they are not liable to be both impaired in case of fire or accident
- each assembly station, or embarkation place if they are not separated, should have sufficient space to accommodate all persons assigned to assembly at that station, with at least 0,35 m^2 per person.

6.4.3 At least two widely separated fixed metal ladders or stairways are to be provided extending from the deck to the surface of the water. The fixed metal ladders or stairways and sea areas in their vicinity are to be adequately illuminated by emergency lighting.

6.4.4 If fixed ladders cannot be installed, alternative means of escape with sufficient capacity to permit all persons on board to descend safely to the waterline should be provided.

7 Radio life-saving appliances

7.1 Two-way VHF radiotelephone apparatus

7.1.1 All lifeboats are to carry a two-way VHF radiotelephone apparatus.

7.1.2 At least three two-way VHF radiotelephone apparatuses are to be available on the unit, so stowed that they can be rapidly placed in any liferaft. All two-way VHF radiotelephone apparatuses are to comply with IMO Resolution A.809(19) as amended by IMO Resolution MSC.149(77).

7.2 Search and rescue locating device

7.2.1 All lifeboats are to carry one radar SART or AIS-SART.

7.2.2 At least two radar SARTs or AIS-SARTs are to be available on the unit, so stowed that they can be rapidly placed in any liferaft. All SARTs or AIS-SARTs are to comply with IMO Resolution A.802(19) as amended by IMO Resolution MSC.247(83) and IMO Resolution MSC.246(83).

8 Operating instructions

8.1

8.1.1 Illustrations and instructions should be provided on or in the vicinity of survival craft and their launching controls and should:

a) illustrate the purpose of controls and the procedures for operating the appliance and give relevant instructions or warnings

b) be easily seen under emergency lighting conditions, and

c) use symbols in accordance with the recommendations of the IMO.

9 Means of escape

9.1 General requirements

9.1.1 Requirements of the present Article are additional to those of Ch 4, Sec 8.

9.1.2 Escape ways on units with production and process plant are to be adequately protected against potential fire loadings emanating from the topside plant and production facilities. The following objectives are to be considered when evaluating the unit's requirements for escape, evacuation and rescue:

- to maintain the safety of all personnel when they move to another location to avoid the effects of a hazardous event
- to provide a refuge on the unit for as long as required to enable a controlled evacuation of the unit
- to facilitate recovery of injured personnel
- to ensure safe abandonment of the unit.

Where sufficient physical barriers do not exist, escape ways are to be protected by way of active (deluge cooling) or passive (fire screen) type systems.

9.2 Exits

9.2.1 Any space in which more than 10 persons are liable to be present at the same time, or space involving particular fire hazards (machinery, galleys, dangerous storage, etc.) is to be provided with two exits at least, located as far as possible one from the other. These exits are to be signalled by lighting posts supplied by the emergency power source.

9.3 Escape routes

9.3.1 Escape routes are to be:

- clearly signalled by lighting posts supplied by the emergency power source
- provided with a lighting supplied by the emergency power source
- with 2 m minimum headroom.

9.3.2 Stairways and corridors used as means of escape are to be not less than 700 mm in clear width and are to have a handrail on one side. Stairways and corridors with a clear width of 1800 mm and over are to have handrails on both sides. Clear width is considered the distance between the handrail and the bulkhead on the other side or between the handrails. The angle of inclination of stairways should be in general 45°, but not greater than 50°, and in machinery spaces and small spaces not more than 60°. Doorways which give access to a stairway are to be of the same size as the stairway.

9.3.3 In addition to the requirements given in [9.3.1], main escape ways from major process and production areas are, in general, to have a minimum clear width of 1000 mm, to enable the safe passage of potentially injured personnel (i.e. stretcher evacuees).

10 Enclosed spaces

10.1

10.1.1 Enclosed spaces of deckhouses and superstructures used for accommodation and/or "temporary refuge" are to be maintained at an overpressure relative to the external area to prevent the potential ingress of smoke and hazardous gases, in the event of a major incident, in hazardous areas.

Part C
Facilities

CHAPTER 5
SUSTAINABILITY

Section	1	General Requirements
Section	2	Requirements for the Additional Class Notation SUSTAINABILITY-1
Section	3	Requirements for the Additional Class Notation SUSTAINABILITY-2

Section 1 General Requirements

1 Scope and application

1.1 Scope

1.1.1 This Chapter applies to units that are designed, built and equipped with a focus on the following sustainability aspects:

- prevention of sea and air pollution
- protection of the marine environment
- reduction of greenhouse gases emissions
- preparation for unit recycling
- enhancement of people well-being on board.

1.1.2 Additional class notations

Units complying with the requirements of this Chapter may be assigned one of the following additional class notations:

- **SUSTAINABILITY-1** when the unit complies with the requirements of Ch 5, Sec 2.
- **SUSTAINABILITY-2** when the unit complies with the requirements of Ch 5, Sec 2 and Ch 5, Sec 3.

2 Definitions and abbreviations

2.1 Definitions related to sea pollution

2.1.1 Advanced Wastewater Treatment (AWT)

Advanced Wastewater Treatment (AWT) means any treatment of wastewater that goes beyond the secondary or biological water treatment stage and may include the removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids.

2.1.2 Garbage

Garbage means all kinds of victual, domestic and operational waste excluding fresh fish and parts thereof, generated during the normal operation of the unit and liable to be disposed of continuously or periodically, except those substances which are defined or listed in Annexes I, II, III and IV of MARPOL 73/78.

Garbage includes all kinds of solid wastes like plastics, paper, oily rags, glass, metal, bottles, and incinerator ash. Food wastes are considered as garbage.

2.1.3 Grey water

Grey water includes drainage from dishwashers, showers, sinks, baths and washbasins, laundry and galleys.

2.1.4 Hazardous wastes

Hazardous wastes are those wastes composed of substances which are identified as marine pollutants in the International Maritime Dangerous Goods Code (IMDG Code).

Hazardous wastes include in particular:

- photo processing chemicals
- dry cleaning waste
- used paints
- solvents
- heavy metals
- expired chemicals and pharmaceuticals
- waste from printers
- hydrocarbons and chlorinated hydrocarbons
- used fluorescent and mercury vapour light bulbs
- batteries.

Note 1: Empty packagings previously used for the carriage of hazardous substances are considered as hazardous substances.

2.1.5 No discharge operation

No discharge operation means a condition without discharge of hazardous wastes, treated and untreated wastewater, oily wastes or garbage into the sea and without incineration carried out.

2.1.6 Oil residue (sludge)

Oil residue (sludge) means the residual waste oil products generated during the normal operation of a unit such as those resulting from the purification of fuel or lubricating oil, separated waste oil from oil filtering equipment, waste oil collected in drip trays, and waste hydraulic and lubricating oils.

2.1.7 Oil residue (sludge) tank

Oil residue (sludge) tank means a tank which holds oil residue (sludge), and from which sludge may be disposed directly through the standard discharge connection or any other approved means of disposal.

2.1.8 Oily bilge water

Oily bilge water means water which may be contaminated by oil resulting from things such as leakage or maintenance work in machinery spaces. Any liquid entering the bilge system including bilge wells, bilge piping, tank top or bilge holding tanks is considered oily bilge water.

2.1.9 Oily bilge water holding tank

Oily bilge water holding tank means a tank collecting oily bilge water prior to its discharge, transfer or disposal.

2.1.10 Oily wastes

Oily wastes means oil residues (sludge) and oily bilge water.

2.1.11 Sewage

Sewage means:

- drainage and other wastes from any form of toilets, urinals, and WC scuppers, here designated as black waters
- drainage from medical premises (dispensary, sick bay, etc.) via wash basins, wash tubs and scuppers located in such premises
- drainage from spaces containing live animals, or
- other wastewaters when mixed with the drainages defined above.

2.1.12 Sewage sludge

Sewage sludge means any solid, semi-solid, or liquid residue removed during the treatment of onboard sewage.

2.1.13 Wastewater

Wastewater includes both sewage and grey water as defined in [2.1.11] and [2.1.3].

2.2 Definitions related to air pollution

2.2.1 Emission

Emission means any release of substances, subject to control by Annex VI of MARPOL 73/78, from the unit into the atmosphere or sea.

2.2.2 Installed (for a marine diesel engine)

Installed means a marine diesel engine that is or is intended to be fitted on a unit, including a portable auxiliary marine diesel engine, only if its fuelling, cooling or exhaust system is an integral part of the unit. A fuelling system is considered integral to the unit only if it is permanently affixed to the unit. This definition includes a marine diesel engine that is used to supplement or augment the installed power capacity of the unit and is intended to be an integral part of the unit.

2.2.3 NOx Technical Code

NOx Technical Code means the Revised Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines adopted at MEPC 58 on 10 October 2008 with IMO Resolution MEPC.177(58), as amended by IMO Resolution MEPC.317(74).

2.2.4 Onboard incineration

Onboard incineration means the incineration of wastes or other matter on board the unit, if such wastes or other matter were generated during normal operation of that unit.

2.2.5 Onboard incinerator

Onboard incinerator means an onboard facility designed for the primary purpose of incineration.

2.2.6 Ozone-depleting substances

Ozone-depleting substances means controlled substances defined in paragraph (4) of article 1 of the Montreal Protocol on Substances that Deplete the Ozone Layer, 1987, listed in Annexes A, B, C or E to the said protocol in force at the time of application of Annex VI of MARPOL 73/78.

Ozone-depleting substances that may be found on board include, but are not limited to:

- Halon 1211 Bromochlorodifluoromethane
- Halon 1301 Bromotrifluoromethane
- Halon 2402 1,2-Dibromo-1,1,2,2-tetrafluoroethane (also known as Halon 114B2)
- CFC-11 Trichlorofluoromethane
- CFC-12 Dichlorodifluoromethane
- CFC-113 Trichloro-1,2,2-trifluoroethane
- CFC-114 1,2-Dichloro-1,1,2,2-tetrafluoroethane
- CFC-115 Chloropentafluoroethane.

2.2.7 Permanently sealed equipment

Permanently sealed equipment means equipment where there is no refrigerant charging connections or potentially removable components containing ozone-depleting substances.

2.3 Definitions related to greenhouse gases

2.3.1 Global Warming Potential (GWP)

Global Warming Potential or GWP means the climatic warming potential of a greenhouse gas relative to that of carbon dioxide ('CO2'), calculated in terms of the 100-year warming potential of one kilogram of a greenhouse gas relative to one kilogram of CO2.

2.4 Abbreviations

2.4.1

AWT : Advanced Wastewater Treatment

GHG : Greenhouse gas.

3 Documents to be submitted

3.1 General

3.1.1 Certificates

The certificates to be submitted for the additional class notations **SUSTAINABILITY-1** or **SUSTAINABILITY-2** are listed in Tab 1.

3.1.2 Operational procedures

The operational procedures to be submitted for the additional class notations **SUSTAINABILITY-1** or **SUSTAINABILITY-2** are listed in Tab 2.

3.1.3 Documents

The documents to be submitted for the additional class notations **SUSTAINABILITY-1** or **SUSTAINABILITY-2** are listed in Tab 3.

Table 1 : Certificates required for the additional class notations SUSTAINABILITY-1 and SUSTAINABILITY-2

Certificate	Reference
IOPP certificate of the unit **(1)**	Annex I of MARPOL 73/78, Appendix II and IMO Resolution MEPC.311(73)
Type approval certificate of the Oil discharge monitoring and control system	IMO Resolution MEPC.108(49) as amended by IMO Resolution MEPC.240(65), Part 3 of the annex
Type approval certificate **(4)** of: • 15 ppm bilge separator • 15 ppm bilge alarm	IMO Resolution MEPC.107(49) as amended by IMO Resolution MEPC.285(70): • Part 1 of the Annex • Part 2 of the Annex
ISPP certificate of the unit **(1)**	Annex IV of MARPOL 73/78, Appendix

(1) Only where required by MARPOL 73/78, according to the unit's gross tonnage and IMO Resolution MEPC.311(73)
(2) Onboard incinerator is not required. However, when fitted on board, it is to be of a type approved
(3) Only where required by Annex VI of MARPOL 73/78, according to the engine power and intended use
(4) The type approval certificate is to bear an indication of the 10 ppm performance for units to be assigned the additional class notation **SUSTAINABILITY-2**

Certificate	Reference
Type approval certificate of the sewage system	IMO Resolution MEPC.227(64) as amended by IMO Resolution MEPC.284(70)
Type approval certificate of the incinerator **(2)**	• IMO Resolution MEPC.244(66) • Annex VI of MARPOL 73/78, Appendix IV
IAPP certificate of the unit **(1)**	• Annex VI of MARPOL 73/78, Appendix I • IMO Resolution MEPC.194(61)
EIAPP certificates of diesel engines **(3)**	NOx Technical Code 2008, Appendix I
IAFS certificate of the unit or Declaration on Anti-fouling system	International Convention on the control of Harmful and Anti-fouling systems, 2001, Annex 4, Appendices 1 and 2
International Ballast Water Management certificate of the unit or Ballast water record book stating that an exemption has been granted	International Convention for the control and management of ships' ballast water and sediments, 2004, Regulation A-4 and Appendices 1 and 2
(1) Only where required by MARPOL 73/78, according to the unit's gross tonnage and IMO Resolution MEPC.311(73) **(2)** Onboard incinerator is not required. However, when fitted on board, it is to be of a type approved **(3)** Only where required by Annex VI of MARPOL 73/78, according to the engine power and intended use **(4)** The type approval certificate is to bear an indication of the 10 ppm performance for units to be assigned the additional class notation **SUSTAINABILITY-2**	

Table 2 : Operational procedures to be submitted for the additional class notations SUSTAINABILITY-1 and SUSTAINABILITY-2

Operational procedure	Requirements
Shipboard oil pollution emergency plan **(1)**	IMO Resolution MEPC.54(32) as amended by IMO Resolution MEPC.86(44)
Procedure to prepare and maintain an oil record book **(1)**	Annex I of MARPOL 73/78, Appendix III
Procedure to maintain, operate and troubleshoot bilge water treatment systems	IMO Circular MEPC.1/Circ.677
Bunkering procedure	
Measures to prevent oil pollution and Management and disposal of oil leakage and spillage	
Sewage and grey water management plan and discharge control plan **(1)**	
Garbage management plan including procedures to prepare and maintain a garbage record book and hazardous waste procedures **(1)**	• IMO Resolution MEPC.220(63) • IMO Circular MEPC/Circ.317 • Annex V of MARPOL 73/78, Appendix • IMO Resolution MEPC.92(45)
In case ballast water exchange according to D-1 standard is foreseen: Ballast water management plan, with procedures to prepare and maintain a Ballast Water Record Book	• International Convention for the control and management of ships' ballast water and sediments, 2004, Regulation B-1 • IMO Resolution MEPC.127(53) as amended by IMO Resolution MEPC.306(73)
Refrigerant management plan: Operating procedure to be followed to minimise the risk and the consequences of refrigerant leakage, under normal and emergency conditions, including: • checking of the piping tightness • recharge • detection of leakage • maintenance and repair	
Procedure to prepare and maintain the ozone-depleting substances record book	
Fuel oil quality management plan	Annex VI of MARPOL 73/78, Regulation 18 and Appendix VI IMO Resolution MEPC.182(59)
Management and storage plan for liquid effluents and solid waste in case of no-discharge operation **(2)**	
(1) Only where required by MARPOL 73/78, according to the unit's gross tonnage **(2)** Only for units to be assigned the additional class notation **SUSTAINABILITY-2**.	

Table 3 : Documents to be submitted for the additional class notations SUSTAINABILITY-1 or SUSTAINABILITY-2

No.	I/A **(1)**	Document **(2)**
1	 I I A	General: • general arrangement plan with indication of the waste collection and conveying circuits, storage means and treatment installations intended for the prevention of pollution by oil, sewage, grey waters, garbage and hazardous packaged substances • capacity plan • program for a waste source reduction, minimization and recycling
2	 I I I A A A A	Prevention of pollution by oil: • diagram of the oil residue (sludge) system, • diagram of the independent clean drain system, where provided • diagram of the oily bilge system (pumping, treatment, discharge including automatic stopping device and recirculation facilities) • diagram of the ballast water seawater discharge system • details of the bilge water holding tank • calculation of the bilge water holding tank capacity • diagram of produced water system including treatment system and monitoring and recording devices
3	 I I A A I A	Prevention of pollution by wastewater: • diagram of the grey water system (collection, treatment, discharge) • diagram of the sewage system (collection, treatment, discharge) • details of the sewage holding tank and grey water holding tank • calculation of the sewage holding tank and grey water holding tank capacity • description of the sewage treatment plant, AWT plant or comminuting/disinfecting system • calculation of the storage capacity for solid wastes and liquid effluents **(3)**
4	 I A A	Prevention of pollution by garbage: • general information on the equipment intended for collecting, storing, processing and disposing of garbage (except where type-approved and type approval certificate submitted) • calculation of the necessary storing, processing and disposing capacities • diagram of control and monitoring systems for garbage handling equipment
5	 A I A I	Prevention of pollution by oil spillage and leakage: • diagram of the fuel oil and lubricating oil overflow systems • diagram of the fuel oil and lubricating oil filling, transfer and venting systems • arrangement of the fuel oil and lubricating oil spillage containment systems • diagram of the control and monitoring system for fuel oil filling, transfer and overflow systems
6	 A	Prevention of pollution by anti-fouling systems: • specification of antifouling paint
7	 A A	Prevention of pollution by refrigerants and fire-fighting media: • arrangement of retention facilities including material specifications, structural drawings and welding details, as applicable • means to isolate portions of the plant so as to avoid release of medium
8	 I	Energy efficiency and GHG emission reduction: • Energy efficiency and GHG emission management plan
9	 A I A I I	Hydrocarbon blanket gas system: • process and instrumentation diagrams of the hydrocarbon blanket gas system and of its connection to the cargo tanks system, to the inert gas system, to the venting systems and to the cargo tank vents recovery system • cause and effect diagram for the system • settings of the pressure/vacuum protection devices • HAZID and HAZOP reports • explosion hazard study which investigates hydrocarbon leaks from tank hatches or hydrocarbon blanket gas pipes.
10	 A I A I	Vent recovery system: • process and Instrumentation diagrams of the vent recovery system and of its connection to the cargo tanks system, to the inert gas system, to the hydrocarbon blanket gas system, and to the flare system • cause and effect diagram for the system • settings of the pressure / vacuum protection devices • HAZID and HAZOP reports

(1) A = To be submitted for approval ; I = To be submitted for information
(2) Diagrams are to include information about monitoring and recording of parameters
(3) Only for units to be assigned the additional class notation **SUSTAINABILITY-2**

4 Onboard surveys

4.1 Initial surveys tests

4.1.1 After installation on board, the equipment and systems relevant to the requirements of the present Chapter are to be tested in the presence of the Surveyor under operating conditions. The control, monitoring and alarm systems are also to be tested in the presence of the Surveyor or their functioning is to be simulated according to a procedure agreed with the Society.

4.2 Periodical tests and measurements done by the Owner

4.2.1 Purpose

The following tests and measurements, done under the responsibility of the Owner, are intended to demonstrate the effective implementation of the waste management procedures and the constant level over time kept by the quality of the effluents discharged at sea.

4.2.2 Initial period tests

During the first year of commercial operation, the Owner is to proceed with the following measurements and analyses:

- collection of actual onboard data concerning the volume of waste generation, using the waste streams as defined in Ch 5, Sec 2, Tab 4
- yearly analyses of the effluent from the sewage treatment plant for pollutant concentration
- quarterly analyses of the effluent from the AWT plant for pollutant concentration, for units assigned the additional class notation **SUSTAINABILITY-2**.

4.2.3 Periodical tests after first year of service

The effluents and wastes usually discharged to sea are to be periodically sampled and analysed by a qualified laboratory. The frequency of these tests in a five-year period is specified in Tab 4.

Tab 5 lists the number of occurrences where the pollutant maximum concentration may exceed the limit concentration specified in Tab 6 for the effluent standard for analyses of waters, without exceeding the reject value.

Test results of the measurements are to be recorded in the wastewater and garbage logbooks and made available to the surveyor during the periodical surveys.

Table 4 : Frequency of analyses of waste streams after the first year of service

Waste stream	Number of analyses in a 5-year period
Effluent analyses for sewage treatment plant	2
Effluent analyses for AWT **(1)**	20
Oil content analyses of machinery bilge water	2
(1) Applies only to units assigned the additional class notation **SUSTAINABILITY-2**	

Table 5 : Permissible number of analyses exceeding limit values

Number of analyses in a 5-year period	Maximum number of analyses above limit
2-5	0
20	2

Table 6 : Analyses standard for waters

Water to be tested	Pollutant	Limit concentration	Reject value
Effluent of oil filtering equipment	Oil	15 ppm **(3)**	–
Effluent of sewage treatment plant	Thermotolerant coliforms (TC)	100 TC/100 ml	–
	Total suspended solids (TSS)	35 mg/l	–
	5-day biochemical oxygen demand (BOD5) **(1)**	25 mg/l	–
	Chemical oxygen demand (COD)	125 mg/l	–
Effluent of AWT plant **(2)**	5-day biochemical oxygen demand (BOD5) **(1)**	25 mg/l	60 mg/l
	Chemical oxygen demand (COD)	125 mg/l	–
	Total nitrogen	20 mg/l	–
	Total phosphorus	1,0 mg/l	–

(1) BOD5 is the amount, in milligrams per litre, of oxygen used in the biochemical oxidation of organic matter in five days at 20°C.
(2) Only for units assigned the additional class notation **SUSTAINABILITY-2**
(3) 10 ppm for units assigned the additional class notation **SUSTAINABILITY-2**

Section 2 Requirements for the Additional Class Notation SUSTAINABILITY-1

1 Prevention of sea and air pollution

1.1 International regulations

1.1.1 It is a prerequisite for the assignment of **SUSTAINABILITY-1** or **SUSTAINABILITY-2** that the unit complies with the following regulations:

- The following annexes of MARPOL 73/78
  - Annex I as detailed in IMO Resolution MEPC.311(73) "2018 guidelines for the application of MARPOL Annex I requirements to floating production, storage and offloading facilities (FPSOs) and floating storage units (FSUs)"
  - Annex IV
  - Annex V
  - Annex VI.
- International Convention on the control of harmful anti-fouling systems, 2001.

Note 1: Additional requirements may be imposed by the Administration.

1.2 Waste management

1.2.1 Separation of waste streams

Design arrangements and procedures for collecting, sorting, treating, storing and discharging solid and liquid waste and harmful substances are to be such that the discharge or discharge prohibition criteria laid down in annexes I, IV and V of MARPOL 73/ 78 can be fulfilled.

1.3 Waste minimization and recycling program

1.3.1 Direct waste minimization and recycling programs aiming at reducing the amount and/or environmental impact of waste and discharges listed in Tab 2 and Tab 3 are to be implemented. Such programs are to cover, where relevant, the influence of measures such as:

- Use of technical water (e.g. air conditioning condensate) where possible.
- Use of water recovery systems (e.g. filtering and reuse of laundry water - last rinse use for first wash).
- Reclamation and reuse of properly treated and filtered wastewaters as technical water (e.g. in toilet flushing, laundry, open deck washing). Effluents from water treatment plants may be reused or recycled only if they comply with a recognised quality standard for potable water.
- Active water conservation (e.g. use of reduced flow shower heads, vacuum systems for toilets, laundry equipment that utilizes less water).
- Use of reusable packaging and bulk packaging.
- Replacement of plastic packaging by containers built in other material.
- Minimization of the amount of oily bilge water and processing of the oily bilge water and oil residue (sludge) in accordance with the Integrated Bilge Water Treatment System (IBTS) concept (see IMO Circular MEPC.1/Circ.642 as amended).

1.3.2 In addition to the procedures required in [1.6.9], the garbage management plan is to include the procedures for garbage source reduction, minimization and recycling.

1.4 Prevention of pollution by oil

1.4.1 Prevention of pollution by oil spillage and leakage

a) Compliance with MARPOL 73/78

The unit is to comply with MARPOL 73/78 Annex I, Reg. 12A (Oil fuel tank protection).

b) Overflow systems

All fuel and lubricating oil tanks having a capacity exceeding 10 m^3 are to be fitted with an overflow system and a high level alarm or a flow alarm in the overflow system. The alarm signal is to be given where the person in charge of the bunkering or transfer operation will normally be located.

As an alternative to the overflow system, the Society may accept spill deck containment system in way of the concerned tank, provided it has a capacity:

- of at least that 160 litres, and
- commensurate with the maximum expected filling flow rate of the tank and the time necessary to activate the shutdown of the transfer pump in case of high level in the tank.

The overflow system is to comply with the provisions of Ch 1, Sec 7, [9.3].

c) Containment systems

1) On the weather and superstructure decks, each fuel or lubricating oil tank vent, overflow and fill pipe connection and each other area where oil spillage may occur is to be fitted with a fixed deck container or enclosed deck area with a capacity of 160 litres.

The deck container or area is to be fitted with a closed drainage system.

As an alternative arrangement to the closed drainage system, the Society may accept manual draining by gravity or by means of a portable pump, in conjunction with a procedure covering the draining operation, the disposal of the drained oil and the cleaning of the container.

2) A seven-barrel spill kit containing the following is to be available on board, ready to be used during bunkering operation:

- sorbents sufficient to absorb seven barrels of oil
- non-sparking hand scoops, shovels and buckets
- portable containers suitable for holding seven barrels of recovered solid waste and seven barrels of recovered liquid waste
- a minimum of 60 litres of a deck cleaning agent
- appropriate protective clothing to protect personnel from inhalation hazards, eye exposure and skin contact
- non-sparking portable pumps with appropriate hoses.

d) Oil detection in cooling water circuits

Hydrocarbon detectors are to be provided in auxiliary engines sea water and fresh water cooling systems comprising fuel oil or lubricating oil heat exchangers in order to detect any contamination of the water.

For closed loop circuits, visual means to detect a hydrocarbon leakage in the expansion tanks may be accepted as an alternative to hydrocarbon detectors.

e) Operational procedures

The onboard operational procedure is to cover:

- measures to prevent oil pollution
- oil leakage and spillage management and disposal, and cleaning of the deck containers.

1.4.2 Oily wastes

a) Compliance with MARPOL 73/78

The unit is to comply with the following requirements of MARPOL 73/78 Annex I, and with the relevant unified interpretations and provisions of IMO Resolution MEPC.311(73):

- Reg. 12 for arrangement and capacity of oil residues (sludge) tanks
- Reg. 13 for standard discharge connection
- Reg. 14 for oil filtering equipment
- Reg. 15 for oil discharge criteria
- Reg. 17 for oil record book (machinery space operations).

b) Bilge water holding tank

All machinery space bilges and spaces containing hydraulic equipment are to be drained into a bilge water holding tank before separation and oil filtration or discharge ashore. This bilge holding tank is to be separate and independent from the sludge tanks.

Sea or freshwater drains not contaminated by oil may be discharged overboard.

For units operating with heavy fuel oil having a relative density greater than 0,94 at 15°C, the bilge water holding tank is to be fitted with heating facilities, except if the oily water separator capability to efficiently treat the oily water at ambient temperatures (without heating) is justified.

The bilge water holding tank is to be arranged so as to facilitate the separation of any oil (or oil emulsions resulting from the use of bilge cleaning agents) from the bilge water and the removal of accumulated sediments.

The discharge piping system from the bilge water holding tank is to be terminated by the standard discharge connection specified in MARPOL 73/78 Annex I, Reg. 13.

c) Oil water separating equipment

The following equipment is to be provided on board and is to comply with IMO Resolution MEPC.107(49) as amended by IMO Resolution MEPC.285(70):

- 15 ppm bilge separator
- 15 ppm bilge alarm
- automatic stopping device.

The bilge separator, bilge alarm and automatic stopping device are to be of a type approved and individually certified by the Society. Existing type approval or certification (e.g. Directive 2014/90/EU) may be considered by the Society.

The capacity of the bilge separator is to take into account the operation requirements of the unit, the volume of the bilge water holding tanks and the separating technology.

The 15 ppm bilge separator and the 15 ppm bilge alarm are to be installed in accordance with the provisions of IMO Resolution MEPC.107(49), paragraph 6 as amended by IMO Resolution MEPC.285(70).

d) Oil residue (sludge) tanks

The minimum capacity of the oil residue (sludge) tank is to be calculated following criteria specified in MARPOL 73/78 Annex I, Unified Interpretation 16.

The arrangement of the oil residue (sludge) tank is to comply with MARPOL 73/78 Annex I, Reg. 12 and is to:

- Be provided with a designated pump that is capable of taking suction from the oil residue (sludge) tank(s) for disposal of oil residue (sludge). Oil residue (sludge) may be disposed of directly from the oil residue (sludge) tanks through the standard discharge connection referred to in MARPOL 73/78 Annex I, Reg. 13, or any other approved means of disposal.
- Have no discharge connections to the bilge system, oily bilge water holding tank(s), tank top or oily water separators unless for arrangement authorized in MARPOL 73/78 Annex I, Reg. 12.3 (see also IACS Recommendation 121).
- Be designed and constructed so as to facilitate their cleaning and the discharge of residues to reception facilities.

e) Overboard discharges from the bilge pumping system

The overboard discharge valve of any bilge overboard discharge line, unless passing through the 15 ppm bilge separator, is to be kept shut and provided with lead-sealing arrangements.

Note 1: Lead-sealing arrangements is not to be understood as a requirement for the valves to be blanked or physically locked. Emergency bilge discharge, and other overboard discharge valves of similar nature, must be available for use at all times in case of an emergency (SOLAS II-1/21). Valve sealing may be accomplished through use of a breakable seal, electronic tracking, or similar method.

f) Segregation of oil and water ballast

No ballast water is to be carried in any fuel oil or lubricating oil tank.

g) Discharge records

Provisions are to be made to record the following parameters related to the oily water discharge, according to IMO Circular MEPC.1/Circ.736/Rev.2:

- date and time of the discharge
- quantity and oil content of oily water discharged.

The unit is to be provided with an oil discharge monitoring and control system complying with the requirements of IMO Resolution MEPC.108(49) as amended by IMO Resolution MEPC.240(65). The oil discharge monitoring and control system is to be of a type approved and individually certified by the Society. Existing type approval or certification (e.g. Directive 2014/90/EU) may be considered by the Society.

h) Operational procedures

Operational procedures covering oil pollution prevention are to cover the following topics:

- procedure to maintain, operate and trouble shoot bilge water treatment systems
- procedure to prepare and maintain an oil record book.

i) The bilge water holding tank is to have a capacity that provides flexibility of operation to the unit, without the need to discharge de-oiled water overboard. The minimum capacity of the bilge water holding tank, in m^3, is not to be less than the value calculated from Tab 1. Lower capacity may however be accepted based on justification e.g. taking into account operational feed-back from similar units.

Table 1 : Minimum capacity of the bilge water holding tank according to engine rating

Engine rating (kW)	Capacity (m^3)
Up to 1 000	4
Above 1 000 up to 20 000	P/250 **(1)**
Above 20 000	40 + P/500 **(1)**
(1) P = engine rating in kW	

1.4.3 Produced water

a) Where produced water disposal into the sea is foreseen, arrangements are to be made so that the oil and grease content does not exceed 42 mg/l daily maximum and 29 mg/l monthly average.

b) Discharge records

Provisions are to be made to record the following parameters related to produced water discharge:

- date and time of the discharge
- quantity and oil and grease content of produced water discharged.

1.5 Wastewaters

1.5.1 Compliance with MARPOL 73/78

The unit is to comply with the relevant requirements of MARPOL 73/78 Annex IV:

- Reg. 9 for sewage systems
- Reg. 10 for standard discharge connection
- Reg. 11 for discharge criteria.

Note 1: Discharge of grey water is not regulated by MARPOL 73/78.

1.5.2 Design and arrangement of the sewage and grey water systems

The unit is to be fitted with a sewage system and a grey water system designed and arranged as follows:

- an approved sewage treatment plant or sewage comminuting and disinfecting system is to be provided
- a tank is to be provided for the storage of untreated or treated sewage with a capacity complying with [1.5.3]
- a tank is to be provided for the storage of grey waters with a capacity complying with [1.5.3]
- grey waters from galleys are to be collected separately from other grey waters and led through a grease trap prior to additional treatment, storage or discharge.

Note 1: Treated sewage and grey water holding tanks may be combined together.

Note 2: Plastic garbage is to be separated from sewage and/or grey waters before entering the treatment unit.

1.5.3 Holding tanks

Holding tanks for sewage and grey water are to have a capacity sufficient for 24 hours operation of the unit, having regard to the maximum number of persons on board, the daily production of wastewater given in Tab 2 and other relevant factors.

The holding tanks are to be protected against corrosion and fitted with a level indicator and a high level alarm.

The holding tank capacity is to be justified in regards of the unit's intended usage, the maximum number of people on board and the sewage treatment systems installed on board. The wastewater quantities to be considered are to be derived from the experience gained on similar types of units operated in similar conditions. Where no data are available, the figures listed in Tab 2 are to be used.

The sewage discharge pipes connection to reception facilities is to be fitted with standard discharge connection in accordance with MARPOL 73/78 Annex IV, Reg. 10.

Sewage, including drainage from medical premises, is to be collected separately from grey water, except if a common treatment installation is installed on board.

Note 1: This does not preclude the mixing of effluents after treatment (e.g. treated sewage mixed with grey water).

Note 2: When sea water is mixed with wastewater (e.g. for the purpose of washing the holding tanks), the discharge requirements for the wastewater apply to the resulting mixture.

Note 3: When categories of wastewater having different discharge requirements are mixed together, the most stringent requirements apply to the resulting mixture.

Table 2 : Wastewater generation quantities

No.	Type of wastewater	Quantities (litres/person/day)
1	Black water	12 for a vacuum system 100 for a conventional flushing system
2	Grey water (excluding laundry and gallery)	100
3	Laundry	40
4	Galley	60
5	Total grey water (2+3+4)	200

1.5.4 Sewage treatment plants and piping

Sewage treatment plants are to be of a type approved and individually certified by the Society. Existing type approval or certification (e.g. Directive 2014/90/EU) may be considered by the Society. Sewage treatment plants are to comply with the provisions of IMO Resolution MEPC.227(64), as amended by IMO Resolution MEPC.284(70).

Provisions are to be made in the design for easy access points for the purpose of obtaining representative influent and effluent samples.

The capacity of the sewage treatment plant is to be enough to accommodate the maximum number of people on board. The wastewater quantities to be considered are to be derived from the experience gained on similar types of units operated in similar conditions. Where no data are available, the figures listed in Tab 2 are to be used.

1.5.5 Sewage sludge

Arrangements are to be made for sludge from sewage treatment to be collected and stored in view of being transferred ashore or, where permitted, incinerated on board.

Where provided, incineration devices are to completely burn the sludge to a dry and inert ash and not to discharge fly ash, malodors or toxic substances.

The capacity of the sewage sludge tanks is to be calculated taking into consideration the operation of the unit, the number of crew, the equipment and systems to store and handle the sewage and the incinerator capacity.

Arrangements are to be made to dispose of ashes from sludge incineration ashore.

1.5.6 Operational procedures

The wastewater management plan is to cover the following topics:

- sewage and grey water installation and maintenance
- procedures and arrangement to obtain representative influent and effluent samples
- discharge control plan and procedure following requirements of MARPOL 73/78 Annex IV, Reg.11 and, as relevant, other regulations such as IMO Resolution MEPC.264(68), Part II-A, Chapter 4.

1.6 Garbage and hazardous wastes

1.6.1 Compliance with MARPOL 73/78

The unit is to comply with the requirements of MARPOL 73/78 Annex V:

- Reg. 3, 4, 5 and 6 for disposal into the sea criteria.
- Reg. 9 for placards, garbage management plans and garbage record-keeping.

1.6.2 Storage and disposal

Except otherwise stated in this Article, storage arrangements are to be provided for all kinds of liquid and solid wastes, with a capacity corresponding to a duration to be justified based on the operational profile of the unit.

Note 1: Although disposal into the sea and onboard incineration are possible in the conditions specified in MARPOL 73/78, storage in view of discharge to port reception facilities is to be given first priority. Attention is drawn to the specific requirements that may be made mandatory by certain Administrations, which may restrict or prohibit waste discharge and/or incineration in the waters under their jurisdiction.

1.6.3 Handling of hazardous waste

Hazardous wastes are to be collected and stored in separate leakproof containers prior to disposal ashore. The storage capacity is to be sufficient for the average production of 30 days. The contents of all containers are to be clearly marked.

Note 1: Waste fluids associated with photo processing, including X-ray development, may be treated to remove silver for recycling. The effluent from the recovery unit may be led to the grey water provided it contains less than 5 parts per million (ppm). The residues from the recovery unit are to be landed ashore for disposal or recycling.

1.6.4 Collection of garbage

Garbage bins are to be placed at suitable places and within a suitable distance in accommodation spaces and open decks. Hazardous wastes, plastics and food contaminated wastes are to be collected separately from other wastes.

1.6.5 Storage of garbage

The unit is to have sufficient capacity to store all kinds of garbage produced during a duration to be justified based on the operational profile of the unit, taking into account the daily waste generation figures given in Tab 3 and the values of density given in Tab 4.

When an incinerator is used, the needed capacity for wastes other than glass and tins may be reduced by 40%, without being less than the needed volume corresponding to the duration based on the operational profile of the unit.

Table 3 : Garbage generation quantities

No.	Type of waste	Quantities (kg/person/day)
1	Plastics	0,1
2	Paper and cardboard	1,0
3	Glass and tins	1,0
4	Food wastes	0,7
5	Total garbage (1+2+3+4)	2,8

Table 4 : Waste density

Type of waste	Density (kg/m^3)	
	Compacted waste	Uncompacted waste
Glass, tin	1600	160
Paper, cardboard, plastic	410	40
Food wastes	–	300

1.6.6 Food wastes

Arrangements are to be made to store food wastes prior to discharge to port reception facilities or, where permitted, disposal into the sea.

The onboard storage capacity is to be sufficient for the food waste production over a duration to be justified based on the operational profile of the unit, taking into account the figures given in [1.6.5] and the values of density given in Tab 4.

Where food waste disposal into the sea is permitted, precautions are to be taken to ensure that plastics contaminated by food wastes, like plastic food wrappers, are not discharged to sea with other food wastes.

1.6.7 Incinerators

Where fitted, incinerators are to be of a type approved and individually certified by the Society. Existing type approval or certification (e.g. Directive 2014/90/EU) may be considered by the Society. Incinerators are to be designed and constructed according to the requirements of:

- IMO Resolution MEPC.244(66), as amended by IMO Resolution MEPC.368(79)
- MARPOL 73/78 Annex VI, Appendix IV.

Hazardous waste management procedures including segregating hazardous wastes are to be instituted on board each unit to ensure hazardous wastes are not introduced into the incinerator. In particular, batteries are to be removed from any waste that will be incinerated on board.

1.6.8 Discharge records

Provisions are to be made to record the following parameters related to garbage discharge:

- date and time of discharge
- estimated amounts discharged for each category, including incinerator ash (in cubic meters).

1.6.9 Operational procedures

Procedures for collection, sorting, processing and disposal of garbage are to be available in the garbage management plan required by MARPOL 73/78 Annex V, Reg. 9.

The garbage management plan is to follow IMO Resolution MEPC.220(63) “2012 Guidelines for the development of garbage management Plan”. Restrictions to the discharge of garbage into the sea are to be clearly indicated and in accordance with MARPOL 73/78 Annex V (see also IMO Resolution MEPC.295(71) “2017 Guidelines for the implementation of MARPOL 73/78 Annex V”, Table 1).

The garbage management plan is to include procedures in order to make sure that the following hazardous wastes are not discharged at sea nor mixed with other waste streams:

- photo processing waste (including X-ray development fluid waste)
- dry cleaning waste, containing in particular tetrachloroethylene or perchloroethylene (PERC)
- printing materials, like inks, except soy based, non-chlorinated hydrocarbon-based ink products
- laser printer toner cartridges
- unused and outdated pharmaceuticals
- fluorescent / mercury vapour bulbs
- batteries
- used cleaners, solvents, paints and thinners
- products containing metals such as lead, chromium, copper, cadmium and mercury.

1.7 Hull anti-fouling systems

1.7.1 Compliance with IMO AFS Convention

The unit is to comply with the relevant requirements of IMO Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001, requiring the complete prohibition of organotin compounds which act as biocides and of cybutryne in anti-fouling systems.

1.7.2 Type-approval of anti-fouling systems

Anti-fouling paints are to be of a type approved by the Society, on the basis of the following criteria:

- the product is to be free of organotin tributyltin (TBT)
- small quantities of organotin compounds acting as a chemical catalyst are allowed provided their concentration does not exceed 2500 mg total tin per kg of dry paint
- average values of cybutryne are not to exceed 200 mg of cybutryne per kg of dry paint.

1.8 Ballast water management

1.8.1 Compliance with the International Ballast Water Management Convention

The unit is to comply with the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 and with the relevant Guidelines, as amended.

Note 1: Exemption granted by the Administration in pursuance of Regulation A-4 of the International Ballast Water Management Convention is acceptable.

1.8.2 Ballast water exchange

In case an exemption is granted by the Administration allowing ballast water exchange operations in accordance with standard D-1, the following provisions are to be complied with:

a) Design of the pumping and piping systems:

The pumping and piping systems involved in the ballast water exchange are to comply with the provisions of Ch 1, Sec 7, [7].

b) Sediment handling:

Arrangements are to be made for:

- monitoring the sediment build up
- leaning the tanks and removing the sediments
- disposing the sediments to reception facilities.

c) Ballast water exchange operations:

The ballast water management plan is to describe ballast water exchange procedure in accordance with IMO Resolution MEPC.288(71).

d) Discharge records:

Provisions are to be made to get and record the following parameters related to the ballast water discharge:

- date and time of discharge
- unit location (latitude and longitude)
- amounts of water exchanged
- amount of sediments disposed to reception facilities.

1.9 Refrigeration systems

1.9.1 Compliance with MARPOL 73/78

The unit is to comply with MARPOL 73/78 Annex VI, Reg. 12 (Ozone-Depleting Substances).

1.9.2 Application

The requirements of this sub-article apply to the unit's refrigeration and air conditioning permanent installations with an initial charge of more than 3kg or more than 5 tonnes of CO2 equivalent of refrigerant.

They do not apply to permanently sealed equipment as defined in Ch 5, Sec 1, [2.2.7].

1.9.3 Acceptable refrigerants

The use of halogenated substances, including hydrochlorofluorocarbons (HCFCs), as refrigerant is prohibited.

1.9.4 Retention facilities

Refrigeration systems are to be fitted with retention facilities having the capability to retain the volume of refrigerant contained in the largest individual refrigeration unit, should the necessity arise to empty any one unit. The retention facilities may be either:

- fully independent from the refrigeration system, i.e. separate tanks, or
- part of the refrigeration system, i.e. redundant condensors. In this case, the combined capacity of the condensors is to be sufficient to store the total volume of refrigerant in the system considering that any one condensor is unavailable e.g. for repair or maintenance reasons.

The retention facilities may be tanks for liquid media and/or bottles for gaseous media. If only tanks for liquid are used as retention facilities, one or more compressors having the combined capacity to discharge completely the medium from the system into the tanks are to be installed.

1.9.5 Prevention of leakage

The following measures are to be taken in order to avoid deliberate emissions of ozone-depleting substances:

- Refrigeration systems are to be designed in such a way as to minimise the risk of medium release in the case of maintenance, repair or servicing.
- Arrangements are to be made to isolate those sections which are to be serviced by a system of valves and by-passes, in such a way as not to stop the operation of the plant, while in service, preventing the risk of release of the medium outside of the plant.
- Means are to be provided to avoid the possibility of leak to the atmosphere of the refrigerants or its vapours in any case of failure of the plant.
- A warning instruction plate stating that deliberate emissions of halogenated substances is prohibited is to be displayed in the vicinity of the vessels and of the releasing devices.

This requirement does not apply to spaces containing only pipes.

1.9.6 Leak detection

Provisions are to be made in the onboard operational procedure for checking of the refrigerants for leakage by trained people at a frequency shown in Tab 5, depending on the initial charge of the system in tonnes of CO2 equivalent, and corrective actions and repairs in case of leakage detection.

Table 5 : Leak checks minimum frequency

Charge of fluorinated greenhouse gas, C (tonnes of CO2 equivalent)	Leak checks maximum interval
$5 \le C < 50$	6 months
$50 \le C < 500$	3 months
$C \ge 500$	1 months

1.9.7 Records

Provisions are to be made to record:

- recharge, full or partial, of equipment containing ozone-depleting substances
- repair or maintenance of equipment containing ozone-depleting substances, including checks for leakages
- discharge of ozone-depleting substances to the atmosphere and leakage
- discharge of ozone-depleting substances to land-based reception facilities
- supply of ozone-depleting substances to the unit, storage location and quantities.

1.9.8 Operational procedures

The refrigerant management plan is to include:

- maintenance procedure
- leakage checking frequency and procedure
- list and quantity of all refrigerants on board
- qualification and training of personnel.

1.10 Fire-fighting systems

1.10.1 Compliance with MARPOL 73/78

The unit is to comply with MARPOL 73/78 Annex VI, Reg. 12 (Ozone-Depleting Substances).

1.10.2 Acceptable fire-fighting media

The use of halon and halocarbons media in the fixed and portable fire-fighting equipment is prohibited.

Extinguishing media containing perfluorooctane sulfonic acid (PFOS) are not allowed.

1.10.3 Design requirements for fire-fighting systems

Provisions are to be made for the safe containment and disposal of fire-fighting media in case of spillage during maintenance or repair.

1.11 Emission of nitrogen oxides (NOx)

1.11.1 Compliance with MARPOL 73/78

Diesel engines installed on the unit are to comply with the requirements of:

- MARPOL 73/78 Annex VI, Reg. 13
- NOx Technical Code (2008), as amended.

1.11.2 Application

The requirements of this sub-article apply to all diesel engines, independently of the service, with a rated power of more than 130 kW, installed on the unit, with the exceptions of:

- emergency diesel engines, diesel engines installed in lifeboats and any other diesel engines intended to be used solely in an emergency situation, independently of their rated power
- engines which are subject to alternative measures for limiting NOx emission, under special consideration of the Society.

Note 1: NOx emissions from gas only engines, gas turbines, boilers and incinerators are not subject to these requirements.

1.11.3 NOx certification of engines

Prior to installation on board the unit, engines are to be NOx-certified in accordance with the relevant provisions of the NOx Technical Code for the intended application. A valid EIAPP certificate (or statement of compliance) is normally to be issued by the Society.

1.12 Emission of sulphur oxides (SOx)

1.12.1 Compliance with MARPOL 73/78

The unit is to comply with the relevant requirements of MARPOL 73/78 Annex VI and related Guidelines:

- Reg. 14 for Sulphur Oxides (SOx) and Particulate Matter.
- Reg. 18 and Appendices V and VI for fuel oil quality.
- IMO Resolution MEPC.182(59) and IMO Circular MEPC.1/Circ.889 for the sampling of fuel oil for consumers inside hull machinery space.

1.12.2 Use of low sulphur fuel oils

A verification procedure is to be available on board, allowing to determine whether the fuel oil delivered to, in use or carried for use on board the unit is meeting the applicable sulphur limit of MARPOL 73/78 Annex VI, Reg.14. This procedure is to be in accordance with MARPOL 73/78 Annex VI, Appendix VI and is to include the positions of the sampling arrangements on the fuel oil systems.

Arrangements are to be made to record the volume of fuel oil in each tank.

1.13 Emission of hydrocarbon vapours and Volatile Organic Compounds (VOC)

1.13.1 A hydrocarbon blanket gas system coupled with a vent recovery system is to be provided on board.

The hydrocarbon blanket gas system is to comply with the requirements of Pt D, Ch 1, Sec 18, [5]. The vent recovery system is to be capable of recovering gas from all vents from the process and from the cargo tanks. The cargo oil tank vent system is to comply with the requirements of Pt D, Ch 1, Sec 16, [3].

2 Energy efficiency and GHG emission management plan

2.1 General

2.1.1 An energy efficiency and GHG emission management plan is to be established, describing a continuous process in order to reduce GHG emissions, possibly by improving energy efficiency. The energy efficiency and GHG emission management plan is to:

- make an inventory of the onboard energy production systems, main energy users and the GHG emission sources from the unit, as well as the monitoring systems used on board and mitigation measures
- address and document energy efficiency improvement measures and GHG emission reduction targets with specific management organization and procedures:
  - to ensure the execution of the improvement measures, and
  - to plan any necessary corrective actions.

2.2 Description of the unit

2.2.1 The first part of the plan is to describe the unit with the aim to reflect the current status of the unit energy usage and sources of GHG emissions, including on the one hand the hull systems and on the other hand the topside systems.

Each part, hull and topside, is to include the following:

- the energy production systems (electric power production, heat production and direct mechanical power production), main users and electric system arrangement

- the sources of GHG emissions, including refrigerant fluids, are to be listed with GHG emitted, estimated emission rate/quantity, impact on environment and other relevant data such as Global Warming Potential (GWP).

2.3 Monitoring systems

2.3.1 The energy efficiency and the GHG emissions of the unit are to be quantitatively monitored by established methods following a recognized standard. The monitoring tools are to target at least the goal indicators set out in [2.5].

The plan is to:

- describe the monitoring systems
- describe the procedure for collecting data and the monitoring intervals
- indicate the personnel responsible to collect and process the data.

Relevant methods for monitoring from IMO Resolution MEPC.346(78) may be applied.

2.4 Mitigation measures

2.4.1 The mitigation measures and energy saving measures already applied on board (for example, heat recovery system, vapour recovery system, etc.) are to be described. The effectiveness of such measures is also to be assessed.

Operational activities such as leakage monitoring and maintenance may be mentioned if relevant.

2.5 Emission reduction and energy efficiency improvement

2.5.1 The energy efficiency and GHG emission plan is to set improvement targets with associated Key Performance Indicators (KPIs), as a result of previous assessment done in [2.2] [2.3] and [2.4]. They are to be specific to the unit.

The emission reduction and energy efficiency actions to be taken to achieve the targets set up are to be documented and planned as far as possible. Both technical and operational solutions are acceptable.

2.6 Management and crew training

2.6.1 The person in charge of the plan is to be identified in the Energy efficiency and GHG emission management plan.

A brief description of the organization for management, including reference to the applied quality standards, and follow up of the implementation of the action decided in [2.5] and corrective actions if necessary is to be provided.

The training of personnel in charge of applying the actions decided is to be described and recorded.

3 Preparation for unit recycling

3.1 GREEN PASSPORT

3.1.1 The unit is to comply with the requirements for the additional class notation **GREEN PASSPORT**, as defined in NR528 Green Passport.

4 Enhancement of people well-being on board

4.1 Habitability

4.1.1 The accommodation block and hull control stations are to be in compliance with the criteria applicable to passenger ships according to the Maritime Labour Convention 2006, Regulation 3.1, Standard A3.1. Alternative arrangements for transit situations may be accepted by the Society on a case-by-case basis.

4.2 Noise and vibrations

4.2.1 Noise

The unit is to comply with the requirements for the additional class notation **COMF-HEALTH-NOISE- 2**, as defined in Pt A, Ch 1, Sec 2, [8.4.3].

4.2.2 Vibration

The unit is to comply with the requirements for the additional class notation **COMF-HEALTH-VIB-2**, as defined in Pt A, Ch 1, Sec 2, [8.4.3].

Section 3 Requirements for the Additional Class Notation SUSTAINABILITY-2

1 Prevention of sea and air pollution

1.1 Waste management

1.1.1 The storage capacity for each of the following solid and liquid wastes is to be sufficient to allow the no discharge operation of the unit during a reference duration D (in days):

- plastics
- paper and cardboard
- glass and tins
- food waste
- sewage
- grey water
- sewage sludges (where applicable)
- bilge water
- oil residues (sludges)
- hazardous wastes
- washwater treatment residues from exhaust gas cleaning units (where applicable).

1.1.2 The reference no discharge duration D (in days) is to be at least one day. A longer no discharge duration may be considered if specified by the Owner.

1.1.3 Except otherwise stated, the storage capacities are to be based on:

- the maximum number of persons on board
- the daily production of solid waste and liquid effluents given in Ch 5, Sec 2, [1.5.4] and Ch 5, Sec 2, [1.6.5].

1.1.4 Unless otherwise justified, the minimum capacity required for the bilge water holding tank is not to be less than D times the capacity given in Ch 5, Sec 2, [1.4.2], item i).

1.2 Wastewaters

1.2.1 The unit is to be fitted with an advanced wastewater treatment (AWT) plant, capable of treating both sewage and grey waters with an effluent quality complying with the provisions of [1.2.3].

Note 1: Effluents from the AWT plant may be reused or recycled only if they comply with a recognized quality standard for potable water.

1.2.2 The capacity of the AWT plant is to be sufficient for the maximum number of persons on board, taking into account the sewage and grey water quantities given in Ch 5, Sec 2, [1.5.4].

1.2.3 The AWT plant is to be of a type approved and individually certified by the Society. Existing type approval or certification (e.g. Directive 2014/90/EU) may be considered by the Society. The AWT plant is to comply with the effluent standards given in IMO Resolution MEPC.227(64), paragraph 4.1 and with the additional standards given in Tab 1.

Table 1 : Additional effluent standards for AWT plants

Parameter	Limit	Reference of the standard
Total nitrogen	20 Q_i/Q_e mg/l or at least 70% reduction **(1)(2)**	IMO Resolution MEPC.227(64), paragraph 4.2
Total phosphorus	1,0 Q_i/Q_e mg/l or at least 80% reduction **(1)(2)**	IMO Resolution MEPC.227(64), paragraph 4.2

(1) The dilution factor Q_i/Q_e is equal to the ratio of the influent Q_i (sewage, grey water and other liquid streams to be processed by the treatment plant) to the effluent Q_e (treated wastewater produced by the treatment plant).
(2) Reduction in relation to the load of the influent.

1.3 Prevention of pollution by oil

1.3.1 Oily condensates from venting pipes

Vent pipes from engines crankcases are to be led to a venting box provided with a draining pipe connected to an oily drain tank.

This requirement is not applicable to vent pipes from gas and dual-fuel engines crankcases for which a drip tray is to be fitted with suitable draining arrangement.

Procedures covering the draining operation, the disposal of the drained oil and the cleaning of the drip tray are to be provided.

1.3.2 The oily water separator (OWS) required by Ch 5, Sec 2, [1.4.2], item c) is to be capable of producing effluents having a hydrocarbon content not exceeding 10 ppm. The bilge alarm and the automatic stopping device are also to be efficient for the 10 ppm limit.

Note 1: ppm means parts of oil per million parts of water by volume.

1.4 Refrigeration systems

1.4.1 Acceptable refrigerants

All refrigerants used on board are to have:

- a Global Warming Potential (GWP) not exceeding 2000
- an Ozone Depleting Potential (ODP) equal to zero.

1.5 Emission of sulphur oxides (SOx)

1.5.1 Use of ultra-low sulphur fuel oils

The unit is to be designed to store and use fuel oil with a sulphur content not exceeding 0,10% m/m.

The verification procedure required by Ch 5, Sec 2, [1.12.2] is to allow determining whether the fuel oil delivered to, in use or carried for use on board the unit is meeting this limit.

2 Enhancement of people well-being on board

2.1 Habitability

2.1.1 The accommodation block and hull control stations are to be in compliance with the requirements of NR467 Pt F, Ch 6, Sec 6, as applicable to passenger ships.

2.2 Noise and vibrations

2.2.1 Noise

The unit is to comply with the requirements for the additional class notation **COMF-HEALTH-NOISE- 1**, as defined in Pt A, Ch 1, Sec 2, [8.4.3].

2.2.2 Vibration

The unit is to comply with the requirements for the additional class notation **COMF-HEALTH-VIB-1**, as defined in Pt A, Ch 1, Sec 2, [8.4.3].

BUREAU VERITAS MARINE & OFFSHORE

Tour Alto
4 place des Saisons
92400 Courbevoie - France
+33 (0)1 55 24 70 00

marine-offshore.bureauveritas.com/rules-guidelines

Shaping a World of Trust