TÜRK LOYDU

RULES FOR THE CLASSIFICATION OF NAVAL SHIPS

Part E

Chapter 107 - Ship Operation Installations And Auxiliary Systems
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This latest edition incorporates all rule changes. The latest revisions are shown with a vertical line. The section title is framed if the section is revised completely. Changes after the publication of the rule are written in red colour.

Unless otherwise specified, these Rules apply to ships for which the date of contract for construction is on or after 01st of January 2016.

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Chapter 107 – Ship Operation Installations And Auxiliary Systems

Section 6 Starting Equipment and Air Compressors

Section 7 Storage of Liquid Fuels, Lubricating and Hydraulic Oils as Well as Oil Residues

Section 8 Piping Systems, Valves and Pumps

Section 9 Fire Protection and Fire Extinguishing Equipment

SECTION 1

GENERAL RULES AND INSTRUCTIONS

A. General

1. Scope

1.1 These Rules apply to ship operation installations and auxiliary systems of seagoing surface ships and craft intended for naval activities, which are not part of the direct propulsion system.

1.2 Apart from machinery, equipment and auxiliary systems detailed below, these Rules are also individually applicable to other systems and equipment where this is necessary for the safety of the ship and its crew.

1.3 Designs which deviate from these Rules may be approved, provided that such designs have been recognized as equivalent by TL.

1.4 Installations and systems which have been developed on novel principles and/or which have not yet been sufficiently tested in shipboard service require special TL approval.

In such cases TL is entitled to require additional documentation to be submitted and special trials to be carried out.

2. Further requirements and deviations

In addition to these Rules, TL reserve the right to impose further requirements in respect of all types of machinery where this is unavoidable due to new findings or operational experience, or TL may permit deviations from the Rules where these are specially warranted.

The right of interpretations of the Rules rests with TL alone.

3. Reference to further rules and regulations

3.1 If the requirements for systems and equipment are not defined in these Rules for Classificationand Construction, the application of other regulations and standards has to be defined.

3.2 The regulations of the "International Convention for the Safety of Life at Sea 1974/1978" **(SOLAS),** as amended are considered in these Rules as far as they appear applicable to naval surface ships. The scope of application has to be defined in the building specification.

These Rules are also in compliance with the provisions of the "International Convention for the Prevention of Pollution from Ships" of 1973 and the relevant Protocol of 1978 **(MARPOL** 73/78).

3.3 For ships of NATO states the Nato Agreement for Standardisation (STANAG) may be considered in addition.

3.4 National regulations, international standards and special definitions in the building specification respectively in the mission statement of the actual ship may be considered too. The application of such regulations is not affected by TL Rules.

4. Design

The design of the systems has to fulfil the following conditions:

4.1 The operation of the naval ship and the living conditions designated aboard as well as the functioning of all systems under the operational conditions of combat, wartime cruising, peacetime cruising and peacetime in-port readiness shall be ensured at all times.

4.2 The power distribution network shall be designed to ensure operability in case of network failure.

4.3 The operation of certain systems and equipment, which are necessary for safety, is to be guaranteed under defined emergency conditions.

4.4 The risks for crew and ship from operation of the ship must be minimized.

4.5 High working reliability shall be achieved by simple and clearly arranged operation processes as well as by application of type-approved products.

4.6 The requirements concerning design, arrangement, installation and operation which are defined in Chapter 101 - Classification and Surveys and the Chapters 102 - Hull Structures and Ship Equipment, 104 -Propulsion Plants, 105 - Electrical Installations and 106 - Automation of these Rules must be fulfilled.

4.7 A high degree of survivability of the ship must be achieved by redundancies in design and functioning of essential equipment.

4.8 The principles of ergonomic design of systems and equipment have to be considered.

4.9 Where in a class of naval ships, originally planned to be identical, deviations become necessary, TL shall be duly informed and modifications properly documented.

5. Equivalence

5.1 Naval ships deviating from the TL Rules in their type, equipment or in some of their parts may be classed, provided that their structures or equipment are found to be equivalent to the TL requirements for the respective Class.

5.2 In this respect, **TL** can accept alternative design, arrangements and calculation/analyses (FE, FMEA, etc.) which are suitable to satisfy the intent of the respective **TL** requirements and to achieve the equivalent safety level.

B. Definitions

1. Auxiliary power

The auxiliary electrical power [kVA] is defined as the continuous electrical power at continuous speed v_0, which is not directly used for propulsion of the ship, but for driving of all kinds of auxiliary devices and equipment. The degree of redundancy shall be defined in the building specification.

2. Essential equipment

2.1 Principal requirements

Essential equipment is required to ensure continuity of the following functions:

- Propulsion, manoeuvrability, navigation and safety of the ship
- Safety of the crew and embarked troops
- Functioning of all equipment, machinery and appliances needed for flooding control, fire fighting, NBC defence, degaussing, etc.
- Functioning of all equipment, machinery and appliances needed to an unrestricted extent for the primary duty of the naval ship

These requirements apply for the mechanical part of the equipment and complete equipment units supplied by subcontractors.

Essential equipment is subdivided into:

- Primary essential equipment according to 2.2
- Secondary essential equipment according to 2.3

2.2 Primary essential equipment

Primary essential equipment is that required to be operative at all times to maintain the manoeuvrability of the ship as regards propulsion and steering and that required directly for the primary duty of the naval ship.

It comprises e.g.:

- Steering gear
- Controllable pitch propeller installation
- Scavenging air blowers, fuel oil supply pumps, fuel booster pumps, fuel valve cooling pumps, lubricating oil pumps, cooling water pumps for main and auxiliary engines and turbines neces-sary for propulsion
- Forced draught fans, feed water pumps, water circulating pumps, vacuum pumps and condensate pumps for auxiliary boilers of ships where steam is used for equipment supplying primary essential equipment
- Burner equipment for auxiliary steam boilers of

ships where steam is used for equipment supplying primary essential equipment

- Azimuth thrusters which are the sole means for propulsion/steering including lubricating oil pumps, cooling water pumps
- Electric generator units and associated power sources supplying primary essential equipment
- Hydraulic pumps for primary essential equipment
- Weapon systems (effectors)

2.3 Secondary essential equipment

Secondary essential equipment is that required for the safety of ship and crew, and is such equipment which can briefly be taken out of service without the propulsion, steering and equipment needed for the primary duty of the naval ship, being unacceptably impaired.

It comprises e.g. :

- Windlasses and capstans
- Azimut thrusters, if they are auxiliary equipment
- Fuel oil transfer pumps and fuel oil treatment equipment
- Lubrication oil transfer pumps and lubrication oil treatment equipment
- Starting air and control air compressors
- Bilge, ballast and heel-compensating installations
- Fire pumps and other fire fighting installations
- Ventilating fans for engine and boiler rooms
- Equipment considered necessary to maintain endangered spaces in a safe condition
- Equipment for watertight closing appliances auxiliary and main engine starting installations
- Generator units supplying secondary essential equipment, if this equipment is not supplied by generators as described in 2.2
- Hydraulic pumps for secondary essential equipment
- Parts of the shipboard aircraft installations
- NBC fans and passage heaters decontamination equipment

3. Non-essential equipment

Non-essential equipment is that whose temporary disconnection does not impair the principal requirements defined in 2.1.

C. Documents for Approval

1. All documents have to be submitted to TL for approval in Turkish or English language.

2. The survey of the ship's construction will be carried out on the basis of approved documents. The drawings must contain all data necessary for approval. Where necessary, calculations and descriptions of the symbols used are to be explained in a key list. All documents have to indicate the number of the project and the name of the Naval Authority and/or shipyard.

3. The supporting calculations shall contain all necessary information concerning reference documents

Literature used for calculations has to be cited, important but not commonly known sources shall be added in copy.

The choice of computer programs according to the "State of the Art" is free. The programs may be checked by TL through comparative calculations with predefined test examples. A generally valid approval for a computer program is, however, not given by TL.

The calculations have to be compiled in a way which allows to identify and check all steps of the calculation in an easy way. Hand written, easily readable documents are acceptable.

Comprehensive quantities of output data shall be presented in graphic form. A written comment to the main conclusions resulting from the calculations has to be provided.

4. A summary of the required documents is contained in Chapter 101- Classification and Surveys, Table 4.1. Further details are defined in the following Sections of this Chapter.

5. TL reserve the right to demand additional documentation if that submitted is insufficient for an assessment of the naval ship. This may especially be the case for plants and equipment related to new developments and/or which are not tested on board to a sufficient extent.

6. The drawings and documents are to be submitted in triplicate, all calculations and supporting documentation in one copy for examination at a sufficiently early date to ensure that they are approved and available to the Surveyor at the beginning of the manufacture of or installation on the naval ship.

7. Once the documents submitted have been approved by TL they are binding for the execution of the work. Subsequent modifications and extensions require approval of TL before being put into effect.

8. At the commissioning of the naval ship or after considerable changes or extensions of the systems the documentation for approval as defined in the different Sections, showing the final condition of the systems, has to be given on board. All documents have to indicate the name of the ship, the newbuilding number of the shipyard and the date of execution.

The operating and maintenance instruction, warning warning signs, etc. have to be prepared in English or Turkish language. If the user's language is different, a trans-lation into the user language has to be provided and be carried also on board.

D. Ambient Conditions

1. General operating conditions

1.1 The selection, layout and arrangement of the ship's structure and all shipboard machinery shall be such as to ensure faultless continuous operation under defined standard ambient conditions.

More stringent requirements must be observed for class notation **AC1**, see Chapter 101 - Classification and Surveys, Section 2, C.

For the class notation **ACS** variable requirements for unusual types and/or tasks of naval ships can be discussed case by case, but shall not be less than the basic requirements.

Components in the machinery spaces or in other spaces which comply with the conditions for the Notations **AC1** or **ACS** must be approved by TL.

1.2 Inclinations and movements of the ship

The design conditions for static and dynamic inclina tions of a naval ship have to be assumed independently from each other. The standard requirements and the requirements for class notation **AC1** are defined in Table 1.1.

The effects of elastic deformation of the ship's hull on the machinery installation have to be considered.

1.3 Environmental conditions

The design environmental conditions of a naval ship are contained in Table 1.2. In this Table the standard requirements and the requirements for Class Notation **AC1** are defined.

2. Vibrations

2.1 Machinery, equipment and hull structures are normally subjected to vibration stresses. Design, construction and installation must in every case take account of these stresses.

The faultless long-term service of individual components shall not be endangered by vibration stresses.

2.2 For further details see Chapter 104 – Propulsion Plants, Section 1, D.2. and Chapter 102 - Hull Structures and Ship Equipment, Section 16, C.

Table 1.1 Design conditions for ship inclinations and movements

Type of movement	Type of inclination and affected equipment	Design conditions	
		Standard requirements	Notation AC1
Static condition	**Inclination athwartships: (1)**		
	Main and auxiliary machinery	15°	25°
	Other installations **(2)**	22,5°	25°
	No uncontrolled switches or functional changes	45°	45°
	Ship's structure	acc. to stability requirements	acc. to stability requirements
	Inclinations fore and aft: (1)		
	Main and auxiliary machinery	5°	5°
	Other installations **(2)**	10°	10°
	Ship's structure	acc. to stability requirements	acc. to stability requirements
Dynamic condition	**Rolling:**		
	Main and auxiliary machinery	22,5°	30°
	Other installations **(2)**	22,5°	30°
	Pitching:		
	Main and auxiliary machinery	7,5°	10°
	Other installations **(2)**	10°	10°
	Accelerations:		
	vertical (pitch and heave)	a_z [g] **(3)**	pitch: 32 $°/s^2$ heave: 1,0 g
	Transverse (roll, yaw and sway)	a_y [g] **(3)**	roll: 48 $°/s^2$ yaw: 2 $°/s^2$ sway: a_y **(3)** [g]
	longitudinal (surge)	a_x [g] **(3)**	a_x **(4)** [g]
	combined acceleration	acceleration ellipse **(3)**	direct calculation

(1) *athwartships and fore and aft inclinations may occur simultaneously*

(2) *ship's safety equipment, switch gear and electric/electronic equipment*

(3) *defined in Chapter 102 - Hull Structures and Ship Equipment, Section 5, B.*

(4) *to be defined by direct calculation*

Table 1.2 Design conditions for the environment

Environmental area	Parameters	Design conditions	
		Standard requirements	Notation AC1
Outside the ship/air	Temperature	-25 °C to +45 °C (1)	-30 °C to +55 °C **(1)**
	Temperature (partially open spaces)	-	-10 °C to +50 °C**(1)**
	Salt content	1 mg/m^3	1 mg/m^3
		withstand salt-laden spray	withstand salt-laden spray
	Dust/sand	to be considered	filters to be provided
	Wind velocity (systems in operation)	43 kn **(3)**	90 kn
	Wind velocity (systems out of operation)	86 kn **(3)**	100 kn
Outside the ship/ seawater	Temperature **(4)**	-2 °C to +32 °C	-2 °C to +35 °C
	Density acc. to salt content	1,025 t/m^3	1,025 t/m^3
	Flooding	withstand temporarily	withstand temporarily
Outside the ship/ icing of surface	Icing on ship's surfaces up to 20 m above waterline	see Chapter 1, Section 2, B.3.4	see Chapter 1, Section 2, B.3.4
Outside the ship/ navigation in ice	Ice class B	drift ice in mouth of rivers and coastal regions	drift ice in mouth of rivers and coastal regions
Entrance to the ship/ for design of heating/cooling systems	Air temperature	-15°Cto+35°C	-15°Cto+35°C
	Max. heat content of the air	100 kJ/kg	100 kJ/kg
	Seawater temperature	-2 °C to +32 °C	-2 °C to +35 °C
Inside the ship/ all spaces **(5)**	Air temperature	0 °C to +45 °C	0 °C to +45 °C
	Atmospheric pressure	1000 mbar	1000 mbar
	Max. relative humidity	up to 100 % (+45 °C)	100 %
	Salt content	1 mg/m^3	1 mg/m^3
	Oil vapour	withstand	withstand
	Condensation	to be considered	to be considered
Inside the ship/ air-conditioned areas	Air temperature	0 °C to +40 °C	0 °C to +40 °C
	Max. relative humidity	80%	100 %
	Recommended ideal climate for manned computer spaces	-	air temperature +20 °C to +22 °C at 60% rel. humidity
Inside the ship/ in electrical devices with higher degree of heat dissipation	Air temperature	0 °C to +55 °C	0 °C to +55 °C
	Max. relative humidity	100 %	100 %

(1) *higher temperatures due to radiation and absorption heat have to be considered*
(2) *100 % for layout of electrical installations*
(3) *for lifting devices according to TL Rules Chapter 50 - Guidelines for the Construction and Survey of Lifting Appliances, Section 2*
(4) *TL may approve lower limit water temperatures for ships operating only in special geographical areas*
(5) *for recommended climatic conditions in the ship's spaces see also Section 11, F.*

3. Shock

Details for shock requirements are described in Chapter 102 - Hull Structures and Ship Equipment, Section 16, D.

E. Materials

1. The materials used for components of auxiliary systems and equipment have to fulfill the quality requirements defined in TL Rules Chapter 2 - Materials, and Chapter 3 - Welding. The approved materials for the different systems are defined in the following Sections.

2. Materials deviating from the defined quality requirements may only be used with special approval of TL. The suitability of the material has to be proven.

F. Consumables for Operation

All consumables like fuels, lubrication oils and greases, etc. used for the operation of auxiliary systems and equipment must be in accordance with the requirements of the manufacturers of these systems.

G. Safety Equipment and Protective Measures

Auxiliary systems and equipment are to be installed and safeguarded in such a way that the risk of accidents is largely ruled out. Besides of national regulations particular attention is to be paid to the following:

1. Moving parts, flywheels, chain and belt drives, linkages and other components which could be an accident hazard for the operating personnel are to be fitted with guards to prevent contact.

2. The design and installation of all systems and equipment has to guarantee that elements, which have to be used during normal operation of the ship by the crew and where no thermal insulation is provided, are kept within the following restrictions concerning accidental contact with hot surfaces:

2.1 No skin contact is possible with elements warmed up under operating conditions to surface temperatures above 70 °C.

2.2 Components, which may be used without body protection (e.g. protective gloves) and with a contact time up to 5 s, are to have no higher surface temperature than 60 °C.

2.3 Components made of materials with high thermal conductivity, which may be used without body protection and with a contact time of more than 5 s are not to achieve a surface temperature above 45 °C.

2.4 Exhaust gas lines and other apparatus and lines transporting hot media have to be insulated effectively. Insulation material must be non-combustible. Locations where inflammable liquids or moisture may penetrate into the insulation are to be protected in a suitable way by coverings etc., see **TL** Rules Chapter 4 - Machinery, Section 18, B.4.1.

3. Dead-man's circuits are to be provided for rotating equipment.

4. In operating spaces, anti-skid floor plates and floor coverings must be used.

5. Service gangways, operating platforms, stairways and other areas open to access during operation are to be safeguarded by guard rails. The outside edges of platforms and floor areas are to be fitted with coamings unless some other means is adopted to prevent persons and objects from sliding off.

6. Safety valves and means for shut-off must be capable of safe operation.

7. Safety valves are to be installed to prevent the occurrence of excessive operating pressures.

H. Survivability

1. Definition

Survivability of a naval ship is to be regarded as the degree of ability to withstand a defined weapon threat and to maintain at least a basic degree of safety and operability of the ship.

It is obvious that survivability is an important characteristic of a naval ship which may be endangered by

- Loss of global strength of the hull structure
- Loss of buoyancy and/or stability
- Loss of manoeuvrability
- Fire in the ship and ineffective fire protection or fire fighting capability
- Direct destruction of machinery, equipment or control systems
- Direct destruction of weapons and sensors threat to the crew

2. Measures for improved survivability

The design of a ship which is classed as naval ship has to consider a series of possible measures to improve survivability. These TL Rules for naval surface ships offer in the different Chapters various measures and Class Notations to achieve improved survivability, which are summarized at the beginning of each Chapter. The degree of including such measures in an actual project has to be defined by the Naval Authority.

3. Measures for ship operation installations and auxiliary systems

In this Chapter the following main measures to improve survivability are included.

3.1 Bilge systems

The requirements for a separate bilge installation in each watertight compartment and the arrangement of pumps and eductors are defined in Section 8, N.

3.2 Fire protection

The requirements for fire protection are defined in Section 9, B.

3.3 Fire alarms

The requirements for the arrangement of fire alarm systems are defined in Section 9, C.

3.4 Fire extinguishing equipment

A summary of fixed fire extinguishing systems is given in Section 9, D. The details of the various systems are defined in the following Sub-sections.

3.5 NBC protection plants

The arrangement of NBC protection plants for the ventilation of each damage control zone and the relevant construction details are defined in Section 11, C.

3.6 Compartment autonomy

Compartment autonomy means that a compartment between two watertight bulkheads is provided with an autonomous supply from auxiliary systems like fire extinguishing (see Section 9, O.3.), ventilation (see Section 11, A.8.), bilge system (see 3.1), etc.

3.7 Damage control zone

The establishment of damage control zones will be a major contribution to survivability of larger naval ships. A damage control zone includes normally several watertight compartments and is at its fore and aft end separated from the other parts of the ship by fire resisting divisions. If no compartment autonomy according to 3.6 is established, at least an autonomy of the damage control zone is recommended.

SECTION 2

STEERING GEARS AND STABILIZERS

A. Steering Gears

1. General

1.1 Scope

The rules in this Section apply to the steering gear, the steering station and all transmission elements from the steering station to the steering gear. For the rudder and manoeuvring arrangement, see Chapter 102 - Hull Structures and Ship Equipment, Section 12.

1.2 Documents for approval

Assembly and general drawings of all steering gears, diagrams of the hydraulic and electrical equipment together with detail drawings of all important load-transmitting components are to be submitted to TL in triplicate for approval.

The drawings and other documents must contain all the information relating to materials, working pressures, pump delivery rates, drive motor ratings etc. necessary to enable the documentation to be checked.

2. Materials

2.1 Approved materials

2.1.1 As a rule, important load-transmitting components of the steering gear shall be made of steel or cast steel complying with the TL Rules Chapter 2 - Materials and especially Chapter 103 - Special Materials for Naval Ships.

With the consent of TL, cast iron may be used for certain components.

Pressure vessels should in general be made of steel, cast steel or nodular cast iron with a predominantly ferritic matrix.

For welded structures, the TL Rules Chapter 3 - Welding are to be observed.

2.1.2 The pipes of hydraulic steering gears are to be made of seamless or longitudinally welded steel tubes. The use of cold-drawn, unannealed tubes is not permitted.

At points where they are exposed to damage, copper pipes for control lines are to be provided with protective shielding and are to be safeguarded against hardening due to vibration by the use of suitable fastenings.

2.1.3 High-pressure hose assemblies may be used for short pipe connections subject to compliance with Section 8, if this is necessary due to vibrations or flexibly mounted units.

2.1.4 The materials used for pressurized components including the seals must be suitable for the hydraulic oil in use.

2.2 Testing of materials

2.2.1 The materials of important load-transmitting components of the steering gear as well as of the pressurized casings of hydraulic steering gears are to be tested under the supervision of TL in accordance with the Rules for Metallic Materials.

For pressurized oil pipes the requirements according to Section 8, Table 8.3 are to be observed.

For welded pressurized casings, the TL Rules Chapter 3 - Welding are to be applied.

3. Design and equipment

3.1 Number of steering gears

Every ship must be equipped with at least one main and one auxiliary steering gear. Both steering gears are to be independent of each other and, wherever possible, act separately upon the rudder stock. TL may agree to components being used jointly by the main and auxiliary steering gear.

3.2 Main steering gear

3.2.1 Main steering gears shall, with the rudder fully immersed in calm water, be capable of putting the rudder from 35° port to 35° starboard and vice versa at the ship's speed for which the rudder has been designed in accordance with the Rules in Chapter 102 -Hull Structures and Ship Equipment, Section 12. The time required to put the rudder from 35° on either side to 30° on the other side shall not exceed 28 seconds.

3.2.2 The main steering gear must be power-operated.

3.3 Auxiliary steering gear

3.3.1 Auxiliary steering gears shall, with the rudder fully immersed in calm water, be capable of putting the rudder from 15° port to 15° starboard or vice versa within 60 seconds at 50 % of the ship's maximum speed, subject to a minimum of eight knots. Hydraulically operated auxiliary steering gears must be fitted with their own piping system independent of that of the main steering gear. The pipe or hose connections of steering gears must be capable of being shut off directly at the pressurized casings.

3.3.2 Manual operation of auxiliary steering gear systems is permitted up to a theoretical stock diameter of 230 mm referring to steel with a minimum nominal upper yield stress R_{eH} = 235 N/mm^2.

3.4 Power unit

3.4.1 Where power operated hydraulic main steering gears are equipped with two or more identical power units, no auxiliary steering gear need be installed provided that the following conditions are fulfilled.

3.4.1.1 Conditions 3.2.1 and 4.1 must be fulfilled while any one of the power units is out of operation.

3.4.1.2 In the event of failure of a single component of the main steering gear including the piping, excluding the rudder tiller or similar components as well as the cylinders, rotary vanes and casing, means must be provided for quickly regaining control of one steering system.

3.4.1.3 In the event of a loss of hydraulic oil, it must be possible to isolate the damaged system in such a way that the second control system remains fully serviceable.

3.5 Rudder angle limitation

The rudder angle in normal service is to be limited by devices fitted to the steering gear (e.g. limit switches) to a rudder angle of 35 ° on both sides. Deviations from this Rule are permitted only with the consent of TL.

3.6 End position limitation

For the limitation by means of stoppers of the end positions of tillers and quadrants, see Chapter 102 - Hull Structures and Ship Equipment, Section 12, H.

In the case of hydraulic steering gears without an end position limitation of the tiller and similar components, an end position limiting device must be fitted within the rudder actuator.

3.7 Locking equipment

Steering gear systems are to be equipped with a locking system effective in all rudder positions, see also Chapter 102 - Hull Structures and Ship Equipment, Section 12, H.

Where the hydraulic plant is fitted with shutoffs directly at the cylinders or rotary vane casings, special locking equipment may be dispensed with.

In the case of steering gears with cylinder units which have mutually independent operation, these shut-off devices do not have to be fitted directly on the cylinders.

3.8 Overload protection

3.8.1 Power-operated steering gear systems are to be equipped with overload protection (slip coupling, relief valve) to ensure that the driving torque is limited to the maximum permissible value.

The overload protection device must be secured to prevent later adjustment by unauthorized persons. Means must be provided for checking the setting while in service.

The pressurized casings of hydraulic steering gears which also fulfil the function of the locking equipment mentioned in 3.7 are to be fitted with relief valves unless they are so designed that the pressure generated when the elastic limit torque is applied to the rudder stock cannot cause rupture, deformation or other damage of the pressurized casing.

3.8.2 Relief valves have to be provided for protecting any part of the hydraulic system which can be isolated and in which pressure can be generated from the power source or from external forces.

The relief valves must be set to a pressure value equal or higher than the maximum working pressure but lower than the design pressure of the steering gear (definition of maximum working pressure and design pressure in accordance to 4.1).

The minimum discharge capacity of the relief valve(s) should not be less than 1,1 times the total capacity of the pumps, which can deliver through it (them).

With this setting any higher peak pressure in the system than 1,1 times the setting pressure of the valves must be prohibited.

3.9 Additional functions for the stabilization of rolling

If a stabilization of rolling by using the rudder and the steering gear is intended and this function is failing, the main steering function shall not be influenced. Such a failure has to be signalled to the bridge or the machinery control centre (MCC).

3.10 Controls

3.10.1 Control of the main and auxiliary steering gears must be exercised from a steering station on the bridge. Controls must be mutually independent and so designed that the rudder cannot move unintentionally.

3.10.2 Means must also be provided for exercising control from the steering gear compartment. The transmission system must be independent of that serving the main steering station.

3.10.3 Suitable equipment is to be installed to provide means of communication between the bridge, all steering stations and the steering gear compartment.

3.10.4 Failures of single control components, e.g. control system for variable displacement pump or flow control valve, which may lead to loss of steering shall be monitored by an audible and visible alarm on the navigating bridge, if loss of steering cannot be prevented by other measures.

3.11 Rudder angle indication

3.11.1 The rudder position must be clearly indicated on the bridge and at all steering stations. Where the steering gear is operated electrically or hydraulically, the rudder angle must be signalled by a device (rudder position indicator) which is actuated either by the rudder stock itself or by parts which are rigidly connected to it. In case of time-dependent control of the main and auxiliary steering gear, the midship position of the rudder must be indicated on the bridge by some additional means (signal lamp or similar). In general, this indicator is still to be fitted even if the second control system is a manually operated hydraulic system. See also Chapter 105 - Electrical Installations, Section 9, B.2.

3.11.2 The rudder position at any time must also be indicated at the steering gear itself.

It is recommended that an additional rudder angle indicator is fitted at the main engine control station.

3.12 Piping

3.12.1 The pipes of hydraulic steering gear systems are to be installed in such a way as to ensure maximum protection while remaining readily accessible.

Pipes are to be installed at a sufficient distance from the ship's shell. As far as possible, pipes should not pass through cargo spaces, hangars and landing craft docks.

Connections to other hydraulic systems are not permitted.

3.12.2 For the design and dimensions of pipes, valves, fittings, pressure vessels etc., see Section 8, Piping Systems, Valves and Pumps, and Section 16, Pressure Vessels.

3.13 Oil level indicators, filters

3.13.1 Tanks forming part of the hydraulic system are to be fitted with oil level indicators.

3.13.2 The lowest permissible oil level is to be monitored. Audible and visual alarms shall be given on the navigating bridge and in the machinery space. The alarms on the navigating bridge shall be individual alarms.

3.13.3 Filters for cleaning the operating fluid are to be located in the piping system.

3.14 Storage tank

In power-operated steering gear systems, an additional permanently installed storage tank is to be fitted which has a capacity sufficient to refill at least one of the control systems including the service tank.

This storage tank is to be permanently connected by pipes to the control systems so that the latter can be recharged from a position inside the steering gear compartment.

3.15 Arrangement

Steering gears are to be so installed that they are accessible at all times and can be maintained without difficulty.

3.16 Electrical equipment

For the electrical part of steering gear systems see Chapter 105 - Electrical Installations, Section 7, A.

4. Power and design

4.1 Power of steering gears

The power of the steering gear has to comply with the requirements set out in 3.2 and 3.3.

The maximum effective torque for which the steering gear is to be equipped shall not be less than

$$M_{max} = \frac{\left(\frac{D_t}{4,2}\right)^3}{k_r} \quad [\text{Nm}] \qquad \textbf{(1)}$$

D_t = Theoretical rudder stock diameter [mm], derived from the required hydrodynamic rudder torque as calculated by formula based on the ahead running conditions in accordance with the Rules Chapter 102 - Hull Structures, Section 12, C.

The working torque of the steering gear must be larger than the hydrodynamic torque Q_R of the rudder according to Chapter 102 - Hull Structures, Section 12, B.1.2, B.2.2, B.2.3 and cover the friction moments of the related bearing arrangement.

The corresponding maximum working pressure is the maximum expected pressure in the system, when the steering gear is operated to comply with the power requirements as mentioned above.

Frictional losses in the steering gear including piping have to be considered within the determination of the maximum working pressure.

The design pressure for calculation to determine the scantlings of piping and other steering gear components subjected to internal hydraulic pressure shall be at least 1,25 times the maximum working pressure as defined above and has not to be less than the setting of the relief valves as described under 3.8.2.

In the case of multi-surface rudders controlled by a common steering gear the relevant diameter is to be determined by applying the formula:

$$D_t = \sqrt[3]{D_{t1}^3 + D_{t2}^3 + \ldots}$$

$D_{tl}, D_{t2}, \ldots$ = Theoretical rudder stock diameter [mm] for the different rudders

k_r = Material factor

$$k_r = \left(\frac{235}{R_{eH}}\right)^e \qquad \textbf{(2)}$$

e = 0,75 where R_{eH} >235 N/ mm^2

= 1,0 where R_{eH} ≤ 235 N/ mm^2

R_{eH} = Minimum upper yield stress of rudder stock material [N/mm^2].

In no case R_{eH} is to be greater than 450 N/mm^2 or 0,7 · R_m, whichever is less

R_m = Tensile strength [N/mm^2]

4.2 Design of transmission components

4.2.1 The design calculations for those parts of the steering gear which are not protected against overload are to be based on the elastic limit torque of the rudder stock.

The elastic limit torque to be used is

$$M_F = 2 \cdot \frac{\left(\frac{D}{4,2}\right)^3}{k_r} \quad [\text{Nm}] \qquad \textbf{(3)}$$

D = Minimum actual rudder stock diameter [mm]. The value used for the actual diameter need not be larger than 1,145 · D_t.

The stresses in the components of the steering gear determined in this way must be below the yield stress of the materials used. The design of parts of the steering gear with overload protection is to be based on the loads corresponding to the response threshold of the overload protection.

4.2.2 Tiller and rotary vane hubs made of material with a tensile strength of up to 500 N/mm^2 have to satisfy the following conditions in the area where the force is applied (see Figure 2.1):

Height of hub H ≥ 1,0 · D [mm]

Outside diameter D_a ≥ 1,8 · D [mm]

In special cases the outside diameter may be reduced to

D_a = 1,7 · D [mm]

But the height of the hub must then be at least

H = 1,14 · D [mm]

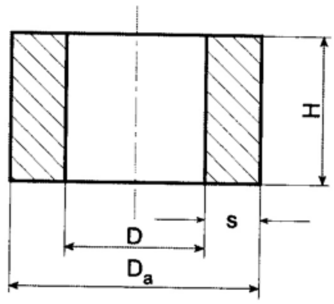


Fig. 2.1 Hub dimensions

4.2.3 Where materials with a tensile strength greater than 500 N/mm^2 are used, the section of the hub may be reduced by 10 %.

4.2.4 Where the force is transmitted by clamped or tapered connections, the elastic limit torque may be transmitted by a combination of frictional resistance and a positive locking mechanism using adequately tightened bolts and a key.

For the elastic limit torque according to formula (3) the thread root diameter of the bolts can be determined by applying the following formula:

$$d_k \geq 9,76 \cdot D_t \sqrt{\frac{1}{z \cdot k_r \cdot R_{eH}}} \quad [\text{mm}] \qquad \textbf{(4)}$$

z = Total number of bolts [-]

k_r = See 4.1

R_{eH} = Minimum upper yield stress of the bolt material [N/mm^2]

4.2.5 Split hubs of clamped joints must be joined together with at least four bolts.

The key is not to be located at the joint in the clamp.

4.2.6 Where the oil injection method is used to join the rudder tiller or rotary vanes to the rudder stock, the methods of calculation appropriate to elasticity theory are to be applied. Calculations are to be based on the elastic limit torque allowing for a coefficient of friction μ_o = 0,15 for steel and μ_o = 0,12 for nodular cast iron. The von Mises equivalent stress calculated from the specific pressure p and the corresponding tangenttial load based on the dimensions of the shrunk joint shall not exceed 80 % of the yield strength of the materials used.

4.2.7 Where circumferential tension components are used to connect the rudder tiller or rotary vanes to the rudder stock, calculations are to be based on two and a half times the maximum torque (but not more than the elastic limit torque) allowing for a coefficient of friction of μ_o = 0,12. The von Mises equivalent stress calculated from the contact pressure p and the corresponding tangential load based on the dimensions of the shrunk-on connection shall not exceed 80 % of the yield strength of the materials used.

When more than one circumferential tension component is used the transmittable torque is to be determined from the sum of the individual torques allowing for a weakening factor v = 0,9.

5. Tests in the manufacturer's factory (FAT)

5.1 Testing of power units

The power units are required to undergo tests on a test stand in the manufacturer's factory.

5.1.1 For diesel engines see Chapter 104 Propulsion Plants, Section 3.

5.1.2 For electric motors see Chapter 105 - Electri cal Installations, Section 14.

5.1.3 For hydraulic pumps and motors the TL Guidelines for Design, Construction and Testing of Pumps are to be applied analogously. Where the drive power is 50 kW or more, this testing is to be carried out in the presence of a TL Surveyor.

5.2 Pressure and tightness tests

Pressure components are to undergo a pressure test. The test pressure is:

p_C = 1,5 · p

p = The maximum allowable working pressure [bar] or the pressure at which the relief valves open. However, for working pressures above 200 bar the test pressure need not exceed p + 100 bar.

For pressure testing of pipes, their valves and fittings, see Section 8, B.4 and U.6.

Tightness tests are to be performed on components to which this is appropriate, at the discretion of the TL Surveyor.

5.3 Final inspection and operational test

Following testing of the individual components and after completion of assembly, the steering gear is required to undergo final inspection and an operational test. Among other things the overload protection is to be adjusted at this time.

6. Shipboard trials

The operational efficiency of the steering gear is to be proved during the sea trials. For this purpose, the Z manoeuvre corresponding to 3.2.1 and 3.3.1 is to be executed as a minimum requirement.

B. Stabilizers

1. General

1.1 Scope

The requirements apply to drive units for roll stabilizers.

1.2 Documents for approval

Assembly and general drawings together with diagrams of the hydraulic and electrical equipment containing all the data necessary for checking are to be submitted in triplicate for approval.

2. Design and construction

2.1 A.2.1.3 and A.2.1.4 are applicable in analogous manner to the pipe connections of hydraulic drive units.

2.2 For retraceable stabilizer fins the actual position has to be indicated at the bridge and at the machinery control centre (MCC).

2.3 The sealing arrangement at the penetration of the fin shaft through the ship's shell into the watertight drive compartment has to the specially considered and submitted for approval.

3. Pressure and tightness test

A.5.2 is applicable analogously.

4. Shipboard trials

The operational efficiency of the stabilizer equipment is to be demonstrated during the sea trials.

SECTION 3

LIFTING APPLIANCES AND LIFTS

A. General

1. Scope

1.1 The dimensioning, testing and examining of lifting appliances and lifts normally is not part of the Classification of a naval ship. The Classification does, however, include checking the structure of the ship's hull and foundations in way of the forces transmitted by lifting appliances and lifts.

1.2 The rules in this Section are applied by TL in all cases where TL is commissioned to assess lifting appliances, lifts and lifting attachments. They are the basis on which the TL Certificates are issued.

1.3 The TL Certification according to 1.2 is based on ILO Convention 152 for lifting appliances and on EN 81 for lifts.

1.4 In case that lifting appliances shall get the Class Notation **LA** additional requirements for the approval, survey, testing and certification of mechancal and electrical components are to be met as described in the TL Rules Chapter 50 - Regulations for the Construction and Survey of Lifting Appliances.

2. National regulations

Where national regulations differ from the rules in this Section, TL may base the approval, testing and examination on these divergent regulations in so far as this is necessary or agreed, and provided that they are placed at the disposal of TL, as may be required.

3. Other applicable Rules

The following TL Rules complement, where relevant, the provisions of this Section:

- TL Rules Chapter 2 – Materials Principles and Test Procedures, Section 2
- TL Rules Chapter 3 -Welding, Chapter 1 - General Requirements, Proof of Qualifications, Approvals, Section 3
- Chapter 105 - Electrical Installations

B. Cranes

1. Scope

1.1 The following types of equipment are not considered in this Section:

- Launching cranes / davits, see Chapter 102 - Hull Structures and Ship Equipment, Section 19, J.
- Systems for replenishment at sea, see Section 4

1.2 It is recommended on principle to examine the crane drawings for new cranes to be constructed in order to establish the degree of inherent safety with a view to subsequent practical testing and certification.

1.3 The documents and rigging plans to be submitted are to indicate the type of crane, see 2. and the working ranges (possibly restricted) permissible for strength or ship's stability reasons, together with the permissible inclinations of the floating body. If necessary, special stability data shall be appended.

2. Types of cranes

2.1 On naval ships the following types of cranes are normally used:

- Deck cranes for general military cargo, containers, palletised goods
- Deck cranes for provisions, drone handling, etc.
- Cranes in machinery rooms and hangars

If cranes are used for transport of personnel, the safe working load SWL has to be restricted for that purpose and special measures for the crane control have to be provided.

2.2 The cranes are further subdivided with regard to the hoist load coefficients and the proof of fatigue strength:

- Type A cranes: includes all the cranes that do not handle cargo. They are characterised by an irregular usage pattern with lengthy rest periods.

- Type B cranes: includes all cranes that do handle cargo but not always lift the full SWL. These cranes are characterized by a regular usage pattern with lengthy rest periods.

- Cranes with special loading conditions will be subject to special considerations.

3. Calculation procedure

3.1 The vertical dynamic forces due to the acceleration or movement of lifting appliances, parts thereof or hoist loads are considered in calculation by the dead load coefficient φ and the hoist load coefficient, Ψ by which the static loads shall be multiplied.

3.2 The dead load coefficient φ is defined as follows:

3.2.1 The weights of movable lifting appliance components, such as booms or jibs, are to be multiplied by a dead load coefficient in accordance with Table 3.1.

3.2.2 For travelling lifting appliances or parts thereof, the dead load coefficient is φ = 1,2. This value covers the dead load coefficients stated in 3.2.1.

Table 3.1 Dead load coefficients for cranes

Safe working load SWL [t]	Dead load coefficient φ
up to 60t SWL	1,1
over 60 t up to 100t SWL	1,05
over 100 t	1,00

3.3 The hoist loads or the stresses arising there-from shall be multiplied by a hoist load coefficient Ψ. If a crane has several hoisting equipments, these may have differing hoist load coefficients. The hoist load coefficients are defined in Table 3.2.

Table 3.2 Hoist load coefficients for cranes

Type of shipboard crane	Hoist load coefficient Ψ depending on hoisting speed v_H	
	$v_H \leq 90$ [m/min]	$v_H > 90$ [m/min]
Type A cranes	Ψ = 1,1 + 0,0022 · v_H	Ψ = 1,3
Type B cranes	Ψ = 1,2 + 0,0044 · v_H	Ψ = 1,6

3.4 For a detailed calculation see Section 4 of the TL Regulations defined in A. 1.4 and for the condition "ship in a seaway".

4. Construction

4.1 At sea all movable and rotable masses have to be lashed by special and suitable measures.

4.2 Movable cranes

4.2.1 Rail-mounted cranes and trolleys shall be safeguarded against derailment, overturning and dislodging as well as against unintentional movement in a seaway and in operation. Rail stops, warning devices and rail clearers shall be provided.

4.2.2 Cranes which can be moved athwartships shall be fitted with a direct drive (rack and pinion drive or equivalent). The drive shall be self-locking or be equipped with brakes.

4.2.3 Where cranes which can be moved fore and aft in longitudinal direction of the ship are not fitted with a direct drive, they have to be equipped with a self-locking device or with brakes. For the latter case calculations are to be submitted proving that the cranes are able to move against a 2° inclination and against a wind load 50 % higher than normally applied for "lifting appliances in operation" (wind speed of 22 m/s), with or without load, by friction contact only. For ships which operate at least temporarily with a considerable trim, like dock landing ships during docking manoeuvres, a direct drive with rack and pinion is recommended for the longitudinal movement.

4.2.4 The top of the crane rail shall lie parallel to the construction waterline (DWL) of the ship

4.2.5 Where the operator has to move with the crane control unit, the speed of travel may not exceed 0,5 m/s.

4.2.6 Cranes in machinery rooms or maintenance hangars, etc.

4.2.6.1 For cranes and trolleys up to 1,5 t SWL travelling athwartships, the requirement according to 4.2.2 is considered to be met if the load can be held safely by means of suitable restraints (tackles, pulley blocks, etc.) even against movement of the ship.

4.2.6.2 Cranes or trolleys travelling in longitudinal direction of the ship have to be equipped with a direct drive according to 4.2.2 if they shall be used for repair and maintenance duties at sea.

4.2.7 Free travelling lifting appliances

4.2.7.1 Cranes and floorborne lifting appliances shall have a sufficient and proven stability.

4.2.7.2 Plate thickness and stiffeners of decks where cranes or floorborne lifting appliances are travelling, shall carry the loads defined in Chapter 102 - Hull Structures and Ship Equipment, Section 5, F.

4.2.7.3 At cranes and floorborne lifting appliances as well as at the hull structure pad eyes have to be provided to enable sea lashing. For the arrangement of these pad eyes the stress distribution in the hull has to be considered.

4.3 Accesses in general

The railings of access ways, platforms, etc. shall be at least 0,90 m in height with a handrail at the top and an intermediate rail half way up. Additionally a foot bar at least 0,10 m in height shall be provided.

4.4 Safety measures

4.4.1 In accessible areas, the distance between fixed parts of the ship and moving parts of the crane shall be at least 0,50 m in all directions and where passageways adjoin at least 0,60 m. Where guard rails are used as boundaries for working spaces and passageways, these shall be at least 0,10 m away from any moving part.

4.4.2 If at certain points a distance of 0,50 m cannot be provided, the area concerned shall be identified with prominent black and yellow paintwork. Warning notices are to be fitted.

4.4.3 Where the free movement of moveable lifting appliances and their loads have to be limited, scratch boards are to be installed. As regards to their need and extent each individual case shall be cleared with TL.

4.4.4 The complete working area of the lifting appliances have to be sufficiently lighted for night operation.

4.5 Machinery spaces

4.5.1 In machinery spaces (aboard the ship and in cranes) adequately-dimensioned facilities for the attachment of hand-operated hoists, holding or other devices shall be provided in suitable places and suitable facilities for setting down of engine parts shall be installed.

4.5.2 To permit the performing of the load tests on existing hoists within the framework of the thorough examination every five years, eye plates shall be provided at suitable places.

4.6 Miscellaneous

4.6.1 Subordinate members and auxiliary structures such as ladders, consoles, cable trays, etc. shall not be welded to highly stressed members. Where anyhow necessary, proof of fatigue strength shall be supplied for this case.

4.6.2 Rope drums which cannot be under observation by the operator at all times shall be provided with a forced guide system for the rope running onto the drum. This forced guide system shall be installed as a matter of principle where the rope cannot wind itself satisfactorily onto the drum. Such a forced guide system may be a grooved drum, a coiling gear or a similar device.

4.6.3 The sheaves of cranes shall be fitted with a rope guard to prevent the ropes from jumping out of the groove.

5. Equipment

5.1 Crane booms

5.1.1 Direct or indirect acting luffing or swinging cylinders shall be fitted with retaining valves to safeguard against pipe fracture.

5.1.2 Cranes whose booms are held by luffing ropes shall be provided with stoppers for the upper end positions.

5.1.3 When a jib is in the stowed/lowest position, at least three safety turns shall remain on the rope drum.

5.2 Control stands and equipment

5.2.1 Control stands and controls shall be so designed and located that the crane driver has an unobstructed view of the load itself or at least of the person guiding him.

5.2.2 Control stands of cranes of type B shall be closed driver's cabins with adequate lighting, heating and ventilation. They shall be fitted with accident-proof window panes, sun shields, window wipers and protective grids.

5.2.3 The controls shall be marked to indicate their function. Movements of the controls shall be appropriately related to the corresponding crane movements.

5.3 Safety devices

5.3.1 Limit switches

5.3.1.1 Limit switches shall be provided on principle when the operator is unable to oversee the entire execution of the movement. This does not apply to those movements of the load for which there is visual communication with an observer.

5.3.1.2 The following end positions are to be controlled by limit switches:

- Highest hook position
- Lowest hook position
- Highest crane boom position
- Lowest crane boom position
- Ends of travel
- Limit of swinging range

5.3.1.3 Limit switches shall be so designed and positioned that their efficiency is not affected by the weather or by fouling. Movement in the opposite direction shall be possible following their response. Preferably, proximity switches should be used.

5.3.1.4 It should not be possible to overrun end positions, with the exception of the lowest crane boom position, should this be necessary for set-down. When the end position is overrun, the crane driver shall receive a continuous warning. Item 5.1.3 is to be observed.

5.3.1.5 Limit switches are to be located and adjusted in such a way that no damage can occur, even if they are approached at maximum speed and with full Safe Working Load (SWL). If necessary, pre-limit switches are to be used.

5.3.1.6 End position limitation for the highest crane boom position shall be such that after setting down of load, no damage can occur as a result of released luffing ropes.

5.3.1.7 If necessary, limit switches shall act on other movements in order to prevent damage. This can for example be necessary for the highest hook position in conjunction with the luffing of the crane boom.

5.3.1.8 In case of cranes with hydraulically operated hoisting gear, whose SWL does not exceed 1 t, the upper limit switch may be replaced by a relief valve or a slipping clutch. A prerequisite for this is a low hoisting speed, appropriate design of the upper hook stop and an adequate safety factor of the rope.

5.3.2 Emergency switches / keys

5.3.2.1 At the place of control or inside the cabin an emergency switch or emergency cut-out with mechanical locking device is to be provided. In case of hydraulic drives the emergency switch shall also act on the electric drive of the hydraulic pump.

5.3.2.2 Return to service shall be restricted to the zero position of the respective control elements or operating instruments.

5.3.3 Load radius-dependent SWLs

5.3.3.1 If cranes have different SWLs for different load radii:

- a jib angle indicator shall be fitted in cases where the angle of the boom can be adjusted only in the unloaded condition

- a load moment limiter shall be fitted in cases where the angle of the boom can be changed under load

5.3.3.2 Cranes of type B with load radius-dependent SWLs shall have a load radius diagram in the driver's cabin. The actual load radius shall be indicated continually visibly to the driver. If not the load radius but the boom inclination is indicated, an appropriate conversion table shall be provided.

5.3.4 Overload protection

5.3.4.1 Cranes and hoisting winches shall be so designed or pre-set that it is not possible to exceed the SWL by more than 10 % (exceptionally by 15 %).

5.3.4.2 Where the SWL of the crane varies with the load radius, the overload protection device shall adjust automatically to load radius changes.

5.3.4.3 In cases as in 5.3.4.2 the overload protection device shall act also on the luffing system of the crane, i.e. the load moment shall be limited.

5.3.4.4 After an overload protection device has responded, crane movements to reduce the load and/or load moment shall still be possible.

5.3.5 Control of slack rope

5.3.5.1 It is to be ensured by appropriate measures that either slack rope cannot develop or proper running of the wire rope onto the drum is still maintained.

5.3.5.2 In case that slack rope may occur it shall further be ensured that the hoist load coefficient on which the design is based may not be exceeded when lifting the load.

5.3.6 Warning devices

5.3.6.1 Outside the crane operator's cab, a signal horn is to be provided enabling the crane driver to issue audible warnings which shall be well perceptible within the operating range of the crane.

5.3.6.2 Mobile cranes should issue a visual and audible alarm when in motion.

5.3.7 Ship stability

5.3.7.1 Where the safe operation of cranes requires the simultaneous operation of a system for limiting the heel or trim, this system shall either function automatically or shall be so installed that its operator cancleарly oversee the motions of all deck cranes.

5.3.7.2 Devices shall be fitted, or operation instructions provided, to allow the accident-proof transmission of instructions from a supervisor to the crane driver.

Operating instructions shall be enclosed with the rigging plans.

5.4 Miscellaneous

5.4.1 It is recommended that in the event of a failure of the drive power, it shall be possible to set down the suspended load without danger.

5.4.2 Devices enabling the slewing or hoisting mechanisms to be disconnected, are not permitted.

5.4.3 All cranes shall have a data plate containing at least the following details:

- Manufacturer or supplier
- Year of construction
- Serial number
- Type (if a type designation exists)

5.4.4 A plate prohibiting access to unauthorised members of the crew shall be fitted at each crane.

5.5 Operating instructions

5.5.1 Each crane shall be permanently and clearly marked with the different permitted SWLs and the min. and max. load radii.

5.5.2 Any special working conditions, restrictions or operating instructions are to be included in the rigging plans or attached to these.

5.5.3 Provision shall be made to ensure that when the designated limit weather conditions (seaway, wind) occur, the crane is securely lashed and/or refuge is sought in sheltered waters.

6. Foundations

6.1 General

6.1.1 Foundations, crane pedestals and also boom stowages are regarded as being part of the ship's classification if they are firmly welded to the hull.

6.1.2 For the use of high-strength bolts for slew ring bolting, the requirements of the TL Rules Chapter 50- Guidelines for the Construction and Survey of Lifting Appliances, Section 2, E.5. are to be observed.

6.1.3 For proof of fatigue strength, crane founda tions/pedestals shall be categorized in the same stress group as the associated crane.

6.2 Crane foundations

6.2.1 Foundations shall be dimensioned adequately for the conditions "crane in operation" and "crane out of operation". For boom stowages, the condition "crane out of operation" is the decisive one.

6.2.2 Wherever bending moments have to be transmitted and the constraint does not extend over two decks of the ship, foundations and boom stowages shall be so fixed to the connecting deck and the associated stiffening arrangements that the stresses can be accepted and transmitted safely.

6.2.3 Doubling plates underneath foundations and boom stowages are permitted only for the transmission of compression forces.

6.2.4 If high-strength pre-stressed bolts of the strength group 10.9 and 12.9 are used, constraint may be taken into consideration for the dimensioning of flanges at the location of bolts.

6.3 Crane pedestals

Cylindrical and rectangular crane pedestals are to be dimensioned according to the TL Rules Chapter 50 - Guidelines for the Construction and Survey of Lifting Appliances, Section 4, F.3.

The headroom of accesses shall be at least 2 m, the clear width at least 0,6 m. The clear height of an opening may be reduced by a sill of up to 0,6 m in height.

6.4 Connection to the hull

6.4.1 Wherever possible, crane pedestals should be fixed to the hull over a full deck height; if necessary, e.g. in the case of crane pedestals located at the ship's side, even to a greater depth to the structure of the ship.

6.4.2 Crane pedestals which by virtue of their location act as stiffness-discontinuities in the longitudinal structure of the ship, such as crane pedestals at the sides, are to have suitable taper brackets fitted along the longitudinal walls.

7. Testing and examination

7.1 Supervision of construction

7.1.1 The basis for the supervision of construction and final test and examination at the manufacturers is the approved documentation, plus additional documentation, reports, certificates, etc. which the TL Surveyor needs for assessment of the parts to be examined or tested.

7.1.2 Commencement of construction is to be announced to the respective TL Inspection Office in sufficient time for a TL Surveyor to attend the construction process from the very beginning.

7.1.3 Final testing and examination at the manufacturers is required even if the lifting appliance is not assembled completely there. New-design lifting appliances or the first crane in every delivery shall undergo a test run in the presence of the TL Surveyor according to a programme approved by TL.

7.2 Initial test and examination

7.2.1 Prior to being put into use testing and examination at the place of operation aboard is required, conducted resp. supervised by the TL Surveyor. All tests have to be executed with power from the ship's own power supply system.

7.2.2 A function test serves to provide proof of the working order of all components, installation systems and safety devices. The test procedure is left to the TL Surveyor's discretion.

The function test furthermore serves to verify whether parts of the ship's structure or the ship's equipment restrict the working range or impede the working process. No certificate will be issued for this test.

7.2.3 The function test carried out for the TL Surveyor normally does not serve to check whether all the possible operations wanted by the owner can be effected. Proof of this is the responsibility of the manufacturer or supplier.

7.2.4 With the exception of the test of the overload protection devices, the function test may be carried out with any given load.

7.2.5 Each lifting appliance with a defined SWL shall undergo a load test with weights prior to being put into use at the place of operation. For shipborne cranes their foundations shall be included in the test. The size of the test load shall be taken from Table 3.3.

Table 3.3 Test loads

Shipborne lifting appliances **(1)**	
SWL	Test load (PL_{dyn})
up to 20 t	SWL **+** 25%
20 t up to 50 t	SWL **+** 5 t
over 50 t	SWL **+** 10%
(1) *According to international ILO regulations*	

7.3 Periodic tests and examination

7.3.1 Lifting appliances subject to continuous supervision by TL shall at regular intervals be thoroughly examined by a TL Surveyor and subjected to load tests in his presence.

7.3.2 The following due dates for examinations are stipulated:

- Annual thorough examination
- Quinquennial thorough examination, load testing
- Thorough examination after damage and/or re-pair with load testing after repair of load bearing parts

7.4 Further details

A detailed description of supervision of construction, tests and examinations is given in Section 13 of the TL Rules defined in A. 1.4.

C. Rope and Chain Hoists

1. General

1.1 The requirements herein apply to rope and chain hoists in series production.

1.2 For individual or special production rope and chain hoists the requirements defined in B. have to be applied in analogous manner.

1.3 A plan approval is required on principle. If a type test certificate from a recognised institution is available, the examination of drawings may be omitted.

2. Construction notes

2.1 Rope and chain hoists used for handling cargo shall have upper and lower limit switches for the cargo hook. The control circuits of these limit switches shall be designed on the closed-circuit current principle or shall be self regulating. Any failure of such a control circuit is to be indicated visibly and audibly.

2.2 For rope and chain hoists up to a SWL of 6 t the upper limit switch may be replaced by a slipping clutch provided these appliances do not handle cargo.

2.3 The electrical protection class for use below deck shall be at least IP 54. The protection class for use on deck shall be at least IP 56, under certain circumstances even IP 66.

3. Acceptance test on the manufacturer's premises

3.1 An acceptance test on the manufacturer's premises in accordance with B.7.1 is required on principle.

3.2 If a type test certificate from a recognised institution is available, or if a type test has been carried out by TL, the acceptance test may be omitted.

4. Examinations and tests on board

The initial and periodic tests and examinations on board have to be carried out in analogous form as defined in B.7.

D. Lifting Eyes

1. General

1.1 Lifting eyes as integral part of lifting appliances

Lifting eyes which form an integral part of lifting appliances have to be designed as described in the following and have to be approved together with the lifting appliance to which they belong.

1.2 Lifting eyes for various duties

Lifting eyes shall be provided on board of naval ships for assistance in installation, operation, maintenance and rescue. Lifting eyes and their substructures need special plan approval.

2. Design

Normal size, design and welding are defined in the TL Rules Chapter 50 - Guidelines for the Construction and Survey of Lifting Appliances. If lifting eyes are connected to the ship's structure sufficient substructures considering the safe working load (SWL) of the lifting eye are required.

A lifting eye plan has to be provided which shall contain the exact location on the ship, a consecutive number and the safe working load (SWL) for all lifting eyes on board.

3. Approval

3.1 For approval a successful plan approval and a visual check of the finally installed lifting eyes is basically required.

3.2 For lifting eyes according to 1.1, the approval procedure of the lifting appliance has to be followed before putting into operation.

3.3 For lifting eyes according to 1.2 additional checks, such as non-destructive testing of welding seams and load tests may be requested by the Naval Authority before putting into operation. Load tests are to be performed as static tests (at least for a duration of 5 minutes) according to the requirements of Table 7.4 of the TL Rules defined in 2. and have to be documented on TL Form 208.

Following these load tests the lifting eyes and their welding connections have to undergo a visual inspect-tion.

3.4 After the tests according to 3.2 and 3.3 and if the lifting eyes are free of visible defects they have to be stamped as defined in TL Form 208. This stamping shall include consecutive number and SWL of the lifting eye as well as TL's anchor stamp: TL. Instead of stamping the lifting eye itself, the stamping may be durably engraved on a suitable, clearly visible plate fixed in the vicinity of the lifting eye.

4. Surveys

4.1 Lifting eyes according to 1.1 have to undergo periodical visual checks and load tests as defined for the lifting appliance to which they belong, see B.7.3.

4.2 Lifting eyes according to 1.2, as far as they are accessible, have to undergo visual random checks and, if required by the Naval Authority, also load tests at the occasion of the periodical Class Surveys of the naval ship, see Chapter 101 - Classification and Surveys, Section 3.

E. Lifts

1. General

1.1 The classification according to A.1. includes checking the structure of the ship's hull in way of the forces transmitted by lifts as well as checking for weather tightness and structural fire protection.

2. Types of lifts

On board of naval ships normally three types of lifts can be expected:

2.1 Passenger lifts

Passenger lifts are designated to transport crew members or embarked troops. Escape measures as laid down in ISO 8383 for crew members have to be provided.

2.2 Goods lifts

This type of lift will be used for transporting military supplies in big naval ships, vehicles in amphibious warfare ships and aircraft in large ships for aircraft operations.

2.3 Service lifts

Service lifts, e.g. for transport of provisions, food from the galley to messes, etc., are not accessible to persons and exclusively designated to carry goods. To meet the requirement of not being accessible the following dimensions are to be observed:

- car floor area ≤ 1,0 m^2
- depth ≤ 1,0 m
- height ≤ 1,2 m (for each compartment if several are used above each other)

3. Applied rules and standards

3.1 TL approval

Lifts onboard are subject to the following standards:

- EN 81, Part 1 for electric lifts
- EN 81, Part 2 for hydraulic lifts
- EN 81, Part 3 for service lifts

In addition to these standards, the ship specific peculiarities according to Section 5, D. of the TL Rules defined in A. 1.4 have to be considered.

3.2 National regulations

For lifts on board national regulations apply with priority. If lifts are not covered by such regulations the rules and standards defined in 3.1 apply. However for the ship specific peculiarities the requirements according to Section 5, D. of the TL Rules defined in A. 1.4 shall be complied with.

3.3 Special requirements for vibration and shock

To withstand vibration and shock loads and to prove this to TL, the following requirements have to be met:

- the loads defined by the Naval Authority in the building specification have to be observed
- safety relevant components shall be vibration and shock tested and the test documents have to be submitted
- withstanding shock loads on the lift system has to be proven by calculations
- the necessity of special storage at an end position in non-operation mode has to be considered

4. Tests and examinations

4.1 Before taking newly constructed lifts into use and after significant modifications, a test and thorough examination is required. Initial tests and examinations always require a preceding plan approval by TL Head Office.

4.2 For passenger lifts at intervals of no more than 2,5 years, a thorough examination by a TL expert is required together with a series of tests. Additionally the attendance of a mechanic from the manufacturer of the lift or the lift maintenance firm is required for this. A survey report will be issued by the attending TL Surveyor and each report shall be filed in the lift register book.

4.3 For passenger lifts at intervals of 1 to 2 years an intermediate examination shall be conducted by a TL Surveyor.

4.4 For goods and service lifts at intervals of no more than five years, a thorough examination by a TL expert is required together with a series of tests. A survey report will be issued by the attending TL Surveyor and each report shall be filed in the lift register book.

4.5 For goods and service lifts an intermediate examination at intervals of no more than 2,5 years has to be conducted by a TL Surveyor.

4.6 The detailed guidelines for tests and examinations are given in the standards EN81 and the Rules Chapter 50 - Guidelines for the Construction and Survey of Lifting Appliances, Section 5, F.

4.7 If there are national regulations for tests and examinations which require different or more procedures, these have to be applied with priority.

F. Requirements for Transport of Ammunition

1. General

1.1 The complete transport system for ammunition, missiles, mines, etc. and its components shall be designed in a way that embarkation/delivery and internal transport are not disturbing the normal ship operation.

1.2 Safety has to be considered carefully in relation to ship and crew. Safety measures have to be taken to avoid damage to the ammunition and transport system as well as to avoid injuries to the personnel operating the system. Obstacles along the transport ways are not permitted.

1.3 Every lifting appliance has to be designed to guarantee sufficient space for movement during loading and unloading.

1.4 The standard profiles and the weights of ammunition, missiles, torpedoes and mines have to be defined by the Naval Authority. Also the maximum inclinations and accelerations allowed for the operation of the transport system have to be defined.

2. Ammunition cranes and transport devices

Ammunition cranes have to meet the requirements of B. and have to be provided with high reliability and safety standards, which are to be defined by the Naval Authority in the building specification.

To secure supply of ammunition even in difficult combat situations an emergency operation mode might be recommendable, which bridges safety measures being prescribed for normal operation. In this case only specially trained personnel has to be allowed to operate the crane or transport device.

3. Ammunition lifts

3.1 The loading of ammunition storage rooms is mainly done by lifts. The hatches in the different decks have therefore to be positioned vertically above each other to minimize the distance from the open deck to the storage. Lifts for supplying the turrets from the storage spaces may be part of the weapon system and are not included in the considerations of this Section.

3.2 The input and output positions at the lifts have to be equipped with steel doors. Whether or not these doors have to be watertight and/or gastight is to be decided on the requirements defined in Chapter 102 -Hull Structures and Ship Equipment, Section 9, B. For details of the lift construction see D.

3.3 Similar as for cranes a combat emergency operation mode might be recommendable, which bridges the usual safety measures. The operation has then to be done only by specially trained personnel.

4. Horizontal transport

4.1 The horizontal transport systems have to be provided with load guides allowing oscillation-free movements. At the loading/unloading stations manipulating tables have to be provided to ensure a Safe ammunition handling.

4.2 Movable transport devices have to be stowed safely near their place of use but in any case outside the ammunition rooms.

5. Tests and examinations

5.1 The essential drawings have to be submitted to TL and the manufacturing process may only start after final approval by TL.

5.2 The manufacturing process will be closely followed by a TL Surveyor and intermediate examinations will be performed.

5.3 Extensive tests will be executed after completion at the manufacturer's premises and on board. The detailed type and scope of the tests will be agreed case by case on the basis of a test program prepared by the manufacturer.

G. Ramps

1. General

1.1 The following requirements apply to movable shipborne vehicle ramps moved and/or used for loading/unloading in calm water.

1.2 In addition to 1.1 ramps as well as their seatings or locks must also be adequately dimensioned for the condition "ship in a seaway" i.e. for acceleration forces according to TL Regulations defined in A. 1.4.

1.3 As regards naval-architectural concerns such as ship's strength, watertightness, stressing by sea impact, etc. the requirements in Chapter 102 -Hull Structures and Ship Equipment apply.

1.4 All data relevant to dimensioning, such as deadweights, location of centres of gravity, end positions, methods of actuating, permissible loads, operating conditions, etc. are to be submitted for examination together with the drawings and calculations.

1.5 The loading conditions shall be laid down precisely and considered in the strength calculations.

1.5.1 Where ramps are in the working position, moving loads shall be multiplied by the factor 1,2.

1.5.2 Where ramps are moving, the live loads and/

or the dead loads shall be multiplied by the factor 1,1.

2. Construction notes

2.1 Ramps shall not hang from ropes, neither when operating nor in the stowed position.

2.2 The inclination of the ramp should in general not exceed the ratio 1:10.

2.3 The dimensions of locking devices shall match the forces arising and shall guarantee the water-tightness of the hull if the ramp acts as external hull closure.

2.4 Ramps shall be provided with welded-on or bolted-on anti-slip safeguards. Anti-slip paint may in special cases be permitted in lieu thereof.

2.5 Ramps and ramp deck openings shall have scratch boards and railings. The boundary conditions of movable railings, barriers, etc. (colour markings, photoelectric barriers, warning signals) shall in each individual case be clarified with the TL Head Office as regards their extent and need.

2.6 Ramps shall have a notice affixed durably and easily visible and showing the permissible load (SWL).

3. Dimensioning

3.1 The loads on ramps caused by vehicles and transported goods can be taken as for internal decks defined in Chapter 102 - Hull Structures and Ship Equipment, Section 5, F.

The dimensioning has to be based on the safety factors for dead and live loads defined in Table 3.4.

3.2 In general, the permissible deflection for ramps in working position shall not exceed the following:

$$f = \ell / 200$$

f = deflection

ℓ = spacing of supports

In the stowed position the deflection may not endanger neither the watertightness of the ship nor any vehicles underneath.

Table 3.4 Safety factors for calculation

Position of ramp	Dead loads	Live loads	Additional forces
Working condition	1,0	1,2	Static inclinations of at least ± 5° athwartships and ± 2° fore and aft if not otherwise defined by the Naval Authority
Ramp moving	1,1	1,1	
Stowed position	1,0	1,0	Dynamic forces due to ship motion acc. to Chapter 102 - Hull Structures and Ship Equipment, Section 5, B.

3.3 The calculations for the dimensioning of the ramp plating are prescribed in the TL Rules Chapter 50-Guidelines for the Construction and Survey of Lifting Appliances, Section 6, D.2.

4. Examination and testing

4.1 The essential drawings have to be submitted to TL and the manufacturing process may only start after final approval by TL.

4.2 The manufacturing process shall be closely followed by a TL Surveyor and intermediate examinations will be performed.

4.3 Tests with live loads shall be executed after completion on board. The detailed type and scope of the tests will be agreed case by case on the basis of a test program prepared by the manufacturer.

SECTION 4

EQUIPMENT FOR REPLENISHMENT AT SEA

A. General

1. Scope

If the requirements of this Section are met, the notation **RAS** will be assigned to a supplying as well as to a receiving ship, see Chapter 101 - Classification and Surveys, Section 2, C.

2. Other Rules

This Section is based on the TL Rules Chapter 50 - Guidelines for the Construction and Survey of Lifting Appliances, as amended. All aspects not defined there shall be treated in accordance with this Section.

Note

For ships of NATO nations reference is made to publication ATP 16(D)/ MTP16(D): "Replenishment at Sea".

3. Documents to be submitted for approval

3.1 The documents listed below will be examined by TL. TL may ask for additional documents or calculations, if needed for approval. They have to be submitted at least in triplicate in pursuable condition for examination of the:

3.2 Arrangement

- Definition of operational requirements
- Overall arrangement of the system
- Description of the overall function
- Rigging plans

3.3 Supporting structural parts

- Shop drawings for the masts, posts, derrick booms
- Foundations of all kinds including counter points at the ships to be supplied
- Strength calculations
- Welding and testing plans

3.4 Operating gear

- Details of ropes, rope-end connections, rope sheaves
- Sectional and assembly drawings with parts list of lifting winches and hydraulic systems, if any
- Design calculations
- Data sheets with standard construction components

3.5 Electrical installation

- Description of function with list of elements
- Details of the rated characteristics and types of enclosures of the drive motors employed
- Wiring diagrams, cable listing, verification of cable design
- Details of all safety devices including alarms, etc.
- Control equipment

3.6 Operating manual

All operation procedures and safety precautions have to be summarized in an operating manual.

B. Systems for Transfer of Personnel and Dry Goods

1. General

1.1 Safety precautions

1.1.1 A good communication has to be established from bridge to bridge and from transfer station to transfer station by telephone lines between the ships. In addition hand and flag signals shall be available. The responsibilities have to be clearly defined.

1.1.2 It is recommended to use a distance line during all abeam replenishment at sea operations. This line shall be equipped with different signs for day operations respectively with different lamps for night operations which make the reached distance at any time clear for the personnel at the bridges.

1.1.3 All personnel assigned to replenishment operations has to be thoroughly instructed and shall wear safety clothes and equipment. Only essential personnel shall be admitted at a transfer station during replenishment.

1.1.4 Guardrails shall not be lowered unless absolutely necessary; if they are lowered, temporary life lines are to be rigged.

1.2 Emergency breakaway

During replenishment at sea an emergency breakaway, caused e.g. by loss of power, gyro compass or steering failure, enemy attack, etc. must be considered.

1.2.1 The objective is to disengage quickly without damaging the rigs or endangering personnel. During an ongoing personnel transfer the breakaway can only be started if the person in transition has safely reached the receiving ship.

1.2.2 Emergency tools, like axes, hammers, pliers, marlinespikes, wire rope cutters shall be kept ready at the transfer stations.

1.2.3 On the winches used for replenishment at sea the wire rope ends shall be secured to the winch drum by only one wire rope clip or specially designed clamp or by a hemp tail line that itself is secured to the barrel.

In case of power loss winches shall be controlled by the brakes and wires slacked off (paid off) by use of the brakes. Extreme care should be exercised when trailing wires are in the water.

1.2.4 A tensioned wire rope shall not be released or cut. If excessive tension develops, the crews of both ships have to clear the replenishment areas.

2. High line system

2.1 Arrangement

This system is suitable for the board to board transfer of persons and dry goods up to a nominal lifting capacity of abt. 300 kg, see Fig. 4.1. As no special winches are used the transfer capacity is limited.

2.2 System elements

The system shall contain the following main elements:

- Manila high line as support line for the traveller block, to be operated manually on board of the supplying ship
- Release hook of the support line at the counter point on the receiving ship
- Traveller block running on the support line for a chair to transfer one/two persons (the chair should have eye-catching paintwork, the person must be protected against dropping out during travelling) or rigged litter for a wounded/ill person or for light cargo, like mail, etc.
- Manila line for hauling out to be operated manually onboard of the receiving ship
- Manila line for hauling in to be operated manually onboard of the supplying ship

Further details are contained in Table 4.1 and Fig. 4.1.

Table 4.1 Equipment for high line transfer system

Pos.	Designation of Equipment	Number		Remarks
		Supplying ship	Receiving ship	
1	Support line	1		32 mm dia / 300 kg SWL
2	Eye plate for support line	2	1	
3	Release hook	-	1	
4	Support line block	2	-	
5	Traveller block running on support line	1		
6	Connecting shackle system	1		
7	Wire preventer	1		
8a/b	Transfer at sea chair or rigged litter	1		alternatively
9	Outhaul line	-	1	16 mm dia, braided
10	Inhaul line	1	-	16 mm dia, braided
11	Eye plate for haul line block	2	2	
12	Haul line block	2	2	

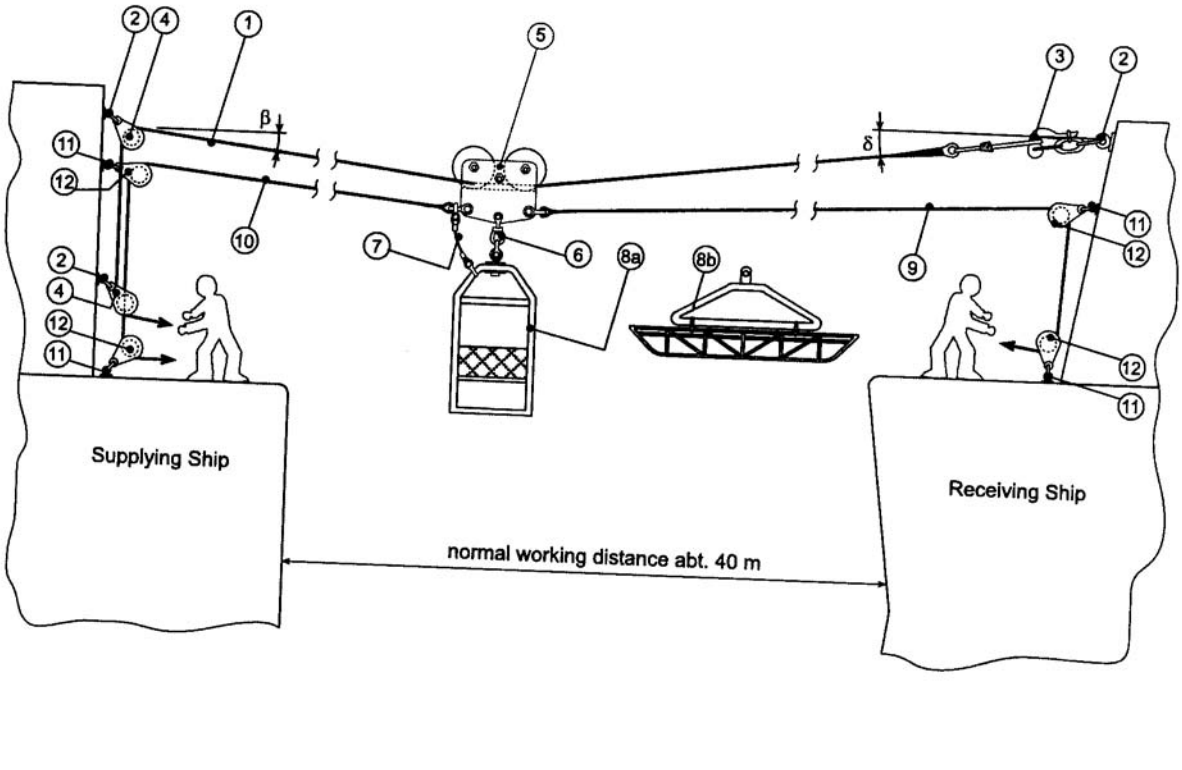


Figure 4.1 High line transfer system for personnel transport and dry cargo of limited size

2.3 Operation control

Operation to be carried out manually only by specially trained crews on both ships.

3. Wire high line system

3.1 Arrangement

For this type in principle the same arrangement is used as for the high line system, but using a derrick boom at the supplying ship and winches for line handling, see Fig. 4.2. Therefore the nominal lifting capacity can be increased to abt. 1000 - 2000 kg.

3.2 System elements

The system shall contain the following main elements:

- Wire high line as support line for the traveller block running from the top of a derrick boom at the supplying ship to the counter point at the receiving ship

- Pallets for material transport

- Support line winch for automatic constant tension at the supplying ship to keep the supporting high line in right tension even, if the working distance of the ships is varying

- Wire lines for hauling in and out with an auxiliary winch at the supplying ship and a windlass/capstan at the receiving ship

- Cargo drop reel at the hook of the traveller block to avoid coordinated tightening and releasing of the lines

Further details are contained in Fig. 4.2 and in Table 4.2.

4. Fast automatic shuttle transfer system

4.1 Arrangement

Where a FAST (Fast Automatic Shuttle Transfer) system is installed, the arrangement has to be designed according to Fig. 4.3 and shall contain the following main elements:

- M-frames or posts with mechanically lifted or lowered sliding padeyes on both ships

- Hydraulic/pneumatic suspension cylinder/tensioning device to avoid load peaks on the support line

- High line as support line, which is always kept under constant tension by a special winch

- Wire lines for hauling in and out the traveller block operated by hauling winches

Further details are contained in Fig. 4.3 and Table 4.3.

4.2 Operation control

4.2.1 The system is to be operated from a central control stand at the supplying ship which oversees the complete operation. The standard procedure of material transfer shall follow an electronic data processing program (EDP) initiated from the supplying ship. If this program fails, manually controlled operation must be possible.

4.2.2 All movements of sliding blocks, cylinders, etc. have to be controlled by limit and emergency limit switches. The automated main and auxiliary winches have to be equipped with overload protections to safely avoid rope breaking.

4.2.3 If the main electrical supply systems of the ships fail, the brake feeding shall be automatically switched to emergency power supply or battery feeding. In addition it must be possible to open and close the brakes of main and auxiliary winches manually in a controlled way.

4.2.4 All controls and electronic equipment shall be concentrated in an extra replenishment control room which is properly ventilated and heated.

Table 4.2 Equipment for wire high line transfer system

Pos.	Designation of Equipment	Number		Remarks
		Supplying ship	Receiving ship	
1	Support line	1		1000-2000 kg SWL
2	Eye plate for support line block	2	1	
3	Release hook	-	1	
4	Support line block	2	-	
5	Support line winch (constant tension)	1	-	
6	Traveller block	1		
7	Hook system	1		
8	Outhaul line	-	1	
9	Inhaul line	1	-	
10	Eye plate for haul line block	2	2	
11	Haul line block	2	2	
12	Haul line windlass	1	-	
13	Capstan / winch for inhaul	-	1	
14	Derrick mast	1	-	
15	Derrick boom	1	-	
16	Span tackle	1	-	
17	Span line shackle	1	-	
18	Lower span tackle block	1	-	
19	Upper span tackle block	1	-	
20	Span bearing	2	-	
21	Lead block	1	-	
22	Span winch	1	-	

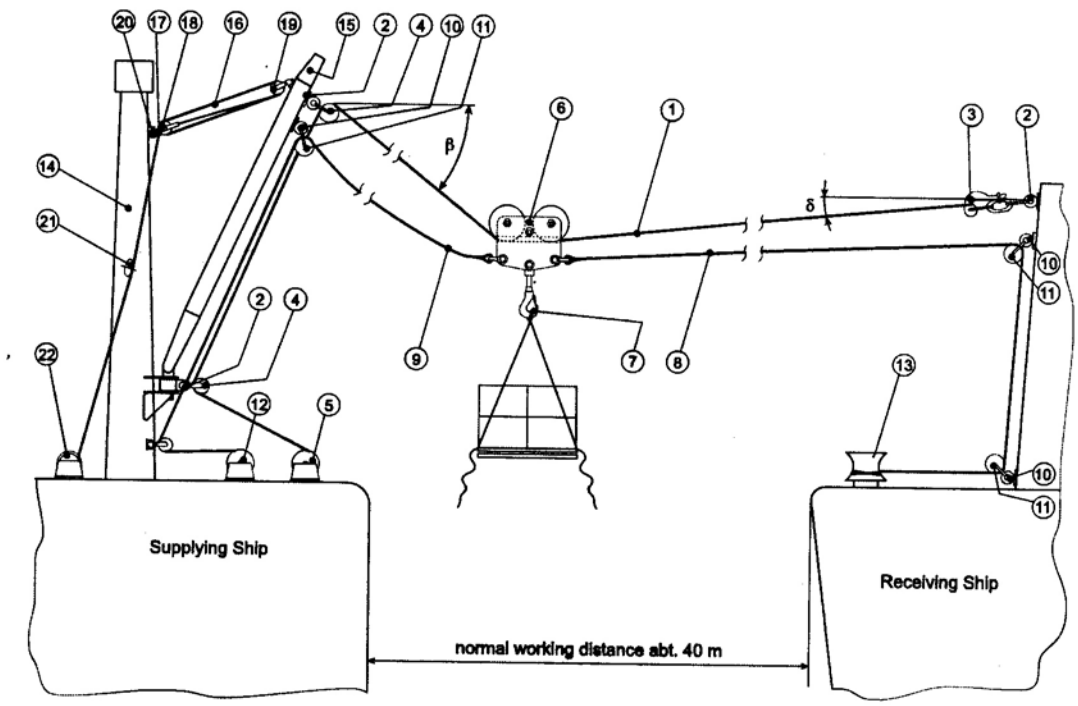


Figure 4.2 Wire high line transfer system for dry cargo

Table 4.3 Equipment for FAST system

Pos.	Designation of Equipment	Number		Remarks
		Supplying ship	Receiving ship	
1	M-frame or RAS post	1	-	Up to 4000 kg SWL
2	RAS post	-	1	
3	Sliding padeye	1	1	
4	Padeye drive (chain drive)	1	1	Hydraulic or screw drive as option
5	Release hook	-	1	
6	Support line	1		
7	Eye plate for support line	1	1	
8	Support line block	1	-	
9	Tensioning device (hydraulic cylinder)	1	-	
10	Support line winch (constant tension)	1	-	
11	Traveller block running on support line	1		
12	Hook system	1		
13	Outhaul line	-	1	
14	Inhaul line	1	-	
15	Eye plate for outhaul line block	-	2	
16	Inhaul line / outhaul line block	1	2	
17	Eye plate for inhaul line block	1	-	
18	Haul line winch	1	1	
Alternative with only an outhaul line operated from the delivering ship:				
19	Travelling surf	1	-	
20	Release hook	-	1	
21	Surf hook	1	-	
22	Messenger line	1	-	

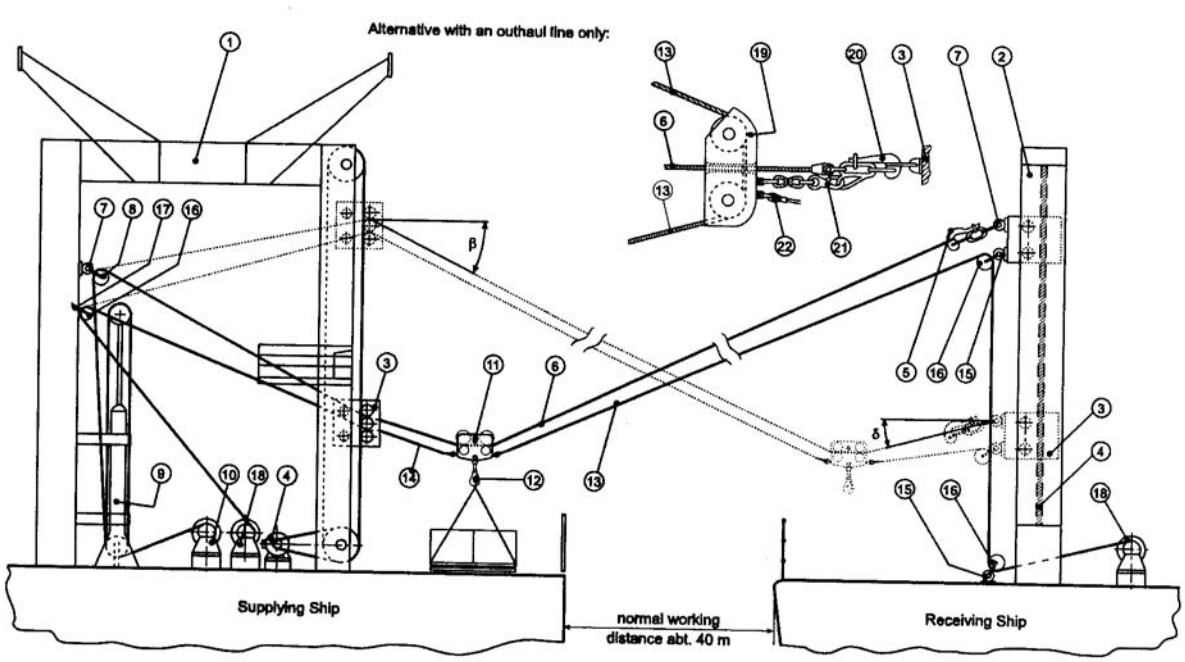


Figure 4.3 FAST system for dry cargo

Note:

If a shipyard installs or a Naval Authority operates a greater number of replenishment systems it is recommended to establish a testing station at a quay of the shipyard or at a naval base. This station shall be equipped with winches for simulating the counterpart of the ship to be tested. An EDP shall simulate the movements of the "ship ashore". This station can serve for the initial tests of a new system, but also to optimise tests after repairs or for the periodical surveys according to E.

C. Systems for Replenishment of Liquids from Board to Board

1. General

1.1 Safety precautions

In addition to the general safety precautions defined in B.1. the following precautions are mandatory during fuel replenishment:

1.1.1 No smoking is allowed during the replenishment operation. Adequate signs have to be installed at the operation stations.

1.1.2 All necessary fire fighting equipment must be stowed near the replenishment operation station.

1.1.3 All hose fittings, couplings and tools used for the replenishment of aviation fuel or other gasoline products shall be made of non-ferrous material.

1.1.4 A ground/earth wire must be rigged between the ships during aviation fuel and gasoline replenishment. It shall be connected before the hose is brought on board of the receiving ship and disconnected only after the hose is clear of the receiving ship.

1.2 Emergency breakaway

In addition to the general emergency breakaway requirements defined in B.1. the following requirements are recommended for fuel replenishment:

- the pumping system at the supplying ship shall be able to stop the liquid transfer immediately at the moment an emergency breakaway becomes apparent

- a breakable spool coupling which may be struck with a sledge hammer has to be provided at the receiving ship

1.3 Hose cleaning after liquid transfer

1.3.1 At the supplying ship installations have to be provided to remove the excess liquids from the hoses, avoid spillage to the sea and make the system ready for the next replenishment. The two following methods may be used.

1.3.2 Blowing the hoses through with air respectively with NO_2 or inert gas for gasoline hoses.

It must be ensured that at the end of the replenishment procedure the receiving ship has still enough volume in the tanks for the receipt of the additional fuel from the blow through. The necessary volume depends on the actual size of the replenishment installation.

Only a medium with a low pressure of not more than 6 kg/cm^2 is allowed to be injected into the hose.

1.3.3 For removing the liquid in the hose by back suction the pressure has to be limited by creating it by a venturi effect at the piping manifold of the supplying ship when the liquid is recycling through the manifold. If the whole residual liquid cannot be removed from the replenishment hoses by this method totally, back suction has to be combined with the blow through method according to 1.3.2.

2. Standard tension replenishment alongside method

2.1 Arrangement

The STREAM (Standard Tension Replenishment Alongside Method) system is a ram tensioned, span-wire rig for relatively large distances between the ships (from 25 m up to abt. 55 m) and up to three transfer hoses at one replenishment station, see Fig. 4.4.

2.2 System elements

The system shall contain the following main elements:

- A hose assembly which shall consist of easy to handle hose lengths with tight and secured couplings in between, flow-through saddles, riding line fittings and the male fuelling probe at the outside end

- High mast or post at the supplying ship to rig from there the high support line to a counterpoint with quick slipping device at the receiving ship

- Main winch with ram tensioner at the supplying ship to achieve constant pull of the support line

- Up to four traveller blocks on the support line

- Auxiliary winches with wire ropes for positioning and hauling in the traveller blocks

- Female receiver for the probe of the hose assembly and rigging devices for support line, messenger and riding lines at the receiving ship

Further details are contained in Fig. 4.4 and Table 4.4

2.3 Operation control

2.3.1 For liquid transfers the operation and control concept, which has to be submitted to TL, shall consider the following requirements:

- The number of revolutions of the delivery pump is to be controlled on the supplying ship

- Variation of supply pressure must be possible

- Automatic shut down of the liquid transfer at minimum revolutions of the pump to avoid lack of pump lubrication must be provided

- Automatic shut down of the liquid transfer is to be arranged for if suddenly the delivery pressure is dropping, e.g. resulting from a breaking of the transfer hose

- Automatic shut down of the liquid transfer at overpressure at the tanks of the receiving ship must be available

- Possibility for emergency shut down must be given

2.3.2 The tanks in the receiving ship are in general dimensioned for the relatively lowest pressure in the transfer system. Therefore it must be checked before the start of every liquid transfer that the ventilation pipes are open.

2.3.3 It is recommended to install a pressure measuring system with direct feed back to the shut down control of the system in the tanks to be filled.

2.3.4 Quick closing valves have to be installed on both ends of the transfer hose to minimize spillage to the sea in case of hose breaking.

2.3.5 At the supplying ship different pumps, piping systems, transfer hoses, etc. have to be provided for each type of liquid to avoid pollution of the liquids.

3. Large derrick system

3.1 Arrangement

If a normal working distance between the ships of abt. 37 to 43 m is required, the large derrick system according to Fig. 4.5 has to be used. For distances which are less and in the range of abt. 30 m the similar close-in method with less saddles according to Fig. 4.6 and Table 4.6 has to be applied.

3.2 System elements

The system shall contain the following main elements:

- A hose assembly which shall consist of easy to handle hose lengths with tight and secured couplings in between, flow through saddles, riding line fittings, securing adapters and shut-off valve with breakable spool coupling or probe coupling, male at the outside end

- High mast or M-frame with large derrick at the supplying ship to carry the major part of the hose to the receiving ship

- Lines and auxiliary winches for derrick movement

- Recovery line to the fore end of the hose with winch at the supplying ship

- Hose line from the fore end of the hose assembly to an auxiliary winch at the receiving ship

- Saddle lines to several saddles for hose support with winches

- Quick release coupling or probe coupling, female and rigging devices for messenger and hose line at the receiving ship

Further details are contained in Fig. 4.5 and Table 4.5.

3.3 Operation control

An operation control according to 2.3 has to be established.

D. Systems for Replenishment of Liquids via the Stern

1. Arrangement

For this system the receiving ship has to be positioned sidewards (abt. 12 m) aft of the stern of the supply ship (150 - 200 m depending on actual weather). The supplying ship has to put the hose with the liquid to be transferred via its stern to the sea. The floating hose may be taken on board of the receiving ship at the bow area, see Fig. 4.7, or at the stern, see Fig. 4.8.

2. System elements

For safe operation such a system shall contain the following main elements:

- Float assembly with spout type float and hose rig messenger connected to the outside end of the hose to establish the connection between the two ships

- Floating hose assembly with quick closing valves at both ends to minimise oil spillage in case of hose damage

- The couplings between the pipe systems of the ships and the floating hose must be kept free of pulling forces from the floating hose by pendants to mooring points on the ships

- Marker buoy with adequate wire line to define the position of the receiving ship in relation to the supplying ship. Thus it shall be guaranteed that the transfer hose forms always a loop and no towing forces are transferred to the floating hose.

Further details are contained in Fig. 4.7, 4.8 and in Table 4.8. All other precautions for the liquid transfer are the same as defined in C.

3. Loads

The loads acting on the system are mainly depending on:

- Maximum speed planned for replenishment

- Distance between the ships

- Volume of liquid to be transferred in a time unit

These parameters have to be defined by the Naval Authority.

Note

If no other loads are defined, the approximate values given in Table 4.7 may be used.

E. Approval and Testing

1. Tests during manufacturing

1.1 As a basis for approval and testing a complete set of documents as described in A. 3. has to be submitted to TL in due time before start of the manufacturing.

1.2 The manufacturing process has to be surveyed and confirmed in writing by TL Surveyors.

Table 4.4 Equipment for STREAM system

Pos.	Designation of equipment	Number		Remarks
		Supplying ship	Receiving ship	
1	M-frame or RAS post	1	-	
2	Hose assembly	1	-	
3	Probe receiver assembly	-	1	
4	Eye plate for support line	1	1	
5	Support line block or release hook	1	1	
6	Support line	1	-	
7	RAM tensioner	1	-	or only constant tension winch
8	Support line winch	1	-	
9	Free traveller block	2-3	-	
10	Traveller block for saddles	3	-	
11	Flow-through saddle	4	-	up to two further saddles below
12	Inhaul line	3	-	1 inhaul line for saddle 3 & 4
13	Block with anti-toppling device	1	-	
14	Inhaul line eye plate	4	-	
15	Inhaul line block	4	-	
16	Haul line winch	3	-	
17	Stress wire to outboard saddle	1	-	prevents hose from taking strain
18	Riding line including block & tackle	-	2-4	secures hose to receiving ship
19	Eye plate	-	2-4	for riding lines
20	Horn cleat	-	2-4	for riding lines
21	Hose messenger	1	-	for hose outhaul **(1)**
22	Ground / earth wire	1	-	for aviation fuel and gasoline **(1)**

(1) *not shown in Fig. 4.4*

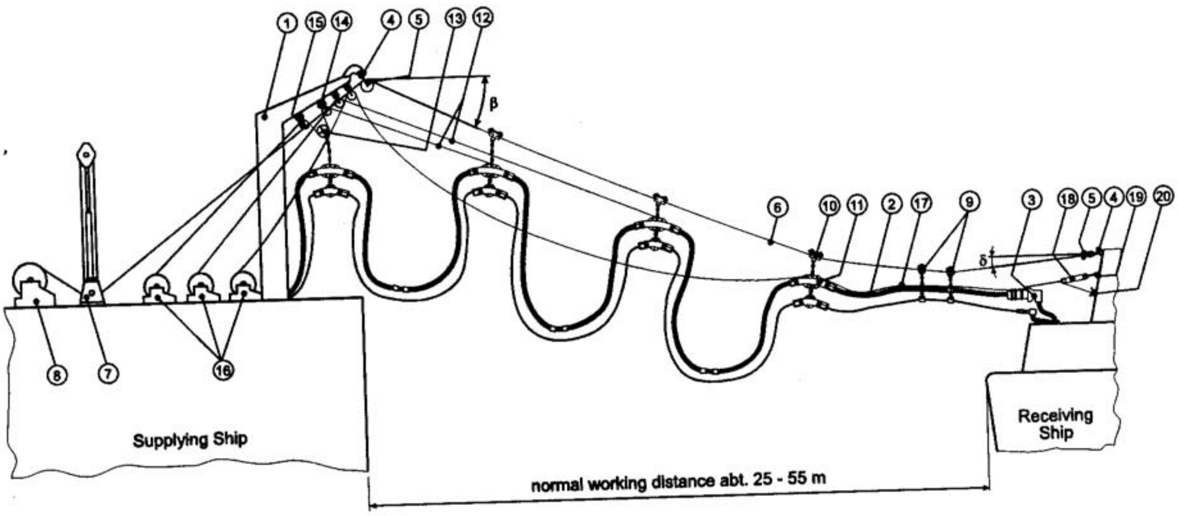


Figure 4.4 STREAM system for liquid transfer

Table 4.5 Equipment for large derrick system

Pos.	Designation of equipment	Number		Remarks
		Supplying ship	Receiving ship	
1	M-frame or high mast	1	-	
2	Large derrick	1	-	
3	Span tackle	1 - 3	-	Derrick movement & position
4	Span winch	1 - 3		
5	Hose assembly	1	-	
6	Quick release or probe coupling	-	1	
7	Recovery line	1	-	For hose inhaul
8	Eyeplate for recovery line block	2	-	
9	Recovery line block	2	-	
10	Recovery line winch	1	-	
11	Saddle line	3	-	
12	Lead block for saddle line	3 - 6	-	
13	Saddle line block	3 - 6	-	
14	Saddle line winch	3	-	
15	Saddle Line tackle block	1	-	
16	Hose line	-	1	
17	Eyeplate for hose line	-	1 - 2	
18	Release hook for hose line	-	1	
19	Hose line block	-	1 - 2	
20	Hose line winch	-	1	
21	Hose messenger	1	-	for hose outhaul **(1)**
22	Ground / earth wire	1	-	for aviation fuel and gasoline **(1)**
(1) *not shown in Fig. 4.5*				

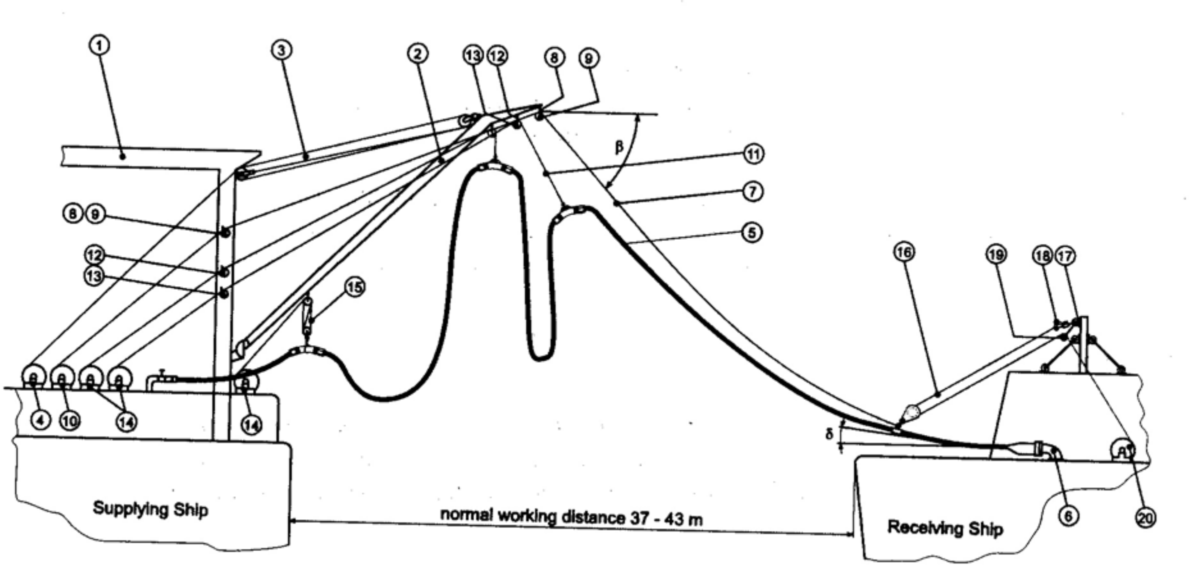


Figure 4.5 Large derrick system for liquid transfer

Table 4.6 Equipment for close-in system

Pos.	Designation of equipment	Number		Remarks
		Supplying ship	Receiving ship	
1	M-frame or high mast	1	-	
2	Small derrick	1	-	
3	Span tackle / guy tackles	1 -3	-	Derrick movement & position
4	Span winch / guy winches	1 -3		
5	Hose assembly	1	-	
6	Quick release or probe coupling	-	1	
7	Recovery line	1	-	For hose inhaul
8	Recovery line eye plate	1	-	
9	Recovery line block	1	-	
10	Recovery line winch	1	-	
11	Saddle line	2	-	
12	Saddle line link	2-4	-	
13	Saddle line tackle block	1	-	
14	Saddle line block	2-4	-	
15	Saddle line winch	2	-	
16	Hose line	-	1	
17	Hose line eye plate	-	1 -2	
18	Release hook for hose line	-	1	
19	Hose line block	-	1 -2	
20	Hose line winch	-	1	
21	Hose messenger	1	-	for hose outhaul **(1)**
22	Ground / earth wire	1	-	for aviation fuel and gasoline **(1)**
(1) *not shown in Fig. 4.6*				

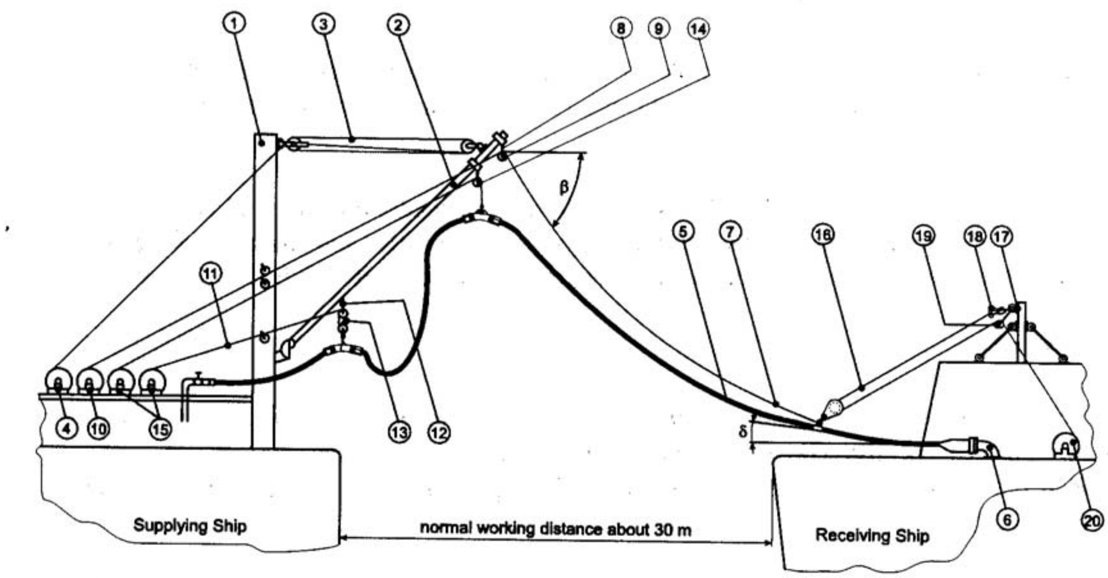


Figure 4.6 Close-in system for liquid transfer

Table* 4.7 *Approximate loads for liquid transfer via the stern

Diameter of floating hose [mm]	*Load on supplying ship [kN]*	*Load on receiving ship [kN]*
DN65	*32*	*32*
DN 150	*50*	*50*

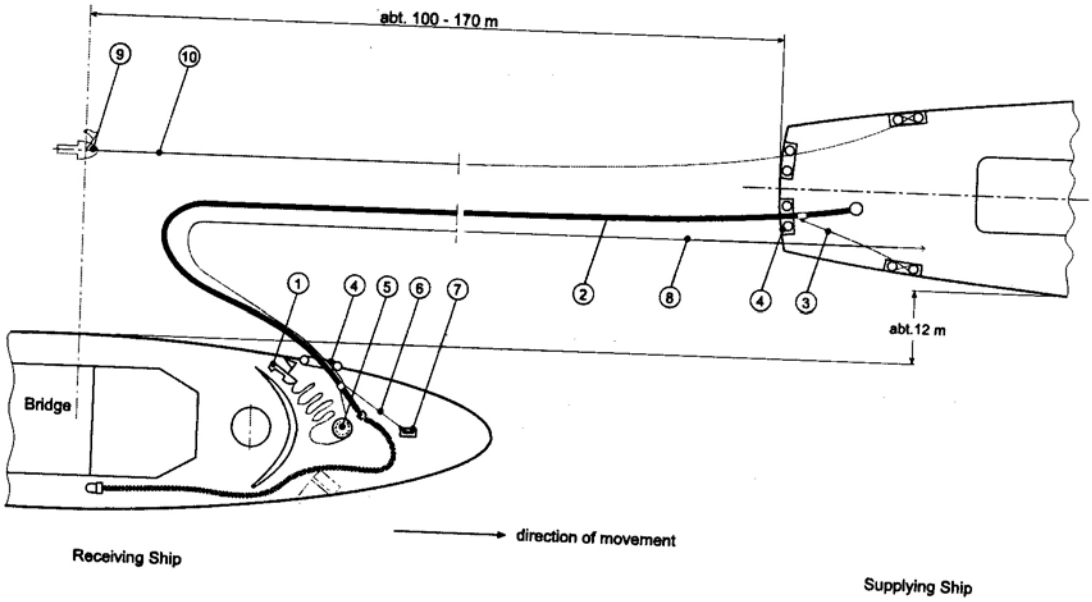


Figure 4.7 Stern /bow system for liquid transfer

1.3 All accessories, like chains, blocks, shackles of the RAS system have to be tested with a static load of 2,0 x nominal load and certified by a TL Surveyor.

1.4 Load bearing ropes and wires need a test certificate for being pulled to destruction. Support ropes used for personnel transport shall be of 3.1. C type, all other wire ropes of 3.1.B type according to DIN EN 10204.

1.5 Hydraulic cylinders, pumps and motors are to be subjected to function and pressure tests in the presence of the TL Surveyor. The test pressure amounts to 1.5 times the maximum operating pressure p_{max}, but in case of operating pressures above 200 bar it need not be more than p_{max} + 100 bar.

1.6 For the finished winches an inspection has to be carried out including especially:

- Visual inspection
- Idle running test
- Test and adjustment of brakes
- Functional test as far as possible
- Static overload test with 2,0 x nominal holding capacity

2. Initial tests of the equipment ready for operation on board

2.1 Tests before being taken into use

These tests have to be carried out by the manufacturer, with the equipment installed completely aboard, in presence of TL. Adequate test installations shall be available to carry out all tests.

A test program and the operation manuals have to be submitted to TL for approval.

Prior to the main tests the manufacturer has to test the electrical equipment according to IEC 60364, Part 610 resp. to VDE 0100, Part 610.

Table 4.8 Equipment for replenishment via the stern

Pos.	Designation of Equipment	Number		Remarks
		Supplying ship	Receiving ship	
1	Float assembly	1	-	Spout-type float & messenger
2	Hose assembly	1	-	Float assistance by air filling
3	Pendant for hose-assembly	2	-	
4	Roller fairlead	1	1	
5	Capstan or auxiliary winch	1	1	
6	Connecting pendant	-	1	Including safety hook
7	Eyeplate for pendant	-	1	
8	Recovery line	1	-	
9	Marker buoy	1	-	
10	Marker buoy line	1	-	

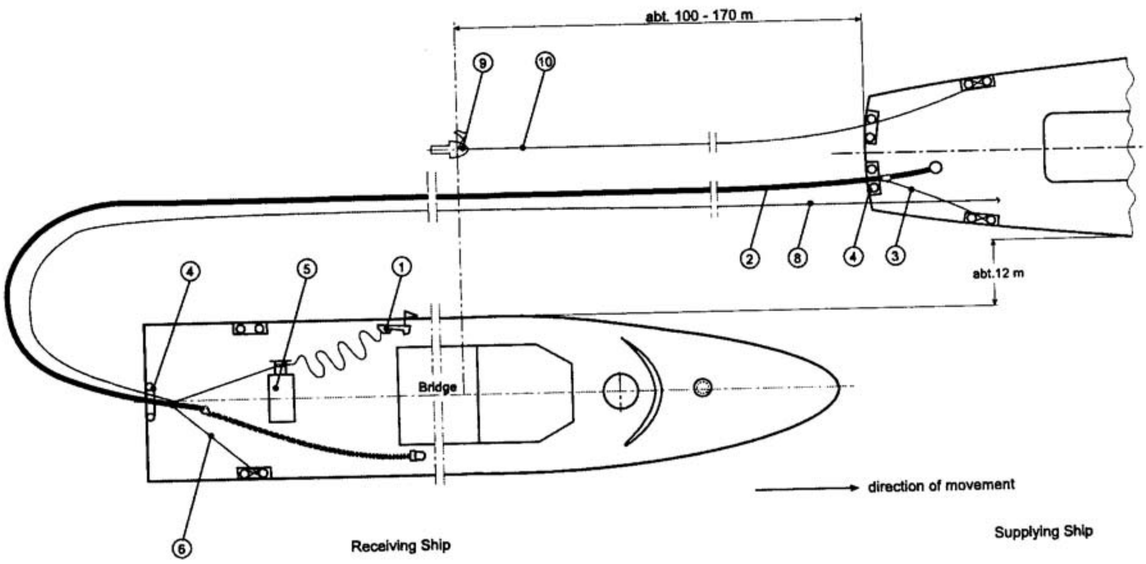


Figure 4.8 Stern/stern system for liquid transfer

2.2 Visual check

Before and after the function and overload tests the complete system shall undergo a visual check. All wire ropes have to be rigged in their planned position.

2.3 Static overload test

About 10 % up to 20 % of all counter points of the RAS system shall be tested with 2 x nominal load. The counter points to be tested shall be selected by the Naval Authority and agreed by TL

2.4 Function tests

2.4.1 A dynamic function test has to be executed with 1,25 x nominal load. All operational functions have to be tested for the full range of the horizontal and vertical inclination angles α and γ respectively β and δ of the wire ropes between the supplying ship and the receiving ship. For loads see also Chapter 102 - Hull Structures and Ship Equipment, Section 5, H.4.

Note

If no other definitions are available from the Naval Authority the inclinations defined in Table 4.9 may be chosen for the different replenishment systems.

2.4.2 During the tests all safety functions have to be checked by simulation of relevant situations, like overload protection, limit switches, emergency stops, etc. All steering and control possibilities and their control indicators have to be tested.

2.4.3 The tests have to be executed for port and starboard installations if existing on board.

2.4.4 The certificate for the system becomes valid if all tests have been carried out successfully with the required test loads.

Table 4.9 Range of wire rope inclinations on the supplying ship and on the receiving ship

Replenishment System	*Supplying Ship*		*Receiving Ship*	
	Angle α **(1)**	*Angle β* **(2)**	*Angle γ* **(1)**	*Angle δ* **(1)**
High line	*+/- 50°*	*+/- 20°*	*+/- 50°*	*+/- 20°*
Wire high line	*+/- 50°*	*0°/- 20°*	*+/- 50°*	*- 10°/+ 20°*
FAST-system	*+/- 30°*	*+ 10°/-20°* [3]	*+/- 30°*	*0°/- 20°*
STREAM-system	*+/- 50°*	*0°/- 20°*	*+/- 50°*	*0°/- 20°*
Large derrick	*+/- 30°*	*-30°*	*+/- 30°*	*-30°*
Close in	*+/- 50°*	*0°/- 45°*	*+/- 50°*	*+ 20°*

(1) *Angle of the vertical wire rope plane in relation to the y-z-plane of the ships (not shown in figures)*
(2) *Angle of the wire rope in relation to the x-y-plane of the ships as shown in the figures*
(3) *High position*

SECTION 5

WINDLASSES, CAPSTANS, CHAIN STOPPERS, MOORING AND TOWING EQUIPMENT

A. Windlasses

1. General

1.1 Scope

The following rules apply to bower anchor windlasses, stern anchor windlasses, combined anchor and mooring winches and chain stoppers. For anchors and chains, see Chapter 102 - Hull Structures and Ship Equipment, Section 18.

1.2 Documents for approval

1.2.1 For each type of anchor windlass and chain stopper, general and sectional drawings, circuit diagrams of the hydraulic and electrical systems and detail drawings of the main shaft, cable lifter, brake, stopper bar, chain pulley and axle are to be submitted in triplicate for approval.

One copy of a description of the anchor windlass including the proposed overload protection and other safety devices is likewise to be submitted.

1.2.2 Where an anchor windlass is to be approved for several strengths and types of chain cable, the calculation relating to the maximum braking torque is to be submitted and proof furnished of the power and hauling-in speed in accordance with 4.1 corresponding to all the relevant types of anchor and chain cable.

2. Materials

2.1 Approved materials

2.1.1 The following provisions are to be applied to the choice of materials.

2.1.1.1 As a rule important load-transmitting components of the windlasses are generally to be made of steel or cast steel complying with the TL Rules Chapter 2 - Materials, especially Chapter 103 - Special Materials for Naval Ships.

With the consent of TL, cast iron may be used for certain components.

Pressure vessels should in general be made of steel, cast steel or nodular cast iron with a predominantly ferritic matrix.

For welded structures, the TL Rules Chapter 3 - Welding are to be observed.

2.1.1.2 The pipes of hydraulic windlasses are to be made of seamless or longitudinally welded steel tubes. The use of cold-drawn, unannealed tubes is not permitted.

At points where they are exposed to damage, copper pipes for control lines are to be provided with protective shielding and are to be safeguarded against hardening due to vibration by the use of suitable fastenings.

2.1.1.3 High-pressure hose assemblies may be used for short pipe connections subject to compliance with Section 8, if this is necessary due to vibrations or flexibly mounted units.

2.1.1.4 The materials used for pressurized components including the seals must be suitable for the hydraulic oil in use.

2.1.2 Cable lifters and chain pulleys are generally to be made of cast steel. Nodular cast iron is permitted for stud link chain cables of

up to a diameter of 50 mm for grade K 1

up to a diameter of 42 mm for grade K 2

up to a diameter of 35 mm for grade K 3.

In special cases, nodular cast iron may also be used for larger chain diameters by arrangement with TL.

Grey cast iron is permitted for stud link chain cables of

up to a diameter of 30 mm for grade K 1

up to a diameter of 25 mm for grade K 2

up to a diameter of 21 mm for grade K 3.

2.2 Testing of materials

2.2.1 The materials for forged, rolled and cast parts which are stressed by the pull of the chain when the cable lifter is disengaged (main shaft, cable lifter, brake bands, bed frame, brake spindles, brake bolts, tension straps, stopper bar, chain pulley and axle) are to be tested under the supervision of TL in accordance with the TL Rules Chapter 2 - Materials.

In the case of anchor windlasses for chains up to a diameter of 14 mm an acceptance test certificate issued by the steel producer may suffice as proof.

2.2.2 In the case of hydraulic systems, the material used for pipes, see Section 8, Table 8.3, as well as for pressure vessels is also to be tested.

3. Design and equipment

3.1 Type of drive

3.1.1 Windlasses are normally to be driven by an engine which is independent of other deck machinery. The piping systems of hydraulic windlass engines may be connected to other hydraulic or steam systems provided that this is permissible for the latter. The windlasses must, however, be capable of being operated independently of other connected systems.

3.1.2 In the case of hydraulic drives with a piping system connected to other hydraulic systems it is recommended that a second pump unit is fitted.

3.1.3 In the case of windlasses with two cable lifters it must also be possible to engage both cable lifters simultaneously.

3.2 Reversing mechanism

Power-driven windlasses must be reversible. For windlasses on ships with a restricted service range up to **K50/20** and on agreement with TL a reversing mechanism may be dispensed with.

3.3 Overload protection

For the protection of the mechanical parts in the event of the windlass jamming, an overload protection, e.g. slip coupling, relief valve, is to be fitted to limit the maximum torque of the drive engine (cf. 4.1.2). The setting of the overload protection is to be specified, e.g. in the operating instructions.

3.4 Clutches

Windlasses are to be fitted with clutches between the cable lifter and the drive shaft. In case of an emergency, hydraulic or electrically operated clutches must be capable of being disengaged by hand.

3.5 Braking equipment

Windlasses must be fitted with cable lifter brakes which are capable of holding a load in accordance with 4.2.3 with the cable lifter disengaged. In addition, where the gear mechanism is not of self-locking type, a device like gearing brake, lowering brake or oil hydraulic brake is to be fitted to prevent paying out of the chain should the power unit fail while the cable lifter is engaged.

3.6 Pipes

For the design and dimensions of pipes, valves, fittings, pressure vessels, etc. Section 16 - Pressure Vessels and Section 8 - Pipes, Valves, Fittings and Pumps, A., B., C., D. and U. are to be applied, as appropriate, to hydraulic piping systems.

3.7 Cable lifters

Cable lifters shall have at least five snugs.

3.8 Windlass as warping winch

Combined windlasses and warping or mooring winches shall not be subjected to excessive loads even when the maximum pull is exerted on the warping rope.

3.9 Electrical equipment

The electrical equipment is to comply with Chapter 105 - Electrical Installations, Section 7, E.2.

3.10 Hydraulic equipment

For oil level indicators see Section 2, A.3.13.1. For filters see Section 14, B.3.2.

4. Power and design

4.1 Driving power

4.1.1 Depending on the grade of the chain cable and anchor depth windlasses must be capable of exerting the following nominal pull at a mean speed of at least 0,15 m/s:

Z = nominal pull [N]

$Z = d^2 \, (f + 0{,}218 \cdot (h - 100))$

d = diameter of anchor chain [mm]

h = anchor depth [m]

f = nominal pull factor [-]

Grade of chain	K1	K2	K3
f	37,5	42,5	47,5

The calculation of nominal pull shall be based on a minimum anchor depth of 100 m.

The pull of stern windlasses with an anchor rope can be determined by reference to the anchor weight and the diameter of the corresponding chain cable.

4.1.2 The nominal output of the power units must be such that the conditions specified in 4.1.1 can be met for 30 minutes without interruption. In addition, the power units must be capable of developing a maximum torque corresponding to a maximum pull of

$Z_{max} = 1{,}5 \cdot Z$ [N]

at a reduced speed, for at least two minutes.

4.1.3 An additional reduction gear stage may be fitted in order to achieve the maximum torque.

4.2 Design of transmission elements and chain stoppers

4.2.1 The basis for the design of the load-transmitting components of windlasses and chain stoppers are the anchors and chain cables specified in Chapter 102 - Hull Structures and Ship Equipment, Section 18.

4.2.2 The cable lifter brake is to be so designed that the anchor and chain can be safely stopped while paying out the chain cable.

4.2.3 The dimensional design of those parts of the windlass which are subjected to the chain pull when the cable lifter is disengaged (cable lifter, main shaft, braking equipment, bedframe and deck fastening) is to be based on a theoretical pull equal to 80 % of the nominal breaking load of the chain as specified in the TL Rules Chapter 2, 3 - Materials and Welding. The design of the main shaft has to take account of the breaking forces, and the cable lifter brake shall not slip when subjected to this load.

4.2.4 The theoretical pull may be reduced to 45 % of the nominal breaking load for the chain, provided that a chain stopper approved by TL is also fitted.

4.2.5 The design of all other windlass components is to be based upon a force acting on the cable lifter pitch circle and equal to the maximum pull specified in 4.1.2.

4.2.6 At the theoretical pull specified in 4.2.3 and 4.2.4, the force exerted on the brake handwheel shall not exceed 500 N.

4.2.7 The dimensional design of chain stoppers is to be based on a theoretical pull equal to 80 % of the nominal breaking load of the chain.

4.2.8 The total stresses applied to components must be below the minimum yield point of the materials used.

4.2.9 The foundations and pedestals of windlasses and chain stoppers are governed by the Rules in Chapter 102 - Hull Structures and Ship Equipment, Section 14, B.4.

5. Tests in the manufacturer's factory (FAT)

5.1 Testing of driving engines

Section 2, A.5.1 is applicable as appropriate.

5.2 Pressure and tightness tests

Section 2, A.5.2 is applicable as appropriate.

5.3 Final inspection and operational testing

5.3.1 Following manufacture, windlasses are required to undergo final inspection and operational testing at the maximum pull. The hauling-in speed is to be verified with continuous application of the nominal pull. During the tests, particular attention is to be given to the testing and, where necessary, setting of braking and safety equipment.

In the case of anchor windlasses for chains > 14 mm in diameter this test is to be performed in the presence of the TL Surveyor.

In the case of anchor windlasses for chains ≤ 14 mm diameter, the manufacturer's acceptance test certificate may suffice.

5.3.2 Where the manufacturing factory does not have adequate facilities, the aforementioned tests including the adjustment of the overload protection can be carried out on board ship. In these cases, functional testing in the manufacturer's factory is to be performed under no-load condition.

Following manufacture, chain stoppers are required to undergo final inspection and operational testing in the presence of the TL Surveyor.

6. Shipboard trials (SAT)

The anchor equipment is to be tested during sea trials.

As a minimum requirement, this test is required to demonstrate that the conditions specified in 3.1.3 and 4.2.2 can be fulfilled.

B. Special Requirements for Anchor Capstans

1. Basis for design and equipment

The basic requirements defined for windlasses in A. in respect to materials, driving power, tests, etc. are also valid for capstans.

2. Additional requirements

2.1 The foundation of the capstan is to be connected to the reinforced edge of the deck opening for the capstan by bolts and a suitable sealing system has to guarantee that the connection is watertight.

2.2 The operation of the capstan is to be established by a handwheel or similar device on the top of the capstan or via a stand alone control console. Such a watertight console has to be situated at a position from where a good observation of the anchoring procedure will be possible.

3. Capstan as warping device

Where a warping head is installed on top of the anchor cable lifter and the capstan is used also for warping duties the design must ensure that the two functions are only used alternatively i.e. not at the same time. The warping part has to fulfill the requirements defined in C.

C. Warping / Mooring Winches and Capstans

1. General

1.1 Scope

The following requirements apply to warping winches and capstans. Also mooring winches with drums and constant pull are considered. For mooring ropes see Chapter 102 - Hull Structures and Ship Equipment, Section 18, Tables 18.1 and 18.2.

1.2 Documents for approval

For each type of winch or capstan circuit diagrams of the hydraulic or electrical systems and detailed drawings of the main shaft, mooring head and brake are to be submitted in triplicate for approval.

One copy of a description of the mooring winch or capstan including the proposed overload protection is likewise to be submitted.

2. Materials

2.1 As a rule, load transmitting components of the winch shall be made of steel or cast steel complying with the TL Rules Chapter 2- Metallic Materials, especially Chapter 103 -Special Materials for Naval Ships. With the consent of TL, cast iron may be used for certain components.

2.2 The mooring heads are generally to be made of cast steel.

2.3 The materials for forged, rolled and cast parts which are stressed by the pull of the mooring rope are to be tested in accordance with the TL Rules defined in 2.1.

3. Design and equipment

3.1 Layout

The maximum pulling force at the warping head shall be in accordance with 80 % of the breaking loads for the relevant mooring ropes as defined in Chapter 102 - Hull Structures and Ship Equipment, Section 18, Table 18.1. The drive must provide a working speed of 10 m/min for the maximum pull. The speed shall not be lower than 30 m/min for the hauling of a slipped mooring line. The nominal output of the power unit must be such that the maximum torque can be developed for 30 minutes without interruption.

During operation the mooring lines have to pass first the hawses before reaching the winch or capstan, thus avoiding unforeseeable pulling directions.

3.2 Direct estimate of mooring forces

If deemed necessary in special cases, a direct estimate of the mooring loads on the winch head can be found under the assumption that a bow and a stern winch are hauling the ship to the quay.

The mooring load F_H on a winch head caused by water resistance may be calculated as follows

$$F_H = 0{,}5 \cdot q_{UH} \cdot c_{fUH} \cdot A_{UH} \quad [kN]$$

q_{UH} = Dynamic pressure of water at the underwater hull

= $0{,}5 \cdot \rho \cdot v_H^2$ [kN/m²]

ρ = Density of the water [t/m³]

v_H = Hauling speed at the winch head [m/s] equivalent to ship's transverse speed

c_{fUH} = Form coefficient of underwater hull [-]

A_{UH} = Underwater lateral area [m²]

The mooring load F_W on a winch head caused by wind resistance may be calculated as follows:

$$F_W = 0{,}5 \cdot q_{AH} \cdot c_{fAH} \cdot A_{AH} \quad [kN]$$

q_{AH} = Dynamic pressure of wind above the hull's design waterline

= $0{,}5 \cdot \rho_L \cdot v_W^2$ [kN/m²]

ρ_L = Density of the air [t/m³]

v_W = Transverse wind speed + v_H [m/s]

c_{fAH} = Form coefficient for the ship's hull above design waterline, substructures and deckhouses [-]

A_{AH} = Lateral area of the ship's hull above design waterline, superstructures and deckhouses [m²]

The total hauling force F_{TOT} at a winch is:

$$F_{TOT} = F_H + F_W \quad [kN]$$

3.3 Mooring winches with constant pull

This type of winch is equipped with an additional drum for storage of the mooring line, which can be kept under a constant, adjustable pull.

3.3.1 The mooring rope must be fastened on the winch drum to hold the mooring line with a pull of 80 % of the nominal breaking load of the mooring line.

3.3.2 The diameter of the winch drum must not be less than 16 times the rope diameter and the drum must be capable of winding up the full length of a mooring rope as prescribed in Chapter 102 - Hull Structures and Ship Equipment, Section 18, Table 18.1.

3.4 Equipment

The equipment for mooring winches is to be provided in analogous way as defined in A. and B.

4. Testing

4.1 Following manufacture warping and mooring winches and capstans are required to undergo final inspection and operational testing at the maximum pull in the manufacturer's factory (FAT). The warping or hauling speed is to be verified with continuous application of the nominal pull. During the tests, particular attention is to be given to the testing and, where necessary, to setting of braking and to the safety equipment.

4.2 Where the manufacturer does not have adequate facilities, the aforementioned tests can be carried out on board ship. In these cases functional testing in the factory is to be performed under no-load conditions.

D. Towing Equipment

In emergency cases the towing of naval ships will generally be effected by the use of warping capstans as described in C., hawses and bollards. For towing lines see Chapter 102 - Hull Structures and Ship Equipment, Section 18, Table 18.1.

SECTION 6

STARTING EQUIPMENT AND AIR COMPRESSORS

A. Starting Equipment

1. General

A starting equipment shall be provided, which is capable to bring machinery on board into operation without external aid.

2. Starting with compressed air

2.1 Main engines which are started with compressed air are to be equipped with at least two starting air compressors. At least one of the air compressors must be driven independently of the main engine and must supply at least 50 % of the total capacity required.

2.2 The total capacity of the starting air compressors is to be such that the starting air receivers designed in accordance with 2.4 or 2.5, as applicable, can be charged from atmospheric pressure to their final pressure within one hour.

Normally, compressors of equal capacity are to be installed.

This does not apply to an emergency air compressor which may be provided to meet the requirement stated in 1.

2.3 If the main engine is started with compressed air, the available starting air is to be divided between at least two starting air receivers of approximately equal size which can be used independently of each other.

2.4 The total capacity of air receivers is to be sufficient to provide, without being replenished, not less than 12 consecutive starts alternating between Ahead and Astern of each main engine of the reversible type, and not less than six starts of each main non-reversible type engine connected to a controllable pitch propeller or other device enabling the start without opposite torque.

2.5 With multi-engine installations the number of start-up operations per engine may, with TL's agreement, be reduced according to the concept of the propulsion plant.

2.6 If starting air systems for auxiliaries or for supplying pneumatically operated regulating and manoeuvring equipment or tyfon units are to be fed from the main starting air receivers, due attention is to be

2.7 Other consumers with a high air consumption, apart from those mentioned in 2.6, may not be connected to the main starting air system. Separate air supplies are to be provided for these units. Deviations require the agreement of TL.

2.8 For the approximate calculation of the starting air storage capacity, the formulae given in B. may be used.

2.9 Safety devices in the starting air system

The following equipment is to be fitted to safeguard the starting air system against explosions due to failure of starting valves:

2.9.1 A non-return isolation valve is to be fitted to the starting air line serving each engine.

2.9.2 Engines with cylinder bores > 230 mm are to be equipped with flame arrestors as follows:

- on directly reversible engines immediately in front of the start-up valve of each cylinder
- on non-reversible engines, immediately in front of the intake of the main starting air line to each engine

2.9.3 Equivalent safety devices may be approved by TL.

3. Electrical starting equipment

3.1 Where main engines are started electrically, two mutually independent starter batteries are to be installed. The batteries are to be so arranged that they cannot be connected in parallel with each other. Each battery must enable the main engine to be started from cold.

The total capacity of the starter batteries must be sufficient for the provisions according to 2.4 or 2.5 for an execution within 30 minutes.

3.2 If two or more auxiliary engines are started electrically, at least two mutually independent batteries are to be provided. Where starter batteries for the main engine are fitted, the use of these batteries is acceptable.

The capacity of the batteries must be sufficient for at least three start-up operations per engine.

If only one of the auxiliary engines is started electrically, one battery is sufficient.

3.3 The starter batteries may only be used for starting and preheating, where applicable and for monitoring equipment belonging to the engine.

3.4 Steps are to be taken to ensure that the batteries are kept charged and the charge level is monitored.

4. Start-up of emergency generator sets

4.1 Emergency generator sets are to be so designed that they can be started up readily even at a temperature of 0 °C. Other temperature ranges may be defined by the Naval Authority.

If the set can be started only at higher temperatures, or where there is a possibility that lower ambient temperatures may occur, heating equipment is to be fitted to ensure reliable starting.

The operational readiness of the set must be guaranteed under all weather and seaway conditions. Fire flaps required in air inlet and outlet openings must only be closed in case of fire and are to be kept open at all other times. Warning signs to this effect are to be provided. In case of automatic fire flap actuation dependent on the operation of the set warning signs are not required. Air inlet and outlet openings must not be fitted with weatherproof covers.

4.2 Each emergency generator set required to be capable of automatic starting is to be equipped with an automatic starting system approved by TL, the capacity of which is sufficient for at least three successive starts, see Chapter 105 - Electrical Installations, Section 7, D.6.

In addition, a second energy source is to be installed capable of three further starting operations within 30 minutes. This requirement may be dispensed with if the set can also be started by hand.

4.3 In order to guarantee the availability of the starting equipment, steps are to be taken to ensure that

- Electrical and hydraulic starting systems are supplied with energy from the emergency switchboard
- Compressed air starting systems are supplied via a non-return valve from the main and auxiliary compressed air receivers or by an emergency air compressor, the energy for which is provided via the emergency switchboard
- The starting, charging and energy storage equipment is located in the emergency generator room

4.4 Where automatic starting is not specified, reliable manual starting systems may be used, e.g. by means of hand cranks, spring-loaded starters, hand-operated hydraulic starters or starters using ignition cartridges.

4.5 Where direct manual starting is not possible, starting systems in accordance with 4.2 and 4.3 are to be provided, in which case the starting operation may be initiated by hand.

4.6 The starters of emergency generator sets may be used only for this purpose.

5. Start-up of emergency fire-extinguisher sets

5.1 Diesel engines driving emergency fire pumps are to be so designed that they can still be reliably started by hand at a temperature of 0 °C. Other temperature ranges may be defined by the Naval Authority.

If the engine can be started only at higher temperatures, or where there is a possibility that lower temperatures may occur, heating equipment is to be fitted to ensure reliable starting.

5.2 If manual start-up by using a hand crank is not possible, the emergency fire-extinguisher set is to be fitted with a starting device approved by TL which enables at least 6 starts to be performed within 30 minutes, two of these being carried out within the first 10 minutes or within a time period to be defined by the Naval Authority.

B. Approximate Calculation of the Starting Air Supply

1. Starting air for installations with non-reversible engines

For each non-reversible four-stroke main engine driving a controllable pitch propeller or where starting without torque resistance is possible, the following assumptions may be used. For an initial pressure of 30 bar and a final pressure of 9 bar in the starting air receivers, the preliminary calculation of the starting air supply may be performed as follows though it shall not be less than needed for 6 start-up operations:

$$J = 0{,}209 \cdot \sqrt[3]{\frac{H}{D}} \cdot (z + 0{,}056 \cdot p_{e,e} \cdot n_A + 0{,}9) \cdot V_h \cdot c$$

J = Total capacity of the starting air receivers for starting without torque resistance [dm^3]

D = Cylinder bore [mm]

H = Stroke [mm]

V_h = Swept volume of one cylinder [dm^3]

$p_{e,perm}$ = Maximum permissible working pressure of the starting air receiver [bar]

z = Number of cylinders

$p_{e,e}$ = Mean effective working pressure in cylinder at rated power [bar]

c = 1 for $p_{e,perm}$\ = 30 bar

$$c = \frac{0{,}0584}{1 - e^{(0{,}11 - 0{,}05 \cdot \ln p_{e,perm})}}$$

for $p_{e,zul} \neq 30$ bar, if no pressure-reducing valve is fitted.

e = Euler's number (2,718....)

If a pressure-reducing valve is fitted, which reduces the pressure $p_{e,perm}$ to the starting pressure p_A, the value of "c" shown in Fig. 6.1 is to be used.

The following values of n_A are to be applied:

$n_A = 0{,}06 \cdot n_o + 14$ where $n_o \leq 1000$

$n_A = 0{,}25 \cdot n_o - 176$ where $n_o > 1000$

n_o [min^{-1}] = rated speed

2. For reversible engines the total capacity J of starting air receivers has to be doubled.

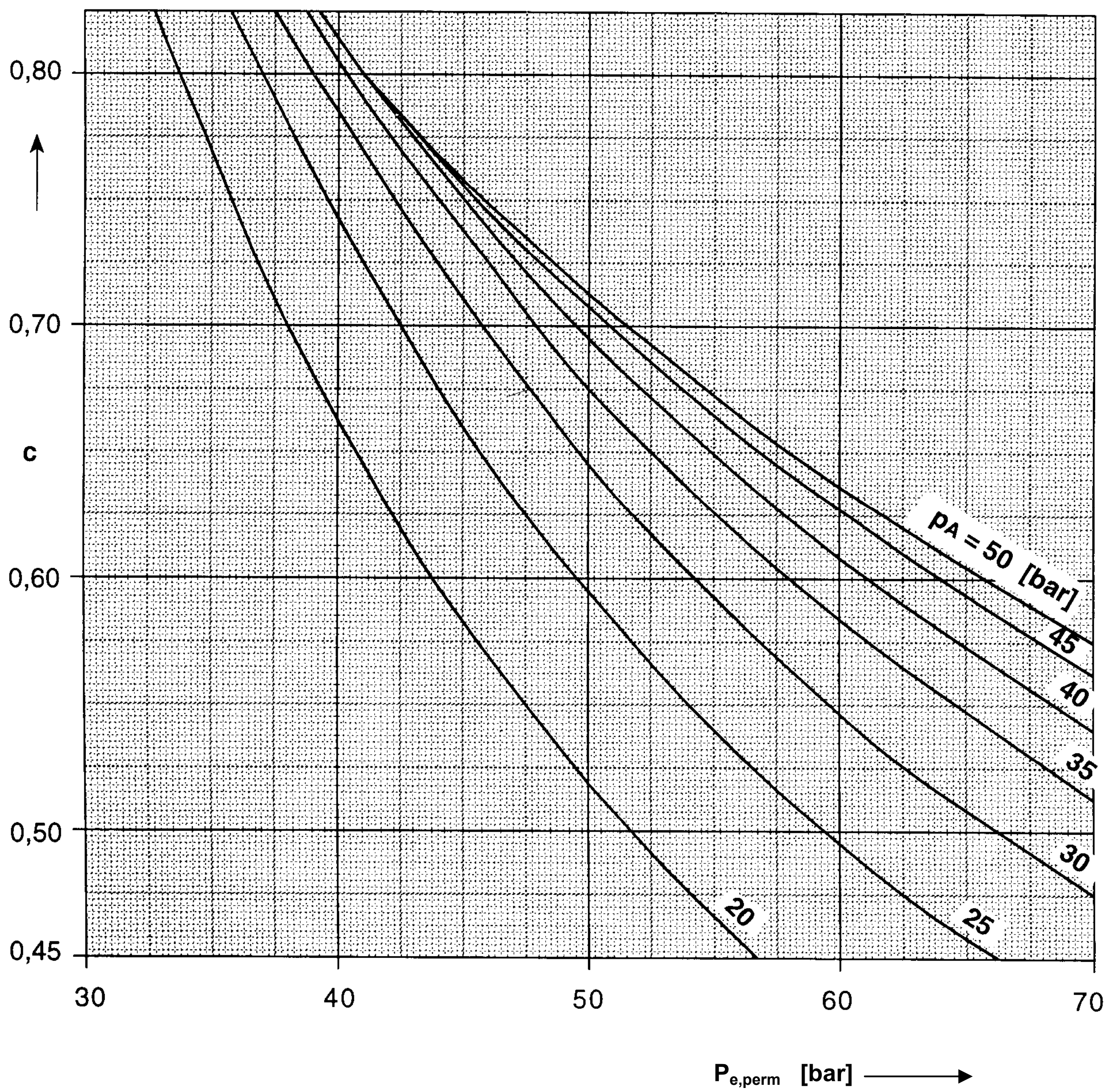


Fig. 2.7 The value of "c" where a pressure – reducing valve is fitted

C. Air Compressors

1. General

1.1 Scope

The following requirements apply to reciprocating compressors of the normal marine types. Where it is intended to install compressors to which the following rules and calculation formulae cannot be applied, TL requires proof of their suitability for shipboard use.

1.2 Documents for approval

Drawings showing longitudinal and transverse cross-sections, the crankshaft and the connecting rod are to be submitted to TL in triplicate for each compressor type.

2. Materials

2.1 Approved materials

In general, the crankshafts and connecting rods of reciprocating compressors shall be made of steel, cast steel or nodular cast iron according to the TL Chapter 2 - Materials. The use of special cast iron alloys is to be agreed with TL.

2.2 Material testing

Material tests are to be performed on crankshafts with a calculated crank pin diameter > 50 mm. For crank pin diameters ≤ 50 mm works certificates are sufficient.

3. Crankshaft dimensions

3.1 The diameters of journals and crank pins are to be determined as follows:

$$d_k = 0{,}126\sqrt[3]{D^2 \cdot p_c \cdot C_1 \cdot C_W \cdot (2 \cdot H + f \cdot L)}$$

d_k = Minimum pin/journal diameter [mm]

D = Cylinder bore for single-stage compressors [mm]

= D_{Hd} = cylinder bore of the second stage two-stage compressors with separate pistons,

= 1,4 · D_{Hd} for two stage compressors with a stepped piston as in Fig. 6.2,

= $\sqrt{D_{Nd}^2 - D_{Hd}^2}$ for two-stage compressors with a differential piston as in Fig. 6.3.

p_c = Design pressure PR, applicable up to 40 bar,

H = Piston stroke [mm]

L = Distance between main bearing centers where one crank is located between two bearings. L is to be substituted by L_1 = 0,85 · L where two cranks at different angles are located between two main bearings, or by L_2 = 0,95 · L where 2 or 3 connecting rods are mounted on one crank.

= 1,0 where the cylinders are in line

= 1,2 where the cylinders arranged 90° ⎫
= 1,5 where the cylinders arranged 60° ⎬ V or W
= 1,8 where the cylinders arranged 45° ⎭ type

C_1 = Coefficient according to Table 6.1 [–]

z = Number of cylinders [–]

C_w = Material factor according to Table 6.2 or 6.3, depending on the tensile strength R_m [N/mm^2] of the material.

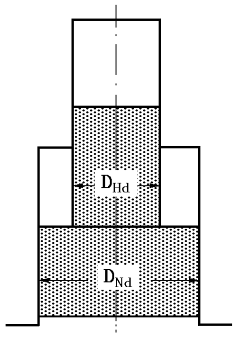


Figure 6.2 Cylinder bores for compressors with a stepped piston

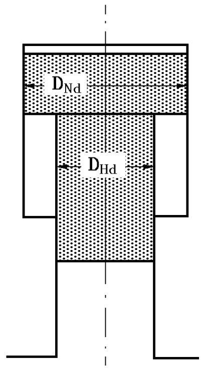


Figure 6.3 Cylinder bores for compressors with a differential piston

3.2 Where increased strength is achieved by a favourable configuration of the crankshaft, smaller values of d_k may be approved.

Table 6.1 Values of C_1

z	1	2	4	6	>8
C_1	1,0	1,1	1,2	1,3	1,4

Table 6.2 Values of C_w for steel shafts

R_m [N/mm^2]	C_w
400	1,03
440	0,94
480	0,91
520	0,85
560	0,79
600	0,77
640	0,74
≥ 680	0,70
720 **(1)**	0,66
≥ 760 **(1)**	0,64
(1) *Only for drop-forged crankshafts*	

Table 6.3 Values of C_w for nodular cast iron shafts

R_m [N/mm^2]	C_w
370	1,20
400	1,10
500	1,08
600	0,98
700	0,94
≥ 800	0,90

4. Construction and fittings

4.1 General

4.1.1 Cooler dimensions are to be based on a sea-water temperature of at least 32 °C in case of water cooling, and on an air temperature of at least 45 °C in case of air cooling, unless higher temperatures are dictated by the temperature conditions related to the ship's tasks or by the location of the compressors or cooling air intakes.

Where fresh water cooling is used, the cooling water inlet temperature shall not exceed 40 °C.

4.1.2 Unless they are provided with open discharges, the cooling water spaces of compressors and coolers must be fitted with safety valves or rupture discs of sufficient cross-sectional area.

4.1.3 High-pressure stage air coolers shall not be located in the compressor cooling water space.

4.2 Safety valves and pressure gauges

4.2.1 Every compressor stage must be equipped with a suitable safety valve which cannot be blocked and which prevents the maximum permissible working pressure from being exceeded by more than 10 % even when the delivery line has been shut off. The setting of the safety valve must be secured to prevent unauthorized alteration.

4.2.2 Each compressor stage must be fitted with a suitable pressure gauge, the scale of which must indicate the relevant maximum permissible working pressure.

4.2.3 Where one compressor stage comprises sev eral cylinders which can be shut off individually, each cylinder must be equipped with a safety valve and a pressure gauge.

4.3 Air compressors with oil-lubricated pres sure spaces

4.3.1 The compressed air temperature, measured directly at the discharge from the individual stages, may not exceed 160 °C for multi-stage compressors or 200 °C for single-stage compressors. For discharge pressures of up to 10 bar, temperatures may be higher by 20 °C.

4.3.2 Compressors with a power consumption of more than 20 kW should be fitted with thermometers at the individual discharge connections, wherever this is possible. If this is not practicable, they are to be mounted at the inlet end of the pressure line. The thermometers are to be marked with the maximum permissible temperatures.

4.3.3 Behind the final stage, all compressors are to be equipped with a water trap and an aftercooler.

4.3.4 Water traps, aftercoolers and the compressed air spaces between the stages must be provided with discharge devices at their lowest points.

4.4 Name plate

Every compressor is to carry a name plate with the following information:

- Manufacturer
- Year of construction
- Effective suction rate [m^3/h]
- Discharge pressure [bar]
- Speed [min^{-1}]
- Power consumption [kW]

5. Tests

5.1 Pressure tests

5.1.1 Cylinders and cylinder liners are to be subjected to hydraulic pressure tests at 1,5 times the final pressure of the stage concerned.

5.1.2 The compressed air chambers of the inter coolers and aftercoolers of air compressors are to be subjected to hydraulic pressure tests at 1,5 times the final pressure of the stage concerned.

5.2 Final inspections and testing

Compressors are to be subjected to a performance test at the manufacturer's works under supervision of TL and are to be presented for final inspection.

SECTION 7

STORAGE OF LIQUID FUELS, LUBRICATING AND HYDRAULIC OILS AS WELL AS OIL RESIDUES

A. General

1. Scope

The following requirements apply to the storage of liquid fuels, lubricating and hydraulic oils as well as to oil residues.

2. Definitions

2.1 Service tanks

Service tanks are settling tanks and daily service tanks including aviation fuel tanks which supply consumers directly.

3. Documents for approval

A tank plan is to be submitted for approval in triplicate. It should include particulars regarding arrangement, type of media and volume of the tanks as well as the specification of the maximum height of the overflow level.

B. Storage of Liquid Fuels for Ship Operation

1. General safety precautions for liquid fuels

1.1 The fuel supply is to be stored in several tanks so that, even in the event of damage to the bot tom of one of the tanks, the fuel supply will not be entirely lost.

No fuel tanks or tanks for the carriage of flammable liquids may be arranged forward of the collision bulk-head.

1.2 Tanks and pipes are to be so located and equipped that fuel may not spread either inside the ship or on deck and may not be ignited by hot surfaces or electrical equipment. The tanks are to be fitted with air and overflow pipes as safeguards against overpressure, see Section 8, R.2.

1.3 Fuel tanks shall normally not be arranged at the shell or directly besides other tanks, if constructional reasons do not force such an arrangement.

1.4 For fuel tanks and tanks of supply ships, a filling ratio of 95 % is permissible.

1.5 Fuel tanks are to be separated by cofferdams from tanks containing lubricating, hydraulic or edible oil as well as from tanks containing boiler feed water, condensate or drinking water. This does not apply to tanks for used lubricating oil adjacent to fuel tanks.

1.6 On small ships the arrangement of cofferdams according to 1.5 may be dispensed with upon approval by TL, provided that the common boundaries between the tanks are arranged in accordance with Chapter 102 - Hull Structures and Ship Equipment, Section 10, A.1.5.

Fuel oil tanks adjacent to lubricating oil circulating tanks are, in addition to the requirements of Chapter 102 - Hull Structures and Ship Equipment, Section 10, to be provided with suitable means, e.g. level alarms by which it shall be ensured that the maximum level in the fuel oil tanks will not exceed the lowest operation level in the lubricating oil circulating tanks.

2. Location and dimensioning of fuel tanks

2.1 Storage and service tanks are to be situated near the consumers.

2.2 Fuel tanks may be located above engines, boilers, turbines and other equipment with a high surface temperature (above 220 °C) only if adequate spill trays are provided below such tanks and if they are protected against heat radiation. Surface temperatures of the elements without insulation and lagging have to be considered.

2.3 Fuel tanks are to be designed as an integral part of the ship's structure. If this is not possible, the tanks shall be located adjacent to an engine room bulkhead and the tank top of the double bottom. The arrangement of free-standing fuel tanks inside engine rooms is to be avoided. Tank locations which do not conform to these rules require the approval of TL.

2.4 A special fuel supply is to be provided for the prime movers of the emergency source of electrical power. The fuel capacity must be sufficient for at least 18 hours continuous operation.

This applies in analogous manner to the emergency fire pumps.

The fuel tank must be located above the uppermost continuous deck, and in both cases outside the engine and boiler rooms and aft of the collision bulkhead.

By the arrangement and/or heating of the fuel tank, the emergency diesel equipment must be kept in a state of readiness also for low outside temperatures.

2.5 For the current consumption of fuel, separated service tanks, e.g. day tanks, have to be provided for the different types of consumers, e.g. main propulsion machinery, generator sets, etc..

The volume of the different service tanks must be sufficient for a full load operation of 8 hours.

3. Fuel tank fittings and mountings

3.1 For filling and suction lines see Section 8, G., for air, overflow and sounding pipes, see Section 8, R.

3.2 Service tanks are to be so arranged that water and residues can settle out despite the movement of the ship at sea.

Fuel tanks located above the double bottom are to be fitted with water drains with self-closing shut-off valves.

At the deepest position of the tank a suction line for pumping out residual fuel and water has to be provided. These lines of the different tanks shall be connected to the oil separator. If it is not possible to install a suction pipe a hose connection shall be provided. For fuel tanks drain pipes to the overflow tank shall be arranged. The shut-down valves shall be secured in a closed position.

3.3 Tank gauges

3.3.1 The following tank gauges are permitted:

- Oil-level indicating devices (type-tested) with central monitoring
- Sounding pipes in addition

3.3.2 Sight glasses and oil gauges fitted directly on the side of the tank and cylindrical glass oil gauges are not permitted.

3.3.3 Sounding pipes of fuel tanks may not terminate in accommodation spaces, nor they shall terminate in spaces where the risk of ignition of spillage from the sounding pipes might arise.

3.3.4 Sounding pipes should terminate outside machinery spaces. Where this is not possible, the following requirements are to be met:

- Sounding pipes are either to terminate in locations remote from ignition hazards or they are to be effectively screened to prevent that spillage through the sounding pipes may come into contact with a source of ignition.
- The sounding pipes are to be fitted with self-closing shut-off devices and self-closing test valves.

In addition Section 8, R has to be considered.

4. Appliances and fittings on fuel tanks

4.1 Appliances, mountings and fittings which are not part of the fuel tank equipment may be fitted to tank walls only by means of intermediate supports. To free-standing tanks only components which are part of the tank equipment may be fitted.

4.2 Valves and pipe connections are to be attached to doubler flanges welded to the tank surfaces. Holes for bolts must not be drilled in the tank surfaces.

Instead of doubler flanges, thick walled pipe stubs with flange connections may be welded into the tank walls.

5. Testing for tightness

Fuel tanks are to be tested for tightness in accordance with Chapter 102 - Hull Structures and Ship Equipment, Section 10, D.

6. Fuels with a flash point of ≤ 60 °C

6.1 If for special reasons fuel with a flash point between 43 °C and 60 °C is used for ship operation, special tanks have to be provided for this fuel. Additional safety measures will become necessary and have to be approved by TL. It has to be ensured that the temperature in the spaces, where the fuel is stored or consumed, stays always 10 °C below the flash point.

Connections to fuel tanks with other flash points are not permissible.

6.2 Storage of petrol

Where in exceptional cases petrol can be used for the drive of ship safety pumps and outboard motors, the storage of petrol is only permitted in seawater resistant and heat protected jettisoning devices on the free deck. A maximum stock of 200 litres in suitable canisters of 20 1 capacity each may be stored on board. For bigger volumes additional measures subject to TL approval will become necessary.

C. Storage of Lubricating and Hydraulic Oils

1. Tank arrangement

Lubricating and hydraulic oil tanks have to be arranged near the respective consumer.

Concerning the arrangement of lubrication and hydraulic oil tanks besides fuel tanks as well as tanks for boiler feed water, condensate and fresh water B.1.5 to B.1.6 apply accordingly.

Different types of lubricating oil may be stored in tanks arranged besides each other.

Furthermore the rules of Chapter 102 - Hull Structures and Ship Equipment, Section 10, A. are to be applied analogously.

2. Tank fittings and mountings

2.1 Filling and suction lines of lubricating oil and hydraulic oil tanks, see Section 8, I.2.2.

2.2 For tank sounding devices for oil tanks, see B.3.3.1, B.3.3.3 and B.3.3.4; in addition Section 8, R. has to be considered.

2.3 For the mounting of appliances and fittings on the tanks B.4. is to be applied.

3. Capacity and construction of lubricating oil tanks

3.1 Lubricating oil drain tanks shall be sufficiently large to ensure that the dwelling time of the oil is long enough for the expulsion of air bubbles, settling out of residues etc. With a maximum permissible filling level of about 85 %, the tanks must be large enough to hold at least the lubricating oil contained in the entire circulation system including the contents of gravity tanks.

3.2 Measures, such as the provision of baffles or limber holes consistent with structural strength requirements, particularly relating to the machinery bed plate, are to be provided to ensure that the entire content of the tank remains in circulation. Limber holes should be located as near the bottom of the tank as possible. Suction pipe connections should be placed as far as practicable away from the oil drain pipe so that neither air nor sludge may be sucked up irrespective of the heel of the ship.

3.3 Lubricating oil drain tanks are to be equipped with sufficient air pipes.

D. Storage of Aviation Fuel

1. General

1.1 For the storage of aviation fuel the safety measures according to B.1 are to be applied analogously.

1.2 The stock of aviation fuel has to be stored in two or more aviation fuel storage tanks.

1.3 A storage in only one tank is permissible if a limited volume (< 10 m^3) is stored or if the arrangement on board does not allow several storage tanks.

1.4 For the direct fuelling an aviation fuel service tank has to be provided.

1.5 For the storage of overflow fuel a separate drainage tank for aviation fuel has to be provided.

2. Capacity and construction of aviation fuel tanks

2.1 The service tanks according to 1.4 are not to be included in the necessary volume of the storage tanks.

2.2 The service tank has to be constructed to allow a settling of impurities and water, e.g. by arrangement of a water pocket. For drainage see also Section 8, H.6.2.

2.3 Aviation fuel tanks have to be provided with a suitable coating.

3. Arrangement of aviation fuel tanks

3.1 For the arrangement of the aviation fuel tanks the requirements according to Section 8, H.3. are to be observed.

3.2 Aviation fuel tanks may not be arranged directly at the shell.

4. Tank equipment

4.1 The construction of the filling and the outlet pipes has to be in accordance with Section 8, H.3.

4.2 For sounding equipment of the tanks see Section 8, H.6.1.

4.3 For the mounting of devices and fittings, B.4. has to be applied analogously.

4.4 For ventilation and overflow equipment as well as drainage and sampling devices, see Section 8, H.6.2.

E. Storage of Oil Residues

1. Arrangement and capacity of sludge tanks

1.1 Sludge tanks are to be provided.

1.2 Arrangement and capacity of sludge tanks have to be defined by the Naval Authority. National requirements, if any, are to be observed.

2. Fittings and mountings of sludge tanks

2.1 Sludge tanks have to be equipped with heating facilities to keep the content pumpable.

2.2 For tank sounding devices B.3.3 is to be applied in analogous way.

2.3 For air pipes, see Section 8, R.

SECTION 8

PIPING SYSTEMS, VALVES AND PUMPS

Page

A. General

1. Scope

1.1 The Rules in this Section apply to piping systems, including the selection of materials and the design of pipes, pipe connections, fittings and pumps, depending on the media conveyed.

1.2 Reference to other TL Rules

- TL Rules Chapter 2 - Materials, - Non-metallic Materials and Chapter 3 - Welding
- Section 9 - Fire Protection and Fire Extinguishing Equipment
- Section 17 - Oil Firing Equipment
- Section 16 - Pressure Vessels
- Section 15 - Auxiliary Steam Boilers
- TL Rules - Guidelines for the Design, Equipment and Testing of Gas Welding Installations on Seagoing Ships

2. Documents for approval

The following drawings/documents are to be submitted for approval in triplicate:

2.1 Engine room arrangement plan

2.2 Diagrammatic plans of the following piping systems including all the details necessary for approval, e.g. lists of valves, fittings and pipes:

- Steam systems
- Boiler feed water systems
- Condensate systems
- Fuel systems (bunkering, transfer and supply systems)
- Seawater cooling systems
- Fresh water cooling systems
- Lubricating oil systems
- Starting air, control air and working air systems
- Exhaust gas systems
- Bilge systems
- Ballast systems
- Cross-flooding arrangements
- Air, overflow and sounding pipes including details of filling pipe cross sections
- Closed overflow systems
- Sanitary water systems (fresh water, seawater)
- Sewage discharge systems
- Drinking water systems
- Equipment for the treatment and storage of bilge water and fuel oil residues
- Chilled water systems
- Fuel storage, transfer and replenishment systems
- Aviation fuel systems

2.3 For remotely controlled valves:

- Diagrammatic piping plans and diagrammatic plans of the arrangement of piping and control stands in the ship;
- Diagrammatic plans and electrical circuit diagrams of the control stations and power units, drawings of as well as the remotely controlled valves, control stands and the corresponding pressure accumulators.

2.4 For pipes, pipe connections and accessories, as far as not defined otherwise in this Section, recognized national or international standards have to be applied.

3. Pipe classes

For the purpose of testing of pipes, selection of jointing, welding and heat treatment, pipes are subdivided into three classes as indicated in Table 8.1.

B. Materials, Testing

1. General

Materials must be suitable for the proposed application and comply with TL Rules Chapter 2 - Materials.

In case of especially corrosive media, TL may impose special requirements on the materials used.

1.2 Where non-magnetic construction is required, non-magnetizable materials are to be selected.

1.3 Potential differences between contiguous elements are to be kept as small as possible.

1.4 Potential differences caused by inevitable combinations of different materials are to be compen sated by suitable measures, such as isolation and/or protection of the material of lower potential. The element made of higher potential material shall be arranged, where possible, downstream.

Table 8.1 Classification of pipes into "pipe classes"

Medium/type of pipeline	Design pressure PR [bar] Design temperature t [°C]		
Pipe class	I	II	III
Inflammable liquids heated above flash point Inflammable liquids with a flash point of 60 °C or less Flammable gases	all	**(1)**	-
Steam	PR > 16 or t > 300	PR ≤ 16 and t ≤ 300	PR ≤ 7 and t ≤ 170
Air, gases (inflammable) Inflammable, hydraulic fluids Boiler feedwater, condensate Seawater and fresh water for cooling Brine in refrigerating plant	PR > 40 or t > 300	PR ≤ 40 and t ≤ 300	PR ≤ 16 and t ≤ 200
Liquid fuels, lubricating oil, flammable hydraulic fluid **(2)**	PR > 16 or t > 150	PR ≤ 16 and t ≤ 150	PR ≤ 7 and t ≤ 60
Cargo pipelines for oil tanker	-	-	all
Refrigerants	-	all	-
Open-ended pipelines (without shutoff), e.g. drains, venting pipes, overflow lines and boiler blowdown lines	-	-	all

(1) *Classification in Pipe Class II is possible if special safety arrangements are available and structural safety precautions are arranged.*

(2) *For liquid fuels > 60 °C the design pressure is to be at least 14 bar*

2. Materials

2.1 Pipes, valves and fittings of steel

Pipes belonging to Classes I and II must be either seamless drawn or fabricated by a welding procedure approved by TL. In general, carbon and carbon-manganese steel pipes, valves and fittings are not to be used for temperatures above 400 °C. However, they may be used for higher temperatures provided that their metallurgical behaviour and their strength property according to C.2.3 after 100 000 h of operation are in accordance with national or international regulations or standards and if such values are guaranteed by the steel manufacturer. Otherwise, alloy steels in accordance with the TL Rules for Materials are to be used.

2.2 Pipes, valves and fittings of copper and copper alloys

Pipes of copper and copper alloys must be of seamless drawn material or fabricated by a method approved by TL. Copper pipes for Classes I and II must be seamless.

In general, copper and copper alloy pipe lines shall not be used for media having temperatures above the following limits:

- Copper and aluminium brass 200°C
- Copper nickel alloys 300°C
- High-temperature bronze 260°C

2.2.2 At locations with restricted cross section as occurring at orifices, valves, etc., pipes made of copper alloys are to be protected by a TL-approved coating, for a length as follows:

- 5 x d upstream of the section restriction
- 10 x d downstream of the restriction

d = inner diameter of pipe

2.3 Pipes, valves and fittings of nodular ferritic cast iron

Pipes, valves and fittings of nodular ferritic cast iron according to the Rules for Materials may be accepted for bilge and ballast pipes within double-bottom tanks and for other purposes approved by TL. In special cases (applications corresponding in principle to classes II and III) and subject to TL's special approval, valves and fittings made of ferritic nodular cast iron may be accepted for temperatures up to 350 °C. Nodular ferritic cast iron for pipes, valves and fittings fitted on the ship's side must comply with the TL Rules for Materials.

2.4 Pipes, valves and fittings of lamellar raphite cast iron (grey cast iron)

Pipes, valves and fittings of grey cast iron may be accepted on supply tankers for cargo pipes within cargo tanks and on the weather deck up to a working pressure of 16 bar.

Ductile materials must be used for cargo hose connections and manifolds.

This applies also to the hose connections of fuel and lubricating oil filling lines.

The use of grey cast iron is not allowed:

- For pipes, valves and fittings for media having temperatures above 220 °C and for pipelines subject to water hammer, severe stresses or vibrations,
- For sea valves and pipes fitted on the ship sides and for valves fitted on the collision bulkhead,
- For valves on fuel and oil tanks subject to static head.

The use of grey cast iron in cases other than those stated is subjected to TL approval.

2.5 Plastic pipes

2.5.1 Plastic pipes may be used after special approval by TL **(1).**

(1) *See IMO Resolution A.753(18) "Guidelines for the Application of Plastic Pipes on Ships" as amended by MSC.313(88).*

The use of plastic pipes made of polyvinyl chloride (PVC) is not permissible .

2.5.2 Pipes, valves and fittings made of plastic materials are to be subjected to a continuous TL-approved quality control by the manufacturer.

2.5.3 Pipe penetrations through watertight bulkheads and decks as well as through fire divisions are to be approved by TL.

2.5.4 Plastic pipes are to be continuously and permanently marked with the following particulars:

- manufacturer's marking
- standard specification number
- outside diameter and wall thickness of pipe
- year of manufacture

2.5.5 Valves and connecting pieces made of plastic must, as a minimum requirement, be marked with the manufacturer's marking and the outside diameter of the pipe.

2.6 Aluminium and aluminium alloys

Aluminium and aluminium alloys must comply with TL Rules Chapter 2 and 3 - Materials and Welding and may in individual cases, with the agreement of TL, be used for temperatures up to 200 °C. They are not acceptable for use in fire extinguishing lines.

2.7 Application of materials

For the pipe classes mentioned in A.3. materials must be applied according to Table 8.2.

3. Testing of materials

3.1 For piping systems belonging to class I and II, tests in accordance with the TL Rules Chapter 2 and 3 - Materials and Welding and under TL's supervision are to be carried out in accordance with Table 8.3 for:

- pipes, bends and fittings
- valve bodies and flanges

3.2 Welded joints in pipelines of classes I and II are to be tested in accordance with the TL Rules Chapter 3 - Welding.

4. Hydraulic Tests on Pipes

4.1 Definitions

4.1.1 Maximum allowable working pressure, PB [bar], Formula symbol: $P_{e,perm}$

This is the maximum allowable internal or external working pressure for a component or piping system with regard to the materials used, piping design requirements, the working temperature and undisturbed operation.

4.1.2 Nominal pressure, PN [bar]

This is the term applied to a selected pressure-temperature relation used for the standardization of structural components. In general, the numerical value of the nominal pressure for a standardized component made of the material specified in the standard will correspond to the maximum allowable working pressure PB at 20 °C.

4.1.3 Test pressure, PP [bar] Formula symbol: p_p

This is the pressure to which components or piping systems are subjected for testing purposes.

4.1.4 Design pressure, PR [bar] Formula symbol: p_c

This is the maximum allowable working pressure PB for which a component or piping system is designed with regard to its mechanical characteristics. In general, the design pressure is the maximum allowable working pressure at which the safety equipment will interfere, e.g. activation of safety valves, opening of return lines of pumps, operating of overpressure safety arrangements, opening of relief valves, or at which the pumps will operate against closed valves.

The design pressure for fuel pipes shall be chosen according to Table 8.3a.

Table 8.2 Approved materials

<table>
<tr><th colspan="2" rowspan="2">Material or application</th><th colspan="3">Pipe class</th></tr>
<tr><th>I</th><th>II</th><th>III</th></tr>
<tr><td rowspan="3">Steels</td><td>Pipes</td><td>Steel pipes for high-temperatures above 300 °C, pipes made of steel with high-/low temperature toughness at temperatures below -10 °C, stainless steel pipes for chemicals</td><td>Pipes for general applications</td><td>Steel not subject to any special quality specification, weldability in accordance with TL Rules for Welding</td></tr>
<tr><td>Forgings, plates, flanges</td><td colspan="3">Steel suitable for the corresponding service and processing conditions, high-temperature steel for temperatures above 300 °C, steel with high-/low temperature toughness for temperatures below -10 °C, steel with high-/low temperature toughness</td></tr>
<tr><td>Bolts, nuts</td><td>Bolts for general machinery constructions, high-temperature steel for temperatures above 300 °C, steel with high-/low temperature toughness for temperatures below -10 °C</td><td colspan="2">Bolts for general machinery construction</td></tr>
<tr><td rowspan="3">Castings (valves, fittings, pipes)</td><td>Cast steel</td><td>High-temperature cast steel for temperatures above 300 °C, cast steel with high-/low temperature toughness at temperatures below -10 °C, stainless castings for aggressive media</td><td colspan="2">Cast steel for general applications</td></tr>
<tr><td>Nodular cast iron</td><td colspan="3">Only ferritic grades, elongation A_5 at least 15 %</td></tr>
<tr><td>Cast iron with lamellar graphite</td><td>-</td><td>-</td><td>At least GG-20 up to 200 °C, grey cast iron is not permitted in valves and fittings on ship's side, on the collision bulkhead and on fuel and oil tanks</td></tr>
<tr><td rowspan="2">Non-ferrous metals (valves, fittings, pipes)</td><td>Copper, copper alloys</td><td>low-temperature copper-nickel-alloys by special agreement</td><td colspan="2">For seawater and alkaline water only corrosion resistant copper and copper alloys</td></tr>
<tr><td>Aluminium, aluminium alloys</td><td>-</td><td colspan="2">Only with the agreement of TL up to 200 °C, not permitted in fire extinguishing systems</td></tr>
<tr><td>Non-metallic materials</td><td>Plastics</td><td>-</td><td>-</td><td>On special approval (see 2.5)</td></tr>
</table>

Table 8.3 Approved materials and types of certificates

Pipe class	Type of component	Approved materials	Design temperature	Subject to testing	TL Rules Chapter 2 - Materials	Type of material certificate according to EN 10204		
						3.2 (TL)	3.1	2.2
I+ II	Pipes, pipe elbows, fittings	Steel, copper, copper alloy		DN >32 **(3)**	Chapter 2, Section 4 Chapter 2, Section 10	X	-	-
				DN≤32		-	X	-
	Valves, flanges, metal expansion, joints and hoses, other components	Steel, cast steel	> 300 °C	DN>32	Chapter 2, Section 4, Chapter 2, Section 6	X	-	-
				DN≤32		-	X	-
		Steel, cast steel, nodular cast iron	≤ 300 °C	PB x DN > 2500 **(4)** or DN > 250	Chapter 2, Section 5 Section 6, Section 7	X	-	-
				PB x DN ≤ 2500 or DN ≤ 250		-	X	-
		Copper, copper alloy	> 225 °C	DN>32	Chapter 3, Section 10	X	-	-
				DN≤32		-	X	-
			≤ 225 °C	PBxDN>1500		X	-	-
				PBxDN<1500		-	X	**-**
III	Valves, **(2)** flanges, other components	Steel, cast steel, grey cast iron **(1)** nodular cast iron, copper, copper alloy	**-**	-	Chapter 2, Section 5 Section 6 Section 7 Chapter 3, Section 10	-	-	X

(1) *No material test in the case of grey cast iron*
(2) *Casings of valves and pipe branches fitted on the ship sides are to be included in Pipe Class II*
(3) *Nominal diameter*
(4) *Maximum allowable working pressure [bar]*

Table 8.3a Design pressure for fuel pipes

Max. working temperature / Max.working pressure	T≤60°C	T>60°C
PB≤7 bar	3 bar or max. working pressure, whichever is greater	3 bar or max. working pressure whichever is greater
PB>7 bar	Max. working pressure	14 bar or max. working pressure, whichever is greater

4.2 Pressure test prior to installation on board

4.2.1 All Class I and II pipes as well as steam lines, feedwater pressure pipes, compressed air and fuel lines having a design pressure PR greater than 3,5 bar together with their integral fittings, connecting pieces, branches and bends, after completion of manufacture but before insulation and coating, is this is provided, shall be subjected to a hydraulic pressure test in the presence of the Surveyor at the following value of pressure:

$$p_p = 1{,}5 \cdot p_c \ \text{[bar]}$$

where p_c is the design pressure. For steel pipes and their integral fittings intended to be used in systems with working temperature above 300 °C the test pressure PP is to be as follows:

$$p_p = \frac{1{,}5 \cdot \sigma_{perm}(100°)}{\sigma_{perm}(t)} \cdot p_c$$

where

σ_{perm} (100°) = allowable stress at 100°C

σ_{perm} (t) = allowable stress at the design temperature t (°C)

However, the test pressure need not exceed:

$p_p = 2 \cdot p_c$ [bar]

With the approval of the TL, this pressure may be reduced to 1,5 p_c where it is necessary to avoid excessive stress in way of bends, T-pieces and other fittings.

In no case may the membrane stress exceed 90% of the yield strength or 0,2% of the maximum elongation.

4.2.2 Pipe connections on the ship’s side are subject to a hydraulic test with a pressure of at least 5 bar.

4.2.3 Where for technical reasons it is not possible to carry out complete hydraulic pressure tests on all sections of piping before assembly on board, proposals are to be submitted for approval to the TL for testing pipe connections carried out on board, particularly in respect of welding seams.

4.2.4 When the hydraulic pressure test of piping is carried out on board, these tests may be conducted in conjunction with the tests required under 4.3.

4.2.5 Pressure testing of pipes with a nominal diameter less than 15 mm. may be omitted at the TL's discretion depending on the application.

4.3 Test after installation on board

4.3.1 After assembly on board, all pipe lines covered by these Rules are to be subjected to a tightness test in the presence of a TL Surveyor.

In general, all pipe systems are to be tested for leakage under operational conditions. If necessary, special techniques other than hydraulic pressure tests are to be applied.

4.3.2 Heating coils in tanks and pipe lines for liquid or gas fuels are to be tested to not less than 1,5 PR but in no case less than 4 bar.

4.4 Pressure testing of valves

The following valves are to be subjected in the manufacturer's works to a hydraulic pressure test in the presence of a TL Surveyor:

- Valves of pipe classes I and II to 1,5 PR,
- Valves on the ship's side to not less than 5 bar.

Shut-off devices of the above type are to be additionally tested for tightness with the nominal pressure.

Shut-off devices for boilers, see Section 15, E.10.

5. Structural Tests, Heat Treatment and Non-Destructive Testing

Attention should be given to the workmanship in construction and installation of the piping systems according to the approved data in order to obtain the maximum efficiency in service. For details concerning structural tests and tests following heat treatments, see TL Rules Chapter 2 and 3 - Materials and Welding.

C. Calculation of Wall Thickness and Elasticity

1. Minimum Wall Thickness

1.1 The pipe thickness stated in Tables 8.5 8.7 are the assigned minimum thicknesses, unless due to stress analysis, see 2, greater thicknesses are necessary.

Provided that the pipes are effectively protected against corrosion, the wall thicknesses of group M and D stated in Table 8.5 may with the TL's agreement be reduced by up to 1 mm, the amount of the reduction is to be in relation to the wall thickness.

Protective coatings, e.g. hot-dip galvanizing, can be recognized as an effective corrosion protection provided that the preservation of the protective coating during installation is guaranteed.

For steel pipes the wall thickness group corresponding to the laying position is to be as stated in Table 8.4.

Table 8.4 Minimum wall thickness group of steel pipes and approved locations

<table>
<tr><th rowspan="2">Piping system</th><th colspan="14">Installation position</th></tr>
<tr><th>Machinery spaces</th><th>Cofferdams / void snaces</th><th>Cargo holds</th><th>Ballast water tanks</th><th>Fuel and changeover tanks</th><th>Fresh cooling water tanks</th><th>Lubricating oil tanks</th><th>Hydraulic oil tanks</th><th>Drinking water tanks</th><th>Condensate and feedwater tanks</th><th>Living quarters</th><th>Fuel pump rooms</th><th>Weather deck</th><th>Ammunition stores</th></tr>
<tr><td>Bilge lines</td><td rowspan="3">M</td><td rowspan="12">M</td><td>M</td><td>D</td><td rowspan="3">D</td><td rowspan="5">X</td><td rowspan="4">X</td><td rowspan="4">X</td><td rowspan="8">X</td><td rowspan="5">X</td><td>M</td><td rowspan="2">M</td><td>-</td><td>-</td></tr>
<tr><td>Ballast lines</td><td rowspan="3">D</td><td rowspan="2">M</td><td>X</td><td rowspan="11">N</td><td rowspan="11">N</td></tr>
<tr><td>Seawater lines</td><td>M(2)</td><td>M</td></tr>
<tr><td>Fuel lines</td><td rowspan="9">N</td><td>D</td><td>N</td><td rowspan="2">X</td><td rowspan="4"></td></tr>
<tr><td>Lubricating lines</td><td>-</td><td>X</td><td>X</td><td>N</td><td rowspan="3">-</td></tr>
<tr><td>Steam lines</td><td rowspan="7">M</td><td rowspan="2">M</td><td rowspan="2">M</td><td rowspan="2">M</td><td rowspan="2">M</td><td rowspan="3">N</td><td rowspan="2">N</td></tr>
<tr><td>Condensate lines</td></tr>
<tr><td>Feedwater lines</td><td rowspan="3">X</td><td rowspan="2">X</td><td rowspan="2">X</td><td rowspan="2">X</td><td rowspan="3">X</td><td>X</td><td rowspan="2">X</td></tr>
<tr><td>Drinking water lines</td><td>N</td><td rowspan="4">X</td><td>N</td></tr>
<tr><td>Fresh cooling water lines</td><td>D</td><td>N</td><td>D</td><td rowspan="3">X</td><td>X</td><td>-</td></tr>
<tr><td>Compressed air lines</td><td rowspan="2">M</td><td rowspan="2">M</td><td>M</td><td>M</td><td rowspan="2">N</td><td>N</td><td rowspan="2">N</td></tr>
<tr><td>Hydraulic lines</td><td>X</td><td>X</td><td>X</td></tr>
</table>

(1) *Only for steel pipes*
(2) *Seawater discharge lines, see 8., T*
x *Pipelines are not to be installed.*
(-) *Pipelines may be installed after special agreement with TL.*

Table 8.5 Minimum wall thickness for steel pipes

Group N				Group M		Group D	
d_a [mm]	s [mm]	d_a [mm]	s [mm]	d_a [mm]	s [mm]	d_a [mm]	s [mm]
< 10,2	1,6	≥ 406,4	6,3	≥ 21,3	3,2	≥ 38,0	6,3
≥ 13,5	1,8	≥ 660,0	7,1	≥ 38,0	3,6	≥ 88,9	7,1
≥ 20,0	2,0	≥ 762,0	8,0	≥ 51,0	4,0	≥ 114,3	8,0
≥ 48,3	2,3	≥ 864,0	8,8	≥ 76,1	4,5	≥ 152,4	8,8
≥ 70,0	2,6	≥ 914,0	10,0	≥ 177,8	5,0	≥ 457,2	8,8
≥ 88,9	2,9			≥ 193,7	5,4		
≥ 114,3	3,2			≥ 219,1	5,9		
≥ 133,0	3,6			≥ 244,5	6,3		
≥ 152,4	4,0			≥ 660,4	7,1		
≥ 177,8	4,5			≥ 762,0	8,0		
≥ 244,5	5,0			≥ 863,6	8,8		
≥ 323,9	5,6			≥ 914,4	10,0		

1.2 The minimum wall thicknesses for austenitic stainless steel pipes are given in Table 8.6.

Table 8.6 Minimum wall thicknesses for austenitic stainless steel pipes

Pipe outside diameter	Minimum wall thickness
d_a [mm]	s [mm]
up to 17,2	1,0
up to 48,3	1,6
up to 88,9	2,0
up to 168,3	2,3
up to 219,1	2,6
up to 273,0	2,9
up to 406,0	3,6
over 406,0	4,0

Table 8.7 Minimum wall thicknesses for copper and copper alloy pipes

Pipe outside diameter d_a [mm]	Minimum wall thickness s [mm]	
	Copper	Copper alloys
8,0 - 10,0	1,0	0,8
12,0 - 20,0	1,2	1,0
25,0 - 44,5	1,5	1,2
50,0 - 76,1	2,0	1,5
88,9 - 108,0	2,5	2,0
133,0 - 159,0	3,0	2,5
193,7 - 267,0	3,5	3,0
273,0 - 457,2	4,0	3,5
(470)	4,0	3,5
508	4,5	4,0

1.3 For the minimum wall thickness of air, sounding and overflow pipes through weather decks, see R, Table 8.19.

For CO_2 fire extinguishing pipelines, see Section 9, Table 9.3.

1.4 Where the application of mechanical joints results in reduction in pipe wall thickness (bite type rings or other structural elements) this is to be taken into account in determining the minimum wall thickness.

2. Calculation of Pipe Wall Thicknesses

2.1 The following formula is to be used for calculating the wall thicknesses of cylindrical pipes and bends subject to internal pressure:

$$s = s_o + c + b \text{ [mm]} \quad \textbf{(1)}$$

$$s_o = \frac{d_a \cdot p_c}{20 \cdot \sigma_{perm} \cdot v + p_c} \text{ [mm]} \quad \textbf{(1a)}$$

s = Minimum thickness (see 2.7) [mm]

s_o = Calculated thickness [mm]

d_a = Outer diameter of pipe [mm]

p_c = Design pressure (see B.4.1.4) **(2)** [bar]

σ_{perm} Maximum allowable design stress (see 2.3). [N/mm^2]

b = Allowance for bends (see 2.2) [mm]

v = Weld efficiency factor (see 2.5) [-]

c = Corrosion allowance (see 2.6) [mm].

2.2 For straight cylindrical pipes which are to be bent, an allowance b shall be applied for the bending of the pipes. The value of b shall be such that the stress due to the bending of the pipes does not exceed the maximum allowable design stress σ_{perm}. The allowance b can be determined as follows:

(2) *For pipes containing fuel heated above 60°C the design pressure is to be taken not less than 14 bar.*

$$b = 0{,}4 \cdot \frac{d_a}{R} \cdot s_o \qquad (2)$$

R = Bending radius [mm].

2.3 Permissible stress: σ_{perm}

2.3.1 Steel pipes

The permissible stress σ_{perm} to be considered in formula (1a) is to be chosen as the **lowest** of the following values using the safety factors A and B according to Table 8.9:

a) Design temperature ≤ 350 °C

$\frac{R_{m,20°}}{A}$ where $R_{m,20°}$ = Specified minimum tensile strength at room temperature [N/mm^2],

$\frac{R_{eH,t}}{B}$ where $R_{eH,t}$ = Specified minimum yield stress at design temperature t [N/mm^2],

or

$\frac{R_{p0,2,t}}{B}$ where $R_{p0,2,t}$ = Minimum value of the 0,2 % proof stress at design temperature t [N/mm^2]

b) Design temperature > 350 °C, whereby it is to be checked whether the calculated values according to a) give the decisive smaller value

$\frac{R_{m100000}}{B}$ where $R_{m100000,t}$ = Minimum stress to produce rupture in 100000 hours at the design temperature t

$R_p 1\% 100\,000, t$ = Mean value of the stress to produce 1% creep in 100000 hours at the design temperature t

$R_{m100000(t+15)}$ = Average stress to produce rupture in 100000 hours at the design temperature t plus 15 °C higher than the design temperature t

In the case where neither a) or b) is applicable for pipes which:

- Are covered by a detailed stress analysis acceptable to TL, and

- Are made of material tested by TL ,

TL may, on special application, agree to a safety factor B of 1,6.

2.3.2 Pipes made of metallic materials without a definite yield point

Materials without a definite yield point are covered by Table 8.8. For other materials, the maximum allowable stress is to be stated with TL agreement, but must be at least

$$\sigma_{perm} = \frac{R_{m,t}}{5}$$

where $R_{m,t}$ is the minimum tensile strength at the design temperature.

2.3.3 The mechanical characteristics of materials which are not included in the TL Rules Chapter 2 and 3- Materials and Welding are to be agreed with TL with reference to Table 8.9.

Steel pipes without guaranteed properties may be used only up to a working temperature of 120 °C where the maximum allowable stress σ_{perm}≤80 N/mm^2 will be approved.

2.4 Design temperature

2.4.1 The design temperature is the maximum temperature of the medium inside the pipe. In case of steam pipes, filling pipes from air compressors and starting air lines to internal combustion engines, the design temperature is to be at least 200 °C.

Table 8.8 Allowable stress, σ_{perm} for copper and copper alloys (annealed)

Pipe material		Minimum tensile strength [N/mm²]	Permissible stress σ_{perm} [N/mm²]										
			50 °C	75 °C	100 °C	125 °C	150 °C	175 °C	200 °C	225 °C	250 °C	275 °C	300 °C
Copper		215	41	41	40	40	34	27,5	18,5	-	-	-	-
Aluminum brass Cu Zn 20 Al		325	78	78	78	78	78	51	24,5	-	-	-	-
Copper nickel alloys	Cu Ni 5 Fe Cu Ni 10 Fe	275	68	68	67	65,5	64	62	59	56	52	48	44
	Cu Ni 30 Fe	365	81	79	77	75	73	71	69	67	65,5	64	62

Table 11.10 Coefficients A, B for determining the allowable stress σ_{perm}

Material \ Pipe class	I		II,III	
	A	B	A	B
Unalloyed and alloyed carbon steel	2,7	1,6	2,7	1,8
Rolled and forged stainless steel	2,4	1,6	2,4	1,8
Steel with yield strength **(1)** > 400 N/mm²	3,0	1,7	3,0	1,8
Grey cast iron	-	-	11,0	-
Nodular cast iron	-	-	5,0	3,0
Cast steel	3,2	-	4,0	-

(1) *Minimum yield strength or minimum 0,2 % proof stress at 20 °C.*

2.5 Weld efficiency factor v

- For seamless pipes v = 1,0
- For welded pipes, the value of v is to be taken equal to that assigned at the works acceptance test approved by TL.

2.6 Corrosion allowance, c

The corrosion allowance c depends on the application of the pipe, in accordance with Tables 8.10a and 8.10b. With the agreement of TL, the corrosion allowance of steel pipes effectively protected against corrosion may be reduced by not more than 50 %.

With agreement of TL, no corrosion allowance need be applied to pipes made of corrosion-resistant materials (e.g. austenitic steels and copper alloys) (see Table 8.6 and 8.7).

2.7 Tolerance allowance t

The negative manufacturing tolerances on the thickness according to the standards of the technical terms of delivery are to be added to the calculated wall thickness s_o and specified as the tolerance allowance t. The value of t may be calculated as follows:

$$t = \frac{a}{100 - a} \cdot s_o \ \text{[mm]} \qquad \textbf{(3)}$$

where

a = Negative tolerance on the thickness, [%]

s_o = Calculated wall thickness according to 2.1 [mm].

Table 8.10a Corrosion allowance c for carbon steel pipes

Type of piping system	Corrosion allowance c [mm]
Saturated steam lines	0,8
Steam heating coils inside tanks	2,0
Feedwater lines: - in closed circuit systems - in open circuit systems	 0,5 1,5
Boiler blow-down lines	1,5
Compressed air lines	1,0
Hydraulic oil lines, lubricating oil lines	0,3
Fuel lines	1,0
Refrigerant lines for Group 1 refrigerants	0,3
Seawater lines	3,0
Fresh water lines	0,8

Table 8.10b Corrosion allowance c for non-ferrous metals

Pipe material	Corrosion allowance c [mm]
Copper, brass and similar alloys	0,8
Copper-tin alloys except those containing lead	
Copper nickel alloys (with Ni ≥ 10 %)	0,5

3. Analysis of elasticity

3.1 The forces, moments and stresses caused by impeded thermal expansion and contraction are to be calculated and submitted to TL for the following piping systems for approval:

- Steam pipes with working temperatures above 400 °C;

- Pipes with working temperatures below -110 °C.

3.2 Only approved methods of calculation may be applied. The change in elasticity of bends and fittings due to deformation is to be taken into consideration.

Procedure and principles of methods as well as the technical data are to be submitted for approval. TL reserves the right to perform confirmatory calculations.

For determining the stresses, the hypothesis of the maximum shear stress is to be considered. The resulting comparison of stress of primary loads due to internal pressure and the dead weight of the piping system itself (gravitational forces) may not exceed the maximum allowable stress according to 2.3. The equivalent stresses obtained by adding together the above-mentioned primary forces and the secondary forces due to impeded expansion or contraction may not exceed the mean low cycle fatigue value or the mean time yield limit in 100 000 hours, whereby for fittings such as bends, T-connections, headers etc. approved stress increase factors are to be considered.

4. Fittings

Pipe branches may be dimensioned according to the equivalent surface areas method where an appropriate reduction of the maximum allowable stress as specified in 2.3 is to be proposed. Generally, the maximum allowable stress is equal to 70 % of the value according to 2.3 for diameters over 300 mm. Below this figure, a reduction to 80 % is sufficient. Where detailed stress measuring, calculations or type approvals are available, higher stresses can be permitted.

5. Calculation of Flanges

Flange calculations by a recognized method and using the permitted stress specified in 2.3 are to be submitted if flanges do not correspond to a recognized standard, if the standards do not provide for conversion to working conditions or where there is a deviation from the standards.

Flanges in accordance with standards in which the value of the relevant stresses or the material are specified may be used at higher temperatures up to the following pressure:

$$p_{perm} = \frac{\sigma_{perm\ standard}}{\sigma_{perm\ (t,\, material)}} \cdot p_{standard}$$

where;

σ_{perm} (t, material) = Allowable stress according to 2.3 for proposed material at design temperature t,

$\sigma_{perm\ standard}$ = Allowable stress according to 2.3 for the material at the temperature corresponding to the strength data specified in the standard,

$p_{standard}$ = Nominal pressure PN specified in the standard.

D. Principles for the Construction of Pipe Lines, Valves, Fittings and Pumps

1. General Principles

1.1 Pipe lines are to be constructed and manufactured on the basis of standards generally used in shipbuilding.

1.2 Welded connections rather than detachable couplings should be used for pipe lines carrying toxic media and inflammable liquefied gases as well as for superheated steam pipes with temperatures exceeding 400 °C.

1.3 Expansion in piping systems due to heating and shifting of their suspensions caused by deformation of the ship are to be compensated by bends, compensators and flexible pipe connections. The arrangement of suitable fixed points is to be taken into consideration

1.4 Where pipes are protected against corrosion by special protective coatings, e.g. hot-dip galvanising, rubber lining etc., it is to be ensured that the protective coating will not be damaged during installation.

2. Pipe Connections

2.1 The following pipe connections may be used:

- Fully penetrating butt welds with/without provision to improve the quality of the root,
- Socket welds with suitable fillet weld thickness and possibly in accordance with recognized standards,
- Steel flanges may be used in accordance with the permitted pressures and temperatures specified in the relevant standards,
- Mechanical joints (e.g pipe unions, pipe couplings, press fittings) of approved type.

For the use of these pipe connections, see Table 8.11.

Table 8.11 Pipe connections

Types of connections	Pipe class	Outside diameter d_a
Welded butt-joints with special provisions for root side	I,II,III	all
Welded butt-joints without special provisions for root side	II,III	
Socket weld	III	≤ 60,3
	II	

2.2 Flange connections

2.2.1 Dimensions of flanges and bolting shall comply with recognized standards.

2.2.2 Gaskets are to be suitable for the intended media under design pressure and temperature conditions and their dimensions and construction shall be in accordance with recognized standards.

2.2.3 Steel flanges may be used as shown in Tables 8.15 and 8.16 in accordance with the permitted pressures and temperatures specified in the relevant standards.

2.2.4 Flanges made of non-ferrous metals may be used in accordance with the relevant standards and within the limits laid down in the approvals. Flanges and brazed or welded collars of copper and copper alloys are subject to the following requirements:

- Applicable to all classes of pipes:

  Welding neck flanges according to standard up to 200 °C or 300 °C according to the maximum temperatures indicated in Table 8.8; loose flanges with welding neck

- Only for pipe class III up to a nominal pressure of 16 bar and a temperature of 120 °C:

  Plain brazed flanges

2.2.5 Flange connections for pipe classes I and II with temperatures over 300 °C are to be provided with necked-down bolts.

2.3 Welded socket connections

2.3.1 Welded socket connections may be accepted according to Table 8.11. The following conditions are to be observed:

- The thicknessses of the sockets are to be in accordance with C.1.1, yet at least equal to the thicknesses of the pipes,

- The clearance between the pipes and the sockets is to be as small as possible,

- The use of socket welded connections in systems of pipe class II may be accepted only under the condition that in the systems no excessive stress, erosion and corrosion are expected.

2.4 Screwed socket connections

2.4.1 Screwed socket connections with parallel and tapered threads shall comply with requirements of recognized national or international standards.

2.4.2 Screwed socket connections with parallel threads are permitted for pipes in class III with an outside diameter ≤ 60,3 mm. as well as for subordinate systems e.g. sanitary and hot water heating systems. They are not permitted for systems for flammable media.

2.4.3 Screwed socket connections with tapered threads are permitted for the following:

- Class I, outside diameter not more than 33,7 mm.

- Class II and class III, outside diameter not more than 60,3 mm.

Screwed socket connections with tapered threads are not permitted for piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur.

2.5 Brazed connections may be used after special approval by TL.

2.6 Mechanical joints

2.6.1 Type approved mechanical joints **(3)** may be used as shown in Tables 8.12 to 8.14.

(3) *See also TL "List of Type-Tested Appliances and Equipment" (for details see TL homepage: www.turkloydu.org).*

Table 8.12 Examples of mechanical joints

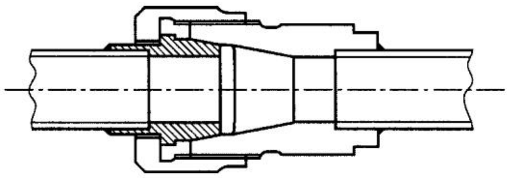
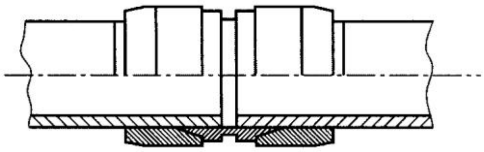
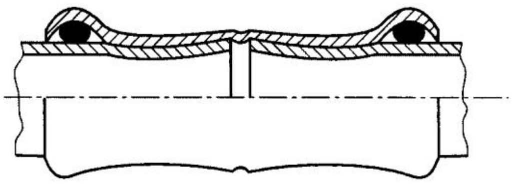
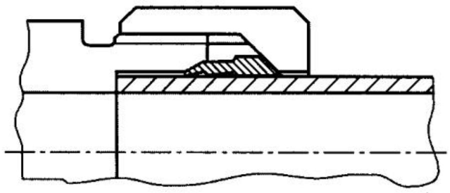
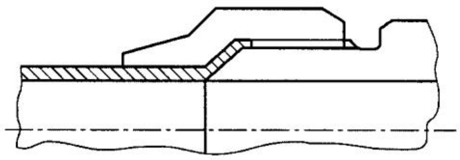
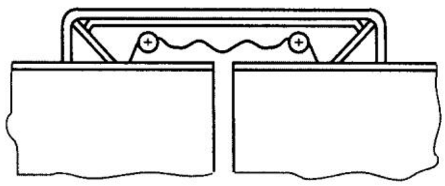
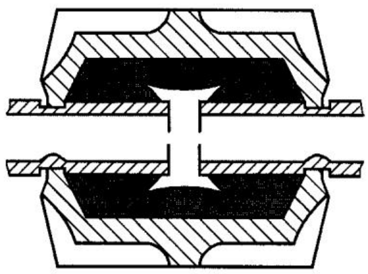
Pipe Unions	
Welded and brazed type	
Compression Couplings	
Swage type	
Press type	
Bite type	
Flared type	
Slip-on Joints	
Grip type	
Machine grooved type	

Table 8.12 Examples of mechanical joints (continued)

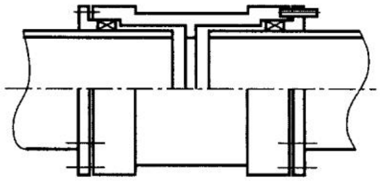
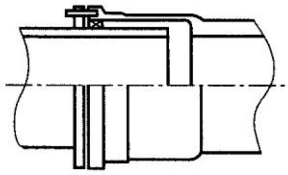
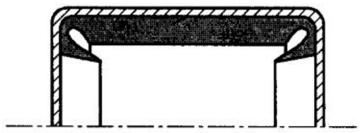
Slip type	  

Table 8.13 Application of mechanical joints

Systems	Kind of connections		
	Pipe Unions	Compression couplings (6)	Slip-on joints
Flammable joint (flash points <60°C)			
Cargo oil lines	+	+	+ **(5)**
Crude oil washing lines	+	+	+ **(5)**
Vent lines	+	+	+ **(3)**
Inert gas			
Water steal effluent lines	+	+	+
Scrubber effluent lines	+	+	+
Main lines	+	+	+ **(2) (5)**
Distributions lines	+	+	+ **(5)**
Flammable fluids (Flash point > 60°C)			
Cargo oil lines	+	+	+ **(5)**
Fuel oil lines	+	+	+ **(2) (3)**
Lubricating oil lines	+	+	+ **(2) (3)**
Hydraulic oil	+	+	+ **(2) (3)**
Thermal oil	+	+	+ **(2) (3)**
Sea Water			
Bilge lines	+	+	+ **(1)**
Fire main and water spray	+	+	+ **(3)**
Foam system	+	+	+ **(3)**
Sprinkler system	+	+	+ **(3)**
Ballast system	+	+	+ **(1)**
Cooling water system	+	+	+ **(1)**
Tank cleaning services	+	+	+
Non-essential systems	+	+	+

Table 8.13 Application of mechanical joints (continued)

Systems	King of connections		
	Pipe Unions	Compression couplings (6)	Slip-on joints
Fresh water			
Cooling water system	+	+	+ **(1)**
Condensate return	+	+	+ **(1)**
Non-essential system	+	+	+
Sanitary/Drains/Scuppers			
Deck drains (internal)	+	+	+ **(4)**
Sanitary drains	+	+	+
Scuppers and discharge (overboard)	+	+	-
Sounding / Vent			
Water tanks/ Dry spaces	+	+	+
Oil tanks (F.p. > 60°C)	+	+	+ **(2) (3)**
Miscellaneous			
Starting /Control air **(1)**	+	+	-
Service air (non-essential)	+	+	+
Brine	+	+	+
CO_2 system **(1)**	+	+	-
Steam	+	+	-

Abbreviations :

+ Application is allowed

- Application is not allowed

Footnotes:

(1) *Inside machinery spaces (main spaces) acc. to Chapter 1, Section 20, A.2.3 only approved of fire resistant types.*

(2) *Not inside machinery spaces (main spaces) or accommodation spaces acc. to Chapter 1, Section 20 A.2.2. May be accepted in other machinery spaces provided the joint are located in easily visible and accessible positions.*

(3) *Approved fire resistant types*

(4) *Above freeboard 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.*

Table 8.14 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 type	+ (d_a ≤ 60,3 mm)	+ (d_a ≤ 60,3 mm)	+
Compression Couplings			
Stage-type	+	+	+
Press type	-	-	+
Bite type Flared type	+ (d_a ≤ 60,3 mm)	+ (d_a ≤ 60,3 mm)	+
Slip-on Joints			
Machine grooved type	+	+	+
Grip type	-	+	+
Slip type	-	+	+

Abbreviations :

+ Application is allowed

- Application is not allowed

Table 8.15 Use of flange types

Pipe class	Toxic, corrosive and combustible media, liquefied gases (LG)		Steam, thermal oils		Lubricating oil, fuel oil	Other media	
	PR [bar]	Type of flange	Temperature [°C]	Type of flange	Type of flange	Temperature [°C]	Type of flange
I	> 10 ≤ 10	A A,B **(1)**	> 400 ≤ 400	A A,B **(1)**	A,B	> 400 ≤ 400	A A,B
II	-	A,B,C	> 250 ≤ 250	A,B,C A,B,C,D,E	A,B,C,E **(2)**	> 250 ≤ 250	A,B,C A,B,C,D,E
III	-	-	-	A,B,C,D,E	A,B,C,E	-	A,B,C,D,E,F **(3)**

(1) *Type B only for d_a < 150 mm*
(2) *Type E only for t < 150°C and PR < 16 bar*
(3) *Type F only for water pipes and open-ended lines*

2.6.2 Mechanical joints in bilge and seawater systems within machinery spaces or spaces of high fire risk, e.g. cargo pump rooms and car decks, must be flame resistant.

2.6.3 Mechanical joints are not to be used in piping sections directly connected to sea openings or tanks containing flammable liquids.

2.6.4 The use of mechanical joints is not permitted in:

- Bilge lines inside ballast and fuel tanks,
- Seawater and ballast lines including air and overflow pipe inside cargo holds and fuel tanks,
- Fuel and oil lines including air and overflow pipes inside machinery spaces, cargo holds and ballast tanks,
- Non water filled pressure water spraying systems (dry pipe systems)

Mechanical joints inside tanks may be permitted only if the pipes contain the same medium as the tanks.

Unrestrained slip on joints may be used only where required for compensation of lateral pipe movement.

3. Layout, Marking and Installation

3.1 Piping systems must be adequately identified according to their purpose. Valves are to be permanently and clearly marked.

3.2 Pipe leading through bulkheads and tank walls must be water and oil tight. Bolts through bulkheads are not permitted. Holes for set screws may not be drilled in the tank walls.

3.3 Pipe penetrations through watertight bulkheads and decks as well as through fire divisions which are not welded are to be approved by TL.

3.4 Piping systems close to electrical switch-boards must be so installed or protected that possible leakage cannot damage the electrical installation.

3.5 Piping systems are to be so arranged that they can be completely emptied, drained and vented. Piping systems in which the accumulation of liquids during operation could cause damage must be equipped with special drain arrangements.

3.6 Pipes lines laid through ballast tanks, which are coated in accordance with Chapter 102, Hull Structures and Equipment, Section 3 are to be either effectively protected against corrosion or they are to be of low susceptibility to corrosion.

The protection against corrosion of the tanks as well as that of the pipes must be compatible to each other.

3.7 The wall thickness of pipes between ship's side and first shut-off device is to be in accordance with Table 8.20 column B. Pipes are to be connected by welding or by flanges.

4. Shut-off Devices

4.1 Shutoff devices must comply with a recognized standard. Valves with screwed-on covers are to be secured to prevent unintentional loosening of the cover.

4.2 Hand-operated shut-off devices are to be closed by turning in the clockwise direction.

4.3 Valves must be clearly marked to show whether they are in the open or closed position.

4.4 Change-over devices in piping systems in which a possible intermediate position of the device could be dangerous in service must not be used.

4.5 Valves are to be permanently marked. The marking must comprise at least the following details:

- Material of valve body,
- Nominal diameter,
- Nominal pressure.

5. Ship's Side Valves

5.1 For the mounting of valves on the ship's side, see Chapter 102, Hull Structures and Ship Equipment, Section 7, B.

5.2 Ship's side valves shall be easily accessible. Seawater inlet and outlet valves must be capable of being operated from above the floor plates. Cocks on the ship's side must be so arranged that the handle can only be removed when the cock is closed.

5.3 Valves with only one flange may be used on the ship's side and on the sea chests only after special approval.

5.4 Where discharge pipes are connected to the ship's hull below the freeboard deck without shut-off devices, their wall thicknesses are to be in accordance with Table 8.20, column B

6. Remote Controlled Valves

6.1 Scope

These Rules apply to hydraulically, pneumatically or electrically operated valves in piping systems and sanitary discharge pipes.

6.2 Construction

Remote controlled bilge valves and valves important to the safety of the ship are to be equipped with an emergency operating arrangement.

6.3 Arrangement of valves

6.3.1 The accessibility of the valves for maintenance and repairing is to be taken into consideration.

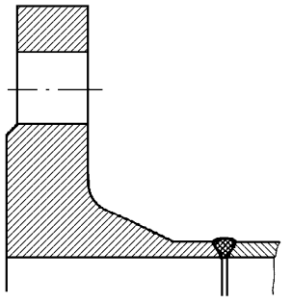
Valves in bilge lines and sanitary pipes must always be accessible.

6.3.2 Bilge lines

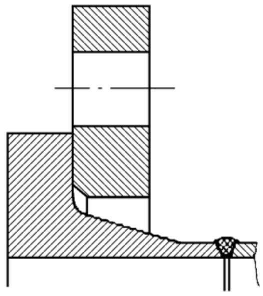
Valves and control lines are to be located as far as possible from the bottom and sides of the ship.

Table 8.16 Types of flange connections

Type A

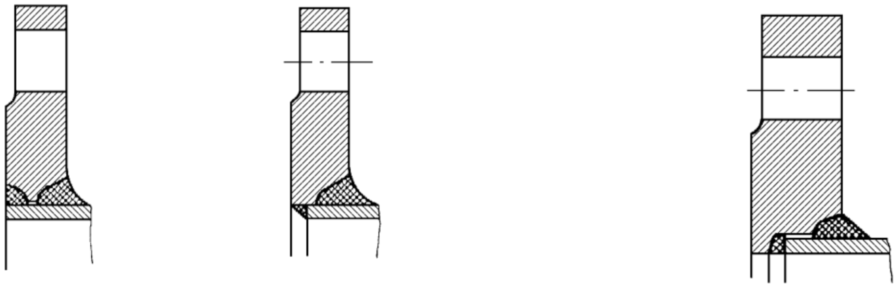


Welding neck flange



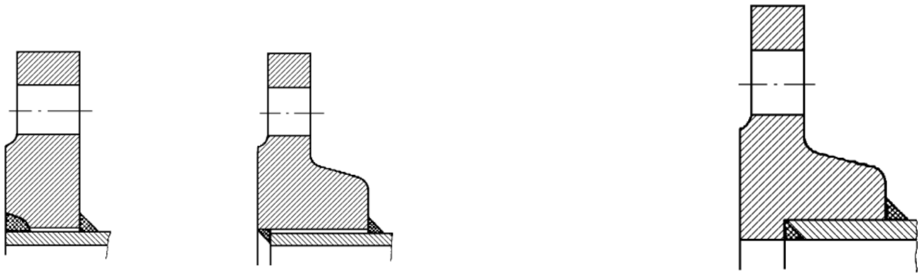
Loose flange with welding neck

Type B



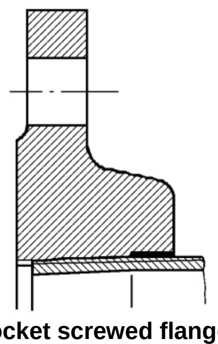
Slip-on welding flange-fully welded

Type C



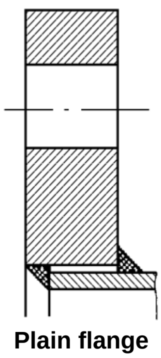
Slip-on welding flange

Type D



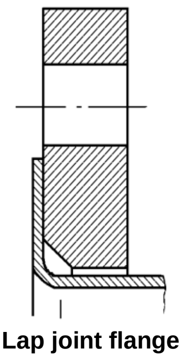
Socket screwed flange
- conical threads -

Type E



Plain flange
- welded on both sides -

Type F



Lap joint flange
- on flanged pipe -

6.3.3 Ballast Pipes

The requirements stated in 6.3.2 also apply here to the location of valves and control lines.

Where remote controlled valves are arranged inside the ballast tanks, the valves should always be located in the tank adjoining that to which they relate.

6.3.4 Fuel pipes

Remote controlled valves mounted on fuel tanks located above the double bottom must be capable of being closed from outside the compartment in which they are installed See also G.2.1 and I.2.2.

If remote controlled valves are installed inside fuel or oil tanks, 6.3.3 has to be applied accordingly.

6.3.5 Bunker lines

Remote controlled shut-off devices mounted on fuel tanks shall not be automatically closed in case the power supply fails, unless suitable arrangements are provided, which prevent inadmissible pressure rise in the bunker line during bunkering.

6.4 Control stands

6.4.1 The control devices of remote controlled valves are to be arranged together in one control stand.

6.4.2 The control devices are to be clearly and permanently identified and marked.

6.4.3 It must be recognized at the control stand whether the valves open or closed.

In the case of bilge valves and valves for changeable tanks, the closed position is to be indicated by limit-position indicators approved by TL.

6.4.4 The control devices of valves for changeable tanks are to be interlocked to ensure that only the valve relating to the tank concerned can be operated.

6.5 Power units

6.5.1 Power units are to be equipped with at least two independent sets for supplying power for remote controlled valves.

6.5.2 The energy required for the closing of valves which are not closed by spring power is to be supplied by a pressure accumulator.

6.5.3 Pneumatically operated valves can be supplied with air from the general compressed air system.

Where the quick-closing valves of fuel tanks are closed pneumatically, a separate pressure accumulator is to be provided. This is to be of adequate capacity and is to be located outside the engine room. Filling of this accumulator by a direct connection to the general compressed air system is allowed. A non-return valve is to be arranged in the filling connection of the pressure accumulator.

The accumulator is to be provided either with a pressure control device with a visual and acoustic alarm or with a hand-compressor as a second filling appliance.

The hand-compressor is to be located outside the engine room.

6.6 After installation on board, the entire system is to be subjected to an operational test.

7. Pumps

7.1 For materials and construction requirements the TL Rules - Guidelines for the Design, Construction and Testing of Pumps are to be applied.

7.2 For the pumps listed below, a performance test is to be carried out in the manufacturer's works under the TL supervision:

- Bilge pumps/bilge ejectors,

- Ballast pumps,
- Cooling sea water pumps,
- Cooling fresh water pumps,
- Fire pumps
- Emergency fire pumps including drive units,
- Condensate pumps,
- Boiler feedwater pumps,
- Boiler water circulating pumps,
- Lubricating oil pumps,
- Fuel oil booster and transfer pumps,
- Brine pumps,
- Refrigerant circulating pumps,
- Cooling pumps for fuel injection valves,
- Hydraulic pumps for controllable pitch propellers.

Other hydraulic pumps/motors, see Section 14.

8. Protection of Piping Systems Against Over-pressure

The following piping systems are to be fitted with safety valves to avoid unallowable overpressures:

- Piping systems and valves in which liquids can be enclosed and heated;
- Piping systems which may be exposed in service to pressures in excess of the design pressure.

Safety valves must be capable of discharging the medium at a maximum pressure increase of 10 % of the allowable working pressure. Safety valves are to be fitted on the low pressure side of reducing valves.

9. Piping on ships with character of classification mark + or [+]

9.1 The following Rules apply additionally to ships for which proof of buoyancy in damaged condition is provided, see also Chapter 102 – Hull Structures and Ship Equipment, Section 2, C.

9.2 Chapter 102 - Hull Structures and Ship Equipment, Section 19, E. is to be additionally applied for scuppers and discharge lines, Chapter 102 - Hull Structures and Ship Equipment, Section 19, F. is to be additionally applied for vent, overflow and sounding pipes.

9.3 For pipe penetrations through watertight bulkheads, see Chapter 102 - Hull Structures and Ship Equipment, Section 9, B.

9.4 Pipelines with open ends in compartments or
tanks are to be laid out so that no additional compartments or tanks can be flooded in any damaged condition to be considered.

9.5 Where shutoff devices are arranged in cross flooding lines of ballast tanks, the position of the valves is to be indicated on the bridge.

9.6 For sewage discharge pipes, see T.2.

9.7 Tightness of bulkheads

9.7.1 Where it is impossible to lay pipes outside the damaged zone, the tightness of the bulkheads is to be ensured by applying the provisions in 9.7.1 to 9.7.6.

9.7.2 In bilge pipelines, a non-return valve is to be fitted either on the watertight bulkhead through which the pipe passes to the bilge suction or at the bilge suction itself.

9.7.3 In ballast water and fuel pipelines for the filling and emptying of tanks, a shut-off valve is to be fitted either at the watertight bulkhead through which the pipe leads to the open end in the tank or directly at the tank.

9.7.4 The shut-off valves required in 9.7.3 must be capable of being operated from a control panel located on the bridge or at the machinery control centre (MCC), where it must be indicated when the valves are in the "closed" position. This requirement does not apply to valves which are opened at sea only momentarily for supervised operations.

9.7.5 Overflow pipes of tanks in different watertight compartments which are connected to one common overflow system are each.

- To be led, above the most unfavourable damage water line, or

- To be fitted with a shut-off valve. This shut-off valve is to be located at the watertight bulkhead of the relevant compartment and is to be secured in open position to prevent unintended operation. The shut-off valves must be capable of being operated from a control panel located on the navigation bridge, where it must be indicated when the valve is in the "closed" position.

9.7.6 The shut-off valves may be dispensed with if the bulkhead penetrations for these pipes are arranged such that in no damage condition, including temporary maximum heeling of the ship, they will be below the waterline.

E. Steam Lines

1. Operation

Every steam consumer must be capable of being shut off from the system.

2. Calculation of Pipelines

2.1 Steam lines are to be constructed for the design pressure (PR) according to B.4.1.4.

2.2 Calculations of pipe thickness and elasticity analysis in accordance with C. are to be carried out. Sufficient compensation for thermal expansion is to be proven.

3. Laying Out of Steam Lines

3.1 Steam lines are to be so installed and supported that expected stresses due to thermal expansion, external loads and shifting of the supporting structure will be safely compensated, considering both, normal service as well as operating troubles.

3.2 Steam lines are to be so installed that water pockets will be avoided.

3.3 Means are to be provided for the reliable drainage of the piping system.

3.4 Steam lines are to be effectively insulated to prevent heat losses.

Where persons may come into contact with steam lines, the surface temperature of the insulation shall not exceed 80°C.

3.5 Steam heating lines, except for heating purposes, are not be led though the following spaces:

- Accommodations

- Spaces below ammunition rooms

- Spaces where instruments are installed which are sensitive to humidity and increased temperature

- Provision stores

3.6 Sufficiently rigid positions are to be chosen as fixed points for the steam piping systems.

3.7 Steam lines are to be fitted with sufficient expansion arrangements.

3.8 Where a steam system can be supplied from a system with higher pressure, it is to be provided with reducing valves and with relief valves on the low pressure side.

3.9 Welded connections in steam lines are subject to the requirements specified in the TL Rules Chapter 3 - Welding.

4. Steam Strainers

Wherever necessary, machines and apparatus in steam systems are to be protected against foreign matter by steam strainers.

5. Steam connections to equipment and pipes carrying oil, e.g. steam atomizers or steam out arrangements, are to be so secured that fuel and oil cannot penetrate into the steam lines.

F. Boiler Feedwater and Circulating Arrangement, Condensate Recirculation

1. Feedwater pumps

1.1 At least two feedwater pumps are to be provided for each boiler installation.

1.2 Feedwater pumps are to be so arranged or equipped that no backflow of water can occur when the pumps are not in operation.

1.3 Feedwater pumps are not to be used for purposes other than supplying feed water to boilers.

2. Capacity of Feedwater Pumps

2.1 Where two feedwater pumps are provided, the capacity of each is to be equivalent to at least 1,25 times the rated output of all connected boilers.

2.2 Where more than two feedwater pumps are installed, the combined capacity of the remaining feedwater pumps, in the event of the failure of any one pump, is to comply with the requirements of 2.1.

2.3 For continuous flow boilers the capacity of the feedwater pumps is to be at least 1,0 times the rated output of the boiler.

2.4 Special arrangement may be made for the capacity of the feedwater pumps for plants incorporating a combination of oil fired and exhaust gas boilers.

2.5 The required capacity according to 2.1 to 2.4 is to be achieved against the maximum allowable working pressure of the steam producer.

2.6 In case the safety valve is blowing off the delivery capacity is to be 1,0 times the approved steam output at 1,1 times the allowable working pressure.

2.7 The resistances to flow in the piping between the feedwater pump and the boiler are to be taken into consideration. In the case of continuous flow boilers the total resistance of the boiler must be taken into account.

3. Power supply to feedwater pumps

3.1 At least two independent power sources are to be available for the operation of feedwater pumps.

3.2 For steam-driven feedwater pumps, the supply of all the pumps from only one steam system is allowed provided that all the steam producers are connected to this steam system.

3.3 For electric drives, separate supply lines from the common bus-bar to each pump motor are sufficient.

4. Feedwater lines

Feedwater lines may not pass through tanks which do not contain feedwater.

4.1 Feedwater lines for auxiliary steam producers (auxiliary and exhaust gas boilers)

4.1.1 The provision of only one feedwater line for auxiliary and exhaust gas boilers is sufficient if the preheaters and automatic regulating devices are fitted with by-pass lines.

4.1.2 Each feedwater line is to be fitted with a shut-off valve and a check valve at the boiler inlet. Where the shut-off valve and the check valve are not directly connected in series, the intermediate pipe is to be fitted with a drain.

4.1.3 Continuous flow boilers need not be fitted with the valves required according to 5.1.2 provided that the heating of the boiler is automatically switched off should the feedwater supply fail and that the feedwater pump supplies only one boiler.

5. Boiler Water Circulating Systems

5.1 Each forced-circulation boiler is to be equipped with two circulating pumps powered independently of each other. Failure of the circulating pump in operation is to be signalled by an alarm. The alarm may only be switched off if a circulating pump is started or when the boiler firing is shut down.

5.2 The provision of only one circulating pump for each boiler is sufficient if:

- The boilers are heated only by gases whose temperature does not exceed 400 °C; or

- A common stand-by circulating pump is provided which can be connected to any boiler; or

- The burners of oil or gas fired auxiliary boilers are so arranged that they are automatically shut-off should the circulating pump fail and the heat stored in the boiler does not cause any unacceptable evaporation of the available water in the boiler.

6. Feedwater Supply

One storage tank may be considered sufficient for auxiliary boiler units.

7. Condensate Recirculation

7.1 The main condenser is to be equipped with two condensate pumps, each of which must be able to transfer the maximum volume of condensate produced.

7.2 The condensate of all heating systems used to heat oil (fuel, lubricating, cargo oil etc.) is to be led to condensate observation tanks. These tanks are to be fitted with air vents.

7.3 Heating coils of tanks containing fuel or oil residues, e.g. sludge tanks, leak oil tanks, bilge water tanks etc. are to be provided at the tank outlet with shut-off devices and devices for testing the condensate for the presence of oil.

G. Oil Fuel Systems

1. Bunker Lines

The bunkering of oil fuels is to be effected by means of permanently installed lines either from the open deck or from bunkering stations located below deck which are to be isolated from other spaces.

Bunker stations are to be so arranged that the bunkering can be performed from both sides of the ship without danger. This requirement is considered to be fulfilled where the bunkering line is extended to both sides of the ship. The bunkering connections are to be fitted with blank flanges.

2. Tank Fiiling and Suction Lines

2.1 Filling and suction lines from storage, settling and daily service tanks situated above the double bottom and in case of their damage fuel oil may leak, are to be fitted directly on the tanks with shut-off devices capable of being closed from a safe position outside the space concerned.

In the case of deep tanks situated in shaft or pipe tunnel or similar spaces, shut-off devices are to be fitted on the tanks. The control in the event of fire may be effected by means of an additional shutoff device in the pipe outside the tunnel or similar space. If such additional shut-off device is fitted in the machinery space it shall be operated from a position outside this space.

2.2 Shutoff devices on fuel oil tanks having a capacity of less than 500 ℓ need not be provided with remote control.

2.3 Filling lines are to extend to the bottom of the tank. Short filling lines directed to the side of the tank may be approved.

Storage tank suction lines may also be used as filling lines.

2.4 Where filling lines are led through the tank top and end below the maximum oil level in the tank, a non-return valve at the tank top is to be arranged.

2.5 Tank suctions are to be arranged sufficiently away from the drains in the tank so that water and impurities which have settled out will not be aspirated.

2.6 Tanks are to be provided with self-closing valves at their deepest point, for complete emptying or taking samples. Where tanks are arranged at the bottom, a sampling connection is to be provided in the fuel line, behind the pump.

2.7 Where tanks for different fuels (multipurpose) are provided, adequate measures to prevent one fuel grade being contaminated with another one have to be arranged.

3. Pipe Layout

3.1 Fuel lines may not pass through tanks containing feedwater, drinking water, lubricating oil.

3.2 Fuel lines which pass through ballast tanks are to have an increased wall thickness according to Table 8.4.

3.3 Fuel lines may not be laid in the vicinity of boilers, turbines or equipment with high surface temperatures (over 220 °C) or in way of electrical equipment.

3.4 Fuel oil lines shall 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 other surfaces of ignition.

The number of detachable pipe connections is to be limited. In general, flanged connections according to recognized standards shall be used.

3.5 Shut-off valves in fuel lines in the machinery spaces are to be operable from above the floor plates.

3.6 Glass, and plastic components are not permitted in fuel systems.

Sight glasses made of glass located in vertical overflow pipes may be permitted.

3.7 Fuel pumps must be capable of being isolated from the piping system by shut-off valves.

4. Fuel Transfer, Feed and Booster Pumps

4.1 Fuel transfer, feed and booster pumps shall be designed for the proposed operating temperature of the medium pumped.

4.2 A fuel transfer pump is to be provided. Other service pumps may be used as a stand-by pump provided they are suitable for this purpose.

Fuel transfer pumps must be designed for the following functions:

- Filling of the storage tanks, and eventually of the supply tanks
- Transfer from any tank to the transfer connection(s)
- Transferring from a storage tank to a supply tank
- Transferring of fuel from starboard to port and vice-versa, or from fore ship to aft and vice-versa, for changing heel or trim of the ship

4.3 At least two means of oil fuel transfer are to be provided for filling the service tanks.

4.4 Where a feed or booster pump is required to supply fuel to main or auxiliary engines, standby pumps shall be provided. Where, the pumps are attached to the engines, stand-by pumps may be dispensed with for auxiliary engines.

Fuel oil supply for oil fired auxiliary boilers, see Section 17, B.3.

4.5 For emergency shut-down devices, see Section 9, B.7.

5. Plants With More Than One Main Engine

For plants with more than one engine, complete spare feed or booster pumps stored on board may be accepted instead of stand-by pumps provided that the feed or booster pumps are so arranged that they can be replaced with the means available on board.

For plants with more than one main engine, see also Chapter 104 - Propulsion Plants, Section 3,G.

6. Shut-off Devices

6.1 On cargo ships 500 gross tonnage or above and on all passenger ships for plants with more than one engine shut-off devices for isolating the fuel supply and overproduction/recirculation lines to any engine from a common supply system shall be provided. These valves shall be operable from a position not rendered inaccessible by a fire on any of the engines.

6.2 Instead of shut-off devices in the overproduction/recirculation lines check valves may be fitted. Where shut-off devices are fitted, they are to be locked in the operating position.

7. Filters

7.1 Fuel oil filters are to be fitted in the delivery line of the fuel pumps.

7.2 Mesh size and filter capacity are to be in accordance with the requirements of the manufacturer of the engine.

7.3 Uninterrupted supply of filtered fuel has to be ensured under cleaning and maintenance conditions of filter equipment. In case of automatic back-flushing filters, it is to be ensured that a failure of the automatic back-flushing will not lead to a total loss of filtration.

7.4 Back-flushing intervals of automatic back-flushing filters provided for intermittent back-flushing are to be additionally monitored.

7.5 Fuel oil filters are to be fitted with differential pressure control. On engines provided for operation with gas oil only, differential pressure monitoring may be dispensed with.

7.6 Engines for the exclusive operation of emergency generators and emergency fire pumps may be fitted with simplex filters.

7.7 Fuel transfer units are to be fitted with a simplex filter on the suction side.

7.8 Filter arrangement, see Chapter 104, Section 3, G.3.

8. Purifiers

8.1 Manufacturers of purifiers for cleaning fuel and lubricating oil must be approved by TL.

8.2 Where a fuel purifier may exceptionally be used to purify lubricating oil the purifier supply and discharge lines are to be fitted with a change-over arrangement which prevents the possibility of fuel and lubricating oils being mixed.

Suitable equipment is also to be provided to prevent such mixing occurring over control and compression lines.

8.3 The sludge tanks of purifiers are to be fitted with a level alarm.

H. Aircraft Fuel Transfer Installations

1. General

1.1 For storage and handling of aviation fuel on board, separate tank and piping systems are to be provided, which are not connected to other fuel systems of the ship.

The following types of fuel supply systems for aircraft are to be distinguished:

- Fuelling on the landing deck or in the hangar

- Fuelling of helicopters in hovering condition

1.2 These Rules apply to aviation fuel with a flash point of not less than 60 °C (danger class A III).

2. Aviation fuel pumping and fuelling systems

2.1 The following functions are to be met:

- Filling of storage tanks
- Filling of service tanks, from any of the storage tanks, using the transfer pump
- Discharging from any of the tanks via the connections, with the fuel transfer pump
- Transfer of fuel between any of the storage tanks, using the transfer pump
- Fuelling of the aircraft from the service tank, using the fuelling pump
- Use of the transfer pump as emergency fuelling pump, and vice-versa
- De-fuelling of the aircraft tanks by an eductor or a hand pump, or by gravity to the storage tanks
- Flushing of the fuelling hoses to the storage tanks

2.2 The capacity of the fuelling pump and of the de-fuelling eductor/hand pump depends on the required time for fuelling, respectively de-fuelling of the aircraft envisaged. The vent pipes of the fuel tanks are to be considered accordingly.

2.3 Over pressure release is to be safeguarded. Hammering during fuelling, e.g. when shutting-off the pistol, is to be prevented by means of pressure release to the suction side of the pump.

3. Systems for replenishment of aviation fuel at sea

3.1 The pertaining elements such as pumps, pipes, hoses, couplings, etc., are to be designed in accordance with the requirements defined in Section 4 - Equipment for Replenishment at Sea. For the replenishment operations - normally from board to board-aviation fuel transfer connections are to be arranged readily accessible on the open deck. The sockets shall normally be of DN 65 mm.

3.2 The position of the replenishment connections is to be determined in conformity with the other installations for replenishment of liquid fuels. The equipment for fuelling of aircraft is dealt with under 4. to 6.

4. Fuelling and de-fuelling systems on flight deck

4.1 On the flight deck, suitably arranged installa tions for fuelling of aircraft and hovering helicopters are to be provided. When determining the location of the fuelling station, the following requirements are to be observed:

- fuelling must be possible while rotors or propellers are running
- the fuelling connection on the flight deck must be arranged at a position adjusted to the fuelling connection of the aircraft, outside the danger zone of the stern rotor or the propellers or jet nozzles of the aircraft

4.2 The installation consists of the following elements:

- Fuelling coupling with shut-off, flow meter and by-pass line for fuelling/de-fuelling on flight deck
- Hose(s)
- Hose pressure regulator with pressure fuelling connection
- Filling limit valve
- Intermediate hose
- Fuelling pistol
- De-fuelling connection

For fuelling of hovering helicopters:

- Intermediate hose
- Suspension device on deck, with tearing-off coupling (at lower end)
- Hose

- Hose pressure regulator
- Suspension device at the aircraft, with tearing-off coupling (upper end)
- Pressure fuelling connection
- Connection for rinsing via pressure fuelling coupling and gravity fuelling
- Funnel for draining of the fuelling pistol

4.3 The elements of the fuelling system are to be arranged and stored in a well ordered manner and properly protected against ignition and environmental effects.

4.4 Type and manufacturer of the parts are to be decided upon together with the Naval Authority. All elements shall be made of material resistant to sea water.

4.5 Where fuelling in hovering condition is envisaged, the force necessary for tearing-off the coupling shall ensure that the helicopter is not endangered; the tearing-off force for the upper connection shall be larger than for the lower connection.

The couplings shall be so designed that in case of tearing-off the amount of fuel spilled is as small as possible (self-closing fitting) and the elements can be re-assembled easily.

5. Filters and water traps for aviation fuel systems

To achieve sufficient purity and low water content for the aviation fuel, the following systems for treatment are to be provided:

- a filter and water separator in the filling line of the supply tank
- a safety filter in the pressurized line before the fuelling connection

These elements are to be so dimensioned that the following values will not be exceeded:

- content of free water: 5 ppm
- solid residues: 0,5 mg/l

To determine the grade of contamination of the filters, these are to be equipped with suitable differential pressure gauges. The capacities of the conveying and fuelling pumps are to be considered when choosing the filter.

6. Safety systems

6.1 Contents gauging and monitoring systems

6.1.1 The aviation fuel storage and supply tanks are to be equipped with reliable, remote level indicators in the pump room.

Where a data logging installation is provided, the individual measuring stations must be capable of being called/selected from the machinery control centre and damage control centre. Additionally, the aviation fuel tanks shall be equipped with sounding pipes.

6.1.2 For the service tank, a shut-off system is to be provided, which automatically stops the fuelling pump - or the conveying pump if used as emergency fuelling pump - when the fuel level in the tank reaches a defined minimum value.

Furthermore, an installation is to be provided, which stops the conveying pump - or the fuelling pump if used as emergency conveying pump - when the service tank is filled. At the fuelling stations on deck and at the control stand for aircraft handling, an emergency stop switch is to be provided for the fuelling pump and the transfer pump, if used as fuelling pump

6.2 Venting, overflow, water draining and sampling systems

6.2.1 The air and overflow pipes of the aviation fuel storage tanks and the service tank are to be assembled in a control box. From the box, a draining line shall lead to the fuel overflow tank. The venting and overflow pipe of the control box shall be linked with the vent and overflow pipe of the overflow tank and led to open deck, see also R.2. The volume of the overflow tank depends on the size/capacity of the replenishment installations.

The service tank is to be so designed that impurities and water may settle, e.g., by forming a water pocket. At the lowest point, a drain with a self-closing valve is to be provided. The drain line is to be led, together with the drain lines of the filter/ water separator and the safety filter, into an open sampling tray, where the drain may be controlled visually.

The sampling tray is to be drained to a fuel leakage tank.

6.2.3 To extract remaining fuel and water suction outlets are to be provided (stripping line) at the lowest points of the storage tanks and the overflow tank.

There may be no fixed connection to other stripping lines.

Sampling connections are to be provided at the supply tank and at the pressure fuelling connection.

I. Lubricating Oil Systems

1. General Requirements

1.1 Lubricating oil systems are to be designed to ensure reliable lubrication as well as adequate heat transfer over the whole range of speeds and during run-down of the engines.

1.2 Priming pumps

Where necessary, priming pumps are to be provided for supplying lubricating oil to the engines.

1.3 Emergency lubrication

A suitable emergency lubricating oil supply (e.g. gravity tank) is to be arranged for machinery which may be damaged in case of interruption of lubricating oil supply.

1.4 Lubricating oil treatment

Equipment necessary for adequate treatment of lubricating oil (purifiers, automatic back-flushing filters, filters and free-jet centrifuges) are to be provided.

2. Arrangement

2.1 Lubricating oil circulating tanks and gravity tanks

2.1.1 For the capacity and location of these tanks see Section 7, C.

Where an engine lubricating oil circulation tank extends to the bottom shell plating on ships for which a double bottom is required in the engine room shut-off valves are to be fitted in the drain pipes between engine casing and circulating tank. These valves are to be capable of being closed from a level above the lower platform.

2.1.3 The lubrication oil pump suction is to be arranged away from the crankcase oil drain pipes.

2.1.4 The overflow from gravity tanks is to be led to the circulating tank.

Arrangements are to be made for observing the flow of excess oil in the overflow pipe.

2.2 Filling and suction lines

2.2.1 Filling and suction lines of lubricating oil tanks with a capacity of 500 l and more and located above the double bottom and which in case of their damage lubricating oil may leak, are to be fitted directly on the tanks with shutoff devices according to G.2.1. The remote operation of shutoff devices according to G.2.1, may be dispensed with.

- For valves which are kept closed during normal operation,

- Where an unintended operation of a quick closing valve would endanger the safe operation of the main propulsion plant or essential equipment.

2.2.2 Where lubricating oil lines must be arranged in the vicinity of hot machinery, fully welded steel pipes are to be used. Screening should be provided if necessary.

2.3 Transfer pumps

2.3.1 Transfer pumps are to be provided for:

- Filling of the tanks

- Suction from any tank and supplying the replenishment system

- Transfer of lubrication oil from any storage tank to collecting tanks or to other parts of the lubricating installation, e.g. the oil sump of diesel engines

2.3.2 For diesel engine and gas turbine installations as well as gears up to a lubricating oil volume of 500 litres per unit, hand operated pumps are admissible for transferring of lubricating or waste oil.

For installations with larger lubricating oil volumes, electrically driven pumps are to be provided.

2.3.3 For each type of lubricating oil, a separate transfer pumping installation shall be provided.

2.4 Filters

2.4.1 Lubricating oil filters are to be fitted in the delivery line of the lubricating oil pumps.

2.4.2 Mesh size and filter capacity are to be in accordance with the requirements of the manufacturer of the engine.

2.4.3 Uninterrupted supply of filtered lubricating oil has to be ensured under cleaning and maintenance conditions of filter equipment. In case of automatic back-flushing filters, it is to be ensured that a failure of the automatic back-flushing will not lead to a total loss of filtration.

2.4.4 Back-flushing intervals of automatic back-flushing filters provided for intermittent back-flushing are to be monitored.

2.4.5 Main lubricating oil filters are to be fitted with differential pressure monitoring. On engines provided for operation with gas oil only, differential pressure monitoring may be dispensed with.

2.4.6 Engines for the exclusive operation of emergency generators and emergency fire pumps may be fitted with simplex filters.

2.4.7 For protection of the lubricating oil pumps simplex filters may be installed on the suction side of the pumps if they have a minimum. mesh size of 100 μ.

2.4.8 For the arrangement of filters, see Chapter 104 - Propulsion Plants, Section 3, G.3.

2.5 Lubricating oil coolers

It is recommended that turbine and large engine plants be provided with more than one oil cooler.

2.6 Oil level indicator

Machinery with inherent oil charge are to be provided with a means of determining the oil level from outside during operation. This requirement also applies to reduction gears, thrust bearings and shaft bearings.

2.7 Purifiers

The requirements in G.7 apply as appropriate.

3. Lubricating Oil Pumps

3.1 Main engines

3.1.1 Main and independent stand-by pumps are to be arranged.

Main pumps driven by the main engines are to be so designed that the lubricating oil supply is ensured over the whole range of operation.

3.1.2 For plant with more than one main engine, see Chapter 104 - Propulsion Plants, Section 3, G.4.2.

3.2 Main turbine plant

3.2.1 Main and independent stand-by lubricating oil pumps are to be provided.

3.2.2 Emergency lubrication

The lubricating oil supply to the main turbine plant for cooling the bearings during the run-down period is to be assured in the event of failure of the power supply. By means of suitable arrangements such as gravity tanks the supply of oil is also to be assured during starting of the emergency lubrication system.

3.3 Main reduction gearing (motor vessels)

3.3.1 Lubricating oil is to be supplied by a main pump and an independent stand-by pump.

3.3.2 Where a reduction gear has been approved by TL to have adequate self-lubrication at 75 % of the torque of the propelling engine, a stand-by lubricating oil pump for the reduction gear may be dispensed with up to a power ratio of

$$P/n_1 = 3{,}0 \quad [\text{kW/min}^{-1}]$$

n_1 = Gear input revolution [min^{-1}]

3.3.3 The multi-propeller plants and plants with more than one engine 3.1.2 has to be observed.

3.4 Auxiliary machinery

3.4.1 Diesel generators

Where more than one diesel generator is available, stand-by pumps are not required.

Where only one diesel generator is available (e.g. on turbine-driven vessels where the diesel generator is needed for startup etc.) a spare pump is to be carried on board.

3.4.2 Auxiliary turbines

Turbogenerators and turbines used for driving important auxiliaries such as boiler feedwater pumps etc. are to be equipped with a main pump and an independent auxiliary pump. The auxiliary pump is to be designed to ensure a sufficient supply of lubricating oil during the startup and run-down operation.

J. Engine Cooling Seawater Systems

1. Sea suctions

1.1 At least two sea chests are to be provided. Seawater inlets are to be so arranged that they do not emerge at minimum displacement of the ship and at a heel of 30°.

Landing ships and similar units, as well as ships of unconventional type such as hydrofoil craft etc., are exempted from this requirement.

1.2 For service in shallow waters, it is recommended that an additional high seawater intake should be provided.

1.3 It is to be ensured that the total seawater supply for the engines can be taken from only one sea chest.

1.4 Each sea chest is to be provided with an effective vent. The following venting arrangements will be approved:

- An air pipe of at least 32 mm. ID which can be shut-off and which extends above the bulkhead deck;

- Adequately dimensioned ventilation slots in the shell plating.

1.5 Steam or compressed air connections are to be provided for clearing the sea chest gratings. The steam or compressed air lines are to be fitted with shut-off valves fitted directly to the sea chests. Compressed air for blowing through sea chest gratings may exceed 2 bar only if the sea chests are constructed for higher pressures.

1.6 The net flow area of the sea chest gratings shall be at least 2,5 times the sectional area of the seawater intake line.

1.7 To avoid ingress of air, the intake pipes are to be designed as immersed pipes.

1.8 All outlet valves are to be so arranged or fitted, respectively, that the discharge of water will not be impaired by ice at any possible draught of the ship.

1.9 Scoops

1.9.1 Small ships such as fast attack craft may be provided with scoops instead of sea chests, upon special agreement.

1.9.2 Scoops are to be so arranged that

- Influences originating from the boundary layer are avoided and water intake is not impeded

- At minimum displacement and 30° heel the intake opening will not emerge

1.9.3 The free flow sectional area of a scoop shall at least correspond to the sectional area of the connected piping. For each scoop, a compressed air connection shall be provided for clearing.

At the seawater intakes, measures may have to be taken to reduce water-borne sound emission.

1.9.4 The circulation and discharge of seawater is to be designed as for sea chests.

2. Special Rules for Ships With Ice Class

2.1 For one of the sea chests specified in 1.1 the sea inlet is to be located on the ship's center line and as far aft as possible. The seawater discharge line of the entire engine plant is to be connected to the top of the sea chest.

2.2 All discharge valves shall be so arranged that the discharge of water at any draught will not be obstructed by ice.

2.3 Where necessary, a steam connection or a heating coil is to be arranged for de-icing the sea chests.

2.4 Additionally, cooling water supply to the engine plant may be arranged from ballast tanks with circulation cooling.

2.4 For the fire pumps, see Section 9, E.2.1.6.

3. Sea Valves

3.1 Sea valves are to be so arranged that they can be operated from above the floor plates.

3.2 Cooling water discharges below the water line are to be fitted with two shut-off valves at the shell.

3.3 Discharges above the water line, scoops, and the vent pipes of sea chest are to be provided with at least one shut-off valve at the ship's shell or at the sea chest wall respectively.

4. Strainer

The suction lines of the seawater pumps are to be fitted with strainers.

The strainers are to be so arranged that they can be cleaned during operation of the pumps.

Where cooling water is supplied by means of a scoop, strainers in the main seawater cooling line can be dispensed with.

5. Cooling Seawater Pumps

5.1 Diesel engine plants

5.1.1 Main propulsion plants are to be provided with main and stand-by cooling water pumps.

5.1.2 The main cooling water pump may be attached to the propulsion plant. It is to be ensured that the attached pump is of sufficient capacity for the cooling water required by main and auxiliary engines over the whole speed range of the propulsion plant.

The drive of the stand-by cooling water pump is to be independent of the main engine.

5.1.3 Main and stand-by cooling water pumps are each to be of sufficient capacity to meet the maximum cooling water requirements of the plant.

Alternatively, three cooling water pumps of the same capacity and delivery head may be arranged, provided that two of the pumps are sufficient to supply the required cooling water for full load operation of the plant at design temperature.

With this arrangement it is permissible for the second second pump to be automatically put into operation only in the higher temperature range.

5.1.4 Ballast pumps or other suitable seawater pumps may be used as stand-by cooling water pumps.

5.1.5 Where cooling water is supplied by means of a scoop, the main and stand-by cooling water pumps are to be of a capacity which will ensure reliable operation of the plant under partial load conditions and astern operation as required in Chapter 104 – Propulsion Plants, Section 3, E.5.1.1 f. The main cooling water pump is to be automatically started as soon as the speed falls below that required for the operation of the scoop.

5.2 Multi-propeller plant; plant with more than one main engine

For plants with more than one engine and with separate cooling water systems, complete spare pumps may be accepted instead of stand-by pumps provided that the main seawater cooling pumps can be replaced with the means available on board.

5.3 Cooling water supply for auxiliary engines

Where a common cooling water pump is provided to serve more than one auxiliary engine, an independent stand-by cooling water pump with the same capacity is to be fitted. Independently operated cooling water pumps of the main engine plant may be used to supply cooling water to auxiliary engines while at sea, provided that the capacity of such pumps is sufficient to meet the additional cooling water demand.

If each auxiliary engine is fitted with an attached cooling water pump, stand-by cooling water pumps need not be provided.

6. Cooling water supply in dry-dock

It is recommended that for dry-docking a supply of cooling water, e.g. from a water ballast tank, is available so that at least one diesel generator and, if necessary, the domestic refrigerating plant may be run when the ship is in dry-dock.

K. Engine Cooling Fresh Water Systems

1. General

1.1 Engine cooling fresh water systems are to be so arranged that the engines can be sufficiently cooled under all operating conditions.

1.2 Depending on the requirements of the engine plant, the following fresh water cooling systems are allowed:

- A single cooling circuit for the entire plant;
- Separate cooling circuits for the main and auxiliary plant;
- Several independent cooling circuits for the main engine components which need cooling (e.g. cylinders, pistons and fuel valves) and for the auxiliary engines;
- Separate cooling circuits for various temperature ranges.

1.3 The cooling circuits are to be so divided that, should one part of the system fail, operation of the auxiliary systems can be maintained.

Change-over arrangements are to be provided for this purpose if necessary.

1.4 The temperature controls of main and auxiliary engines as well as of different circuits are to be independent of each other as far as practicable.

1.5 Where, in automated engine plants, heat exchangers for fuel or lubricating oil are incorporated in the cylinder cooling water circuit of main engines, the entire cooling water system is to be monitored for fuel and oil leakage.

1.6 Common cooling water systems for main and auxiliary plants are to be fitted with shut-off valves to enable repairs to be performed without taking the entire plant out of service.

1.7 For the storage of treated fresh coolant water and for receiving water from the cooling system, separate tanks are to be provided.

2. Heat Exchangers, Coolers

2.1 The construction and equipment of heat exchangers and coolers are subject to the Requirements of Section 16.

2.2 The coolers of cooling water systems, engines and equipment are to be designed to ensure that the specified cooling water temperatures can be maintained under all operating conditions. Cooling water temperatures are to be adjusted to meet the requirements of engines and equipment.

2.3 Heat exchangers for auxiliary equipment in the main cooling water circuit are to be provided with by-passes if by this means it is possible, in the event of a failure of the heat exchanger, to keep the system in operation.

2.4 It is to be ensured that auxiliary machinery can be operated while repairing the main coolers. If necessary, means are to be provided for changing over to other heat exchangers, machinery or equipment through which a temporary heat transfer can be achieved.

2.5 Shut-off valves are to be provided at the inlet and outlet of all heat exchangers. Every heat exchanger and cooler is to be provided with a vent and a drain.

2.6 Keel coolers, chest coolers

2.6.1 Arrangement and construction drawings of keel and box coolers are to be submitted for approval.

2.6.2 Permanent vents for fresh water are to be provided at the top of keel coolers and box coolers.

2.6.3 Keel coolers are to be fitted with pressure gauge connections at the fresh water inlet and outlet.

3. Expansion Tanks

3.1 Expansion tanks are to be arranged at sufficient height for every cooling water circuit.

Different cooling circuits may only be connected to a common expansion tank if they do not interfere with each other. Care must be taken here to ensure that damage to or faults in one system cannot affect the other system.

3.2 Expansion tanks are to be fitted with filling connections, vents, water level indicators and drains.

4. Fresh Water Cooling Pumps

4.1 Main and stand-by cooling water pumps are to be provided for each cooling fresh water system.

4.2 Main cooling water pumps may be driven directly by the main or auxiliary engines which they are intended to cool provided that a sufficient supply of cooling water is assured under all operating conditions.

4.3 The drives of stand-by cooling water pumps are to be independent of the main engines.

4.4 Stand-by cooling water pumps are to have the same capacity as main cooling water pumps.

4.5 Main engines are to be fitted with at least one main and one stand-by cooling water pump. Where according to the construction of the engines more than one water cooling circuit is necessary, a stand-by pump is to be fitted for each main cooling water pump.

4.6 For cooling fresh water pumps of essential auxiliary engines the rules for sea cooling water pumps in J.5.3 may be applied.

4.7 A stand-by cooling water pump of a cooling water system may be used as a stand-by pump for another system provided that the necessary pipe connections are arranged. The shut-off valves in these connections are to be secured against unintended operation.

4.8 Equipment providing for emergency cooling from another system can be approved if the plant and system are suitable for this purpose.

4.9 For plants with more than one main engine, see J.5.2.

5. Temperature Control

Cooling water circuits are to be provided with temperature controls in accordance with the requirement. Control devices whose failure may impair the functional reliability of the engine are to be equipped for manual operation.

6. Preheating for Cooling Water

Means are to be provided for preheating cooling fresh water.

7. Emergency Generators

Internal combustion engines driving emergency generating units are to be fitted with independent cooling systems. Such cooling systems are to be made proof against freezing.

L. Compressed Air Lines

1. General

1.1 Pressure lines connected to air compressors are to be fitted with non-return valves at the compressor outlet.

1.2 Oil and water separators, see Chapter 104 - Propulsion Plants, Section 3.

1.3 Starting air lines may not be used as filling lines for air receivers.

1.4 Only type-tested hose assemblies made of metallic materials may be used in permanently pressurised starting air lines of diesel engines.

1.5 The starting air line to each engine is to be fitted with a non-return valve and a drain.

1.6 Tyfons are to be connected to at least two compressed air receivers.

1.7 A safety valve is to be fitted behind each pressure-reducing valve.

1.8 Pressure water tanks and other tanks connected to the compressed air system are considered as pressure vessels and must comply with the requirements in Section 16 for the working pressure of the compressed air system.

1.9 For compressed air connections for blowing through sea chests refer to J.1.5.

1.10 For the compressed air supply to pneumatically operated valves and quick-closing valves refer to D.6.

1.11 Requirements for starting engines with compressed air, see Section 6.

1.12 Starting air installations for diesel engines shall be designed for a working pressure of 30 to 40 bar.

In the compressed air receivers, a working pressure up to 250 bar is permissible. Corresponding pressure reducing valves are to be provided.

1.13 When determining the necessary volume of the starting air receivers for pneumatic starting of gas turbines, at least 5 successive starting procedures without refilling shall be taken into account.

1.14 With exception of the air compressors, separate compressed air systems are to be provided for the ship and the weapons systems.

1.15 The compressed air demand of diesel engines and gas turbines serving propulsion plants shall be provided by at least two air receivers per compartment. Where diesel engines or gas turbines driving aggregates for electrical power supply are arranged in the same compartment, the compressed air for these engines is also to be taken from the receivers mentioned above.

1.16 Where a compartment contains only diesel generators not serving propulsion purposes, the compressed air may be stored in one receiver only.

1.17 Where diesel engines are arranged in several compartments, also the air compressors are to be distributed to at least two compartments. Where compressed air installations such as compressors and receivers are located in several compartments, it must be possible via independent pipe lines to fill every receiver from every compressor.

1.18 Air compressors are to be arranged in the compartments in such a way that no oil vapours may be aspirated.

1.19 For each air receiver an emergency pressure release installation is to be provided. From this instal lation, a pipe is to be led to a readily accessible place on the open deck.

At the end of this pipe, a valve is to be provided in the "locked closed" status, while the valve at the receiver is to be maintained in the "locked open" condition.

1.20 Instead of one air receiver, several receivers may be provided forming a group. In such a case, the receivers are to be connected to a common manifold.

Between the receivers and the manifold, no shut-off devices are allowed.

Upon special approval, the receivers for the diesel engines within one compartment may be connected to a group. In this case also the transfer line may be arranged as single line.

2. Control Air Systems

2.1 Control air systems for essential consumers are to be provided with the necessary means of air treatment.

2.2 Pressure reducing valves in the control air system of main engines are to be redundant.

M. Exhaust Gas Lines

1. Pipe Layout

1.1 Engine exhaust gas pipes are to be installed separately from each other, taking the structural fire protection into account. Other designs are to be submitted for approval. This applies to boiler uptakes as well.

1.2 Account is to be taken of thermal expansion when laying out and suspending the lines.

1.3 Where exhaust gas lines discharge near water level, or where cooling water is injected into the exhaust gas line, provisions are to be made to prevent water from entering the engines.

1.4 Where the exhaust gas discharge can be arbitrarily switched to either ship side, the line cross section in the manifold may not be reduced. The position of the flaps is to be indicated in the machinery control centre (MCC).

1.5 Where the exhaust gas line ends below or near the water line, entry of seawater into the engine has to be prevented for normal operating conditions, by adequately arranging the pipes. At the shell a shut-off device has to be provided. If the exhaust gas lines pass several watertight compartments the water integrity of the compartments in case of damage must be maintained by suitable means.

1.6 If provisions are made to shut off the outlet, self-closing flaps shall be used, where possible. The actual position of the flaps shall be indicated in the MCC.

2. Silencers

2.1 Engine exhaust pipes are to be fitted with effective silencers or other suitable means are to be provided. The planned noise reduction is to be defined in the building specification.

2.2 Silencers are to be provided with openings or equivalent arrangements for internal inspection.

3. Water Drains

Exhaust lines and silencers are to be provided with suitable drains of adequate size.

4. Insulation

Insulation of exhaust gas lines inside machinery spaces, see Section 9, B.2.1.

N. Bilge Systems

1. General

1.1 For each watertight compartment, a separate installation is to be provided.

1.2 Bilge systems have to be arranged so that, apart from their proper task, they are also suitable for the removal of water from drencher or water spraying systems, e.g. from ammunition stores

1.3 All not permanently manned spaces below the waterline, as well as spaces equipped with water spray and/or sprinkler installations, shall be provided with bilge alarms.

2. Calculations

2.1 Definition of capacity

2.1.1 The stripping installations shall have a capacity Q to extract the water from a watertight compartment within 1 hour:

$$Q = 0.9 \times V \ [m^3/h]$$

V = Net volume of the spaces below the waterline within a watertight compartment at combat displacement, excluding the volume occupied by tanks and all other equipment

2.1.2 The bilge system is to be so dimensioned that all watertight compartments within the "longitudinal extent of damage" defined in Chapter 102 - Hull Structures and Ship Equipment, Section 2, C. can be stripped simultaneously.

2.1.3 The total stripping capacity, however, need not exceed a volume corresponding to 1/3 of the combat displacement of the ship.

2.2 Bilge systems for spraying systems

2.2.1 Bilge systems for spaces with water spray and sprinkler facilities are to be designed to remove not less than 110 % of the volume that can be produced by the water spray/sprinkler facilities.

2.2.2 Water spraying and sprinkler installations as well as bilge systems must be capable of being operated simultaneously.

2.2.3 At the start of spraying installations, the bilge pumps must be started automatically.

3. Design of the bilge systems

3.1 Electrically driven pumps and/or eductors using driving water from the fire fighting system may be used for bilge pumping.

3.2 Bilge pumps and eductors are to be so arranged that they are capable of stripping the space where they are located, and one adjoining space.

3.3 Bilge pumps are to be located in a watertight bilge pump room. This space must be arranged adjacent to a watertight bulkhead and must be equipped with suitable sluice valves.

3.4 Eductors are to be arranged within the corresponding watertight compartment.

3.5 Bilge pumps and the suction ends of the eductors, respectively, are to be arranged, if possible, near the centre line of the ship in a readily accessible location.

4. Piping

4.1 The required pipe thicknesses of bilge lines are to be in accordance with Table 8.4.

4.2 Bilge pipes may not be led through tanks for lubricating oil, drinking water or feedwater.

4.3 Discharge pipes of the bilge system are to be provided with shut-off valves at the shell.

4.4 Bilge pipes from spaces not accessible during the voyage if running through fuel tanks located about double bottom are to be fitted with a non-return valve directly at the point of entry into the tanks.

4.5 Where the discharge of a bilge pump is arranged less than 500 mm above the waterline at combat displacement of the ship, two non-return devices are to be provided. Where the discharge ends at a higher level, one non-return device is sufficient.

4.6 The non-return device may be a scew-down non-return valve, or a combination of non-return valve and a stop valve.

4.7 Bilge valves are to be arranged so as to be always accessible irrespective of the ballast and load ing condition of the ship.

4.8 Discharge pipes of the bilge system are to be alternately arranged at the starboard and port side of the ship.

4.9 When designing the non-return valves or flaps in the bilge lines, it shall be kept in mind that in case of NBC protection an excess pressure of 5 mbar must be maintained inside the ship.

4.10 Fittings necessary for the functioning of the bilge pumping system (shut-off device for the drive water of the eductor, sluice valves, etc.) must be capable of being operated from the machinery control centre and the damage control centre/ local control position.

O. Bilge Stripping and De-Oiling Systems

1. General

1.1 Machinery spaces and spaces, in which oily water may accumulate, are to be equipped with a bilge stripping and de-oiling system, in addition to the bilge systems as described under N.

1.2 Stripping lines and sucking heads are to be so arranged that also in unfavourable trim conditions the spaces are drained completely.

1.3 Bilge suctions are to be provided with easily removable, corrosion resistant strums, and to be so arranged that cleaning of bilges and bilge wells is possible.

1.4 Chain lockers must be capable of being drained by suitable facilities.

2. Stripping Facilities

2.1 A bilge water collecting tank is to be provided, capable of storing the bilge water from all the spaces connected to the bilge pumping system.

2.2 Ships with one damage control zone are to be equipped with a bilge pump. Additionally, a portable pump is to be provided. Suitable connections are to be provided for this portable pump at the collecting tank.

2.2 Ships with more than one damage control zone are to be equipped with at least two stripping pumps, which are to be arranged in different damage control zones. In the case of failure of a pump, the remaining pump(s) must be capable of draining all the spaces connected to the stripping system.

2.3 Stripping systems must be so designed that the stripping pumps are capable of being used also for conveying bilge water from the collecting tank and directly from the bilges to the transfer stations on deck.

3. Equipment for the Treatment of Bilge Water and Fuel/Oil Residues

3.1 Ships of 400 tons gross and above shall be fitted with an oily water separator or a filter plant for the separation of oil/water mixtures **(4)**.

3.2 Ships of 10.000 tons gross and above shall be fitted, in addition to the equipment required in Item 1.1, with a 15 ppm alarm system.

3.3 A sampling device is to be arranged in the discharge line of oily water separating equipment/ filtering systems.

3.4 By-pass lines are not permitted for oily water separating equipment/filtering systems.

3.5 Recirculating facilities have to be provided to enable the oil filtering equipment to be tested with the overboard discharge closed.

4. Discharge of Fuel /Oil Residues

4.1 For oil residues a sludge tank is to be provided. For equipment and dimensioning of sludge tanks, see Section 7, E.

(4) *With regard to the installation on ships of oily water separators, filter plants, oil collecting tanks, oil discharge lines and a monitoring and control system or an 15 ppm alarm device in the water outlet of oily water separators, compliance is required with the provisions of the International Convention for the Prevention of Pollution from Ships. 1973, (MARPOL) and the Protocol of 1978 as amended.*

From F 323 (MP1) is to be submitted for approval.

4.2 A self-priming pump is to be provided for sludge discharge to reception facilities. The capacity of the pump shall be such that the sludge tank can be emptied in a reasonable time. The utilization of a bilge pump for sludge discharge is permissible.

4.3 A separate discharge line is to be provided for discharge of fuel/oil residues to reception facilities.

4.4 Where incinerating plants are used for fuel and oil residues, compliance is required with Section 9 and with the TL Rules - Guidelines for the Design, Manufacture, Equipment, Installation and Testing of Incinerators on Board Seagoing Ships and for the Performance of Type Tests of Incinerators.

P. Ballast Systems

1. Ballast Lines

1.1 Arrangement of piping-general

Suctions in ballast water tanks are to be so arranged that the tanks can be emptied despite unfavourable conditions of trim and list.

1.2 Pipes passing through tanks

Ballast water pipes may not pass through drinking water, feedwater or lubricating oil tanks.

1.3 Piping systems

1.3.1 Where a tank is used alternately for ballast water and fuel (change-over tank), the suction in this tank is to be connected to the respective system by three-way cocks with L-type plugs, cocks with open bottom or change-over piston valves. These must be arranged so that there is no connection between the ballast water and the fuel systems when the valve or cock is in an intermediate position. Change-over pipe connections may be used instead of the above mentioned valves. Each change-over tank is to be individually connected to its respective system. For remotely controlled valves see D.6.

1.3.2 Where pipelines are led through the collision bulkhead below the freeboard deck, a shut-off valve is to be fitted directly at the collision bulkhead inside the fore peak.

The valve has be capable of being remotely operated from above the freeboard deck.

Where the fore peak is immediately adjacent to a permanently accessible room e.g. bow thruster room, this shut-off valve may be fitted directly at the collision bulkhead inside this room without provision for remote control.

2. Ballast Pumps

2.1 The number and capacity of the pumps must satisfy the vessel's operational requirements.

2.2 For filling the ballast water tanks the fire main system may be used.

2.3 For emptying ballast water tanks eductors may be used.

3. Operational testing

The ballast arrangement is to be subjected to operational testing under TL supervision.

Q. Ballast Systems for Special Tasks

1. Special ballasting requirements

The following special ballast operations must be considered:

- Maintaining a horizontal position of the flight deck in transverse and longitudinal direction regardless of the ship's loading condition

- Reduction of the dynamic movements of the ship as a platform for sensors, weapons and aircraft operation in the seaway

- Changing the ship's trim to allow dock landing operations with landing craft entering or leaving the ship through the lowered stern/bow gate

- Cross flooding for equalizing flooding in case of damage

- For further ballast requirements the arrangement and the operating conditions have to be agreed with TL

For these operating conditions the following requirements have to be observed.

2. Anti-heeling arrangements

Anti-heeling arrangements, which may produce heeling angles of more than 10° according to Chapter 102 - Hull Structures and Ship Equipment, Section 2, A.5, are to be provided as follows:

- A shut-off device is to be provided in the cross channel between the tanks designated for this purpose in front and behind the anti-heeling pump.

- These shut-off devices and the pump are to be remotely operated. The control devices are to be arranged in one control stand.

- At least one of the arranged remote controlled shut-off devices shall automatically shut down in the case of power supply failure.

- The position "closed" of the shut-off devices shall be indicated on the control standby type approved end position indicators.

- Additionally, Chapter 105 - Electrical Installations, Section 7, G. is to be observed.

3. Cross-flooding arrangements

As far as possible, cross-flooding arrangements for equalizing asymmetrical flooding in case of damage should operate automatically. Where the arrangement does not operate automatically, any shut-off valves must be capable of being operated from the bridge or another central location above the bulkhead deck.

The position of each closing device has to be indicated on the bridge and at the central operating location (MCC). The cross-flooding arrangements must ensure that in case of flooding, equalization is achieved within 15 minutes.

4. Anti rolling systems

If a system of ballast water tanks is used for roll stabilization the following requirements have to be met:

- The stability of the ship must in no operating condition be endangered by the system

- For the transfer pipe system remote controlled shut-off valves have to be provided

- The control of the system must be failsafe, as far as possible

- Emergency stops from the bridge and the MCC have to be provided

5. Stability check

The respective stability check in connection with the ballast requirements has to be done in accordance with Chapter 102 - Hull Structures and Ship Equipment, Section 2.

R. Air, Overflow and Sounding Pipes

1. General

1.1 For the arrangement of air, overflow and sounding pipes Table 8.4. has to be observed

1.2 Definitions

The pipes are defined as follows:

- Air and overflow pipes: used for venting and overflow of tanks

- Sounding pipes: used for measuring liquid levels in tanks or spaces below deck which are not readily accessible, e.g. void spaces or spaces protected by water spray, such as ammunition rooms

- Sounding/air pipes: used for ullageing and venting
- Sounding / filling pipes: used for ullageing and also for filling of spaces, which are not connected to other pipe systems
- Sounding / suction pipes: used for ullageing and also for draining of spaces, which are not connected to the bilge pumping system (by portable pumps)
- Sounding / ventilation pipes: used for ullageing and also for ventilating spaces normally not manned, before entering for inspection

2. Air and Overflow Pipes

2.1 Arrangement

2.1.1 All tanks, void spaces etc. are to be fitted at their highest position with air pipes or overflow pipes. Air pipes must normally terminate above the open deck.

2.1.2 Air and overflow pipes are to be laid vertically.

2.1.3 Air and overflow pipes passing through cargo holds are to be protected against damage.

2.1.4 For the height above deck of air and overflow pipes see, Chapter 102 - Hull Structures and Ship Equipment, Section 19, F.

2.1.5 Air pipes from unheated leakage oil tanks and lubricating oil tanks may terminate in the engine room. Where these tanks form part of the ship's hull, the air pipes are to terminate above the free board deck. It must be ensured that no leaking oil can spread onto heated surfaces or electrical equipment.

2.1.6 Air pipes from lubricating oil tanks and leakage oil tanks which terminate in the engine room are to be provided with funnels and pipes for safe drainage in the event of possible overflow.

2.1.7 Air pipes of fuel service and settlings tanks and of lubricating oil tanks which terminate on open deck are to be arranged such that in the event of a broken air pipe this shall not directly lead to the risk of ingress of sea or rain water.

2.1.8 Wherever possible, the air pipes of feedwater and distillate tanks should not extend into the open deck. Where these tanks form part of the ship's shell the air pipes are to terminate within the engine room casing above the freeboard deck.

2.1.9 Air pipes for cofferdams and void spaces with bilge connections are to extend above the open deck

2.1.10 Where fuel service tanks are fitted with change-over overflow pipes, the change-over devices are to be so arranged that the overflow is led to one of the storage tanks.

2.1.11 The overflow pipes of changeable tanks must be capable of being separated from the fuel overflow system.

2.1.12 Where the air and overflow pipes of several tanks situated at the shell lead to a common line, the connections to this line are to be above the freeboard deck, as far as practicable, but at least so high above the deepest load waterline that should a leakage occur in one tank due to damage to the hull or listing of the ship, fuel or water cannot flow into another tank.

2.1.13 The air and overflow pipes of lubricating oil tanks shall not be led to a common line.

2.1.14 For the cross-sectional area of air pipes and air/overflow pipes, see Table 8.17

2.1.15 The air and overflow pipes are to be so arranged, that the planned filling levels can be achieved, see Section 7, B.1.4. The pipes are to be led into the tanks to a level abt. 20 mm below the maximum planned liquid surface. The estimated trim has to be considered.

2.1.16 Where NBC protection is to be provided for the ship, an aeration valve is to be arranged in the citadel, and an air-release valve on the open deck respectively. The aeration valve shall open at 50 mbar under-pressure, and the air-release valve at 5 mbar over-pressure, see Section 11.

2.1.17 For spaces, for which a spraying installation is required, a suitable venting arrangement is to be provided. This venting arrangement is to be designed also for overflow duties, if the water from the spraying installation can not be drained by other means.

The venting arrangement is to be combined with the overall ventilation system, see Section 11.

2.2 Number of air and overflow pipes

2.2.1 The number and arrangement of the air pipes is to be so performed that the tanks can be aerated and deaerated without exceeding the tank design pressure by over- or under-pressure.

2.2.2 Tanks which extend from side to side of the ship must be fitted with an air/overflow pipe at each side. At the narrow ends of double bottom tanks in the forward and aft parts of the ship, only one air/overflow pipe is sufficient.

2.3 Air pipe closing devices

Air/overflow pipes terminating above the open deck are to be fitted with approved air pipe heads.

Table 8.17 Cross-Sectional areas of air and overflow pipes

Tank filling systems		Cross-sectional areas of air and overflow pipes	
		Air pipes	Air/overflow pipes
Filling	by gravity	1/3 f per tank	-
	Pumping	-	1,25 f per tank **(1)**

f *= Cross-sectional area of tank filling pipe*
(1) *1,25 f as the total cross-sectional area is sufficient if it can be proved that the resistance to flow of the air and overflow pipes including the air pipe closing devices at the proposed flow rate cannot cause unacceptably high pressures in the tanks in the event of overflow.*

2.4 Overflow systems

2.4.1 The air and overflow pipes of fuel tanks or fresh water tanks are led to an overflow-monitoring box. Pipes from the different watertight compartments may not be led together.

2.4.2 Ballast water tanks

Proof by calculation is to be provided for the system concerned that under the specified operating conditions the design pressures of all the tanks connected to the overflow system cannot be exceeded.

2.4.3 Storage tanks

2.4.3.1 The overflow collecting manifolds of tanks are to be led with a gradient to an overflow tank of sufficient capacity.

The overflow tank is to be fitted with a level alarm which operates when the tank is about 1/3 full.

2.4.3.2 For the size of the air and overflow pipes, see Table 8.18.

2.4.3.3 The use of a fuel storage tank as overflow tank is permissible but requires the installation of a high level alarm and an air pipe with 1,25 times the cross-sectional area of the main bunkering line.

2.5 Determination of the pipe cross-sectional areas

2.5.1 For the cross-sectional areas of air and overflow pipes, see Tables 8.17 and 8.18.

The minimum diameter of air and overflow pipes shall not be smaller than 50 mm.

2.5.2 The minimum wall thicknesses of air and overflow pipes are to be in accordance with Tables 8.19 and 8.20, whereby A, B and C are the groups for the minimum wall thickness.

2.6 For pipe material see B

Table 8.18 Cross-sectional areas of air and overflow pipes (closed overflow systems)

<table>
<tr><th colspan="2" rowspan="2">Tank filling and overflow systems</th><th colspan="3">Cross-sectional areas of air and overflow pipes</th><th rowspan="2">Remarks</th></tr>
<tr><th>Air pipe</th><th>Overflow pipe (2)</th><th>Drainage pipe</th></tr>
<tr><td rowspan="2">Filling</td><td>Stand-pipe</td><td>1/3 f</td><td>-</td><td>-</td><td>cross-sectional area of stand-pipe ≥ 1,25 F</td></tr>
<tr><td>Relief valve</td><td>1/3 f (1)</td><td>min.1,25 F</td><td>-</td><td>cross-sectional area of relief valve ≥ 1,25 F</td></tr>
<tr><td rowspan="3">Overflow system</td><td>Overflow chest</td><td>1/3 F at chest</td><td>min.1,25 F</td><td>1,25 F</td><td>-</td></tr>
<tr><td>Manifold</td><td>1/3 F</td><td>min.1,25 F</td><td>-</td><td>-</td></tr>
<tr><td>Overflow tank</td><td>1/3 F</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="6">Explanatory notes : f = Cross-sectional area of tank filling pipe
F = Cross-sectional area of main filling pipe
(1) 1/3 only for tanks in which an overflow is prevented by structural arrangements.
(2) Determined in accordance with 1.4.</td></tr>
</table>

Table 8.19 Choice of minimum wall thicknesses

<table>
<tr><th rowspan="4">Piping system or position of open pipe outlets</th><th colspan="8">Location</th></tr>
<tr><th rowspan="3">Tanks with same media</th><th rowspan="3">Tanks with disparate-media</th><th colspan="3">Drain lines and scupper pipes</th><th colspan="2">Air, sounding and overflow pipes</th><th rowspan="3">Spaces for operation of internal combustion engines and oil-fired steam boilers</th></tr>
<tr><th colspan="2">below freeboard deck on bulkhead deck</th><th rowspan="2">above free board deck</th><th rowspan="2">above weather deck</th><th rowspan="2">below weather deck</th></tr>
<tr><th>without shut-off on ship's side</th><th>with shut-off on ship's side</th></tr>
<tr><td>Air, Overflow and sounding pipes</td><td rowspan="4">A</td><td>C</td><td>-</td><td>-</td><td>-</td><td>C</td><td>A</td><td rowspan="4">A</td></tr>
<tr><td>Scupper pipes from open deck</td><td rowspan="3">B</td><td>-</td><td rowspan="3">A</td><td>A</td><td rowspan="3">-</td><td rowspan="3">-</td></tr>
<tr><td>Discharge and scupper pipes leading directly overboard</td><td>B</td><td>-</td></tr>
<tr><td>Discharge pipes of pumps for sanitary systems</td><td>-</td><td>A</td></tr>
</table>

Table 8.20 Minimum wall thicknesses of air, overflow, sounding and sanitary pipes

Pipe outside diameter [mm]	Minimum wall thickness [mm]		
	A**(1)**	B **(1)**	C **(1)**
50 - 82,5	4,5	7,1	6,3
88,9	4,5	8,0	6,3
101,6 -114,3	4,5	8,0	7,1
127 - 139,7	4,5	8,8	8,0
152,4	4,5	10,0	8,8
159 - 177,8	5,0	10,0	8,8
193,7	5,4	12,5	8,8
219,1	5,9	12,5	8,8
244,5 -457,2	6,3	12,5	8,8

(1) *wall thickness, see group, see Table 8.19*

3. Sounding Pipes

3.1 General

3.1.1 Sounding pipes are to be provided for all tanks with the exception of fresh water tanks, cofferdams and void spaces with bilge connections and for bilges and bilge wells in spaces which are not accessible at all times.

The provision of sounding pipes for bilge wells in not permanently accessible spaces may be dispensed with, where level alarms are provided. The level alarms are to be separate from each other and are to be approved by TL.

3.1.2 Where the tanks than fuel tanks are fitted with remote level indicators which are type-approved by TL, the arrangement of sounding pipes can be dispensed with.

3.1.3 As far as possible, sounding pipes are to be laid straight and are to extend as near as possible to the bottom. If this is not possible, a bending radius of 500 mm at minimum must be provided.

3.1.4 Sounding pipes which terminate below the deepest load waterline are to be fitted with self-closing shut-off devices. Such sounding pipes are only allowable in spaces which are accessible at all times.

All other sounding pipes are to be extended to the open deck. The sounding pipe openings must always be accessible and fitted with watertight closures.

3.1.5 Sounding pipes of tanks are to be provided close to the top of the tank with holes for equalizing the pressure.

3.1.6 Sounding pipes passing through compartments for military cargo are to be protected against damage.

3.2 Sounding pipes for fuel tanks

3.2.1 Sounding pipes which terminate below the open deck are to be provided with self-closing devices as well as with self-closing test valves, see also Section 7, B.3.3.

3.2.2 Sounding pipes shall not to be located in the vicinity of firing plants, machine components with high surface temperatures or electrical equipment.

3.2.3 Sounding pipes must not terminate in accommodation or service spaces.

3.2.4 In addition to the provision of sounding pipes fuel tanks have to be equipped with TL type approved remote level indicators with centralised monitoring in the MCC.

3.3 Cross-sections of pipes

3.3.1 Sounding pipes shall have a nominal bore of at least 50 mm.

3.3.2 The nominal bore of sounding pipes which pass through refrigerated spaces at temperatures below 0 °C is to be increased to a nominal bore of 65 mm.

3.3.3 The minimum wall thicknesses of sounding pipes are to be in accordance with Tables 8.19 and 8.20.

3.3.4 For pipe materials see B.

S. Freshwater Systems

1. Calculation of the fresh/drinking water demand

1.1 The drinking water demand is to be determined by the Naval Authority, depending on the number of crew and the planned endurance at sea.

Note

For the design, the following guidance values may be assumed:

- *ships equipped with drinking water production installations (evaporators): 150-200 l per man and day*

- *ships without drinking water production: 40-80 l per man and day*

1.2 Freshwater will be used for the following duties:

- For waste water installations flushed with fresh water:

Note

As guidance may be assumed 10-12 l per man and day.

- Freshwater cooling system of diesel engines:

  The volume of the cooling water circulation for one diesel engine serving propulsion and one diesel engine serving power supply is to be taken as basis for the demand per day.

- Cleaning water for gas turbines and aircraft according to data delivered by manufacturers

1.3 For ships with evaporators the storage capacity should correspond at least to three times the daily demand. The water shall be kept in at least two tanks. Possibly, for fresh water used in technical systems a separate installation may be provided.

2. Basic requirements

2.1 Freshwater installations are to be completely independent/separated from all other installations.

2.2 The drinking water systems are to be so designed that at any of the taps the quality of the water corresponds to the relevant national requirements regarding drinking water quality

2.3 The design of the installation shall safeguard that no contaminated water and no other liquids and substances may enter the system, and that the inspection, disinfection and flushing of the installation can be carried out in a satisfactory manner.

2.4 For cleaning of the spaces in the food handling and sanitary areas fresh water taps are to be provided.

3. Drinking water tanks

3.1 For the design and arrangement of drinking water tanks see Chapter 102 - Hull Structures and Ship Equipment, Section 10.

3.2 Drinking/fresh water tanks are to be provided with an approved coating for corrosion prevention.

4. Fresh water replenishment installations

4.1 Pipe connections for replenishment of freshwater at sea are to be arranged on the open deck on port and starboard side, and if needed in the fore ship and aft region, at locations well accessible. The number of connections and the detailed arrangement depend on the ship size and its supply conditions/ duties.

4.2 On ships with the size of fast attack craft or minesweepers, one transfer connection may suffice, if it can be arranged amidships and is accessible from either side, see also Section 4.

4.3 The connecting pieces are to be designed as goosenecks with a standard hose connection, e.g. coupling, and a shut-off valve. The coupling shall face downward and be arranged at least 500 mm above the deck. It shall be gas- and watertight and provided with a cap secured by a chain.

The fresh water pipe connections are to be marked with a special colour coding.

5. Venting, overflow and drainage

5.1 The air and overflow pipes of the freshwater tanks are to be led, per compartment, to monitoring boxes. The outlet pipes of the boxes shall be equipped with water locks and be drained to a scupper. The air pipes of the inspection boxes are to be led to the citadel and be provided with goosenecks and meshwire gauze to prevent ingress of dirt and insects.

5.2 Air and overflow pipes may not be led through tanks (except freshwater tanks). For naval ships with a size comparable to fast attack craft or minesweepers, the air and overflow pipes may end below deck, but above the waterline calculated for the damage case, and shall be equipped with goosenecks and protection against ingress of insects. Overflowing freshwater is to be discharged, via a funnel, to the bilges.

5.3 The drain devices (drain plugs) in the tanks are to be arranged so as to ensure emptying of the tanks under all normal operating conditions.

6. Contents gauging and sampling installations

6.1 To measure the contents of freshwater or drinking water tanks, level measuring arrangements are to be provided which do not affect the hygienic condition of the water. Sounding pipes are not permitted.

6.2 Sampling installations shall be so arranged that water samples may be taken from the bottom area of the tank.

Further stations for sampling of drinking water are to be provided behind a sterilizing plant, if provided, as well as on the pressure side of the freshwater line near the pump.

6.3 For the extraction of samples, reliably closing taps are to be provided. They are to be arranged at a height where they can not be flooded by bilge water.

The taps shall be provided with hoses so that the samples may be aspirated.

7. Freshwater generating installations

7.1 For freshwater generating installations it is recommended that they are designed to satisfy a daily drinking / freshwater demand during 18 hours of daily operation.

7.2 It is recommended to provide two or more generating installations for the calculated drinking water quantity. In case of vacuum evaporators with an evaporation temperature of less than 80 °C, a sterilizing plant is to be provided in the line supplying drinking water.

7.3 Where the distillate produced by the ship's own evaporator unit is used for the drinking water supply, the treatment of the distillate has to comply with current regulations of national health authorities.

8. Freshwater pumping installations with pressure tanks and taps

8.1 For conveying the freshwater, at least 2 freshwater pumps are to be provided. At each pump discharge a screw-down non-return valve is to be fitted. On board of smaller naval ships, the second drinking water pump may be a pump carried on board as spare pump.

8.2 The pressure vessels are to be designed according to the requirements of Section 16. The material shall be corrosion-resistant. Safety valves shall be arranged below the lowest water level. Where relevant, shock proof installation and foundation of the pressure vessels is to be ensured.

9. Piping system

9.1 Drinking water pipe lines are not to be connected to pipe lines carrying other media.

9.2 Drinking water pipe lines are not to be laid through tanks which do not contain drinking water.

9.3 Drinking water inlets into tanks which are not destined for drinking water, e.g., freshwater for cooling purposes, are to be provided with open funnels or backflow protection.

9.4 It must be possible to drain the tanks, and to pump the freshwater to other tanks.

9.5 To establish the drinking water /freshwater supply via the shore connection, a connection line is to be provided between the supply line and the pressure main, incorporating a pressure reduction to 4 or 6 bar, respectively.

9.6 Freshwater pumping and replenishment installations on supply ships shall be independent from the freshwater system of the ship itself.

9.7 To avoid germ accumulation in drinking water systems, care shall be taken that no water or air pockets can develop.

9.8 Sealing material used in freshwater systems must be suitable for drinking water.

10. Fittings

10.1 For filling the pressure vessels with air, sniffle valves are to be provided in the suction pipes of the freshwater pumps. They are to be arranged so as to avoid ingress of dirt into the system.

10.2 To avoid hammering in the freshwater lines, all tap stations are to be provided with non-hammering taps.

10.3 For the emergency supply of the galley a hand pump is to be provided.

10.4 For the lavatories in the treatment room of the hospital area, an emergency drinking water supply is to be provided.

11. Washing installations

11.1 Washing installations, with exception of the showers in the NBC locks, are to be supplied with drinking water and the following requirements have to be observed:

- hoses and hose showers as well as washing machines and similar devices may only be connected using interrupters (backflow protections)
- for shower installations, a maximum temperature of 39°C is to be ensured

11.2 The showers in the NBC sluices are to be supplied with seawater. The showers are to be equipped with suitable shower heads.

12. Water heaters

For the installations/systems serving the supply of individual or group consumers with heated freshwater the requirements in Section 16, E. have to be observed.

13. Seawater systems

13.1 Seawater systems serve the supply of NBC showers, the emergency supply of the NBC lock, the gravity operated toilets, as well as the emergency flushing of the toilets.

13.2 The feed lines are to be of flexible type. It has to be ascertained that no seawater will enter the freshwater system(s), e.g., removal of a pipe connection, change-over joint. Backflow protections are not considered to be sufficient.

13.3 Seawater systems will be fed by the seawater fire extinguishing installation. The water pressure is to be diminished correspondingly.

Where the supply with freshwater is abundant, the consumers listed in 13.1 may be connected to the freshwater installation, affirmed by the Naval Authority. However, an emergency supply with seawater must be provided.

T. Waste Water Systems

1. Definitions

1.1 Waste water

Waste water is the water collected in drainage and sewage systems, contaminated on the ship by normal operations or originating from rain and seawater spray. It is distinguished as follows:

1.2 Sewage (Black water)

Sewage is a mixture of the following:

- Drainage and other wastes from any form of toilets and urinals
- Drainage from medical premises, like dispensary, sick bags, etc., via wash basins, wash tubs and scuppers located in such premises
- Other waste waters when mixed with the drainages defined above

1.3 Grey water

Grey water is a mixture of the following:

- Drainage from wash basins, showers, etc., located in the accommodation for the crew
- Galley water containing food and fat residues, as usually produced in kitchen and galley installations

2. Sewage system

The sewage system is composed of:

- Toilet and urinal system
- Sewage treatment system
- Drainage system
- Sewage storage tanks
- Replenishment installations

2.1 Toilet and urinal system

2.1.1 The number of toilets and urinals depends on the number of crew and the type of ship, and is to be determined by the Naval Authority separately for the areas:

- hygiene
- NBC locks
- sanitary areas

2.1.2 Preferably, vacuum toilets and urinals shall be provided. The capacity, layout and redundancy are to be determined by the Naval Authority.

Note

The black water quantity may be taken as 12 l per man and day.

2.1.3 For vacuum systems, flushing with freshwater is to be provided. For emergency flushing, a hose with spraying pistol and connection to the seawater installation is to be provided. Failures shall be indicated at the location itself and at the machinery control centre.

2.1.4 For each vacuum system, one toilet with gravity draining to the treatment or storage tank and fresh water flushing (with switch-over, via hose, to seawater supply) is to be provided.

2.1 Sewage treatment system

2.2.1 It is generally recommended to install sewage water treatment installations onboard of the ship.

2.2.2 For out-lay and design of sewage treatment system, the standard ISO 15 749 or equivalent shall be complied with.

2.3 Drainage system

Scuppers and sinks are to be designed and executed according to the standard ISO 15749 or equivalent.

2.4 Sewage tanks

2.4.1 Where the installation of a sewage treatment system is not possible, storage tanks with sufficient capacity are to be provided.

Note

For dimensioning, in case of vacuum systems, a sewage water quantity of 12 l per person and day may be supposed.

2.4.2 Sewage tanks are to be equipped with a rinsing connection and an overflow alarm.

2.4.3 Sewage tanks are to be provided with air pipes leading to the open deck. For air pipe closures, see R.2.3.

2.4.4 The sewage tanks are to be provided with a suitable anti-corrosion protection coating.

2.4.5 It is recommended to dimension the sewage storage tanks so that also the grey water produced on board can be stored during 48 hours, either in the general sewage tank or in a separate grey water tank. Regarding the design quantity of grey water, see ISO 15749.

2.5 Replenishment installations

2.5.1 For the installations used for transferring black water, the same requirements are to be observed as for the discharging of grey water according to ISO 15749.

2.5.2 The discharge connections are to be arranged on the open deck on both ship sides at easily accessible locations. For naval ships with a size comparable to fast attack craft or minesweepers, a single connection is considered sufficient, if it is arranged amidships and easily accessible from either side.

2.5.3 An overboard discharge with a gate valve directly at the shell and a non-return valve upstream of the gate valve is to be provided below the water line.

2.5.4 A second means of reverse-flow protection is to be fitted in the suction or delivery line of the sewage pump from sewage storage tanks or sewage treatment plants if, in the event of a 5° heel to port or starboard, the lowest internal opening of the discharge system is less than 200 mm above the design water line **(5).**

(5). *Where sanitary treatment arrangements are fitted with emergency drains to the bilge or with openings for chemicals, these will be considered as internal openings in the sense of these Rules.*

The second means of reverse-flow protection may be a pipe loop having an overflow height above the summer load line of at least 200 mm at a 5° heel. The pipe loop is to be fitted with an automatic ventilation device located at 45 ° below the crest of the loop.

2.5.5 Where at a heeling of the ship of 5° at port or starboard, the lowest inside opening of the sewage system lies on the design water line or below, the discharge line of the sewage storage tank is to be fitted in addition to the required reverse-flow protection device according to 2.5.3, with a gate valve directly on the ships' side. In this case the reverse-flow protection device need not to be of screw-down type.

2.5.6 Where the sewage storage tank or the sewage treatment installation are located below the design waterline, a pipe loop with vent is to be provided to prevent back-flow.

2.5.7 The sewage storage tanks are to be drained using the sewage pump(s). After draining, a sewage tank is to be rinsed with grey water.

Ballast and bilge pumps may not be used for emptying sewage tanks.

3. Grey water system

3.1 The grey water system is composed of:

- Shower and wash basin system
- Galley waste water system
- Drainage system
- Grey water storage tanks, if applicable
- Discharge system
- Replenishment installations, if applicable

3.2 Grey water may be directly discharged over board.

3.3 For galley waste water it is recommended to install a grease trap.

3.4 If grey water is collected in a grey water tank or in the sewage tanks according to 2.4 the grease trap for galley water is not required.

4. Additional Rules for ships with classification mark + or [+]

4.1 The waste water arrangement and their discharge lines are to be so located that in the event of damage of one compartment no other compartments can be flooded.

4.2 If this condition cannot be fulfilled, e.g. when:

- Watertight compartments are connected with each other through internal openings of the waste water discharge lines, or

- Waste water discharge lines from several watertight compartments are led to a common drain tank, or

- Parts of the waste water discharge system are located within the damage zone (see D. 9.) and these are connected to other compartments over internal openings

the watertightness is to be ensured by means of remote controlled shut-off devices at the watertight bulkheads.

The operation of the shut-off devices must be possible from an always accessible position above the bulkhead deck. The position of the shut-off devices must be monitored at the remote control position.

4.3 Where the lowest inside opening of the waste water discharge system is below the bulkhead deck, a screw-down non-return valve and a second reverse-flow protection device are to be fitted in the discharge line of the sewage treatment arrangement. In this case, discharge lines of sewage tanks are to be fitted with a gate valve and two reverse-flow protection devices. Concerning the shut-off devices and reverse-flow protection devices, 2.5.3, 2.5.4 and 2.5.5 are to be applied.

U. Hose Assemblies and Compensators

1. Scope

1.1 The following requirements are applicable for hose assemblies and compensators made of non-metallic and metallic materials.

2. Definitions

2.1 Hose assemblies

Hose assemblies consist of metallic or non-metallic hoses provided with end fittings ready for installation.

2.2 Compensators

Compensators consist of bellows with end fittings as well as anchors for absorption of axial loads where angular or lateral flexibility is to be ensured. End fittings may be flanges, welding ends or approved pipe connections.

2.3 Burst pressure

Burst pressure is the internal static pressure at which a hose assembly or compensator will be destroyed.

3. Pressure criteria

3.1 High-pressure hose assemblies made of non-metallic materials

Hose assemblies which are suitable for use in systems with distinct dynamic load characteristics.

3.2 Low-pressure hose assemblies and compensators made of non-metallic materials

Hose assemblies or compensators which are suitable for use in systems with predominant static load characteristics.

3.3 Maximum allowable working pressure respectively nominal pressure of hose assemblies and compensators made of non- metallic materials

3.3.1 The maximum allowable working pressure of high pressure hose assemblies is the maximum dynamic internal pressure permitted to be imposed on the components.

3.3.2 The maximum allowable working pressure respectively nominal pressure for low pressure hose assemblies and compensators is the maximum static internal pressure permitted to be imposed on the com ponents.

3.4 Test pressure

3.4.1 For non-metallic high pressure hose assemblies the test pressure is 2 times the maximum allowable working pressure.

3.4.2 For non-metallic low pressure hose assemblies and compensators the test pressure is 1,5 times the maximum allowable working pressure or 1,5 times the nominal pressure.

3.4.3 For metallic hose assemblies and compensators the test pressure is 1,5 times the maximum allowable working pressure or 1,5 times the nominal pressure.

3.5 Burst pressure

For non-metallic as well as metallic hose assemblies and compensators the burst pressure is to be at least 4 times the maximum allowable working pressure or 4 times the nominal pressure. Excepted hereof are non-metallic hose assemblies and compensators with a maximum allowable working pressure or nominal pressure of not more than 20 bar. For such components the burst pressure has to be at least three times the maximum allowable working pressure or three times the nominal pressure.

4. Area of Application

4.1 Hose assemblies and compensators made of non-metallic and metallic materials may be used according to their suitability in fuel-, lubricating oil-, hydraulic oil-, bilge-, ballast-, fresh water cooling-,sea water cooling-, compressed air-, auxiliary steam and exhaust gas systems as well as in secondary piping systems.

4.2 Metallic hose assemblies and compensators may be used according to their suitability in piping systems of class I to III as well as in secondary piping systems.

4.3 Hose assemblies and compensators made of non-metallic materials are not permitted in permanently pressurized starting air lines.

4.4 Compensators made of non-metallic materials are not approved for the use in cargo lines of naval supply ships.

5. Requirements

5.1 Hoses and compensators used in the systems mentioned in 4.1 and 4.2 are to be of approved type. **(6)**

5.2 Manufacturers of hose assemblies and compensators **(7)** must be recognized by TL.

5.3 Hose assemblies and compensators including their couplings are to be suitable for media, pressures and temperatures they are designed for.

5.4 The selection of hose assemblies and compensators is to be based on the maximum allowable working pressure of the system concerned. A pressure of 5 bar is to be considered as the minimum working pressure.

5.5 Hose assemblies and compensators for the use in fuel-, lubricating oil-, hydraulic oil-, bilge- and sea water systems are to be flame-resistant

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(6) *See TL Rules - Test Requirements for Mechanical Components and Equipment*

(7) *See TL Rules - Guidelines for the Recognition of Manufacturers of Hose Assemblies and Compensators*

6. Installation

6.1 Non-metallic hose assemblies shall only be used at locations where they are required for compensation of relative movements. They shall be kept as short as possible under consideration of the installation instructions of the hose manufacturer.

6.2 The minimum bending radius of installed hose assemblies shall not be less than the radii specified by the manufacturers.

6.3 Non-metallic hose assemblies and compensators are to be located at visible and accessible positions.

6.4 In fresh water systems with a working pressure ≤ 5 bar and in charging and scavenging air lines, hoses may be fastened to the pipe ends with double clips.

6.5 Where hose assemblies and compensators are installed in the vicinity of hot components, they must be provided with approved heat-resistant sleeves.

7. Tests

7.1 Hose assemblies and compensators are to be subjected in the manufacturer's works to a pressure test in accordance with 3.4 under the supervision of TL.

7.2 For compensators intended to be used in exhaust gas pipes the pressure test according to 7.1 may be omitted.

8. Transfer hoses

Transfer hoses are to be type approved **(7)**.

9. Marking

Hose assemblies and compensators must be permanently marked with the following particulars:

- Manufacturer's mark or symbol
- Date of manufacturing
- Type
- Nominal diameter
- Maximum allowable working pressure, respectively nominal pressure
- Test certificate number and sign of the responsible TL inspection office

SECTION 9

FIRE PROTECTION AND FIRE EXTINGUISHING EQUIPMENT

A. General

1. Scope

1.1 The requirements in this Section apply to fire protection in the machinery and boiler spaces of naval surface ships and to fire extinguishing equipment throughout the ship.

2. Documents for approval

Diagrammatic plans, drawings and documents covering the following are to be submitted in triplicate for approval:

- water fire extinguishing equipment, including details of the capacities and pressure heads of the fire pumps and hydraulic calculations of the performance at the fire hose nozzles specified in E.

- CO_2 fire extinguishing system with arrangement drawing, operating diagram, CO_2 room, tripping devices alarm diagram, design calculations

- foam fire extinguishing system, including drawings of storage tanks for foam concentrate, monitors and foam applicators and the calculations and details relating to the supply of foam concentrate

- pressure water spraying system, manually operated, including calculations of water demand and pressure drop, spray nozzles, remote control

- for pressure water spraying systems in vehicle decks/special category spaces, also documentary proof of water drainage system

- dry powder fire extinguishing system, including the powder vessels, propellant containers and the relevant calculations for design

- fire extinguishing equipment for galley range exhaust ducts

- fixed local fire extinguishing arrangement for fuel oil purifiers for heated fuel oil

3. Further rules applicable

3.1 For structural fire protection see Chapter 102 - Hull Structures and Ship Equipment, Section 20.

3.2 For pressure vessels see Section 16.

3.3 For oil firing equipment see Section 17.

3.4 For fuel and oil storage see Section 7.

3.5 For pipes, valves, fittings and pumps see Section 8.

3.6 For machinery for ships with ice class see Section 8, J.2.

3.7 For additional fire protection and fire extinguishing equipment in automated plants see Chapter 106 - Automation, Section 11, H.

3.8 For electrical plant see:

Chapter 105 - Electrical Installations and
Chapter 106 - Automation, Section 7, K.

3.9 In addition national and/or international regulations have to be considered if prescribed by the Naval Authority.

4. Definitions

4.1 NBC spraying system

System for wetting and washing of outward surfaces of the ship and equipment which are accessible and may be contaminated by warfare agents.

4.2 Water spraying system

System for cooling of bulkheads and ceilings of spaces containing combustible materials, flammable liquids and explosives as well as of the shell to avoid impermissible high temperatures.

4.3 Sprinkler system

Water spraying system with automatic release and fire alarm.

4.4 Drencher system

Water spraying fire extinguishing system, manually activated, for fire fighting and for cooling of bulkheads.

4.5 Foam/water drencher system

Water drencher system with automatic mixing of a film forming foam agent for the production of fire extinguishing foam for fire fighting.

4.6 Fire alarm system

Fixed system to report fires at one or several locations with manually and/or automatically releasing sensors as well as optical or acoustic alarm signalling at the control centres.

4.7 Cabinets for fire fighting equipment

Cabinets for storage of fire fighting hoses, nozzles and hose couplings as well as for further mobile fire fighting equipment.

4.8 Hydrant

Shut-off valve with hose coupling for the standardized fire hoses on board.

4.9 Extinguishing system

System for fire fighting with special extinguishing media.

4.10 Extinguishing media

Media for fire extinguishing like seawater, foam, powder, water fog and gaseous media, e.g. CO_2, N_2, etc.

4.11 Operating spaces

Spaces which contain systems or machinery and devices for damage control, electrical installation, propulsion plants or supply and medical sections. They are named according to the systems installed in these spaces.

4.12 Control stations

Control stations are the bridge, radio room, combat information centre (CIC), machinery control centre (MCC), damage control centre (DCC) and flight control centre (FCC) as well as gyro compass and analogous rooms, or locations for the emergency source of power and emergency switchboard, if applicable.

4.13 Watertight compartment

Compartment of a ship which is enclosed by watertight bulkheads which are reaching at least up to the bulkhead deck, see also Chapter 102 - Hull Structures and Ship Equipment, Section 2.

B. Fire Protection

1. Machinery space arrangement

1.1 The arrangement of machinery spaces shall be so that safe storage and handling of flammable liquids is ensured.

1.2 All spaces in which internal combustion engines, oil burners or fuel settling or service tanks are located must be easily accessible and sufficiently ventilated.

1.3 Where leakage of flammable liquids may occur during operation or routine maintenance work, special precautions are to be taken to prevent these liquids from contact with sources of ignition.

1.4 Materials used in machinery spaces normally shall not have properties increasing the fire potential of these rooms.

1.5 Materials used as flooring, bulkhead lining, ceiling or deck in control rooms, machinery spaces or rooms with oil tanks must be non-combustible. Where there is a danger that oil may penetrate insulating materials, these must be protected against the penetration of oil or oil vapours.

2. Insulation of piping and equipment with high surface temperatures

2.1 All parts with surface temperatures above 220 °C, e.g. steam, exhaust gas lines, exhaust gas boilers and silencers, turbochargers etc., are to be effectively insulated with non-combustible materials. The insulation must be such that oil or fuel cannot penetrate into the insulating material.

Metal cladding or hard jacketing of the insulation is considered to afford effective protection against such penetration.

2.2 Boilers are to be provided with non-combustible insulation which is to be clad with steel sheet or equivalent.

2.3 Insulation must be resistant to vibration.

3. Fuel and lubricating oil tanks

Section 7 has to be observed.

4. Protection against fuel and oil leakages

4.1 Suitable means of collecting leakages are to be fitted below hydraulic valves and cylinders as well as below potential leakage points in lubrication oil and fuel oil systems.

Where oil leakages are liable to be frequent, e.g. with oil burners, separators, drains and valves of service tanks, the collectors are to be drained to an oil drain tank.

Leakage oil drains may not be part of an overflow system.

4.2 The arrangement of piping systems and their components intended for combustible liquids, shall be such that leakage of these liquids cannot contact with heated surfaces or other sources of ignition. Where this cannot be precluded by structural design, suitable precautionary measures are to be taken.

4.3 Tanks, pipelines, filters, preheaters etc. containing combustible liquids may neither be placed directly above heat sources such as boilers, steam lines, exhaust gas manifolds and silencers or items of equipment which have to be insulated in accordance with 2.1 nor above electrical switch gear.

4.4 Fuel injection pipes of diesel engines are to be shielded or so installed that any fuel leaking out can be safely drained away, see also Section 8, G.3.4 and Chapter 104 - Propulsion Plants, Section 3, G.2.2.

5. Bulkhead penetrations

Pipe penetrations through bulkheads with fire protection must be designed such, that the fire integrity of the division is not impaired.

Where steam and exhaust gas lines pass through bulkheads, the bulkhead must be suitably insulated to be protected against excessive heating.

6. Means of closure

Means must be provided for the airtight sealing of boiler rooms and machinery spaces. The air ducts to these spaces are to be fitted with fire dampers made of non-combustible material which can be closed from the deck. Machinery space skylights, equipment hatches, doors and other openings are to be so arranged that they can be closed from outside the rooms, see also Section 11.

7. Emergency stops

Electrically powered fuel pumps, purifiers, fan motors, boiler fans and cargo pumps must be equipped with emergency stops which, as far as practicable, are to be grouped outside the spaces in which the equipment is installed and which must remain accessible even in the event of a fire, see also Chapters 105 -Electrical Installations and 106 - Automation.

8. Remotely operated shutoff devices

The outlet pipes of fuel tanks located above the double bottom are to be fitted with quick closing valves capable of being closed from the main deck.

The fuel feeding pipes for internal combustion engines and gas turbines as well as the fuel oil pipes for boilers are to be equipped with quickclosing valves at the service tanks capable of being closed from main deck.

9. Machinery space safety station

It is recommended that the following safety devices be grouped in a central, readily accessible location outside the machinery space, e.g. damage control centre:

- cut-off switches for engine room ventilation fans, boiler blowers, fuel transfer pumps, purifiers, thermal oil pumps

- means for closing the

  - quick-closing fuel valves

  - remote controlled water tight doors and skylights in the machinery space area

  - fire dampers

- starting of fire extinguishing pumps

- actuation of the fire extinguishing system for the following spaces/areas:

  - machinery space
  - flight deck
  - hangars

- actuation of the spraying system for the ammunition rooms

Concerning the alarm and operating panels see Chapter 105 - Electrical Installations, Section 9, C.3.

C. Fire Alarms

1. Protected areas

1.1 Spaces with increased risk of fire which are not easily accessible or which are not permanently manned, have to be monitored by an automatic fire alarm system.

2. Design of fire alarm systems

2.1 Fire alarm systems on ships other than those with class notation **SFP** have to be provided for the following types of spaces:

- unmanned machinery spaces

- machinery capsules

- missile silos

- acoustic capsules

- rooms for flammable liquids

- galleys

- aircraft hangars, refuelling and maintenance facilities

- ro-ro spaces

- ammunition rooms

- corridors, stairways

- trunks forming part of these spaces

2.2 Fire alarm and detection systems have to meet the requirements of Chapter 105 – Electrical Installations, Section 9.

2.3 At a permanently manned location a fire alarm panel has to be established. Fire alarm panels have to be equipped with a printer for recovering of any alarms from the system. At the damage control centre (DCC) and at the machinery control centre (MCC) parallel panels with optical and acoustic alarms have to be provided. On board of ships with several independent fire protection zones a fire alarm panel has to be provided for each zone.

D. Fire Extinguishing Equipment

1. General

1.1 Any ship is to be equipped with a general water fire extinguishing system in accordance with E. and with portable and mobile extinguishers as specified under M.

1.2 In addition, depending on their nature, size and the propulsion power installed, spaces subject to a fire hazard are to be provided with fire extinguishing equipment in accordance with Table 9.1. The design of this equipment is described in the following.

Table 9.1 Types of fixed fire extinguishing systems

Type of space	Method of protection	Type of fire fighting system	Remarks
Machinery spaces with internal combustion engines, oil-fired auxiliary boilers and pumps for flammable liquids	Total flooding system	Foam / water drencher system foam extinguishing system gas fire extinguishing system	Foam flooding system for larger naval ships only
Encapsulated internal combustion engines, gas turbines		Gas fire extinguishing system	
Missile silos (ship integrated) for vertical launching systems (VLS)	Room /object protection system with cooling and extinguishing function	Drencher and flooding system	
Paint locker and rooms containing flammable liquids	Total flooding system	Gas fire extinguishing system	
Stores for flammable gases	Total flooding system with cooling and extinguishing function	Drencher system	
Galleys and galley range exhaust	Object protection system with automatic release	Fixed fire extinguishing system	
Flight decks	Object protection system for: - Fire at aircraft - Fire at landing deck in case of a crash - Fire during refueling	CO_2 extinguishing system with hose and director Powder extinguishing system with hose and pistol Foam/water cannon	
Aircraft hangars, ro-ro spaces for vehicles with fuel in their tank	Total flooding system	Foam/water drencher system	
Electrical switch gear spaces	Object protection system	Gas extinguishing system	Portable fire extinguisher
Waste storage spaces, cooled	Total flooding system	Drencher system	
Ammunition rooms	Total flooding system with cooling and extinguishing function	Water spraying system	

Unless otherwise specified, this equipment is normally to be sited outside the spaces and areas to be protected and, in the event of a fire, must be capable of being actuated from points of readily accessible locations.

1.3 Application of fire extinguishing appliances and equipment

The following systems are to be applied for fire fighting:

- general water fire extinguishing systems
- water spraying systems
  - pressure water drencher systems
  - pressure water/foam drencher systems
  - water mist systems
  - sprinkler systems
- foam fire extinguishing systems gas fire extinguishing systems
  - CO_2 fire extinguishing systems
  - fire extinguishing systems with other extinguishing gases according to special approval
- powder fire extinguishing systems

1.4 Approval of extinguishing equipment

Equipment necessary for fire fighting, like hoses, nozzles, fire extinguishers, fire protection materials and extinguishing media have to meet a recognized standard defined by the Naval Authority.

E. General Water Fire Extinguishing Equipment

1. Calculation and design

1.1 The concept of the system has to be oriented on the seawater supply for fire fighting, NBC spraying, water spraying of ammunition storages as well as for the supply of water for the power jet of the drainage ejectors.

1.2 If the water drencher systems are supplied with seawater from the general water fire extinguishing system, the following tasks have to be fulfilled simultaneously.

- drenching of the ammunition storage rooms with a water capacity according to N.2.2
- fire extinguishing with a water capacity of at least 25 m^3/h for ships with one damage control zone respectively of at least 60 m^3/h for ships with several damage control zones
- discharging of the water of the drencher system by supplying a water capacity for the supply of the drainage ejectors, if any

For the estimation of the total pumping capacity it can be assumed that in case of fire extinguishing and drenching no NBC spraying will be executed.

1.3 Systems serving purposes other than those defined in 1.1 may not be supplied from the water fire extinguishing system except of the following:

- seawater emergency supply for internal combustion engines
- seawater supply for the NBC lock and cleaning of sanitary rooms
- cleaning of the waste water and bilge water collecting tanks

Seawater emergency cooling supplies are to be established with standard fire hoses; permanently installed piping is only permitted with approval of the Naval Authority. Pressure reduction is to be provided.

2. Fire pumps

2.1 Number and construction of pumps

2.1.1 The number of the fire pumps is depending on the total capacity of the fire extinguishing, drencher and spraying systems according to 1.2.

2.1.2 As far as practicable fire pumps with the following nominal capacities at a pressure of 9 bar have to be provided, see Table 9.2

2.1.3 All fire pumps on a ship shall have equal nominal capacities and pump characteristics.

Table 9.2 Standardized pump capacities

Pump size	Nominal capacity [m3/h]
1	25
2	50
3	100
4	150

2.1.4 Means are to be provided to ensure a minimum flow in order to prevent overheating of the pumps.

2.1.5 Seawater fire pumps are to be self-priming centrifugal pumps.

2.1.6 Each pump has to have its own seawater inlet.

2.2 Arrangement of fire pumps

2.2.1 The fire pumps should be equally arranged over the watertight compartments of the naval ship.

2.2.2 As far as practicable not more than one fire pum should be situated in any one watertight compartment.

2.2.3 Two fire pumps have to be provided for each damage control zone.

2.2.4 At least two of the fire pumps have to be installed in the ship in a way to enable a faultless operation at the inclinations defined in Section 1, D.

2.3 Emergency fire pumps

2.3.1 If an emergency fire pump is required by the Naval Authority the following has to be observed:

- the energy supply for the pump has to be ensured for an operation of at least 18 hours
- the capacity of the emergency fire pump has to be determined in the same way as for the other fire pumps; the pump shall have at least the following capacities at 9 bar:
  - 50 m^3/h for ships with one damage control zone
  - 100 m^3/h for ships with several damage control zones

2.3.2 The emergency fire pump is to be installed in such a way that the delivery at the prescribed rate and pressure is ensured under all conditions of list, trim and pitch likely to be encountered in service, compare Section 1, D.

2.3.3 The sea suction is to be located as low as possible and together with the pump suction and delivery pipes of the pump to be arranged outside the spaces containing the main fire pumps.

2.3.4 If the electrical cables to the emergency fire pump pass through other high fire risk areas, they are to be of fire resistant type.

2.4 Pressure control pumps

If the installation of a pressure control pump is required by the Naval Authority, a pump with a capacity of 25 m^3/h at a pressure head of 5 bar is to be provided, which can be used also for deck washing and other cleaning tasks.

The power supply of the pressure control pump has to be ensured in the same way as for the fire pumps, see also Chapter 105 - Electrical Installations, Section 7, D.1.

2.5 Remote control and remote monitoring

2.5.1 The release system as well as the remote monitoring have to be situated outside the spaces to be protected. Besides of a local manual release a remote release and a remote monitoring from two separated control centres of the ship (e.g. MCC and DCC) must be provided.

2.5.2 Mechanical remote control devices shall be operated from the weather deck or the deck where the damage control parties start their tasks. The electrical remote control shall be released from the MCC.

3. Fire mains

3.1 International shore connection

An international shore connection has to be provided on the first open deck for each damage control zone to allow water from external sources to be supplied to the ship's fire main.

The dimensions of the shore connection flange shall be as shown in Fig. 9.1.

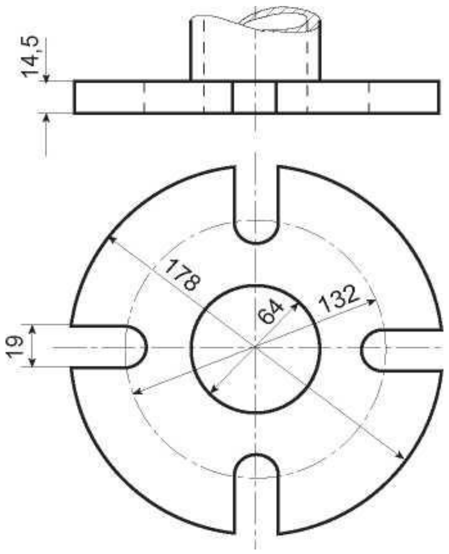

Fig. 9.1 International shore connection

3.2 Arrangement of fire mains

3.2.1 Separate mains have to be provided for the fire extinguishing system and the drencher system.

3.2.2 The fire extinguishing main has to be in stalled at the starboard side, the drencher main at the port side of the ship at different heights above keel. The fire extinguishing main has to be installed below the waterline.

At watertight bulkheads, shut-offs have to be installed at one side, with a means of manual operation also from the other side of the bulkhead. Shut-off devices at the boundaries of damage control zones have to be provided with a remote control system.

For ships with several damage control zones the fire mains and the drenching mains have to be connected to a ring main at the fore and aft ship. At these connections a shut-off valve with remote control has to be provided.

3.2.3 The discharge pipes of the fire pumps have to be connected to the fire and the drencher mains by connecting pipelines. For a selective supply a shut-off valve with remote control has to be installed in each connecting pipeline in immediate vicinity of the fire and drencher mains.

3.2.4 Each fire pump has to be connected to the fire main via a non-return valve with positive means of closing.

3.2.5 Riser mains to fire extinguishing valves above the bulkhead deck have to be provided with a shut-off near the main and a drain valve. Riser mains are not to be led through watertight bulkheads below the bulkhead deck.

3.2.6 Branch lines from the fire main for hawse pipe cleaning are to be provided with a shut-off at the open deck or at another readily accessible location.

3.3 Design of the fire main system with compartment autonomy

3.3.1 For ships with a larger number of watertight compartments and a corresponding number of fire pumps a fire main system with compartment autonomy is recommended.

3.3.2 For a system with compartment autonomy a main has be to be installed as low as possible providing protection by the machinery foundations, longitudinal girders and similar structural elements against splinters. To this main all fire pumps have to be connected.

Shut-off valves are to be arranged such that each compartment can be isolated from the fire main. These valves shall be operable from either side of the bulkheads.

The minimum cross section of the main has to be dimensioned according to the capacity of a fire pump.

3.3.3 In the compartments with fire pumps two riser mains shall be installed as far apart from each other. These riser mains shall supply the following consumers within the compartment:

- fire hydrants:
- drencher nozzles:
  depending on the delivery rate to be distributed to the two riser mains
- spray nozzles:
  to be connected only to one riser main

3.3.4 Consumers in compartments without fire pumps and therefore also without riser mains have to be supplied from the adjoining compartments.

3.4 Dimensioning of the piping system

3.4.1 The fire extinguishing and drencher systems have to be designed for a nominal pressure of

P_N = 10 bar.

3.4.2 The piping for the fire extinguishing and drencher systems has to be dimensioned such that at each consumer position at the level of the bulkhead deck and for a maximum consumption a pressure between 7,5 and 8,0 bar exists.

3.4.3 For the wall thickness of the pipes see Section 8, Table 8.4, seawater pipes group.

3.5 Positions of hydrants

3.5.1 The hydrants have to be equipped with couplings of an approved type.

3.5.2 The arrangement in the ship has to be done, considering

- that a connection between neighbouring hydrants can be established by a 15 m long hose
- that the gastight and watertight bulkheads between the compartments in case of fire need not be penetrated by hoses.

If bulkheads have to be penetrated by fire hoses, pipe sockets have to be used which are welded into the bulkhead and are provided with blind couplings at each side.

3.5.3 Generally hydrants have to be provided in following locations:

- besides the cabinets for fire fighting equipment
- close to the companion stairs at the deck where the damage control parties are starting their activities
- in operating spaces one hydrant each at the front and the rear bulkhead close to the companion ways or emergency exits, as far as possible diagonally to each other
- at the free deck, in a position such that by two standard fire hoses (each 15 m long) every location at the deck can be watered at the same time
- close to devices for foam branch pipes for medium expansion foam
- close to emergency drencher connections

3.6 Fire hoses and nozzles

3.6.1 At each hose connection in operating rooms a fire hose with coupled nozzle has to be provided.

In the other areas fire hoses are stored in the equipment cabinets, see also M.

3.6.2 Individual lengths of fire hoses may not exceed 25 m and should be in accordance with the room size. Every hose must be provided with quick-acting couplings of an approved type, a nozzle and a coupling spanner.

3.6.3 Only dual purpose spray/jet nozzles with a shut-off device are to be provided.

The diameter of the nozzles shall be at least 12 mm.

F. Water Spraying Systems

1. General

The following systems are applied for water drencher systems:

- drencher systems
- foam/water drencher systems for machinery rooms, hangars and ro-ro spaces
- water mist systems
- sprinkler systems

Which of the defined systems have to be provided for the different fire fighting areas depends mainly on the type and scope of the fire hazard and can be taken from Table 9.1 or may be evaluated by risk analysis.

2. Drencher system

2.1 General

2.1.1 Manually released drencher systems have to be used mainly for the cooling of bulkheads and for fire fighting below the floor plates, in bilges of machinery rooms, etc. The system has to be divided into separately supplied sections.

2.1.2 A drencher section shall only range within one watertight compartment. The release valves are to be located outside the spaces to be protected at positions which remain accessible even after the outbreak of fire.

2.1.3 The number and arrangement of the nozzles shall ensure the homogenous distribution of a water quantity of at least 5 l/m^2 per min over the complete areas to be protected.

2.1.4 The pump for supplying the drencher system and its power source are to be located outside the spaces to be protected. The pump must at least be capable of supplying all the drencher nozzles in the largest enclosed space with the required quantity of water at the necessary pressure simultaneously.

2.1.5 The system is to be maintained at the necessary pressure. In the event of a pressure drop, the pump shall start up automatically.

2.1.6 The pump is to be equipped with a direct sea suction. The shut-off device is to be secured in the open position.

2.1.7 In the choice of materials, special attention is to be given to corrosion resistance.

2.1.8 By a flexible connection with back flash protection to the sanitary freshwater system a possibility for flushing the pressureless part of the system has to be provided.

2.2 Remote control, remote monitoring

2.2.1 The remote monitoring of spaces with manually released drencher systems has to be established by fire detectors.

2.2.2 The release of the systems is done manually after checking the actual situation. The remote control and remote monitoring of the pumps and valves have to be activated from the centres and panels where the occurrences are reported.

3. Foam/water drencher system (FDS)

3.1 General

3.1.1 These systems are used for fire fighting in operating spaces of naval surface ships. They can be designed as room protection or object protection system. Preferably foam/water drencher systems have to be provided for fighting of fires of fire class B according to Table 9.5 (liquids), see also Table 9.1.

3.1.2 Foam compound is added to the drencher water in order to improve the fire fighting effect.

3.2 Design

3.2.1 The FDS system has to be designed and in stalled only by contractors approved by TL. In principle only type approved components, suitable for the specific requirements are permitted for installation.

3.2.2 The FDS system has to be designed as low-pressure drencher system (operating pressure 6-9 bar) and for a capacity of at least 5 l/m^2 min.

3.2.3 The FDS system has to be designed as combined total flooding room protection and object protection system with sectional release. Even if a drencher main is damaged, the total flooding system must be able to hinder the spreading of the fire. To meet these requirements adequate valves (self-closing or remote controlled) have to be provided.

3.2.4 A sufficient supply of water and foam compound from outside the zones to be protected has to be ensured.

Systems, devices, fittings and electrical power supply necessary for the operation of the FDS must neither be installed in the spaces to be protected nor pass them. They must be easily accessible.

From the distribution and release station separate mains have to lead to the different fire fighting zones.

3.2.5 As extinguishing medium a mixture of sea-water and aqueous film-forming foam (AFFF) has to be used.

3.2.6 The size of the stock of foam compound shall allow continuous fire fighting in the largest space to be protected for a duration of at least 30 minutes as suming an addition of 3 % foam compound to the sea water.

It should be possible to fight two fire scenarios at the same time, e.g. fire at the flightdeck and in a machinery room.

3.3 Arrangement

3.3.1 The stock of foam compound and the mixing system have to be situated at least at two locations of the ship with the maximum possible distance from each other (*). They have to be connected by a main.

*(*) Note: In special conditions, based on ship length and damage control area, number of tank of foam can be reduced when agreed with **TL.** Ships which keel laying date is after 1 January 2012, this situation can be applied by **TL.***

3.3.2 Remote controlled shut-offs have to be provided at the boundaries of damage control zones up/downstream of the feeding positions for the spaces to be protected.

For smaller naval ships, like patrol boats one foam mixing station will be sufficient.

3.3.3 The pipes in the different spaces up to the shut-off valves have to be provided as dry system, the supply main has to be designed as wet part of the system.

3.3.4 The supply main has to be equipped with standard fire hose couplings (Storz-C-couplings or similar) for the connection of generating devices, with shut-off valves at the bulkheads as well as with con nections for flushing and drainage.

3.3.5 Alternatively to the central foam mixing stations also local mixing stations may be approved in agreement with Naval Authority and TL, if a compa rable safety and survivability can be assumed.

3.3.6 Besides the basic fire fighting function the system has also a cooling function for the walls and ceilings to the adjacent spaces.

3.3.7 If no permanently installed and redundant system is provided, emergency drencher couplings with standard fire valves are to be provided as an emergency supply (30 % of the design capacity).

3.4 Foam/water drencher system as room protection

3.4.1 For room protection systems the following minimum water quantities have to be planned:

horizontal surfaces to be protected **(1)**: 5 l/m^2 per min

The drencher water volume has to be assumed as at least 2 l/m^3 per min ± 0,2 l related to the gross space volume.

(1) *including all surfaces where fuel/oil can be spread*

3.4.2 The fittings and nozzles installed in spaces to be protected shall be sufficiently resistant to fire.

3.4.3 To avoid a shockwise creation of steam, effective openings for release of pressure, which limit the overpressure in the room to 10 mbar, are to be provided.

3.5 Foam/water drencher system as object protection

3.5.1 For object protection systems the following minimum water quantities have to be planned:

internal combustion engines 20 l/m^2 per min

various systems 5 l/m^2 per min

The spraying nozzles have to be arranged in a way that the drenching area exceeds the object to be protected at least by 0,5 m.

3.6 Foam/water drencher system for aircraft hangars

For aircraft hangars a water quantity analogous to 3.4.1 has to be provided.

3.7 Foam/water drencher system for special rooms/equipment

The system can be designed as space or object protection system. The lay-out shall be analogous to 3.4 or to 3.5 respectively.

3.8 System components

3.8.1 Tanks for foam compounds

3.8.1.1 The foam compound shall be stored in at least two tanks arranged as far apart from each other as possible (*). The total storage volume of these tanks shall be 200 % of the compound necessary to fight two fire scenarios according to 3.2.6 and the volume shall be equally distributed to the tanks. It must be possible to supply the foam compound from each tank to all consumers, including to the provided hydrants.

( ) Note: In special conditions, based on ship length and damage control area, number of tank of foam can be reduced when agreed with* ***TL.*** *Ships which keel laying date is after 1 January 2012, this situation can be applied by* ***TL****.*

3.8.1.2 The tanks have to be manufactured of corrosion-resistant materials or to be suitably coated. They have to be equipped with a filling level remote indicator, low level alarm and automatic pump shut-off, an air pipe, means of drainage and a sampling valve.

3.8.1.3 The foam compound replenishment system has to be positioned at the weather deck.

3.8.2 Foam pumps

3.8.2.1 For each storage tank two foam pumps have to be installed. If two tanks are located in a space, only two pumps are needed in this space.

3.8.2.2 The pumps have to be equipped with a non return valve at the delivery side. Besides the remote control an on/off switch has to be provided locally close to the pumps. If drencher systems with automatic release are provided, the foam pumps have to be started automatically together with the other fire fighting system.

3.8.2.3 The power supply for the foam pumps has to be ensured in the same way like for the fire pumps.

3.8.2.4 For flushing of the foam system, a connection from the seawater fire extinguishing main to the foam suction pipe has to be provided.

3.8.3 Foam proportioners

Only approved foam proportioners have to be provided.

3.8.4 Pipes and fittings

Pipes and fittings have to be corrosion-resistant according to the foam compound used.

3.8.5 Spray nozzles

3.8.5.1 Only approved types of spraying nozzles made of materials resistant to corrosion and heat have to be used, e.g. material number 1.4571 **(2)**.

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(2) *defined in Key of Steels, Verlag Stahlschlüssel Wegst GmbH, D-71672 Marbach/Neckar*

Shadowed surfaces which are not impinged by the spray, e.g. below platforms of more than 1 m^2 size, are to be equipped with additional nozzles.

3.8.5.2 The arrangement of the spraying nozzles has to meet the following requirements:

- the vertical distance of the nozzles to the surface to be protected shall not exceed 5 m
- a cooling of bulkheads and walls is to be safe-guarded
- the distribution of the foam/water mixture over the surfaces to be protected/cooled shall be homogeneous

3.9 Remote operation and remote monitoring

3.9.1 The release devices have to be situated out side of zones to be protected.
Besides of a local manual release a remote release from the machinery control centre and the damage control centre have to be provided.

3.9.2 Object protection systems may be equipped with automatic release, if suitable fire detection is provided.

The release of a FDS has to be signalled at the operation and control displays.

3.10 Protection of electrical systems

In spaces protected by FDS suitable measures to protect the electrical installations have to be provided. Direct measures (e.g. increase of the degree of protection) or indirect measures (e.g. protected installation) are permissible.

3.11 Warning devices

3.11.1 Spaces and zones protected by FDS have to be equipped with acoustic/optical alarms which shall come into operation automatically upon the release of the system.

3.11.2 The alarm signals must be clearly distinguishable from other alarms in the ship. The sound level of the alarms must be at least 5 dB(A) above the operation noise level.

3.11.3 The release of alarms must be signalled at the control position of the related system.

4. Water mist systems

4.1 General

4.1.1 Any water-based fire extinguishing system for use in operating spaces with internal combustion engines or oil fired auxiliary boilers and pump rooms will be approved by TL based on the requirements of international guidelines.

4.2 Principal requirements for the system

4.2.1 The system shall be capable of manual release.

4.2.2 The system shall be available for immediate use and capable of continuously supplying water for at least 30 minutes in order to prevent re-ignition of fire spread within that period of time. Systems which operate at a reduced discharge rate after the initial extinguishing period shall have a second full fire-extinguishing capability available within a 5-minute period of initial activation. A pressure tank shall be provided for the immediate water supply and an automatic start of the necessary pumps.

4.2.3 The system and its components shall be suitably designed to withstand ambient temperature changes, vibration, humidity, shock, impact, clogging and corrosion normally encountered in operating rooms with internal combustion engines or oil fired boilers and pump-rooms in ships. Components within the protected spaces shall be designed to withstand the elevated temperatures which could occur during a fire.

4.2.4 The system and its components shall be de signed and installed in accordance with international standards acceptable to TL.

4.2.5 The nozzle location, type of nozzle and nozzle characteristics should be within the limits tested to provide fire extinction.

4.2.6 The electrical components of the pressure source for the system shall have a minimum rating of IP 54. The system shall be supplied by both main and emergency sources of power and shall be provided with an automatic change-over switch. The emergency power supply shall be provided from outside the protected machinery space.

4.2.7 The system shall be provided with a redundant means of pumping or otherwise supplying the water-based extinguishing medium. The system shall be fitted with a permanent sea inlet and be capable of continuous operation using seawater.

4.2.8 The piping system shall be sized in accordance with a recognized hydraulic calculation technique. **(3)**

4.2.9 Systems capable of supplying water at the full discharge rate for 30 minutes may be grouped into separate sections within a protected space. The sectioning of the system within such spaces shall be approved by the Administration in each case.

4.2.10 In all cases the capacity and design of the system shall be based on the complete protection of the space demanding the greatest volume of water.

4.2.11 The system operation controls shall be available at easily accessible positions outside the spaces to be protected and shall not be liable to be cut off by a fire in the protected spaces.

4.2.12 Pressure source components of the system shall be located outside the protected spaces.

4.2.13 A means for testing the operation of the system for assuring the required pressure and flow shall be provided.

(3) *Where the Hazen-Williams Method is used, the following values of the friction factor "C" for different pipe types which may be considered should apply:*

Pipe type	*C*
Black of galvanized mild steel	*100*
Copper and copper alloys	*150*
Stainless steel	*150*

4.2.14 Activation of any water distribution valve shall give a visual and audible alarm in the protected space and at a continuously manned central control station. An alarm in the central control station shall indicate the specific valve activated.

4.2.15 Operating instructions for the system shall be displayed at each operating position.

4.2.16 Spare parts and operating and maintenance instructions for the system shall be provided as recommended by the manufacturer.

5. Sprinkler systems

Sprinkler systems with automatic release are normally not used for naval ships. The application is limited to spaces/zones with fire hazards from solids, e.g. spaces for the storage and/or incineration of solid waste according to L.

If sprinkler systems are to be used for other duties such systems have to be designed and installed according to the TL Rules, Part B, Chapter 04 – Machinery Rules, Section 18, L.

G. Foam Fire Extinguishing Systems General

1.1 For foam fire extinguishing the following types are to be applied:

- systems with low expansion foam
- systems with medium and high expansion foam
- foam flooding systems for operating spaces

1.2 Low expansion foam systems are mainly to be used for fire fighting on open decks (flight decks).

1.3 Medium and high expansion foam systems are especially to be used for fire fighting in operating spaces if no effective fire fighting with gas fire extinguishing systems is possible.

Such operating spaces are:

- gas turbine rooms
- rooms with internal combustion engines
- reduction gear rooms
- electric power stations
- rooms for fuel pumps

The flooding of the spaces with medium expansion foam is to be provided via foam down mains which are situated outside the endangered zone at higher decks. The foam production is effected by means of mobile foam generators.

1.4 The design and construction of foam fire extinguishing systems used for external fire fighting have to be defined together with the Naval Authority.

2. Foam compound

2.1 Only approved aqueous film forming foam media (AFFF) shall be used. The foam concentrate must be frost-proof down to a temperature of -5 °C at minimum.

2.2 Low expansion foam is produced by adding 3-6 % foam concentrate, the foam expansion ratio, i.e. the ratio of the volume of foam produced to the mixture of water and foam concentrate supplied, shall not exceed 12 :1.

Medium and high expansion foam, produced by adding 1 - 3 % foam concentrate, the foam expansion ratio may be 20 :1 up to 1000:1.

3. Low expansion foam fire extinguishing systems

3.1 For fire fighting at flight decks a fixed low expansion foam system with monitor and manual foam nozzle has to be provided. It must be possible to operate this system under all weather conditions allowing aircraft operation and to deliver fire fighting foam at any location of the flight deck.

3.2 The system has to be equipped with a remote control water/foam monitor with a capacity of 1600 l/min. In addition at least two couplings for foam branch pipes with a water/foam capacity of 400 l/min each have to be provided.

3.3 The stored quantity of foam concentrate must enable an operation of the fixed monitors for at least 5 minutes.

3.4 Design and arrangement of the system components, like foam tanks, foam media pumps, foam proportioner, pipelines and fittings have to be provided analogously to F.3.8.

3.5 The devices for release of the system shall be situated outside the zones to be protected.

4. Medium and high expansion foam extinguishing systems

4.1 The system serves to fight fires of fire classes A and B according to Table 9.5 in engine rooms. The flooding of the operating rooms is done from the top by down mains.

4.2 The foam production and filling devices have to be installed at the upper decks outside the rooms to be protected.

4.3 The required quantity of extinguishing water for each monitor or down main is 24 m^3/h at a pressure of 8 bar and it has to be supplied from the seawater fire extinguishing system via standard hose connections. The water supply of the foam media mixer has to be ensured by a 15 m long fire hose.

4.4 The necessary storage quantity for the foam compound is to be calculated for flooding of the largest space for a duration of 30 minutes.

4.5 Design and arrangement of the system components, like foam tanks, foam media pumps, foam proportioner, pipelines and fittings have to be provided analogously to F.3.8.

4.6 The devices for release of the system shall be situated outside the zones to be protected. Besides a manual release locally, a remote release from the machinery control centre (MCC) and from the damage control centre (DCC) has to be provided.

H. Gas Fire Extinguishing Systems

1. General

The application of gas fire extinguishing systems is suitable for fire fighting in sound absorbing capsules and in closed spaces with special devices or high fire hazard, see Table 9.1.

These systems can be applied for room protection with manual release or for object protection with automatic release.

As extinguishing gas primarily CO_2 shall be used. Other gases may be used with approval of TL.

2. High pressure CO_2 fire extinguishing systems

2.1 Approved systems

Approved are high pressure CO_2 fire extinguishing systems with manual release for room protection as well as for object protection with automatic release.

For warning the crew and embarked troops a clearly noticable odorous substance shall be added to the CO_2.

2.2 Calculation of the necessary quantity of CO_2

The calculation of the necessary quantity of CO_2 is to be based on a gas volume of 0,56 m^3 per kg of CO_2.

If two or more individually floodable spaces are connected to the CO_2 system, the total CO_2 quantity available need not be more than the largest quantity required for one of these spaces.

2.2.1 Machinery and boiler spaces

2.2.1.1 The quantity of gas available for spaces containing internal combustion machinery, oil-fired boilers or other oil-fired equipment and for purifier spaces must be sufficient to give a minimum volume of free gas equal to the larger of the following:

- 40 % of the gross volume of the largest space including the casing up to the level at which the horizontal area of the casing is less than 40 % of the horizontal area of the space concerned

- 35 % of the gross volume of the largest space including the casing

2.2.1.2 For machinery spaces without casing, e.g. incinerator or inert gas generator spaces, the volume of free gas available is to be calculated as 35 % of the gross volume of the space.

2.2.1.3 Where two or more spaces containing boilers or internal combustion machinery are not entirely separated, they are to be considered as a single space for the purpose of determining the quantity of CO_2 required.

2.2.1.4 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 extinguishing medium. Alternatively, a discharge pipe, led from the safety valves to the open air, may be fitted.

2.3 Tightness of spaces and protection of spaces against over-/underpressure

2.3.1 All spaces in which gas fire extinguishing is provided have to be sufficiently gastight to the adjacent spaces to avoid hazards to the crew. Where this is not possible the adjacent spaces have to be equipped with CO_2 evacuation alarm which is released at the same time as the alarm in the space to be flooded.

2.3.2 Access doors to CO_2 protected spaces have to be of self-closing type or have to be equipped with monitoring devices and indication at the MCC.

2.3.3 It has to be ensured that no impermissible over or under pressure will be created by CO_2 flooding. If necessary, suitable devices for pressure equalization have to be provided. A proof by an adequate calculation has to be made.

2.4 CO_2 cylinders

2.4.1 Design and equipment

2.4.1.1 In respect of their material, manufacture, type and testing, CO_2 cylinders must comply with the requirements of Section 16, G. for gas cylinders.

2.4.1.2 CO_2 cylinders may normally only be filled with liquefied CO_2 in a ratio of 2 kg CO_2 to every 3 litres of cylinder capacity.

2.4.1.3 Cylinders intended for flooding boiler rooms, machinery spaces and pump rooms must be equipped with quick-opening valves for group release enabling these spaces to be flooded with 85 % of the required gas volume within two minutes. Cylinders intended for the flooding of cargo spaces need only be fitted with individual release valves.

For spaces for the carriage of motor vehicles with fuel in their tanks CO_2 cylinders with quick-opening valves suitable for group release are to be provided for flooding of these spaces within 10 minutes with 2/3 of the prescribed quantity of CO_2.

2.4.1.4 Cylinder valves must be approved by a recognised institution and be fitted with an overpressure relief device.

2.4.1.5 Siphons must be securely connected to the cylinder valve.

2.4.2 Disposition

2.4.2.1 CO_2 cylinders are to be stored in special spaces, securely fastened and connected to a manifold. Check valves are to be fitted between individual cylinders and the manifold.

If hoses are used to connect the cylinders to the manifold, they must be type-approved.

2.4.2.2 At least the cylinders intended for the quick flooding of boiler rooms and machinery spaces are to be grouped in one room.

2.4.2.3 The cylinders for CO_2 fire extinguishing systems for scavenge trunks and for similar purposes may be stored in the machinery space, provided that the total CO_2 volume installed in the space is not more than 4% of the net volume of the space.

2.5 Rooms for CO_2 cylinders

2.5.1 Location

2.5.1.1 Rooms for CO_2 cylinders may not be located forward of the collision bulkhead and shall, wherever possible, be situated on the open deck. Access should be possible from the open deck. CO_2 cylinder rooms below the open deck must have a stairway or ladder leading directly to the open deck. The CO_2 cylinder room shall not be located more than one deck below the open deck. Direct connections via doors or other openings between cylinder rooms and machinery spaces or accommodation spaces below the open deck are not permitted. In addition to the cabins themselves, other spaces provided for use by the crew such as sanitary spaces, public spaces, stair wells and corridors are also considered to be part of the accommodation space.

The size of the cylinder room and the arrangement of the cylinders must be convenient to efficient operation.

Means are to be provided for conveying cylinders to the open deck.

2.5.1.2 Cylinder rooms shall be lockable. The keys to such rooms are to be kept in a glass-fronted case fixed to the door. The doors of cylinder rooms must open outwards.

Cylinder rooms shall not be used for other purposes.

2.5.1.3 Cylinder rooms are to be equipped with sufficient lighting connected to the emergency power distribution.

2.5.2 Insulation

Cylinder rooms are to be protected or insulated against heat and solar radiation in such a way that the room temperature does not exceed 45 °C. The room temperature has to be monitored from the MCC. The boundaries of the cylinder room must conform to the insulation values prescribed for control stations, see Chapter 102 - Hull Structures and Ship Equipment, Section 20.

2.5.3 Ventilation

Cylinder rooms are to be provided with adequate ventilation. Spaces where access from the open deck is not provided or which are located below deck are to be fitted with mechanical ventilation, see Section 11, D.4. The exhaust duct should be led to the bottom of the space. Other spaces may not be connected to this ventilation system.

2.6 Piping

2.6.1 Piping is to be made of weldable materials in accordance with the TL Rules Chapter 2 Materials. The control pipes are to be manufactured of stainless steel, e.g. material number 1.4571, see F.3.8.5.1, or equivalent.

2.6.2 The manifold from the cylinders up to and including the distribution valves are to be designed for a nominal pressure of PN = 100 bar (see Section 8, B.4.1.2). In the collecting line a safety valve 130 bar with escape to the free main deck as well as a manometer for leakage control of the CO_2- cylinder valves and monitoring at the MCC have to be provided.

Material certificates are to be provided acc. to the requirements for pipe class I, see Section 8. Manufacturers' inspection certificates acc. to EN10204-3.1B may be accepted as equivalent provided that by means of the pipe marking (name of pipe manufacturers, heat number, test mark) unambiguous reference to the certificate can be established. The rules regarding remarking are to be observed when processing the pipes.

2.6.3 Pipe work between distribution valves and nozzles is to be designed for a nominal pressure of PN = 40 bar. However, for the purpose of material certification this piping may be considered as pipe class III.

2.6.4 All pipework is to be protected against external corrosion. Distribution lines serving spaces other than machinery spaces are to be galvanised internally.

2.6.5 Wherever possible, welded pipe connections are to be used for CO_2 systems. For detachable con nections which cannot be avoided and for valves and fittings, flanged joints are to be used. For pipes with a nominal bore of less than 50 mm, welded compression type couplings may be used.

Only welding connections are permitted in pipelines passing through accommodation areas.

2.6.6 Bends or suitable compensators are to be provided to accommodate the thermal expansion of the pipelines. Hoses for connecting the CO_2 cylinders to the manifold are to be type-approved.

2.6.7 Distribution piping for quick-flooding is to be designed such that icing due to expansion of the extinguishing gas cannot occur.

2.6.8 The minimum nominal bore of flooding lines and of their branches to nozzles is 20 mm, that of the nozzle connections 15 mm.

The pipe thicknesses are shown in Table 9.3.

2.6.9 A compressed air connection with a non-return valve and a shut-off valve is to be fitted at a suitable point. The compressed air connection must be of sufficient size to ensure that, when air is blown through the system at a pressure of 5 to 7 bar, it is possible to check the outflow of air from all nozzles.

2.6.10 CO_2 pipes may not be led through refrigerated spaces.

2.6.11 Pipes and fittings have to be arranged and marked in a way that it is clearly noticeable to which spaces they are leading.

2.6.12 Where condensed water may be created a drainage has to be provided at the lowest point. The drainage has to be secured against unauthorized opening.

Table 9.3 Minimum thicknesses for CO_2 steel pipes

Outer diameter d_a [mm]	From cylinders to distribution valves s [mm]	From distribution valves to nozzles s [mm]
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

2.6.13 The piping system has to be reliably mounted at the ship's structure and has to be protected against damage. The pipes have to be connected to earth to avoid static electricity.

2.7 Release devices

2.7.1 On principle the release of the system has to be activated manually.

2.7.2 The release stations have to be situated near the entrance of the spaces to be protected. They have to be easily accessible from the open deck or from the main companion ways. Additional release positions, e.g. MCC or the bridge, are permissible and may be defined by the Naval Authority.

2.7.3 The release stations have to be equipped with non-lockable doors. These have to be kept closed and sealed. It has to be arranged that the doors of the stations can not be closed as long as the distribution valve is opened.

A separate release station is to be provided for each space which can be flooded separately, the space to which it relates being clearly indicated.

An operating manual has to be attached at the release station.

2.7.4 Release of the CO_2 cylinders, whether individually or in groups, and opening of the distribution valve must be actuated independently of each other.

2.7.5 Remotely operated cylinder actuating devices and distribution valves must be capable of local manual operation.

2.7.6 A distribution valve is to be located in every flooding line outside the space to be protected and in a readily accessible position.

2.7.7 Distribution valves are to be protected against unauthorised and unintentional actuation and fitted with signs indicating the space to which the associated CO_2 lines lead.

2.7.8 Distribution valves are to be made of a seawater-resistant material. The valve position 'open' or 'closed' must be indicated.

2.8 CO_2 discharge nozzles

2.8.1 The number and arrangement of the nozzles provided must ensure even distribution of the CO_2.

2.8.2 Boiler rooms and machinery spaces

The nozzles are to be arranged preferably in the lower part of the machinery space, taking into account the room configuration, and in the bilges. At least eight nozzles are to be provided, not less than two of which shall be located in the bilges.

Nozzles shall be provided in the engine or funnel casing, if fire hazard equipment, e.g. oil fired equipment, is installed.

The number of nozzles may be reduced for small machinery spaces.

2.9 Alarm systems

2.9.1 For machinery spaces, boiler and similar spaces acoustic alarms of horn or siren sound are to be provided which shall be independent of the discharge of CO_2. The audible warning is to be automatically actuated a suitable time before flooding occurs and is to be clearly distinguishable from all other alarm signals.

The period of time necessary to evacuate the space to be flooded shall be considered as adequate but not less than 20 s. The system is to be designed such that flooding is not possible before this period of time has elapsed by means of a mechanical timer.

Opening the door of the release station must trip the CO_2 alarm in the protected space.

The alarm must sound as long as the distribution valves are open. A visual alarm is also to be installed where necessary.

2.9.2 Where adjoining and interconnecting spaces, e.g. machinery space, purifier room, machinery control room, have separate flooding systems, any danger to persons must be excluded by suitable alarms in the adjoining spaces.

2.9.3 Alarm systems are also to be provided in spaces for military vehicles and spaces to which personnel normally has access. In small spaces, e.g. small compressor rooms, paint stores, etc., alarms may be dispensed with by TL on application.

2.9.4 The power supply to electrical alarm systems must be guaranteed in the event of failure of the ship's main power supply.

2.9.5 If the alarm is operated pneumatically, a permanent supply of compressed air for the alarm system is to be ensured.

2.10 General arrangement plan

Arrangement plans are to be displayed at the bridge (MCC or DCC) and in the CO_2 rooms showing the disposition of the entire CO_2 system. The plan must also indicate how many cylinders are to be released to extinguish fires in individual spaces.

2.11 Warning signs

2.11.1 For CO_2 systems the following signs are to be displayed:

2.11.2 At the release stations:

"Do not operate release until personnel has left the space, the ventilation has been shut off and the space has been sealed."

2.11.3 At the distribution stations and in the CO_2 room:

"Before flooding with CO_2 shut off ventilation and close air intakes. Open distribution valves first, then the cylinder valves!"

2.11.4 In the CO_2 room and at entrances to spaces which can be flooded:

"WARNING!"

"In case of alarm or release of CO_2, leave the space immediately (danger of suffocation).

The space may be re-entered only after thorough ventilating and checking of the atmosphere."

2.11.5 In the CO_2 cylinder room:

"This space may be used only for the storage of CO_2 cylinders for the fire extinguishing system. The temperature of the space is to be monitored."

2.12 Testing

2.12.1 After installation, piping between cylinders and distribution valves and piping passing through accommodation spaces is to be subjected to hydraulic tests at 120 bar and 50 bar respectively. A test pressure of 10 bar is required for all other piping.

The hydrostatic test may also be carried out prior to installation on board for piping which is manufactured complete and equipped with all fittings. Joints welded on board must undergo a hydrostatic test at the appropriate pressure.

Where water cannot be used as test medium, because the piping cannot be dried prior to putting the system into service, proposals for alternative test media or test procedures are to be submitted to TL for approval.

2.12.2 After assembly on board, a tightness test is to be performed using air or other suitable media. The selected pressure depends on the method of leak detection to be used.

2.12.3 All piping is to be checked for free passage and tightness.

2.13 CO_2 fire extinguishing systems for object protection

2.13.1 For fire fighting in acoustic capsules of gas turbines, propulsion diesel engines as well as electrical power aggregates CO_2 systems with automatic release are permitted.

2.13.2 The release of the fire fighting action has to be controlled by temperature and flame detectors and activated from the fire control board in the damage control centre or the MCC. The release has to be indicated in the other centres.

2.13.3 Besides this, the other requirements defined in H. apply analogously.

2.14 CO_2 fire extinguishing systems for aircraft operation

2.14.1 To fight turbine fires on board of ships with a flightdeck, a CO_2 extinguishing system has to be provided which has to be equipped as follows:

- 2 CO_2 containers of 26,4 kg each
- an applicator pipe with shut-off valve, safety valve and pressure manometer, etc.
- a 30 m CO_2 hose on a reel
- a release station, if applicable

The CO_2 containers can be stored in a flightdeck fire fighting room. This room must fulfil the requirements for CO_2 storage rooms. The outlets of valve bursting disks and of safety valves have to be led to the open deck.

2.1.4.2 In relation to the system components the requirements concerning CO_2 systems already defined have to be applied.

2.1.4.3 For extended flight operations with a large number of helicopters or fixed wing aircraft special considerations have to be made between Naval Authority, shipyard and TL

3. Installation of fixed gas fire-extinguishing systems using gases other than CO_2 for operating rooms with internal combustion engines or oil fired boilers and pump rooms

3.1 General

3.1.1 Systems using extinguishing gases other than CO_2 shall be approved in accordance with a standard acceptable to TL.

3.1.2 No fire extinguishing gas shall be used which is carcinogenic, mutagenic or teratogenic at concentrations expected during its use or which is not considered to be environmentally acceptable.

No fire extinguishing gas shall be used in concentrations greater than the cardiac sensitisation level NOAEL

(No Observed Adverse Effect Level), without the use of controls.

In no case an extinguishing gas is permitted to be used in concentrations above its LOAEL (Lowest Observed Adverse Effect Level) nor its ALC (Approximate Lethal Concentration).

3.1.3 For systems using halocarbon agents, the system shall be designed for a discharge of 95% of the design concentration in not more than 10 s.

For systems using inert gases, the discharge time shall not exceed 120 s for 85% of the design concentration.

3.2 Calculation of the supply of extinguishing gas

3.2.1 The supply of extinguishing gas shall be calculated based on the net volume of the protected space at the minimum expected ambient temperature using the design concentration specified in the system's type approval certificate.

3.2.2 The net volume is that part of the gross volume of the space which is accessible to the free extinguishing gas including the volumes of the bilge and of the casing. Objects that occupy volume in the protected space should be subtracted from the gross volume. This includes, but is not necessarily limited to:

- internal combustion engines
- reduction gears
- boilers
- heat exchangers
- tanks and trunks
- exhaust gas pipes, -boilers and -silencers

3.2.3 The volume of free air contained in air receivers located in a protected space shall be added to the net volume unless the discharge from the safety valves is led to the open air.

3.2.4 In systems with centralised gas storage for the protection of more than one space the quantity of extinguishing gas available need not be more than the largest quantity required for any one space so protected.

3.3 Gas containers

3.3.1 Containers for the extinguishing gas or a propellant needed for the discharge shall comply in respect of their material, construction, manufacture and testing with the relevant TL Rules on pressure vessels.

3.3.2 The filling ratio shall not exceed that specified in the system's type approval documentation.

3.3.3 Means are to be provided for the ship's personnel to safely check the quantity of medium in the containers.

3.4 Storage

3.4.1 Centralised systems

Gas containers in centralised systems are to be stored in a storage space complying with the requirements for CO_2 storage spaces, see 2.5, with the exception that storage temperatures up to 55 °C are permitted, unless otherwise specified in the type approval certificate.

3.4.2 Modular systems

3.4.2.1 All systems covered by these Rules may be established as modular systems with the gas containers and containers with the propellant, if any, permitted to be stored within the protected space, provided that conditions to be defined by TL are complied with.

3.4.2.2 The arrangement of gas containers, electrical circuits and piping essential for the release of the system shall be such that in the event of damage to any one power release line through fire or explosion in the protected space, at least five sixth parts of the extinguishing gas calculated for the space can still be discharged, having regard to the requirement for uniform distribution of the extinguishing gas throughout the space.

In case that due to the size of the space it is impracticable to arrange a minimum of 6 containers, special approval by TL is to be applied for.

3.4.2.3 Duplicate sources of power located outside the protected space shall be provided for the release of the system and be immediately available, except that for machinery spaces, one of the sources of power may be located inside the protected space.

3.4.2.4 Electric power circuits connecting the containers shall be monitored for fault conditions and loss of power. Visual and audible alarms shall be provided for indication.

3.4.2.5 Pneumatic or hydraulic power circuits connecting the containers shall be duplicated. The sources of pneumatic or hydraulic pressure shall be monitored for loss of pressure. Visual and audible alarms shall be provided to indicate this.

3.4.2.6 Within the protected space, electrical circuits essential for the release of the system shall be heat-resistant, e.g. mineral-insulated cable or equivalent. Essential piping systems for the release of systems which are designed to be operated hydraulically or pneumatically shall be of steel.

3.4.2.7 Not more than two discharge nozzles shall be fitted to any container.

3.4.2.8 The containers shall be monitored for decrease in pressure due to leakage or discharge. Visual and audible alarms in the protected space and at the damage control centre shall be provided to indicate this.

3.4.2.9 Each container is to be fitted with an over pressure release device which due to fire causes the contents of the container to be automatically discharged into the protected space.

3.5 Piping and nozzles

3.5.1 Piping is to be made of weldable steel materials and to be designed according to the working pressure of the system.

3.5.2 Wherever possible, pipe connections are to be welded. For detachable pipe joints, flange connections are to be used. For pipes with a nominal internal diameter of less than 50 mm threaded welding sockets may be employed.

3.5.3 Flexible hoses may be used for the connection of containers to a manifold in centralised systems or to a rigid discharge pipe in modular systems. Hoses shall not be longer than necessary for this purpose and be type approved for the use in the intended installation. Hoses for modular systems are to be flame resistant.

3.5.4 Only nozzles approved for use in the system shall be installed. The arrangement of nozzles shall comply with the parameters specified in the system's type approval certificate, giving due consideration to obstructions. In the vicinity of passages and stairways nozzles shall be arranged such as to avoid personnel being endangered by the discharging gas.

3.5.5 The piping system shall be designed to meet the requirements stipulated in 2.6.

3.6 Release arrangements and alarms

3.6.1 The system is to be designed for manual release only.

The controls for release are to be arranged in lockable cabinets (release stations), the key being kept conspicuously next to the release station in a locked case with a glass panel.

Separate release stations are to be provided for each space which can be flooded separately. The release stations shall be arranged near to the entrance of the protected space and shall be readily accessible also in case of a fire in the related space. Release stations shall be marked with the name of the space they are serving.

3.6.2 Centralised systems shall be provided with additional means of releasing the system from the storage space.

3.6.3 Mechanical ventilation of the protected space is to be stopped automatically before the discharge of the extinguishing gas.

3.6.4 Audible and visual alarms shall be provided in the protected space and additional visual alarms at each access to the space.

3.6.5 The alarm shall be actuated automatically by opening of the release station door. For installations with a design concentration in excess of the NOAEL, compare 3.1.2, means shall be provided to safeguard that the discharge of extinguishing gas is not possible before the alarm has been actuated for a period of time necessary to evacuate the space but not less than 20 s.

3.6.6 Audible alarms shall be of horn or siren sound and be clearly distinguishable from other audible signals.

3.6.7 Electrical alarm systems shall have power supply from the main and emergency source of power.

3.6.8 For the use of electrical alarm systems in gas dangerous zones refer to Chapter 105 - Electrical In stallations, Section 9, B. and C.

3.6.9 Where pneumatically operated alarms are used the permanent supply of compressed air is to be safeguarded by suitable arrangements.

3.7 Tightness of the protected space

3.7.1 Means for closing all ventilation openings and other openings in the boundaries of the protected space shall be provided.

3.7.2 A minimum agent holding time of 15 min should be provided.

3.7.3 The release of the system may produce significant over- or underpressurisation in the protected space which may necessitate the provision of suitable pressure equalising arrangements.

3.7.4 Escape routes which may be exposed to leakage from the protected space should not be rendered hazardous during or after the discharge of the extinguishing gas. Control stations and other locations that require manning during a fire should have provisions to keep HF and HCl below 5 ppm at that location. The concentrations of other products should be kept below values considered hazardous for the required duration of exposure.

3.8 Warning signs and operating instructions

3.8.1 Warning signs are to be provided at each access to and inside a protected space as appropriate:

- "WARNING! This space is protected by a fixed gas fire extinguishing system using… Do not enter when the alarm is actuated!"

- "WARNING! Evacuate immediately upon sounding of the alarm of the gas fire extinguishing system."

3.8.2 Brief operating instructions are to be posted at the release stations.

A comprehensive manual including the description of the system and maintenance instructions is to be provided on the ship. The manual shall contain an advice that any modifications to the protected space that alter the net volume of the space will render the approval for the individual installation invalid. In this case amended drawings and calculations have to be submitted to TL for approval.

3.9 Documents

3.9.1 Prior to commencing of the installation the following documents are to be submitted in triplicate to TL for approval:

- arrangement drawing of the protected space showing machinery, etc. in the space, and the location of nozzles, containers (modular system only) as well as release lines as applicable

- list of volumes deducted from the gross volume

- calculation of the net volume of the space and required supply of extinguishing gas

- isometrics and discharge calculations

- release schematic

- drawing of the release station and its location in the ship

- release instructions for display at the release station

- drawing of storage space (centralised systems only)

- schematic of alarm system

- parts list

- shipboard manual

3.10 Testing

3.10.1 Piping up to a shut-off valve if available is subject to hydrostatic testing at 1,5 times the max. allowable working pressure of the gas container.

3.10.2 Piping between the shut-off valve or the container valve and the nozzles is subject to hydro static testing at 1,5 times the max. pressure assessed by the discharge calculations.

3.10.3 Piping passing through spaces other than the protected space is subject to tightness testing after installation at 10 bar and at 50 bar if passing through accommodation spaces.

I. Fire Extinguishing Systems for Flight Decks and Hangars

1. Requirements for operation of a limited number of helicopters

1.1 For helicopter flight decks the following permanently installed fire extinguishing systems have to be provided:

- a heavy foam system according to G.3.1

- a CO_2 system according to H.2.14

- hydrants to the water fire fighting system according to E.3.5.

- a powder fire extinguishing system according to 1.2

For hangars and secondary spaces a permanently installed pressure water foam drencher system according to F.3. has to be provided.

1.2 Powder fire extinguishing system

1.2.1 For the rescue of persons out of a burning helicopter a powder fire extinguishing system with 250 kg extinguishing powder has to be provided. The extinguishing powder shall be BC-powder.

1.2.2 The system for the flightdeck has to be stored in a fire fighting room and shall consist at least of the following components:

- container for 250 kg of extinguishing powder with the relevant vessels for the propellant

- a hose reel at port and starboard with a 30 m hose each and extinguishing nozzles

- the extinguishing nozzles have to be designed for a flow rate of 3,5 kg/s extinguishing powder and a range of 12 -15 m.

1.3 Mobile fire extinguishing devices for flightdecks

1.3.1 Besides of the permanently mounted fire extinguishing systems near to the accesses to the flight deck mobile devices and equipment have to be kept ready for use in a fire fighting room arranged at port and at starboard.

An easy access to these rooms from outside must be guaranteed. A ventilation of these rooms has to be arranged.

1.3.2 Equipment for each fire fighting room

For each fire fighting room the following equipment has to be provided, protected against weather influences and kept ready for immediate action:

1.3.2.1 At least one multi-purpose nozzle including coupling spanner and sufficient hoses to reach every position of the flightdeck. Additionally the following needed:

- 6 fire extinguishers, dry powder 12 kg

- 2 fire extinguishers, CO_2, 6 kg

- a low expansion foam branch pipe for each room

1.3.2.2 One fire fighter's outfit including breathing apparatus.

1.3.2.3 A set of the following tools:

- adjustable spanner (rolling forked open jaw)

- fire blanket

- claw or rescue hook

- heavy type metal saw with 6 spare blades

- ladder

- rescue line 5mm, 15 m long

- side cutter

- set of various screwdrivers

- knife with sheath

- bolt cutter 600 mm

2. Requirements for extended flight operations

Requirements concerning fire fighting for extended flight operations with a greater number of helicopters and/or fixed wing aircraft have to be defined case by case and to be agreed between the Naval Authority, shipyard and TL.

3. Drainage of flight decks

The equipment for the drainage of flightdecks has to be manufactured from flame-proof material and has to be arranged in a way that no drained liquids can flow on other parts of the ship. The drains have to be led directly overboard.

J. Fire Extinguishing Systems for Paint Lockers and Flammable Liquid Lockers

1.1 A fixed fire extinguishing system based on CO_2, dry powder, water or an equivalent extinguishing medium and capable of being operated from outside the room is to be provided.

2. If CO_2 is used, the extinguishing medium supply is to be calculated for a concentration of 40 % relative to the gross volume of the room concerned.

3. Dry-powder fire extinguishing systems are to be designed with a least 0,5 kg per cubic metre of the gross volume of the room concerned. Steps are to be taken to ensure that the extinguishing medium is evenly distributed.

4. For pressure water spraying systems, a uniform distribution rate of 5 ℓ/m^2 per min relative to the floor area is to be ensured. The water may be supplied from the fire main. The addition of film creating foam concentrate is recommended.

5. For lockers of a deck area of less than 4 m^2, which do not give access to accommodation spaces, CO_2 portable fire extinguisher(s), which can be discharged through a port in the boundary of the locker may be used. The fire fighting medium contained in the portable fire extinguishers must be in accordance with 2. The extinguishers are to be stowed adjacent to the port. Alternatively, a port or hose connection may be provided for this purpose to facilitate the use of fire main water.

K. Fire Extinguishing Systems for the Galley Area

1. Scope of the fire protection equipment

The systems designed as object protection have to be applied for fire fighting tasks at open kitchen devices with high fire hazard, like

- frying pans
- deep-frying pans
- grill devices

as well as in the cooking stove area, including waste air ducts as well as air exhaust and circuit ducts.

The equipment to be protected has to be monitored by fire detectors. They have to shut-down automatically in case of fire. The automatic release of the fire extinguishing system shall be established by a fusible plug reacting at 74 °C.

2. Extinguishing system

A suitable system for extinguishing and cooling of fires, cooking ranges and deep fryers has to be provided.

3. Galley area exhaust duct

3.1 If exhaust ducts from cooking stoves are led through rooms with moderate or high fire hazard, a permanently mounted system for fire fighting within the duct has to be provided. This system shall be so designed that the extinguishing medium is effective over the entire length between the outer fire damper and the fire damper at the lower end of the duct.

3.2 Manual activation is to be provided. The controls are to be installed together with the emergency shut-off for the galley ventilation supply and exhaust fans and the activating equipment for the fire dampers near the access to the galley, see Chapter 102 -Hull Structures and Ship Equipment, Section 20, C.8.4.

An additional automatic release of the fire extinguishing system may be provided with agreement of TL.

L. Waste Incineration

1. Incinerator spaces, waste storage spaces or combined incinerator and waste storage spaces are to be equipped with fixed fire extinguishing and fire detection systems as per Table 9.4:

2. The sprinkler system may be connected to the fresh water hydrofor system, provided the hydrofor pump is capable of meeting the demand of the required number of sprinklers.

Table 9.4 Systems for waste spaces

	Automatic pressure water spraying system (sprinkler), see 2.	Fixed fire extinguishing system (CO_2, light foam, pressure water spraying or equivalent)	Fixed fire detection
Combined incinerator and waste storage space	X		
Incinerator space		X	X
Waste storage space	X		

M. Mobile Fire Extinguishing Systems

The following requirements are to be applied for mobile and portable fire extinguishers, portable foam extinguishing units and fog applicators.

1. Extinguishing media and weights of charge

1.1 The extinguishing medium for fire extinguishers must be suitable for the fire classes considered, see Table 9.5.

Toxic extinguishing media and extinguishing media liable to generate toxic gases must not be used.

While CO_2 fire extinguishers may not be located in accommodation areas, water extinguishers may not be installed in machinery spaces.

1.2 Fire extinguishers must be approved in accordance with a recognised standard.

For the use in areas with electrical equipment operating at voltages > 1000 kV the suitability of the extinguishers has to be proven.

1.3 The charge in portable dry powder and gas extinguishers should be at least 5 kg and the content of foam and water extinguishers should be not less than 9 ℓ.

The total weight of a portable fire extinguisher ready for use shall not exceed 23 kg.

Table 9.5 Classification of extinguishing media

Fire class	Fire hazard	Extinguishing media
A	Solid combustible materials of organic nature, e.g. wood, coal, fibre materials	Water, dry powder, foam
B	Flammable liquids, e.g. oils, tars, petrol	Dry powder, foam, carbon dioxide
C	Gases, e.g. acetylene, propane	Dry powder, carbon, dioxide
D	Metals, e.g. aluminium, magnesium, sodium	Special dry powder

1.4 Mobile extinguisher units are to be designed for a standard dry powder charge of 50 kg or for a foam solution content of 45 or 136 litres.

1.5 For fire extinguishers, capable of being recharged on board, spare charges are to be provided:

- 100 % for the first 10 extinguishers of each type
- 50 % for the remaining extinguishers of each type, but not more than 60 (fractions to be rounded off)

1.6 For fire extinguishers which cannot be recharged on board, additional portable fire extinguishers of same type and capacity shall be provided. The number is to be determined as per 1.5.

2. Number and location

2.1 General

2.1.1 One of the portable fire extinguishers is to be located at the access to the individual space it is designated for.

2.1.2 If the portable fire extinguishers are not suitable for fire-fighting in electrical installations, additional extinguishers are to be provided for this purpose. Fire extinguishers are to be marked with the maximum permissible voltage and with the minimum distance to be maintained when in use.

2.2 Crew spaces

2.2.1 Fire extinguishers

Fire extinguishers - of dry powder type with 12 kg charge, for gas or CO_2 with 6 kg charge - have to be provided as follows:

- at least one fire extinguisher of dry powder type in the corridors of working and living quarters
- at least one extinguisher of dry powder type in each workshop, every larger storage space, in front of or in the galley near the door and at the bridge
- at least two extinguishers of dry powder type near the access door to larger rooms or spaces with increased fire hazard, e.g. in engine rooms; the extinguishers have to be installed as far apart from each other as possible
- additionally at least one extinguisher of gas or CO_2 type in the area of electrical or electronic installations
- additionally two extinguishers of dry powder type for petrol storage spaces

2.2.2 Medium expansion foam branch pipe

The components of the fire fighting equipment set have to be stored in fire fighting cabinets, which are to be provided in larger spaces, e.g. engine rooms.

2.2.3 Foam containers

For each damage control zone 10 foam containers have to be provided, of which 4 foam containers have to be installed in standardized mountings at each fire fighting cabinet. The remaining containers may be mounted where suitable.

2.3 Machinery spaces

Machinery spaces are to be provided depending on their designation with portable fire extinguishers, mobile fire extinguishers, portable air foam applicator units and water fog applicators as described hereinafter.

2.3.1 Machinery spaces containing internal combustion machinery and/or oilfired boiler plants

The following is to be provided:

- portable fire extinguishers which shall be so located that no point in the space is more than 10 m walking distance away from an extinguisher

- mobile fire extinguishers of 50 kg dry powder or 45 ℓ foam which shall be so located that the extinguishant can be directed onto any part of the fuel and lubricating oil pressure systems, gearing and other fire hazards

2.4 Pump rooms for flammable liquids

Each space containing pumps for flammable liquids is to be equipped with at least two portable fire extinguishers for extinguishing oil fires.

2.5 Other spaces

Paint lockers, flammable liquid lockers, radio rooms, galleys and motor lifeboats are each to be equipped with one portable fire extinguisher. For small spaces without special fire potential it is sufficient if a fire extinguisher is reachable near the entrance.

2.6 Spaces for motor vehicles with fuel in their tanks

Portable extinguishers suitable for extinguishing oil fires shall be located on both sides not more than 20 m apart. One of such fire extinguishers is to be located at each entrance to these spaces.

2.7 Fire fighting cabinets

To keep devices for fire fighting with foam and sea-water systems ready at any time, fire fighting cabinets have to be installed at the passageways through several compartments.

The location of the cabinets has to enable fire fighting with a maximum of two hose lengths of 15 m each in each room within a compartment separated by vertical water/gastight bulkheads above and below the bulkhead deck.

In compartments without defined passageways the fire fighting cabinets have to be situated near the accesses.

N. Spraying systems

1. General

Spraying systems are to be provided for the following spaces:

- ammunition rooms

- missile silos

- missile starting devices

- torpedo rooms

- mine storage rooms

- special loads

Spraying systems shall cool bulkheads and ceilings as well as the shell above the waterline of ammunition storage rooms and rooms for hazardous materials/provisions against impermissible high temperatures in adjacent rooms.

The spraying/flooding of ammunition storage rooms is a special task which has to be provided principally only with agreement of the Naval Authority, see 2.2.2.

2. Concept, lay-out and arrangement

2.1 Concept

2.1.1 The concept of the spraying system has to ensure that in case of damage spraying water is available in sufficient quantity and the distribution of the water by pipe-system and nozzles achieves a high cooling effect.

The definition of the surfaces surrounding ammunition storage rooms at the same deck as well above/below and which shall be cooled by the spraying system has to based on a fire hazard analysis.

2.1.2 Special attention has to be paid to the drainage of the spraying water by a bilge system designed for the calculated water quantities of the drencher system.

2.2 Lay-out

2.2.1 For the calculation of surfaces which have to be sprayed, the parts of the shell below the lowest waterline need not be considered.

2.2.2 The following ammunition storage spaces are recommended to be equipped with a spraying system:

- ammunition rooms

- ammunition cargo rooms

- ammunition storage decks

For ready use ammunition rooms which are not permanently applied for storage of ammunition a separate spraying connection has to be provided.

Cabinets and lockers for ready use ammunition need no spraying connection.

2.2.3 For the spraying of ammunition rooms the following water quantities have to be considered in relation to the size of the surrounding spaces:

- wall to adjacent space with a depth ≤ 4 m:
  1,00 [$m^3/m^2/h$]

- wall to adjacent space with a depth > 4 m:
  1,70 [$m^3/m^2/h$]

- wall to ammunition rooms:
  0,85 [$m^3/m^2/h$]

- shell: 0

- ceiling to ammunition rooms,
  weather deck or various rooms with
  a height ≤ 2,5 m:
  1,00 [$m^3/m^2/h$]

- ceiling to various other rooms with
  a height h > 2,5 m:
  1,25 [$m^3/m^2/h$]

Coverage by spraying is to be provided also for 1m distance on adjoining walls which are not required to be sprayed.

2.2.4 The required spraying water capacity is the quantity needed for serving the spraying system of all ammunition rooms of one watertight compartment and of the adjacent ammunition rooms in the adjacent compartments.

2.2.5 If the spraying of two rooms at the same time becomes necessary, spraying only at one side of the separating wall is sufficient.

2.2.6 Normally, the spraying water will be taken from the seawater fire fighting system. If this system is not able to deliver the required quantity, an independent spraying pump system has to be provided.

2.3 Arrangement

2.3.1 If the spraying system is connected to the fire main system, the spraying system of each ammunition room has to be provided with a main and an auxiliary feeding from the fire main system.

2.3.2 Between the feeding pipes and the entrance to the ammunition room two remote controlled shut-off valves have to be installed in series. The downstream fitting has to be a non-return valve.

2.3.3 Between the first and second valve a connection with a self closing fitting has to be provided, which serves for checking the tightness of the first valve and for blowing through the spraying system with compressed air or for flushing the connections from the fire main system.

2.3.4 For the spraying system approved spray nozzles have to be used.

2.3.5 The spraying system has to be arranged such that under consideration of the spray characteristic the ceilings and the walls of ammunition rooms are homogeneously wetted. Areas remaining dry are not permitted.

2.3.6 Horizontal wall stiffeners have to be provided with openings for passage of water to reach a homogenous wetting of the walls.

2.3.7 The distance of the spraying system to the ammunition piles, packages, etc. shall be at least 75 mm.

2.3.8 Systems or appliances within ammunition rooms are to be protected against spraying.

2.3.9 If a spraying system independent from the fire main system is to be installed, standardized fire pumps shall be used also for the spraying system.

2.3.10 In a system with several spraying pumps the delivery pipes are to be connected in a way that each pump can serve the spraying system of any ammunition room.

2.3.11 At the delivery side of every spraying pump a shut-off non-return valve has to be provided.

2.3.12 Additionally a connection to the fire main system has to be provided for the spraying system, 2.3.2 and 2.3.3 have to be observed.

2.3.13 For each spraying system an emergency spraying system of adequate lay-out has to be provided.

2.3.14 Emergency spraying pipelines have to be connected to the feeder pipe behind the second shut-off valve and before the entrance to the room spraying system. This emergency pipeline will be fed from fire fighting hoses via emergency connections at the weather deck.

2.3.15 The emergency spraying connections have to be colour coded.

3. Spraying system for missiles

If a spraying system for missiles becomes necessary, adequate connections to the seawater fire main system have to be provided. Details have to be agreed with the Naval Authority.

4. Release

4.1 The release of the spraying system is done manually.

4.2 The remote control and remote monitoring of the pumps and valves is to be done from centres de fined by the Naval Authority.

4.3 Together with the release of the spraying system the drainage system has to be activated, see also Chapter 102 - Hull Structures and Ship Equipment, Section 19, E.

O. NBC Spraying System

1. General

The NBC spraying system serves for wetting and washing of outward ship surfaces which are accessible as well as surfaces of deck equipment, systems devices and components which may be contaminated by warfare agents. A preventive spraying of these areas shall avoid a settling down of chemical or nuclear warfare agents.

2. Layout

2.1 The NBC spraying system must be designed to cover all surfaces considered in the spray water calculation simultaneously.

2.2 Adequate scuppers and freeing ports have to ensure an unhindered drainage of the spraying water.

2.3 The specific spray water quantity, shall be at least

$$0{,}15\ [m^3/m^2/h].$$

As the arrangement of the spray nozzles mostly causes some overlapping the dimensioning of the spraying system and the lay-out of the spray water pumps shall be based on a specific spray water quantity of

$$0{,}18\text{-}0{,}21\ [m^3/m^2/h]$$

depending on the structure of the surfaces to be sprayed.

2.4 For the calculation of the required spray water quantity the following surfaces have to be considered:

- all open decks

- all outside walls with exception of the hull

- all equipment, devices and radomes with exception of mast tops, antennas and comparable systems within 2 m above the highest deck

2.5 The calculated spray water quantity has to be considered for the lay-out of the fire pumps according to E.1.

3. Arrangement

3.1 For planning the arrangement of the spraying mains and the feeding of the fire pumps, the requirements defined in E. have to be observed.

3.2 The transfer of the spray water to the higher decks is done by fire fighting riser mains installed for compartment autonomy, compare Section 1, H.

3.3 The feeding from the fire fighting riser mains to the spray water distribution lines is done separately for each compartment via a remote controlled shut-off valve.

3.4 The pipe system for the spray nozzles at the front of the bridge has to be separated from the other parts of the system. The shut-off valve for controlling this section shall be operated from the bridge.

3.5 For the adjustment of a homogenous spray water distribution valves have to be installed for each section of spraying nozzles.

4. Remote control, remote monitoring

4.1 The release of the spray system is done manually.

4.2 The remote control and monitoring of the pumps and valves has to be operated from the panels and control stands where also any damages of the system are to be indicated.

P. Cooling System for the Reduction of the Infrared Signature

1. General

Where the reduction and/or equalizing of the infrared signature of the naval ships is necessary, cooling by spraying seawater on different parts of the ship's surface must be provided.

2. Design

2.1 Spray nozzles have to be located mainly at the upper part of the vertical and inclined elements of the ship's outer surface to distribute a curtain of cooling seawater homogeneously over the treated part of the ship's surface.

2.2 The system has to be divided in sectors for different duration and intensity of cooling according to the expected surface temperature. Special attention has to be given to the exit of the exhaust gases of the power plant and the possibility of hiding it thermically.

2.2 The system should be combined with the NBC spraying system according to O. The construction details shall be as defined there.

2.3 The feeding of the system may be provided by the fire pumps as normally fire fighting and signature reduction will not be executed to full extent at the same time.

2.4 Further details have to be agreed and defined in the building specification between Naval Authority, shipyard and TL.

3. System control

3.1 The activation of the system shall be done manually from the machinery control centre (MCC) by remote control.

3.2 The fine tuning of the system for the different operating conditions of the naval ship should be done by using the results of an extended temperature measuring program during sea trials and/or a system of sensors on the ship's surface delivering actual temperatures at characteristic positions.

3.3 For assistance of practical operation the use of an individually adopted computer software is recommended.

Q. Water Discharging Systems for Fire Extinguishing, NBC Spraying and other Systems

1. General

Special attention has to be paid to the quantities of water for fire extinguishing in particular at higher decks, which might lead to instability of the ship if no adequate drainage arrangements have been planned.

2. Lay-out

2.1 The quantity of the spraying water is defined for each space. The lay-out of the drainage system has to be adjusted to these quantities.

2.2 The quantity of water for fire fighting has to be based on 25 m^3/h for each nozzle. The maximum number of nozzles to be used for each deck and compartment has to be defined in the building specification. The number of the scuppers and drainage pipes shall be one piece for every commenced m of space or corridor length of a compartment. The minimum number shall be 2 pieces and the section of each drainage scupper/pipe in such a case has to be provided for 100 % of the quantity of water needed for fire fighting.

3. Arrangement

3.1 The location of the drainage pipes has to be chosen, if applicable, diagonally at the fore and aft end of a room or corridor.

The scuppers and pipes shall be readily accessible to facilitate cleaning.

3.2 The water from decks and spaces situated above the weather deck has to be led outboard at about 500 mm above the highest waterline.

SECTION 10

SOLID WASTE HANDLING SYSTEMS

A. General

1. Naval ships have to be equipped with convenient arrangement of spaces for the storage and treatment of solid waste.

2. The fire protection of these spaces and plants has to be ensured according to Section 9, L.

B. Waste Handling Systems

1. Compacting plant

Installation, type and performance of a waste compacting plant have to be defined by the Naval Authority.

The ability to store and pile up the compacted waste as well as an easy transport on board and a transfer to and from ships or land using pallets, has to be ensured.

2. Waste incineration plant

Installation, type and performance of a waste incineration plant have to be defined by the Naval Authority.

Compliance is required with the TL Rules – Guidelines for the Design, Manufacture, Equipment, Installation and Testing of Incinerators on Board Seagoing Ships and for the Performance of Type Tests of Incinerators. In addition relevant requirements as defined in Sections 9, 15, 17, etc. have to be observed, as far as applicable.

For ventilation see Section 11, D.3.

National and international regulations have to be observed, if applicable.

3. Miscellaneous waste treatment

Where the arrangement does not allow the installation of a waste compacting or incineration plant and for ships with a sea endurance time below 72 hours, suitable measures to gather and store the solid waste have to be provided.

4. Galley waste shredding plant

According to the requirements of the Naval Authority a plant for shredding, sacking and hygienic storage of organic waste and the remainder of meals has to be provided. For the treatment of galley waste water see Section 8, T. 3.

SECTION 11

VENTILATION SYSTEMS AND NBC PROTECTION

A. General

1. Scope

1.1 In the following only the requirements for NBC protection are defined. For conventional ventilation of naval ships in the TL Rules Chapter 28 Ventilation are to be applied.

1.2 The requirements of this Section comprise the requirements for air handling plants to ensure NBC protection (NBC ventilation systems).

If the ship is equipped with a NBC protection plant fulfilling the requirements defined in this Section the Notation NBC will be affixed to the Character of Classification, see Chapter 101 Classification and Surveys Section 2, C.4.2.3.

2. Applicable Rules

2.1 The requirements in the other Sections and Chapters of these Rules concerning ventilation plants and elements thereof have to be observed.

2.2 In addition, the generally recognized rules of ventilation technology as well as applicable national and/or international regulations shall be observed, insofar as they are prescribed by the Naval Authority.

3. Documents for approval

The documents listed in 3.1 - 3.6 shall be submitted in triplicate for approval. The drawings are required to contain all the details necessary to carry out an examination in accordance with the following requirements.

3.1. General information

Description of the ventilation system with details on the ventilation principle and the general arrangement of plants and units. In particular, the following details are required:

- type of ventilation
- required air flow rate per hour, air change rates, air flow rate per person and hour, and the flow rate of decontaminated air
- types of fans
- location of installation for the fans and units
- designations of the fans and units
- details of fire flaps and weathertight closures
- specification of the ventilated spaces
- damage control zones
- ventilation zones
- smoke elimination concept
- approval information (flexible ducts, fire dampers, duct penetrations)

3.2 Air condition and ventilation plan

Ship's general arrangement plan with schematic over-view of the various air handling units, including a legend for the graphic symbols used and details on the air flow rates into or out of various spaces.

3.3 Air balance plan

Representation of the air flow in a ship's general ar-rangement plan or similar. In addition, this plan must provide information on the arrangement and dimen-sioning of the air exchange openings and air overflow openings.

Note

If appropriate, this plan can be combined with the air volume plan.

3.4 Air condition and capacity table

The individual air handling units or fans shall be listed in a table providing the following information:

- designation of the plants (with numbering etc.)

- connected spaces (with designations)
- delivery flow rate [m^3/h]
- total pressures [Pa]
- types and power consumption of the fans or units
- types and outputs of the motors
- rotational speeds [l/min]
- types and outputs of the heaters (preheaters and reheaters) [kW]; type of heating medium
- types and outputs of the coolers [kW]; type of cooling medium
- types and air flow rates of the odour filters
- remarks, e.g. a reference to pole-changing motors

3.5 List of individual heating elements

The local heating elements shall be listed in a table, which may be combined with the table according to 3.5 providing the following information:

- location of installation (with room designation)
- number of heating elements
- required heating capacity [kW]
- installed heating capacity [kW]

3.6 List of CO_2 levels in the spaces

For each space within the citadel, the hourly requirements for decontaminated air and the resulting CO_2 level shall be compiled in a plant-related table which must provide the following information:

- delivery rate of the plant
- connected spaces (with designations)
- proportion of decontaminated air supplied by the plant
- supply air per space
- decontaminated air per space
- occupation of each space in each readiness condition
- flow rate of breathing air, permissible maximum CO_2 level as per F.5.
- calculated CO_2 level for each space

4. Tasks of the air condition and ventilating system

4.1 The air handling plant shall ensure air conditions that are within the range required for optimum human performance. Without any limit in duration, it serves to:

- safeguard the breathing air requirement
- ensure that the humidity is within the permissible range
- provide and dissipate heat
- eliminate odours and clean the air
- ensure overpressure within the citadel
- ensure the necessary NBC protection for ships depending on the requirements
- remove gases and smoke in the event of fire, if necessary through transportable units

4.2 As a matter of principle, all spaces in the ship must be ventilated.

4.3 For all external climatic conditions which the ship is likely to encounter in its intended region of deployment as well as for all readiness conditions, the air handling plant must provide interior climate conditions which ensure the uninterrupted operational readiness of crew, plants and units.

5. Definitions

5.1 NBC

NBC is the abbreviation for nuclear, biological and chemical hazards for ship and crew in the surrounding environment (atmosphere and/or seawater).

5.2 Air ducts

Thin-walled piping or ducting (circular or rectangular) used exclusively to conduct air.

5.3 Air lock

A small airtight compartment, with an inner and an outer door operated independently. It serves as an access transition point from the pressurised envelope to atmospheric pressure under NBC threats. Air locks are provided with air sweep fittings to allow use of filtered, pressurised air to purge the air lock of contaminants.

5.4 Air treatment

Air treatment is the treatment of air by heating and cooling, purification, humidification or dehumidification, according to given requirements.

5.5 Air trunks

Parts of the hull which may either themselves be used to conduct air or which contain air ducts as well as other lines (pipes, cables).

5.6 Citadel

Citadel is the entirety of all spaces of a ship included in the collective NBC protection scheme. The citadel is to be so designed that these spaces can, during missions with NBC hazards, be kept at an overpressure relative to the outside atmosphere to preclude entry of hazardous substances from outside.

5.7 NBC Sub-Citadel

A sub-division of a citadel, autonomous with respect to supply of fresh air through NBC filters and gastight integrity and having all features of a citadel, including airlocks for egress. Access is via the craft's cleansing stations.

Note: A sub-citadel will normally include airlocks for egress. Access to the craft's citadel is via cleansing stations and also to the sub-citadels when required by the customer.

5.8 NBC Sub-Citadel with Reduced Pressure

Part of a NBC zone with lower pressure (e.g. machinery spaces, hangar, bridge, etc.)

5.9 IPE (Individual protective equipment)

These equipment may be (but not limited to):

- NBC protective suit.
- Gloves, protective, NBC (inner and outer).
- Over-boots, NBC, (worn over seagoing working boots).
- NBC respirator with carrier. for use outside the citadel or inside the citadel in case of citadel breach.

5.10 Cleansing station

Location with facilities for cleaning and decontamination of personnel and devices which have to enter the citadel. For a craft of frigate size and concept, there will normally be 2 cleansing stations (inside and outside). The number of cleansing stations should be in accordance with owner’s requirements for staff activities when operating in a contaminated zone.

5.11 Control station

Control stations are bridge, radio room, combat information centre (CIC), machinery control centre (MCC), damage control centre (DCC) and flight control centre (FCC) as well as gyro compass and analogous rooms.

5.12 Crew/accommodation spaces

Crew spaces are accommodation spaces allocated for the use of the crew and embarked troops and include cabins, offices, hospitals, sanitary rooms/lavatories, pantries no cooking appliances, mess rooms and similar spaces.

5.13 Damage control zone

Defined in Section 1, H.3.7.

5.14 Decontaminated air

Decontaminated air is air cleaned from NBC substances after passing the NBC protection plant and fed directly to citadel spaces or to air handling, see Figure 11.1

5.15 Operating spaces

Operating spaces are spaces which contain systems or machinery and devices for damage control, electrical installation, propulsion plants, or supply and medical sections. They are named according to their duties.

5.16 Refrigerating machinery spaces

Refrigerating machinery spaces are all spaces in which refrigerating machines are installed. This can also include large machinery spaces, e.g. propulsion engine rooms, power stations, and auxiliary machinery spaces. Refrigerating plants and units should be installed in separate rooms or capsules, alternatively suitable means for the detection of refrigerant leaks and removal are to be provided.

5.17 Sanitary rooms

Sanitary rooms are lavatories, bathrooms, washrooms, shower cubicles etc.

6. Basic requirements

6.1 Ventilation openings shall be arranged so that no air short-circuit is possible. The outdoor air intake openings and discharge air openings must be protected against the ingress of rain and seawater. The intake of exhaust and firing gases, from funnels, artillery, missiles etc., must be excluded.

6.2 In the case of ships for which infrared (IR) protection is to be provided, discharge air openings permitting a direct view of the inside must be covered by screens against the outdoor air.

7. Environmental and operating conditions

The ventilation plants shall be designed for the specified environmental and operating conditions. For details see F.

8. Allocation according to damage control zones

The ventilation plants for the different ship spaces shall be allocated so that at least the damage control zones are separated from each other in a gastight manner with regard to air handling.

9. Watertight subdivision

9.1 The watertight subdivision of the ship shall be ensured by the appropriate arrangement of closures or y the installation of watertight ventlines.

For non-watertight area in watertight bulkheads, Chapter 102 – Hull Structures and Ship Equipment, Section 2, C shall be applied.

9.2 The ventlines shall be made of a watertight type and shall be provided with gas- and watertight closing devices, operable from either side, if necessary, at the bulkhead penetrations. Within the watertight compartments, the number of penetrations in watertight bulkheads shall be kept to a minimum.

9.3 On ships where the ventilation system is not autonomous for each compartment, a closure such as watertight ventilation damper shall be arranged directly on the deck for each penetration of the bulkhead deck by non-watertight ventlines.

Each penetration of watertight bulkheads by non-watertight ventlines shall also be protected by watertight closures, namely at transverse bulkheads towards midships and at longitudinal bulkheads towards the corridors (escape routes).

9.4 All closures must be located in spaces which are accessible at all times. If, in exceptional cases, manually operated closures have to be located in lockable spaces, they shall be fitted with remote control facilities which are so arranged that they can be actuated at any time.

9.5 Penetrations in watertight decks which are not given any gas- and watertight ventilation dampers shall be fitted with a coaming or with a gas- and watertight duct; the height shall be dimensioned in accordance with the stability regulations. Watertight overflow lines which lead from spaces in the underwater hull to another compartment or higher decks shall, like other watertight ventlines, be fitted with watertight closures at their ends.

9.6 In general, ventlines of NBC plants shall be treated as other ventlines.
But where NBC protection plant is located on a deck above the bulkhead deck, the conditions given in 9.1 shall apply.

9.7 For operational reasons, the manned control stations situated below the bulkhead deck, such as the CIC and MCC, must be closable in a watertight manner from inside and outside. The ventlines shall be fitted with ventilation terminal end dampers, and the deck or bulkhead closures with double-sided operating devices.

9.8 Closures or their operating devices in ammunition rooms must be easily accessible and must not be obstructed by equipment or stowed goods.

10 Air treatment

10.1 Air filtering

Air filtering shall be provided for all air conditioning and air handling plants which have to control the pollutant concentrations and keep them within individually specified limits.

10.2 Odour elimination

Suitable air handling units shall be provided to eliminate odours. Noxious or foul-smelling air shall be extracted at the place of origin.

10.3 Heating and cooling

The requirements for heating and cooling of spaces are to be defined by the Naval Authority.

10.4 Air conditioning

Air conditioning units shall be used where the air temperature and the relative air humidity must be kept within prescribed limits.

B. Scope of NBC Protection Plants

1. General requirements

1.1 With regard to the protection against the ingress of NBC warfare agents, the ships shall be rotected in accordance with the requirements of the Naval Authority.

1.2 As far as possible, the citadel shall not be penetrated by unprotected spaces.

1.3 The estimation of the required decontaminated air volume depends on the following:

- personnel requirements

- technical and design requirements

- discharge air volumes needed to eliminate foul-smelling and/or noxious gases or odorous substances

1.4 Requirements for personnel

The quantity of decontaminated air for the personnel depends on the maximum permissible CO_2 content of the various space categories, see F.5.

1.5 Technical and design requirements

1.5.1 This requirement results from possible and calculable losses by leakage in the ship structure:

- losses by leakage through internal installations, units and plants, e.g. cannons, missile launching equipment, vertical launching system, antenna system

- losses by leakage from e.g. air locks, NBC air locks, handling rooms

- allowances for leaky doors/hatches

- discharge air volumes (mechanical and natural discharge air)

1.5.2 Foul-smelling air, noxious gases and odorous substances are eliminated by means of discharge air, the quantity of which must be replaced by decontaminated air. In this connection the air change rates mentioned in F.5. must be observed. Furthermore, the discharge air volumes shall be determined for the galley, for the sound-absorbing capsule of diesel engines / turbines, for the garbage storage space, for the hospital, for auxiliary machinery spaces with refrigerating machines, etc.

1.5.3 For each damage control zone, the decontaminated air volumes shall be determined from the three criteria defined in 1.5, whereby in each case the largest decontaminated air volume must be applied.

The mandatory determination of the decontaminated air requirement shall be performed as described in F.5. The decontaminated air shall be provided to the spaces by air handling units.

1.6 Power supply

1.6.1 Power requirements for NBC related equipment in the NBC citadel may be taken from the standard craft supply system.

1.6.2 NBC related systems in the NBC citadel are to have an arrangement for redundant power supply.

1.6.3 The power supplies to the NBC ventilation system are not to be interrupted at any time.

Note:
Automated load shedding shall not interrupt the power supply to systems required to maintain the citadel pressure.

2. Elements of NBC protection

The design of the NBC citadel shall consist of the following elements:

2.1 Air locks

2.1.1 If NBC protection is active, air locks are normally only to be used for quick leaving of the citadel. The entrance to the citadel via air lock is only permissible if no contamination of the environment has happened up to this time of entry. Otherwise entrance has to take place only via the cleansing station.

2.1.2 The air lock shall be of a simple rectangular form with two doors not less than preferably 1,5 m apart however not less than 1 m. It has to be enclosed by gastight walls and doors.
The doors shall be self-closing and may not have any fixing devices.

2.1.3 Measures have to be provided to guarantee that always only one door can be opened at a time, if NBC protection is active.

2.1.4 An alarm is to be provided, which indicates if more than one of the doors is not fully closed.

2.2 Cleansing station

2.2.1 If NBC protection is active, entering of the citadel by contaminated personnel is only permissible via the cleansing station, see Figure 11.5.

2.2.2 The cleansing station shall have a size, which enables also the transport of wounded personnel on stretchers and with medical equipment into the citadel. It has to be enclosed by gastight walls and doors.

2.2.3 Measures have to be provided to guarantee that always only one door can be opened at a time, if NBC protection is active.

2.2.4 Outside the citadel immediately at the entrance to the cleansing station a shower for a first cleaning of the IPE (Individual protective equipment) with not contaminated water is to be provided.

2.2.5 The inside of the cleansing station is to be equipped for:

- Undressing of IPE (Individual protective equipment)
- Containment of the IPE for later decontamination or destruction
- Containment of undergarment if contaminated
- Storage of other clothes in separate wardrobes
- Decontamination of personnel
- Respirator removal
- Respirator cleaning
- Entry for personnel into the citadel via the lock room
- Transport of stretcher from the outside into the citadel
- Continuous purging of the cleansing station with bleed filtered air from the citadel
- Drainage to be lead overboard.

2.3 NBC protection plants

NBC protection plants shall consist of the following elements as a minimum:

– Jalousie resp. mist eliminator, water trap

– Pre-filter

– NBC filter (particle and gas filter)

– Connection for NBC alarm device

– Non-return damper

– Flow fan

– Measuring device for differential pressure

For a more detailed concept see Figure 11.1.

2.4 Detection systems

The detection system has to consist of the following elements:

2.4.1 Radioactive detection system

– detector outside the citadel for radiation in the atmosphere

– detector for radiation in the water

– detectors in the citadel (e.g. on bridge, combat information centre, damage control centre machinery control centre, accommodation, seawater entrance)

– display of measuring values in combat information centre and on bridge

2.4.2 Chemical detection system

– detectors outside the citadel for chemical agents in the atmosphere (e.g. starboard and port sides of the ship)

– one detector in the citadel for each damage control Zone

– display of measuring values in combat information centre and on bridge

2.4.3 Biological agents detective system

– detectors and display analogous to 2.4.2

– detailed requirements shall be specified by the Naval Authority and agreed upon with TL. The biological agents to be detected and their alarm level should generally fulfil the owners requests.

2.4.4 Alarms

– Adequate acoustic alarms which allow to differ the kind of danger are to be provided, see also the TL Rules Chapter 105 - Naval Ship

Technology, Electrical Installations, Section 9.

2.5 NBC spraying system

The NBC spraying system for the outside surfaces of the ship has to be installed in accordance with Section 9, P.

2.6 Control and monitoring

2.6.1 General guidelines

The control, switching and regulating arrangements for air handling plants shall be structurally and functionally separated from each other according to ventilation zones / damage control zones. Within the corresponding ventilation zone / damage control zone, these arrangements may be grouped structurally. In the case of ships with only one damage control zone, the grouping of the components shall be with regard to the corresponding ventilation zone.

2.6.2 Electrical control, switching and regulating Arrangements

The necessary monitoring and operating positions shall be provided in accordance with Table 11.4. For the construction and selection of electrical installations, the requirements as per TL Rules Chapter 105 - Naval Ship Technology, Electrical Installations shall apply.

2.6.3 Overpressure in citadel

The overpressures in the spaces within the citadel are to be monitored. Pressure indicators for each area are to be provided at the machinery control centre (MCC).

Should the overpressure in any one of the areas fall below 0,5 mbar, an audible and visual alarm shall be activated.

2.7 Air condition units

Air condition units shall be provided for spaces where it is necessary to establish environmental conditions specified by the Naval Authority (or Tables 11.1 and 11.2). Air condition units consist in general of heating and cooling devices, humidity control devices and filters for dust, particles and odour, etc.

2.8 Air filters

2.8.1 General

Air filters are to be easy to exchange.

2.8.2 Dust filters

The outdoor air and recirculated air is to be cleaned by dust filters. The dust filter casings shall be arranged in the direction of flow at the intake of the air handling units.

Dust filters for NBC protection units, hospital and odour filters shall comply with the standard EN 779, class F7.

2.8.3 Grease trap

Grease traps shall be arranged in galley canopies above or next to the cooking and frying plates.

2.8.4 Pre filters

Pre filters are to be designed realizing a collection efficiency of G4 according to EN 779 or a collection efficiency equivalent to 90 % of particles of 10 μm or greater.

2.8.5 NBC filter

Depending on the operation concept of the ship, suitable filters shall be provided. If the filter inserts are stored on board, the filters shall be mounted near the NBC protection plant and protected against vibration.

2.8.5.1 Particulate filters

High efficiency particle air filters (HEPA) realizing a collection efficiency H13 according to EN 1822-1 or a collection efficiency of 99,97 % of particles of 0,3 μm or greater.

2.8.5.2 Gas filters

Activated carbon filters shall be provided to eliminate chemical agents and other gases. A proven standard, like STANAG 4447, can be accepted.

2.8.6 Dummies

With regard to dimensions and air resistances, dummies shall correspond to the original filters.

2.8.7 Odour filters

As odour filters activated carbon filters with dust filters complying at least with class G4 as per EN 779 shall be provided.

C. Ventilation of Spaces inside the Cidatel

1. General

1.1 NBC protection plants shall be fitted with throttle dampers or dummy filters and/or orifice. At the nominal air flow rate, it shall be possible to adjust with these dampers or dummy filters and/or orifice the same filter resistance as for operation with the original filter. In the NBC ventilation duct downstream of each NBC protection plant, a measurement point shall be provided for connecting a measurement unit in order to verify, using a tracer gas method, the tightness of the plant after a filter change.

1.2 The number of NBC protection plants needed shall be so chosen that the overpressure in the citadel specified in 1.6 can be safeguarded. Two adjacent plants shall be provided with a connecting line. In this line, two ventilation flaps shall be installed, one on either side of the compartment bulkhead, at a spacing of at least 0,5 m (normal operation: flap closed; emergency operation: adjacent compartment can be supplied as well). The duct between the flaps shall be constructed to be gas- and watertight and with the corresponding wall thickness.

1.3 Within the citadel, discharge air fans shall be so interlocked with the associated NBC protection plants that the discharge air fan is switched off in the event of failure of an NBC protection plant, to ensure that the pressure in the citadel does not fall below the atmospheric level. Alternative equivalent interlock methods may be accepted.

1.4 For each damage control zone and each autonomous ventilation zone, at least one NBC protection plant shall be provided. The NBC protection plants shall be decentralized. It shall be possible to operate each damage control zone/compartment autonomously. The supply air inlet openings for the NBC protection plant is to be arranged as high as possible, taking into account the requirements regarding the permissible heeling and trim of the vessel. The plants themselves shall be installed above the main deck and on the outside walls of the superstructures/ deckhouses. Ventilation plants shall only provide ventilation for individual compartments. Penetrations of compartment bulkheads above the final waterline according to the damage stability calculations within a damage control zone shall be limited to supply of decontaminated air. They are to be secured with closures which are operable from either side. The same applies for a decontaminated air line connecting two damage control zones / autonomous ventilation zones, whereby in each damage control zone/ autonomous ventilation zone a closure is to be arranged at least 1 m from the bulkhead separating the damage control zones / autonomous ventilation zones. The line between the closures shall be of a gas- and watertight type.

Compressed air which is used for control and regulation purposes within the citadel shall only be produced by a compressor drawing in air from the citadel. The lines shall be constructed to be gas- and watertight with closures if the compressor is not located in an NBC-protected operating space.

On ships with NBC protection, connections for fixed and transportable breathing air compressors shall be provided at the decontaminated air line.

To ensure the breathing air requirement on ships designed for permanent NBC protection, an individual regulation of the air volumes is only permissible if the proportion of decontaminated air (decontaminated air volume) per space is kept constant independently of the supply air volume per space.

For the rough estimation of the decontaminated air volume, 45 m^3/h of decontaminated air shall be assumed per person (with respect to the ship and considering all leakage losses), whereby the special requirements regarding the permissible CO_2 values shall be observed.

1.5 Subdivision according to damage control zones

The air handling plants of the ship spaces shall be subdivided so that at least the damage control zones are separated from each other in a gastight manner with regard to the air handling (including the associated switching and monitoring devices, as well as the refrigerating plants).

For the supply of decontaminated air and cold water from the adjacent damage control zone / autonomous ventilation zone, a transfer possibility must be provided. If overlaps and penetrations of the damage control zone / autonomous ventilation zone by decontaminated air lines are necessary, gas- and watertight closures shall be provided.

1.6 Ensuring the overpressure

The NBC protection plants shall be so designed that an overpressure of 5 hPa (mbar) in relation to the atmospheric pressure is achieved in all spaces of the citadel. If the machinery spaces are included in the NBC protection scheme, they shall be under overpressure of 4 hPa (mbar), and inside sound-absorbing capsules an overpressure of 3 to 3,5 hPa (mbar), shall be maintained in relation to the atmospheric pressure, i.e. the required differential pressure shall be as follows:

- citadel/machinery space:
  1,0 hPa/mbar

- machinery space/acoustic capsule:
  0,5 -1,0 hPa/mbar

1.7 Sound-absorbing capsules

If NBC protection is stipulated for machinery spaces, a pressure must be attained in the sound-absorbing capsule that is at least 0,5 hPa (0,5 mbar) lower than the pressure of the machinery space.

The sound-absorbing capsule shall be so designed that on failure of the capsule cooling, the diesel engine can be operated further with at least half the output and with the capsule opened.

2. Requirements for the ventilation of various Spaces

2.1 Air Handling Units

The air handling units and components needed to maintain the NBC protection are not to be used for areas not under NBC protection. As air inlets and outlets on the upper deck, louvres, grilles, mushroom and discharge hoods, goosenecks etc. are to be installed with weathertight closures in commercial quality.

Discharge air from sanitary rooms, medical rooms, etc. and from galleys shall be routed outside the ship.

2.2 Crew spaces

2.2.1 Within a citadel, the crew spaces shall be ventilated by air handling plants. The exhaust air of the spaces shall be treated as recirculated air with the aid of dust filters and, if applicable, odour filters, and if necessary cooled or heated, and then returned as supply air to the spaces with the required proportion of decontaminated air as per F.5.

2.2.2 The exhaust air must escape from the spaces via openings to the corridors or via ducts. Part of the exhaust air must be drawn in again by the air handling plants, whilst the remainder must be routed through relief dampers or control dampers as natural supply air for ship operating spaces or sanitary rooms or outside as discharge air (in accordance with the decontaminated air volume). Discharge air fans shall only be provided in a limited number. If discharge air is routed by a fan directly to the outside via a ventline, the outlet opening to the atmosphere shall be provided with a relief flap. The control shall be dependent on the pressure difference between space and atmosphere. The volume flow of discharge air must have a balanced relationship to the volume flow of decontaminated air.

2.3 Control stations

2.3.1 All control stations in the citadel shall be ventilated by means of air handling plants, see Figure 11.2. If gastight construction of the control stations is planned, each ventilation duct at the entry point into the corresponding control station must be fitted with gas- and watertight ventilation dampers which can be operated from inside the space. As a matter of principle, the CIC, MCC and the bridge (closed part) shall each be ventilated by separate plants, whereby redundancies shall be stipulated by the Naval Authority. If this is not possible, it must be possible in the event of dense smoke development to cool the gastight space in the recirculating mode. The heat flow to be removed shall be so dimensioned that limited operation can be maintained, i.e. continuation of operation for gastight bulkheads. The proportion of decontaminated air in the supply air shall be determined as per F. 5.

2.3.2 In order to allow operation also with an open bridge for ships which can sail with permanent NBC protection, the following items shall be observed during planning, see Fig 11.3:

- gastight sealing of bridge / remaining citadel
- bridge and chart room must be ventilated by an own ventilation unit with a proportion of decontaminated air which can be set to a fixed value
- an air lock must be provided
- doors to the air lock must have a window

The recirculated air shall be treated appropriately, concerning e.g. filtering, cooling, warming.

2.3.3 Control stations and switch compartments located within the citadel must be enclosed in a gastight manner against engine rooms, machinery spaces or power stations. The decontaminated air should be allowed to escape through relief dampers to the outside (via engine room or machinery space or power stations) or to adjacent corridors etc. via overflow openings. In principle, ventlines and air outlets shall not be arranged behind or above switchboards. Ventlines running above or behind switchboards by way of an exception shall be watertight. Furthermore, the line construction must ensure that cooling water cannot escape in the event of leakages, and that any condensation water is drained away. On principle, connecting elements for cooling water lines (inlet/return) are not permissible behind and above switchboards.

2.4 Medical rooms

2.4.1 Spaces with medical facilities shall be provided with artificial (mechanical) ventilation. Ship's hospitals shall be ventilated by their own air handling plant, which shall not be used to supply any other spaces. Moreover, natural air flows from the hospital to other areas of the ship are inadmissible. The supply air shall on principle consist only of outdoor air / de contaminated air. The discharge air must be extracted directly to the outside via a discharge air fan and relief dampers. It must be ensured that anaesthetic gases and disinfection agents are removed at a suitable point, see Figure 11.4.

For the ventilation of rooms with medical facilities, the national requirements for such operating spaces must be observed additionally wherever applicable.

2.4.2 If limitations become necessary in the design of ships for which a permanent NBC protection is intended, e.g. by reduced volume flow of decontami nated air, operation with recirculated air, the relevant approvals shall be obtained from the Naval Authority for the envised design. The following shall be observed:

For medical facilities, the proportion of recirculated air shall be extracted via dust filters (special class S) and activated carbon filters. For rooms which are to be used for medical purposes only temporarily, e.g. mess-rooms during combat, the filter plant can be bypassed during normal operation.

During operation with recirculated air, medical facilities may be ventilated by a limited supply of decontaminated air, see Figure 11.4.

2.4.3 In addition the following principles shall be observed.

The necessary volume flows of air and the flow paths shall be approved by the Naval Authority. The proportion of decontaminated air / discharge air for the treatment room must permit an air change of 4 times per hour, whereby any proportion of recirculated air cannot be taken into account. Ingress of air into the treatment room by natural means shall be excluded.

2.5 Operating spaces

2.5.1 The operating spaces shall be ventilated with recirculated air and a proportion of supply air corresponding to the discharge air proportion. The heat generated shall, depending on requirements, be removed by air coolers operating with seawater or chilled water. At least two air handling plants which work independently from each other shall be provided for each space.

2.5.2 If the operating spaces with combustion engines belong to the citadel, suitable measures, e.g. sound-absorbing capsules, shall be taken for diesel engines and gas turbines to prevent the escape of nitrous fumes and/or contaminated gases into the corresponding operating space. The combustion air for diesel engines, gas turbines and boilers shall be drawn in from the outside by means of gastight trunks leading directly to the engines or boilers.

2.5.3 The amount of air needed to maintain the overpressure in the operating spaces shall be routed out of the occupied citadel area into the spaces via relief dampers. For this, a pressure differential is needed, see C.1.2.

2.5.4 The discharge air (resulting from the volume flow of decontaminated air) should be routed to the outside partly via the sound-absorbing capsules and partly via the space, in each case via relief dampers. Here the required volume flow of discharge air needed to maintain the differential pressure in the sound-absorbing capsule shall be given priority. Discharge air lines from sound-absorbing capsules shall be gastight. If the duct network resistance of the discharge air system results in inadmissible high overpressure in the space or in the capsule when a gas fire extinguishing system is used, additional relief openings shall be provided, which shall be fitted with relief dampers. The maximum overpressure which can arise shall be determined by calculation.

2.5.5 Emergency ventilation for smoke extraction

Downstream of the recirculation ventilators, a remote-controlled change-over damper with a discharge air duct shall be so arranged that in an emergency the air delivered by the recirculation ventilator can be extracted directly to the outside. The discharge air duct shall be provided with a gas- and watertight end damper. Extraction possibilities shall be provided in the lower part of the space. For further details, see E.

2.6 Sanitary rooms

On principle sanitary rooms shall be ventilated.

The exhaust air shall either be routed to the outside as discharge air or, after suitable treatment by air handling units, recirculated into these rooms.

As a result of the underpressure, the supply air will flow into these rooms from the corridors via openings in the walls or doors. These admission openings shall be covered by suitable blinds, so that the rooms are not open to view.

The rooms shall be fitted with heating facilities and/or warming them up to the required temperatures must be possible by means of connected air handling plants.

2.7 Laundry

The exhaust air shall either be routed to the outside as discharge air or, after suitable treatment by air handling units, recirculated into these rooms.

It must be ensured that the latent heat is reliably dissipated at all times. A diversity factor shall not be applied.

2.8 NBC cleansing station and air lock

2.8.1 Exhaust air from the citadel has to be blown into the cleansing station for ventilation and purging. After entering the station and closing of the outside door purging shall be done with five complete air changes of the station volume, see Fig. 11.5. For this time automatically an increased ventilation capacity of at least 25 air changes per hour has to be provided.

2.8.2 Exhaust air from the citadel has to be blown into the air lock via a non-return damper for ventilation and purging, see Fig. 11.5. After entering the air lock and closing of the outside door purging shall be done with five complete air changes of the lock volume. For this time automatically an increased ventilation capacity of at least 25 air changes per hour has to be provided. The incoming air flows via low-located relief dampers to the outside.

2.9 Galleys

2.9.1 The galleys shall be provided with through-ventilation. The relationship between direct exhaust air and decontaminated air must be 3:2, so that the resulting pressure difference (between the galley and the other rooms) ensures the admission of supply air from corridors or adjacent rooms. For this purpose, appropriate admission openings shall be provided.

For reasons of fire protection air ducts for galleys shall be provided with the following special equipment:

- In the supply air and exhaust air ducts, automatic fire dampers (electrically interlocked with the supply, exhaust and discharge air fans) shall be arranged at the points of penetration through the hull's structural walls. On triggering of the fire dampers, there shall be a corresponding indication / alarm via the automatic fire detection system in the MCC or DCC, with signalling of the damper position.

- Exhaust air ducts shall be made of steel, and within the galley area of stainless steel for reasons of hygiene.

- On principle, quick-release connectors shall be provided for the exhaust air ducts, so that they are easy to clean.

- The grease traps to be provided at the extraction openings must be easy to remove and to clean.

- The exhaust air ducts must be condensate-tight and installed with the proper gradient. If this is not possible, drainage points must be provided. Cleaning openings shall be provided in the discharge air line.

- The flexible connections at the fans and at the ventlines should be made of a non-combustible asbestos-free material.

- On principle the exhaust air duct shall be provided with fire protection insulation.

- A fixed fire extinguishing system as per Section 9, K. shall be provided.

2.8.2 The air conditioning unit must be readily accessible and easy to clean.

The ventilation system of the galley must be operational for both open and closed ship. This can be achieved by fans with pole-changing motors or by suitable design of the discharge air fan characteristic.

2.8.3 Galley ventilation in discharge air mode

The supply air shall be delivered by an air handling plant, and the exhaust air shall be extracted by a discharge air fan, if possible from the vicinity of the heat and odour sources (above the stove, the tipping frying pan etc.) and conveyed to the open air.

2.8.4 Galley ventilation in combined recirculation / discharge air mode

The supply air should be delivered to the galley by an air handling plant, while part of the exhaust air should be extracted by a discharge air plant.

The supply air fan draws in part of the galley's exhaust air via grease traps and dust filters, after which the air is cooled or heated and then passed partly into the galley, whilst the other part should be blown out into a corridor.

The discharge air fan should extract part of the exhaust air over the stove, the tipping frying pan or the boiling kettle and then convey it directly to the outside via relief dampers. In the case of spring-loaded relief dampers, coordination of the overall plant is necessary.

2.10 Workshops, operating spaces, storerooms and holds for military cargo

2.10.1 Workshops and operating spaces shall be connected to air handling units and supplied with decontaminated air in relation to the number of crew members working there. For these spaces, stationary heating elements may be provided.

Gases, vapours and noxious substances caused by welding work etc. shall be conveyed via discharge air fans directly to the outside by means of fume extractor hoods or similar welding bench facilities. The gas quantities to be discharged shall correspond to the decontaminated air volumes, in order to maintain the required overpressure. If this is not possible, welding facilities with the necessary air handling measures shall be arranged outside the citadel.

2.10.2 Storerooms and material/equipment holds within the citadel must be supplied with decontaminated air in accordance with the overpressure to be built up. The air treatment for these spaces shall be as deemed necessary.

2.10.3 Ventilation of the cold provision rooms shall only be performed during the out-of-service condition, namely by

- supply air, which preferably should be provided by the plant ventilating the galley

- recirculated air, which is delivered by the fans at the evaporator

- exhaust air through the open door to the corridor

2.11 Stowage spaces for explosive, combustible or foul-smelling substances

2.11.1 Ammunition rooms

Ammunition rooms shall be ventilated by air handling units, compare Figure 11.6.

The type of ventilation, the temperature to be maintained and, if applicable, the relative air humidity shall on principle be determined on the basis of the requirements for the ammunition to be stowed there. Details shall be stipulated by the Naval Authority.

The exhaust air from several spaces can be included in one recirculated air cycle if it is ensured that only ammunition of the same type is stored in the spaces and no firing gases can enter the ammunition rooms. If this condition is not satisfied, the exhaust air must be delivered separately to the corresponding ammunition rooms as recirculated air or conveyed directly to the outside via relief dampers. At the point of entry into the ammunition room, the supply air and exhaust air duct shall on principle be given a gas- and watertight ventilation damper capable of being operated from either side of the bulkhead or with means of remote control.

2.11.2 Battery rooms and boxes

Battery rooms shall be arranged outside the citadel if possible, see also E.7.

If the battery rooms are situated inside the citadel, the discharge air shall be conveyed by fans directly to the outside via ducts and relief dampers.

2.11.3 Batteries in operating spaces with combustion engines

If the operating spaces are located inside the citadel, it shall be checked whether the volume flow of decontaminated air ensures that no explosive air/hydrogen mixture can occur.

Care must be taken to ensure that the batteries are located in a sufficient stream of moving air.

2.11.4 Battery rooms outside the operating spaces containing combustion engines

If possible, battery rooms shall be arranged outside the citadel and vented mechanically.

The entrance doors to the installation spaces shall be provided with openings of sufficient area in their lower and upper parts to provide for natural supply of air in the event of failure of the discharge air fans. The fans shall be installed outside the battery rooms. If the battery rooms are situated inside the citadel, the discharge air shall be conveyed by fans directly to the outside via ducts and relief dampers.

2.11.5 Storage spaces for solid waste

Storage spaces for solid waste intended for long-term storage shall be cooled. These spaces shall normally belong to the citadel, must be gastight against all other spaces and must have a pressure differential in relation to the citadel. These spaces are not ventilated during the refrigeration period.

If no separate refrigerating machinery space is available, the garbage storage space is ventilated in the out-of-service condition by:

- supply air, from the air conditioning plant
- recirculated air, which is delivered by the fans at the evaporator/cooler
- exhaust air through the open door to the corridor

If there is a separate refrigerating machinery space, the discharge air fan is switched over and draws in air from the storage space. The supply air flows in from the refrigerating machinery space.

If the solid waste is to be treated or compacted in the storage space, a ventilation for actual demand shall be provided.

2.12 Refrigerating machinery spaces

2.12.1 Refrigerating machinery spaces shall be ventilated with recirculated air. The air flow rates shall be dimensioned with due consideration for the cold or heat demand calculation. The supply air of at least 100 m^3/h shall be supplied from adjacent or overlying corridors. An air flow rate of the same magnitude shall be removed continuously via the discharge air duct. It must be possible to seal off the room to be gastight against its environment.

2.12.2 On the suction side, ducts permitting extraction from near the deck shall be provided. Furthermore, the sensor for a refrigerant warning device shall be arranged on the suction side or within the space itself. A remote-controlled change-over damper shall be installed on the pressure side, from which a duct must lead directly to the outside. The mounting of the warning device and damper control together shall be outside the refrigerating machinery space. If the warning device is triggered, the refrigerating machinery space must be vented through the discharge air duct after the damper has been changed over. An optical warning device for refrigerant leakage shall be provided inside and at the entrance to the refrigerating machinery space.

2.12.3 An air change rate of at least 15 times an hour must be ensured in the discharge air ventilation mode.

2.12.4 The following sign shall be affixed to the entrance (hatchway or gastight door) to the refrigerating machinery space:

"Caution! Before opening the door/hatch, check that the refrigerating machinery space is free of refrigerant. If refrigerant is detected in the air of the refrigerating machinery space, ensure adequate ventilation of the space by switching to discharge air mode and opening the door/hatch."

2.13 Hangar area

2.13.1 The hangar area includes workshops, operating spaces, storerooms, the briefing room, ammunition room(s) and, if applicable, the refuelling space, see Figure 11.7.

All spaces belonging to the hangar area shall be connected to the ventilation plant of the hangar, insofar as they are directly linked to the hangar or accessible from the hangar. If the hangar is compartmentalized, independent ventilation plants shall be provided for each compartment, to which the corresponding spaces shall be connected. For workshops, operating spaces and storerooms, the requirements as per 2.10 shall apply, and for ammunition rooms the corresponding requirements as per 2.11.1.

2.13.2 The hangar and the spaces connected to the hangar in terms of the ventilation should normally not belong to the citadel because the hangar doors must be open over a long period of time during normal operation of the aircraft. For this reason the area must be separated from the main part of the ship as regards ventilation and damage control.

In the case of NBC attack, the ventilation plant of the hangar must be able to build up an overpressure in the hangar with the doors closed. The gastightness of the hangar door must be given particular attention.

2.13.3 The air handling plants must meet the follow ing conditions:

- The exhaust air of several compartments (for autonomous compartment ventilation) or of one damage control zone shall be delivered to the hangar by means of relief dampers which are powered by auxiliary drives (e.g. pneumatic, electrical) and controlled by the differential pressure.

- The discharge air shall be extracted via gas- and watertight relief dampers which are powered by auxiliary drives and controlled by the differential pressure. The corresponding requirements for the resistance to pressure and the tightness of ventilation dampers on the upper deck shall be observed.

- A discharge air plant shall be provided which is designed according to the incoming air flow rate (from the citadel and/or via the NBC protection plant from outside), taking into account the re- quired overpressure. 60 % of the discharge air volume shall be extracted at a height of max. 0,8 m above deck, and 40 % above % of the hangar height.
- The recirculating air plants to be installed in the hangar shall be so dimensioned that, for an out- side temperature of-15 °C, a room temperature of 15 °C is attained in the hangar 30 mins after closing the hangar doors. During this time, the air temperature at the outlet of the heat exchangers shall not exceed 60 °C. The arrangement of the heat exchangers must be such as to ensure that parts of the aircraft or other materials are not heated over 45 °C.

2.14 Machinery spaces

2.14.1 General

The machinery space shall be surrounded by gastight walls and decks. Access into the engine space shall be enabled by air locks. Returning to the citadel during NBC operation shall be enabled via a cleansing station according to Naval Authority's demands.

2.14.2 Supply of combustion air

The combustion air for Diesel engines, gas turbines and auxiliary boilers shall be supplied either from the machinery space or directly from outside.

When the supply of air is from the machinery space additional demand of air has to be taken into account during the design of the ventilation system.

If the air supply is directly from outside, the following requirements have to be complied with:

– The intake openings are to be located as high as possible and at sheltered locations.

– Combustion air shall be provided via air ducts directly to the engines/consumers.

– Diesel engines shall either be of gastight design or totally encased.

If non-encased Diesel engines are fitted, these shall be checked for tightness before use in a NBC environment. An instruction to this end is to be included in the Operations and Equipment Manual.

– Diesel engines shall be provided withautomatic overspeed protection which shall also be effective if there are flammable gases or vapours in the combustion air.

– The number of dismountable pipe joints in the combustion air ducts shall be kept to a minimum.

– If the charge air temperature after the turbocharger exceeds 135 °C, a temperature sensor has to be provided with a remote indication and an alarm on the bridge.

2.14.3 Supply of air for machinery space

During NBC operation the engine space shall be provided with air either from the exhaust air lines of the citadel via non return valves or from the NBC protection plant dedicated to the machinery space. The engine space shall be provided with internal cooling devices eliminating heat radiation from the machinery.

2.14.4 Auxiliary systems

2.14.4.1 The number of dismountable pipe joints in the exhaust gas line has to be kept to a minimum.

2.14.4.2 The supply of cooling water is to be so designed that the machinery can be cooled without direct intake of sea water (e.g. box cooling or skin cooling) during NBC operation.

2.14.4.3 Vent pipes and filling connections of service tanks shall be so designed or arranged that hazardous substances cannot enter the tanks. The drinking-water tank vent pipe outlets shall be located inside the citadel.

D. Ventilation of Spaces outside the Citadel

Ventilation requirements for spaces outside the citadel are specified in the Chapter 28 Ventilation and are to be applied also for naval ships.

E. Removal of Smoke / Fire-Extinguishing Gas

Adequate gas elimination is achieved when the visibility is so good that the salvage, rescue and damage control work can be carried out successfully.

Attention shall be paid to the following principles:

1. The gas elimination must be achieved effecttively and rapidly within 5 to max. 10 minutes.

2. For effective gas elimination, the correspondlant circuits and portable fans are to be provided.

3. CIC, MCC, DCC and the closed part of the bridge shall each be ventilated by separate plants.

4. On principle the engine room ventilators shall be so planned and constructed that:

- Recirculation ventilation plants can work as discharge air plants by switching-over a damper. A discharge air duct of corresponding dimensions is required.
- The extraction of fire-extinguishing gas/air mixtures has to be ensured, also from the bilges.
- Possibilities for connection with the correspond ing ducts are available for additional portable fans to be set up on the upper deck. For large ships, it may be necessary to route the ducts right down into the bilge area.
- If possible from the overall design walk-in fan rooms shall be provided for machinery spaces. These rooms shall also permit to eliminate fumes from the surrounding areas like workshops, accommodation, etc. through opening of doors and with the machinery space ventilation switched from recirculation to full extracting power. Thus the unaffected machinery spaces will not be involved.

5. It shall be possible to use portable fans to convey air from the outside into the affected areas and to transfer the air again out of these areas. Connections for portable fans to be used for such a pressure ventilation shall be situated near stairwells, if possible with regard to the ship structures.

6. It shall be ensured that the entrances to the affected areas/compartments/decks remain free of fumes to a large extent and the fire-fighting and rescue work is not hindered.

7. Ducts, flexible lines or openings in walls or decks have to be provided to bring the air from the portable fans (or NBC protection plants) to the affected areas. Exhaust air ducts/trunks or discharge air ducts/trunks and discharge air fans (portable fans) have to be installed to convey the exhaust air and fumes to the outside. Thus it shall be ensured that the entrances to the affected areas/compartments/decks remain free of fumes to a large extent and the fire-fighting and rescue work is not hindered.

8. Where necessary, the following shall be ensured:

- Connecting flanges shall be provided with blank flanges and sockets for the operation of portable fans on the upper deck

.

- Pipes shall be routed from the bottom of large or especially endangered rooms to the connecting flanges for the portable fans.

Details shall be defined in the building specification.

7. For rooms with a permanent increased fire risk during normal operation and without external influences like machinery spaces and galleys, fixed smoke-gas discharge lines and discharge fans shall be provided and details to be defined in the building specification. To ensure functional readiness of the fans during a fire, the fans shall be installed at an appropriate distance from the origin of a possible fire.

8. For each damage control zone a separate smoke elimination shall be designed, taking into account the design aspects mentioned in 1. to 7. and the structural aspects of the ship's hull and superstructures.

F. Guide Values for Calculation and Design

1. External climatic conditions

Calculations of the air handling plants shall be based on the external climatic conditions according to Section 1, D, if no other definitions are included in the building specification:

2. Internal climatic conditions, room temperatures

For ship spaces, the following shall apply, if not otherwise defined in the building specification.

2.1 The temperature limits in °C of dry air shall be specified by the Naval Authority. The data defined in Table 11.1 may be used as a guideline.

2.2 The limit temperatures are to be included in the calculations for heat insulation. For the heating and cooling demand calculations, the heat transfer values for the most unfavourable external climatic conditions shall be considered.

3. Climatic ranges

3.1 The guideline values for permanently or frequently manned operating spaces or day rooms are defined by the standard for human climatic comfort, i.e. the corrected normal effective temperature (CNET), see Table 11.2

If the climatic conditions are outside these ranges, only a limited stay is advisable.

3.2 Since Table 11.2 is only valid for air flow speeds permissible for sedentary work, the air flow speed must be measured at all places of work and recreation. If the air flow speed is over 0,2 m/s, the CNET values must be corrected and be within the admissible limits of 16 to 27 °CNET.

4. Dissipated heat by machines, units and persons

4.1 Sound-absorbing capsules

In the case of sound-absorbing capsules, the heat dissipated to the room air shall be considered. Heat emissions of units located in control stations such as the units of weapon control systems, computers, radio transmitters etc. shall be specified by the manufacturers and used for the calculation.

4.2 Lighting and personnel

The heat emitted by lighting in rooms and by personnel must also be considered.

Note

Reference value for lighting:

20 W/m^2 of floor area and 40 W per working place

Heat emitted by personnel:

70 W /person for the sensible heat dissipated through convection and radiation

80 W / person for the latent heat dissipated through evaporation.

These figures refer to a room temperature of +26 °C.

5. Hourly air flow demand for different Spaces

5.1 Design of the ventilation

The ventilation of the citadel is to be so designed that during service in a NBC environment the overpressure never drops below 0,5 mbar relative to the outside atmosphere in any of the spaces.

The following CO_2 concentrations of the air inside the citadel may not be exceeded:

– service spaces and rest rooms 0,15 %

– mess rooms 0,25 %

– workshops 0,50 %

The room temperatures shall comply with Table 11.1.

5.2 Layout of the ventilation system

During service in a hazardous atmosphere, machinery spaces may be ventilated using exhaust from the accommodation and engine enclosures using exhaust from the machinery space.

The direction of flow from the accommodation to the machinery spaces and from the machinery space into the engine enclosure is to be ensured by an appropriate gradation of overpressures.

Following values for overpressures relative to the outside atmosphere may be used for guidance:

– accommodation, work- and service spaces: 4 mbar

– engine room: 3 mbar

– engine enclosures: 2 mbar

Openings connecting the accommodation to the machinery spaces shall be kept to a minimum. They are to be provided with adjustable non-return valves as well as closures. The closures must close automatically if the engine room CO_2 fire extinguishing system is activated. Manual closure from the accommodation shall also be possible.

Table 11.1 Guidelines for room temperature limits

Room designation	Temperature limits [°C]	
	Lower limit	Upper limit
Ship control stations, permanently manned	21	28 **(1)**
Ship control stations, not manned	15	35
Accommodation, offices, messes	21	28
Generator and converter rooms	5	45
Gyro compass room	15	40
MCC, DCC, etc.	21	28
Machinery spaces	5(15) **(2)**	45 (35) **(2)**
Machinery workshops, store rooms	15	35
Electronics and precision mechanics work shop	21	28
Ammunition rooms	5	30 **(3)**
Hangars, closed	15	35
Galleys	19	30
Provision rooms (daily and dry provisions)	5	25
Wash rooms/ shower rooms	24	-
Toilets	20	-
Hospital	22 (24) **(4)**	28
Medical stores	22	25
Stores for hazardous materials	5	30
Storage space for solid waste	0	12

(1) *the requirements of the manufacturers for the control equipment shall be observed*
(2) *in spaces and areas where a watch is permanently present*
(3) *depending on type of ammunition, to be defined by the Naval Authority*
(4) *in operation rooms, bath rooms*

Table 11.2 Guideline for the parameters of the climatic range required for optimum human climatic comfort

Designation of parameter	Optimum value	Range of comfort	Limits	
			lower	upper
Corrected nominal temperature for sedentary work [°CNET]	21	18-24	16	27
Relative air humidity RH [%]	50	35-60**(1)**	30	70
Air flow speed for sedentary work	0	≤0,1 m/s	0	0,2 m/s at 50 % RH
(1) *Values other than this range shall be agreed upon with Naval Authority*				

The decontaminated air plant has to be designed for a flow rate which ensures an adequate supply of breathing air for the ship's crew.

The decontaminated air quantity may not drop below the following value:

$$SLM = ALM \cdot n \cdot \frac{a}{b_2 - b_1} \ [m^3/h]$$

SLM = decontaminated air quantity

ALM = breathing air quantity

– resting 0,50 m^3/h/person

– on light work 0,75 m^3/h/person

– on heavy work 1,25 m^3/h/person

n = number of people on board

a = CO_2 content of air breathed out (4 Vol. %)

b_1 = CO_2 content of outside air (0,03 Vol. %)

b_2 = permissible CO_2 content of the air in the area under design

– 0,15 % in service spaces and rest rooms

– 0,25 % in mess rooms

– 0,50 % in workshops

5.3 Air change rates

Guidelines for air change rates of the different rooms of the ship are given in Table 11.3. Using these air change rates the required air volume for the relevant room can be determined by considering the gross volume of the room (up to the suspended ceiling) without any subtraction of the volume of fittings and equipment.

Table 11.3 Guidelines for air change rates

Room to be ventilated	Change rates per hour	
	Supply air	Discharge air
Sanitary room	-	12-15
Laundry	10-20	15-20
Drying room	25	30
Stores for hazardous working materials	10	-
Waste incineration room (see D.3.)	>10	-
CO_2 room (see D.4.)	-	15
Closed vehicle decks (see Chapter 105, Section 15)	>10	-
Refrigerating machinery space (see C.2.11)	15 (30) **(1)**	-
(1) *with refrigerants of group 1, see Section 12, C.*		

G. Components

1. General

All components must be designed with the target of low maintenance.

For those parts of the air handling plants specified by the Naval Authority as being subject to requirements concerning shock resistance, vibration resistance or noise reduction, the corresponding proofs shall be submitted to TL, see also Chapter 102 - Hull Structures and Ship Equipment, Section 16.

2. Ventlines, ducts, fittings

2.1 Ventilating paths

Ship spaces with a connection to the air handling plants must be provided with air exchange openings

Ventilation grids or air exchange louvres with vision screens shall be installed in partitions.

Exhaust air which is not extracted from the rooms via ventilation ducts shall stream through ventilation openings, etc. into the adjoining corridors and from there to the outside, partly via the sanitary and service spaces or via the relief dampers arranged in the outer walls. An other part of the exhaust air should flow to the outside via machinery spaces, engine rooms, power stations or sound-absorbing capsules.

Air ducts and ventilation pipelines which convey heated or cooled air shall, wherever necessary, be insulated against heat losses. Cold air lines must be insulated to prevent condensation water.

Outdoor air trunks which are located in rooms / corridors shall be insulated in accordance with the requirements stipulated for these rooms/corridors.

2.2 Drainage and cleaning

Main ventilation trunks, especially those of the welded type, shall be provided - insofar accessible - with cleaning flaps and drainage arrangements. In the case of ventilation ducts conveying filtered air, cleaning openings can be omitted.

For the extraction of the condensate, galley canopies containing grease filters and drain channels shall be arranged above the cooking and frying facilities. Un-hindered drainage shall be ensured. The drains must be arranged outside the personnel's working area.

Regarding the construction of the ducts for the exhaust air of the galley see C.2.8.

2.3 Ventlines

Penetrations in decks and bulkheads shall be reinforced and welded in according to 5. The penetrations shall be provided with corner radii of sufficient size. The minimum lengths for pipe connections shall be in compliance with Table 11.4 and/or in relation to the insulation thickness. Penetrations in light partitions shall be covered with facing. Insofar required for the watertightness of the ship, ventlines shall be welded according to the ship structural requirements; moreover, ventlines which can be contaminated shall be welded to be gastight.

On principle ventlines inside the ship shall not be routed behind ceiling or wall panelling.

2.4 Water separation

To protect the outdoor air or discharge air openings in the outer walls against the ingress of surge and spray water, the incoming or outgoing air shall be routed via baffle-plate chambers, water traps or water separators. These devices are to be welded on the inner side of the wall. Outside openings shall be fitted with louvers that are easily removable.

The baseplates of water traps shall be arranged with a slight inclination outwards; a good drainage of water must be ensured.

If the velocity of the delivery air is larger than 2,3 m, the coolers of the air handling units must be followed by water separators. The separated water shall be drained away in a suitable manner.

2.5 Air mixing box

For double-pipe plants, commercial-grade air mixing units can be provided.

2.6 Supply air outlets and exhaust air inlets

Perforated ceilings, air diffusers and air outlet grids can be used as supply air outlets for air handling units in living quarters, day rooms and vital rooms.

For control stations and operating spaces, air nozzles can be installed in addition to the usual ventilation grids and sliding grids outside the passageways.

In the case of single-pipe plants, supply air and exhaust air boxes shall be used for wall and ceiling mounting.

In rooms with a high air change rate, perforated ceilings can be used besides other types of outlet fittings which are intended to provide a good circulation of air.

Exhaust air facilities may be of commercial-grade type such as ventilation grids, sliding grids, exhaust air nozzles, exhaust louvres etc. as required.

2.7 Change-over, control and non-return dampers

2.7.1 To adjust the ventilating pathes, control dampers shall be provided. To regulate the flow rates of supply air and exhaust air, control dampers shall be provided, either manually operated or with servomotor. For large ventilation cross-sections, conventional damper structures of the shutter type with counteracting dampers shall be used. When the air flow rates have been calibrated, the position of the control dampers shall be durably marked (e.g. by drilling a hole), in order to be able to reinstate the original setting at any time.

2.7.2 For elimination of smoke / fire-extinguishing gases after an outbreak of fire, change-over dampers shall be so provided that a selective and effective ventilation of the affected area can take place. The change-over dampers shall be arranged at the air handling plants and/or the structural walls. They shall be made of steel.

2.7.3 Non-return dampers shall be provided wherever there is a risk that, in the event of fan failure, odours and stale air could pass into adjacent rooms through common ducts:

- Non-return dampers at NBC protection plants shall be provided in the ventline between the filter unit and fan, in order to maintain the over pressure in the citadel if the fan fails.

- Non-return dampers in ship spaces shall be used wherever a certain pressure difference is to be maintained between different spaces.

3. Silencing and damping of air handling plants

3.1 Noise level

The noise level values stipulated in the building specification shall be observed.

The noise level at the ventilation openings on the open deck shall not exceed 85 dB (A) measured at a distance of 1 m from the edge of the opening at an angle of 30° to the direction of the gas stream and as far as possible away from reflecting surfaces. The airborne noise level generated by the air handling plants and other machinery shall not exceed the level stipulated by the Naval Authority, owing to other possible influences from the ship machinery. If no other specifications have been set for other factors exerting an influence on the overall airborne noise level in the space, the airborne noise level at the outlet opening shall be at least 5 dB lower (under the same measurement conditions as defined above) than the permissible overall level in that space. This shall be defined in the building specification.

Air outlets shall be optimized, considering noise development.

Ducts leading through spaces with a high noise level shall be protected against noise impingement by means of external soundproofing.

3.2 Vibrations

Vibration-damping measures going beyond the state of the art shall be provided according to the requirements of the Naval Authority.

Where necessary, absorption silencers, sound-absorbing ducts and noise-insulating distribution chambers shall be installed in the ventilation plants.

Flexible connections in air handling plants shall be made of materials which are at least flame-retardant. The fans shall be mounted on vibration absorbers.

4. Materials

On principle all ducts shall be made of non-combustible or fire resisting material. Smoke extraction ducts in main machinery spaces shall be made of steel or shall be of adequate design.

Ducts in the galley shall be made of stainless steel. Exhaust air ducts outside the galley can be made of steel.

Materials for removable ducts, trunks and pipes shall be stated in the corresponding building specification.

The internal surfaces of the trunks, ducts and pipes must be smooth and abrasion-resistant, to prevent the accumulation of dust.

Ventlines shall be protected against corrosion; it must also be possible to protect the internal surfaces of ventilation trunks. Inspection openings shall be provided in sufficient quantity.

For expansion joints, elastic connections and hoses, materials which are at least flame-retardant shall be used.

5. Wall thicknesses

Where trunks, ducts and pipes are permanently fixed to the hull, the thickness of the ventilation ducts depends on the thickness of the structural walls through which they are routed. The minimum wall thickness is defined in Table 11.4

Ducts and trunks shall be made of thicker material if it is necessary due to their location. Wall thicknesses for ventilation pipelines shall be in compliance with the duct wall thicknesses. The deck penetrations of fan ducts must be strong enough to protect up to a height of 15 cm above deck against mechanical damage.

6. Installation and dismantling

For the arrangement of the units, simple and reliable operating, maintenance, accessibility and exchange shall be ensured.

7. Electrical installations

Electrical installations must comply with the requirements set out in Chapter 105 - Electrical Installations, Section 1, J.

8. Closures

8.1 General

All closures shall be arranged for satisfactory operating at easily accessible places. The damper position shall be defined clearly and marked in the user's language.

8.2 Gas- and watertight ventilation dampers

The following types of ventilation dampers are to be used:

- casing dampers
- ventilation terminal end dampers
- quick-closing dampers
- gas- and watertight ventilation dampers

Ventilation dampers in bulkheads and decks, or in gas- and watertight ducts which have to be provided between the bulkheads/decks, shall only be made of steel.

8.3 Relief dampers

These closures shall be provided for all external openings of the air handling plants of a citadel, where discharge air leaves the ship or flows over to spaces with a contamination hazard.

Spring-loaded, adjustable relief dampers or power-operated relief dampers shall be provided. If power-operated dampers are used, a failure of the supply power must not lead to failure of the damper function

.

8.4 Non-gastight and non-watertight ventilation dampers

The following types of ventilation dampers are to be used:

- fire protection dampers
- change-over dampers
- throttle dampers
- control dampers
- smoke dampers
- fire dampers

Table 11.4 Minimum wall thicknesses of ventilation ducts

Type and size of ventilation line	Material	
	Aluminium	Steel **(1)**
Non-watertight ducts, riveted, bolted, lock-seamed or spot-welded:		
Up to 250 mm side length	1,0 mm	0,7- 1,0 mm
Over 250 mm to 500 mm side length	1,25 mm	1,25 mm
Over 500 mm side length	1,25 mm **(2)**	1,25 mm **(2)**
Non-watertight ducts, welded:		
All sizes	2,0 mm	2,0 mm
Watertight ducts and trunks, welded:		
Up to 700 mm side length	3,0 mm	3,0 mm
Over 700 mm side length	5,0 mm	4,0 mm **(2)**
Pipe connections for deck and bulkhead penetrations without closures:		
Up to 300 mm side length	3,0 mm	3,0 mm
Over 300 mm side length	5,0 mm	5,0 mm

(1) *normal strength hull structural steel*
(2) *if necessary stiffeners are to be provided*

8.4.1 Fire dampers

Fire dampers serve as closures of fire zones in air handling plants. In the galley exhaust air ducts, they shall be arranged as close as possible to the galley wall or bulkhead. Only dampers which close automatically shall be installed.

The closing process shall be triggered by a thermal threshold or by the fire detection system of the galley or the corresponding area. To switch off the relevant fan in case of fire, each fire damper must be fitted with a limit switch which is electrically interlocked with the fan motors. It must be possible to close and open the dampers by hand. The monitoring of the fire dampers (damper position, damper has been triggered etc.) shall be performed according to Table 11.5.

9. Air filters

Air filters shall comply with B.2.8.

10. Air cooling

The type of air cooling which is to be preferred depends on the stipulated requirements and applications.

10.1 Water-operated coolers

Air coolers operating with seawater shall be used primarily for ventilation of operating spaces and machinery spaces.

Air coolers operating with chilled water shall be used where several air handling plants (air conditioning plants) have to be supplied simultaneously with chilled water and/or the heat loads differ in the connected spaces, or where the possibility of individual control of the different rooms is required. The surfaces shall, wherever necessary, be provided with insulation against condensation.

10.2 Refrigerant-operated air coolers

For this type of air cooling see Section 12.

10.3 Supply air cooling units (compact design)

Supply air cooling units in compact designs (with air coolers which are operated by chilled water or refrigerants) shall be used for low cooling requirements for spaces which need an independent cooling system or for groups of spaces with nearly the same heat loads in the individual rooms.

Table 11.5 Control and monitoring positions for ventilation plants

No.	Ventilation plant Type of control/monitoring device	Location and type of monitoring					Location and type of control				
		MCC		DCC		locally	MCC		DCC		locally
		-	IMCS	-	IMCS		-	IMCS	-	IMCS	
1	supply, discharge and recirculating fans for machinery spaces	F**(1)**C	FC	C	FC	-	IOEO **(2)**	IOEO **(2)**	EO**(2)**	IOEO**(2)**	I**(7)**O**(7)**
2	supply, discharge and recirculating fans for other spaces [8]	F**(1)**	F**(1)**C	C	F**(1)**C	-	EO**(2)**	IOEO **(2)**	IOEO **(2)**	IOEO**(2)**	-
3	NBC protection plant	F**(3)**	F**(4)**	-	F**(4)**	C	-	IO	IO	IO	-
4	indication of excess pressure in the citadel	F**(5)**D **(6), (7)**	F**(5)** D**(5)**	M	M	M	-	-	-	-	-
5	NBC alarm device	FD	FD	-	FD	-	-	IO	-	IO	-
6	measuring device for differential pressure for prefilter	-	F	-	F	M	-	-	-	-	-
7	hot water boiler, oil firing plant	F**(1)**C	FC	FC	FC	FC	EO	IOEO	EO	IOEO	IO

Abbreviations:

IMCS = Integrated Maschinery Control System

F = failure message

I = switching in

O = switching off

C = identification of operation condition

M = measuring instrument

D = digital indication

EO = central emergency shut-off for ships with integrated machinery control (IMCS)

(1) *collective fault message for fans and heaters for each compartment or damage safety zone for ships without compartment independent ventilation*

(2) *central emergency shut-off for damage control zone (compartment for IMCS)*

(3) *collective fault message for each NBC protection plant, preheater and air quantity control*

(4) *failure message for each NBC protection plant for fans, preheater and air quantity control*

(5) *for each compartment or damage control zone for ships without compartment independent ventilation*

(6) *digital measuring instrument with selection choice*

(7) *entrance to the machinery space, emergency shut-off not for capsule circulating fan*

(8) *electrical heater interlocked with fan*

The units shall be mounted elastically. Sufficient space shall be kept free for cleaning the condensers and the dust filters.

For refrigerating facilities, see Section 12, e.g. refrigerant-operated air coolers.

11. Air heating

The ship's interior is heated either by hotwater-operated air heaters or by electrically operated supply air heating units.

11.1 Electrical space heating units

Electrical space heating units (electrical heating elements) must comply with the requirements as per Chapter 105 - Electrical Installations, Section 1, F. and J.

In general, the space heating units shall be fitted with built-on step switches. For space heating units in sanitary rooms, these switches shall be mounted outside the rooms.

In addition, the electrical space heating elements shall be so constructed or enclosed by panelling that it is not possible to deposit things on them.

11.2 Electrical air heaters

The air heaters shall be so electrically interlocked with the associated fans that operation of the heaters is not possible if the fans are switched off.

12. Heat insulation

For the heat insulation of air handling plants, mineral fibres or an equivalent material shall be used.

The insulation of air ducts and pipelines conveying cold air must be provided with water vapour and oil vapour diffusion blockers on the outside surface.

The insulating materials shall be non-combustible (see Chapter 102 - Hull Structures and Ship Equipment, Section 20, A.2.1.2) and serviceable for temperatures up to 750 °C. The insulating materials that are used must be halogen-free and also the covers and grounds shall be non-combustible. All pipelines, tanks, units, pressure vessels, valves and fittings shall be insulated against heat loss and as a safeguard against accidental contact, as required

13. Control, switching and regulating arrangements

13.1 General guidelines

B.2.6.1 is to be applied.

13.2 Electrical control, switching and regulating arrangements

B.2.6.2 is to be applied.

13.2.1 Control, switching and regulating arrangements on ships with an automation system

If the ship is equipped with an Integrated Machinery Control System (IMCS), all fans are registered, monitored and controlled by the automation system. In this case it is permissible for several fans, air coolers, damper functions, air heaters and air humidifiers with the associated safety appliances of a ventilation zone to be grouped to form functional units (modules) which have their own internal regulating circuitry. With these functional units, all start and stop sequences of the individual units are controlled by an internal program.

The functional units shall be linked to the automation system via a serial interface, via which also the alarms are handled and measurement values are transmitted.

In addition safety-related requirements of Chapter 106 - Automation shall be applicable, as and where appropriate.

13.2.2 Control, switching and regulating arrangements on ships without an automation system

13.2.2.1 For ships without an automation system, the air handling units shall be electrically driven/powered/ controlled according to damage control zones via fan groups, to achieve an emergency shut-off in a simple manner.

13.2.2.2 Fan groups have switch and distribution cabinets, which apart from the electrical supply installations also contain control, switching and regulating arrangements for the associated fans, electrical air heaters, air coolers, NBC protection units or dampers of the corresponding damage control zone.

The required components shall be grouped to form functional units and arranged in withdrawable units/ modules. Withdrawable units with the same function must be interchangeable.

Fan groups shall not contain any switching or monitoring arrangements for consumer feeders. Only pilot lamps for indicating the busbar voltage shall be provided.

13.2.2.3 Fan groups should not be installed in fan rooms. They shall be arranged inside the citadel, preferably in the immediate vicinity of the corresponding fan rooms, if possible in recesses or in suitable places that are accessible at all times, and if necessary to gether with other switchgear installations:

- If motor protection arrangements are stipulated in the building specification, they shall be accommodated in the fan groups within the switch and control units belonging to the fan motors.

- For electrical air heaters and positioning elements (control valves) at the air heaters and coolers, the necessary switch and regulating stages shall be provided in the fan groups and set up for remote switch-on via pushbuttons / pushbutton switches or ganged switches.

- Following manual start-up, an automatic temperature regulation should be achieved through the activation or deactivation of heating power stages, or the opening and closing of control valves and possibly air dampers by means of positioning elements.

- Power stages of separately operated air heaters of low capacity up to approx. 12 kW can also be controlled manually after start-up.

- The control units of electrical air heaters of a damage control zone / ventilation zone or of the entire ship shall be so electrically interlocked that several control stages cannot be switched on simultaneously.

- Whether an interlocking of the air heaters only or an interlocking for the entire ship is necessary, shall be examined in each individual case.

- After triggering of the overheating protection of an electrical air heater, there shall be no automatic reconnection.

- Electrical air heaters shall only be in operation when the corresponding fans are also switched on.

13.2.3 Special aspects for NBC protection plants

The following special aspects have to be considered for NBC protection plants.

The control units of NBC protection plants shall be so interlocked electrically with the associated fans that, when the fan is switched on or off, the corresponding control units are also switched on or off automatically. On failure of the fan, an alarm shall be triggered at the positions listed in Table 11.5 and the associated air heater must then be switched off automatically.

For the remote monitoring of each NBC protection plant, an air volume measurement section shall be provided.

The dust filter shall be monitored locally by means of a differential pressure gauge.

The electrical heaters of NBC protection plants shall be switched in relation to the outdoor air temperature. On failure of the heater, an alarm must be triggered at the positions listed in Table 11.5.

For ships without an automation system, a binary display shall be provided in the fan groups to indicate the following fault conditions:

- overheating protection of heater has been triggered

- motor protection arrangement of the fan has been triggered

- local monitoring panel/annunciator has detected a fault

For ships with an automation system, the signals are transmitted directly or via the serial interface of the air handling functional units to the automation system.

13.2.4 Operating and monitoring panels

13.2.4.1 Ships with automation system

The following aspects have to be considered for ships with an automation system.

The operating and monitoring functions at the damage control stations shall be performed by video workstations (display consoles).

For particulars, see the Table 11.5.

For each engine room, turbine room etc., an emergency switch-off device shall be installed which allows to stop the corresponding fans.

Details on additional switching and monitoring devices in the machinery control centre and on individual switching points shall be obtained from the Table 11.5 or shall be defined in the building specification.

13.2.4.2 Ships without automation system

The following aspects have to be considered for ships without an automation system.

At the damage control stands, one switchboard and one monitoring panel shall be arranged, and these shall, inter alia, contain all the necessary remote-control and monitoring elements for the electrical installations of the air handling plant that are located in the associated damage control zone and ventilation zone. Besides the required switching points, two pilot lamps shall be provided for each of the individual consumers, to show the current operating conditions.

For particulars see the Table 11.6.

Each of the damage control stations shall be provided with a common emergency-off switch for all fans, electrical air heaters and refrigerating plants of the associated damage control zone /ventilation zone.

Furthermore, for each associated engine room, turbine room etc. an emergency-off switch shall be installed with which the corresponding fans can be switched off.

Details on additional switching and monitoring devices in the machinery control centre and on individual switching points shall be defined in the building specification.

13.3 Pneumatic control, switching and regulating arrangements

Pneumatic control, switching and regulating arrangements shall only be provided for air handling plants with hot water- and steam-operated air heaters and for regulated cold water air coolers if no electrical regulation is stipulated for that purpose.

The compressed air required for operation shall be supplied by a separate compressed-air plant via a compressed-air pressure reducer (with adjustment range). The air must be dry, and free from dust and oil.

The units to be used, e.g. pneumatic temperature regulators, control valves, reducing valves, must comply with the state of the art.

H. Schedules for Ventilation Plants

Typical schedules for ventilation plants are shown in Figures 11.1 to 11.7. The components of these plants are summarized in Table 11.6.

I. Testing

1. General

1.1 The tests listed in this section are acceptance tests to be carried out in connection with new constructions.

1.2 Tests are to be planned and performed in close co-operation with the owner.

Table 11.6 Components of ventilation plants

No.	Designation	Remarks
5	Protection air unit (NBC)	
6	Protection air unit, door type (NBC)	
7	Air conditioning unit (ACU)	
9	Flow fan	
11	Filter	D = dust, NB = micron, O = odour filter
12	Air heater	
13	Air cooler	
15	Water eliminator	
16	Silencer	Acc. to ISO/DIN 14617-21
17	Ventilation damper	Not gas and water tight
18	Non-return damper	Not gas and water tight
19	Change damper	Not gas and water tight
20	Fire protection damper	Not gas and water tight
22	Ventilation damper, general	Gas and water tight
23	Relief damper	Gas and water tight
24	Air diffuser	
30	Panel air outlet	For supply air
31	Water trap	
32	Pressure wave protection	
33	Jalousie	
35	Air inlet	u = inlet near to floor, o = inlet near to ceiling
36	Air outlet	u = outlet near to floor, o = outlet near to ceiling
43	Ventilation duct / pipe, general	
44	Ventilation duct / pipe	Gas and water tight
45	Duct / pipe going upwards	
46	Duct / pipe going downwards	
51	Measuring device for differential pressure	
52	Connection for NBC alarm device	
53	Refrigerant warning device	
54	Remote control	
56	Door	Gas and water tight
57	Folding wall and swing-door	
58	Shower for cleaning of protection clothes and equipment	Decontamined water to be provided

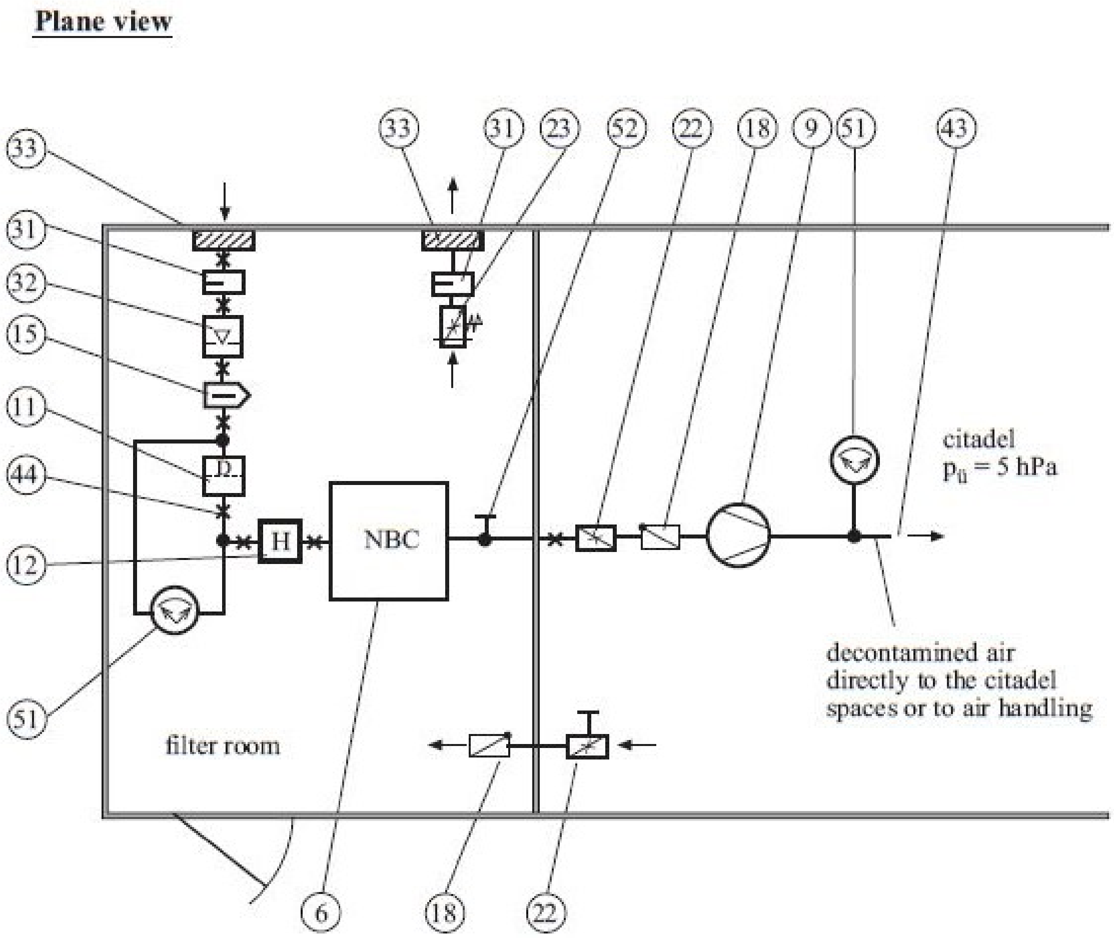


Figure 11.1 NBC protection plant

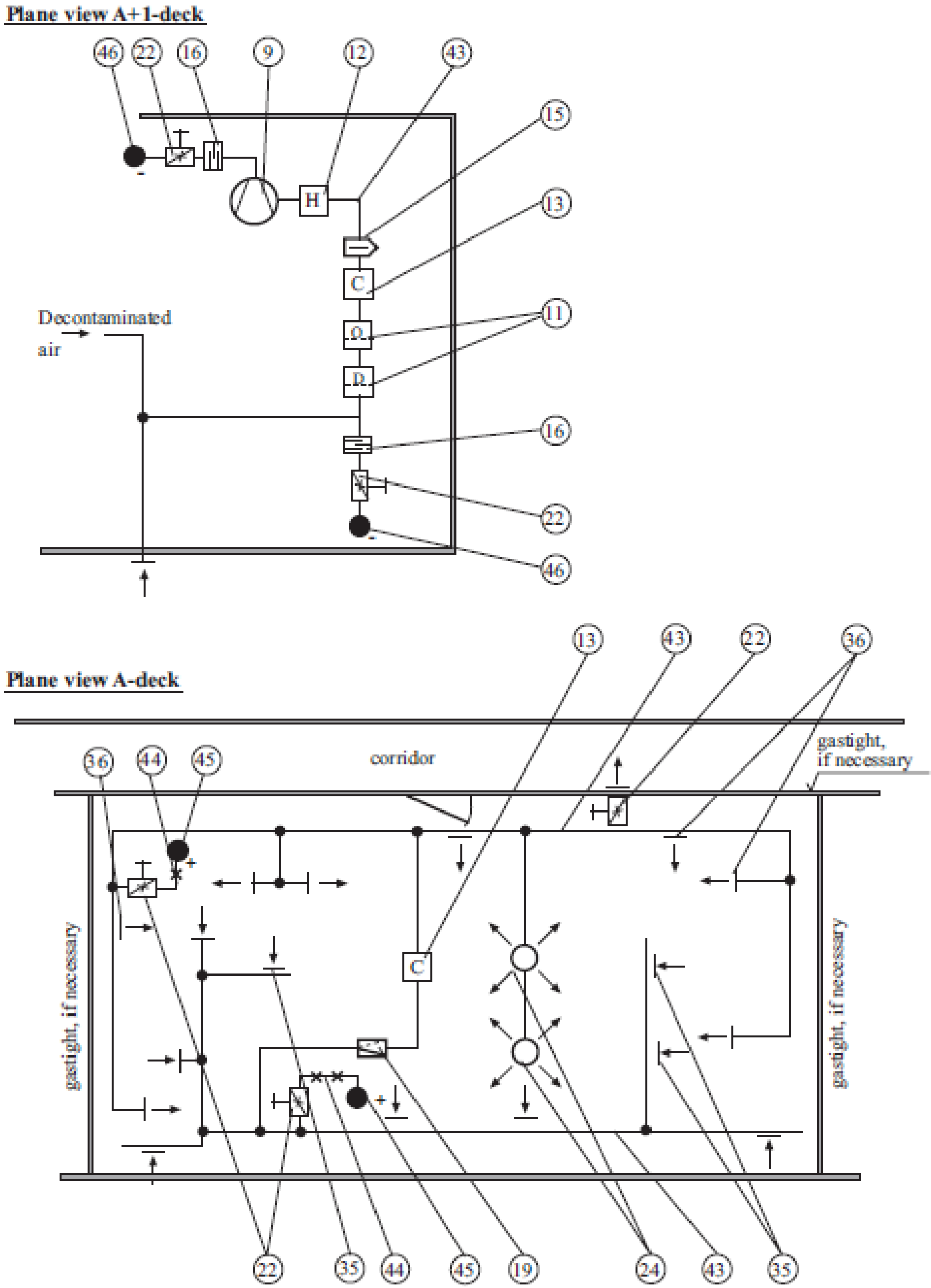


Figure 11.2 Ventilation of ship control stations

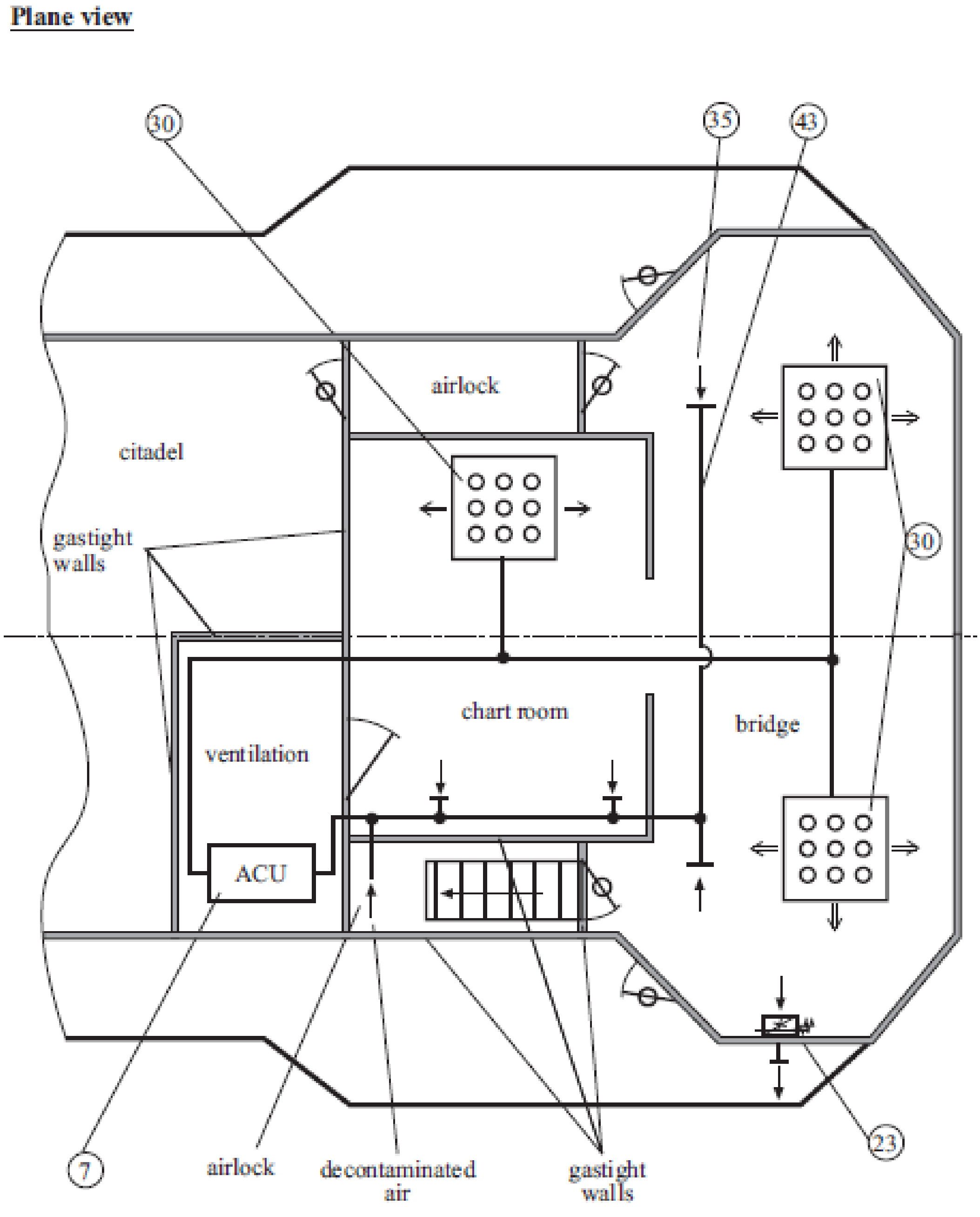


Figure 11.3 Ventilation of a bridge with NBC protection

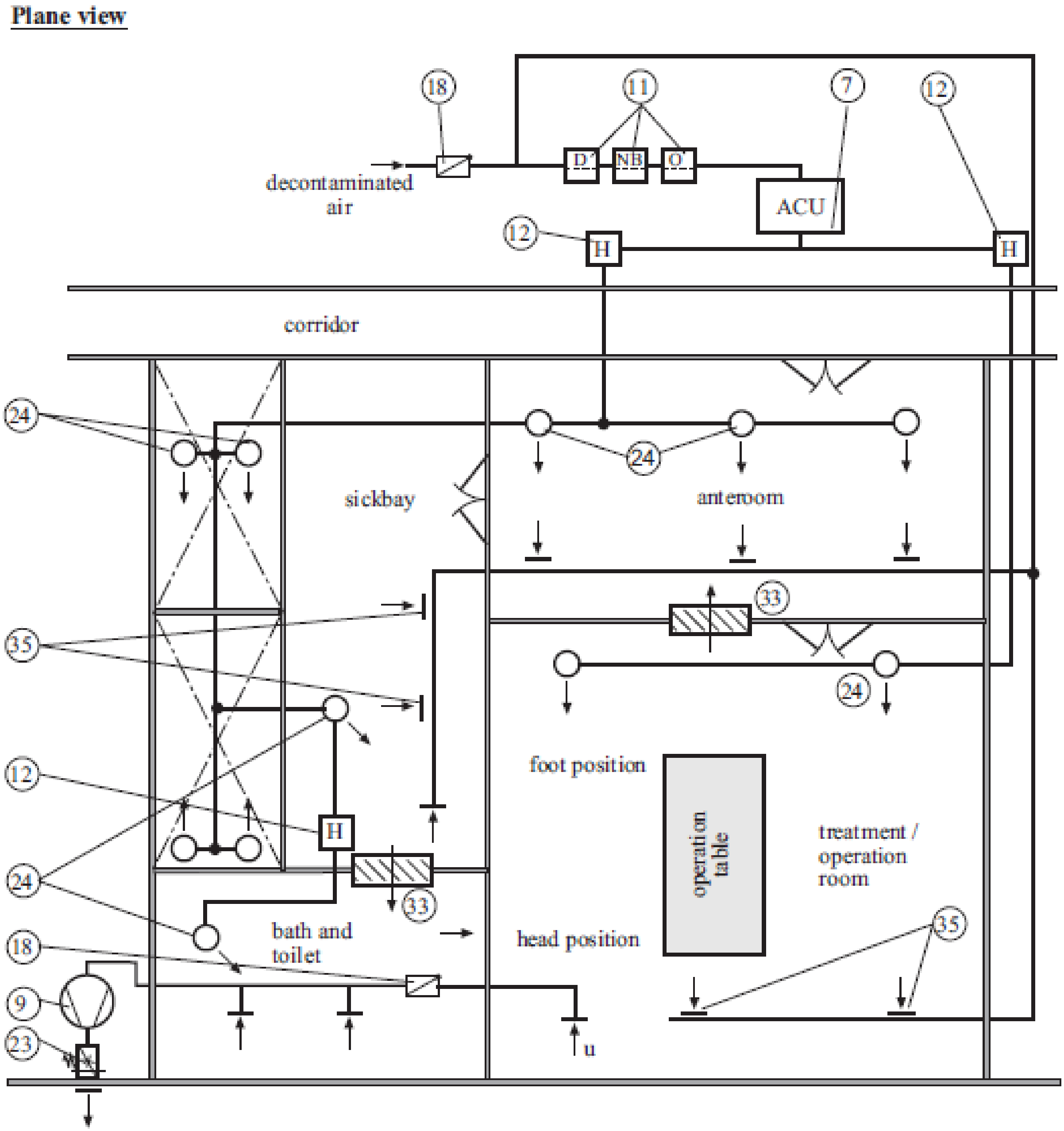


Figure 11.4 Ventilation of the ship's hospital

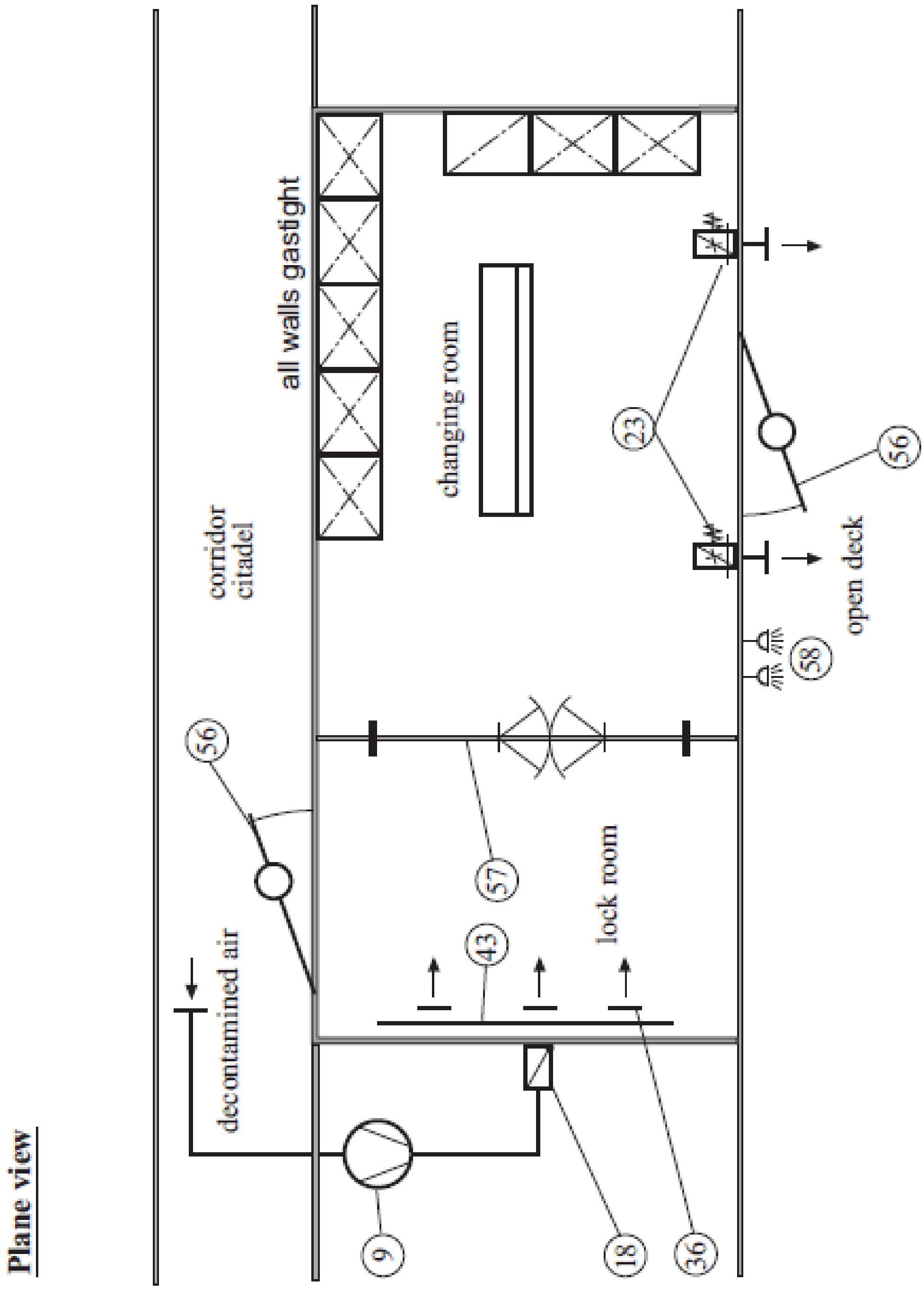


Figure 11.5 Ventilation of NBC cleansing station

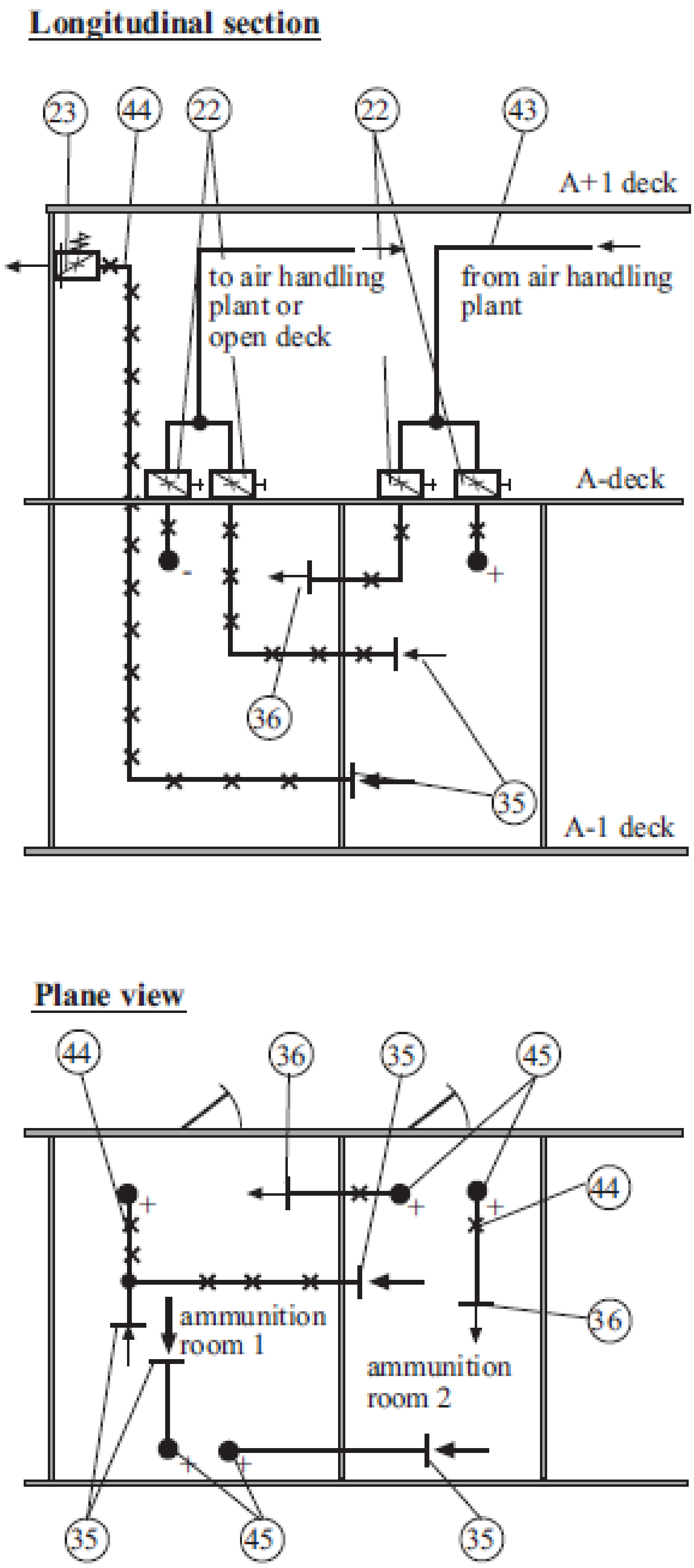


Figure 11.6 Ventilation of ammunition rooms

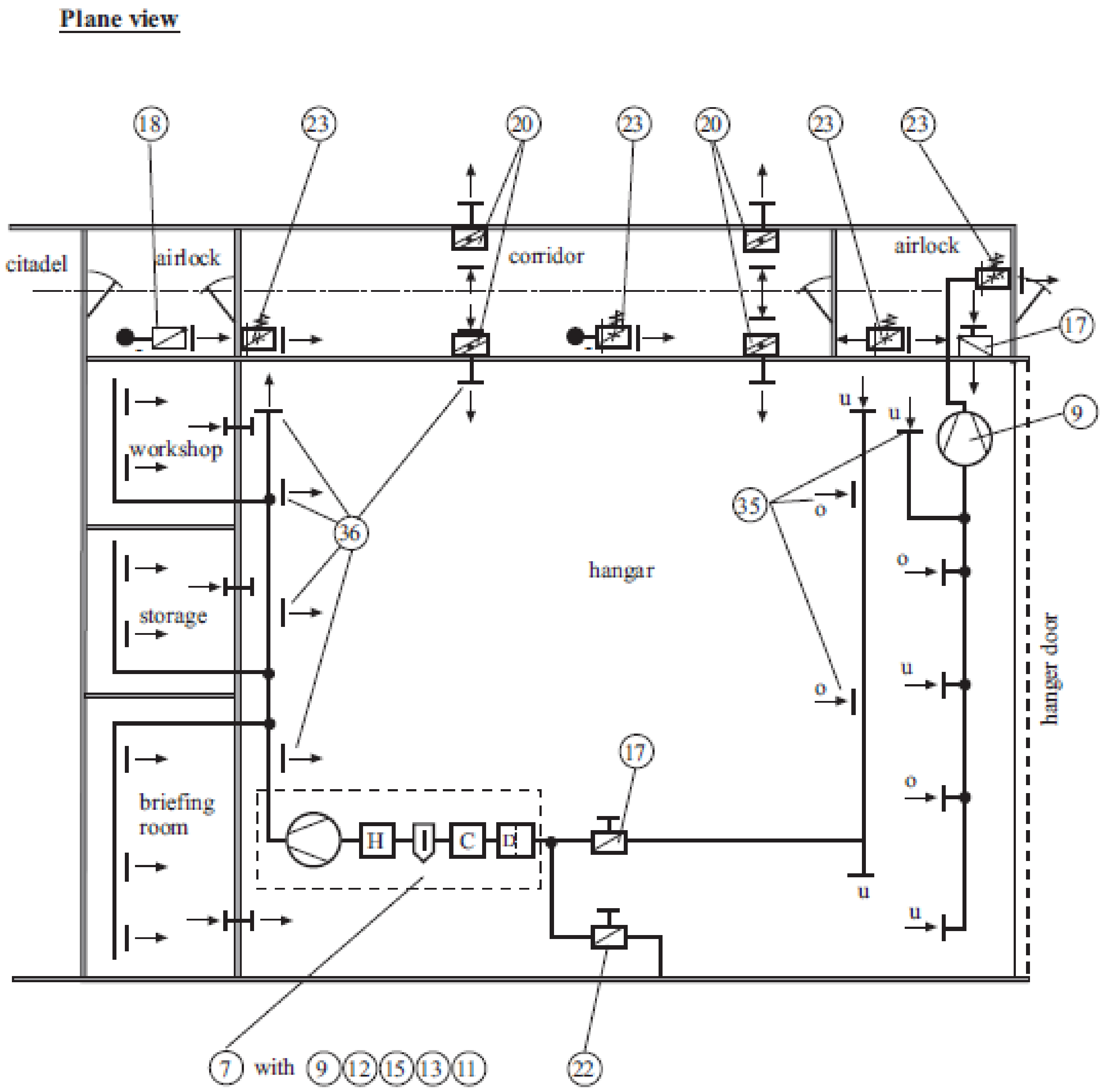


Figure 11.7 Ventilation of aircraft hangars

2. NBC citadel

2.1 Each NBC citadel is to be subjected to a harbour acceptance tests or sea acceptance tests by pressurising the NBC citadel. The NBC citadel is to be checked for leaks by a recognised method.

Note:

Air leakage to weather and unprotected spaces, other than air through overpressure valves should generally not exceed 1% of the total supplied air quantity.

2.2 A harbour acceptance trial comprising a functional control of remotely operated closing appliances is to be carried out, as applicable.

2.3 Following sea acceptance trials are to be carried out with the NBC or dummy filters engaged:

a) Pressure test of each NBC-zone to ensure that the required pressure is maintained.

b) The NBC-zone is to be able to maintain a 0.5 kPa over-pressure for a 24 hours period.

c) The prescribed CO_2 and temperature levels are to be maintained in all parts of the citadel for a 24-hour period with a defined number of crew present in those parts.

d) Function check of overpressure valves.

e) Function and pressure controls of air locks.

f) Checking that water seals for plumbing drains and traps is not breached in heavy seas, the water seal to sustain a pressure of at least 1.5 kPa.

g) Function control of cleansing stations with recording of air pressure drop through the station.

3. Pre-wetting and wash-down system

3.1 The pre-wetting and wash-down system are to be subjected to a harbour acceptance trial comprising:

- pressure tests

- function control of remote controlled or operated valves without water pressure.

3.2 The pre-wetting and wash-down system are to be subjected to a sea acceptance trial comprising:

- function test of the whole system to prove that full coverage has been obtained

- drainage functions of the system

- complete system trials to check coverage

- system trials of each section

- drainage functions

- capacity test.

Testing plans including proposed environmental conditions shall be submitted for approval.

Note:
The pre-wet and wash-down system should be tested at full capacity under the following conditions:

- *at zero craft speed and wind speed*

- *at 20 knots relative wind from ahead*

- *at 20 knots relative wind from ahead while weaving the craft 15° port and starboard of mean course.*

Craft with full speed less than 20 knots will be subject to special considerations.

4. Detection systems

4.1 The detection systems are to be subjected to a functionality test compromising:
- functionality without contamination present.

Test plans should be submitted to the Society for approval.

SECTION 12

REFRIGERATING INSTALLATIONS

A. General

1. Scope

These Rules apply to refrigerating plants, as well as refrigerators and freezers aboard naval ships.

2. References to other rules

2.1 The rules, guidelines, standards, referred to in this Section have to be applied.

2.2 Furthermore national regulations for operation, environmental protection and accident prevention as amended are to be considered.

3. Deviation from the Rules

TL reserve the right to modify or amend the present Rules if deemed necessary in the light of experience, technical progress and special design requirements.

4. Documents for approval

4.1 Each of the following documents is to be submitted in triplicate:

- description of the refrigerating plant concerning application, refrigerating capacity, energy demand, arrangement and scope of components. For provision refrigerating installations the temperatures of the refrigerated spaces have to be defined.

- drawings showing the layout of refrigerant, chilled water and cooling water pipelines with details of the wall thickness and materials of the pipes

- drawings of all vessels and equipment under refrigerant pressure, e.g. condensers, evaporators and oil separators as well as brine tanks and air coolers, together with details of the materials used

- drawings showing the arrangement and equipment of the refrigerated spaces with details of air circulation and space ventilation

- a general arrangement plan of the refrigerating installation with details of the ventilation of the refrigerating machinery spaces.

- description of automatic control systems, e.g. for temperatures, pressures, leakage of refrigerant.

- circuit diagram

- component list

5. Ambient and operation condition

Refrigerating plants and their assessories have to be constructed for the operational and ambient conditions specified for the actual ship, compare also Section 1, D.

6. Tests and proofs

The scope of the tests given in L. has to be applied.

B. Design and Construction of Refrigerating Installations

1. General

1.1 Safety against shock and vibration

1.1.1 Refrigerating plants have to be safe from vibration and to fulfil the requirements of Chapter 102 - Hull Structures and Ship Equipment, Section 16 for design and installation. Plants which would restrict the operability of the naval ship in case of failure have to be shock-proof in design and installation. The chosen configuration has to be defined in the building specification. The Naval Authority may accept a proof by calculation instead of a shock test certificate.

1.1.2 For refrigerating devices such as refrigerators, freezers, etc. in cabins and messes a proof concerning shock safety may be dispensed with.

1.2 Noise reduction

If special requirements for noise reduction are demanded, adequate measures according to state-of-the-art have to be provided.

2. Air conditioning plants

2.1 Distribution of refrigerating capacity

If not specified otherwise at least two refrigerating plants are to be provided for cooling of chilled water in the air conditioning system. These plants have to be located in different damage control areas. For larger naval ships a refrigerating plant has to be provided in each damage control area, where reasonable.

The total refrigerating capacity has to be distributed to at least two separately installed refrigerating sets. For two sets of the same size the refrigerating capacity of each set should be 60 - 70 % of the total capacity required. If three sets of the same size are envisioned the refrigerating capacity of each set shall be abt. 50 % of the total capacity. Different distributions of the refrigerating capacity have to be specially agreed.

The supply of chilled water for the air coolers in the different damage control areas must be ensured even if any refrigerating set fails. Adequate switching possibilities have to be provided.

2.2 Estimation of cooling load

The estimation of the cooling load for the refrigerating sets has to be based on the external and internal climatic conditions according to Section 11 considering energy loss due to pumps and pipelines.

3. Refrigerating plants for provisions and cargo

3.1 For each refrigerating plant for provisions and cargo two condensing units of the same type and size have to be provided. Each of these units has to be dimensioned on its own for the total refrigerating demand. Parallel operation need not to be considered.

3.2 Estimation of cooling load

3.2.1 The estimation of the cooling load for provisions and cargo is to be based on a permissible heat transmission k · Δt **(1)** of 12 - 17 W/m^2. For the calculation of the heat transmission the final internal dimensions of the refrigerating spaces have to be used. Additional heat loads caused by lighting, thermal bridges, evaporator fans, defroster equipment, respiration heat of the provisions and opening of the doors to the refrigerating room have to be considered.

Note:

For the different refrigerated rooms for provisions the following storage temperatures may be assumed:

- *frozen food stores* - 21 °C
- *cold stores (meat, fat, sausages)* + 1 °C
- *vegetable and fruits* + 4 °C
- *potato stores (up to 4 months storage)* + 9 °C
- *bread store* + 4 °C
- *mixed provisions* + 4 °C

3.2.2 For the estimation of the cooling load at continuous operation an additional cooling down of provisions according to Table 12.1 shall be considered.

Table 12.1 Additional cooling down of provisions

Provisions to be cooled down	After cooling by [K]	Cooling down time [h]
Deep frozen provisions	5	36
Cold stores (meat, fat, sausages, etc.)	8	36
Vegetables, fruits	15	48
Potatoes	10	48
Bread	25	48
Mixed provisions	12	48

(1) k = coefficient of heat transfer $\left[\frac{W}{m^2 \cdot k}\right]$

Δt = temperature difference [k]

3.2.3 Refrigerating plants for provisions and cargo have to be dimensioned in steady-state for a maximum running time of 18 hours within 24 hours.

C. Refrigerants

1. General

Safety refrigerants of group 1 or class L respectively according to DIN 8960 have to be used exclusively. National **(2)** and international **(3)** regulations for the protection of the ozone layer are to be considered. The danger of suffocation by using these refrigerants shall be pointed out. The type and application of the refrigerants have also to be approved by the Naval Authority.

2. Working pressures

2.1 For the common refrigerants, the allowable working pressures PB (= design pressures PR) are laid down in Table 12.2 separated for the high- and low-pressure side.

Table 12.2 Allowable working pressure PB

Refrigerant	PB [bar]	
	High-pressure side (HP)	Low-pressure side (LP)
R134a	13,9	10,6
R404A	25,0	19,7
R407A	25,2	19,8
R407B	26,5	20,9
R407C	23,9	18,8
R410A	33,6	26,4

For other refrigerants, the design pressure PR is determined by the pressure at the bubble point at a temperature of 55 °C on the high-pressure side and at a temperature of 45 °C on the low-pressure side.

2.2 For the purpose of these rules, the low-pressure side of the plant includes all parts exposed to the evaporation pressure of the refrigerant. However, these parts are also subject to the design pressure for the high pressure side if a switch-over of the system, such as for hot gas defrosting, can subject them to high pressure.

Medium-pressure vessels of two-stage plants are a part of the high-pressure side.

3. Storage of reserve supplies of refrigerants

3.1 Reserve supplies of refrigerants may be stored only in steel bottles approved for this purpose.

(2) *CFC Halon Prohibition Regulation*

(3) *IMO Resolution A.719 (17)*

The level of filling must be suitable for tropical conditions.

3.2 Bottles containing refrigerant may be stored only in well ventilated spaces specially prepared for this purpose or in refrigerating machinery spaces.

3.3 On ships where there is no refrigerating machinery space and the refrigerating machinery is in stalled in the main or auxiliary engine room, the storage bottles immediately required for replenishing the system may be kept in the main or auxiliary engine room if they contain not more then 20 % of the total refrigerant charge.

3.4 Bottles containing refrigerant are to be secured in an upright position and protected against overheating.

D. Refrigerating Machinery Spaces

1. Definition

Refrigerating machinery spaces are spaces separated by bulkheads from other service spaces and which contain refrigerating machinery and the associated equipment.

2. Installation of refrigerating machinery

Refrigerating machinery is to be installed in refrigerating machinery spaces. Deviations therefrom need the approval of the Naval Authority. Independent of the location, refrigerating machinery is to be installed in with sufficient space for operation, servicing and repair. As far as necessary installation openings and installation aids have to be provided.

Refrigerating machinery spaces are not to be arranged adjacent to crew accommodation.

3. Equipment and accessories

3.1 Doors of refrigerating machinery spaces must not lead to accommodation or accommodation corridors. The doors shall open up to the outside and have to be of self-closing construction.

3.2 Provision must be made for the bilge pumping or drainage of refrigerating machinery spaces.

3.3 Refrigerating machinery spaces have to be monitored in respect of refrigerant concentration in the air. Concentrations above 50 % of the threshold limit value (TLV) at the working place have to release an alarm.

4. Ventilation

4.1 Refrigerating machinery spaces must be provided with a suitably arranged forced ventilation system with at least 30 air changes per hour. The exhaust air is to be conveyed into the open air independently of other space ventilation ducting. The inlet ducting shall not be connected to the ventilation system serving the accommodation spaces.

4.2 If refrigerating plants are installed in a space provided for other machinery and equipment, e.g. machinery rooms, fan rooms, the requirement of 30 air changes per hour will become inapplicable under the condition that the level of the complete refrigerant in the form of superheated vapour after a leakage does not exceed 200 mm above the floor. A specific volume for a superheated temperature of + 25 °C room temperature and atmospheric pressure is to be considered.

4.3 It must be possible to switch the fans for refrigerating machinery spaces on and off from outside the space. The switches have to be marked clearly.

E. Refrigerant Compressors

1. General

The type of the refrigerant compressors is to be selected in respect of operation reliability, refrigerating capacity, sound requirements as well as the energy demand. For refrigerating plants for provisions normally reciprocating compressors of open or semi-hermetic type have to be used.

2. Drives for refrigerant compressors

2.1 Where the compressors are electrically driven, the motors and other items of the electrical plant must comply with the requirements in Chapter 105 - Electrical Installations.

2.2 Other compressor drives, e.g. diesel engines, turbines, must comply with the requirements in Chapter 104 - Propulsion Plants, Section 3 and 4.

3. Equipment

3.1 A well functioning oil return to the compressor is to be ensured. For parallel operation of compressors automatic oil equalizing devices have to be provided. As far as necessary compressors have to be equipped with a crankcase heating.

3.2 Provisions have to be made, e.g. in the form of overpressure safety switches, to ensure that the compressor drive switches off automatically, should the maximum allowable working pressure be exceeded.

3.3 Compressors are to be equipped with devices such as pressure relief valves, rupture discs, etc., which, if the maximum allowable working pressure is exceeded, will equalize the pressures on the discharge and suction sides. Semi-hermetic compressors in automatic installations may be exempted from this requirement, provided that they are protected by over pressure safety switches and can be operated with permanently open shut-off valves in such a way that the safety valves fitted to the installation remain effective.

3.4 Refrigerant compressors are to be provided with a monitoring system in accordance with I.2.

3.5 A manufacturer's plate bearing the following information is to be permanently fixed to each refrigerant compressor:

- manufacturer type
- logistics number and/or designation of components, as far as existing

- year of construction
- volume flow [m^3/h]
- allowable working pressure [bar]
- number of revolutions [1/min]
- nominal voltage [V], frequency [Hz]
- rated power [kW], amperage [A] (limitation of starting current, if applicable)
- circuit arrangement of motor
- type of refrigerant and charge [kg]
- maximum allowable working pressure [bar] (only for turbo compressors).

F. Pressure Vessels and Apparatus under Refrigerant Pressure

1. General

Pressure vessels and apparatus under refrigerant pressure must comply with Section 16.

2. Safety equipment

2.1 Vessels and apparatus with shut-off devices, which contain liquid refrigerant are to be equipped with a safety valve. For the construction of safety valves see I.1.2.

2.2 Filters and dryers need not be equipped with safety valves provided that refrigerant inlets and outlets cannot be inadvertently closed at the same time.

3. Refrigerant condensers

3.1 General

3.1.1 Normally refrigerant condensers for refrigerants with seawater cooling and of shell and tube type have to be provided. For each compressor a condenser has to be attached. Type and arrangement of the refrigerant condenser have to enable easy cleaning by ship's own means.

3.1.2 The location for installation has to be kept free from frost.

3.2 Water-cooled condensers

3.2.1 Water-cooled condensers have to be designed for a cooling water velocity in a range of 1,5 - 2,5 m/s. By suitable measures it has to be ensured that these values are met at each mode of operation for the cooling water supply.

3.2.2 The design of water-cooled condensers has to consider pollution of the water side.

3.2.3 Condensers have to be equipped with means for drainage and purging of the water side.

At each cooling water connection a protective tube thermometer has to be provided. Water cooled condensers are to be additionally fitted with a connection for flushing with fresh water.

3.2.4 The connecting pipes at the cooling water side are to be arranged in such a way that the condenser cannot drain off.

3.2.5 Concerning the control of the refrigerant pressure in the condenser see G.4.2.1.

3.3 Air-cooled condensers

3.3.1 The use of air-cooled condensers has to be restricted to such plants for which the supply of cooling water is only possible with increased effort or where failures during the operation can be expected. The utilization of such condensers shall be limited furthermore to a maximum refrigerating capacity of 50 kW for air conditioning and abt. 10 kW for the cooling of provisions.

3.3.2 A sufficient heat removal at the installation area of air-cooled condensers has to be ensured for all operating conditions to be considered, including NBC protection.

4. Refrigerant receivers

4.1 The capacity of refrigerant receivers has to be designed in a way that the total refrigerant charge at the highest summer temperature is not more than 90 % of the receiver capacity.

4.2 Refrigerant receivers have to be equipped with an indicator which directly monitors the liquid level enabling the determination of the highest and lowest refrigerant level.

4.3 The requirement according to 4.2 is to be applied analogously for condensers which are additionally designed as refrigerant receivers.

5. Evaporators / air coolers

5.1 General

5.1.1 Evaporators/air coolers must be made of corrosion-resistant material or be protected against corrosion by galvanizing.

5.1.2 As far as it is not specified otherwise, the following evaporation methods have to be provided:

- direct evaporation of the refrigerant in an evaporator with forced air circulation for provision and cargo refrigerating systems

- direct evaporation of the refrigerant in a water chiller for the feeding of air cooling systems

- direct evaporation of the refrigerant for systems in refrigerating plants with natural air circulation

5.2 Evaporators for provision and cargo refrigerating plants

5.2.1 Evaporators of deep freezing and refrigerating spaces have to be designed for a temperature dif ference between evaporation temperature and room temperature of less than 10 K. The distance between the fins of the evaporator shall not be less than 7 mm.

5.2.2 For fruits and fresh vegetables the evaporators for refrigerating spaces have to be designed for a temperature difference between evaporation temperature and room temperature of less than 8 K.

5.2.3 Evaporators for refrigerating spaces with temperatures below 4 °C have to be equipped with an electric defrosting heating as well as an additional heating for drip-trays and drains. The switching on and off of the defrosting heating must be automatically operated. An impermissible increase of temperatures during the defrosting process has to be avoided by installation of a safety thermostat. Melting water has to be drained off from the refrigerating spaces in the shortest way. For the drainage frost-safe siphon traps have to be provided.

5.2.4 The evaporator fans shall have a sufficient air velocity to ensure an even air distribution. Motors are to be protected as three phase type with motor protection switch or full thermistor protection against over loading.

The evaporators are to be arranged in a way that air ducting and air distribution are ensured under all loading conditions.

5.2.5 Heating rods and fan motors have to be easily replaceable.

5.3 Evaporator / water chiller

5.3.1 For chilled water systems an evaporator/water chiller has to be attached to each compressor unit.

5.3.2 For the use of additives to chilled water, e.g. antifreeze, attention has to be paid to the material compatibility. The influence on the thermal conductivity by chilled water additives has to be considered for the design of the heat exchange surface.

5.2.4 Water chillers have to be principally equipped with two antifreeze devices which safely avoid the freezing of the cooler. If antifreeze thermostats are used a sensor has to be located at the refrigerant injection of the chiller as well as at the chilled water side, see also I.2.3.

G. Pipes, Valves, Fittings and Pumps

1. Pipelines

1.1 Pipes for refrigerants and chilled water are to be designed in accordance with the rules defined in Section 8.

1.2 Pipes for refrigerant and chilled water have to be marked according to the respective flow medium.

1.3 When installing refrigerant pipes, care is to be taken to provide all pipes whose working temperatures are below the normal ambient temperatures with insulation in accordance with H. These pipes are to be protected externally against corrosion. Unless some other kind of corrosion protection has been demonstrated to TL to be likewise effective, steel pipes are to be galvanized on the outside.

1.4 At points where they are supported or pass through decks or bulkheads, the pipes mentioned in 1.3 may not come directly into contact with steel members of the ship's structure.

1.5 Where necessary, refrigerant pipes between compressors and condensers are to be protected against being inadvertently touched.

1.6 Refrigerant pipes, which have to run to other spaces, e.g. evaporators/ air coolers of air conditioning plants, and are leading through corridors and other spaces have to be provided with protection pipes (gas tight, if necessary double shell pipes). The protective pipes must be open to the refrigerating machinery spaces to enable blow-off of the refrigerant.

1.7 Refrigerant pipes have to run as much accessible as possible. Connections of refrigerant pipes have to be restricted to controllable locations.

1.8 Penetrations of pipelines through watertight bulkheads below the bulkhead deck have to be situated as much as possible amidships, but at least at a distance of 0,2 · **B** from the shell.

1.9 All shut-off valves at watertight penetrations have to be located in permanently accessible spaces. If in exceptional cases manually operated shut-off valves are located in lockable spaces they have to be equipped with remote control for operation at any time.

2. Fittings

2.1 Fittings for refrigerants as well as for chilled water and seawater have to meet the requirements of Section 8.

2.2 Automatic control valves have to be arranged or provided with a by-pass to be able to operate the system also manually.

3. Hose assemblies and compensators

Hose assemblies and compensators have to meet the requirements of Section 8, U.

4. Chilled and cooling water supply

4.1 Chilled water pumps

If only one water chiller is provided, at least two independent chilled water pumps have to be arranged for, one of them acting as stand by unit. For several water chillers one chilled water pump is sufficient for each system, assuming that one pump covers the complete cold water demand of the ship.

4.2 Cooling water supply for refrigerant condensers

4.2.1 General

Pipes, valves and fittings must comply with the requirements according to Section 8. Pipelines for seawater have to be manufactured from seawater resistant materials.

A constant condenser pressure has to be ensured by a suitable and automatic control of cooling water. Deviations therefrom need approval from the Naval Authority.

4.2.2 Cooling water pumps

The requirements defined in 4.1 are valid in analogous way.

4.2.3 Stand-by cooling water supply

Where the stand-by cooling water supply system of the refrigerating installation is connected to the cooling water system of the main propulsion plant, the stand-by cooling water pump specified in 4.1. may be dispensed with provided that the stand-by cooling water pump of the main propulsion plant is capable of the adequate supply of cooling water to the refrigerating installation without adversely affecting the operation of the main propulsion plant.

4.2.4 Suction lines

Each cooling water pump must be equipped with its own suction line and must be able to draw from at least two sea chests. Seawater filters are to be fitted and so arranged that they can be cleaned without interrupting the cooling water supply.

4.2.5 Dock operation

By suitable hose connections, measures shall be taken to ensure that, when necessary, the refrigerating installation can also be operated while the ship is docked.

H. Insulation of Pressure Vessels, Apparatus, Pipes, Valves and Fittings

1. All pressure vessels, apparatus, pipes, valves and fittings operating temperatures of which may drop below the ambient temperature at the points where they are installed, are to be provided with cold insula tion. Items of the plant which are accommodated in specially insulated refrigerating machinery spaces are exempted from this requirement.

2. Refrigerant and chilled water pipes which pass through uncooled spaces are to be insulated with special care and are to be installed so that they are protected from damage.

3. All air, sounding, thermometer and drain pipes in refrigerated and air-cooler spaces are to be adequately insulated.

4. Before being insulated, the items concerned are to be protected against corrosion.

5. Cold insulation is to be at least sufficiently thick to prevent condensation on its surface at a maximum relative humidity of 90 %.

6. The insulation is to be free from discontinuities and its final layer must be given a vapourtight coating.

7. Insulation is to be protected at points which are endangered by mechanical damage.

8. Insulating materials shall not be combustible and have to be approved by the Naval Authority. Not readily ignitable insulating materials may be approved if the basic construction and the cover consist of non-combustible materials.

I. Safety and Monitoring Equipment

1. Safety equipment

1.1 Pressure limiting device

1.1.1 Refrigerating plants have to be equipped with pressure limiting devices. Air-cooled systems with a filling weight of less than 10 kg are exempted from this requirement.

1.1.2 Pressure limiting devices of refrigerating plants have to be designed and adjusted in a way that an excess of the permissible working pressure by more than 10 % leads to shut down and locking of the refrigerant compressor. Re-start shall only be possible after manual reset.

1.2 Over pressure safety devices

1.2.1 Pressure vessels and apparatus which can be separated and which contain liquefied refrigerants must be equipped with a safety valve. It has to be ensured that safety valves cannot be made ineffective by shut-off valves. Shut-off valves fitted before safety valves are to be secured in the open position by a cap and are to be fitted with lead sealing.

1.2.2 Safety valves are to be set to the maximum allowable working pressure and to be secured against inadvertently alteration.

1.2.3 Fitting a rupture disc in front of a safety valve is permitted only where, between the rupture disc and the safety valve, no uncontrolled pressure build-up can occur which, in the event of a sudden pressure surge, would not allow either the safety valve or the rupture disc to respond.

The space between the rupture disc and the safety valve cone must therefore be fitted with an alarm pressure gauge or equivalent device. Instead of this a free outlet duct may be used, provided that it traverses oil-filled sight glasses or the like which reveal any leakage through the rupture disc.

A screen for the retention of broken fragments is to be fitted behind the rupture disc.

1.2.4 Where rupture discs are used, it has to be proven that the bursting pressure does not exceed the maximum allowable working pressure. The range of tolerance is 10 %.
Refrigerant which is blown off must be led directly and safely to the open air.

2. Monitoring equipment

2.1 Low pressure cut-out

Refrigerating plants have to be equipped with a low pressure cut-out which shut down the compressor in case of low condensing pressure. The use of combined high- and low pressure safety cut-out is permissible.

2.2 Oil pressure differential switch

Refrigerant compressors with pressure lubrication have to be equipped with oil pressure differential switches which are shutting-off and locking the compressor if the preset pressure difference between oil pressure and refrigerant suction pressure falls short. A possibility for manual reset has to be provided.

2.3 Thermostats for frost protection

Water chillers have to be equipped with thermostats, sensors of which are to be arranged near the cooler.
The thermostats have to be adjusted in a way that they trip before the freezing point of the refrigerating medium is reached. Thermostats for frost protection have to be lead sealed after adjusting the set value.

2.4 Flow indicators

In the chilled water circuits flow indicators have to be installed. They have to be interlocked with the control circuit of the refrigerant compressor. The start of the compressor shall only be possible if a chilled water flow is existing. Start-delay via a timing relay has to be provided.

2.5 Pressure gauges

2.5.1 Pressure and suction pipelines of the refrigerant compressors and medium pressure vessels as well as the lubricating oil pressure pipeline to the compressor have to be equipped with pressure gauges. For refrigerating plants of more than 100 kW refrigerating capacity pressure gauges have to be installed at the chilled water side before and after the water coolers.

2.5.2 Before each pressure gauge a manually operated shut-off valve has to be installed.

2.5.3 Pressure gauges for refrigerants have to be equipped with pressure and temperature scales for the actual type of refrigerant. The maximum allowable working pressure has to be marked with a red line.

2.6 Thermometers

2.6.1 Supply and return pipelines of chilled and seawater circuits have to be equipped with protective tube thermometers.

2.6.2 In each refrigerating space for provisions and cargo thermometers have to be installed at suitable positions. Outside the refrigeration spaces (lobby, passage way) additional remote thermometers have to be arranged which enable a central monitoring of the temperatures in the refrigerating spaces. An alarm is to be initiated in case the desired temperature inside refrigerating spaces is exceeded, see also 2.8.

2.7 Sight glasses

Refrigerant pipelines are to be fitted with easily visible sight glasses with humidity indicators.

2.8 Warning systems

2.8.1 Cold stores for provisions and cargo have to be equipped with visual and audible alarms which are initiated at a temperature increase of 6 K above the set value. The alarm has to be connected to a permanently manned station (MCC).

2.8.2 In refrigerating machinery spaces and at the suction side of the attached air circulating system a refrigerant warning device respectively the sensor thereof has to be installed. In case of refrigerant leakage the warning devices shall initiate a visual warning inside and outside the refrigerating machinery space. This requirement is valid for ships with NBC protection, where the ventilation of the ship in a far extent is provided by recirculated air and a monitoring of the refrigerating machinery spaces is necessary.

For ships without NBC protection refrigerant warning devices are not necessary.

2.9 Lock-in alarm

Refrigerating spaces have to be provided with an emergency call system which enables locked-in persons to attract attention. It must be possible to send an emergency call from each refrigerating space to a permanently manned station (MCC).

2.10 Operation and failure indication

2.10.1 If not defined otherwise, failure indicating lamps, signal lamps to show the operational status and, where necessary, measuring instruments have to be provided for the switchboard of each refrigerating plant.

2.10.2 For each refrigerating plant a summary failure indication has to be provided in the machinery control centre (MCC).

2.10.3 Illuminated indicators, switching devices, operating and monitoring positions are to be provided according to the rules in Chapter 105 - Electrical Installations, Section 9.

2.10.4 The functions and operating conditions shall be indicated according to Tables 12.3 and 12.4.

Table 12.3 Location of operating devices

Location of operation	
Locally	Damage control centre (DCC)
Switching-on and switching-off of the plant	Switching-on and switching-off of the plant Central emergency switching-off of the plants of each damage control area (main fire protection zone)

Table 12.4 Control and monitoring of operation

Location		
Locally	Machinery control centre (MCC)	Damage control centre (DCC)
Failure indicating lamp	Collective failure indication for each refrigerating plant	Signal lamps for indication of the operating status
Signal lamps for indication of the operation status, like defroster heating on/off, operation hour counter, etc.	Exceeding of threshold values at the different refrigerating spaces	

J. Refrigerating Devices

1. General

1.1 The requirements are destined for refrigerating/cooling devices such as the refrigerators, top opening and upright freezers used on board.

1.2 The devices have to be designed to meet the special requirements for operation on board, especially for vibrations.

1.3 Exclusively refrigerators and freezers, refrigerators for medical duties and deep freezing devices which are suitable for operation on board seagoing ships will be approved. Exceptions may be granted for refrigerators for mess-rooms and cabins.

1.4 Cooling devices must be lockable. Magnetic catches for refrigerators are not permissible, with the exception of refrigerators in mess-rooms and cabins, which are to be equipped additionally with a lockable closure.

1.5 Insulating materials for cooling devices are to be non-combustible according to DIN 4102, class A or equivalent. Not readily ignitable insulation materials analogous to DIN 4102 class B1 or equivalent may be approved, if protected with a non-combustible covering.

1.6 Condensers for cooling devices have to be designed for a maximum ambient temperature of + 43 °C. For the installation of a cooling device the heat leakage into the space of installation has to be considered.

1.7 Unrestricted operation of the cooling devices is to be ensured for maximum inclination of the ship as specified in Section 1, D., unless the definitions in the building specification are decisive.

1.8 For electromagnetic compatibility the requirements of Chapter 105 – Electrical Installations have to be applied.

1.9 Three phase drive motors are to be protected against overloading by motor protection switches or full thermistor protection.

1.10 Condensers for cooling devices have to be resilient mounted.

Cooling devices have to be connected to bulkheads, walls or decks and, where necessary, to be resiliently mounted.

2. Refrigerators

Horizontal type refrigerators (cooled sideboards) are to be installed below a given working table (table height) or the top of the refrigerator has to be fitted in height, form and design to the adjacent devices. The shipyard has to establish a coordination at an early stage and to inform the different subcontractors.

3. Refrigerators for medical duties

3.1 Refrigerators which are installed in the treatment and auxiliary rooms of the ship's hospital have to be explosion-proof. Deviations may be defined in the building specification if no explosive mixtures can be produced in the installation area.

3.2 The refrigerators have to be equipped with a safety lock and a remote thermometer.

3.3 The average temperature in the refrigerator has to be adjustable in the range of + 4 °C ± 1K. The evaporator shall be of ice cell type.

3.4 Refrigerators for medical duties are essential consumers and have to be electrically connected to the adequate consumer group (supply from two electrical power stations).

4. Top opening and upright freezers

4.1 Preferably top opening freezers have to be used. Top opening freezers with separate condenser unit are also approved.

4.2 Top opening freezers have to be equipped with remote thermometers.

4.3 The internal temperature of top opening freezers has to be adjustable in the temperature range of -18°C to -21°C.

K. Special Tools, Spare Parts

1. Special tools

If special tools have to be used for maintenance and repair of machinery and equipment, which are not part of the standard equipment of a ship, the shipyard and its subcontractors have to define and provide such tools.

2. Spare parts on board

The scope of spare parts and replacement fillings, etc. has to be agreed between Naval Authority and shipyard and is to be specified in the building specification.

L. Pressure and Tightness Tests

1. General

1.1 The testing in presence of a TL Surveyor has to be done for:

- refrigerant compressors
- pumps for refrigerants, cooling water and chilled water
- vessels and apparatus under refrigerant pressure
- finally installed refrigerating plants and compressor - condenser units

Tests of electric motors and switchboards see Chapter 105 - Electrical Installations, Section 16.

If additional type testing of compressor - condenser units is contractually agreed, the scope of the testing has to be agreed with TL.

Testing of components is generally to be carried out at the manufacturer's works.

1.2 Refrigerant compressors

After completion, refrigerant compressors are to be subjected to a trial run without refrigerant at the manufacturer's works and to the pressure and tightness tests specified in Table 12.5.

1.3 Pumps

Refrigerant, cooling and chilled water pumps are to be subjected to a hydrostatic pressure test as well as to a hydraulic performance test according to the TL Rules - Guidelines for the Design, Construction and Testing of Pumps.

1.4 Vessels and apparatus under refrigerant pressure

1.4.1 After completion, pressure vessels and apparatus under refrigerant pressure are to be subjected to the pressure and tightness tests specified below.

1.4.2 As a rule, pneumatic tightness tests are to be performed after the hydraulic pressure tests.

Exceptionally, TL may, on application, waive the hydraulic pressure test provided that a pneumatic pressure test is performed at the test pressure specified for the hydraulic test. National accident prevention regulations are to be complied with.

2. Test pressures

2.1 Components under refrigerant pressure

The test pressures to be used are specified in Table 12.5. According to the refrigerant used, HP is to be substituted by the design pressure on the high-pressure side and LP by the design pressure on the low-pressure side in accordance with Table 12.2.

2.2 Components under cooling water or chilled water pressure

The test pressures shown in Table 12.6 are to be applied.

Table 12.5 Test pressures for components under refrigerant pressure

Test	Item to be tested	Test pressure [bar] **(1)**	
		hydraulic	pneumatic
Prior to installation	Compressor (high-pressure side)	1,5 · HP	1 · HP
	Compressor (low-pressure side)	1,5 · LP	1 · LP
	Compressors with integrally cast cylinders and crankcase	1,5 · HP	1 · HP
	Motor compressors, assembled	-	1 · HP
	Refrigerant circulating pumps	1,5 · HP	1 · HP
	High-pressure vessels and apparatus	1,5 · HP	1 · HP
	Low-pressure vessels and apparatus	1,5 · LP	1 · LP
	Refrigerant valves and fittings (except automatic control valves)	1,5 · HP	1 · HP
Prior to start-up	Complete installations: High-pressure side Low-pressure side	-	1 · HP 1 · LP

(1) *Where the low-pressure side of the installation (LP) can be subjected to the pressure of the high-pressure side (HP) by operational switching, e.g. for defrosting with hot gas, the vessels and equipment involved are to be designed and tested at the pressures prescribed for the high-pressure side.*

Table 12.6 Test pressure for components under cooling water or brine pressure

Test	Item to be tested	Hydraulic test
Prior to installation	Cooling water spaces of machines and equipment, cooling water pumps	1,5 $p_{e, perm}$, minimum 4 bar
	Vessels and equipment on the pressure side of chilled water pumps, chilled water pumps	1,5 $p_{e, perm}$, minimum 4 bar
	Vessels and equipment on the suction side of chilled water pumps	1,5 $p_{e, perm}$, minimum $p_{e,perm}$ + 0,2 bar
Prior to start-up	Cooling water lines, valves and fittings	1,5 $p_{e, perm}$, minimum 4 bar
	Chilled water pipelines, valves and fittings (prior to insulation)	1,5 $p_{e, perm}$, minimum 4 bar

(1) *$p_{e, perm}$ = maximum allowable working pressure [bar]*

SECTION 13

AIRCRAFT HANDLING SYSTEMS

A. General

1. Scope

For ships executing flight operations and to which the Class Notation **FO** shall be assigned, the main elements of aircraft handling have to be included in the classification procedure. The overall aspects of such ships are dealt with in Chapter 102 - Hull Structures and Ship Equipment, Section 23.

The Naval Authority has to define the type of aircraft to be flown and up to which seaway condition the aircraft operation shall be possible.

2. Documents for approval

The following documentation has to be submitted for approval.

2.1 Helicopter handling

- general arrangement of flight deck including position of control stand for helicopter handling
- general arrangement of the rapid securing device
- general arrangement of transfer system
- details of the transfer track
- documentation on mechanical, electrical and hydraulic systems
- description of back up measures in case of failure of the main system

2.2 Hangar doors

- general arrangement of the hangar doors and their connection to the hangar structure
- details of door elements including strength calculations
- documentation on mechanical, electrical and hydraulic systems
- description of safety measures

2.3 Aircraft lifts

- general arrangement of the lift embedded in the ship's structure
- drawing of the construction of the lift platform including strength calculations
- drawing of the guiding tracks
- arrangement of railings on the lift platform, at deck and hangar
- details of railing drive
- documentation on mechanical, electrical and hydraulic systems of main lift drive
- further details on request

B. Helicopter Handling Systems

1. Tasks of the handling system

Helicopter handling systems on board of naval ships of limited size, like frigates, destroyers, etc., which have to endure considerable motions in rough seas, have to fulfil the following tasks:

- rapid securing of the helicopter at the landing deck immediately after landing and rapid releasing before starting
- moving the helicopter between the landing deck and the hanger or vice versa
- securing the helicopter at its parking place in the hanger
- transport of heavy weapons, like torpedoes, etc. from the hangar to the landing deck

2. General requirements

The design of the system shall consider the following requirements:

- the loads acting on the system are defined in Chapter 102 - Hull Structures and Ship Equipment, Section 5, H.3. The accelerations at the landing deck can be estimated by using the formulae defined in Chapter 102 - Hull Structures and Ship Equipment, Section 5, B.

- the system shall not create any obstructions on the landing deck or at least in the aiming circle

- the stationary elements of the system shall be concentrated in a separate space or at a convenient place in the hangar, from where also the local control of the system must be possible

- from a control stand or a portable control console the operator must be able to overlook the whole handling procedure. All commands to the system including emergency stop must be given to the system from this control device

- the accuracy of the system must be especially high in the range of the hangar door

3. Fully automatic systems

Fully automatic systems have to fulfil additionally the following requirements:

- guiding down of the helicopter to the landing position and rapidly anchoring it against slipping and overturning without manual assistance, up to seaway conditions defined by the Naval Authority

- rapid securing of the helicopters with a claw and grid system, a robot arm, etc.

- the surface of the track shall be flush with the deck surface. It is recommended to manufacture the track of stainless steel and to pay special attention to avoid foreign matters getting into it. Therefore it will be of advantage to cover the top slot with a stainless spring steel band. The track has to be drained.

- if any element of the system fails, e.g. if wire ropes or chains break, the operation must stop and the helicopter be secured in its momentary position

- back up means shall be provided for the securing, aligning and travelling of the helicopter in the event of electrical and/or hydraulic failures

4. Manual or half automatic systems

4.1 Manual or half automatic systems are systems where an operating crew on the flight deck is needed. Such systems may also be a combination of a rapid securing device and a wire rope transfer system without rails on the flight deck.

4.2 The following requirements have to be met:

- fail safe mechanical brakes shall be fitted to the winch system to secure the helicopter in case of a power failure

- if deemed appropriate to use the system for increased seaway conditions a five-wire rope system with restraining rails is recommended to reduce deviations from the intended transfer track

- to optimize the coordinated action of the wire ropes, the winch should be computer controlled and the rope tension should consider the ship's motions

Note

If no other information is available the operational limits for the different levels of manual and half automatic systems may be defined as follows:

- *manual transfer with lashings and wheel taper keys:*
  rolling: ± 4° pitching: ± 1°

- *three-wire system:*
  rolling: ± 7° pitching: ±2°

- *five-wire system: rolling:*
  rolling: ± 10° pitching: ± 2°

5. Hangar Doors

The handling system will be tested with the biggest helicopter operated, full loaded in the harbour (HAT) and during the trials (SAT) in presence of a **TL** Surveyor. All different steps of the handling procedure have to be demonstrated.

C. Special Requirements for Drone Handling

1. Handling Requirements

The handling requirements depend very much on size and weight of the drone.

2. Big drones

For drones of a size near to a light helicopter which are equipped with wheels the handling may be organized as defined in B.

3. Medium sized drones

3.1 For other, medium sized drones without wheels it has to be ensured that the drone can be safely transferred from the drone hangar to the starting/ landing areas and vice versa.

3.2 Transport platform

3.2.1 For the requirements according to 3.1 it might be favourable to introduce a movable transport platform of reasonable size from where the drone can start and land and which can be transfered with the drone into the hangar.

3.2.2 The drone has always to be fixed with its legs to the platform and the connection shall only be opened after running warm and immediately before the start. Opening and closing of the leg connection has to be possible for all legs simultaneously.

3.2.3 The transport platform should be equipped with small wheels and permanently be connected to glide bearings within deck slots (or within a guiding construction bolted to the deck, if no occasional helicopter landings are planned on this deck) leading from the open start/landing area to the storage, maintenance and refuelling location in the drone hangar. It will be recommendable to cover such a slot with a stainless spring steel band.

The movement of this platform may be done manually by the crew, but at the locations in the hangar and outside for starting/landing the platform is to be safely locked. If the movement is established mechanically, e.g. by pulling rope and winch or by a rack and pinion system, limit switches and locking devices are to be provided at the end positions of this movement. In case of mechanical drive an emergency operation is to be made possible.

3.2.4 If the platform is designed also as turntable, several useful positions around the circumference are to be locked safely.

4. Small drones

Small drones may be handled manually by several crew members. But also for such drones the storage/ maintenance/re-fuelling location inside the hangar has to be equipped with a safe fixing of the drone to the ship during all its thinkable movements.

5. Other solutions

Other solutions achieving the demonstrated requirements for drone handling in different ways may be presented and have to be agreed by TL.

D. Hangar Doors

1. Size of hangar doors

The width of the hangar door shall enable to transfer aircraft according to A.1., at least in wing or rotor folded condition, into the hangar, including at both sides a means of escape of at least 0,6 m. If helicopter handling is not executed by a rail tracked system, compare B., the movement tolerances of the system considered have to be added to this width.

The height of the door has to enable safe aircraft handling and should include a tolerance of 0,3 m as a minimum for the highest aircraft.

2. Door construction

2.1 The door must be able to withstand wind loads as well as forces from green water on deck.

2.2 The door shall be weathertight. If the hangar is part of the citadel, the door must be able to keep the slightly increased pressure inside, compare Section 11, C. In addition, the door should also hinder any light to penetrate from the hangar to the outside .

2.3 The door has to be provided with thermal insulation. According to the operation area of the naval ship, a de-icing system may be necessary.

2.4 A coverable bulleye / window in suitable height shall be provided. It has to be checked if also an emergency door as a means for escape has to be provided within the hangar door, or if such a door can be arranged in a hangar wall for reaching the open deck.

3. Door drive

3.1 For opening and closing the door a main drive and an independent emergency drive have to be provided. When the emergency drive is in operation, the main drive must be interlocked. The emergency drive may be manually driven. The time limits for opening and closing the door for each drive system are to be defined by the Naval Authority and have to be met.

Note

For normal operation closing or opening should be possible in abt. 1 minute. With the emergency drive closing should be possible in abt. 2 min, opening (even with manual drive) should not take longer than 10-15 min.

3.2 The control of the door drive must be possi ble from outside the hangar as well as from inside. An emergency button has to be provided inside and out side at an easily noticeable position.

3.3 If the drive fails, e.g. when wire ropes break, etc. a safety device must prevent the door from further closing or uncontrolled opening.

E. Flight Deck Lifts

1. The loads with the heaviest aircraft and eventually arising from secondary tasks, like transport of vehicles of embarked troops, as well as the proposed stowage arrangements on the lift platform have to be defined by the Naval Authority. The assumed dimensioning loads on the lift platform have to consider the increase due to ship motion as well as acceleration or deceleration during the lift movement.

2. The scantlings and structural arrangements are not to be less as required by the rules for the supporting or surrounding structure of the lift. When transferring the aircraft to and from the lift, the deflection of the platform edge shall be less than 25 mm.

3. The alignment of the lift to the flight and hangar deck is to be provided by holders to be engaged at the stops. If shock resistance is asked for by the Naval Authority, latches are to be provided at the stops to restrain the platform when stationary.

4. At the deck and hangar boundaries of the lift, as well as on the lift platform itself, raiseable and lowerable railings have to be activated before the lift starts to move. In the lowered position the top part of the railing must be flush with deck and platform. If a part of the lift is the outer side of the flight deck, a hinged railing with protective network as defined in Chapter 102 - Hull Structures and Ship Equipment, Section 23, B.5.4 has to be provided at the outer sides.

5. Further requirements concerning mechanical, electrical and safety equipment of the lift are defined in Section 3, D.

SECTION 14

HYDRAULIC SYSTEMS

A. General

1. Scope

The requirements contained in this Section apply to hydraulic systems used, such as closing appliances in the ship's shell, bulkheads, hatch covers and hoists. The requirements are to be applied in analogous manner to the ship's other hydraulic systems. For pipes, valves and pumps Section 8 shall be considered in addition, as far as necessary.

2. Documents for approval

The diagram of the hydraulic system together with drawings of the cylinders containing all the data necessary for assessing the system, e.g. operating data, descriptions, materials used, etc., are to be submitted for approval in triplicate.

3. Design

3.1 For the design of pressure vessels, see Section 16; for the dimensions of pipes and hose assemblies, see Section 8.

3.2 The hydraulic fluids must be suitable for the intended ambient and service temperatures.

4. Materials

4.1 Approved materials

4.1.1 Components fulfilling a major function in the power transmission system shall normally be made of steel or cast steel in accordance with the TL Rules Chapter 2 – Materials. The use of other materials is subject to special agreement with TL.

Cylinders are preferably to be made of steel, cast steel or nodular cast iron with a predominantly ferritic matrix.

4.1.2 Pipes are to be made of seamless or longitudinally welded steel tubes.

4.1.3 The pressure-loaded walls of valves, fittings, pumps, motors, etc. are subject to the requirements of Section 8, B.

4.2 The materials used for pressurized components including the seals must be suitable for the hydraulic oil in use.

4.3 Testing of materials

The following components are to be tested under supervision of TL in accordance with TL Rules Chapter 2 - Materials:

- pressure pipes with nominal diameter D_N > 32, see Section 8, Table 8.3

  cylinders, where the product of the pressure times the diameter:

  $p \cdot D > 20\,000$

  p = maximum allowable working pressure [bar]

  D_i = inside diameter of tube [mm].

For testing the materials of hydraulic accumulators see Section 16, B.

Testing of materials by TL may be dispensed with in the case of cylinders for secondary applications, provided that evidence by a works test certificate, e.g. to EN 10204-2.3, is supplied.

B. Hydraulic Equipment for Hatch Covers

1. Scope

The following requirements apply to hydraulic power equipment for opening and closing of hatch covers described in Chapter 102 - Hull Structures and Ship Equipment, Section 14, D.

2. Design and construction

2.1 Hydraulic operating equipment for hatch covers may be served either by one common power station for all hatch covers or by several power stations individually assigned to a single hatch cover. Where a common power station is used, at least two pump units are to be fitted. Where the systems are supplied individually, change-over valves or fittings are required so that operation can be maintained should one power station fail.

2.2 Movement of hatch covers may not be initiated merely by starting the pumps. Special control stations are to be provided for controlling the opening and closing of hatch covers. The controls are to be so designed that, as soon as they are released, movement of the hatch covers stops immediately.

The hatches should normally be visible from the control stations. Should this, in exceptional cases, be impossible, opening and closing of the hatches is to be signalled by an audible alarm. In addition, the control stations must be equipped with indicators for monitoring the movement of the hatch covers.

At the control stations, the controls governing the opening and closing operations are to be appropriately marked.

2.3 Suitable equipment must be fitted in or immediately adjacent to each power unit (cylinder or similar) to enable the hatches to be closed slowly in the event of a power failure, e.g. due to a pipe rupture.

3. Pipes

3.1 Pipes are to be installed and secured in such a way as to protect them from damage while enabling them to be properly maintained from outside.

Pipes may be led through tanks in pipe tunnels only. The laying of such pipes through spaces for military supplies is to be restricted to the unavoidable minimum. The piping system is to be fitted with relief valves to limit the pressure to the maximum allowable working pressure.

3.2 The piping system is to be fitted with filters for cleaning the hydraulic fluid.
Equipment is to be provided to enable the hydraulic system to be vented.

3.3 The oil storage space of the hydraulic accumulator must have permanent access to the relief valve of the connected system. The gas chamber of the accumulator may be filled only with inert gases. Gas and operating medium are to be separated by accumulator bags, diaphragms or similar.

3.4 Connection between the hydraulic system used for hatch cover operation and other hydraulic systems is permitted only with the consent of TL.

3.5 Tanks being part of the hydraulic system are to be fitted with oil level indicators.

4. Hose assemblies

The construction of hose assemblies shall be according to Section 8, U. The requirement that hose assemblies should be of flame-resistant construction may be dispensed with for hose lines in spaces not subject to a fire hazard and in systems not important to the safety of the ship.

5. Emergency operation

It is recommended that devices be fitted which are independent of the main system and which enable hatch covers to be opened and closed in the event of failure of the main system.

C. Hydraulic Equipment for Closing Appliances in the Ship's Shell

1. Scope

The following requirements apply to the power equipment of hydraulically operated closing appliances in the ship's shell such as shell and landing doors which normally are not operated while at sea. For the design and arrangement of the closures, see Chapter 102 - Hull Structures and Ship Equipment, Section 22, B. and C.

2. Design and construction

2.1 The movement of shell doors etc. may not be initiated merely by the starting of the pumps at the power station.

2.2 Local control, inaccessible to unauthorized persons, is to be provided for every closing appliance.

As soon as the controls such as push-buttons, levers or similar are released, movement of the appliance must stop immediately.

2.3 Closing appliances in the ship's shell should normally be visible from the control stations. If the movement cannot be observed, audible alarms are to be arranged. In addition, the control stations are to be equipped with indicators enabling monitoring of the movement.

2.4 Closing appliances in the ship's shell are to be fitted with devices which prevent them from moving into their end positions at excessive speed. Such de vices shall not cause the power unit to be switched off.

As far as is required, mechanical means must be provided for locking closing appliances in the open position.

2.5 Every power unit driving horizontally hinged or vertically operated closing appliances is to be fitted with throttle valves or similar devices to prevent sudden dropping of the closing appliance.

2.6 It is recommended that the driving power be shared between at least two independent pump sets.

3. Pipes, hose assemblies

B.3. and B.4. are to be applied in analogous manner to the pipes and hose lines of hydraulically operated closing appliances.

D. Hydraulic Equipment for Bulkhead Closures

1. Scope

1.1 The following requirements apply to the power equipment of hydraulically-operated watertight bulkhead doors.

1.2 For details regarding the number, design and arrangement of bulkhead doors, see Chapter 102 – Hull Structures and Ship Equipment, Section 11.

2. Design

Bulkhead doors shall be power-driven sliding doors moving horizontally. Other designs require the approval of TL and the provision of additional safety measures where necessary.

3. Piping

Wherever applicable, the pipes in hydraulic bulkhead closing systems are governed by the Rules in B.3., whereby the use of flexible hoses is not permitted.

4. Drive unit

4.1 A selector switch with the switch positions "local control" and "close all doors" is to be provided at the central control station on the bridge.

Under normal conditions this switch should be set to "local control".

In the "local control" position, the doors may be locally opened and closed without automatic closure.

In the "close all doors" position, all doors are closed automatically. They may be reopened by means of the local control device but must close again automatically as soon as the local door controls are released.

It shall not be possible to open the closed doors from the bridge.

4.2 Closed or open bulkhead doors shall not be actuated automatically in the event of a power failure.

4.3 The control system is to be designed in such a way that an individual fault inside the control system, including the piping, does not have any adverse effect on the operation of other bulkhead doors.

4.4 The controls for the power drive are to be located at least 1,6 m above the floor on both sides of the bulkhead close to the door. The controls are to be installed in such a way that a person passing through the door is able to hold both controls in the open position.

The controls must return to their original position automatically when released.

4.5 The direction of movement of the controls is to be clearly marked and must be the same as the direction of movement of the door.

4.6 Where an individual element fails inside the control system for the power drive, including the piping, but excluding the closing cylinders on the door or similar components, the manually-operated control system must not be impaired.

4.7 The movement of the power driven bulkhead doors may not be initiated simply by switching on the drive units but only by actuating additional devices.

4.8 The control and monitoring equipment for the drive units is to be housed in the central control station on the bridge, respectively in the damage control centre (DCC).

5. Manual control

5.1 Each door must have a manual control system which is independent of the power drive.

5.2 The manual control must be capable of being operated at the door from both sides of the bulkhead.

5.3 The controls must allow the door to be operated in both directions.

6. Indicators

Visual indicators to show whether each bulkhead door is fully open or closed are to be installed at the central control station on the bridge.

7. Electrical equipment

For details of electrical equipment, see Chapter 105 - Electrical Installations, Sections 9, C. and 14.

8. Alarms

Whilst all the doors are being closed from the central control station, an audible alarm must be sounded.

E. Hydraulic Equipment for Hoists

1. Scope

For the purposes of the requirements in E., hoists include hydraulically operated appliances such as lifts and similar equipment. For the mechanical part, see Section 3.

2. Design and construction

2.1 Hoists may be supplied either by a combined power station or individually by several power stations.

In case of a combined power supply and of hydraulic drives whose piping system is connected to other hydraulic systems, a second pump unit is to be fitted.

2.2 The movement of hoists shall not be capable of being initiated merely by starting the pumps. The movement of hoists is to be controlled from special operating stations. The controls are to be so arranged that, as soon as they are released, the movement of the hoist stops.

2.3 Local controls, inaccessible to unauthorized persons, are to be fitted. The movement of hoists should normally be visible from the operating stations. If the movement cannot be observed, audible and/or visual warning devices are to be fitted. In addition, the operating stations are to be equipped with indicators for monitoring the movement.

2.4 Devices are to be fitted which prevent the hoist from reaching its end position at excessive speed. These devices are not to cause the power unit to be switched off. As far as necessary, mechanical means must be provided for locking the hoist in its end positions.

If the locking devices cannot be observed from the operating station, a visual indicator is to be installed at the operating station to show the locking status.

2.5 B.2.3 is to be applied in analogous manner to those devices which, if the power unit fails or a pipe ruptures, ensure that the hoist is slowly lowered.

3. Pipes, hose assemblies

B.3. and B.4. apply in analogous manner to the pipes and hose lines of hydraulically operated hoists.

F. Tests and Trials

1. Tests in the manufacturer's factory (FAT)

1.1 Testing of power units

The power units are required to undergo testing on a test bed. Factory test certificates for this testing are to be presented at the final inspection of the hydraulic system.

1.2 Pressure and tightness tests

Pressure components are to undergo a pressure test. The test pressure is p_c

p_c = $1{,}5 \cdot p$ [bar]

p = maximum allowable working pressure [bar] or the pressure at which the relief valves open. However, for working pressures above 200 bar the test pressure need not exceed p + 100 bar.

For pressure testing of pipes, their valves and fittings, see Section 8, B.4. and U.6.

Tightness tests are to be performed on components to which this is appropriate at the discretion of the TL Surveyor.

2. Shipboard trials (SAT)

After installation on board, the equipment is to undergo an operational test.

The operational test of watertight doors has to include the emergency operating system and determination of the closing times.

G. Hydraulic Equipment for Stabilizers

1. General

1.1 Scope

The requirements contained in G. apply to hydraulic stabilizer drive units necessary for the operation and safety of the ship. For the mechanical part, see Section 2,B.

1.2 Documents for approval

Diagrams of the hydraulic equipment containing all the data necessary for checking are to be submitted in triplicate for approval.

2. Design and construction

2.1 The pipes of hydraulic systems are to be made of seamless or longitudinally welded steel tubes.

The use of cold-drawn, unannealed tubes is not permitted.

At points where they are exposed to danger, copper pipes for control lines are to be provided with protective shielding instead of steel tubes. In case that copper pipes are used for control purposes they have to be shielded by steel protection. Such pipes shall be protected against vibration by suitable mounts.

2.2 High-pressure hose assemblies may be used for short pipe connections subject to compliance with Section 8, U., if this is necessary due to vibrations or flexibly mounted units.

3. Pressure and tightness test

F.1 .2 is applicable in analogous manner,

4. Shipboard trials

The operational efficiency of the stabilizer equipment is to be demonstrated during the sea trials.

SECTION 15

AUXILIARY STEAM BOILERS

A. General

1. Scope

1.1 For the purpose of these requirements, the term "boiler" includes all closed vessels and piping systems used for:

- Generating steam at a pressure above atmospheric pressure (steam generators)

- Raising the temperature of water above the boiling point corresponding to atmospheric pressure (hot water generators)

The term "steam generator" also includes any equipment directly connected to the aforementioned vessels or piping systems in which the steam is superheated or cooled, external drums, the circulating lines and the casings of circulating pumps serving forced-circulation boilers.

1.2 For hot water generators with a permissible discharge temperature of not more than 120 °C and all systems incorporating steam or hot water generators which are heated solely by steam or hot liquids Section 16 applies regarding materials, design calculations and manufacturing principles. For equipment and testing G. applies.

2. Other requirements

As regards their construction, equipment and operation, steam boiler plants are also required to comply with the applicable national regulations.

3. Documents for approval

Drawings of all boiler parts subject to pressure, such as drums, headers, tubes, manholes and inspection covers etc., are to be submitted to TL in triplicate. These drawings must contain all the data necessary for strength calculations and design assessment, such as working pressures, superheated steam temperatures, materials to be used and full details of welds including filler materials.

Details and drawings are also to be submitted covering the valves and fittings and their arrangement together with a description of the boiler plant specifying the arrangement of the boiler with reference to the ship's longitudinal axis, the essential boiler data and equipment items, e.g. steam conditions, heating surfaces, allowable steam output, feed, firing system, safety valves, controllers and limiters.

4.1 Steam boiler walls

Steam boiler walls are the walls of the steam and water spaces located between the boiler isolating devices. The bodies of these isolating devices are part of the boiler walls.

4.2 Maximum allowable working pressure

The maximum allowable working pressure PB is the approved steam pressure in bar (gauge pressure) in the saturated steam space prior to entry into the superheater. In once-through forced flow boilers, the maximum allowable working pressure is the pressure at the superheater outlet or, in the case of continuous flow boilers without a superheater, the steam pressure at the steam generator outlet.

4.3 Heating surface

The heating surface is that part of the boiler walls through which heat is supplied to the system, i.e.:

- the area [m^2] measured on the side exposed to fire or exhaust gas

- in the case of electrical heating, the equivalent heating surface

$$H = \frac{P \cdot 860}{18000} \quad \left[m^2\right]$$

P = electric power [kW]

4.4 Allowable steam output

The allowable steam output is the maximum quantity of steam which can be produced continuously by the steam generator operating under the design steam conditions.

5. Lowest water level - highest flue - dropping time

5.1 The highest flue is the highest point of the heating surface on the side which is in contact with the water and is exposed to the flame radiation, or which is heated by gases of which temperature exceeds 400 °C at maximum continuous power. The highest flue on water tube boilers with an upper steam drum is the top edge of the highest gravity tubes.

5.2 The requirements relating to the highest flue do not apply to

- water tube boiler risers up to an outer diameter of 102 mm
- once-through forced flow boilers
- super heaters
- flues and exhaust gas heated parts in which the temperature of the heating gases does not exceed 400 °C at maximum continuous power

5.3 The lowest water level must lie at least 150 mm above the highest flue even if the ship heels 4° to either side. Heated surfaces with a specified highest flue must remain wetted even at the static heeling angles of the ship laid down in Section 1, D., Table 1.1. The set point of the low water level limiter is crucial for the height of the water level.

5.4 The heat accumulated in furnaces and other heated boiler parts may not lead to any undue lower ing of the water level due to subsequent evaporation when the firing system is switched off.

The lowest water level is to be set so that the dropping time is not less than 5 minutes.

5.5 The "dropping time" is the time to drop the water level from the lowest water level to the level of the highest flue under the condition of interrupted feed and allowable steam output.

$$T = \frac{60 \cdot V}{D \cdot v'} \quad [\min]$$

T = dropping time

V = volume of water in steam boiler between the lowest water level and the highest flue [m^3]

D = allowable steam output [kg/h]

v' = specific volume of water at saturation temperature [m^3/kg]

5.6 The lowest specified water level is to be indicated permanently on the boiler shell by means of a water level pointer. Reference plates are to be attached additionally beside or behind the water level gauges pointing at the lowest water level.

6. Manual operation

6.1 A facility is to be provided for manual operation. At least the water level limiters must remain active even in manual operation.

6.2 Manual operation demands permanent and direct supervision of the system.

6.3 For detailed requirements in respect of manual operation of the firing system see Section 17.

B. Materials

1. General requirements

Materials for steam boilers have to satisfy special technical requirements, i.e. during manufacturing their workability and good weldability will be needed, for the subsequent operation of the boiler particularly high-temperature strength has to be ensured.

2. Approved materials

If the materials defined in Table 15.1 are used, the requirements specified in 1. are recognized as having been complied with.

For materials which are not defined in this Table manufacturers have to proof suitability for steam boilers and adequate mechanical properties of the chosen material to TL.

3. Material testing

3.1 The materials of boiler parts subject to pres sure, including flue gas economizer tubes, must be tested by TL in accordance with the TL Rules Chapter 2 - Materials and Welding, cf. Table 15.1.

Material testing by TL may be waived in the case of:

- small boiler parts made of unalloyed steels, such as stay bolts, stays of < 100 mm diameter, reinforcing plates, handhole and manhole closures, forged flanges up to a nominal diameter DN 150 and branch pipes up to DN 150

- smoke tubes (tubes subject to external pressure)

The properties of these materials are to be attested by material certificates in accordance with EN 10 204 3.1. B.

3.2 Special agreements may be made regarding the testing of unalloyed steels to recognized standards.

3.3 The materials of valves and fittings must be tested by TL in accordance with the data specified in Table 15.2 for allowable working pressure PB and nominal diameters DN.

3.4 Parts not subject to material testing, such as external supports, lifting brackets, pedestals, etc. must be designed for the intended purpose and must be made of suitable materials.

C. Principles Applicable to Manufacture

1. Manufacturing processes applied to boiler materials

Materials are to be checked for defects during the manufacturing process. Care is to be taken to ensure that different materials cannot be confused. During the course of manufacture care is likewise required to ensure that marks and inspection stamps on the materials remain intact or are transferred in the prescribed manner.

Boiler parts whose structure has been adversely affected by hot or cold forming are to be subjected to heat treatment in accordance with TL Rules Chapter 2 - Materials, Section 8, A.

2. Welding

Boilers are to be manufactured by welding. The execution of welds, the approval of welding shops and the qualification testing of welders are to be in accordance with TL Rules Welding in the Various Fields of Application,

3. Tube expansion

Tube holes must be carefully drilled and deburred. Sharp edges are to be chamfered. Tube holes should be as close as possible to the radial direction, particularly in the case of small wall thicknesses.

Tube ends to be expanded are to be cleaned and checked for size and possible defects. Where necessary, tube ends are to be annealed before being expanded.

Smoke tubes with welded connection between tube and tube plate at the entry of the second path shall be roller expanded before and after welding.

Table 15.1 Approved materials

Materials semi finished materials products	Limits of application	Material grades in accordance with the Rules for Classification and Construction Chapter 2 - Materials, Section 3-6
Steel plates and steel strips	-	Plates and strips of high-temperature steels according to Chapter 2, Section 3, E.
Steel pipes	-	Seamless and welded pipes and ferritic steels according to Chapter 2, Section 4, B. and C.
Forgings and formed parts: a) drums, headers and similar hollow components without longitudinal seam b) covers, flanges, branch pipes, end plates	-	Forgings for boilers, vessels and pipelines according to Chapter 2, Section 5, E. Formed and pressed parts according to Chapter 2 Section 6, A. and B.
Nuts and bolts	-	Fasteners according to Chapter 2, Section 8, C. High-temperature bolts according to DIN 17 240
	t ≤ 300 °C PR ≤ 40 bar ≤ M30	DIN 267, Parts 3 and 4 or equivalent standards
Steel castings	-	Cast steel for boilers, pressure vessels and pipelines according to Chapter 2, Section 6 D.
	t ≤ 300 °C	Also GS 38 and GS 45 to DIN 1681 and GS 16 Mn5 and GS 20 Mn5 acc. to DIN 17 182
Nodular cast iron	t ≤ 300 °C PR ≤ 40 bar for valves and fittings DN ≤ 175	Nodular cast iron according to Chapter 2, Section 7 B.
Lamellar (grey) cast iron: a) Boiler parts (only for unheated surfaces) b) Valves and fittings (except valves subject to dynamic stresss)	t ≤ 200 °C PR ≤ 10 bar ≤ 200 mm diameter t ≤ 200 °C PR ≤ 10 bar DN ≤ 175	Grey cast iron according to Chapter 2, Section 7 C.
Valves and fittings of cast copper alloys	t ≤ 225 °C PR ≤ 25 bar	Cast copper alloys according to Chapter 3, Section 10, B.

t = design temperature   PR = design pressure   DN = nominal diameter

Table 15.2 Testing of materials for valves and fittings

Type of material **(1)**	Service temperature m	Testing required for: PB [bar] DN [mm]
Steel, cast steel	>300	DN>32
Steel, cast steel, nodular cast iron	≤300	PB · DN > 2500**(2)** or DN > 250
Copper alloys	≤225	PB · DN>1500 **(2)**

(1) *no test is required for grey cast iron*
(2) *testing may be dispensed with if DN is < 32 mm*
DN = nominal diameter

4. Stays, stay tubes and stay bolts

4.1 Stays, stay tubes and stay bolts are to be so arranged that they are not subjected to undue bending or shear forces.

Stress concentrations at changes in cross-section, in threads and at welds are to be minimized by suitable component geometry.

4.2 Stays and stay bolts are to be welded preferably by full penetration. Possible stresses due to vibration of long stays have to be considered.

4.3 Stays are to be drilled at both ends in such a way that the holes extend at least 25 mm into the water or steam space. Where the ends have been upset, the continuous shank must be drilled to a distance of at least 25 mm.

4.4 Wherever possible, the angle formed by gusset stays and the longitudinal axis of the boiler shall not exceed 30 °. Stress concentrations at the welds of gusset stays are to be minimized by suitable component geometry. Welds are to be executed as full penetration welds. In firetube boilers, gusset stays are to be located at least 200 mm from the firetube.

4.5 Where flat surfaces exposed to flames are stiffened by stay bolts, the distance between centres of these bolts shall not exceed 200 mm.

5. Stiffeners, straps and lifting eyes

5.1 Where flat end surfaces are stiffened by profile sections or ribs, the latter shall transmit their load directly, i.e. without welded-on straps, to the boiler shell.

5.2 Doubling plates may not be fitted at parts under pressure subject to flame radiation.

Where necessary to protect the walls of the boiler, strengthening plates are to be fitted below supports and lifting brackets.

6. Welding of flat unrimmed ends to boiler shells

Flat unrimmed ends (disc ends) on shell boilers are only permitted as socket-welded ends with a shell projection of ≥ 15 mm, see Fig. 15.14. The end/shell wall thickness ratio S_B/S_M shall not be greater than 1,8. The end is to be welded to the shell by a full penetration weld.

7. Standpipes and flanges

Standpipes and flanges are to be of rugged design and properly welded to the shell. The wall thickness of nozzles must be sufficiently large to safely withstand additional external loads. The wall thickness of welded-in nozzles shall be appropriate to the wall thickness of the part into which they are welded.

Welding-neck flanges must be made of forged material with favourable grain orientation.

8.1 Steam boilers are to be provided with openings through which the internal space can be cleaned and inspected. Especially critical and high-stressed welds, parts subjected to flame radiation and areas of varying water level shall be sufficiently accessible for inspection. Boiler vessels with an inside diameter of more than 1200 mm, and those measuring over 800 mm in diameter and 2000 mm in length are to be provided with means of access.

Parts inside drums must not obstruct inner inspection or must be capable of being removed.

8.2 Inspection and access openings are required to have the following minimum dimensions:

Manholes	300 x 400 mm or 400 mm diameter; where the annular height is > 150 mm the opening shall be 320 x 420 mm
Headholes	220 x 320 mm or 320 mm diameter
Handholes	87 x 103 mm
Sightholes	diameter of at least 50 mm; they should, however, be provided only where the design of the equipment makes a handhole impracticable.

8.3 The edges of manholes and other openings, e. g. for domes, are to be effectively reinforced if the plate has been inadmissible weakened by the cutouts. The edges of openings closed with covers are to be reinforced by flanging or by welding on edge stiffeners if it is likely that the tightening of the crossbars etc. would otherwise cause undue distortion of the edge of the opening.

8.4 Cover plates, manhole frames and crossbars must be made of ductile material (not grey or malleable cast iron). Grey cast iron (at least GG-20) may be used for handhole cover crossbars of headers and sectional headers, provided that the crossbars are not located in the heating gas flow. Unless metal packings are used, cover plates must be provided on the external side with a rim or spigot to prevent the packing from being forced out. The gap between this rim or spigot and the edge of the opening is to be uniform around the periphery and may not exceed 2 mm for boilers with a working pressure of less than 32 bar, or 1 mm where the pressure is 32 bar or over. The height of the rim or spigot must be at least 5 mm greater than the thickness of the packing.

8.5 Only continuous rings may be used as pack ing. The materials used must be suitable for the given operating conditions.

9. Boiler drums, shell sections, headers and firetubes

For welding of boiler drums, shell sections, headers and fire tubes see the TL Rules - Welding in the Various Fields of Application, Section 2.

D. Design Calculation

1. Design principles

1.1 Range of applicability of design formulae

1.1.1 The following strength calculations represent the minimum requirements for normal operating conditions with mainly static loading. Separate allowance must be made for additional forces and moments of significant magnitude.

1.1.2 The wall thicknesses arrived at by applying the formulae are the minima required. The undersize tolerances permitted in TL Rules Chapter 2 and 3 - Materials and Welding are to be added to the calculated values.

The greater undersize tolerances for tubes which are only localized, need not to be considered.

1.2 Design pressure PR [bar]
Formula symbol: p_c

1.2.1 The design pressure is to be at least the maximum allowable working pressure. Additional allowance is to be made for static pressures of more than 0,5 bar.

1.2.2 In designing once-through forced flow boilers, the pressure to be applied is the maximum working pressure anticipated in main boiler sections at maximum allowable continuous load.

1.2.3 The design pressure applicable to the superheated steam lines from the boiler is the maximum working pressure which safety valves prevent from being exceeded.

1.2.4 In the case of boiler parts which are subject in operation to both internal and external pressure, e. g. attemporators in boiler drums, the design may be based on the differential pressure, provided that it is certain that in service both pressures will invariably occur simultaneously. However, the design pressure of these parts is to be at least 17 bar. The design is also required to take account of the loads imposed during the hydrostatic pressure test.

1.3 Design temperature t

Strength calculations are based on the temperature at the centre of the wall thickness of the component in question. The design temperature is made up of the reference temperature and a temperature addition in accordance with Table 15.3. The minimum value is to be taken as 250 °C.

Table 15.3 Addition for design temperatures

Reference temperature	Addition		
	Unheated parts	Heated parts, heated mainly by	
		contact	radiation
Saturation temperature at PB	0°C	25 °C	50 °C
Super-heated steam temperature	15 °C **(1)**	35 °C	50 °C

(1) *the temperature allowance may be reduced to 7 °C provided that special measures are taken to ensure that the design temperature cannot be exceeded*

1.4 Allowable stress

The design of structural components is to be based on the allowable stress σ_{perm} [N/mm^2]. In each case, the minimum value deduced from the following relations is applicable:

1.4.1 Rolled and forged steels

Design temperature ≤ 350 °C:

$$\frac{R_{m,20°}}{2,7} \qquad \frac{R_{eH,t}}{1,6}$$

$R_{m,20°}$ = guaranteed minimum tensile strength at room temperature [N/mm^2]

$R_{eH,t}$ = guaranteed minimum yield stress at design temperature t [N/mm^2]

Design temperature > 350 °C:

$$\frac{R_{m,100000,t}}{1,5}$$

$R_{m,100000,t}$ = average breaking strength after 100000 h of operation at design temperature t [N/mm^2]

1.4.2 Cast materials

a) Cast steel: $\frac{R_{m,20°}}{3,2}$; $\frac{R_{eH,t}}{2,0}$; $\frac{R_{m,100000,t}}{2,0}$

b) Nodular cast iron: $\frac{R_{m,20°}}{4,8}$; $\frac{R_{eH,t}}{3,0}$

c) Grey cast iron: $\frac{R_{m,20°}}{11}$

1.4.3 Special arrangements may be agreed for high-ductility austenitic steels.

1.4.4 In the case of cylinder shells with cutouts and in contact with water, a nominal stress of 170 N/mm^2 shall not be exceeded in view of the protective magnetite layer.

1.4.5 Mechanical characteristics are to be taken from the TL Rules Chapter 2 and 3- Materials and Welding or from the standards specified therein.

1.5 Allowance for corrosion and wear

The allowance for corrosion and wear is to be c = 1 mm. For plate thicknesses of 30 mm and over and for stainless materials, this allowance may be dispensed with.

1.6 Special cases

Where boiler parts cannot be designed in accordance with the following rules or on general engineering principles, the dimensions in each individual case must be determined by tests, e.g. by strain measurements.

2. Cylindrical shells under internal pressure

2.1 Scope

The following design requirements apply to drums, shell rings and headers up to a diameter ratio D_a/D_i of up to 1,7. Diameter ratios of up to D_a/D_i = 2 may be permitted provided that the wall thickness is ≤ 80mm.

2.2 Symbols

p_c = design pressure [bar]

s = wall thickness [mm]

D_i = inside diameter [mm]

D_a = outside diameter [mm]

c = allowance for corrosion and wear [mm]

d = diameter of opening or cutout [mm]

hole diameter for expanded tubes and for expanded and seal-welded tubes, see a and b in Fig. 15.1

inside tube diameter for welded-in pipe nipples and sockets, see Fig. 15.1, c

t, t_ℓ, t_u = pitch of tube holes (measured at centre of wall thickness for circumferential seams) [mm]

v = weakening factor [-]

for welds:

the qualitative ratio of the welded joints to the plate (weld quality rating)

for holes drilled in the plate:
the ratio of the weakened to the unweakened plate section

σ_{perm} = allowable stress [N/mm^2], see 1.4

s_A = necessary wall thickness at edge of opening or cutout [mm]

s_S = wall thickness of branch pipe [mm]

b = supporting length of parent component [mm]

ℓ = width of ligament between two branch pipes [mm]

ℓ_s = supporting length of branch pipe [mm]

ℓ'_s = internal projection of branch pipe [mm]

A_p = area subject to pressure [mm^2]

A_σ = supporting cross-sectional area [mm^2]

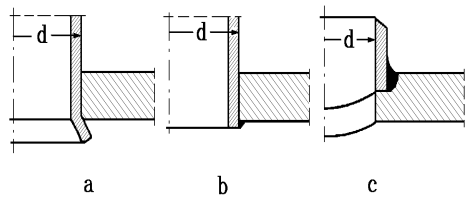


Fig. 15.1 Hole diameters for different tube types

2.3 Calculation of parameters

2.3.1 The necessary wall thickness s is given by the expression:

$$S = \frac{D_a \cdot p_c}{20 \cdot \sigma_{perm} \cdot v + p_c} + c \quad \textbf{(1)}$$

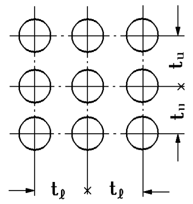
2.3.2 In the case of heated drums and headers with a maximum allowable working pressure of more than 25 bar, special attention is to be given to thermal stresses. For heated drums not located in the first pass (gas temperature up to 1000 °C max.), special certifi-cation in respect of thermal stresses may be waived subject to the following provisions: Wall thickness up to 30 mm and adequate cooling of the walls by virtue of close tube arrangement.

The description "close tube arrangement" is applicable if the ligament perpendicular to the direction of gas flow and parallel to the direction of gas flow does not exceed 50 mm and 100 mm respectively.

2.3.3 **Weakening factor** v

The weakening factor v is defined in Table 15.4 and in Fig. 15.27.

Table 15.4 Weakening factor v

Construction	Weakening factor v	
Seamless shell rings and drums	1.0	
Shell rings and drums with longitudinal weld	weld quality rating see Rules for Welding	
Rows of holes **(1)** in:		
longitudinal direction	$\frac{t_\ell - d}{t_\ell}$	
circumferential direction	$2 \cdot \frac{t_u - d}{t_u}$	
(1) *The value of v for rows of holes may not be made greater than 1.0 in the calculation. For staggered pitches, see Fig.15.27. Refer also to Figures 15.1a-c in 2.2.*		

2.3.4 Weakening effects due to cutouts or individual branch pipes are to be taken into account by compensation of areas in accordance with the expression:

$$\frac{p_c}{10} \cdot \left[\frac{A_p}{A_\sigma} + \frac{1}{2}\right] \leq \sigma_{perm} \qquad \textbf{(2)}$$

The area under pressure A_p and the supporting cross-sectional area A_σ are defined in Fig. 15.2.

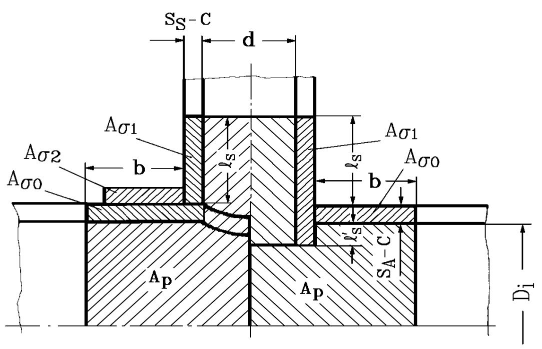


Fig. 15.2 Definition of areas A_p and A_σ

The values of the effective lengths may not exceed:

for the parent component $\quad b = \sqrt{(D_i + s_A - c) \cdot (s_A - c)}$

for the branch pipe $\quad \ell_S = 1.25\sqrt{(d + s_S - c) \cdot (s_S - c)}$

Where a branch projects into the interior, the value introduced into the calculation as having a supporting function may not exceed $\ell'_s < 0{,}5 \cdot \ell_s$.

Where materials with different mechanical strengths are used for the parent component and the branch or reinforcing plate, this fact is to be taken into account in the calculation. However, the allowable stress in the reinforcement may not be assumed greater than that for the parent material in the calculation.

Disk-shaped reinforcements should not be thicker than the actual parent component thickness, and this thickness is the maximum which may be allowed for in the calculation.

Disk-shaped reinforcements are to be fitted on the outside.

The wall thickness of the branch pipe should not be more than twice the required wall thickness at the edge of the cutout.

Cutouts exert a mutual effect, if the ligament is

$$\ell \leq 2\sqrt{(D_i + s_A - c) \cdot (s_A - c)}$$

The corresponding area of compensation is then as show in Fig. 15.3.

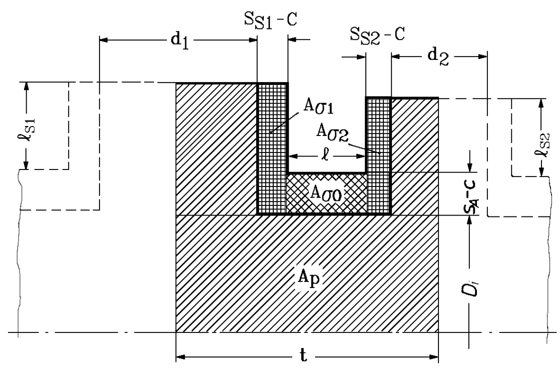


Fig. 15.3 Area compensation of cutouts

2.4 Minimum allowable wall thickness

For welded and seamless shell rings the minimum allowable wall thickness is 5 mm. For non-ferrous metals, stainless steels as well as cylinder diameters up to 200 mm, smaller wall thicknesses may be permitted.

The wall thickness of drums into which tubes are expanded is to be such as to provide a cylindrical expansion length of at least 16 mm.

3. Cylindrical shells and tubes with an outside diameter of more than 200 mm subject to external pressure

3.1 Scope

The following requirements apply to the design of plain and corrugated cylindrical shells with an outside diameter of more than 200 mm which are subjected to external pressure. Fire tubes are tubes exposed to flame radiation.

3.2 Symbols

a = greatest deviation from cylindrical shape [mm], see Fig. 15.5

b = thickness of stiffening ring [mm]

c = allowance for corrosion and wear [mm]

d = mean diameter of plain shell [mm]

d_a = outside diameter of plain shell [mm]

d_i = minimum inside diameter of corrugated shell [mm]

E_t = modulus of elasticity at design temperature [N/mm^2]

h = height of stiffening ring [mm]

ℓ = length of tube or distance between two effective stiffeners [mm]

p_c = design pressure [bar]

s = wall thickness [mm]

S_k = safety factor against elastic buckling [-]

u = out-of-roundness of shell [%]

ν = Poisson's ratio

= 0,3 for steel

σ_{perm} = allowable stress [N/mm^2]

3.3 Design calculations

3.3.1 Cylindrical shells and plain firetubes

Calculation of resistance to plastic deformation:

$$p_c \le 10 \cdot \sigma_{perm} \cdot \frac{2 \cdot (s - c)}{d} \cdot \frac{1 + 0{,}1 \cdot \frac{d}{\ell}}{1 + 0{,}03 \cdot \frac{d}{s - c} \cdot \frac{u}{1 + 5 \cdot \frac{d}{\ell}}} \qquad \textbf{(3)}$$

Calculation of resistance to elastic buckling:

$$p_c \le 20 \cdot \frac{E_t}{S_k} \cdot \left\{ \frac{\frac{s - c}{d_a}}{\left(n^2 - 1\right) \cdot \left[1 + \left(\frac{n}{Z}\right)^2\right]^2} + \frac{\left(\frac{s - c}{d_a}\right)^3}{3 \cdot \left(1 - \nu^2\right)} \cdot \left(n^2 - 1 + \frac{2 \cdot n^2 - 1 - \nu}{1 + \left(\frac{n}{Z}\right)^2}\right) \right\} \qquad \textbf{(4)}$$

$$Z = \frac{\pi \cdot d_a}{2 \cdot \ell}$$

$n \ge 2$

$n > Z$

n (integer) is to be chosen as to reduce p_c to its minimum value. n represents the number of buckled folds occurring round the periphery in the event of failure. n can be estimated by applying the following approximation formula:

$$n = 1{,}63 \cdot \sqrt[4]{\left(\frac{d_a}{\ell}\right)^2 \cdot \frac{d_a}{s - c}}$$

3.3.2 In the case of corrugated tubes of Fox and Morrison types, the required wall thickness s is given by the expression:

$$s = \frac{p_c}{20} \cdot \frac{d_i}{\sigma_{perm}} + 1 \text{ mm} \qquad \textbf{(5)}$$

3.4 Allowable stress

Contrary to 1.4, the values for the allowable stress σ_{perm} [N/mm^2] of firetubes used in the calculations are to be as follows:

- Plain firetubes, horizontal $\frac{R_{eH,t}}{2,5}$

- Horizontal firetubes, vertical $\frac{R_{eH,t}}{2,0}$

- Corrugated tubes $\frac{R_{eH,t}}{2,8}$

- Tubes heated by exhaust gases $\frac{R_{eH,t}}{2,0}$

3.5 Design temperature

Contrary to 1.3, the design temperature to be used for firetubes and heated tubes is shown in Table 15.5.

Table 15.5 Design temperatures for shells and tubes under external pressure

For tubes exposed to fire (firetubes): plain tubes t [C°] = saturation temperature +4 · s +30°C Corrugated tubes t [C°] = saturation temperature +3 · s +30°C	but at least 250°C
For tubes heated by exhaust gases: t [C°] = saturation temperature +2 · s +15°C	

3.6 Stiffening

Apart from the firetube and firebox end-plates, the types of structure shown in Figure 15.4 can also be regarded as providing effective stiffening.

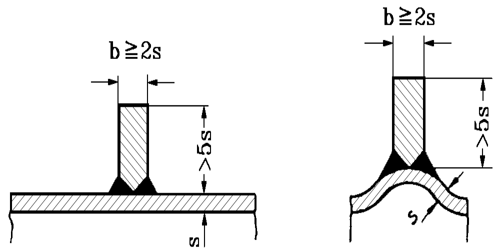


Fig. 15.4 Types of structure for stiffening

3.7 Safety factor S_k

A safety factor S_k of 3,0 is to be used in the calculation of resistance to elastic buckling. This value is applicable where the out-of-roundness is 1,5 % or less. Where the out-of-roundness is more than 1,5 % and up to 2 %, the safety factor S_k to be applied is 4,0.

3.8 Modulus of elasticity

Table 15.6 shows the modulus of elasticity for steel in relation to the design temperature.

3.9 Allowance for corrosion and wear

An allowance of 1 mm for corrosion and wear is to be added to the wall thickness s. In the case of corrugated tubes, s is the wall thickness of the finished tube.

Table 15.6 Values for the modulus of elasticity

Design temperature [°C]	E_t **(1)** [N/mm^2]
20	206000
250	186400
300	181500
400	171700
500	161900
600	152100

(1) *Intermediate values should be interpolated*

3.10 Minimum allowable wall thickness and maximum wall thickness

The wall thickness of plain firetubes shall be at least 7 mm, that of corrugated firetubes at least 10 mm.

For small boilers, non-ferrous metals and stainless steels, smaller wall thicknesses are allowable. The maximum wall thickness may not exceed 20 mm. Tubes which are heated by flue gases < 1000 °C may have a maximum wall thickness of up to 30 mm.

3.11 Maximum unstiffened length

For firetubes, the length ℓ between two stiffeners may not exceed 6 · d. The greatest unsupported length shall not exceed 6 m or, in the first pass from the front end-plate, 5 m. Stiffenings of the type shown in Figure 15.4 are to be avoided in the flame zone, i.e. up to approximately 2 · d behind the lining.

The plain portion of corrugated firetubes need not be separately calculated provided that its stressed length, measured from the middle of the end-plate attachment to the beginning of the first corrugation, does not exceed 250 mm.

3.12 Out-of-roundness

The out-of-roundness [%], i.e.

$$u = \frac{2(d_{max} - d_{min})}{d_{max} + d_{min}} \cdot 100$$

of new plain tubes is to be given the value u = 1,5 % in the design formula.

In the case of used firetubes, the out-of-roundness is to be determined by measurements of the diameters.

$$u = \frac{4 \cdot a}{d} \cdot 100$$

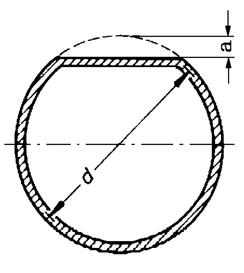


Fig. 15.5 Determination of out-of-roundness

3.13 Firetube spacing

The clear distance between the firetube and boiler shell at the closest point shall be at least 100 mm. The distance between any two firetubes shall be at least 120 mm.

4. Dished End-Plates Under Internal and External Pressure

4.1 Scope

4.1.1 The following Rules apply to the design of unstayed, dished end-plates under internal or external pressure see Fig. 15.6. The following requirements are to be complied with:

The radius R of the dished end may not exceed the outside end-plate diameter D_a, and the knuckle radius r may not be less than 0,1· D_a.

The height H may not be less than 0,18 · D_a.

The height of the cylindrical portion, with the exception of hemispherical end-plates, shall be 3,5 · s, s being taken as the thickness of the unpierced plate even if the endplate is provided with a manhole. The height of the cylindrical portion need not, however, exceed the values show in Table 15.7.

Table 15.7 Height of cylindrical portion

Wall thickness s [mm]	h [mm]
up to 50	150
over 50 up to 80	120
over 80 up to 100	100
over 100 up to 120	75
over 120	50

4.1.2 These rules also apply to welded dished end plates. Due account is to be taken of the weakening factor of the weld.

4.2 Symbols

p_c = Design pressure, [bar]

s = Wall thickness of endplate, [mm]

D_a = Outside diameter of endplate, [mm]

H = Height of end-plate curvature, [mm]

R = Inside radius of dished end, [mm]

h = Height of cylindrical portion in, [mm]

d = Diameter of opening measured along a line passing through the centers of the end-plate and the opening. In the case of openings concentric with the end-plate, the maximum opening diameter. [mm]

σ_{perm} = Allowable stress (see 1.4), [N/mm^2]

β = Coefficient of stress in knuckle, [-]

β_o = Coefficient of stress in spherical section, [-]

v = Weakening factor, [-]

c = Allowance for corrosion and wear [mm]

E_t = Modules of elasticity at design temperature, [N/mm^2]

s_A = Necessary wall thickness at edge of opening, [mm]

s_S = Wall thickness of branch pipe, [mm]

b = Supporting length of parent component, [mm]

ℓ = Width of ligament between two branch pipes, [mm]

ℓ_s = Supporting length of branch pipe, [mm]

ℓ'_s = Internal projection of branch pipe, [mm]

A_p = Area subject to pressure, [mm^2]

A_σ = Supporting cross-sectional area, [mm^2]

S_k = Safety factor against elastic buckling, [-]

S'_k = Safety factor against elastic buckling at test pressure [-].

4.3 Design calculation for internal pressure

4.3.1 The necessary wall thickness is given by the expression:

$$s = \frac{D_a \cdot p_c \cdot \beta}{40 \cdot \sigma_{perm} \cdot v} + c \qquad \textbf{(6)}$$

The finished wall thickness of the cylindrical portion must be at least equal to the required wall thickness of a cylindrical shell without weakening.

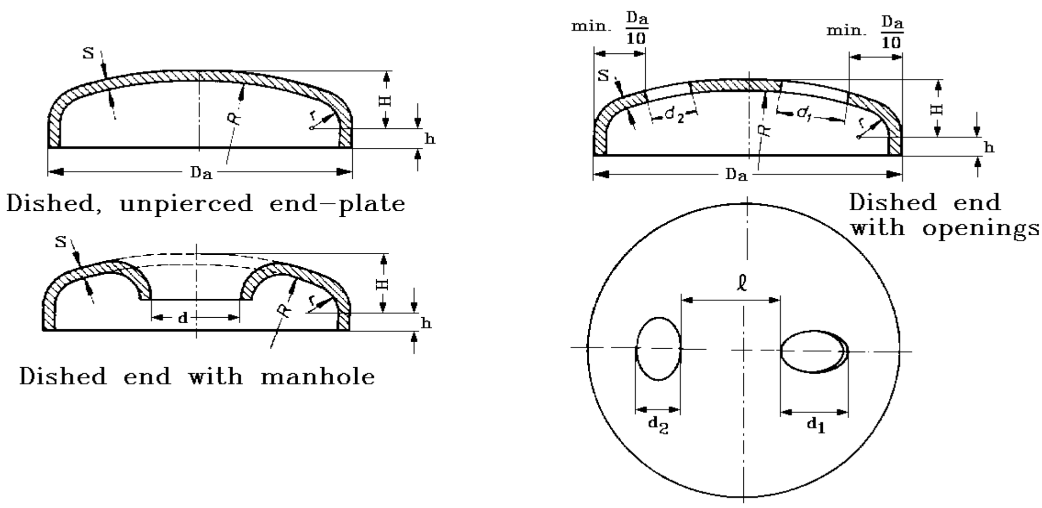


Fig. 15.6 Types of dished end plates

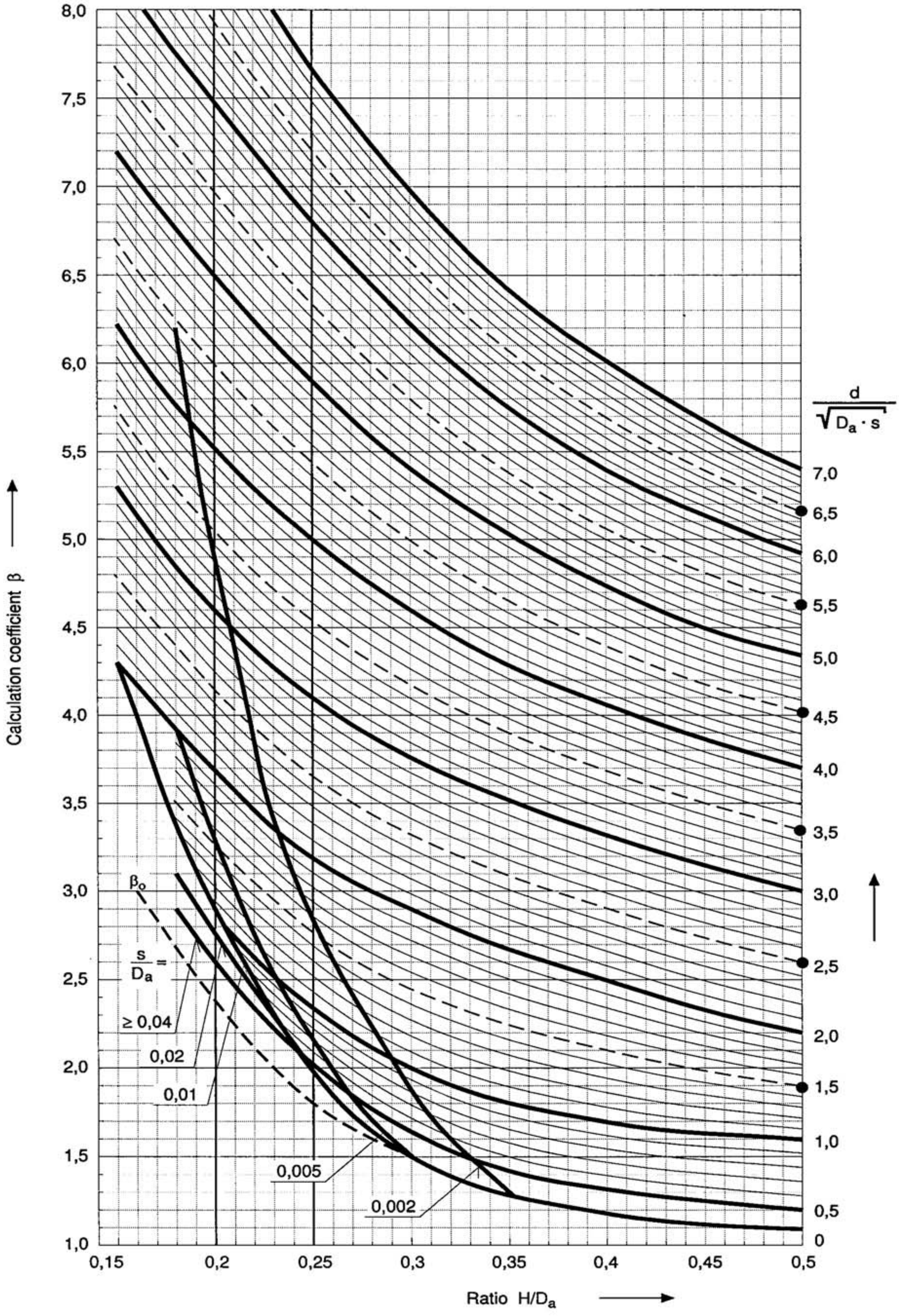


Fig. 15.7 Values of coefficient β for the design of dished ends

4.3.2 Design coefficients β and β_o

The design coefficients are shown in Fig. 15.7 in relation to the ratio H/D_a and parameters $d/\sqrt{D_a \cdot s}$ and s/D_a.

For dished ends of the usual shapes, the height H can be determined as follows:

Shallow dished end ($R = D_a$):

$$H \approx 0{,}1935 \cdot D_a + 0{,}55 \cdot s$$

Deep dished end, ellipsoidal shape ($R = 0.8D_a$):

$$H \approx 0{,}255 \cdot D_a + 0{,}36 \cdot s$$

The values of β for unpierced end-plates also apply to dished ends with openings whose edges are located inside the spherical section and whose maximum opening diameter is $d \leq 4 \cdot s$, or whose edges are adequality reinforced. The width of the ligament between two adjacent, non-reinforced openings must be at least equal to the sum of the opening radii measured along the line connecting the centers of the openings. Where the width of the ligament is less than that defined above, the wall thickness is to be dimensioned as though no ligament were present, or the edges of the openings are to be adequately reinforced.

4.3.3 Reinforcement of openings in the spherical section

Openings in the spherical are deemed to be adequately reinforced if the following expression relating to the relevant areas is satisfied.

$$\frac{p_c}{10}\left[\frac{A_p}{A_\sigma}+\frac{1}{2}\right] \leq \sigma_{perm} \qquad (7)$$

The area under pressure A_p and the supporting cross-sectional area A_σ are shown in Fig. 15.8.

For calculation of reinforcements and supporting lengths the formulae and prerequsites in 2.3.4 are applicable.

The relationship between respective areas of cutouts exerting a mutual effect is show in Fig. 15.9.

The edge of disk-shaped reinforcements may not extend beyond $0{,}8 \cdot D_a$

In the case of tubular reinforcements, the following wall thickness ratio is applicable:

$$\frac{s_S - c}{s_A - c} \leq 2$$

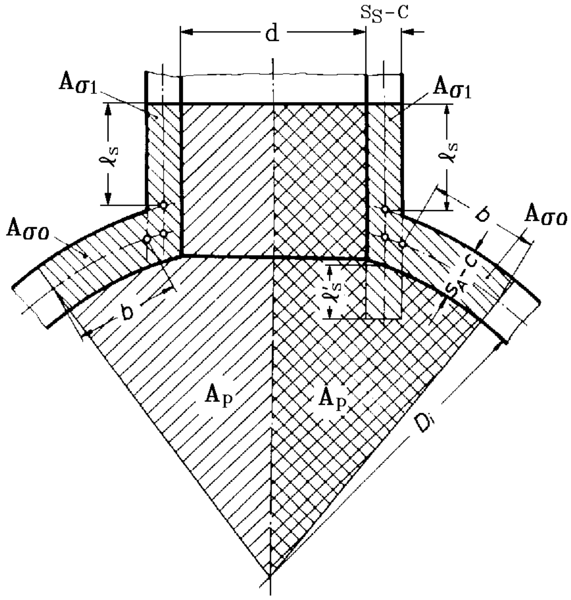


Fig. 15.8 Areas A_p and A_σ

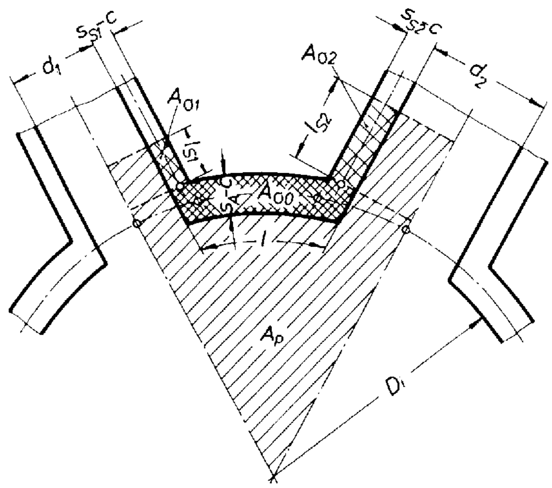


Fig. 15.9 Areas of cutouts

4.4 Design calculation for external pressure

4.4.1 The same formulae are to be applied to dished end-plates under external pressure as to those subject to internal pressure. However, the safety factor used to determine the allowable stress in accordance with 1.4.1 is to be increased by 20%.

4.4.2 A check is also required to determine whether the spherical section of the end-plate is safe against elastic buckling.

The following relationship is to be applied:

$$p_c \leq 3{,}66 \cdot \frac{E_t}{S_k} \cdot \left(\frac{s-c}{R}\right)^2 \qquad \textbf{(8)}$$

The modules of elasticity E_t for steel can be taken according to Table 15.6.

The coefficient S_k against elastic buckling and the required safety coefficient S_k' at the test pressure are shown in Table 15.8.

Table 15.8 Safety coefficients against elastic buckling

(s-c)/R	S_k **(1)**	S'_k **(1)**
0,001	5,5	4,0
0,003	4,0	2,9
0,005	3,7	2,7
0,010	3,5	2,6
0,100	3,0	2,2
(1) *Intermediate values should be interpolated.*		

4.5 Weakening factor

The weakening factor can be taken from Table 15.4 in 2.3.3. Apart from this, with welded dished ends - except for hemispherical ends - a value of v = 1 may be applied irrespective of the scope of the test provided that the welded seam impinges on the area within the apex defined by 0,6 · D_a, see. Fig. 15.10.

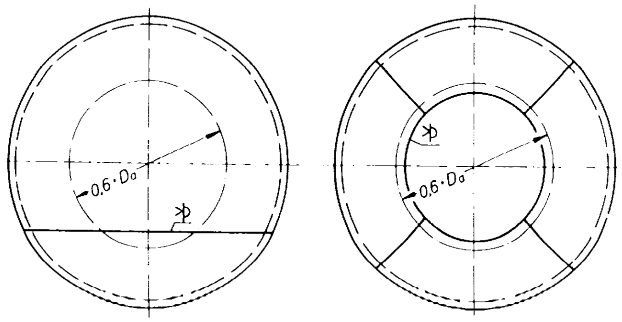


Fig. 15.10 Arrangement of welding seams at dished ends

4.6 Minimum allowable wall thickness

The minimum allowable wall thickness for welding neck endplate is 5 mm. Smaller minimum wall thicknesses are allowed for non-ferrous metals and stainless steels.

5. Flat Surfaces

5.1 Scope

The following Rules apply to stayed and unstayed flat, flanged end-plates and to flat surfaces which are simply supported, or bolted, or welded at their periphery and which are subjected to internal or external pressure.

5.2 Symbols

p_c = Design pressure, [bar]

s = Wall thickness, [mm]

s_1 = Wall thickness in a stress relieving groove, [mm]

s_2 = Wall thickness of a cylindrical or square header at the connection to a flat end-plate with a stress relieving groove, [mm]

D_b = Inside diameter of a flat, flanged end-plate or design diameter of an opening to be provided with means of closure, [mm]

D_1, D_2 = Diameter of circular plates, [mm]

D_ℓ = Bolt-hole circle diameter of a plate subject additionally to a bending moment, [mm]

d_e = Diameter of the largest circle which can be described on a flat plate inside at least three anchorage points, [mm]

d_a = Outside diameter of expanded tubes, [mm]

a, b = Clear supporting or design widths of rectangular or elliptical plates, b always designating the shorter side or axis, [mm]

t_1, t_2 = Pitch of uniformly spaced stays or stay bolts, [mm]

e_1, e_2 = Distances between centers of non-uniformly spaced stays and stay bolts, [mm]

f = Cross-sectional area of ligament, [mm^2]

r_K = Inner corner radius of a flange, or radius of a stress relieving groove, [mm]

h = Inner depth of a flat, welding-neck end-plate, [mm]

C = Design coefficient, [-]

y = Ratio, [-]

σ_{perm} = Allowable stress (see 1.4), [N/mm^2]

c = Allowance for corrosion and wear. [mm]

5.3 Design calculation of unstayed surfaces

5.3.1 Flat, circular, flanged, unpierced end-plates

Flat, circular, flanged unpierced endplates are shown in Fig. 15.11.

The required wall thickness s is given by the expression:

$$s = C \cdot (D_b - r_K) \cdot \sqrt{\frac{p_c}{10 \cdot \sigma_{perm}}} + c \quad (9)$$

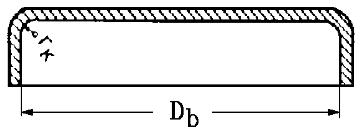


Figure 15.11 Circular flanged endplates

5.3.2 Circular plates

The types of circular endplates to be used are shown in Fig. 15.12 to 15.14.

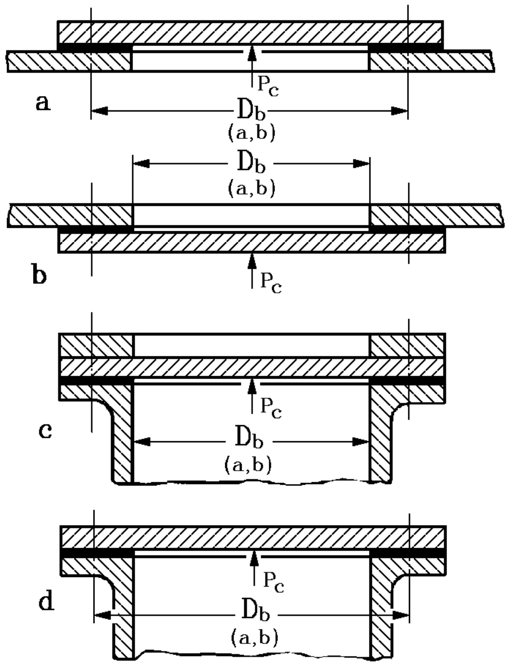


Figure 15.12 Annular end plates

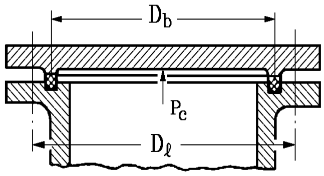


Figure 15.13

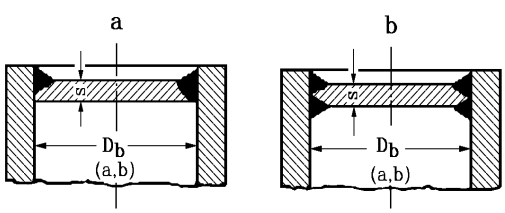


Figure 15.14

The necessary wall thickness s is given by the expression:

$$s = C \cdot D_b \cdot \sqrt{\frac{p_c}{10 \cdot \sigma_{perm}}} + c \qquad \textbf{(10)}$$

5.3.3 Rectangular and elliptical plates

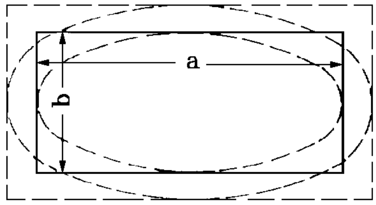


Figure 15.15 Rectangular and elliptical plates

Longitudinal and transverse sections are analogous to Fig. 15.12.

The required wall thickness s is given by the expression:

$$s = C \cdot b \cdot y \cdot \sqrt{\frac{p_c}{10 \cdot \sigma_{perm}}} + c \qquad \textbf{(11)}$$

5.3.4 Welding-neck end-plates

For welding-neck endplates of headers additional requirements are to be found in 5.5.2.

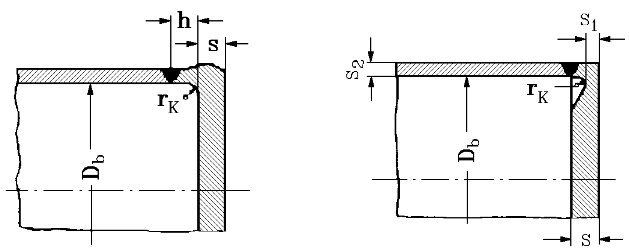


Figure 15.16 **Figure 15.17**

Forms of welding neck endplates

The thickness of the plated s is determined by applying formula (10) or (11) as appropriate.

In the case of end-plates with a stress relieving groove, provision must be made for the effective relieving of the welded seams. The wall thickness s_1 in the stress relieving groove must therefore satisfy the following conditions, cf. Fig. 15.17:

For round end-plates: $s_1 \leq 0{,}77 \cdot s_2$

For rectangular end-plates: $s_1 \leq 0{,}55 \cdot s_2$

Here s_2 represents the wall thickness of the cylindrical or rectangular header [mm]. In addition, provision must be made to ensure that shear forces occurring in the cross-section of the groove can be safely absorbed.

It is therefore necessary that the following is fulfilled:

for round end-plates:

$$s_1 \geq \frac{p_c}{10} \cdot \left[\frac{D_b}{2} - r_K\right] \cdot \frac{1{,}3}{\sigma_{perm}} \qquad \textbf{(12)}$$

and for rectangular end-plates:

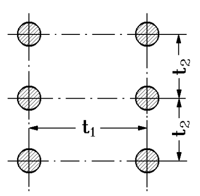
$$s_1 \geq \frac{p_c}{10} \cdot \frac{a \cdot b}{a + b} \cdot \frac{1{,}3}{\sigma_{perm}} \qquad \textbf{(13)}$$

Radius r_K shall be at least 0,2 · s and not less than 5 mm. Wall thickness s_1 must be at least 5 mm.

Where welding-neck end-plates in accordance with Fig. 15.16 or Fig. 15.17 are manufactured from plates, the area of the connection to the shell is to be tested for laminations, e.g. ultrasonic inspection.

5.4 Design calculation of stayed surfaces

5.4.1 For flat surfaces which are uniformly braced by stay bolts, circular stays or stay tubes, cf. Fig. 15.18.



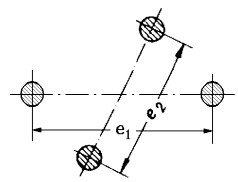


Figure 15.18 **Figure 15.19**

Forms of bracing by stay bolts

The required wall thickness s inside the stayed areas is given by the expression:

$$s = C \cdot \sqrt{\frac{p_c \cdot (t_1^2 + t_2^2)}{10 \cdot \sigma_{perm}}} + c \qquad \textbf{(14)}$$

5.4.2 For plates non-uniformly braced

For flat plates which are non-uniformly braced by stay bolts, circular stays and stay tubes, cf. Fig. 15.19

The required wall thickness s inside the stayed areas is given by the expression:

$$s = C \cdot \frac{e_1 + e_2}{2} \cdot \sqrt{\frac{p_c}{10 \cdot \sigma_{perm}}} + c \qquad \textbf{(15)}$$

5.4.3 Flat plates braced by gusset stays

For flat plates which are braced by corner stays, supports or other means and flat plates between arrays of stays and tubes, cf. Fig. 15.20.

The design calculation is to be based on the diameter d_e of a circle, or on the length of the shorter side b of a rectangle which can be inscribed in the free unstiffened area, the least favorable position from the point of view of stress being decisive in each case.

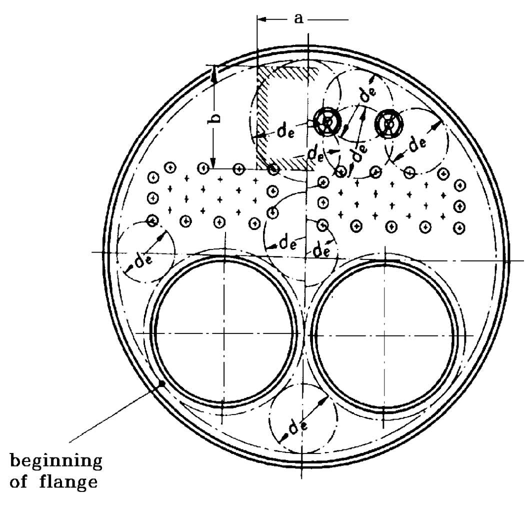


Figure 15.20 Flat end plates braced by stays or other means

The required wall thickness s is given by the expression:

$$s = C \cdot d_e \cdot \sqrt{\frac{p_c}{10 \cdot \sigma_{perm}}} + c \qquad \textbf{(16)}$$

or

$$s = C \cdot b \cdot y \cdot \sqrt{\frac{p_c}{10 \cdot \sigma_{perm}}} + c \qquad \textbf{(17)}$$

The higher of the values determined by the formulae is applicable.

5.4.4 Flat annular plates with central longitudinal staying

Flat annular plates with central longitudinal staying, see Fig. 15.21.

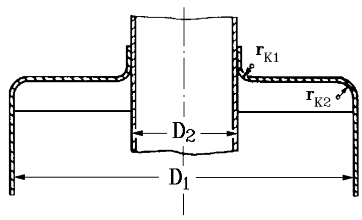


Figure 15.21 Flat annular plates with central longitudinal staying

The required wall thickness s is given by the expression:

$$s = 0{,}25 \cdot (D_1 - D_2 - r_{K1} - r_{K2}) \cdot \sqrt{\frac{p_c}{10 \cdot \sigma_{perm}}} + c \qquad \textbf{(18)}$$

5.5 Requirements for flanges

5.5.1 For application of the above formulae to flanged endplates and to flanges as a means of staying the corner radii r_K of flanges should have minimum values according to Table 15.9.

In addition, the flange radii r_K must be equal to at least 1,3 times the wall thickness, see Figs. 15.11 and 15.21.

Table 15.9 Minimum corner radii of flanges

Outside diameter of end plate [mm]	Corner radius r_K of flanges [mm]
up to 500	30
over 500 up to 1400	35
over 1400 up to 1600	40
over 1600 up to 1900	45
over 1900	50

5.5.2 Welding-neck endplates without groove

In the case of welding-neck endplates without a stress relieving groove for headers, the flange radius must be $r_K \geq 1/3 \cdot s$, subject to a minimum of 8 mm., and the inside depth of the end-plate must be h ≥ s, s for end-plates with openings being the thickness of an unpierced endplate of the same dimensions, see Fig.15.16.

5.6 Ratio coefficient y

The ratio coefficient y takes account of the increase in stress, as compared with round plates, as a function of the ratio b/a of the sides of unstayed, rectangular and elliptical plates and of the rectangles inscribed in the free, unstayed areas of stayed, flat surfaces, see Fig. 15.15 and Table 15.10.

Table 15.10 Values of ratio coefficient y

Shape	Ratio b/a **(1)**				
	1,0	0,75	0,5	0,25	≤ 0,1
Rectangle	1,10	1,26	1,4	1,52	1,56
Ellipse	1,00	1,15	1,3	-	-
(1) *Intermediate values are to be interpolated linearly.*					

5.7 Coefficient C

Coefficient C takes account of the type of support, the edge connection and the type of stiffening. The value of C to be used in the calculation is shown in Tables 15.11 and 15.12.

Where different values of coefficient C are applicable to parts of a plate due to different kinds of stiffening according to Table 15.12, coefficient C is to be determined by the arithmetical mean value.

5.8 Minimum ligament with expanded tubes

The minimum ligament width depends on the expansion technique used. The cross-section A of the ligament between two tube holes for expanded tubes should be for:

Steel $A = 15 + 3{,}4 \cdot d_a$ [mm^2]

Copper $A = 25 + 9{,}5 \cdot d_a$ [mm^2]

Table 15.11 Values of coefficient C for unstayed surfaces

Type of end-plate or cover	C
Flat, forged end-plates or end-plates with machined recesses for headers and flat, flanged end-plates	0,35
Encased plates tightly supported and bolted at their circumference	
Inserted, flat plates welded on both sided	
Welding-neck end-plates with stress relieving groove	0,40
Loosely supported plates, such as manhole covers; in the case of closing appliances, in addition to the working pressure, allowance is also to be made for the additional force which can be exerted when the bolts are tightened (the permitted loading of the bolt or bolts distributed over the cover area).	0,45
Inserted, flat plates welded on one side	
Plates which are bolted at their circumference and are thereby subjected to an additional bending moment according to the ratio: D_ℓ/D_b = 1,0 = 1,1 = 1,2 = 1,3 Intermediate values are to be interpolated linearly.	 0,45 0,50 0,55 0,60

Table 15.12 Values of coefficient C for unstayed surfaces

Type of stiffening and/or end-plate	C
Boiler shell, header or combustion chamber wall, stay plate or tube area	0,35
Stay bolts in arrays with maximum stay bolt center distance of 200 mm.	0,40
Round stays and tubes outside tube arrays irrespective of whether they are welded-in, bolted or expanded	0,45

5.9 Minimum and maximum wall thickness

5.9.1 With expanded tubes, the minimum plate thickness is 12 mm. Concerning safeguards against the dislodging of expanded tubes, see 6.3.3.

5.9.2 The wall thickness of flat end-plates should not exceed 30 mm. in the heated portion.

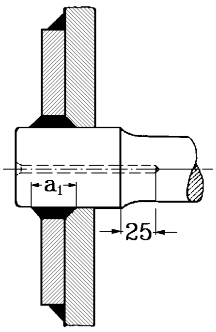
5.10 Reinforcement of openings

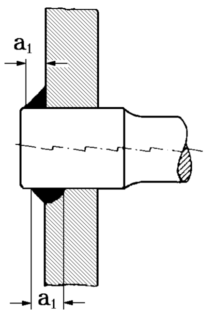
Where cutouts, branches, etc. in flat surfaces lead to undue weakening of the wall and where the edges of the openings are not reinforced, special allowance is to be made when calculating the thickness of the wall.

6. Stays, Stay Tubes and Stay Bolts

6.1 Scope

The following Requirements apply to longitudinal stays, gusset stays, stay tubes, stay bolts and stiffening girders of steel or copper and are subject to the requirements set out in 5., see Fig. 15.22 to Fig.15.24.





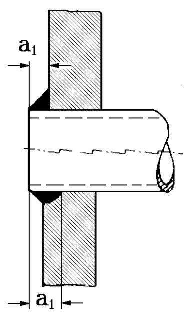


Figure 15.22 **Figure15.23** **Figure15.24**

Types of connections for longitudinal stays

6.2 Symbols

a_1 = Weld height in direction of load, [mm]

A_1 = Calculated required cross-sectional area of stays, stay bolts and stay tubes, [mm^2]

A_2 = Supported area of expanded tubes, [mm^2]

A_p = Plate area supported by one stay, stay bolt or stay tube, [mm^2]

d_a = Outside diameter of tube, stay or stay bolt, [mm]

d_i = Inside diameter of stay tube, [mm]

F = Load on a stay, stay tube or stay bolt, [N]

ℓ_o = Length of expanded section of tube, [mm]

p_c = Design pressure, [bar]

σ_{perm}= Allowable stress [N/mm^2].

6.3 Design calculation

6.3.1 The supporting action of other boiler parts may be taken into consideration when calculating the size of stays, stay tubes and stay bolts. Where the boundary areas of flanged end-plates are concerned, calculation of the plate area A_p is to be based on the flat surface extending to the beginning of the end-plate flange.

In the case of flat end-plates, up to half the load may be assumed to the supported by the directly adjacent boiler wall.

6.3.2 For stays, stay bolts or stay tubes, the necessary cross-sectional area is given by the expression:

$$A_1 = \frac{F}{\sigma_{perm}} \qquad \textbf{(19)}$$

6.3.3 Where expanded tubes are used, a sufficient safety margin must be additionally applied to prevent the tubes from being pulled out of the tube plate. Such a safety margin is deemed to be achieved if the allowable load on the supporting area does not exceed the values specified in Table 15.13.

Table 15.13 Loading of expanded tube

Type of expanded connection	Allowable load on supporting area [N/mm^2]
Plain	$F / A_2 \leq 150$
With groove	$F / A_2 \leq 300$
With flange	$F / A_2 \leq 400$

For the purpose of the calculation, the supporting area is given

by the expression: $A_2 = (d_a - d_i) \cdot \ell_o$

subject to a maximum of: $A_2 = 0.1 \cdot d_a \cdot \ell_o$

For calculating the supporting area, the length of the expanded section of tube (ℓ_o) may not be taken as exceeding 40 mm.

6.3.4 Where longitudinal stays, stay tubes or stay bolts are welded in, the cross-section of the fillet weld subject to shear shell be at least 1,25 times the required bolt or stay tube cross-section:

$$d_a \cdot \pi \cdot a_1 \geq 1{,}25 \cdot A_1 \qquad \textbf{(20)}$$

6.4 Allowable stress

The allowable stress is to be determined in accordance with 1.4.1. In departure from this, however, a value of $R_{eH,t}$/1,8. is to be expected in the area of the weld in the case of stays, stay tubes and stay bolts made of rolled and forged steels.

7. Boiler and Superheater Tubes

7.1 Scope

The design calculation applies to tubes under internal pressure and, up to an outside tube diameter of 200 mm., also to tubes subject to external pressure.

7.2 Symbols

p_c = Design pressure, [bar]

s = Wall thickness, [mm]

d_a = Outside diameter of tube, [mm]

σ_{perm} = Allowable stress, [N/mm^2]

v = Weld quality rating of longitudinally welded tubes. [-]

7.3 Calculation of wall thickness

The necessary wall thickness s is given by the expression:

$$s = \frac{d_a \cdot p_c}{20 \cdot \sigma_{perm} \cdot v + p_c} \qquad \textbf{(21)}$$

7.4 Design temperature t

The design temperature is to be determined in accordance with 1.3.

In the case of once through forced flow boilers, the calculation of the tube wall thicknesses is to be based on the maximum temperature excepted in the individual main sections of the boiler under operating conditions plus the necessary added temperature allowances.

7.5 Allowable stress

The allowable stress is to be determined in accordance with 1.4.1.

For tubes subject to external pressure, a value of $R_{eH,t}$ /2,0 is to be applied.

7.6 Welding factor v

For longitudinally welded tubes, the value of v to be applied shall correspond to the approval test.

7.7 Wall thickness allowances

In the case of tubes subject to relatively severe mechanical or chemical attack an appropriate wall thickness allowance shall be agreed which shall be added to the wall thickness calculated by applying formula (21). The allowable minus tolerance on the wall thickness (see 1.1.2) need only be taken into consideration for tubes whose outside diameter exceeds 76,1 mm.

7.8 Maximum wall thickness of boiler tubes

The wall thickness of intensely heated boiler tubes, e.g. where the temperature of the heating gas exceeds 800°C, shall not be greater than 6,3 mm. This requirement may be dispensed with in special cases, e.g. for superheater support tubes.

8. Plain Rectangular Tubes and Sectional Headers

8.1 Symbols

P_c = Design pressure, [bar]

s = Wall thickness, [mm]

2 · m = Clear width of the rectangular tube parallel to the wall in question [mm], see Fig. 15.25

2 · n = Clear width of the rectangular tube perpendicular to the wall in question [mm], see Fig 15.25

Z = Coefficient according to formula (23), [mm^2]

a = Distance of relevant line of holes from center line of side, [mm]

t = Pitch of holes, [mm]

d = Hole diameter, [mm]

v = Weakening factor for rows of holes under tensile stress, [-]

v' = Weakening factor for rows of holes under bending stress, [-]

r = Inner radius at corners, [mm]

σ_{perm}= Allowable stress [N/mm^2].

8.2 Design calculation

8.2.1 The wall thickness is to be calculated for the center of the side and for the ligaments between the holes. The maximum calculated wall thickness shall govern the wall thickness of the entire rectangular tube.

The following method of calculation is based on the assumption that the tube connection stubs have been properly mounted, so that the wall is adequately stiffened.

8.2.2 The required wall thickness is given by the expression:

$$s = \frac{p_c \cdot n}{20 \cdot \sigma_{perm} \cdot v} + \sqrt{\frac{4.5 \cdot Z \cdot p_c}{10 \cdot \sigma_{perm} \cdot v'}} \qquad \textbf{(22)}$$

If there are several different rows of holes, the necessary wall thickness is to be determined for each row.

8.2.3 Z is calculated by applying the formula:

$$Z = \left| \frac{1}{3} \cdot \frac{m^3 + n^3}{m + n} - \frac{1}{2}(m^2 - a^2) \right| \qquad \textbf{(23)}$$

8.3 Weakening factor, v

8.3.1 If there is only one row of holes, or if there are several parallel rows not staggered in relation to each other, the weakening factors v and v' are to be determined as follows:

$$v = \frac{t - d}{t}$$

$$v' = v = \frac{t - d}{t}, \qquad \text{for holes where } d < 0,6 \cdot m$$

$$v' = \frac{t - 0,6 \cdot m}{t}, \qquad \text{for holes where } d \geq 0,6 \cdot m$$

8.3.2 In determining the values of v and v' for elliptical holes, d is to be taken as the clear width of the holes in the longitudinal direction of the rectangular tube. However, for the purpose of deciding which formula is to be used for determining v', the value of d in the expressions d ≥ 0,6 · m. and d < 0,6 · m. is to be the clear width of the hole perpendicular to the longitudinal axis

8.3.3 In calculating the weakening factor for staggered rows of holes, t is to be substituted in the formula by t_1 for the oblique ligaments, Fig. 15.25.

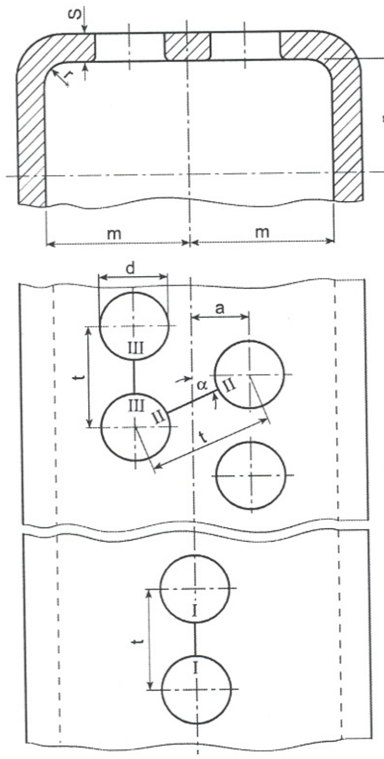


Figure 15.25 Arrangement of staggered rows of boles

8.3.4 For oblique ligaments, the value of Z to be used in formula (22) is that determined by applying formula (23), with a=0, and multiplying by cos α.

8.4 Stress at corners

In order to avoid undue stresses at corners, the following conditions are to be satisfied:

$r \geq 1/2 \cdot s$, subject to a minimum of:

3 mm. for rectangular tubes with a clear width of up to 50 mm.

8 mm. for rectangular tubes with a clear width of 80 mm. or over.

Intermediate values are to be interpolated linearly. The radius shall be governed by the arithmetical mean value of the nominal wall thicknesses on both sides of the corner. The wall thickness at corners may not be less than the wall thickness determined by applying formula (22).

8.5 Minimum wall thickness and ligament width

8.5.1 The minimum wall thickness for expanded tubes shall be 14 mm.

8.5.2 The width of a ligament between two openings or tube holes may not be less than 1/4 of the distance between the tube centers.

9. Straps and Girders

9.1 Scope

The following Rules apply to steel girders used for stiffening of flat plates.

9.2 General

The supporting girders are to be properly welded to the combustion chamber crown at all points. They are to be arranged in such a way that the welds can be competently executed and the circulation of water is not obstructed.

9.3 Symbols

p_c = Design pressure, [bar]

F = Load carried by one girder, [N]

e = Distance between center lines of girders, [mm]

ℓ = Free length between girder supports, [mm]

b = Thickness of girder, [mm]

h = Depth of girder, [mm]

W = Section modules of one girder, [mm^3]

M = Bending moment acting on girder at given load, [Nmm]

z = Coefficient for section modules, [-]

σ_{perm} = Allowable stress (see 1.4) [N/mm^2].

9.4 Design calculation

9.4.1 The simply supported girder shown in Fig. 15.26 is to be treated as a simply supported beam of length ℓ. The support afforded by the plate material may also be taken into consideration.

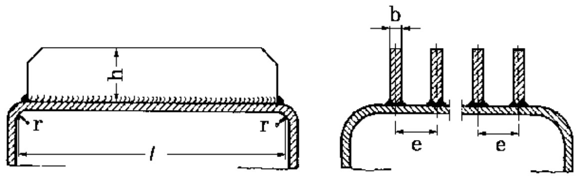


Figure 15.26 Arrangement of self-supported girders

9.4.2 The required section modules of a girder is given by:

$$W = \frac{M_{max}}{1{,}3 \cdot \sigma_{perm} \cdot z} \leq \frac{b \cdot h^2}{6} \quad \textbf{(24)}$$

The coefficient z for the section modules takes account of the increase in the section modules due to the flat plate forming part of the girder. It may in general be taken as z = 5/3.

For the height h, a value not exceeding 8 · b is to be inserted in the formula.

9.4.3 The maximum bending moment is given by the expression:

$$M_{max} = \frac{F \cdot \ell}{8} \quad \textbf{(25)}$$

$$F = \frac{p_c}{10} \cdot \ell \cdot e \quad \textbf{(26)}$$

10. Bolts

10.1 Scope

The following Rules relate to bolts which, as force-transmitting connecting elements, are subjected to tensile stresses due to the internal pressure. Normal operating conditions are assumed.

10.2 General

Necked-down bolts should be used for elastic bolted connections, particularly where the bolts are highly stressed, or are exposed to service temperatures of over 300°C, or have to withstand internal pressures of 80 bar or over. All bolts > M 30 (30 mm. diameter metric thread) must be necked-down bolts. Necked-down bolts are bolts to DIN 2510 (TS 1709) with a shank diameter d_s = 0,9 · d_k (d_k being the root diameter). In the calculation special allowance is to be made for shank diameters < 0,9 · d_k.

Bolts with a shank diameter of less than 10 mm. are not allowed.

Bolts may not be located in the path of heating gases.

At least 4 bolts must be used to form a connection.

To achieve small sealing forces, the jointing material should be made as narrow as possible.

Where standard pipe flanges are used, the strength requirements for the bolts are considered to be satisfied if the bolts used comply with DIN 2401 Part 12, and conform to the specifications contained therein in respect of the materials used, the maximum allowable working pressure and the service temperature.

10.3 Symbols

p_c = Design pressure, [bar]

p' = Test pressure, [bar]

F_S = Total load on bolted connection in service, [N]

F'_S = Total load on bolted connection at test pressure, [N]

F_{So} = Total load on bolted connection in assembled condition with no pressure exerted, [N]

F_B = Load imposed on bolted connection by the working pressure, [N]

F_D = Force to close joint under service condition, [N]

F_{Do} = Force to close joint in assembled condition, [N]

F_Z = Additional force due to stresses in connecting piping, [N]

D_b = Mean sealing or bolt pitch circle diameter, [mm]

d_i = Inside diameter of connected pipe, [mm]

d_s = Shank diameter of necked-down bolt, [mm]

d_k = Root diameter of thread, [mm]

n = Number of bolts forming connection, [-]

σ_{perm} = Allowable stress, [N/mm^2]

φ = Surface finish coefficient, [-]

c = Additional allowance, [mm]

k_1 = Sealing factor for service condition, [mm]

k_o = Sealing factor for assembled condition, [mm]

K_D = Sealing material deformation factor. [N/mm^2]

10.4 Design calculation

10.4.1 Bolted joints are to be designed for the following load conditions:

- Service conditions (design pressure p_c and design temperature t),

- Load at test pressure (test pressure p', t = 20°C) and,

- Assembled condition at zero pressure (p = 0 bar, t = 20°C).

10.4.2 The necessary root diameter of a bolt in a bolted joint comprising n bolts is given by:

$$d_k = \sqrt{\frac{4 \cdot F_S}{\pi \cdot \sigma_{perm} \cdot \varphi \cdot n}} + c \qquad \textbf{(27)}$$

10.4.3 The total load on a bolted joint is to be calculated as follows:

a) For service conditions:

$$F_S = F_B + F_D + F_Z \qquad \textbf{(28)}$$

$$F_B = \frac{D_b^2 \cdot \pi}{4} \cdot \frac{p_c}{10} \qquad \textbf{(29)}$$

$$F_D = D_b \cdot \pi \cdot k_1 \cdot \frac{p_c}{10} \cdot 1{,}2 \qquad \textbf{(30)}$$

Where the arrangement of the bolts deviates widely from the circular, due allowance is to be made for the special stresses occurring.

The additional force F_Z due to connected piping must be calculated from the stresses present in these pipes. F_Z is 0 in the case of bolted joints with no connected pipes. Where connecting pipes are installed in the normal manner and the service temperatures are < 400°C, F_Z may be determined, as an approximation, by applying the expression:

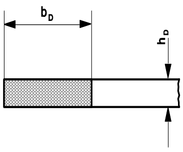
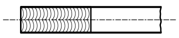
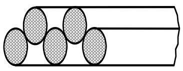
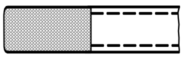
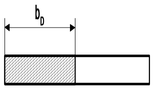
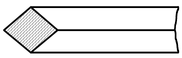
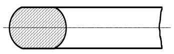
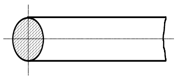
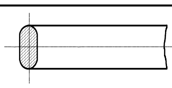
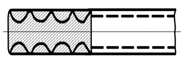
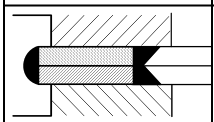
$$F_Z \approx \frac{d_i^2 \cdot \pi}{4} \cdot \frac{p_c}{10}$$

b) For the test pressure:

$$F'_S = \frac{p'}{p_c} \cdot \left[F_B + \frac{F_D}{1{,}2} \right] + F_Z \qquad \textbf{(31)}$$

For calculating the root diameter of the thread, F_S is to be substituted by F'_S in formula (27).

Table 15.14 Jointing factors

Jointing type	Shape	Description	Material	Gasket factor **(1)**					
				for liquids			for gases and vapours		
				assembly **(2)**		service	assembly **(2)**		service
				k_o	$k_o \cdot K_D$	k_1	k_o	$k_o \cdot K_D$	k_1
				[mm]	[N/mm]	[mm]	[mm]	[N/mm]	[mm]
Soft gaskets		Flat gaskets acc. to DIN 2690 DIN 2692	Impregnat-ed sealing material	-	$20b_D$	b_D	-	-	-
			Rubber	-	b_D	$0,5b_D$	-	$2b_D$	$0,5b_D$
			Teflon	-	$20b_D$	$1,1b_D$	-	$25b_D$	$1,1b_D$
			It **(4)**	-	$15b_D$	b_D	-	$200\sqrt{\frac{b_D}{h_D}}$ **(3)**	$1,3b_D$
Combined metal and soft gaskets		Spirally wound gasket	unalloyed steel	-	$15b_D$	b_D	-	$50b_D$	$1,3b_D$
		Corrugated gasket	Al	-	$8b_D$	$0,6b_D$	-	$30b_D$	$0,6b_D$
			Cu, Brass	-	$9b_D$	$0,6b_D$	-	$35b_D$	$0,7b_D$
			Mild steel	-	$10b_D$	$0,6b_D$	-	$45b_D$	$1,0b_D$
		metal-sheated gasket	Al	-	$10b_D$	b_D	-	$50b_D$	$1,4b_D$
			Cu, Brass	-	$20b_D$	b_D	-	$60b_D$	$1,6b_D$
			mild steel	-	$40b_D$	b_D	-	$70b_D$	$1,8b_D$
metal gaskets		Flat gasket acc. to DIN EN 2694	-	$0,8b_D$	-	b_D+5	b_D	-	b_D+5
		Diamond gasket	-	0,8	-	5	1	-	5
		Oval gasket	-	1,6	-	6	2	-	6
		Round gasket	-	1,2	-	6	1.5	-	6
		Ring gasket	-	1,6	-	6	2	-	6
		U-shaped gasket acc. to DIN 2696	-	1,6	-	6	2	-	6
	 Z = number of teeth	Corrugated gasket to DIN 2697	-	$0,4\sqrt{Z}$	-	9+0,2Z	$0,5\sqrt{Z}$	-	9+0,2Z
		Membrane welded gasket to DIN 2695	-	0	-	0	0	-	0

(1) *Applicable to flat, machined, sound, sealing surfaces.*
(2) *Where k_o cannot be specified, the product of $k_o \cdot K_D$ is given here.*
(3) *Must be a gastight grade.*
(4) *For information only.*

c) For the zero pressure, assembled condition:

$$F_{So} = F_{Do} + F_Z \qquad \textbf{(32)}$$

$$F_{Do} = D_b \cdot \pi \cdot k_o \cdot K_D \qquad \textbf{(33)}$$

For calculating root diameter of the thread, F_S is to be substituted by F_{So} in formula (27).

In the zero pressure, assembled condition, the force F_{Do} is to be exerted on the bolts during assembly to effect an intimate union with the sealing material and to close the gap at the flange bearing surfaces.

If the force exerted on assembly F_{Do} is greater than F_S, it may be replaced by the following where malleable jointing materials with or without metal elements are used:

$$F'_{Do} = 0{,}2 \cdot F_{Do} + 0{,}8 \cdot \sqrt{F_S \cdot F_{Do}} \qquad \textbf{(34)}$$

Characteristic k_o, k_1 and K_D depend on the type, design and shape of the joint and the kind of fluid. The relevant values are shown in the Tables 15.14 and 15.15.

Table 15.15 Deformation resistance K_D

Materials	Deformation resistance K_D [N/mm²]
aluminium, soft	92
copper, soft	185
soft iron	343
steel, St 35	392
alloy steel, 13 Cr Mo 44	441
austenitic steel	491
Note *At room temperature K_D is to be substituted by the deformation resistance at 10 % compression δ_{10} or alternatively by the tensile strength R_m.*	

10.4.4 The bolt design is to be based on the greatest root diameter of the thread determined in accordance with the three load conditions specified in items 10.4.1.

10.5 Design temperature t

The design temperatures of the bolts depend on the type of joint and the insulation. In the absence of special proof as to temperature, the following design temperatures are to be applied for medium temperatures above 120°C:

Loose flange + loose flange	temperature of medium contained -30°C
Fixed flange + loose flange	temperature of medium contained -25°C
Fixed flange + fixed flange	temperature of medium contained -25°C

The temperature reductions allow for the drop in temperature at insulated, bolted connections. For non-insulated bolted joints, a further temperature reduction is not permitted because of the higher thermal stresses imposed on the entire bolted joint.

10.6 Allowable stress

The values of the allowable stress σ_{perm} are shown in Table 15.16.

Table 15.16 Allowable stress σ_{perm}

Condition	For necked-down bolts	For full-shank bolts
Service condition	$\frac{R_{eH,t}}{1{,}5}$	$\frac{R_{eH,t}}{1{,}6}$
Test pressure and zero-pressure assembled condition	$\frac{R_{eH,20}}{1{,}1}$	$\frac{R_{eH,20}}{1{,}2}$

10.7 Surface finish coefficient, φ

10.7.1 Full-shank bolts are required to have a surface finish of at least grade mg to DIN 267. Necked down bolts must be machined all over.

10.7.2 In the case of unmachined, plane-parallel bearing surfaces, φ = 0,75. Where the bearing surfaces of the mating parts are machined, a value of

φ = 1,0 may be used. Bearing surfaces which are not plane-parallel (e.g. on angle sections) are not permitted.

10.8 Additional allowance c

The additional allowance c [mm] shall be as shown in Table 15.17 depending on the metric thread.

Table 15.17 Additional allowances c

Condition	c [mm]
For service conditions: up to M 24 M 27 up to M 45 M 48 and over	 3 $5 - 0{,}1 \cdot d_k$ 1
For test pressure	0
For assembled condition	0

E. Equipment and Installation

1. General

1.1 The following requirements apply to steam boilers which are not constantly and directly monitored during operation. Note is also to be taken of the official regulations of the flag country of the vessel, where appropriate.

1.2 In the case of steam boilers which are monitored constantly and directly during operation, some easing of the following requirements may be permitted, while maintaining the operational safety of the vessels.

1.3 In the case of steam boilers which have a maximum water volume of 150 litres, a maximum allowable working pressure of 10 bar and where the product of water volume and maximum allowable water pressure is less than 500, an easing of the following requirements may be permitted.

1.4 With With regard to the electrical installation and equipment also Chapter 105 - Electrical Installations and Chapter 106 - Automation has to be observed.

2. Safety Valves

2.1 Any steam boiler which has its own steam space is to be equipped with at least two reliable, spring-loaded safety valves. At least one safety valve is to be set to respond if the maximum allowable working pressure is exceeded.

In combination, the safety valves must be capable of discharging the maximum quantity of steam which can be produced by the steam boiler during continuous operation without the maximum allowable working pressure being exceeded by more than 10%.

2.2 Any steam boiler which has a shut-off but which does not have its own steam space is to have at least one reliable, spring-loaded safety valve fitted at its outlet. At least one safety valve is to be set to respond if the maximum allowable working pressure is exceeded. The safety valve or safety valves are to be designed so that the maximum quantity of steam which can be produced by the steam boiler during continuous operation can be discharged without the maximum allowable working pressure being exceeded by more than 10%.

2.3 External steam drums are to be fitted with at least two reliable, spring-loaded safety valves. At least one safety valve is to be set to respond if the allowable working pressure is exceeded. In combination, the safety valves must be capable of discharging the maximum quantity of steam which can be produced in continuous operation by all connected steam generators without the maximum allowable working pressure of the steam drum being exceeded by more than 10%.

2.4 The closing pressure of the safety valves shall be no more than 10% below the response pressure.

2.5 The minimum flow diameter of the safety valves must be 15 mm.

2.6 Servo-controlled safety valves are permitted wherever they are reliably operated without any external energy source.

2.7 The safety valves are to be fitted to the saturated steam part or, in the case of steam boilers which do not have their own steam space, to the steam-water outlet of the boiler.

2.8 Steam may not be supplied to the safety valves through pipes in which water may collect.

2.7 Safety valves must be easily accessible and capable of being released safely during operation.

2.8 Safety valves are to be designed so that no binding or jamming of moving parts is possible even when heated to different temperatures. Seals which may prevent the operation of the safety valve due to frictional forces are not permitted.

2.9 Safety valves are to be set in such a way as to prevent unauthorized alteration.

2.10 Pipes or valve housings must have a drain facility, which has no shut-off capability fitted at the lowest point on the blow-off side.

2.11 Combined blow-off lines from several safety valves may not unduly impair the blow-off capability. The discharging mediums are to be drained away safely.

3. Water level indicators

3.1 Steam boilers which have their own steam space are to be fitted with two devices giving a direct reading of the water level.

3.2 Steam boilers which have their own steam space heated by exhaust gases and where the temperature does not exceed 400 °C, are to be fitted with at least one device giving a direct reading of the water level.

3.3 External steam drums of boilers which do not have their own steam space are to be fitted with two devices giving a direct reading of the water level.

3.4 Cylindrical glass water level gauges are not permitted.

3.5 The water level indicators are to be fitted so that a reading of the water level is possible when the ship is heeling and during the motion of the ship when it is at sea. The limit for the lower visual range must be at least 30 mm above the highest flue, but at least 30 mm below the lowest water level. The lowest water level may not be above the centre of the visual range. The water level indicators must be well illuminated and visible from the boiler control station.

3.6 The connection pipes between steam generator and water level indicators must have an inner diameter of at least 20 mm. They must be run in such a way that there are no sharp bends in order to avoid water and steam traps, and must be protected from the effects of the heated gases and against cooling.

Where water level indicators are linked by means of common connection lines or where the connection pipes on the water side are longer than 750 mm, the connection pipes on the water side must have an inner diameter of at least 40 mm.

3.7 Water level indicators are to be connected to the water and steam chamber of the boiler by means of easily accessible, simple to control and quick-acting shut-off devices.

3.8 The devices used for blowing through the water level indicators must be designed so that they are safe to operate and so that blow-through can be monitored. The discharging media are to be drained away safely.

3.9 Remote water level indicators and display equipment of a suitable type to give an indirect reading may be allowed as additional display devices.

3.10 In place of water level indicators, once-through forced flow boilers must be fitted with two mutually independent devices which trip an alarm as soon as water flow shortage is detected. An automatic device to shut down the heating system may be provided in place of the second warning device.

3.11 The cocks and valves of the water level indicators which cannot be directly reached by hand from floor plates or a control platform must have a control facility using pull rods or chain pulls.

4. Pressure gauges

4.1 At least one pressure gauge directly connected to the steam space is to be fitted on each boiler. The maximum allowable working pressure is to be marked on the dial by means of a permanent and easily visible red mark.

4.2 At least one additional pressure indicator having a sensor independent from the pressure gauge has to be located at the machinery control centre or at some other appropriate site.

4.3 Where several steam boilers are incorporated on one ship, the steam chambers of which are linked together, one pressure gauge is sufficient at the machinery control centre or at some other suitable location, in addition to the pressure gauges on each boiler.

4.4 The pipe to the pressure gauge must have a water trap and must be of a blow-off type. A connection for a test gauge must be installed close to the pressure gauge. In the case of pressure gauges which are set off at a lower position the test connection must be provided close to the pressure gauge and also close to the connection piece of the pressure gauge pipe.

4.5 Pressure gauges are to be protected against radiant heat and must be well illuminated.

5. Temperature gauges

5.1 A temperature gauge is to be fitted to the flue gas outlet of fired steam boilers.

5.2 Temperature gauges are to be fitted to the exhaust gas inlet and outlet of steam boilers heated by exhaust gas.

5.3 Temperature gauges must be fitted at the outlets from superheaters or superheater sections, at the inlet and outlet of attemporators, and also at the outlet of once-through forced flow boilers, where this is necessary to assess the behaviour of the materials used.

6. Regulating devices (controllers)

6.1 With the exception of boilers which are heated by exhaust gas, steam boilers are to be operated with rapid-control, automatic firing systems. The control facility must be capable of safely controlling the scope of potential load changes so that the steam pressure and the temperature of the steam stay within safelimits and the supply of feed water is guaranteed.

6.2 Steam pressure must be automatically regu lated by controlling the supply of heat. The steam pressure of boilers heated by exhaust gas may also be regulated by condensing the excess steam.

6.3 In the case of boilers which have a specified minimum water level, the water level must be regu lated automatically by controlling the supply of feed water.

6.4 In case of forced-circulation boilers whose heating surface consists of a coiled pipe, and in case of once-through forced flow boilers, the supply of feed water may be regulated as a function of fuel supply.

7. Monitoring devices (alarms)

7.1 A warning device is to be fitted which is tripped when the specified maximum water level is exceeded.

7.2 In exhaust-gas heated boilers, a warning device is to be fitted which is tripped before the maximum allowable working pressure is reached.

7.3 In exhaust-gas heated boilers with a specified minimum water level, a warning device is to be fitted which is tripped when the water falls below this level.

7.4 Exhaust gas boilers with finned tubes are to have a temperature monitor fitted in the exhaust gas pipe which trips an alarm in the event of fire, see Chapter 106 – Automation

7.5 Where oil or grease may get into the steam or condensate system, a suitable automatic and continuously operating unit is to be installed which trips an alarm and cuts off the feed water supply if the concentration at which boiler operation is put at risk is exceeded.

7.6 Where there is a possibility of acid, lyes or seawater may get into the steam or condensate system, a suitable automatic and continuously operating unit is to be installed which trips an alarm and cuts off the feed water supply if the concentration at which boiler operation is put at risk is exceeded.

7.7 Function testing of the monitoring devices, even during operation, if an equivalent degree of safety is not attained by self-monitoring of the equipment.

7.8 The monitoring devices must trip visual and audible fault warnings in the boiler room or in the machinery control room or any other suitable site. See Chapter 106- Automation.

8. Safety Devices (Limiters)

8.1 The suitability of safety devices for marine use is to be proven by type testing.

The safety devices must be suitable for the use on steam boilers on ships.

8.2 Fired boilers are to be equipped with a reliable pressure limiter which cuts out and interlocks the firing system before the maximum allowable working pressure is reached.

8.3 In steam boilers on whose heating surfaces a highest flue is specified, two reliable, mutually independent water level limiters must respond to cut out and interlock the firing system when the water falls below the specified minimum water level.

The water level limiter must also be independent of the water level control devices.

8.4 The receptacles for water level limiters located outside the boiler must be connected to the boiler by means of lines which have a minimum inner diameter of 20 mm. Shut-off devices in these lines must have a nominal diameter of at least 20 mm. and must indicate their open or closed position. Where water level limiters are connected by means of common connection lines, the connection pipes on the water side must have an inner diameter of at least 40 mm.

Operation of the firing system may only be possible when the shut-off devices are open or else, after closure, the shut-off devices must reopen automatically and in a reliable manner.

Water level limiter receptacles which are located outside the boiler are to be designed in such a way that a compulsory and periodic blow-through of the receptacles and lines can be carried out.

8.5 In the case of forced-circulation boilers with a specified lowest water level, two reliable, mutually independent safety devices must be fitted in addition to the requisite water level limiters, which will cut out and interlock the heating system in the event of any unacceptable reduction in water circulation.

8.6 In the case of forced-circulation boilers where the heating surface consists of a single coiled pipe and of once-through forced flow boilers, two reliable, mutually independent safety devices must be fitted in place of the water level limiters in order to provide a sure means of preventing any excessive heating of the heating surfaces by cutting out and interlocking the firing system.

8.7 The safety devices must trip visual and audible alarms in the boiler room or in the machinery control room or any other appropriate site. Chapter 106 - Automation.

8.8 The electrical devices associated with the limiters are to be designed in accordance with the closed-circuit principle so that, even in the event of a power failure, the limiters will cut out and interlock the systems unless an equivalent degree of safety is achieved by other means.

8.9 To reduce the effects due to swell, water level limiters can be fitted with a delay function provided that this does not cause a dangerous drop in the water level.

8.10 The electrical interlocking of the firing system following tripping by the safety devices may only be cancelled out at the firing system control panel itself.

8.11 If an equivalent degree of safety cannot be achieved by the self-monitoring of the equipment, the safety devices must be subjected to operational testing even during operation. In this case, the operational testing of water level limiters must be carried out without the surface of the water dropping below the lowest water level.

8.12 For details of additional requirements relating to once-through forced flow boilers, see 3.10.

9. Feed and Circulation Devices

9.1 For details of boiler feed and circulation devices, see Section 8, F. The following requirements are also to be noted:

9.2 The feed devices are to be fitted to the steam boiler in such a way that it cannot be drained lower than 50 mm. above the highest flue when the non-return valve is not tight.

9.3 The feed water is to be introduced into the boiler in such a way as to prevent damage occurring to the boiler walls and to heated surfaces.

10. Shut-off Devices

10.1 Each steam boiler must be capable of being shut off from all connected pipes. The shut-off devices are to be installed as close as possible to the boiler walls and must operate without risk.

10.2 Where several boilers which have different maximum allowable working pressures give off their steam into common lines, it is necessary to ensure that the maximum working pressure allowable for each boiler cannot be exceeded in any of the boilers.

10.3 Where are several boilers are connected by common pipes and the shut-off devices for the steam, feed and drain lines are welded to the boiler, for safety reasons while the boilers are running. The shut-off devices are to be protected against unauthorized operation.

11. Scum Removal, Sludge Removal, Drain and Sampling Devices

11.1 Boilers and external steam drums are to be fitted with devices to allow them to be drained and the sludge removed. Where necessary, boilers are to be fitted with a scum removal device.

11.2 Drain devices and their connections must be protected from the effects of the heating gases and capable of being operated without risk. Self-closing sludge removal valves must be lockable when closed or alternatively an additional shut-off device is to be fitted in the pipe.

11.3 Where the scum removal, sludge removal or drain lines from several boilers are combined, a non-return valve is to be fitted in the individual boiler lines.

11.4 The scum removal, sludge removal or drain lines, plus valves and fittings, are to be designed to allow for maximum allowable working pressure of the boiler.

11.5 With the exception of once-through forced flow boilers, devices for taking samples from the water contained in the boiler are to be fitted to steam boilers.

11.6 Scum removal, sludge removal, drain and sampling devices must be capable of safe operation. The mediums being discharged are to be drained away safely.

12. Name Plate

12.1 A name plate is to be permanently affixed to each steam boiler, displaying the flowing information:

- Manufacturer,

- Build number and year of construction,

- Maximum allowable working pressure in bar,

- Steam production in kg/h or t/h,

- Permitted temperature of super-heated steam in °C provided that the boiler is fitted with a super-heater with no shut-off capability.

12.2 The name plate must be permanently attached to the largest part of the boiler or to the boiler frame so that it is visible.

13. Valves and Fittings

13.1 Materials

Valves and fittings for boilers must be made of ductile materials as specified in Table 15.1 and all their components must be able to withstand the loads imposed in operation, in particular thermal loads and possible stresses due to vibration. Grey cast iron may be used within the limits specified in Table 15.1, but may not be employed for valves and fittings which are subjected to dynamic loads, e.g. safety valves and blow-off valves.

Testing of material for values and fittings is to be carried out as specified in Table 15.2.

13.2 Design

Care is to be taken to ensure that the bodies of shutoff gate valves cannot be subjected to unduly high pressure due to heating of the enclosed water. Valves with screw-on bonnets must be safeguarded to prevent unintentional loosening of the bonnet.

13.3 Pressure and tightness tests

13.3.1 All valves and fittings are to be subjected to a hydrostatic pressure test at 1,5 times the nominal pressure before they are fitted. Valves and fittings for which no nominal pressure has been specified are to be tested at twice the working pressure.

In this case, the safety factor in respect of the 20°C yield point may not fall below 1,1.

13.3.2 The sealing efficiency of the closed valve is to be tested at the nominal pressure or at 1,1 times the working pressure, as applicable.

13.3.3 Pressure test and tightness test of valves and fittings shall be carried out in the presence of the TL surveyor.

14. Installation of Boilers

14.1 Mounting

Boilers must be installed in the ship with care must be secured to ensure that they cannot be displaced by any of the circumstances arising when the ship is at sea. Means are to be provided to accommodate the thermal expansion of the boiler in service. Boilers and their seatings must be easily accessible from all sides or must be easily rendered so.

14.3 Fire precautions

For fire precautions see Section 9.

F. Testing of Boilers

1. Manufacturing Test

After completion, boilers are to undergo a constructional test.

The constructional test includes verification that the boiler agrees with the approved drawings and is of satisfactory construction. For this purpose, all parts of the boiler must be accessible to allow adequate inspection. If necessary, the manufacturing test is to be performed at separate stages of manufacture. The following documents are to be presented; material test certificates covering the materials used, reports on the non-destructive testing of welds and, where applicable, the results of tests of workmanship and proof of the heat treatment applied.

2. Hydrostatic Pressure Tests

2.1 A hydrostatic pressure test is to be carried out on the boiler before refractory, insulation and casing are fitted. Where only some of the component parts are sufficiently accessible to allow proper visual inspection, the hydrostatic pressure test may be performed in stages. Boiler surfaces must withstand the test pressure without leaking or suffering permanent deformation.

2.2 The test pressure is generally required to be 1.5 times the maximum allowable working pressure, see A.4.2. In case the maximum allowable working pressure is less than 2 bar, the test pressure has to be at least 1 bar higher than the maximum allowable working pressure.

2.3 In the case of continuous-flow boilers, the test pressure must be at least 1,1 times the water inlet pressure when operating at the maximum allowable working pressure and maximum steam output. In the event of danger that parts of the boiler might be subjected to stresses exceeding 90% of the yield strength, the hydrostatic test may be performed in separate sections. The maximum allowable working pressure is then deemed to be the pressure for which the particular part of the boiler has been designed.

2.4 For boiler parts subject to internal and external pressures which invariably occur simultaneously in service, the test pressure depends on the differential pressure. In these circumstances, however, the test pressure should at least be equal to 1,5 times the design pressure specified in D.1.2.4.

3. Constructional test and hydrostatic pressure test shall be carried out by or in the presence of the TL surveyor.

G. Hot Water Generators

1. Design

Hot water generators with a allowable discharge temperature of > 120°C, which are heated by solid, liquid or gaseous fuels or by exhaust gases or electrically are to be treated in a manner analogous to that applied to boilers. The materials and strength calculations for hot water generators which are heated by steam or hot liquids are subject to the requirements in Section 16, Pressure Vessels.

2. Equipment

The safety equipment of hot water generators is subject to the requirements contained in E, as appropriate.

3. Testing

Each hot water generator is to be subjected to a constructional test and to a hydrostatic pressure test at 1,5 times the maximum allowable working pressure subject to a minimum of 4 bar in presence of a TL surveyor.

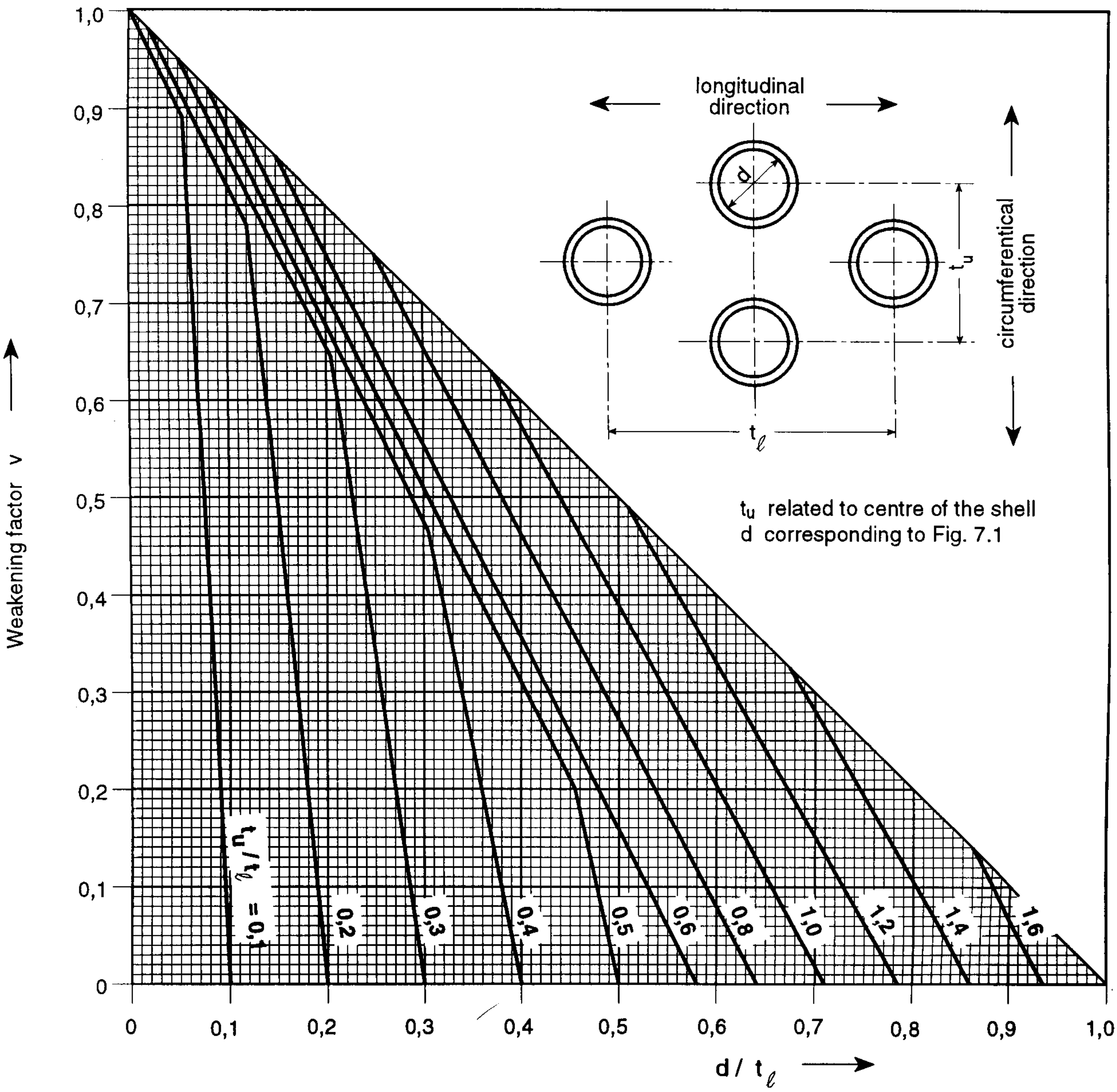


Fig. 15.27 Weakening factor v for cylindrical (shells) with symmetrically staggered rows of holes

SECTION 16

PRESSURE VESSELS

A. General

1. Scope

1.1 The following requirements apply to pressure vessels (gauge or vacuum pressure) for the operation of the main propulsion plant and its auxiliary machinery. They also apply to vessels and equipment necessary for the operation of the ship and to independent containers if these are subjected to internal or external pressure in service.

Gas cylinders are subject to the requirements in G.

1.2 The rules apply to a limited extent only (see 1.4) to pressure vessels and equipment with a maximum allowable working pressure of up to 1 bar gauge and with a total capacity, without deducting the volume of internal fittings, of not more than 1000 l and likewise to pressure vessels with a capacity of < 0,5 l.

1.3 Ship's service pressure vessels manufactured to recognized standards, e.g. pressure vessels for the water supply system, calorifiers and charge air coolers, are not subject to these requirements with respect to their wall thickness or the materials used. In the case of charge air coolers an examination of the drawings can be dispensed with.

1.4 The pressure vessels and equipment mentioned in 1.2 and 1.3 are to be presented to the TL Surveyor for final inspection (constructional test) and to be subjected to a hydrostatic pressure test in accordance with F. 1. in his presence.

1.5 Hot water generators with outlet temperatures above 120 °C which are heated by liquid fuels, by exhaust gases or electrically, as well as economizers heated by flue gas are subject to Section 15 - Auxiliary Steam Boilers.

For reservoirs in hydraulic systems, see also Section 14, F.

2. Documents for approval

Drawings of pressure vessels and equipment containing all the data necessary for their safety assessment are to be submitted to TL in triplicate.

The following details, in particular, are to be specified:

- intended use, substance to be contained in the vessel
- working pressures and temperatures, volumes of the individual spaces, secondary loads, if necessary
- design details of the pressurized parts
- materials to be used, welding details, heat treatment

B. Materials

1. General requirements

1.1 The materials of parts subject to pressure must be suitable for the intended use and comply with the TL Rules Chapter 2 - Materials

1.2 Parts such as ribs or girths, holders, supports, brackets etc. welded directly to pressure vessel walls are to be made of material compatible with that of the wall and of guaranteed weldability.

1.3 Welded structures are also subject to the TL Rules Chapter 3 - Welding.

1.4 For corrosion protection, see *C.7.*

2. Classes

2.1 According to operating conditions, vessels are to be classed in accordance with Table 16.1.

2.2 Pressure vessels filled partly with liquids and partly with air or gases or which are blown out by air or gases, such as pressure tanks in drinking water or sanitary systems and reservoirs, are to be classified as pressure vessels containing air or gas.

3. Approved materials

The materials specified in Table 16.2 are to be used for the classes stated in 2.

4. Testing of Materials

4.1 Tests in accordance with the TL Rules Chapter 2 and 3 - Materials and Welding (DIN EN 10204-3.1.C) or in accordance with another Standard recognized by TL are prescribed for materials belonging to pressure vessel class I used for:

- all parts subject to pressure with the exception of small parts such as welded pads, reinforcing discs, branch pieces and flanges of nominal diameter ≤ DN 32 mm, and forged or rolled steel valve heads for compressed air receivers

- forged flanges for service temperatures > 300 °C and for service temperatures ≤ 300 °C if the characteristic product of PB [bar] and DN [mm] is > 2500 or the nominal diameter is > DN 250

- bolts of size M 30 (30 mm diameter metric thread) and above made of steel with a tensile strength of more than 500 N/mm^2 and alloyed or heat-treated steel bolts larger than of size M 16

- nuts of size M 30 and above made of steel with a tensile strength of more than 600 N/mm^2

- bodies of valves and fittings, see Section 8, B.

4.2 For pressure vessel class II parts subject to mandatory testing, proof of material quality may take the form of work test certificates (DIN EN 10204 - 3.1.B) provided that the test results certified therein comply with TL Rules Chapter 2 and 3 - Materials and Welding.

Work test certificates may also be recognized for series-manufactured class I vessel components made of unalloyed steels, e.g. hand- and manhole covers, and for forged flanges and branch pipes where the characteristic product PB [bar] · DN [mm] ≤ 2500 and the nominal diameter DN ≤ 250 mm for service temperatures ≤ 300 °C.

4.3 For all parts not subject to testing of materials by TL, alternative proof of the characteristics of the material is to be provided, e.g. a work certificate (DIN EN 10204-2.2) as to the properties of the materials used.

C. Manufacturing Principles

1. Manufacturing processes applied to materials

Manufacturing processes must be compatible with the materials concerned. Materials whose grain structure has been adversely affected by hot or cold forming are to undergo heat treatment in accordance with the TL Rules Chapter 2 - Materials, Section 8, A.

2. Welding

The workmanship of welding, the approval of welding shops and the qualifying examination of welders are governed by the TL Rules Chapter 3 - Welding.

3. End plates

3.1 The flanges of dished ends may not be unduly hindered in their movement by any kind of fixtures, e.g. fastening plates or stiffeners. Supporting legs may only be attached to dished ends which have been adequately dimensioned for this purpose.

3.2 Where covers or ends are secured by hinged bolts, the latter are to be safeguarded against slipping off.

Table 16.1 Pressure vessel classes

Operating medium	**Design pressure PR [bar]** **Design temperature t [°C]**		
Class	**I**	**II**	**III**
Refrigerants	Group 2 **(1)**	Group 1 **(1)**	-
Steam, compressed air, gases	PR > 16 or t >300	PR ≤ 16 and t ≤ 300	PR ≤ 7 and t < 170
Liquid fuels	PR >16 or t >150	PR < 16 and t ≤ 150	PR< 7 and t < 60
Water and oils	PR > 40 or t > 300	PR ≤ 40 and t ≤ 300	PR ≤ 16 and t ≤ 200
(1) *see Section 12, C.1.*			

Table 16.2 Approved materials

<table>
<tr><th colspan="2" rowspan="3">Materials
semi-finished materials
Components</th><th colspan="3">Grades of material to be in accordance with TL Rules Chapter 2 - Materials Section 3 - 6</th></tr>
<tr><th colspan="3">Pressure vessel class</th></tr>
<tr><th>I</th><th>II</th><th>III</th></tr>
<tr><td rowspan="16">Rolled and forged steel</td><td rowspan="5">Steel plate, shapes and bars</td><td colspan="3">Plates for boilers and pressure vessels acc. to Chapter 2, Section 3, E.</td></tr>
<tr><td colspan="3">Low-temperature steels acc. to Chapter 2, Section 3, F.</td></tr>
<tr><td colspan="3">Stainless steels acc. to Chapter 2, Section 3, G.</td></tr>
<tr><td rowspan="2">Specially killed steels acc. to Chapter 2, Section 3, C., (with testing of each rolled plate)</td><td colspan="2">General structural steel acc. to Chapter 2, Section 3, C.</td></tr>
<tr><td>-</td><td>Shipbuilding steel acc. to Chapter 2, Section 3, B.</td></tr>
<tr><td rowspan="3">Pipes</td><td colspan="3">Seamless and welded ferritic steel pipes acc. to Chapter 2, Section 4, B. and C.</td></tr>
<tr><td colspan="3">Low-temperature steel pipes acc. to Chapter 2, Section 4, D. for design temperatures below -10 °C</td></tr>
<tr><td colspan="3">Stainless steel pipes acc. to Chapter 2, Section 4, E.</td></tr>
<tr><td rowspan="3">Forgings</td><td colspan="3">Forgings acc. to Chapter 2, Section 5, E.</td></tr>
<tr><td colspan="3">Low-temperature steel forgings acc. to Chapter 2, Section 5, F. for design temperatures below -10 °C</td></tr>
<tr><td>-</td><td colspan="2">Forgings for general plant engineering acc. to Chapter 2, Section 5, B.</td></tr>
<tr><td rowspan="3">Bolts and nuts</td><td colspan="3">Bolts for general plant engineering acc. to recognized standards, e.g. DIN 267 or ISO 898</td></tr>
<tr><td colspan="3">High-temperature steels for design temperatures > 300 °C</td></tr>
<tr><td colspan="3">Low-temperature steels for design temperatures below - 10 °C</td></tr>
<tr><td rowspan="6">Castings</td><td rowspan="4">Cast steel</td><td colspan="3">Steel castings for boilers, pressure vessels and pipelines acc. to Chapter 2, Section 6, D.</td></tr>
<tr><td colspan="3">High-temperature steel castings for design temperatures > 300 °C.</td></tr>
<tr><td colspan="3">Low-temperature steel castings acc. to Chapter 2, Section 6, E. for design temperatures below -10 °C</td></tr>
<tr><td colspan="2">-</td><td>Steel castings for plant engineering acc. to Chapter 2, Section 6, B.</td></tr>
<tr><td>Nodular cast iron</td><td colspan="3">Nodular cast iron acc. to Chapter 2, Section 7, B.
Ferritic grades only
Ordinary qualities up to 300 °C
Special qualities up to 350 °C</td></tr>
<tr><td>Grey cast iron</td><td colspan="2">-</td><td>At least grade with a minimum tensile strength of 200N/mm^{2}acc. to Chapter 2, Section 7, C. Not permitted for vessels in thermal oil systems</td></tr>
<tr><td rowspan="2">Non-ferrous metals</td><td>Pipes and castings of copper and copper alloys</td><td colspan="3">Copper alloys acc. to Chapter 2, Section 10 within the following limits:
copper-nickel alloys up to 300 °C
high-temperature bronzes up to 260 °C
others up to 200 °C</td></tr>
<tr><td>Plate, pipes and castings of aluminium alloys</td><td colspan="3">Aluminium alloys acc. to Chapter 2, Section 9 within the following limits:
design temperature up to 200 °C
only with the special agreement of TL</td></tr>
</table>

4. Branch pipes

The wall thickness of branch pipes must be dimensioned as to enable additional external stresses to be safely absorbed. The wall thickness of welded-in branch pipes should be appropriate to the wall thickness of the part into which they are welded. The walls must be effectively welded together.

For the attachment of piping, pipe connections in accordance with Section 8 are to be provided.

5. Tube plates

Tube holes must be carefully drilled and deburred. Bearing in mind the tube-expansion procedure and the combination of materials involved, the ligament width must be such as to ensure proper expanding process and sufficient tube anchorage. The expanded length should not be less than 12 mm.

6. Compensation for expansion

The design of vessels and equipment has to take account of possible thermal expansion, e.g. between shell and bundle of heating tubes.

7. Corrosion protection

Vessels and equipment exposed to accelerated corrosion owing to the medium which they contain, e.g. warm seawater, must be protected in a suitable manner.

8. Cleaning and inspection openings

8.1 Vessels and equipment are to be provided with inspection and access openings which should be as large as possible and conveniently located. The minimum dimensions are as follows:

Manholes	320 x 420 mm or 400 mm diameter
Headholes	220 x 320 mm or 320 mm diameter
Handholes	87 x 103 mm
Sightholes	are required to have a diameter of at least 50 mm; they should, however, be provided only when the design of the equipment makes a handhole impracticable.

In order to provide access with auxiliary or protective devices, a manhole diameter of at least 600 mm is generally required. The diameter may be reduced to 500 mm where the pipe socket height to be passed through does not exceed 250 mm.

Vessels over 2,0 m in length must have inspection openings at least at both ends or must contain a manhole.

Pressure vessels with an inside diameter of more than 800 mm must be accessible.

8.2 Manhole openings must be designed and sited in such a way that the vessels are accessible without undue difficulty. The edges of inspection and access openings are to be stiffened where they could be deformed by tightening the cover-retaining bolts or crossbars.

Special inspection and access openings are not necessary where internal inspection can be carried out by removing or dismantling parts.

8.3 Inspection openings may be dispensed with where experience has proven the unlikelihood of corrosion or deposits, e.g. in steam jackets.

Where vessels and equipment contain dangerous substances, e.g. liquefied or toxic gases, the covers of inspection and access openings shall not be secured by crossbars but by bolted blind flanges.

9. Identification and marking

Each pressure vessel is to be provided with a plate or permanent inscription indicating the manufacturer, the serial number, the year of manufacture, the capacity, the maximum allowable working pressure and, in case of service temperatures of more than 50 °C or less than -10°C, the service temperature of the pressurized parts. On smaller items of equipment an indication of the allowable working pressure is sufficient.

D. Design Calculations

1. Principles

1.1 The parts of pressure vessels and equipment subject to pressure are to be designed, as far as applicable, by the formulae for steam boilers, Section 15, and otherwise in accordance with the general rules of engineering practice. **(1)** The calculations are to be based on the details specified in 1.2 to 1.7.

1.2 Design pressure PR
Formula symbol: p_c

1.2.1 The design pressure is generally the maximum allowable working pressure (gauge). In determining the maximum allowable working pressure, due attention is to be given to hydrostatic pressures if these cause the loads on the walls to be increased by 5 % or more.

1.2.2 In the case of feedwater heaters located on the delivery side of the boiler feed pump, the maximum allowable working pressure is the maximum delivery pressure of the pump.

1.2.3 For external pressures, the calculation is to be based on a vacuum of 1 bar or on the external pressure at which the vacuum safety valves are actuated. In the event of simultaneous positive pressure externally and vacuum internally, or vice versa, the calculation is to assume an external or, respectively, internal pressure increased by 1 bar.

(1) *The TRB/AD-Merkblätter (Regulations of the Working Party on Pressure Vessels), Beuth Verlag GmbH, D-10787 Berlin, constitute, for example, such rules of engineering practice.*

1.3 Allowable stress

The dimensions of components are governed by the allowable stress σ_{perm} [N/mm^2]. The smallest value determined from the following expressions is to be applied in this case:

1.3.1 Rolled and forged steels

For design temperatures up to 350 °C:

$$\frac{R_{m,20^\circ}}{2,7}\ ,\quad \frac{R_{eH,20^\circ}}{1,7}\ ,\quad \frac{R_{eH,t}}{1,6}$$

$R_{m,20^\circ}$ = guaranteed minimum tensile strength [N/mm^2] at room temperature, may be dispensed with in the case of recognized fine-grained steels with R_{eH} < 360 N/mm^2

$R_{eH,20^\circ}$ = guaranteed yield stress or minimum value of the 0,2 % proof stress **(2)** at room temperature [N/mm^2]

$R_{eH,t}$ = guaranteed yield stress or minimum value of the 0,2 % proof stress **(2)** at design temperatures above 50 °C [N/mm^2]

For design temperature above 350 °C

$$\frac{R_{m,100000,t}}{1,5}$$

$R_{m,100000,t}$ = average breaking strength after 100000 h of operation at design temperature t [N/mm^2]

1.3.2 Cast materials

- Cast steel: $\frac{R_{m,20^\circ}}{3,2}\ ;\ \frac{R_{eH,t}}{2,0}\ ;\ \frac{R_{m,100000,t}}{2,0}$

- Nodular cast iron: $\frac{R_{m,20^\circ}}{4,8}\ ;\ \frac{R_{eH,t}}{3,0}$

- Grey cast iron: $\frac{R_{m,20^\circ}}{11}$

(2) *1 % proof stress in case of austenitic steel.*

1.3.3 Non-ferrous metals

- Copper and copper wrough alloys: $\frac{R_{m,t}}{4,0}$

- Aluminium and aluminium wrough alloys: $\frac{R_{m,t}}{4,0}$

$R_{m,t}$ = guaranteed minimum tensile strength at design temperatures above 50 °C [N/mm^2]

With non-ferrous metals supplied in varying degrees of hardness it should be noted that heating, e.g. at soldering or welding, can cause a reduction in strength. In these cases, calculations are to be based on the strength in the soft-annealed condition.

1.4 Design temperature

1.4.1 The design temperature to be applied is gen erally the maximum temperature of the medium to be contained.

1.4.2 Where heating is provided by means of oil firing, exhaust gases or electrical installations, Section 15, Table 15.3 is to be applied as appropriate. Where electrical heating is used, Table 15.3 applies only to directly heated surfaces.

1.4.3 With service temperatures below 20 °C, a design temperature of at least 20 °C is to be used in calculations.

1.5 Weakening factor

For the weakening factors v, see Section 15, Table 15.4.

1.6 Allowance for corrosion and wear

The allowance for corrosion and wear is generally c = 1 mm. It may be dispensed with in the case of plate thickness of 30 mm or more, stainless steels and other corrosion resistant materials.

1.7 Minimum wall thickness

1.7.1 The wall thickness of the shells and end plates should generally not be less than 3 mm.

1.7.2 Where the walls of vessels are made from pipes or corrosion resistant materials or for vessels and equipment of class III, a minimum wall thickness of 2 mm can be allowed, provided that the walls are not subjected to external forces.

1.8 Other rules applicable for design

Where walls, or parts of walls, cannot be calculated by applying the formulae given in Section 15 or in accor-dance with the general rules of engineering practice, other acknowledged methods are to be used to demonstrate that the allowable stresses are not exceeded.

E. Equipment and Installation

1. Shut-off devices

Shut-off devices must be fitted in pressure lines as close as possible to the pressure vessel. Where several pressure vessels are grouped together, it is not necessary that each vessel should be capable of being shut-off individually and means need only be provided for shutting off the group. In general, not more than three vessels should be grouped together. Starting air receivers and other pressure vessels which are opened under service conditions must be capable of being shut-off individually. Devices incorporated in piping, e.g. water and oil separators, do not require shut-off devices.

2. Pressure gauges

2.1 Each pressure vessel which can be shut-off and every group of vessels with a shut-off device must be equipped with a pressure gauge, also capable of being shut-off. The measuring range and calibration must extend to the test pressure with a red mark to indicate the maximum allowable working pressure.

2.2 Equipment need only be fitted with pressure gauges when this is necessary for its operation.

3. Safety equipment

3.1 Each pressure vessel which can be shut-off or every group of vessels with a shut-off device must be equipped with a spring-loaded safety valve which cannot be shut-off and which closes again reliably after blow-off.

Appliances for controlling pressure and temperature are no substitute for relief valves.

3.2 Safety valves must be designed and set in such a way that the max. allowable working pressure cannot be exceeded by more than 10 %. Means must be provided to prevent the unauthorized alteration of the safety valve setting. Valve cones must be capable of being lifted at all times.

3.3 Means of drainage which cannot be shut-off are to be provided at the lowest point on the discharge side of safety valves for gases, steam and vapours. Facilities must be provided for the safe disposal of hazardous gases, vapours or liquids discharging from safety valves. Heavy oil flowing out must be drained off via an open funnel.

3.4 Steam-filled spaces are to be fitted with a safety valve if the steam pressure is liable to exceed the maximum allowable working pressure.

3.5 Heated spaces which can be shut-off on both the inlet and the outlet side are to be fitted with a safety valve which will prevent an inadmissible pressure increase should the contents of the space undergo dangerous thermal expansion or the heating elements fail.
Besides a temperature controller, electrically heated appliances are also to be equipped with a safety thermal limiter.

3.6 Pressure water tanks are to be fitted with a safety valve on the water side. A safety valve on the air side may be dispensed with if the air pressure supplied to the tank cannot exceed its maximum allowable working pressure.

3.7 Calorifiers are to be fitted with a safety valve at the cold water inlet.

3.8 Rupture discs are permitted only with the consent of TL in applications where their use is specially justified. They must be so designed that the maximum allowable working pressure cannot be exceeded by more than 10 %.

Rupture discs must be provided with a guard to catch the fragments of the rupture element and must be protected against damage from outside. The fragments of the rupture element shall not be capable of reducing the necessary section of the discharge aperture.

3.9 Pressure relief devices can be dispensed with in the case of accumulators in pneumatic and hydraulic control and regulating systems provided that the pressure which can be supplied to these accumulators cannot exceed the maximum allowable working pressure and that the pressure-volume product is
PB [bar] · V [ℓ] ≤ 200.

4. Liquid level indicators and feed equipment for heated pressure vessels

4.1 Heated pressure vessels in which a drop of the liquid level can result in unacceptably high temperatures in the vessel walls must be fitted with a device for indicating the level of the liquid.

4.2 Pressure vessels with a fixed minimum liquid level must be fitted with feed equipment of adequate size.

5. Sight glasses

Sight glasses in surfaces subject to pressure are allowed only if they are necessary for the operation of the plant and other means of observation cannot be provided. They should not be larger than necessary and should preferably be round. Sight glasses must be protected against mechanical damage, e.g. by wire mesh. With combustible, explosive or poisonous media, sight glasses must be fitted with closable covers.

6. Draining and venting

6.1 Pressure vessels and equipment must be capable of being depressurized and completely emptied or drained. Particular attention is to be given to the adequate drainage facilities of compressed air vessels.

6.2 Suitable connections for the execution of hydraulic pressure tests and a vent at the uppermost point must be provided.

7. Installation

7.1 When installing and fastening pressure vessels onboard ship care is to be taken to ensure that the loads due to content and structural weight of the vessel, to movements of the ship and to vibrations cannot rise to any excessive stress increases in the vessel's surfaces. Where necessary, surfaces in the region of supports and mountings are to be fitted with reinforcing plates.

7.2 Pressure vessels and equipment are to be installed in such a way as to provide for practicable all-round visual inspection and to facilitate the execution of periodic tests. Where necessary, ladders or step irons are to be fitted inside vessels.

7.3 Wherever possible, horizontal laying compressed air receivers should be installed at an angle and parallel to the centre line of the ship. The angle should be at least 10 ° (with the valve head at the top). Where vessels are installed athwartships, the angle should be greater, compare Section 1, D.

7.4 Where necessary, compressed air receivers are to be marked on the outside to indicate that they can be installed onboard ship in the position necessary for complete venting and drainage.

7.5 Support considering shock loads

If a naval ship is designed to withstand shock loads additional requirements for the support of pressure vessels in accordance with Chapter 102 - Hull Structures and Ship Equipment, Section 16, D. have to be fulfilled.

F. Tests

1. Pressure tests

1.1 After completion, pressure vessels and equipment have to undergo constructional and hydrostatic tests. No permanent deformation of the walls may result from these tests.

During the hydrostatic test, the stresses specified in the following may not be exceeded:

for materials with a definite yield stress:	for materials without a definite yield stress:
$\frac{R_{eH,20°}}{1,1}$	$\frac{R_{m,20°}}{2,0}$

1.2 The test pressure PP for pressure vessels and equipment is generally 1,5 times the maximum allowable working pressure PB, subject to a minimum of PB + 1 bar.

In the case of pressure vessels and equipment which are only subjected to pressure below atmospheric pressure, the test pressure must at least match the allowable working pressure. Alternatively a pressure test can be carried out with a pressure which is 2 bar in excess of the atmospheric pressure.

1.3 All pressure vessels and equipment located in the fuel oil pressure lines of oil firing equipment for boilers are to be tested on the oil side with a test pressure of 1,5 times the maximum allowable working pressure, subject to a minimum of 5 bar. On the steam side the test is to be performed as specified in 1.2.

1.4 Pressure vessels in water supply systems which correspond to Standard DIN 4810 are to be tested at pressures of 5,2 bar, 7,8 bar or 13,0 bar as specified in the Standard.

1.5 Air coolers, e.g. supercharge air coolers, are to be tested on the water side at 1,5 times the maximum allowable working pressure, subject to a minimum of 4 bar.

1.6 Pressure tests with media other than water may be agreed to in special cases.

2. Tightness tests

For vessels and equipment containing dangerous substances, TL reserve the right to call for a special test of gastightness.

3. Testing after installation on board

Following installation onboard ship, a check is carried out on the fittings of vessels and equipment and on the arrangement and setting of safety appliances, and operating tests are performed wherever necessary.

G. Gas Cylinders

1. General

For the purposes of these requirements, gas cylinders are bottles with a capacity of not more than 150 l with an outside diameter of ≤ 420 mm and a length of ≤ 2000 mm which are charged with gases in special filling stations and are thereafter brought on board ship where the pressurized gases are used, see also Section 9.

2. Manufacture

2.1 Gas cylinders must be manufactured by established methods using suitable materials and must be designed that they are well able to withstand the expected loads.

2.2 The manufacturing process is subject to approval. For this purpose, the following documents are to be submitted:

2.2.1 A description of the manufacturing process with indicating the production controls normally carried out in the manufacturer's works.

2.2.2 Details of the materials to be used (guide analysis, yield point, tensile strength, impact strength, heat treatment).

2.2.3 Drawings in triplicate with details of the stamped marking to be applied.

3. Design calculation

3.1 Definitions

p_c = design pressure (specified test pressure) [bar]

s = wall thickness [mm]

D_a = outside diameter of gas cylinder [mm]

R_{eH} = guaranteed upper yield stress [N/mm^2]

$R_{p0,2}$ = guaranteed 0,2 % proof stress [N/mm^2]

R_m = guaranteed minimum tensile strength [N/mm^2]

R_e = yield stress needed as comparative value for the determination of R [N/mm^2]

either $R_e = R_{eH}$
or $R_e = R_{p0,2}$

R = in each case the smaller of the following two values [N/mm^2]:

1) R_e

2) - 0,75 R_m for normalized or normalized and tempered cylinders

- 0,90 R_m for quenched and tempered cylinders

σ_{perm} allowable stress [N/mm^2] = $\frac{R}{4/3}$

β design coefficient for dished ends [-], see Section 15, D.4.

v weakening factor [-], see Section 15, D.2.

3.2 Cylindrical surfaces

$$s = \frac{D_a \cdot p_c}{20 \cdot \sigma_{perm} \cdot v + p_c}$$

3.3 Dished ends

$$s = \frac{D_a \cdot p_c \cdot \beta}{40 \cdot \sigma_{perm}}$$

3.4 Spherical ends

$$s = \frac{D_a \cdot p_c}{40 \cdot \sigma_{perm} \cdot v + p_c}$$

The conditions applicable to dished ends are shown in Figure 16.1:

4. Test pressure

The specified test pressure for CO_2 bottles with a filling factor of 0,66 kg/l is 250 bar gauge. For other gases, the test pressure can be taken from the German "Technische Regeln Druckgase" (TRG = Technical Rules for Gases under Pressure) or may be agreed with TL.

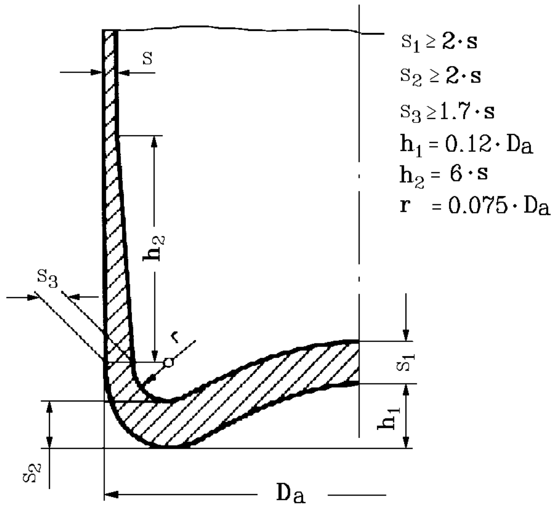


Fig. 16.1 Conditions at dished ends of gas cylinders

5. Testing of gas cylinders

5.1 Sampling

5.1.1 Normalized cylinders

Two sample cylinders from each 400 originating from one melt and one heat treatment.

5.1.2 Quenched and tempered cylinders

Two sample cylinders per 200 out of one melt and one heat treatment.

5.2 Tests

5.2.1 One longitudinal tensile test specimen, three transverse bending test specimens and a set of ISO V-type notched bar impact test specimens longitudinal and transverse are to be taken from the sample cylin ders according to 5.1.1 and 5.1.2. The notched bar impact test specimens are to be tested at -20 °C.

5.2.2 The second test bottle is to be subject to a bursting test according to 5.2.9.

5.2.3 In the case of lots of less than 400 pieces of normalized and/or 200 pieces of quenched and tempered bottles, only every other lot is to be subjected to a bursting test.

5.2.4 The cylindrical wall thickness of all sample cylinders is to be measured in transverse planes at three levels (neck, middle and base). The end plate is also to be sawn through and the thickness measured.

5.2.5 Examination of the inner surface of the neck and bottom portions of the sample cylinders to detect possible manufacturing defects.

5.2.6 Hydrostatic testing of all cylinders submitted for testing.

5.2.7 Final visual inspection of cylinders, including a check on the weight and volumetric capacity of about 10 % of the cylinders submitted for testing. Check of the stamped marking.

5.2.8 The manufacturer must establish the volumetric capacity and weight of each cylinder. Cylinders which have been quenched and tempered are to be submitted by the manufacturer to 100 % hardness testing.

5.2.9 Test bottles intended to be subjected to a bursting test must be clearly identified as to the lot from which they have been taken.

5.2.9.1 The hydrostatic bursting test is to be carried out in two subsequent stages, by means of a testing device enabling the pressure to be continuously increased up to bursting of the bottle and the pressure curve to be recorded as a function of time. The test must be carried out at room temperature.

5.2.9.2 During the first stage, the pressure has to continuously increase, up to the value at which plastic deformation starts; the pressure increase must not exceed 5 bar/sec.

Once the point of plastic deformation has been reached (second stage), the pump capacity must not exceed twice the capacity of the first stage; it has then to be kept constant until the bottle bursts.

6. Marking and identification

Each gas cylinder is to be marked with the following:

- name or trade name of the manufacturer
- serial number
- type of gas
- design strength value [N/mm^2]
- capacity [l]
- test pressure [bar]
- empty weight [kg]
- date of test
- test stamp

7. Recognition of equivalent tests

Tests verified by other institutions may be recognized provided that they are established as being equivalent to those prescribed above.

SECTION 17

OIL FIRING EQUIPMENT

A. General

1. Scope

The following requirements apply to oil firing equipment with fully automatic and semi automatic oil burners.

2. Documents for approval

A sectional drawing of each type of burner together with a description of its mode of operation and also circuit diagrams and equipment lists of the electrical control system are to be submitted to TL in triplicate for approval.

3. Approved fuels

For approved fuels see Chapter 104 Propulsion Plants, Section 1, F.

4. Boiler equipment and burner arrangement

4.1 Oil burners are to be designed, fitted and adjusted in such a manner as to prevent flames from causing damage to the boiler surfaces or tubes which border the combustion space. Boiler parts which might otherwise suffer damage are to be protected by refractory lining.

The firing system shall be arranged as to prevent flames from blowing back into the boiler or engine room and allow unburned fuel to be safely drained.

4.2 Observation openings must be provided at suitable points on the boiler or burner through which the ignition flame, the main flame and the lining can be observed.

4.3 Fuel leaking from potential leak points is to be safely collected in oiltight trays and drained away, see Section 9, B.4.1.

5. Simultaneous operation of oil firing equipment and internal combustion machinery

The operation of oil firing equipment in spaces containing other plants with a high air consumption, e.g. internal combustion engines or air compressors, must not be impaired by variations of the atmospheric pressure.

B. Oil Firing Equipment for Boilers

1. General

1.1 Boilers without permanent and direct supervision are to be operated with automatic firing sys tems.

1.2 A facility is to be provided for manual operation (emergency operation). Flame monitoring must remain operative even in manual operation.

1.3 Manual operation demands permanent and direct supervision of the system.

1.4 Safety devices may only be bridged by means of a key-operated switch.

2. Pumps, pipelines, valves and fittings

2.1 Oil fired boilers must be equipped with at least two fuel oil service pumps and change-over duplex filters in the pump suction and discharge lines. The pumps are to be rated and arranged in such a way that the oil firing equipment remains operational even if one unit should fail.

This applies unless, in the event of failure of a single unit, other means are provided for maintaining continuous operation at sea.

2.2 Fuel oil service pumps may be connected only to the fuel system.

2.3 The requirements in 2.1 apply in analogous manner where the fuel oil is stored in gravity tanks.

2.4 Pipelines must be permanently installed and joined by oiltight welds, oiltight thread connections of approved design or with flanged joints. Flexible pipes may be used only directly in front of the burner to enable the burner to swivel or to be retracted. They must be installed with adequate bending radii and must be protected against inadmissible heating. For non-metallic flexible tubes and expansion compensators, see Section 8, G.

2.5 Suitable devices, e.g. relief valves, must be fitted to prevent any excessive pressure increase in the fuel oil pump or pressurized fuel lines.

2.6 By means of a hand-operated quick-closing device mounted at the fuel oil manifold, it must be possible to isolate the fuel supply to the burners from the pressurized fuel lines. Depending on design and method of operation, a quick-closing device may also be required directly in front of each burner.

3. Safety equipment

3.1 The correct sequence of safety functions when the burner is started up or shut down is to be ensured by means of a burner control box.

3.2 Two automatic shut-off devices must provided at the fuel oil supply line to the burner.

For the fuel oil supply line to the ignition burner one automatic shut-off device will be sufficient, if the fuel oil pump is switched off after ignition of the burner.

3.3 In an emergency it must be possible to close the automatic shut-off devices from the boiler control platform and - where applicable - from the control centre.

3.4 The automatic shut-off device must not release the oil supply to the burner during start up and must interrupt the oil supply during operation (auto matic restart possible), if one of the following faults occur:

a)
- failure of the required pressure of the atomizing medium (steam and compressed air atomizers)
- failure of the oil pressure needed for atomization (pressure atomizers)
- insufficient rotary speed of spinning cup or primary air pressure too low (rotary atomizers)

b) failure of combustion air supply

c) failure of control power supply

d) failure of induced-draught fan or insufficient opening of exhaust gas register

e) burner retracted or pivoted out of position

3.5 The fuel oil supply must be interrupted by closing the automatic shut-off devices and interlocked by means of the burner control box, if

- a flame does not develop within the safety period following start-up, see 4.7
- the flame is extinguished during operation and an attempt to restart the burner within the safety period is unsuccessful, see 4.7
- limit switches are actuated

3.6 If burners are equipped with return lines, these lines must also be provided with an automatic shut-off device. The shut-off device in the return line may be dispensed with if the return line is not under pressure and no oil is able to flow back when the burner is shut down.

3.7 Oil firing equipment with electrically operated components must also be capable of being shut down by an emergency switch located outside the space in which the equipment is installed.

3.8 The suitability of safety and monitoring devices, e.g. burner control box, flame monitoring device, automatic shut-off device and limiters, for marine use is to be proven by type testing.

4. Design and construction of burners

4.1 The type and design of the burner **(1)** and its atomizing and air turbulence equipment must ensure virtually complete combustion.

4.2 Oil burners must be so designed and con structed that personnel cannot be endangered by moving parts. This applies particularly to blower intake openings. The latter must also be protected to prevent the entry of drip water.

4.3 The high-voltage ignition system must be automatically disconnected when the oil burner is retracted or pivoted out of the operating position. A catch is to be provided to hold the burner in the swung out position.

4.4 Where dampers or similar devices are fitted in the air supply duct, care must be taken to ensure that air for purging the combustion chamber is always available unless the oil supply is necessarily interrupted.

4.5 Where an installation comprises several burners supplied with combustion air by a common fan, each burner must be fitted with a shut-off device (e.g. a flap). Means must be provided for retaining the shut-off device in position and its position must be indicated.

4.6 Every burner must be equipped with an igniter. The ignition is to be initiated immediately after purging. In the case of low-capacity burners of monobloc type (permanently coupled oil pump and fan) ignition may begin with start-up of the burner unless the latter is located in the roof of the chamber.

(1) *For the purpose of these rules, the following definitions apply:*

Fully automatic oil burners

are burners equipped with automatic igniters, automatic flame monitors and automatic controls so that the ignition, flame monitoring and burner start-up and shut-down are effected as a function of the controlled variable without the intervention of operating personnel.

Semi-automatic oil burners are burners equipped with automatic igniters, automatic flame monitors and automatic controls. Burner start-up is initiated manually. Shut-down may be initiated manually. Burner shutdown is not followed by automatic re-ignition.

Manually operated oil burners

are burners where every ignition sequence is initiated and carried out by hand. The burner is automatically monitored and shut down by the flame monitor and by limiters where required by the safety system. Re-starting can only be carried out directly at the burner and by hand.

4.7 Every burner is to be equipped with a safety device for flame monitoring. This appliance must comply with the following safety periods **(2)** on burner start-up or when the flame is extinguished in operation:

on start-up	5 seconds
in operation	1 second

Measures must be taken to ensure that the safety period for the main flame is not prolonged by the action of the igniter (e.g. pilot burners).

4.8 Where burners are blown through after shut-down, provision must be made for the safe ignition of the residual oil ejected.

5. Purging of combustion chamber and flues, exhaust gas ducting

5.1 The combustion chamber and flues are to be adequately purged with air prior to every burner start-up. A warning sign is to be mounted to this effect.

5.2 A threefold renewal of the total air volume of the combustion chamber and the flue gas ducts up to the funnel inlet is considered sufficient. Normally purging shall be performed with the total flow of combustion air for at least 15 seconds. It shall, however, in any case be performed with at least 50 % of the volume of combustion air needed for the maximum heating power of the firing system.

5.3 Bends and dead corners in the exhaust gas ducts are to be avoided.

Dampers in uptakes and funnels should be avoided. Any damper which may be fitted must be so installed that no oil supply is possible when the cross section of the purge line is reduced below a certain minimum value. The position of the damper must be indicated at the boiler control platform.

(2) *The safety period is the maximum permitted time during which fuel oil may be supplied to the combustion space in the absence of a flame.*

5.4 Where an induced-draught fan is fitted, an interlocking system must prevent start-up of the firing equipment before the fan has started. A corresponding interlocking system is also to be provided for any flaps which may be fitted to the funnel opening.

6. Electrical equipment

Electrical controls, safety appliances and their types of enclosure must comply with Chapter 105- Electrical Installations and Chapter 106- Automation.

7. Testing

7.1 The installation on board is to be subjected to operational tests including, in particular, determination of the purging time required prior to burner start-up. Satisfactory combustion at all load settings and the reliable operation of the safety equipment are to be checked.

7.2 After installation, the pressurized fuel oil system is to be subjected to a pressure and tightness test, see Section 8, B.4.

SECTION 18

DIVING SYSTEMS AND SYSTEMS FOR BREATHING GASES

A. General Rules and Instructions

1. General

1.1 The requirements defined in this Section are to be applied for diving systems and systems for production, bottling and storage of breathing gases which will be classified by TL and for which the Class Notation **DI** will be affixed to the Character of Classification, see also Chapter 101 - Classification and Surveys, Section 2, C.

1.2 If fixed diving systems are to be installed on board, such systems have to be manufactured and installed according to the TL Rules Chapter 52 - Diving Systems and Diving Simulators.

1.3 For the installation of diving compression chambers the TL Rules Chapter 53- Diving Systems and Diving Simulators have to be applied.

1.4 For the manufacturing and operating of underwater equipment the TL Rules Chapter 54 - Underwater Equipment have to be applied.

1.5 Especially the requirements for systems regarding to breathing gases will be defined in the following.

1.6 Designs differing from these Rules may be permitted provided their suitability has been verified by TL and they have been recognized as equivalent.

For such differing designs TL is entitled to require the submission of additional documentation and the performance of special tests.

1.7 National regulations existing besides the TL Rules are unaffected.

2. Definitions

2.1 Breathing gases/breathing gas mixtures

Breathing gases / breathing gas mixtures are all gases and gas mixtures which are used during diving missions resp. during use of breathing apparatus.

2.2 Bottles / gas cylinders

Bottles/gas cylinders are pressure vessels for storage and transport of breathing gases under pressure.

2.3 Bottling plant

Bottling plants are used for filling pressure vessels for breathing gases. This plant includes the complete equipment necessary to fill the bottles. The plant begins immediately behind the closing valve at the pipeline for the gas to be bottled or at the suction socket of the transfer system.

2.4 Nitrox

Nitrox is a mixture of the breathing gases, compressed air and oxygen with an oxygen content of at least 22 %.

3. Documents for approval

3.1 Before beginning of manufacturing, plans and drawings of all components subject to compulsory inspection, to the extent specified below, are to be submitted to TL in triplicate.

3.2 The drawings must contain all the data necessary to check the design and the loading of the equipment. Wherever necessary, calculations relating to components and descriptions of the system are to be submitted

3.3 The following documents are to be submitted

- piping diagrams, block diagrams and descriptions are to be furnished for the entire gas supply system and/or bottling plant

- description of compressors and compressor drives including longitudinal and transverse sectional drawings of the compressors

- drawings of pressure vessels and apparatus giving full details for appraising the safety of the equipment

Approvals of other institutions may be taken into consideration.

4. Marking

4.1 Permanently installed gas bottles, gas containers and gas piping systems are, in addition, to be marked with a permanent colour code in accordance with Table 18.1 and with the chemical symbol designating the type of gas concerned. The marking of gas bottles must be visible from the valve side.

Table 18.1 Marking of gas systems

Type of gas	Chemical symbol	Colour code
Oxygen	O_2	white
Nitrogen	N_2	black
Air	---	white & black

4.2 Gas bottles, gas containers and gas piping systems for nitrox have to be marked separately with a colour code and have to be provided with the designation "Nitrox".

4.3 Manometers for oxygen and/or nitrox have to be marked as free of oil and grease.

B. Principles for the Design and Construction of Diving Systems

1. General principles

1.1 Bottling plants are to be constructed and operated in a way that the operating, control and maintenance personnel or other persons in the proximity of the plant are not endangered.

1.2 Pipe connections between pressured air bottling plants for the production of breathing gases and other compressed air systems on board are only to be established with special approval of TL and under consideration of additional protection measures.

1.3 Pipelines carrying gas or oxygen under high pressure shall not be routed through accommodation spaces, engine rooms or similar compartments.

1.4 Pipelines for mixed gases containing more than 25 % oxygen are to be treated as pure oxygen lines.

1.5 Filling pipes and intermediate or coupling pieces of filling pipes must be suitable to be released of pressure without danger.

1.6 Filling connections are to be constructed or marked in a way that confusion of the gases to be filled is safely avoided and a correct connection can be established.

1.7 At the gas draw-off position the bottling plant has to be equipped with a manometer which shows the supply pressure.

2. Pressure vessels and apparatus

Pressure vessels and apparatus under pressure are to be designed and manufactured according to the requirements of Section 16.

3. Compressors

3.1 The compressors must be suitable for an operation on board of seagoing ships and are to be operable under the actual operating and ambient conditions of the naval ship.

3.2 Compressors are to be designed for the required delivery rates, types of gas and delivery pressures.

3.3 Compressors are to be so designed that lubricating oil can penetrate the gas circuit.

3.4 Compressors are to be so installed that no harmful gases can be sucked in.

3.5 Oxygen compressors are to be installed in separate spaces with adequate ventilation.

3.6 Compressors must be equipped with adequately designed suction filters, coolers and water separators.

3.7 The breathing air produced by the compressors must fulfil the requirements of EN 12021. National regulations are unaffected from this.

3.8 Each compressor stage must be equipped with a pressure relief valve or rupture disc, neither of which can be disabled. This safety device must be designed and set in such a way that the specified pressure in the compressor stage concerned cannot be exceeded by more than 10 %. The setting must be safeguarded against unauthorized alteration.

3.9 Each compressor stage must be provided with a suitable pressure gauge indicating clearly the final pressure of that stage.

3.10 Where a compressor stage comprises more than one cylinder and each cylinder can be closed off individually, a pressure relief valve and a pressure gauge must be provided for each cylinder.

3.11 Dry-running reciprocating compressors must be equipped at each stage with a device which activates a warning signal and shuts down the drive motor if the final compression temperature stated in the operating instructions is exceeded.

3.12 Diaphragm-type compressors must be equipped at each stage with a diaphragm rupture indicator which shuts down the compressor as soon as damage occurs to the drive or compressor diaphragm.

3.13 Marking

A manufacturer's data plate containing the following details must be permanently fixed to each compressor:

- type designation
- manufacturer's name
- serial number
- year of manufacture
- flow mass
- delivery pressure
- revolutions per minute

4. Piping systems

4.1 Piping systems are to be constructed and manufactured on the basis of standards generally used in shipbuilding.

As far as it is not defined in detail in the following, pipelines of bottling plants have to fulfil the requirements of Section 8, A., B., C. and D.

4.2 Expansion in piping systems is to be compensated by pipe bends or compensators. Attention is to be given to the suitable siting of fixed points.

4.3 Means must be provided for the complete evacuation, drainage and venting of pipelines.

4.4 Pipelines which may be subjected in service to pressures higher than the design pressure must be fitted with overpressure protection.

4.5 The use of hoses is to be restricted to a minimum and only short lengths are permitted to be installed.

5. Pipe connections

5.1 Wherever possible, pipes should be joined by full-penetration butt welds.

5.2 Screwed pipe connections may only be made using bite joints approved by TL.

5.3 Flanged connections may be used provided that the flanges and flange bolts conform to a recognized standard.

6. Valves and fittings

6.1 Shut-off devices must conform to a recognized standard. Valves with screw-down bonnets or spindles are to be protected against unintentional un screwing of the bonnet.

6.2 Manually operated shut-off devices are to be closed by turning in the clockwise direction.

6.3 Oxygen lines may only be fitted with screw-down valves, although ball valves may be used for emergency shut-off purposes.

6.4 Hose fittings are to be made of corrosion-resistant material and are to be so designed that they cannot be disconnected accidentally.

7. Materials

7.1 Materials must be suitable for the proposed application and must conform to the TL Rules Chapter 2 – Materials.

7.2 Welds are to conform to the TL Rules Chapter 3 - Welding in the Various Fields of Application

7.3 Materials for breathing gas systems shall not form any toxic or combustible products.

7.4 In oxygen systems, only those materials may be used which are approved for use with oxygen and which are suitable for the proposed operating conditions.

8. Electrical Installation

The electrical installation has to meet the requirements of Chapter 105 - Electrical Installations and Chapter 106 - Automation.

Systems for breathing gases are to be provided with a sufficient compensation of electrical potential.

9. Control and monitoring

Bottling plants for breathing gases have to be operated and monitored manually.

10. Additional requirements for breathing gas systems for nitrox and oxygen

10.1 Fittings for oxygen are to be constructed to avoid a burn-off or are to be so arranged or protected that the personnel cannot be hurt in case of a burn-off.

10.2 Spindle valves for oxygen have to be constructed for a nominal diameter above 15 mm and operating pressures of more than 40 bar in a way that the spindle thread is outside of the gas space.

10.3 Tighting materials containing combustible elements and which come into contact with compressed gases with oxidizing effects are only approved for fittings if the suitability for the pressures, temperatures and type of installation is proven.

10.4 For oxygen armatures and fittings only lubricants are allowed which are approved for the actual operating conditions.

10.5 Hoses must be suitable for oxygen.

C. Fire Protection and Safety

1. Arrangement of systems for breathing gases

1.1 Production and bottling plants for breathing gases are not to be installed in areas where internal combustion engines or boilers are operated.

1.2 Production and bottling plants for breathing gases have to be installed with sufficient space for operation, maintenance and cleaning, for escape and safety routes as well as for fire fighting.

1.3 Closed spaces for bottling plants are to be provided with a mechanical ventilation of at least 8 air changes per hour. The air must be sucted from an area which is not endangered by explosion.

1.4 On ships with NBC protection the ventilation of the space where the production and bottling plant for breathing gases is installed has to be fed from a fresh air duct provided with a NBC filter.

1.5 Spaces where breathing gas systems for oxygen and/ or nitrox are installed have to be provided with fire warning devices.

Floor drainage has to be avoided.

1.6 Compressed gas from pressure release and safety devices has to be carried off safely.

2. Gas storage

2.1 The breathing gases have to be stored in a fixed gas storage or at a suitable place for gas cylinders.

2.2 Oxygen gas cylinders are to be stored at well ventilated locations, preferably in suitable cabinets at the open deck and shall not be stored near combustible materials.

2.3 Spaces in which oxygen is stored must be separated from the adjoining spaces by bulkheads and decks of a type with 60 minutes fire resistance and must be arranged to facilitate speedy exit in case of danger. Spaces where oxygen can penetrate are to be equipped with an oxygen monitoring device. The oxygen sensor has to be installed near the floor. As an alternative a monitored suction of the space air may be provided near the floor.

D. Tests and Trials

1. General

Systems for breathing gases are subject to constructional and material tests as well as to pressure and tightness tests and trials. All the tests called for in the following are to be performed under TL supervision.

2. Pressure vessels and apparatus

Vessels and apparatuses under pressure are to be checked and tested according to Section 16.

3. Compressors

3.1 Compressor components subjected to pressure are to undergo a hydraulic pressure test at a test pressure equal to 1,5 times the delivery pressure of the compressor stage concerned.

3.2 On completion, compressors are to be subjected to a tightness test at their maximum working pressure. In addition, a performance test is to be carried out in which the final moisture content and any possible contamination of the compressed gas are to be determined.

3.3 Compressor plants have to undergo a functional test after their completion, which has to include a check of the control, monitoring and safety equipment.

4. Pipes and fittings

4.1 After completion of the system, but before insulation and painting all pipes and fittings have to undergo a pressure test with 1,5 times the maximum allowable working pressure PB.

4.2 Pipes and fittings for breathing gases and oxygen have to be cleaned before putting into operation and have to undergo a cleanness test.

4.3 For fittings in oxygen and/or nitrox lines the oxygen suitability has to be proven.

5. Hoses

5.1 The bursting pressure of each hose type has to be proven to TL, whereby for gases at least 5 times the maximum allowable working pressure PB has to be endured.

5.2 Each hose is to be subjected to a hydraulic pressure test at least 2 times the maximum allowable working pressure PB.

6. Electrical equipment

6.1 Electrical machines, components, cables and lines are to be tested in the manufacturer's works in accordance with Chapter 105 - Electrical Installations, Section 6, G.

6.2 The electrical protection equipment has to be tested according to Chapter 105 - Electrical Installations, Section 6, G.

SECTION 19

SPARE PARTS

A. General

1. In order to be able to restore engine operation and manoeuvring capacity to the ship in the event of damage at sea, spare parts for the main drive and the essential equipment, see Section 1, B.2., are to be carried on board every ship, together with the neces sary tools.

These requirements are considered to be complied with if the range of spare parts corresponds to the Tables given below allowing for the extent of the installed systems and components in question at the time of commissioning.

2. Depending on the design and arrangement of the engine plant, the intended service and operation of the ship, and also the manufacturer's recommenda tions, a different volume of spare parts may be agreed between the Naval Authority and TL.

Where the volume of spare parts is based on special arrangements between the Naval Authority and TL, relevant technical documentation is to be provided.

A list of the relevant spare parts is to be carried on board.

3. In the case of propulsion systems and essen-tial equipment, which are not included in the following Tables, the requisite range of spare parts is to be established in each individual case between Naval Authority, shipyard and TL.

B. Volume of Spare Parts

The scope of spare parts has to be in accordance with the following Tables.

A = Unlimited range of service and **Y**
B = All other ranges of service
Explanations:

Restricted International Service – Y

This range of service is limited, in general, to operate along the coast, provided that the distance to the nearest port of refuge and the offshore distance do not exceed 200 nautical miles. This applies also to operation in the North Sea and within enclosed seas, such as the Mediterranean Sea, the Black Sea, the Caspian Sea and waters with similar seaway conditions.

Coastal Service - K50/K20

This range of service is limited, in general, to operate along the coasts, provided that the distance to the nearest port of refuge and the offshore distance do not exceed 50/20 nautical miles. This applies also to operation within enclosed seas, such as the Baltic Sea, Marmara Sea and gulfs with similar seaway conditions.

Coastal Service – K6

This range of service is limited to operate along the coasts, provided that the distance to the nearest port of refuge and the offshore distance do not exceed 6 nautical miles. This area of service is restricted to operate in shoals, bays, haffs and firths or similar waters, where heavy seas do not occur.

1. Starting equipment and air compressors

For starting equipment and air compressors, see Section 6. The volume of spare parts is defined in Table 19.1.

2. Pumps

For pumps, see Section 8. The volume of spare parts is defined in Table 19.2

3. Hydraulic systems

For hydraulic systems, like controllable pitch propeller systems, steering gears, windlasses, hatch cover oper-ating systems, closing appliances in the ship's shell, watertight door closing systems, hoists, see Section 14. The volume of spare parts is defined in Table 19.3.

4. Auxiliary steam boilers

For auxiliary steam boilers, see Section 15. The volume of spare parts is defined in Table 19.4.

5. Other spare parts

For other spare parts for essential auxiliary systems the volume is defined in Table 19.5.

Table 19.1 Spare parts for air compressors

Range of spare parts	A	B
Piston rings of each type and size fitted for one piston	1 set	½ set
Suction and delivery valves complete of each size fitted in one unit	1 set	½ set
For spare parts for refrigerant compressors, see also Section 12, K.		

Table 19.2 Spare parts for pumps

Range of spare parts		A	B
Piston pumps	Valve with seats and springs of each size fitted	1set	1set
	Piston rings of each type and size for one piston	1set	1set
	Bearing of each type and size	1	1
Centrifugal pumps	Rotor sealings of each type and size	1	1
Gear and screw type pumps	Bearings of each type and size	1	1
	Rotor sealings of each type and size	1	1
Where, for a system served by a pump, a stand-by pump of sufficient capacity is available, the spare parts may be dispensed with.			

Table 19.3 Spare parts for hydraulic systems

Range of spare parts	A	B
Pressure hoses and flexible pipes, at least one of each size	20%	20%
Seals, gaskets	1 set	1 set
For seals, this requirement is applicable only to the extent that these parts can be changed with the means available on board. Where a hydraulic system comprises two mutually independent sub-systems, spare parts need to be supplied for one sub-system only.		

Table 19.4 Spare parts for auxiliary steam boilers

Range of spare parts	A	B
Safety valve or disc/spring combination respectively	1	1
Tube plugs for each dimension of boiler and superheater tubes of each boiler	2%	2%
Glasses and gaskets for water level gauges of each boiler	1 set	1 set
Gaskets for inspection openings	1 set	1 set
Expandable parts of each firing plant consisting of burner, fuel supply, blowers, ignition facility, flame safeguard	1 set	1 set
For carrying out maintenance and repair work, a sufficient number of suitable tools and special tools according to the size of the machinery installation must be available on board.		

Table 19.5 Spare parts for essential auxiliary systems

Range of spare parts	**A**	**B**
Safety valve or cone and spring of each type for pressure vessels	1	1
Hoses and compensators	20%	20%
Testing device for fuel injection valves	1	1
Condenser tubes with ferrules	2%	-
Tubes for intercooler of air ejector	10%	-
For carrying out maintenance and repair work, a sufficient number of suitable tools and special tools according to the size of the machinery installation must be available on board.		