Polski Rejestr Statków

RULES
FOR THE CLASSIFICATION AND CONSTRUCTION OF NAVAL SHIPS

PART VI

MACHINERY INSTALLATIONS AND REFRIGERATING PLANTS

2008

GDAŃSK

RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF NAVAL SHIPS prepared and edited by Polski Rejestr Statków S.A., further referred to as PRS, consist of the following Parts:

Part I – Classification Regulations
Part II – Hull
Part III – Hull Equipment
Part IV – Stability and Subdivision
Part V – Fire Protection
Part VI – Machinery Installations and Refrigerating Plants
Part VII – Machinery, Boilers and Pressure Vessels
Part VIII – Electrical Installations and Control Systems
Part X – Statutory Equipment

With regard to materials and welding, the requirements of *Part IX – Materials and Welding* of *the Rules for the Classification and Construction of Sea-going Ships* apply.

Part VI – Machinery Installations and Refrigerating Plants – 2008, was approved by the PRS S.A. Board on 24 June 2008 and enters into force on 1 August 2008.

From the entry into force the requirements of *Part VI – Machinery Installations and Refrigerating Plants* apply to:

– new naval ships, the building contract for which will be signed on or after 1 August 2008 – within the full scope,
– existing naval ships, in accordance with principles specified in *Part I – Classification Regulations*.

The requirements of this Part of the Rules are extended by the following PRS Publications:

Publication No. 7/P – Repair of Cast Copper Alloy Propellers,
Publication No. 8/P – Calculation of Crankshafts for Diesel Engines,
Publication No. 23/P – Pipelines Prefabrication,
Publication No. 33/P – Air Pipe Closing Devices,
Publication No. 50/P – Technical requirements in Scope of Marine Environment Protection for Sea-Going Ships,
Publication No. 53/P – Plastic Pipelines on Ships,
Publication No. 57/P – Type Approval of Mechanical Joints.

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1 GENERAL PROVISIONS

1.1 Application

1.1.1 The present *Part VI – Machinery Installations and Refrigerating Plants* is applicable to machinery spaces and their equipment, shafting and propellers, machinery and naval ship piping systems and special piping systems related to the naval ship type and structural features. The requirements related to fire-extinguishing systems are given in *Part V – Fire Protection.*

1.2 Definitions and Explanations

Definitions relating to the general terminology used in the *Rules for the Design and Construction of the Naval Ships* (hereinafter referred to as *the Rules*) are contained in *Part I – Classification Regulations*. Wherever, in *Part VI*, definitions given in other parts of the *Rules* are used, cross-reference to those parts is made. For the purpose of *Part VI* the following additional definitions have been adopted:

Auxiliary machinery – machinery providing for the operation of main engines, supply of the naval ship with electric or other power, as well as for the operation of shipboard systems and arrangements.

CODAD – naval ship's propulsion system based on diesel engines. Propeller shaft in this system may be driven by one or several such engines.

CODAG – naval ship's propulsion system based on diesel engines and a gas turbine. Propeller shaft in this system may be driven by either diesel engine or gas turbine or simultaneously by both engines.

CODOG – naval ship's propulsion system based on diesel engines and gas turbines. Propeller shaft in this system may be driven by either diesel engine or gas turbine.

COGAG – naval ship's propulsion system based on gas turbines. Propeller shaft in this system may be driven by one or several turbines.

COGOG – naval ship's propulsion system based on gas turbines. Propeller shaft in this system may be driven by one turbine.

Compensator – a short length of metallic or non-metallic tube, generally of the bellows type, provided with end fittings, for absorption of axial loads where angular and/or lateral flexibility is to be ensured.

Control stations:

automatic – position which ensures automatic adaptation of machinery operation parameters for maintaining the set operation program and/or performance of set sequence without intervention of operators;

local – a position fitted with operating controls, measuring and control instruments and means of communication (if necessary), located in close vicinity to, or directly on, the machine;

r e m o t e – a position from which remote adjustment of working parameters, as well as remote starting and stopping (if any) the engines and machinery is possible and which is equipped with indispensable measuring, control and signalling devices.

D e a d s h i p c o n d i t i o n – the condition under which the whole propulsion machinery including generating sets is inoperative and the starting devices of the main engine and auxiliary engines, such as starting air bottles or batteries, are discharged.

D e s i g n p r e s s u r e – pressure not lower than the opening pressure of safety valves or other protecting devices, taken for the strength calculations.

D e s i g n t e m p e r a t u r e – the highest temperature of the medium in pipelines, taken for the calculation of permissible stresses.

E n g i n e C o n t r o l R o o m (E C R) – an enclosed space which contains: a central control station of main engines and auxiliary machinery and of controllable pitch propellers or thrusters, main damage control position, main switchboard together with power distribution control arrangements, control and measuring instruments, warning alarms for reaching the permissible limits of the assumed parameters, alarms announcing the activation of automatic protection devices, means of communication.

E n g i n e r o o m – machinery space where main engines and auxiliary machinery are fitted.

E s s e n t i a l m a c h i n e r y , e q u i p m e n t , s y s t e m s – machinery installations, equipment and systems, whose damage or inefficiency shall cause loss or deterioration of propulsion, manoeuvring characteristics or other essential functions of a naval ship to such extent that the safety of the naval ship, crew or marine environment will be considerably limited.

E x i t – an opening in a bulkhead, deck or shell plating provided with means for closing and intended for passage of persons.

E x i t r o u t e – a route leading from the bottom level of machinery compartment to exit thereof.

F l e x i b l e h o s e a s s e m b l y – a short length of metallic or non-metalic hose complete with end fittings ready for installation.

M a c h i n e r y s p a c e s – all machinery spaces of category A and other spaces containing propulsion machinery, boilers, oil fuel units, incinerators, diesel engines, gas turbines, generators and major electrical machinery, oil bunkering stations, refrigerating, stabilizing, ventilation and air conditioning machinery, and other similar spaces as well as trunks to such spaces.

M a c h i n e r y s p a c e s o f c a t e g o r y A – spaces (including trunks to such spaces) which contain:

– diesel engines and/or gas turbines used for main propulsion;

- diesel engines and/or gas turbines used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW;
- oil fuel-fired boilers and incinerators;
- oil fuel units.

M a i n e n g i n e s – machinery intended for the naval ship propulsion, such as diesel engines, gas turbines, electric motors, etc;

O i l r e s i d u e s (s l u d g e) – residues resulting from oils and fuels separation and oily bilge water purification, as well as oil and fuel leakages and drains and any exhausted oils.

O i l y b i l g e w a t e r – bilge water contaminated with oily products.

R a t e d p o w e r – see *Part VII – Machinery, Boilers and Pressure Vessels,* paragraph 2.1.4.

R a t e d s p e e d – the number of revolutions per minute corresponding to the rated power.

R e f r i g e r a t i n g m a c h i n e r y s p a c e – a space containing the refrigerating plant machinery and equipment intended to lower and maintain required temperature inside refrigerated spaces.

R e f r i g e r a t i n g u n i t – a unit comprising a prime mover, one or more refrigerant compressors, a condenser, necessary fittings as well as adjustment and control arrangements necessary to permit independent operation of the unit.

S a n i t a r y d r a i n a g e – sewage and greywater, according to the definitions given below:

S e w a g e (b l a c k w a t e r) :

- drainage and other wastes from any form of toilets, urinals and scuppers located in premises containing such utensils,
- drainage from medical premises (dispensary, sick bay, etc.), via wash basins, wash tubes, scuppers, etc,
- other waste waters when mixed with the drainages defined above.

G r e y w a t e r :

- drainage from wash basins, wash tubes, showers and scuppers located in premises containing such utensils, provided that the scuppers do not drain blackwater (i.e. they are separated by means of a tight sill from the part of the premises where toilets and/or urinals are located),
- drainage from laundry,
- drainage from sinks after washing of food, cooking utensils, dishes, etc.

W o r k i n g p r e s s u r e – the highest permissible pressure during normal course of long lasting operation.

1.3 Scope of Survey

1.3.1 Survey during manufacture covers machinery and equipment which have effect on:

– safety and reliability of the main propulsion system,
– steering the naval ship,
– operation of systems and installations necessary for a proper operation of the naval ship and associated with the naval ship type (among them are the systems mentioned in 1.4.2, except subparagraphs .3 and .20),
– watertightness of the hull and the watertight compartments located within the hull as well as gas tightness within the shelter.

The above machinery and equipment include among the others:

.1 Main propulsion engines, their gears and flexible couplings, etc.
.2 Steam and heating oil boilers of essential services;
.3 Auxiliary engines being power source for machinery/installations essential as regards naval ship safety and operation at sea;
.4 Steering gear and thrusters;
.5 Pumps, compressors, heat exchangers and pressure vessels indispensable for the operation of main propulsion and essential auxiliary machinery;
.6 Pumps essential for the naval ship safety (e.g. bilge/drainage, ballast pumps) and its operational efficiency (control and cooling of armament),
.7 Ventilation, air filtering and air-conditioning systems equipment.

1.3.2 Pipings of classes I and II and their valves and fittings (see 1.16.2.2) as well as bottom, side, collision bulkhead and remotely controlled valves and fittings are subject to supervision during manufacture.

1.3.3 Systems, machinery and equipment, the documentation of which is subject to consideration and approval, are surveyed during the naval ship construction or modification.

1.3.4 Fitting the mechanical equipment in machinery spaces, as well as fitting and testing the listed below plants forming a part of naval ship's machinery, are subject to survey of PRS:

.1 main engines, their gears and clutches,
.2 boilers, pressure vessels and heat exchangers,
.3 auxiliary machinery,
.4 control, monitoring and signalling systems of machinery installations,
.5 shafting and propellers,
.6 thrusters.

1.3.5 Only results of these measurements, which were performed by approved measuring laboratories are accepted.

1.3.6 After the plants, equipment and systems have been fitted on board the naval ship, the machinery installations are to be subjected to motion tests under load (mooring tests, sea trials) in accordance with the agreed programmes. The sea trials should include determining the manoeuvring characteristics of the propulsion unit.

The test programme for main diesel engines is to comply with the applicable requirements of PRS issued *Publication No. 28/P – Tests of I.C. Engines* and those included in the *PN-V-84006 Standard: Siłownie okrętów wojennych – Próby okrętowych silników spalinowych tłokowych napędu głownego – Wymagania*.

1.4 Technical Documentation of the Naval Ship

Prior to the commencement of the naval ship construction the below listed technical documentation shall be submitted for PRS approval. In the case of naval ships, whose structure and equipment undergo modifications, the below listed documentation is subject to approval in the scope which covers the modifications.

1.4.1 Documentation of Machinery:

.1 arrangement plan of machinery and equipment in machinery spaces, as well as in the spaces containing emergency power sources, including the means of escape;

.2 characteristics of machinery, including the data necessary for the calculations required in this Part of *the Rules*;

.3 calculations (including assumptions taken and conclusions) concerning essential machinery, equipment and systems as well as their foundations and attachments, to confirm compliance with the requirements on contract level of impact loads, or relevant test programmes (see 1.6.2);

.4 diagram and specification of remote control of main machinery, including the data on fitting remote control stations with control devices, instrumentation, warning devices, means of communication and other equipment;

.5 drawings of seating the main engines and their gears on the foundation. PRS may require extending the scope of documentation of foundations and attachments;

.6 shafting:
- general arrangement plan,
- drawings of stern tube and attached parts,
- drawings of shafts (propeller, intermediate and thrust), including the connections and clutches/couplings,
- drawing of seating the propeller thrust bearing on the foundation unless it forms an integral part of main engine or main gear,
- calculation of torsional vibration of main engine – propeller set, for diesel engines in excess of 75 kW rated power and auxiliary engine – power receiver set for diesel engines of more than 110 kW rated power. In case of gas turbine or electric motor driven equipment, the necessity of submitting the torsional vibration calculations is to be agreed in each particular case with PRS,

– calculations of axial and transverse vibrations of the main engine – propeller set for diesel engines, gas turbines and electric motors;

.7 propeller:

– general drawing,
– drawings of blades, boss and fastening elements (for built-up propellers and controllable-pitch propellers),
– diagrams and specifications of control systems for controllable-pitch propellers,
– drawings of essential parts of pitch control gear in the controllable-pitch propeller hub;

.8 thrusters: scope of required documentation is given in 1.4.5, *Part VII – Machinery, Boilers and Pressure Vessels*.

1.4.2 Documentation of Piping Systems:

.1 diagram of gravity overboard drain system (showing arrangement of watertight bulkheads, open deck and the distances between waterline or open deck and particular outlets);
.2 diagrams of bilge system,
.3 diagram of oil residues system,
.4 diagram of ballast system,
.5 diagram of heel and trim equalizing systems,
.6 diagram of air, overflow and sounding pipes;
.7 diagram of exhaust gas system including drawings of silencers and spark arresters,
.8 diagram of ventilation, air filtering and air conditioning systems (showing arrangement of watertight and gastight bulkheads, fire divisions, closing devices of ventilation ducts and openings);
.9 diagram of oil fuel system, including discharge and supply system,
.10 diagram of lubricating oil system, including discharge and supply system,
.11 diagram of thermal oil system,
.12 diagram of sea water take-up system;
.13 diagram of cooling water system,
.14 diagram of compressed air system,
.15 diagram of boiler feed water and condensate systems,
.16 diagram of boiler scum and desludging systems, as well as steam machinery and pipelines blow-through systems,
.17 diagram of steam system,
.18 diagram of steam pipelines for heating and clearing bottom and side sea chests, heating side valves and fittings, heating liquids in tanks and for tanks steaming,
.19 drawings of bottom and side sea chests fittings,
.20 diagram of sanitary sewage system,

.21 diagram of drinking water system,
.22 diagram of hydraulic system driving machinery and equipment,
.23 diagram of the naval ship flushing system.

Where the systems specific for the military function of the naval ship, such as armament, control and heading, etc. systems are to be supplied from the above systems (e.g. sea water, ventilation, air conditioning, compressed air and other systems) they are to be shown on the diagrams of these systems.

1.4.3 Documentation of Refrigerating Plant:

.1 technical specification of refrigerating plant,
.2 plan of naval ship's refrigerating plant,
.3 basic diagrams of the refrigerant system,
.4 arrangement plan of refrigerating machinery space, showing the escape routes,
.5 basic diagrams of the main and emergency ventilation systems of refrigerating machinery space providing number of air changes;
.6 basic diagram of the water curtain system in refrigerating machinery space and refrigerant store room (for II group refrigerants).

1.5 Pressure Tests

1.5.1 Pressure Tests of Shaftline Components

1.5.1.1 The following components are to be subjected to pressure tests upon completion of machining:
- propeller shaft liners – with pressure equal to 0.2 MPa,
- stern tubes – with pressure equal to 0.2 MPa .

1.5.1.2 The seal of the propeller shaft, if lubricated with oil, is to be tested after assembly for tightness to a pressure equal to the head of working level of the lubrication oil in the gravity tank. The propeller shaft is to be turned during the test.

1.5.2 Pressure Tests of Propellers

1.5.2.1 The hub of controllable-pitch propeller, after the propeller assembly, is to be tested for tightness to an internal pressure equal to the head of working level of the lubricating oil in the gravity tank. It is recommended that the blades should be put several times from one extreme position to another during the tests.

1.5.2.2 The rotor sealings of the cycloidal propeller are to be tested for tightness to an internal pressure equal to the head of working level of the lubrication oil in the gravity tank.

1.5.3 Pressure Tests of Valves and Fittings

1.5.3.1 Valves and fittings installed on the piping systems of class I and II (see 1.16.2.2) are to be pressure tested; the test pressure is to be in accordance with paragraph 1.5.2.1 of *Part VII – Machinery, Boilers and Pressure Vessels*.

1.5.3.2 Valves and fittings designed for rated pressures 0.1 MPa or less, as well as for underpressure are to be pressure tested by the pressure equal to at least 0.2 MPa.

1.5.3.3 Valves and fittings installed on bottom and side sea chests as well as on external shell plating, below the load waterline, are to be tested by hydraulic pressure of not less than 0.5 MPa.

1.5.3.4 Completely assembled valves and fittings are to be tested for closing tightness by hydraulic pressure equal to the design pressure.

1.5.4 Pressure Tests of Piping Systems

1.5.4.1 Piping systems of class I and II (see 1.16.2.2), as well as all steam, feed water, compressed air, thermal oil and oil fuel piping of design pressure exceeding 0.35 MPa, irrespective of their class, are, upon completion of fabrication and final machining, but prior to their insulation, to be hydraulically tested, in the presence of PRS surveyor, to a test pressure p_{pr} determined from the formula:

$$p_{pr} = 1.5p, \quad \text{[MPa]} \qquad (1.5.4.1\text{-}1)$$

where:
p – design pressure (see 1.16.3.1), [MPa].

When testing steel pipes for design temperatures exceeding 300 °C, the test pressure p_{pr} is to be determined from the following formula, but it cannot be greater than $2p$:

$$p_{pr} = 1.5\frac{\sigma_{\tau}^{100}}{\sigma_{d}^{t}}p, \quad \text{[MPa]} \qquad (1.5.4.1\text{-}2)$$

where:
σ_{τ}^{100} – permissible stress at 100°C, [MPa],
σ_{d}^{t} – permissible stress at design temperature, [MPa].

If, during the pressure test, excessive stresses may be expected in particular elements, then, upon PRS consent, the test pressure p_{pr} may be reduced to 1.5 p.

In no case the stresses occurring during the pressure tests are to exceed 0.9 of yield point of the material at the test temperature.

1.5.4.2 If, due to technical reasons, the complete pressure test of pipes cannot be carried out prior to installing them on the naval ship, the test programme for particular sections of piping is to be agreed upon with PRS, particularly for assembly connections.

1.5.4.3 Upon agreement with PRS, pressure test may be omitted for pipes of nominal diameter less than 15 mm.

1.5.4.4 Tightness of piping is to be checked, in the presence of the PRS surveyor, during operation test upon assembly on board the naval ship. It is not applicable to heating coils which are to be tested to a pressure equal to 1.5 p, but not less than 0.4 MPa.

1.5.4.5 If, due to technological reasons, the pipes have not been pressure tested in the workshop, the tests can be carried out upon assembly on board the naval ship.

1.5.5 Pressure Tests of the Ventilation Systems and Air Filtering Systems

Ventilation ducts which can be used for air filtering and the air filtering systems are to be tested for tightness to the pressure of 4 kPa, after they are installed onboard naval ship. No pressure drop exceeding 5% of the above value of the pressure, i.e. 0.32 kPa, may be recorded within 1 hour.

1.5.6 Pressure Tests of Refrigerating Plants

1.5.6.1 After the refrigerating plant has been assembled on board the naval ship, the complete refrigerant system is to be pneumatically tested for tightness to a pressure equal to the design pressure p, determined according to 22.2.2.

1.5.6.2 All tightness tests on board the naval ship may be carried out with dry air, carbon dioxide or nitrogen.

1.5.6.3 Upon completion of tests required by 1.5.5.1, the refrigerant system is to be dried and checked for tightness in vacuum conditions to an underpressure not exceeding 1.0 kPa.

1.5.6.4 When the system is filled with refrigerant, all joints and fittings are to be checked for tightness.

1.6 Service Conditions

1.6.1 Machinery items, their foundations and attachments as well as associated systems are to remain operative under conditions given below, unless specified otherwise in other parts of the *Rules*.

– Prolonged trim – ± 5°
– Prolonged list – ± 15°
– Pitching – ± 10°
– Side rolling – ± 45°

It is to be assumed that prolonged lists and trims may be considered simultaneously, while pitching and side rolling are to be considered separately. The emergency power sources are to remain operative at the prolonged list of the naval ship up to 30°.

1.6.2 Essential machinery, equipment and systems, together with their foundations and attachments are to be designed considering the impact load level as specified in the contract, which can be a result of operating own armament, explosions in the vicinity of the naval ship, ship's speed and sea waves effect. The impact loads should not cause damage to the above items and permanent deformations to their foundations and attachments. Consideration of such loads is to be documented in the form of detailed calculations or by appropriate tests.

1.6.3 The machinery and associated systems are to remain operative under the following environmental conditions:

Table 1.6.3
Air temperature

Item	Arrangement of machinery	Temperature range
1	In closed spaces	from 0 °C to +45 °C [1)]
2	On engines and boilers, as well as in places exposed to high and low temperatures	according to the local conditions
3	On open decks	from –25 °C to +45 °C [1)]

Note to Table 1.6.3:
[1)] Upon agreement with PRS, other temperature ranges may be determined for naval ships of restricted service.

The ambient pressure is to be assumed as equal to 1000 hPa, and relative humidity – 60%.

The temperature of sea-water is to be assumed +32 °C. Upon agreement with PRS, a lower temperature of sea-water may be assumed for naval ships of restricted service.

1.7 Materials and Welding

1.7.1 Materials used for production, as well as welding and the scope of acceptance, tests and examination are to comply with the requirements of *Part IX – Materials and Welding*.

1.7.2 Intermediate, thrust and propeller shafts are to be made of forged steel with tensile strength not exceeding 800 MPa.

Propeller shafts are to be ultrasonic tested during manufacture. Upon completion of machining the following parts:
- rear end of cylindrical part of the shaft, together with about 0.3 of the taper length starting from its greater diameter, in the case of taper mounted propeller, or
- rear end of propeller shaft and the flange transition area in the case of flange mounted propeller,

are to be magnaflux or die penetrant tested for surface defects.

1.7.3 Solid, built-up and controllable-pitch propellers are to be made of copper alloys or stainless carbon cast steel.

Propellers for naval ships in which speed is not an essential feature, small size propellers operated in low salinity water, as well as bosses of propellers fitted with blades of stainless cast steel, may be made of carbon cast steel.

Materials for the coupling bolts, blades and bosses of propellers are to be so selected as to avoid electrochemical corrosion.

1.7.4 When alloy steels, including corrosion resistant and high tensile steels, are used for the shafts and propellers, the data on the chemical composition, mechanical and other specific properties of the steels are to be submitted to PRS to confirm their suitability.

1.7.5 Fastening and locking arrangements of blades, housings, liners and sealings are to be made of corrosion resistant materials.

1.7.6 Materials containing asbestos must not be used. This requirement does not apply to:

.1 watertight joints and lining used for the circulation of fluids when, at high temperature (in excess of 350 °C) or pressure (in excess of 7 MPa), there is a risk of fire, corrosion or toxicity,

.2 supple and flexible thermal insulation assemblies used for temperatures above 1000 °C.

1.8 Main Propulsion Machinery, Main Engines

1.8.1 The naval ship propulsion machinery and its necessary auxiliary equipment are to be so designed and manufactured that damage to a single element of the system caused no loss of propulsion..

1.8.2 If the naval ship propulsion system contains several main engines, each of them shall be capable of being disconnected from the common gear. Manual or automatic stop of one of the operating engines shall result in its automatic disconnecting. In the case of failure of one of the engines, the naval ship's operation shall be ensured using other engines.

1.8.3 In the case of multi-screw propulsion, the naval ship's propulsion machinery shall be so designed and manufactured that one propeller shall be capable of operating without overloading the propulsion system. Each propeller shall be driven by its designated engine, irrespective of other propellers that may be driven by this engine.

1.8.4 In order to maintain sufficient manoeuvrability of a naval ship in all normal operational conditions, the main propulsion machinery is to be capable to ensure the naval ship going astern.

1.8.5 The main propulsion machinery is to be capable of maintaining in free route astern at least 70% of the rated ahead rotational speed for a period of at least 30 minutes. The rated ahead rotational speed should be understood as the speed corresponding to the maximum continuous power of the main engine specified in the engine certificate. The reversing characteristics should be demonstrated and measured during sea trials.

1.8.6 The naval ship's propulsion machinery is to be capable to stop the naval ship from going full ahead and to move to full astern in the shortest possible time without failure and afterwards to reverse to going full ahead immediately.

1.8.7 The main propulsion machinery are to be adopted to prolonged operation at partial loads if such loads result from the design operation mode.

1.8.8 The naval ship is to be so equipped that propulsion machinery and generating sets can be brought into operation from the dead ship condition without external aid using only the facilities available on board.

If for this purpose an emergency air compressor or an electric generator is required, these units are to be powered by hand or a hand starting oil-engine or a hand-operated compressor. These appliances are to be capable of starting main propulsion and generating sets from a dead ship condition in not more than 30 minutes.

1.9 Machinery Spaces

1.9.1 Means of escape meeting the requirements of subchapter 2.5 of *Part V – Fire Protection* should be provided for each machinery space. Means of escape from the shaft and pipeline tunnels are to comply with the requirements regarding means of escape from machinery spaces of category A.

The means of escape from the shaft and pipeline tunnels are to be, as far as possible, enclosed with watertight casings extending over the load waterline level. One of these means of escape may lead to the machinery spaces.

The shaft and pipeline tunnel doors leading to the machinery spaces and to the cargo pump rooms are to comply with the requirements contained in sub-chapter 7.3 of *Part III – Hull Equipment*..

1.9.2 Workshops, fuel injectors testing stations, separators' rooms and similar spaces enclosed within machinery spaces, may have exits to these spaces only. ECR enclosed within machinery space shall have, except exit to this space, an independent means of escape.

1.9.3 If two adjacent machinery spaces intercommunicate through a door and each of them has only one means of escape through a trunk, the trunks are to be located at the opposite sides of the naval ship.

1.9.4 Exits from the machinery spaces are to lead to the places providing direct access to the boat (embarkation) deck.

1.9.5 All the doors, as well as the covers of companionways and skylights through which it is possible to leave the machinery spaces, are to be capable of being opened and closed both from the inside and outside by a single move of the hand. The covers of such companionways and skylights are to bear a clear inscription prohibiting to stow any objects on them.

The covers of skylights which do not serve as exits are to be fitted with closing devices arranged for locking them from the inside (see also 11.4.11).

1.9.6 The surfaces of machinery, equipment and pipelines, which can heat up to temperatures exceeding 220 °C are to be provided with thermal insulation so that the insulation surface temperature does not exceed 60 °C. The insulation is to be made of non-combustible materials. The insulation should be of a type and so supported that it will not crack or deteriorate when subject to vibrations. Additionally the insulation is to comply with the requirements of 1.7.6 and 1.16.8.

The insulation is also to be protected against mechanical damage.

1.9.7 All the machinery spaces are to be fitted with ventilation system in compliance with the requirements specified in Chapter 11.

1.10 Arrangement of Engines, Machinery and Equipment

1.10.1 Engines and machinery are to be so arranged in machinery spaces as to ensure passage from their service and control positions to exit routes. The recommended width of the passages along their whole length, the width of the gangways in exit routes and the width of exit doors is to be at least 600 mm.

The width of passages near the electric switchboards is to comply with the requirements of sub-chapter 4.5.7 of *Part VIII – Electrical Installations and Control Systems*.

1.10.2 Engines, machinery, equipment, pipes, valves and fittings are to be so arranged as to provide free access to them for attendance. The machinery spaces and spaces located above are to be so designed that open way for aggregate replacement of main propulsion and auxiliary machinery may be quickly ensured.

1.10.3 The distance from outer surface of the boiler insulation to the walls of oil fuel tanks is to be sufficient to ensure free flow of the air necessary to maintain the temperature of oil fuel in the tanks below the oil fuel flash point, except the cases specified in 12.3.4.

1.10.4 Oil fuel, lubricating oil and other flammable oil tanks, pipes, filters, heaters, etc. are not to be located directly above hot surfaces such as gas turbines, boilers, steam pipes, exhaust manifolds, silencers and other equipment requiring thermal insulation. They are to be installed as far away as possible from such hot surfaces. In particular fuel filters operating under pressure are to be located so that in the event of possible fuel leakage the flow is not directed to such surfaces.

Means are to be provided (e.g. shields), to prevent contact with sources of ignition of any possible leakage of oil fuel, lubricating oil or other readily flammable liquid (see also 1.16.11.12 ÷ 1.16.11.15). Each flange coupling is to be protected with a shield fitted directly on both flanges.

1.10.5 As far as practicable, parts of the oil fuel system containing oil under pressure are to be located in well illuminated positions in machinery spaces and such that possible defects and leakage can be readily observed.

1.10.6 Auxiliary boilers, if installed in a common space with diesel engines, are to be shielded, in the area of burner, with a metal screen or other measures are to be taken to protect the machinery space equipment against effects of a flame accidentally thrown off the furnace.

1.10.7 Around auxiliary oil-fired boilers installed on platforms or in tween-deck, non-watertight spaces, oil-tight coamings at least 200 mm high are to be fitted.

1.10.8 As far as practicable, oil fuel tanks are to be part of the naval ship structure and shall be located outside machinery spaces of category A.

The use of free-standing oil fuel tanks is to be avoided. Where such tanks are employed, they are to be placed in an oil-tight spill tray of an ample size, fitted with drain pipes in accordance with 12.5.2÷12.5.5.

1.10.9 Air compressors are to be installed in such places where the contamination by flammable liquid vapours of air drawn by the compressor is as low as possible.

1.10.10 Hydraulic units with working pressure above 1.5 MPa and power above 5 kW located within machinery spaces of category A are to be placed in separate rooms enclosed by steel bulkheads extending from deck to deck and provided with self-closing steel doors.

If it is impracticable to meet the above requirement, location of the equipment in the machinery space, collecting arrangements for possible leakages and the necessity of shielding will be subject to special consideration by PRS.

1.10.11 Requirements regarding the arrangement of main and emergency sources of electric power, electrical equipment and switchboards are contained in sub-chapters 2.6 and 4.5.6 of *Part VIII – Electrical Installations and Control Systems*.

1.11 Installation of Engines, Machinery and Equipment on Foundations

1.11.1 Engines, machinery and equipment constituting the machinery installations are to be installed on strong and rigid foundations. The foundation design is to comply with the requirements of Chapter 12 of *Part II – Hull* (see also 1.6.2).

1.11.2 Steam boilers are to be installed on the foundations in such a way, that their welded joints do not rest on supports.

1.11.3 To prevent boilers from shifting, special stops and stays are to be fitted, taking into account thermal expansion of the boiler body.

1.11.4 Machinery and other equipment may be installed on the tanktop, watertight bulkheads, shaft tunnel or oil fuel tank walls, provided they are fixed to foundations or supporting brackets welded to stiffeners, or to these parts of plating which are directly stiffened.

1.11.5 Where it is necessary to install engines or machinery on elastic pads, the pads are to be of a design approved by PRS.

The installation of engines and machinery on composite material pads will be subject to special consideration by PRS. Composite materials used for the pads are to be approved by PRS.

1.11.6 Main engines and their gears as well as shaft thrust bearings are to be fixed to the foundations, entirely or in part, with fitted bolts or special stops.

1.11.7 The bolts fixing main engines, main propulsion machinery, auxiliary engines and machinery, as well as shaft main bearings to their foundations are to be secured against loosening.

1.11.8 Engines and machinery with horizontally arranged shafts are to be installed parallel to the naval ship centre line. Other orientation may be accepted, provided that the engine or machinery construction permits its operation at the conditions specified in 1.6, being so installed.

1.11.9 The generators' prime movers are to be installed on a common frame with the generators.

1.12 Control Devices of Main Engine

1.12.1 The starting and reversing arrangements are to be so designed and distributed that each engine can be started or reversed by one person.

1.12.2 Direction of control levers or hand-wheels movement is to be clearly indicated by an arrow and relevant inscription.

1.12.3 At the control stations on the navigation bridge, moving the control levers of main engines ahead or to the right, and in the case of control hand-wheels turning them clockwise, is to correspond with the ahead running of the naval ship.

1.12.4 Transfer of control functions between particular positions is to be controlled and confirmed by their operators (see 1.14).

1.12.5 The design of main engine controls is to preclude the possibility of self-change of pre-set position.

1.12.6 The controls of main engines equipped with mechanical turning gear are to have interlocking system to preclude starting the main engine while the turning gear is engaged.

1.12.7 It is recommended to provide an interlocking system between the engine telegraph and the starting and reversing arrangements to prevent the engine from running in the direction opposite to the pre-set one.

1.13 Machinery Controlling and Control Stations

1.13.1 Essential main and auxiliary machinery are to be provided with efficient means for their operation and control. All control systems essential for the propulsion, control and safety of the naval ship are to be independent or designed in such a way, that failure of one system does not preclude operation of another system. It is also to be possible to control the machinery at or near the machinery concerned.

1.13.2 The local control stations of main engines are to be provided with:
- controls,
- instrumentation, as determined by the manufacturer, to supervise the operation of main propulsion machinery,
- tachometers and indicators of the direction of propeller shaft rotation,
- indicator of blade position of controllable-pitch propeller,
- means of communication.

1.13.3 In naval ships equipped with several independent main engines, each one is to be provided with its own control system, and at least one common control station is to be provided.

1.13.4 Where remote or remote-automatic control of the main propulsion machinery is provided, relevant requirements of Chapters 20 and 21 of *Part VIII – Electrical Installations and Control Systems* are to be complied with.

1.13.5 The control stations at the wings of the navigation bridge are to be so interconnected with the bridge control station that control from each station is possible without any change-over and they are to be capable of being switched off or switched on again when abandoned.

1.14 Means of Communication

1.14.1 At least two independent means are to be provided for communicating orders from the navigating bridge to ECR or to the position in the machinery space from which the engines are normally controlled. One of these means is to be an engine room telegraph, which provides visual identification of the transferred engine control orders and responses to them both in the machinery spaces and in the navigation bridge, fitted with clearly audible sound signal well distinct in tone from any other signals which may resound in the room (see also Chapter 7 of *Part VIII – Electrical Installations and Control Systems*). The other means of communication is to be independent of the engine room telegraph and provide for verification of engine control orders and their confirmations.

At least one means of communication, which provides for verification of both engine control orders and confirmations, from the navigation bridge and the engine room to any other position from which the rotational speed or direction of thrust of the propellers may be controlled, is to be provided. Two control positions located close to each other may be provided with one common means of communication upon consent of PRS.

1.14.2 Two-way communication is to be provided between different machinery rooms.

1.14.3 Means for communicating orders and confirmations are to be provided between the main navigational bridge / auxiliary control station and the steering gear compartment.

1.14.4 Where means of oral communication is provided, measures are to be taken to ensure clear audibility when the machinery is running.

1.15 Instrumentation

1.15.1 Instruments, with the exception of liquid thermometers, are to be checked and accepted by a competent administration body in accordance with the state rules in force.

1.15.2 Permissible limits for the measured parameters (minimum and maximum values) are to be clearly and durably indicated on all instruments.

1.15.3 The accuracy of tachometer indications is to be within ±2.5% of the measuring range. Where barred rotational speed ranges for main engines are specified (see 4.1.3.5), they are to be clearly and durably marked on the indicating dials of all tachometers.

1.15.4 Piping systems are to be fitted with instruments necessary for monitoring their proper operation. When choosing the type and number of the instruments, guidance provided by manufacturers of the mechanisms and equipment employed in particular installation is to be taken into consideration.

1.15.5 Instruments in the oil fuel, lubricating oil and other readily flammable oil piping systems are to be fitted with valves or cocks for cutting-off the instruments from the medium. Temperature sensors are to be fitted in tight pockets.

1.16 General Requirements for Piping Systems

1.16.1 Minimum Number of Pumps Serving Naval Ship Piping Systems

Unless otherwise stated in these *Rules*, at least two pumps, main and emergency, are to serve each essential piping system, each one being sufficient for normal operation of the system.

1.16.2 Class, Material, Manufacture and Application of Pipes

1.16.2.1 Requirements contained in sub-chapter 1.16.2 apply to piping systems referred to in the list of the required documentation, normally employed in naval ships and made of carbon steels, carbon-manganese steels, alloy steels or non-ferrous materials, as well as to piping systems made of other materials (see 1.16.2.8).

The requirements do not cover open-ended exhaust gas lines from diesel engines and gas turbines as well as pipes being an integral part of boilers.

1.16.2.2 For the purpose of determining the scope of tests, the type of joints, the kind of heat treatment and welding procedure, the piping systems, depending on their purpose and parameters of the conveyed medium, are subdivided into three classes in accordance with Table 1.16.2.2.

Table 1.16.2.2
Classes of piping systems

Piping system for	**Class I**	**Class II**	**Class III**
Toxic [2] or strongly corrosive media	Without special safeguards [1]	With special safeguards [1]	—
Flammable media with service temperature above the flashpoint or with the flashpoint below 60 °C, liquefied gases	Without special safeguards [1]	With special safeguards [1]	—
Steam [3]	$p > 1.6$ or $t > 300$	Each combination of pressure p and temperature t applicable neither to class I nor class III – see Fig. 1.16.2.2	$p \leq 0.7$ and $t \leq 170$
Thermal oils [3]	$p > 1.6$ or $t > 300$		$p \leq 0.7$ and $t \leq 150$
Oil fuel, lubrication oil, flammable hydraulic oil [3]	$p > 1.6$ or $t > 150$		$p \leq 0.7$ and $t \leq 60$
Other media [3), 4), 5]	$p > 4.0$ or $t > 300$		$p \leq 1.6$ and $t \leq 200$

Notes to Table 1.16.2.2

1) Special safeguards are reducing the possibility of leakage and preventing damages in the nearby area or reaching possible ignition sources; they include e.g.: piping ducts, shields, screens, etc.

2) Pipings conveying toxic media are counted into Class I.

3) p – design pressure, [MPa], (see 1.16.3.1)
t – design temperature, [°C], (see 1.16.3.1).

4) Media such as water, air, gases, and non-flammable hydraulic oils.

5) Open-ended pipes (drains, overflows, air pipes, exhaust gas lines and discharge pipes from steam safety valves), irrespective of the conveyed medium temperature, belong to Class III piping systems.

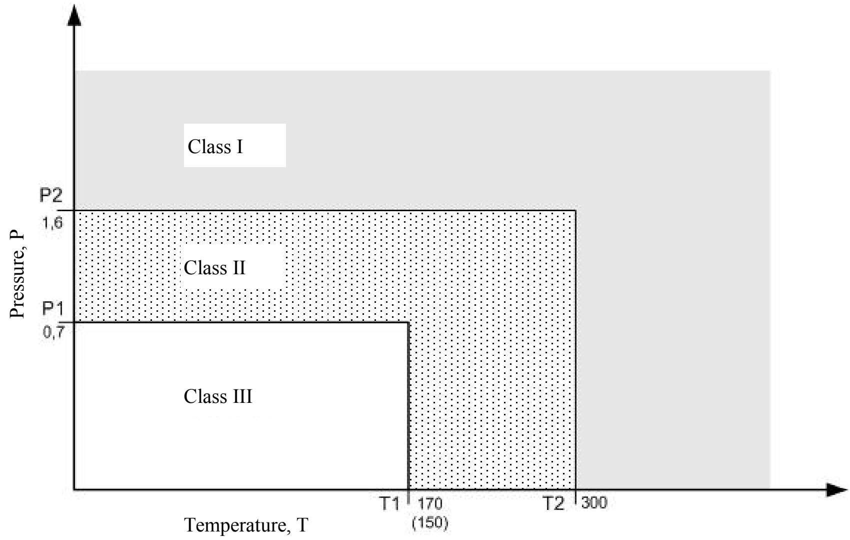


Fig. 1.16.2.2 Piping classes

1.16.2.3 The materials to be used for pipes, valves and fittings, are to comply with the requirements of *Part IX – Materials and Welding*. Materials for pipes, valves and fittings intended for strongly corrosive media are subject to special consideration by PRS.

Prefabrication of piping systems is to comply with the requirements contained in *Publication No. 23/P – Prefabrication of Pipelines.*

1.16.2.4 Steel pipes intended for class I or class II piping systems are to be seamless, hot or cold drawn pipes. Welded pipes, approved by PRS as equivalent to seamless pipes, may also be used.

Pipes, valves and fittings made of carbon steel and carbon-manganese steel are allowed to be used only for media with temperature not exceeding 400 °C and those made of low alloy steel – for media with temperature not exceeding 500 °C.

Such steel may also be used for media with temperature higher than those stated above, provided that at such temperatures their mechanical properties and creep strength limit within 100 000 hours are in accordance with the standards in force and that such values are guaranteed by the manufacturer.

Pipes, valves and fittings intended for media with temperature exceeding 500 °C are to be made of alloy steel

1.16.2.5 Copper and copper alloy pipes are to be seamless or of other type approved by PRS. These pipes for Class I and Class II piping systems are to be seamless.

Copper and copper alloy pipes, valves and fittings are not to be used for media with temperature exceeding:

200 °C – for copper and copper-aluminium alloys,
260 °C – for bronze,
300 °C – for copper-nickel alloys,
as well as for ammonia (NH_3). See also 12.2.7.

1.16.2.6 Nodular cast-iron of the ferritic type may be used for pipes, valves and fittings for media with temperature not exceeding 350 °C, including:
- bilge/drainage and ballast pipes fitted within double bottom,
- ship side valves and fittings, valves and fittings installed on collision bulkhead and on fuel and oil tanks.

The use of this cast-iron for other valves, fittings and pipes as well as for Class II or Class III piping systems is each time subject to special consideration by PRS.

1.16.2.7 Grey cast-iron may be used for Class III piping systems.

Grey cast-iron is not to be used for :
- pipes, valves and fittings subjected to hydraulic shock or excessive strains and vibrations,
- ballast pipes, valves and fittings,
- pipes, valves and fittings of steam and fire-fighting systems,
- pipes connected directly to the external shell plating,
- valves and fittings fitted on the external shell plating or on collision bulkhead,
- valves and fittings fitted directly on oil fuel, lubricating oil or other flammable oil tanks being under hydrostatic pressure.

1.16.2.8 The requirements for plastic pipes as well as conditions of their application in naval ships are contained in the *Publication No. 53/P – Plastic Pipelines on Ships*. PRS has the right to restrict application of such pipes in naval ships.

1.16.3 Pipe Wall Thickness

1.16.3.1 The formulae given below are applicable in the cases when the ratio of outside diameter of the pipe to its inside diameter does not exceed the value 1.7.

The wall thickness s for straight or bent metal pipe exposed to internal pressure (taking into account the requirements of 1.16.3.2) is not to be less than that determined from the formula 1.16.3.1-1:

$$s = s_o + b + c\,, \quad \text{[mm]} \qquad (1.16.3.1\text{-}1)$$

and in no case less than that given in Table 1.16.3.1-1.

$$s_o = \frac{dp}{2\sigma_d \varphi + p}\,, \quad \text{[mm]} \qquad (1.16.3.1\text{-}2)$$

where:

d – outside diameter of the pipe, [mm];

p – design pressure, [MPa] – maximum working pressure, not less than the highest opening pressure of any safety or overflow valve; except for:

– piping for oil fuel heated up to temperature exceeding 60 °C – not less than 1.4 MPa,
– piping for CO_2 fire extinguishing systems – according to the notes to Table 3.10 given in *Part V – Fire Protection*;

φ – safety factor amounting to 1.0 for seamless pipes and for welded pipes, considered as equivalent to seamless pipes; for all other welded pipes, the value of safety factor will be subject to special consideration by PRS;

b – allowance for a reduction of pipe wall thickness due to bending; the value b is to be determined in such a way that the calculated stress in the bend does not exceed the permissible stresses; where the exact value of thickness reduction at the bend is not available, the value b may be determined by the following formula:

$$b = 0.4(d/R)s_o, \quad \text{[mm]} \qquad (1.16.3.1\text{-}3)$$

R – mean inside radius of the bend, [mm];

c – corrosion allowance, [mm], taken:
– for steel pipes – according to Table 1.16.3.1-2,
– for non-ferrous metal pipes – according to Table 1.16.3.1-3;

σ_d – allowable stress, [MPa], taken as:
– for steel pipes – the lowest of the following values:

R_m/2.7; R_e^t/1.8 or $R_{0,2}^t$/1.8; $R_{z/100000/t}$/1.8 and $R_{l/100000/t}$/1.0

where:

R_m – minimum tensile strength, [MPa],

R_e^t, $R_{0,2}^t$ – minimum yield point or 0.2% proof stress, [MPa], at the design temperature t, [°C],

$R_{z/100000/t}$ – average stress, [MPa], to produce rupture in 10^5 hours, at the design temperature t, [°C];

$R_{l/100000/t}$ – average stress, [MPa], to produce 1% creep in 10^5 hours, at the design temperature t, [°C].

Notes:

1. Above specified safety factor 1.8 may be, upon agreement with PRS, reduced to 1.6.
2. PRS may demand $R_{l/100000/t}$ value to be taken into account, if necessary.

– for high alloy steel pipes, σ_d will be specially considered by PRS;
– for copper and copper alloy pipes, σ_d is to be determined from Table 1.16.3.1-4;

t – design temperature [°C], to be considered for determining the allowable stress, is the maximum temperature of the medium inside the pipe; in particular cases, the design temperature will be specially considered by PRS.

Table 1.16.3.1-1
Minimum wall thickness of pipes, *s* [mm]

Nominal diameter [mm]	External diameter [mm]	Carbon steel pipes						Austenitic stainless steel pipes	Copper pipes	Copper alloy pipes
		A	**B**	**C**	**D**	**E**	**F**			
1	2	3	4	5	6	7	8	9	10	11
	< 8	-	-	-	-	-	-	-	1.0	0.8
6	8.0	-	-	-	-	-	-	-	1.0	0.8
	10.2	1.6	-	-	-	-	-	1.0	1.0	0.8
	12	1.6	-	-	-	-	-	1.0	1.2	1.0
8	13.5	1.8	-	-	-	-	-	1.0	1.2	1.0
10	16	1.8	-	-	-	-	-	1.0	1.2	1.0
	17.2	1.8	-	-	-	-	-	1.0	1.2	1.0
	19.3	1.8	-	-	-	-	-	-	1.2	1.0
15	20	2	-	-	-	-	-	-	1.2	1.0
	21.3	2	-	3.2	-	3.2	2.6	1.6	1.2	1.0
	25	2	-	3.2	-	3.2	2.6	1.6	1.5	1.2
20	26.9	2	-	3.2	-	3.2	2.6	1.6	1.5	1.2
	30	2	-	3.2	-	4	3.2	1.6	1.5	1.2
25	33.7	2	-	3.2	-	4	3.2	1.6	1.5	1.2
	38	2	4.5	3.6	6.3	4	3.2	1.6	1.5	1.2
32	42.4	2	4.5	3.6	6.3	4	3.2	1.6	1.5	1.2
	44.5	2	4.5	3.6	6.3	4	3.2	1.6	1.5	1.2
40	48.3	2.3	4.5	3.6	6.3	4	3.2	1.6	2.0	1.5
	51	2.3	4.5	4	6.3	4.5	3.6	-	2.0	1.5
	54	2.3	4.5	4	6.3	4.5	3.6	-	2.0	1.5
50	57	2.3	4.5	4	6.3	4.5	3.6	-	2.0	1.5
	60.3	2.3	4.5	4	6.3	4.5	3.6	2.0	2.0	1.5
	63.5	2.3	4.5	4	6.3	5	3.6	2.0	2.0	1.5
	70	2.6	4.5	4	6.3	5	3.6	2.0	2.0	1.5
65	76.1	2.6	4.5	4.5	6.3	5	3.6	2.0	2.0	1.5
	82.5	2.6	4.5	4.5	6.3	5.6	4	2.0	2.0	1.5
80	88.9	2.9	4.5	4.5	7.1	5.6	4	2.0	2.5	2.0
90	101.6	2.9	4.5	4.5	7.1	6.3	4	-	2.5	2.0

1	2	3	4	5	6	7	8	9	10	11
100	108	2.9	4.5	4.5	7.1	7.1	4.5	-	2.5	2.0
	114.3	3.2	4.5	4.5	8	7.1	4.5	2.3	2.5	2.0
	127	3.2	4.5	4.5	8	8	4.5	2.3	2.5	2.0
	133	3.6	4.5	4.5	8	8	5.0	2.3	3.0	2.5
125	139.7	3.6	4.5	4.5	8	8	5.0	2.3	3.0	2.5
	152.4	4	4.5	4.5	8.8	8.8	5.6	2.3	3.0	2.5
150	159	4	4.5	4.5	8.8	8.8	5.6	2.3	3.0	2.5
	168.3	4	4.5	4.5	8.8	8.8	5.6	2.3	3.0	2.5
	177.8	4.5	5	5	8.8	-	-	-	3.0	2.5
175	193.7	4.5	5.4	5.4	8.8	-	-	-	3.5	3.0
200	219.1	4.5	5.9	5.9	8.8	-	-	2.6	3.5	3.0
225	244.5	5	6.3	6.3	8.8	-	-	-	3.5	3.0
250	273	5	6.3	6.3	8.8	-	-	2.9	4.0	3.5
	298.5	5.6	6.3	6.3	8.8	-	-	-	4.0	3.5
300	323.9	5.6	6.3	6.3	8.8	-	-	3.6	4.0	3.5
350	355.6	5.6	6.3	6.3	8.8	-	-	3.6	4.0	3.5
	368	5.6	6.3	6.3	8.8	-	-	3.6	4.0	3.5
400	406.4	6.3	6.3	6.3	8.8	-	-	3.6	4.0	3.5
	419	6.3	6.3	6.3	8.8	-	-	4.0	4.0	3,5
450	457.2	6.3	6.3	6.3	8.8	-	-	4.0	4.0	3.5
500	508	-	-	-	-	-	-	4.0	4.6	4.0

A – Piping systems other than those mentioned under B, C, D, E, F, or in the Note 8.
B – Air, overflow and sounding pipes of structural tanks, except those mentioned under D, and drain pipes of standard wall thickness covered by 5.6.
C – Sea-water pipes (bilge/drainage, ballast, cooling water, fire systems, etc.) – except those mentioned under D.
D – Bilge/drainage, ballast, air, overflow and sounding pipes in way of oil fuel tanks and bilge, air, overflow, sounding and oil fuel pipes in way of ballast tanks as well as air pipes situated above open deck and drainage pipes of increased wall thickness (see 5.6).
E – Carbon dioxide fire extinguishing piping – from cylinders to distribution valves (see Notes 2, 3, 6, 7).
F – Carbon dioxide fire extinguishing piping – from distribution valves to discharge nozzles (see Notes 2, 3, 6, 7).

Notes to Table 1.16.3.1-1:

1) Wall thickness and pipe diameters listed in the Table are determined according to ISO Recommendations R 336. The minor differences resulting from the use of other standards may be accepted.
2) For the values listed in the Table no allowances need to be made for negative manufacturing tolerance and reduction in thickness due to bending.
3) For the diameters greater than those listed in the Table, the minimum wall thickness is subject to special consideration by PRS.
4) For pipes efficiently protected against corrosion, upon agreement with PRS, the wall thickness listed in columns 4, 5 and 6 may be reduced, but not more than by 1 mm.
5) For sounding pipes the wall thickness listed in columns 4 and 6 applies to these parts located outside the tanks for which the pipes are intended.
6) For threaded pipes, the wall thickness listed is the minimum thickness in the threaded part of the pipe.
7) The pipes listed under E and F are to be galvanized at least inside. Upon agreement with PRS short section of pipes installed in engine room need not to be galvanized.
8) The Table does not cover exhaust gas lines. Minimum wall thickness of the lines are subject to separate consideration by PRS in each particular case.
9) The wall thickness of low pressure carbon dioxide fire extinguishing system from gas storage cylinder to discharge nozzles is to be taken according to the values given in column 8 of the Table.

Table 1.16.3.1-2
Corrosion allowance for steel pipes, *c* [mm]

Piping service	*c*
Saturated steam systems	0.8
Steam coil systems	2.0
Feed water for boilers – open circuit systems	1.5
Feed water for boilers – closed circuit systems	0.5
Boiler blow-down systems	1.5
Compressed air systems	1.0
Hydraulic oil systems	0.3
Lubricating oil systems	0.3
Oil fuel systems	1.0
Refrigerating plants and systems	0.3
Fresh water systems	0.8
Sea-water systems	3.0

Notes to Table 1.16.3.1-2:

1) If the pipes are properly protected against corrosion then, upon agreement with PRS, the corrosion allowance may be reduced, but not more than by 50%.
2) In the case of use of special alloy steel pipes with sufficient corrosion resistance, the corrosion allowance *c* may be reduced to zero.
3) For pipes passing through tanks, the value of allowance *c* is to be taken as the sum of required allowance for the medium in piping and corrosion allowance for the medium in tank; the corrosion allowance is to be taken as equal to the allowance defined in Table for the medium such as the one in the tank.

Table 1.16.3.1-3
Corrosion allowance for copper and copper alloy pipes, *c* [mm]

Pipe material	*c*
Copper and copper alloys except those with lead contents	0.8
Copper-nickel alloys (with nickel content 10% and more)	0.5

Note to Table 1.16.3.1-3:
In the case of special alloy pipes of sufficient resistance to corrosion, the corrosion allowance *c* may be reduced to zero

Table 1.16.3.1-4
Allowable stress for copper and copper alloys depending on the medium temperature, σ_d [MPa]

Pipe material	Material condition	R_m [MPa]	Temperature of medium [°C]										
			50	75	100	125	150	175	200	225	250	275	300
Copper	Annealed	215	41	41	40	40	34	27.5	18.5	–	–	–	–
Aluminium brass	Annealed	325	78	78	78	78	78	51	24.5	–	–	–	–
Copper-nickel alloy 95/5 and 90/10	Annealed	275	68	68	67	65.5	64	62	59	56	52	48	44
Copper-nickel alloy 70/30	Annealed	365	81	79	77	75	73	71	69	67	65.5	64	62

Notes to Table 1.16.3.1-4:
1) Intermediate values are to be determined by linear interpolation.
2) For materials not included in the Table, permissible stress is separately considered by PRS.

1.16.3.2 In the case of pipes with negative manufacturing tolerance, the wall thickness is to be determined by the formula:

$$s_1 = \frac{s}{1-0.01a} \qquad (1.16.3.2)$$

where:
s – wall thickness calculated by formula 1.16.3.1-1, [mm];
a – negative manufacturing tolerance of wall thickness, [%].

1.16.3.3 For pipes with an outside diameter of 80 mm and above, conveying superheated steam at a temperature 350 °C and over, additional stress caused by thermal expansion limitation is to be taken into account, and the flanged joints are to be calculated for strength and tightness.

1.16.4 Pipe Connections

The following types of direct connections may be used for pipings:
– welded butt-joints,

– flanged connections,
– threaded joints,
– mechanical joints.

Where it is reasonable, flexible hose assemblies may be used for connecting pipings with machinery.

Each of the above connections/assemblies is to comply with the recognised standards or is to be proved suitable for the considered application and be accepted by PRS.

1.16.4.1 Butt Welded Joints

1.16.4.1.1 Welding and non-destructive testing of welds are to be performed in accordance with the requirements of the *Publication No. 23/P – Pipelines Prefabrication* and of the *Rules for the Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*.

1.16.4.1.2 Butt welded joints are to be performed with full penetration. Such joints made with special provision for a high quality of root side[1] may be used in all classes pipes, irrespective of the pipe outside diameter. Butt welded joints without special provision for a high quality of root side may be used for piping systems of II and III class, irrespective of outside diameter.

1.16.4.1.3 Slip-on sleeve joints are to have sleeves. Socket welded joints are performed by using pipes ended with a socket. Dimensions of sleeves, sockets and welds are to comply with the requirements of recognised standards. Accepted applications of such connections for the relevant class of piping and outside diameter are presented in Table 1.16.4.1.3.

Table 1.16.4.1.3
Accepted applications of slip-on sleeve and socket welded joints

<table>
<tr><th rowspan="2">Class of piping</th><th rowspan="2">Pipe outside diameter [mm]</th><th colspan="2">Type of connection</th></tr>
<tr><th>Slip-on sleeve</th><th>Socket welded joint</th></tr>
<tr><td>I</td><td rowspan="2">≤ 88.9</td><td colspan="2" rowspan="2">Both joints may be used, except piping:
– conveying toxic media,
– subject to fatigue loads,
– where severe erosion or crevice corrosion is expected to occur</td></tr>
<tr><td>II</td></tr>
<tr><td>III</td><td>Irrespective of the pipe diameter</td><td colspan="2">Both types of connection may be used.</td></tr>
</table>

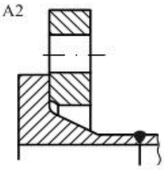
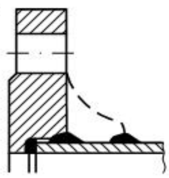
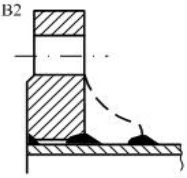
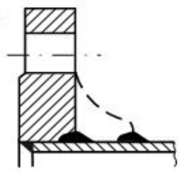
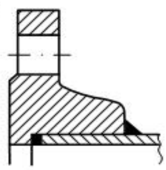
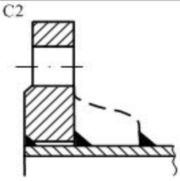
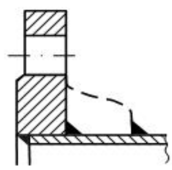
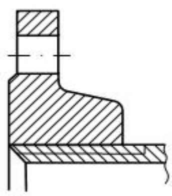
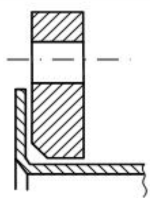
[1] ”Joint made with special provision for a high quality of root side” means that butt welds were accomplished as double welded or by use of backing ring or inert gas back-up on first pass. Subject to PRS’ consent, other similar methods may be accepted.

1.16.4.2 Flange Connections

1.16.4.2.1 Dimensions and type of connected flanges and connecting bolts are to correspond to recognised standards. Dimensions of non-standard flange connections and their bolts are subject to special consideration by PRS.

1.16.4.2.2 The gaskets used in flange connections are to be suitable for the media to be conveyed and environment conditions. They are to be appropriate for the design pressure and temperature and their dimensions and shape are to be in accordance with the recognised standards. Gaskets of oil fuel piping connections are to ensure tightness at the temperature of the conveyed medium reaching at least 120 °C.

Table 1.16.4.2.3
Accepted types of flange connections

A	A1 	A2 	
B	B1 	B2 	B3 
C	C1 	C2 	C3 
D			
E			

Note to Table 1.16.4.2.3:
For the connections of type D, the tapered thread is to be used. Diameter of the screw portion of the pipe over the thread is not to be appreciably less than the outside diameter of the unthreaded pipe. For certain types of thread, after the flange has been screwed hard home, the pipe is to be expanded into the flange.

1.16.4.2.3 Accepted types of flange connections which can be used for connecting pipings, are presented in Table 1.16.4.2.3. The type of flange is selected depending on the structure of the flange and the method of flange fitting to the piping. Use of other types of flange attachments is subject to special consideration by PRS.

1.16.4.2.4 The type of flange connection is to be selected depending on the class of the piping and the conveyed medium in accordance with Table 1.16.4.2.4.

Table 1.16.4.2.4
Accepted types of flange connections depending on the class of piping and the conveyed medium

Class of piping	Toxic, strong corrosive, flammable media [4] and liquefied gas	Lubricating and fuel oil	Steam [3] and thermal oil	Other media [1), 2), 3), 4), 5)]
I	A, B [6]	A, B	A, B [6]	A, B
II	A, B, C	A, B, C,	A, B, C, D [5]	
III	–	A, B, C, E	A, B, C, D, E	A, B, C, D, E,

Notes to Table 1.16.4.2.4:
[1] Including water, air, gas and hydraulic oil.
[2] Type E connections are to be used for water pipes and open-ended lines only.
[3] Only type A when design temperature exceeds 400 °C.
[4] Only type A when design pressure exceeds 1.0 MPa.
[5] Types D and E are not to be used when design temperature exceeds 250 °C.
[6] Type B connections are to be used for pipes with outside diameter less than 150 mm, only.

When selecting the flange connection, external loads or cyclic loads acting on the piping and the flange connections arrangement in the naval ship are to be taken into account.

1.16.4.3 Slip-on Threaded Joints

1.16.4.3.1 Slip-on threaded joints, having pipe threads where pressure-tight joints are made on the threads with parallel or tapered threads are to comply with the recognised standards.

1.16.4.3.2 Slip-on threaded joints in carbon dioxide fire-extinguishing systems shall be allowed only inside protected spaces and CO_2 cylinder stations.

1.16.4.3.3 Slip-on threaded joints may not be used in piping systems conveying flammable or toxic media nor in the systems where fatigue, severe erosion or crevice corrosion is expected to occur.

1.16.4.3.4 Accepted applications of threaded joints, depending on the pipe external diameter and thread type, are given in Table 1.16.4.3.4. The slip-on threaded joints complying with recognised standards may be used for greater diameters of pipes than those given in Table 1.16.4.3.4, upon approval of PRS.

Table 1.16.4.3.4
Accepted applications of threaded joints

Class of piping	Pipe outside diameter [mm]	Thread type	
		Parallel thread	Tapered thread
I	≤ 33.7	No	Yes
II	≤ 33.7	No	Yes
III	≤ 60.3	Yes	Yes

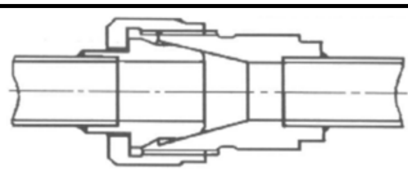
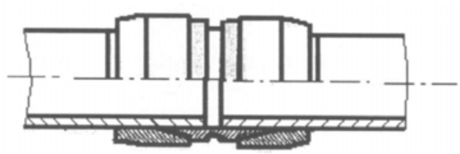
1.16.4.4 Mechanical Connections

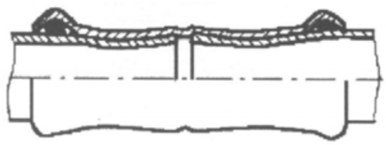
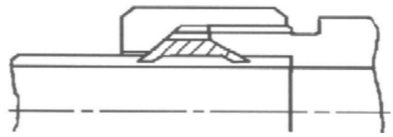
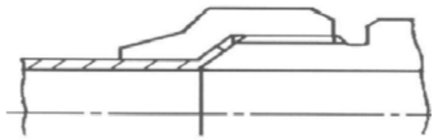
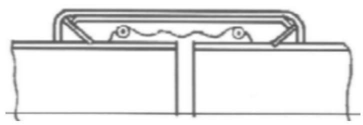
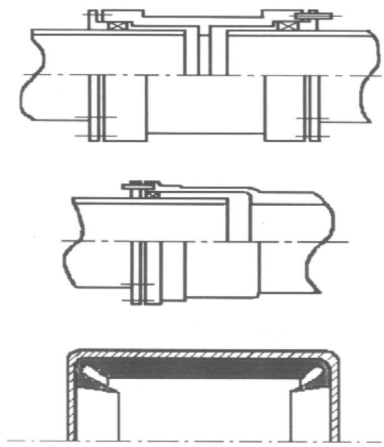
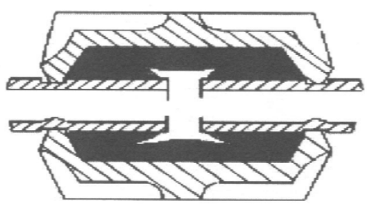
1.16.4.4.1 Due to the great variations in design and configuration of mechanical joints, no specific recommendations regarding calculation method for theoretical strength calculations is given in this sub-chapter. The joints approval is to be based on the results of testing the actual joints.

Publication No. 57/P – Type Approval of Mechanical Joints describes tests, the connections are to be subjected to.

1.16.4.4.2 The requirements given in this sub-chapter apply to pipe unions, compression couplings and slip-on joints presented in Table 1.16.4.4.2. Connections of other design may be accepted by PRS provided they comply with the requirements of this sub-chapter.

Table 1.16.4.4.2
Types of mechanical joints

PIPE UNIONS	
Welded and brazed types	
COMPRESSION COUPLINGS	
Swage types	

Press type	
Bite type	
Flared type	
SLIP-ON JOINTS	
Grip type	
Slip type	
Machine grooved type	

1.16.4.4.3 The mechanical connections are to be of type approved by PRS for the intended service conditions and application.

1.16.4.4.4 Where the application of mechanical joints results in reduction of pipe wall thickness (e.g. due to the use of bite type rings), this is to be taken into account in determining the minimum wall thickness (see 1.16.3).

1.16.4.4.5 Construction of mechanical joints is to prevent the possibility of tightness failure due to pressure pulsation, piping vibration, temperature variation and other similar adverse effects occurring during operation onboard.

1.16.4.4.6 Materials of mechanical joints are to be compatible with the piping material, conveyed medium and ambient environment.

1.16.4.4.7 The mechanical joints, which in the event of damage could cause flooding, are not to be used in piping sections directly connected to naval ship's external plating or tanks containing flammable liquids.

1.16.4.4.8 Mechanical joints are to be designed to withstand internal and external pressure as applicable and where used in suction lines are to be capable of operating under vacuum.

1.16.4.4.9 The number of mechanical joints in fuel and oil systems is to be kept to a minimum. In general, flange connections are to be applied as far as practicable in such systems.

1.16.4.4.10 Piping in which a mechanical joint is installed is to be adequately adjusted and aligned in accordance with the joint manufacturer's guidelines. Supports and hangers are not to be used to force alignment of piping at the point of connection.

1.16.4.4.11 Slip-on joints are not to be used inside cargo holds, tanks and other spaces which are not easily accessible unless approved by PRS. Application of these joints inside tanks may be permitted only for the same media that are in the tanks.

1.16.4.4.12 Unrestrained slip-on joints may be used only where compensation of lateral pipe deformation is necessary. Use of these joints as the main means of pipe connection is not permitted.

1.16.4.4.13 Accepted applications of particular types of mechanical joints, depending on piping class and its external diameter d_Z, are given in Table 1.16.4.4.13.

Table 1.16.4.4.13
Accepted applications of mechanical joints

Joint type	Piping class		
	I	II	III
PIPE UNIONS			
Welded, brazed	Yes	Yes	Yes
COMPRESSION COUPLINGS			
Swage type	Yes	Yes	Yes
Press type	No	No	No
Bite type	Yes (for $d_Z \leq 60.3$ mm)	Yes (for $d_Z \leq 60.3$ mm)	Yes
Flared type	Yes (for $d_Z \leq 60.3$ mm)	Yes (for $d_Z \leq 60.3$ mm)	Yes
SLIP-ON JOINTS			
Grip type	No	Yes	Yes
Machine grooved type	Yes	Yes	Yes
Slip type	No	Yes	Yes

1.16.4.4.14 Table 1.16.4.4.14 specifies approved application of particular kinds of joints for particular piping systems.

Table 1.16.4.4.14
Acceptable application of mechanical connections

Systems		Kind of joint		
		Pipe unions	**Compression couplings** 5)	**Slip-on joints**
1	Gravitation drainage overboard	Yes	Yes	No
2	Bilge	Yes	Yes	Yes 1)
3	Gravitation drainage inside the naval ship	Yes	Yes	Yes 4)
4	Oil residues	Yes	Yes	Yes 2), 3)
5	Ballast and balance	Yes	Yes	Yes 1)
6	Air, overflow and sounding pipes of: • water tanks, void spaces, etc. • flammable liquid tanks	 Yes Yes	 Yes Yes	 Yes Yes 2), 3)
7	Fuel oil	Yes	Yes	Yes 2), 3)
8	Lubricating, heating and hydraulic oil	Yes	Yes	Yes 2), 3)
9	Cooling water	Yes	Yes	Yes 1)
10	Sanitary and fresh water	Yes	Yes	Yes
11	Naval ship flushing	Yes	Yes	Yes 3)
12	Water and foam fire extinguishing	Yes	Yes	Yes 3)
13	Gas smothering 1)	Yes	Yes	No
14	Compressed air: • starting and control air • household	 Yes Yes	 Yes Yes	 No Yes
15	Steam	Yes	Yes	No
16	Sanitary drainage (other than those in 1)	Yes	Yes	Yes

Notes to Table 1.16.4.4.14:

1) Inside machinery spaces of category A, fire-resistant joints of an approved type may only be used.

2) Not allowed to be used in machinery spaces of category A or accommodation spaces. May be used in other machinery spaces, provided the joints are located in easily visible and accessible positions.

3) Approved fire-resistant joints may be used, only.

4) May be used provided they are installed above the open deck (see definitions in 1.2.3 of *Part III – Hull Equipment*).

5) When the 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.

1.16.4.4.15 The mechanical joints are to be installed in accordance with the manufacturer's installation manual. Where special tools or measuring instruments are needed for the installation, they are to be provided by the joints' manufacturer.

1.16.4.5 Flexible Hose Assemblies and Compensators

1.16.4.5.1 The requirements of the present sub-chapter apply to flexible hose assemblies (see 1.2) intended for connection between pipings system and items of machinery. The requirements may also be applied, in reasonable scope, to compensators.

Unless provided otherwise in other provisions of the Rules, flexible hose assemblies complying with the requirements of this subchapter may be applied in oil fuel, lubricating, hydraulic and thermal oil systems, fresh water, compressed air systems and steam systems (class III pipings only) and compensators may additionally be applied in exhaust gas systems.

Flexible hose assemblies and compensators shall not be used in high pressure fuel oil injection systems.

1.16.4.5.2 Flexible hose assemblies are to be designed and constructed in accordance with the requirements of the recognized national or international standards acceptable to PRS.

Flexible hose assemblies constructed of rubber or plastics materials and intended for use in the systems: oil fuel, lubricating, hydraulic and thermal oil systems, compressed air systems, bilge or ballast systems are to incorporate a single or double closely woven integral wire braid or other suitable material reinforcement. Where rubber or plastics materials hoses are to be used in oil supply lines to burners, the hoses are to have external wire braid protection in addition to the integral reinforcement.

Flexible hose assemblies for use in steam systems are to be of metallic construction.

1.16.4.5.3 Flexible hose assemblies are to be provided with type approved end fittings in accordance with the manufacturer's specification. The end connections that do not have a flange are to comply with the requirements of paragraph 1.16.4.4. The prototype of each flexible hose assembly, i.e. hose/fitting combination is to be subjected to tests to the same standard as that required for the hose included in the assembly, with particular reference to pressure and impulse tests.

1.16.4.5.4 The use of hose clamps and similar types of end attachments is not permitted for flexible hoses in the systems: steam, flammable media, starting air systems, as well as sea water systems where failure may result in flooding.

In other piping systems, the use of hose clamps may be accepted by PRS where the working pressure is less than 0.5 MPa and there are double clamps at each end connection.

1.16.4.5.5 Flexible hose assemblies or compensators intended for installation in piping systems where pressure pulses and/or high levels of vibration are expected to occur in service are to be designed for the maximum expected impulse peak pressure and forces due to vibration.

The tests required by paragraph 1.16.4.5.16 to 1.16.4.5.18 are to take into consideration the maximum anticipated in-service pressures, vibration frequencies and forces due to installation.

1.16.4.5.6 Flexible hose assemblies of non-metallic materials intended for installation in piping systems for flammable media and sea water systems where failure may result in flooding are to be of fire-resistant type. Fire resistance is to be demonstrated by testing to ISO 15540 and ISO 15541.

1.16.4.5.7 Flexible hose assemblies are to be selected for the intended location and application taking into consideration ambient conditions, compatibility with fluids under working pressure and temperature conditions consistent with the manufacturer's instructions.

1.16.4.5.8 Flexible hose assemblies are to be limited to a length necessary to provide for relative movement between fixed and flexibly mounted items of machinery/equipment or systems.

1.16.4.5.9 Flexible hose assemblies are to be have appropriate shut-off valves to prevent leakage of readily flammable media or flooding by sea water in the case of the assembly damage.

1.16.4.5.10 Shut-off valves shall be so arranged that a flexible hose assembly can be replaced withaout stopping mechanisms other than served by the assembly.

1.16.4.5.11 Flexible hose assemblies shall not be installed where they may be subjected to torsion deformation (twisting) under normal operating conditions.

1.16.4.5.12 The number of flexible hose assemblies in piping systems is to be kept to a minimum.

1.16.4.5.13 Where flexible hose assemblies are intended to be used in piping systems conveying flammable fluids that are in close proximity of heated surfaces, the risk of ignition due to failure of the hose assembly and subsequent release of fluids is to be mitigated as far as practicable by the use of screens or other similar protection approved by PRS.

1.16.4.5.14 Flexible hose assemblies are to be installed in clearly visible and readily accessible locations.

1.16.4.5.15 The installation of flexible hose assemblies is to be in accordance with the manufacturer's instructions and use limitations, with particular attention paid to the following:
- orientation;
- end connection support (where necessary);
- avoidance of hose contact that could cause rubbing and abrasion;
- minimum bend radii.

1.16.4.5.16 Acceptance of flexible hose assemblies is subject to satisfactory prototype testing. Prototype test programme for flexible hose assembly is to be submitted by the manufacturer to PRS for consideration. The test programme is to be sufficiently detailed to demonstrate performance in accordance with the applicable standards.

1.16.4.5.17 The tests are, as far as applicable, to be carried out on different nominal diameters of flexible hose assembly complete with end fittings and are to include pressure, burst, impulse resistance and fire resistance test in accordance with the requirements of the relevant standards.

The following standards are to be used, as applicable:
- ISO 6802 – Rubber and plastics hose and hose assemblies and flexible hose assemblies – Hydraulic impulse test without flexing,
- ISO 6803 – Rubber and plastics hose and hose assemblies and flexible hose assemblies – Hydraulic impulse test with flexing,
- ISO 15540 – Ships and marine technology – Fire resistance of hose assemblies – Test methods,
- ISO 15541 – Ships and marine technology – Fire resistance of hose assemblies – Requirements for the test bench,
- ISO 10380 – Pipework – Corrugated metal hoses and hose assemblies.

Other standards may be accepted where agreed by PRS.

1.16.4.5.18 All flexible hose assemblies are to be satisfactorily prototype burst tested to an International Standard[1] to demonstrate that they are able to withstand a pressure not less than four times the design pressure p_0 without indication of failure or leakage.

1.16.4.5.19 Flexible hose assemblies are to be durably marked by the manufacturer with the following particulars:
- the manufacturer's name or trademark;

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[1] International Standards, eg. of EN series, for non-metallic hose burst test, require increasing pressure above 4 p_0, until the hose bursts.

– date of manufacture (month/year);
– designation type reference;
– nominal diameter;
– pressure rating;
– temperature rating.

Where flexible hose assembly is made from components produced by different manufacturers, all components are to be clearly identified and traceable to evidence prototype testing.

1.16.5 Radius of Pipe Bends

The mean radius of bend of the boiler scum and blow-down pipes is not to be less than 3.5*d* (*d* – outside diameter of the pipe). The mean radius of bend of the steel and copper pipes subjected to a pressure exceeding 0.5 MPa or to a temperature of the medium exceeding 60 °C, as well as the radius of bend of the pipes intended for self-expansion are to be not less than 2.5*d*.

If, during bending, no reduction of the pipe wall thickness occurs then, upon agreement of the bending procedure with PRS, the specified above radius may be reduced.

1.16.6 Protection of Piping Against Excessive Pressure

1.16.6.1 Where the pressure is likely to develop in excess of the working pressure, the piping is to be provided with means preventing the pressure in the pipeline to rise above the working pressure.

Open escape of oil fuel, lubricating oil and other flammable oil from the safety valves is not allowed.

1.16.6.2 Where provision is made for a reducing valve on the pipeline, a pressure gauge and safety valve are to be installed thereafter. An arrangement for bypassing the reducing valves is recommended.

1.16.7 Protection Against Corrosion

1.16.7.1 Upon completion of bending and welding, pipings of bilge/drainage, ballast and sea-water systems, air, sounding and overflow pipings of water tanks and ballast/fuel tanks, are to be protected against corrosion by a method agreed with PRS.

1.16.7.2 Where bottom and side fittings or their parts are made of copper alloys, provision is to be made for protection of the nearby shell plating and all other elements being in contact with the said fittings against electrolytic corrosion.

1.16.7.3 Where galvanized sea-water pipes are connected to copper alloy casings of pumps, units, heat exchangers and elements of fittings, provision is to be made for protection against electrolytic corrosion.

1.16.7.4 Where steel piping of refrigerant or cooling medium and their connecting elements are not made of stainless steel, they are to be galvanized outside or to be protected against corrosion with other, equivalent means. The surfaces being in contact with refrigerant or cooling medium are not to be galvanized.

The pipes are to be made in compliance with the requirements of 21.4.1 and 21.4.2.

1.16.8 Insulation of Pipings

1.16.8.1 The insulation of pipings is to comply with the requirements given in 2.2.1 of *Part V – Fire Protection*. The requirements do not apply to piping of refrigerating systems within the refrigerated spaces (see also 1.7.6 and 1.9.6).

1.16.8.2 Insulation of refrigerating pipings is to be protected against absorption of moisture. At bulkhead and deck penetrations the pipes are not to be in direct contact with these divisions, to avoid the formation of heat leakage bridges.

1.16.8.3 Antiperspiration materials and adhesives applied with insulation as well as insulation of fittings need not to be in compliance with the requirements given in 1.16.8.1, provided these materials are used in small quantities, and their uncovered surfaces have the LFS material properties (see definitions in sub-chapter 1.2 of *Part V – Fire Protection*).

1.16.9 Valves and Fittings

1.16.9.1 The covers of valves with internal diameter of more than 32 mm, equipped with turning spindles, are to be secured to the bodies by bolts or studs.

The screwed-on covers of valves are to be reliably secured against loosening. The nut of cock plug is to be secured against unscrewing from the taper.

1.16.9.2 Remotely controlled valves, operating with auxiliary source of power with the exception of those mentioned in 1.16.9.4, are to have local manual control, the operation of which is to be independent of the remote control system. Manual control of the valves is not to render any failure in the remote control system.

The design of remotely controlled valves is to be such as to ensure that in the case of failure of remote control system the valves remain in position that not render any state of emergency to the naval ship or they automatically set to such position.

1.16.9.3 Valves installed inside cargo tanks are not to be compressed air controlled.

1.16.9.4 Hydraulically controlled valves installed inside cargo tanks are to be so designed as to be capable of being emergency controlled by means of a hand operated pump. The pump is to be connected by a separate line at a place suitable for emergency control of each valve of the system or directly to the valve's actuators.

1.16.9.5 The tank containing working liquid of hydraulic control system of the valves installed inside cargo tanks is to be located above the cargo tanks upper level, as high as practicable, whereas all the hydraulic installation pipes are to be led into the cargo tanks in their upper part.

Audible and visual alarms of the low level of liquid in the tank are to be provided.

1.16.9.6 Shut-off devices are to be fitted with nameplates clearly specifying their purpose and with ”valve open/closed” indicators.

1.16.9.7 For remotely controlled valves, nameplates specifying their purpose, as well as the ”valve open/valve closed” indicators, are to be provided in the control stations.

1.16.9.8 Valves and fittings installed on watertight and gastight bulkheads are to be secured by studs screwed into pads fitted to the bulkhead, or they may be attached to bulkhead penetration pieces.

The stud holes are not to be through holes.

1.16.9.9 The valve chests and manually controlled valves are to be situated in positions always accessible during the normal operation of the naval ship.

1.16.10 Bottom and Side Sea Chests, Bottom and Side Valves and Fittings

1.16.10.1 The sea-water inlet valves and fittings are to be placed directly on the bottom or side sea chests.

1.16.10.2 An access is to be provided to the inside of the bottom and side sea chests by means of removable covers or gratings.

1.16.10.3 The number of discharge openings in the shell plating is to be kept to a minimum. Therefore, where possible, the pipes of similar purpose are to be connected to common discharge openings.

1.16.10.4 The arrangement of the sea inlet and discharge openings in the shell plating is to preclude:

– possibility of sucking the drains, ashes and other wastes by sea-water pumps,
– passing discharged water and drains into the naval ship spaces through the side scuttles and into launched lifeboats and liferafts; where such arrangement of the openings is not practicable, the openings are to be fitted with arrangements that would prevent water from passing into the naval ship spaces, lifeboats and liferafts.

1.16.10.5 Openings in the naval ship shell plating leading to the bottom and side sea chests are to be fitted with protective gratings, unless the openings are made by appropriate method, e.g. in the form of small holes or slots made in the naval ship’s hull. The total net area of the holes or slots is to be not less than 2.5 times the total cross-sectional area of the sea-water inlet valves installed on the sea chest considered. The diameter of holes or width of slots in the gratings or shell plating is to be about 20 mm.

The bottom sea chests are to be provided with arrangements for clearing the gratings with steam or compressed air. Shut-off non-return valves are to be fitted on the clearing pipes. The steam or compressed air pressure is not to exceed 0.5 MPa.

1.16.10.6 All side inlets and discharges of piping systems, serving the main engines and auxiliary machinery, located in machinery spaces are to be fitted with readily accessible valves or gate valves with a local and/or remote control. The valve controls are to be fitted with ”valve open/ closed” indicators.

Side discharge valves are to be of a shut-off non-return type.

1.16.10.7 The means for operating the bottom sea inlet valves are to be situated in readily accessible positions and fitted with ”valve open/valve closed” indicators. These means are recommended to be located above the floor plating of engine room.

1.16.10.8 The located in machinery spaces means of control of the inlet and discharge side valves, situated below the water line, of sea-water systems and all control means of water ejector drainage systems, are to be so arranged as to enable quick access and operation thereof in the shortest possible time in the event of the space being flooded. If the water level in the flooded compartment is above the means of control, provision is to be made to enable the operation of the valves from the positions situated above the water level.

1.16.10.9 The bottom and side valves and fittings are to be installed on welded pads. The holes for the fastening bolts or studs are not to be of through type.

The valves and fittings are allowed to be installed on the welded distance pieces, provided the latter are of sufficiently rigid construction and as short as possible. The wall thickness of a distance piece is not to be less than the minimum thickness of the shell plating at the naval ship peaks; however, it need not be more than 12 mm.

1.16.10.10 The side valves and fittings installed below the bulkhead deck and bottom valves and fittings, including gaskets, are not to be made of materials easily destructible by fire.

1.16.10.11 The spindles and closing parts of the bottom and side valves and fittings are to be made of materials resistant to the corrosive effect of sea-water.

1.16.11 Arrangement of Piping

1.16.11.1 The number of pipe penetrations in watertight bulkheads is to be kept to a minimum necessary for normal service of the naval ship.

On the pipes passing through main watertight bulkheads, measures are to be taken to prevent the passing of water through the bulkheads in the event of damage to the shell plating and to the pipes.

For naval ships of length *L* equal to 100 m and above, see also *Part IV – Stability and Subdivision*.

1.16.11.2 Every pipe penetrating the collision bulkhead is to be fitted with a shut-off valve installed directly on the bulkhead inside the forepeak. The valve may also be fitted on the collision bulkhead outside the forepeak, provided it is readily accessible in all conditions of naval ship's service.

Operation of the above-mentioned valves is to be effected easily and reliably from the positions above the bulkhead deck. The valves' control devices are not to be exposed to weather.

The pipes penetrating the collision bulkhead above the bulkhead deck need not be fitted with a shut-off valve.

1.16.11.3 Where the pipes penetrate watertight/gastight bulkheads, decks or other watertight/gastight structures, provision is to be made for penetration pieces or other arrangements ensuring the watertight/gastight integrity of the structure concerned.

Holes for bolts and studs are not to pierce the watertight/gastight structures. In the case the pads are used, the holes for the fastening bolts or studs are not to be of through type.

Gaskets made of material easily destructible by fire are not to be used.

Penetration pieces attached by welding to watertight decks or bulkheads are to be thicker by 1.5 to 3 mm than the wall thickness of the pipe to be connected, depending on its diameter.

1.16.11.4 Where it is necessary to pass plastic pipes through watertight bulkheads or decks that confine the watertight compartments included in the naval ship subdivision calculation, valves operated from a position above the bulkhead deck are to be fitted directly at the bulkhead/deck penetration of the pipe. The valves are to be made of steel or other material equivalent to steel with regard to fire resistance.

This requirement does not apply to pipings of ballast system led within the double bottom space.

1.16.11.5 Leading pipes through fire-resisting divisions (see definitions in sub-chapter 1.2 of *Part V – Fire Protection*) is to comply with the following requirements :

.1 penetrations through A Class divisions – the penetration is to be made of steel pipe (or other equivalent with regard to fire resistance) with wall thickness not less than 3 mm. Length of the penetration piece is to be not less than 900 mm and preferably 450 mm to be on each side of the division. The penetration is to be tight and insulated thermally along the whole length to the same level as the division pierced. Penetrations made in a different way may be employed, provided they are subject to tests specified in *FTP Code* (see definitions in sub-chapter 1.2 of *Part V – Fire Protection*), Annex 1, Part 3;

.2 penetrations of pipes, other than steel or copper pipes, through B Class divisions – the penetration is to be made as a steel sleeve with wall thickness not less than 1.8 mm and a length of not less than 900 mm for pipe diameters of 150 mm or more and not less than 600 mm for pipe diameters of less than 150 mm. It is also recommended to equally divide the length of the sleeve to each side of the division. When the pipe is not connected to the sleeve but is only led through, then the clearance between pipe and sleeve is not to exceed 2.5 mm unless it is made tight by means of non-combustible or other suitable material. Penetrations made in a different way may be employed, provided they are subject to fire tests applicable to the division where they are to be fitted.

Uninsulated metallic pipes penetrating A or B Class divisions are to be made of materials having a melting temperature which exceeds 950 °C for A-0 and 850 °C for B-0 class divisions.

Leading ventilation ducts through fire-resisting divisions is to comply with the requirements of sub-chapter 11.2.

1.16.11.6 Where it is necessary to lead plastic pipes through main fire-resisting divisions, penetration pieces of adequate length are to be installed with stop valves on both sides of the division. The valves and penetrations are to be made of steel or other material equivalent to steel with regard to fire-resistance.

1.16.11.7 Means used to secure pipes are not to cause stresses therein due to thermal expansion, deformation of naval ship structure or vibration.

1.16.11.8 The pipes conveying hot media as well as long pipings led along the naval ship are to be fitted with expansion pieces or sufficient number of bends securing compensation and having radii not less than provided in 1.16.5 are to be employed. Where no tunnels are used in leading the pipes through tanks, compensation is to be ensured by means of bends within the tanks.

1.16.11.9 The pipes passing through cargo holds, chain lockers and other spaces where they are liable to mechanical damage are to be efficiently protected.

Hydraulic pipes are not recommended to be led through cargo holds.

1.16.11.10 It is not recommended to lead any pipes through refrigerated spaces unless they are intended to serve these spaces. Where such leading is indispensable, the pipes are to be insulated. In the spaces there should be no sections of pipes where water may collect and freeze.

1.16.11.11 Pipes carrying chemically aggressive media are not to be led through spaces used for the carriage of dangerous materials.

1.16.11.12 The pipings conveying liquid media are not to be led through spaces containing electrical, electronic, etc. equipment associated with military functions and/or safety of the naval ship if the equipment may be subject to failure or damage in result of contact with media leaking from the pipeline. This requirement does not apply to the pipings delivering liquid media necessary for operation (e.g. cooling) of such equipment.

1.16.11.13 In no case pipes subjected to pressure are to be led above and behind the main or emergency switchboards, or the control panels of essential arrangements and machinery unless they are tightly screened.

In front of and alongside the switchboards and control panels, such pipes (not screened) may be led at a distance of at least 1500 mm.

1.16.11.14 Pipes are not to be led through special electrical spaces (see definitions in sub-chapter 1.2 of *Part VIII – Electrical Installations and Control Systems*) and accumulator battery rooms, with the exception of pipes of the fire smothering system and pipes serving the equipment installed in such spaces.

1.16.11.15 Pipes conveying easily flammable media, and especially their connections, are to be screened or otherwise protected as to avoid, as far as possible, spraying or leaking of the medium onto hot surfaces, air intakes to machinery spaces or any potential sources of ignition. The number of joints in such piping systems is to be kept to a minimum.

Such pipes are not to be led through accommodation and service spaces, cargo holds and spaces for the carriage of dangerous or explosive materials unless provided otherwise in the *Rules*.

1.16.12 Marking of Pipings

Marking of pipings is to use distinctive colours in accordance with the requirements of PN-ISO 14726-2 Standard.

1.17 Automation and Remote Control

1.17.1 The automation and remote control systems of machinery and systems covered by the requirements of this Part of the *Rules* are to comply with the relevant requirements of Chapters 20 and 21 of *Part VIII – Electrical Installations and Control Systems*.

1.17.2 The automatic or remote control of systems or equipment is not to exclude the local control, except refrigerating plants equipped with two independent automatic control systems, for which the local control is not required.

1.18 Limitation in the Use of Oil Fuel

1.18.1 Unless provided otherwise in the *Rules*, the following provisions govern the use of oil fuel in naval ships:

- **.1** except the below listed cases, no oil fuel with a flashpoint of less than 60 ºC shall be used;

.2 for emergency generator sets, oil fuel with a flashpoint of not less than 43 ºC may be used;

.3 for machinery located outside the machinery spaces of category A, oil fuel with a flashpoint less than 60 ºC but not less than 43 ºC may be used, subject to the following conditions being complied with:

- fuel tanks (except those in double bottom) are located outside the machinery spaces of category A,
- a device for the measurement of oil fuel temperature is provided on the suction pipe of the oil fuel pump,
- stop valves or cocks are provided on the inlet and outlet side of the oil fuel strainers,
- pipe joints of butt welded construction or of a union type are applied as far as practicable (see 1.16.4).

2 MAIN PROPULSION SHAFTING

2.1 General Provisions

2.1.1 The formulae for calculation of shaft diameters given in the present Chapter determine the minimum shaft diameters without allowance for subsequent machining of journals during operation.

Shaft diameters calculated in accordance with the formulae given in sub-chapters 2.2, 2.4 and 2.5 are sufficient if additional stresses caused by torsional vibrations do not exceed the permissible values determined in Chapter 4.

2.1.2 The space where stern tube is installed is to be a watertight compartment of a moderate size, so that in the case of flooding it, due to stern tube aft seal leakage, the bulkhead deck is not submerged.

2.2 Intermediate Shaft

2.2.1 The design diameter of intermediate shaft d_p is to be not less than that determined by the formula:

$$d_p = Fk\sqrt[3]{\frac{P\,B}{n\,A}} \text{ [mm]} \qquad (2.2.1\text{-}1)$$

where:

P – rated power on the intermediate shaft, [kW];

n – rated intermediate shaft rotational speed, [rpm];

A – correction coefficient of the coaxial hole in hollow shafts determined by the formula:

$$A = 1 - \left(\frac{d_o}{d_a}\right)^4 \qquad (2.2.1\text{-}2)$$

where:

d_o – coaxial hole diameter, [mm];

d_a – actual outside diameter of the shaft, [mm]; when $d_o \le 0.4d_a$ then $A = 1$ may be assumed;

B – material coefficient determined by the formula:

$$B = \frac{560}{R_m + 160} \qquad (2.2.1\text{-}3)$$

for intermediate and thrust shafts $B \ge 0.5833$;

R_m – tensile strength of the shaft material, [MPa];

F – coefficient taking into account the type of main propulsion:

$F = 95$ – for the turbine drive, for diesel engine drive where the slip type coupling is fitted and for electric motor drive,

$F = 100$ – for other types of diesel engine drive;

k – shaft design coefficient:

$k = 1$ – for the shafts forged together with couplings (see also 2.6.4), as well as for shafts with shrink-fitted couplings;
k for shafts with key-fitted couplings and for shafts with keyways, holes and cuts – see 2.3.

For naval ships of restricted service, having additional mark **II** or **III** in their symbol of class, the calculated diameter of intermediate shaft d_p may be reduced by 5%.

2.2.2 Cardan shafts may be used in propulsion systems provided the damage to such shaft does not render the naval ship inoperative. Such shaft shall be adapted to periodical operation of propulsion system with maximum output. Design of the Cardan shafts is subject to approval by PRS. Such shaft may be applied in single propulsion system subject to separate approval by PRS and if the naval ship is equipped with a spare shaft and damaged shaft may be readily replaced.

2.3 Holes and Cuts in Shafts

2.3.1 Where intermediate shafts are provided with keyways, radial holes, transversal through holes or longitudinal cuts, the following values of the *k* coefficient are to be taken in the formula 2.2.1-1:

.1 $k = 1.10$ for the section of shaft with the keyway over the length exceeding by at least $0.2d_p$ the keyway length at each side, while the bottom keyway edges are to be rounded off to a radius of not less than $0.0125d_p$, as well as over the length of $0.2d_p$ from the cone base where the coupling flange is fitted on the key; this requirement does not apply to the propeller shaft cone on which the propeller is fitted;

.2 $k = 1.10$ for the section of shaft with the radial hole or a transversal through hole over the length of not less than 7 diameters of the hole, while the hole diameter is not to exceed $0.3d_p$ and its edges are to be rounded off to a radius of not less than 0.35 of the hole diameter and its inner surface is to be thoroughly grinded;

.3 $k = 1.20$ for the section of shaft with the longitudinal cuts over the length exceeding at least $0.25d_p$ at each side of the cut length; while the cut length is not to exceed $1.4d_p$ and the breadth – $0.2d_p$ (calculated for $k = 1$); the ends of the cuts are to be rounded off to a radius equal to 0.5 of the cut breadth, the edges are to be rounded off to a radius not less than 0.35 of the same breadth, the surface of the cut is to be thoroughly grinded.

2.3.2 The value of coefficient *k* will be specially considered by PRS for the holes and cuts other than those determined in 2.3.1, as well as for the thrust and propeller shafts.

2.3.3 The shaft diameter beyond the section determined in 2.3.1 may be smoothly reduced to the diameter d_p calculated for $k = 1$.

2.4 Thrust Shaft

The diameter d_{op} of the thrust shaft on both sides of the thrust collar over the length equal to d_{op} in the case of slide bearings or in way of the axial bearing where a roller bearing is used as a thrust bearing, is to be not less than the value determined by formula 2.2.1-1 for $k = 1.10$.

The shaft diameter outside the above-determined lengths may be smoothly reduced to the diameter of intermediate shaft.

For naval ships of restricted service, having additional mark **II** or **III** in their symbol of class, the calculated diameter of thrust shaft d_{op} may be reduced by 5%.

2.5 Propeller Shaft

2.5.1 The diameter d_{sr} of the propeller shaft is not to be less than the value determined by formula 2.2.1-1, where:
$F = 100$ for all types of propulsion;
$A = 1$; (i.e. $d_o \leq 0.4\, d_a$);
$B \geq 0.7368$

The value of k coefficient for propeller shaft is equal to:

$k = 1.22$ where the propeller is fitted onto the propeller shaft cone using approved shrink method or is attached to flange forged together with the propeller shaft and the propeller shaft is fitted with a continuous liner or lining of an approved type, or is oil lubricated and provided with approved type of oil sealing gland of an approved type;

$k = 1.26$ where the propeller is keyed onto the propeller shaft and the propeller shaft is fitted with a continuous liner or lining of an approved type or is oil lubricated and provided with oil sealing gland of an approved type.

The above values of k apply to the portion of propeller shaft between the fore edge of the after shaft bearing and the fore face of the propeller boss or, if applicable, the fore face of the propeller shaft flange, but over a length of not less than $2.5d_{sr}$. For propeller shafts of other design than those specified above, the values of k coefficient will be subject to separate decision of PRS.

For the portion of propeller shaft forward of the portion defined above to the forward edge of fore seal of propeller shaft, the value of k is to be assumed equal to 1.15. The reduction of shaft diameter resulting from different values of coefficient k is to be gradual.

The diameter of propeller shaft may be smoothly reduced to the actual diameter of the intermediate shaft over the distance from the forward edge of the fore seal.

For naval ships of restricted service, having additional mark **II** or **III** in their symbol of class, the calculated diameter of propeller shaft d_{sr} may be reduced by 5%.

2.5.2 Where the propeller is fitted to the propeller shaft by means of a key, the taper of a propeller shaft cone is not to exceed 1:12. In the case of keyless shrink fitting of the propeller, the requirements of sub-chapter 2.8 are to be taken into account.

A suitable seal is to be provided to protect the propeller shaft cone against water penetration.

Means are to be provided to secure the propeller nut against unscrewing by structural fixing it against the shaft.

2.5.3 The end of the keyway in the propeller shaft cone intended for the propeller is to be at a distance, from the cone base, not less than 0.2 of the propeller shaft diameter. For shafts of 100 mm in diameter and over, the end of the keyway is to have such a shape, that the lower plane of the keyway gradually rise to the taper surface. Upper edges of the keyway are to be smoothly rounded off. The lower keyway corners are to be rounded to a radius of about 0.0125 of the propeller shaft diameter d_{sr}, but not less than 1.0 mm.

The dimensions of keyways and keys are to be such that the specific load due to mean torque upon the sides of keyways in the shaft cone and in the propeller boss, at the rated rotational speed and rated power, does not exceed 0.75 of the yield point of their material.

Where the method of propeller boss controlled push-up onto the shaft cone is applied, the increase of the specific load may be considered by PRS.

2.5.4 The propeller shaft made of the material not resistant to the corrosive effect of sea-water is to be protected against contact with sea-water by means of sleeves and seals.

2.5.5 Propeller shaft liners are to be made of stainless steel, high quality copper alloys or other approved alloys resistant to the corrosive effect of sea-water.

The thickness of the shaft liner s is to meet the below condition:

$$s \geq 0.03 d_{\acute{s}r} + 7.5\,, \quad \text{[mm]} \qquad (2.5.5)$$

where:
$d_{\acute{s}r}$ – see 2.5.1.

The thickness of the shaft liner between the bearings may be reduced to 0.75s.

The part of the propeller shaft between the propeller boss and stern tube is to be effectively protected against corrosion.

2.5.6 In general, continuous liners are to be used. Liners consisting of lengths may be recognized as the continuous ones, provided the joining methods are agreed with PRS and the joints are not in way of bearings.

Non-continuous liners, with parts between them coated with materials having PRS approval and using a method agreed with PRS, may be recognized as the effective protection of the propeller shaft.

2.5.7 Only seals of a design approved by PRS that meet the requirements of effective protection against exposure to sea-water may be used as the seals of propeller shaft.

2.6 Shaft Couplings

2.6.1 In general, all coupling bolts at the flanges of shafts are to be fitted. The number of fitted bolts may be reduced to 50% of the total number of bolts; however, their number is not to be less than three. The minimum diameter of plain coupling bolts is not to be less than the diameter d_s determined by the formula 2.6.2.

Flange joints transmitting the torque by friction only (without fitted bolts) may be also used but their use will be subject to special consideration by PRS.

Nuts of the bolts coupling flanges are to be protected against loosening.

2.6.2 The diameter d_s of fitted coupling bolts is to be not less than that determined by the formula:

$$d_s = 0.65\sqrt{\frac{d_p{}^3\left(R_{mp}+160\right)}{iDR_{ms}}}, \quad \text{[mm]} \qquad (2.6.2)$$

where:

d_p – the design diameter of intermediate shaft, taking into account the ice strengthenings, if required, [mm]; when the diameter is increased due to torsional vibrations, d_p is to be taken equal to the actual diameter of the intermediate shaft;

i – number of fitted bolts in the coupling;

D – diameter of the pitch circle of the coupling bolts, [mm];

R_{mp} – tensile strength of the shaft material, [MPa];

R_{ms} – tensile strength of the bolt material, [MPa], where

$R_{mp} \leq R_{ms} \leq 1.7R_{mp}$, but not exceeding 1000 MPa.

The diameter of bolts coupling the propeller boss with the propeller shaft flange is subject to special consideration by PRS.

2.6.3 The thickness of coupling flanges (under the bolt heads) of the intermediate shafts and thrust shafts and of the forward coupling flange of the propeller shaft is not to be less than $0.2d_p$ or d_s, determined by the formula 2.6.2 for the shaft material, whichever is greater.

The thickness of the propeller shaft flange, by means of which the propeller shaft is connected with the propeller, is not to be less than 0.25 of the actual shaft diameter.

The use of flanges having non-parallel external surfaces is subject to special consideration by PRS, however their thickness is not to be less than d_s.

2.6.4 The fillet radius at the base of coupling flange is not to be less than 0.08 of actual shaft diameter.

The fillet may be performed with the variable radii, provided however, that the coefficient of the stress concentration is not greater than that obtained with one radius used to carry out the fillet. The fillet surface is to be smooth and not affected by the recesses for heads and nuts of coupling bolts.

2.7 Shaftline Bearings

2.7.1 The length of the propeller shaft bearing next to the propeller is to be determined as follows:

.1 for water lubricated bearings lined with lignum vitae – not less than $4d_{sr}$ (for d_{sr} – see 2.5.1);

Note:
Lignum vitae stands for various species of hard resin wood. The original lignum vitae is almost unobtainable and presently other species such as Bulnesia Sarmiento or Paolo Santo or Bulnesia Arabia are used.

.2 for oil lubricated bearings lined with white metal – not less than $2d_{sr}$, however, if the nominal bearing pressure does not exceed 0.8 MPa, the bearing length may be reduced to the value not less than $1.5d_{sr}$;

.3 for water lubricated bearings of synthetic material – not less than $4d_{sr}$; however reduction of the bearing length to $2d_{sr}$ may be considered, for the bearing types of a proven construction confirmed by satisfactory service results.

.4 for oil lubricated bearings of synthetic rubber, reinforced resins or plastics, – not less than $2d_{sr}$, however, if the nominal bearing pressure does not exceed 0.6 MPa, the bearing length may be reduced to the value not less than $1.5d_{sr}$.

Note:
The nominal bearing pressure in the stern bearing is defined as the weight of the propeller shaft and propeller divided by surface area of horizontal cross projection of the bearing.

2.7.2 Where shut-off valve has been provided on the supply of propeller shaft bearing lubricating water, it is to be fitted to the stern tube or afterpeak bulkhead. A flow indicator and a filter for separation of solid impurities are to be provided in the piping supplying water lubricating the bearing.

It is recommended that a device preventing the water freezing in the stern tube shall be used.

2.7.3 Oil lubricated bearings of propeller shaft are to be provided with means of forced cooling of the oil, unless the afterpeak tank is always filled with water.

Means are to be provided for measuring the temperature of the part of the bearing under load. For bearings of less than 400 mm in diameter, the measurement of oil temperature in way of the bearing may be accepted.

2.7.4 For oil lubricated bearings of propeller shaft, the gravity tanks are to be located above the waterline and are to be provided with level indicators and oil low level alarm.

2.7.5 For shaftline(s) of considerable length, the shafts are to be supported by intermediate bearings. Roller and slide bearings may be used as intermediate bearings. The roller bearings are to be selected taking into account their service life, including survey intervals. In the case of slide bearings, rated load onto the bearing shall not in general exceed 1.2 MPa.

2.8 Keyless Shrink Fitting of Propellers and Shaft Couplings

2.8.1 In the case of keyless fitting of propellers and/or couplings, the taper of the shaft cone is not to exceed 1:15. When the taper does not exceed 1:50, the fitting of coupling on the shaft may be done without retaining nut or other securing the coupling.

2.8.2 Keyless shrink fitting of propeller on propeller shaft is to be done without an intermediate sleeve between the propeller boss and the shaft. The arrangements with intermediate sleeve will be subject to special consideration by PRS.

2.8.3 When fitting detachable keyless shrink joint (see Fig. 2.8.3) the axial shift of the boss in respect to the shaft or intermediate sleeve from the moment of the metallic contact on the cone surface after eliminating the clearance, is to be not less than that determined by the formula:

$$\Delta h = \left[\frac{80B}{hz} \sqrt{\left(\frac{1910PL^3}{nD_w} \right)^2 + T^2} + \frac{D_w(\alpha_y - \alpha_w)(t_e - t_m)}{z} \right] K, \text{ [cm]} \qquad (2.8.3)$$

where:
Δh – assembly axial shift of the boss;
B – material and shape factor of the joint, calculated from the formula:

$$B = \frac{1}{E_y}\left(\frac{y^2+1}{y^2-1} + \nu_y \right) + \frac{1}{E_w}\left(\frac{1+w^2}{1-w^2} - \nu_w \right), \quad [\text{MPa}^{-1}]$$

For connections with non-hollow steel shaft, the B factor may be determined by linear interpolation from Table 2.8.3.

Table 2.8.3
Factor $B \times 10^5$, [MPa^{-1}]

Factor y	Solid steel shaft: $w = 0$; $E_w = 2.059 \times 10^5$ MPa; $\nu_w = 0.3$							
	Copper alloy boss $\nu_y = 0.34$							Steel boss $\nu_y = 0.3$ $E_y = 2.059$ x 10^5, [MPa]
	$E_y =$ 0.98 x 10^5 [MPa]	$E_y =$ 1.078 x 10^5 [MPa]	$E_y =$ 1.178 x 10^5 [MPa]	$E_y =$ 1.274 x 10^5 [MPa]	$E_y =$ 1.373 x 10^5 [MPa]	$E_y =$ 1.471 x 10^5 [MPa]	$E_y =$ 1.569 x 10^5 [MPa]	
1.2	6.34	5.79	5.34	4.96	4.63	4.34	4.09	3.18
1.3	4.66	4.26	3.95	3.66	3.43	3.22	3.04	2.38
1.4	3.83	3.52	3.25	3.03	2.83	2.67	2.52	1.98
1.5	3.33	3,07	2.83	2.64	2.47	2.34	2.21	1.74
1.6	3.01	2.77	2.57	2.40	2.24	2.12	2.01	1.59
1.7	2.78	2.48	2.38	2.22	2.09	1.97	1.87	1.49
1.8	2.62	2.38	2.23	2.09	1.97	1.86	1.76	1.41
1.9	2.49	2.29	2.13	1.99	1.88	1.77	1.68	1.35
2.0	2.39	2.20	2.05	1.92	1.80	1.70	1.62	1.29
2.1	2.30	2.13	1.98	1.86	1.74	1.65	1.57	1.25
2.2	2.23	2.06	1.92	1.79	1.69	1.60	1.53	1.22
2.3	2.18	2.01	1.88	1.75	1.65	1.57	1.49	1.19
2.4	2.13	1.97	1.84	1.72	1.62	1.54	1.46	1.17

E_y – modulus of elasticity of boss material, [MPa];
E_w – modulus of elasticity of shaft material, [MPa];
ν_y – Poisson's ratio for boss material;
ν_w – Poisson's ratio for shaft material; (for steel ν_w = 0.3);
y – mean factor of external boss diameter;
w – mean factor of diameter of shaft hole.

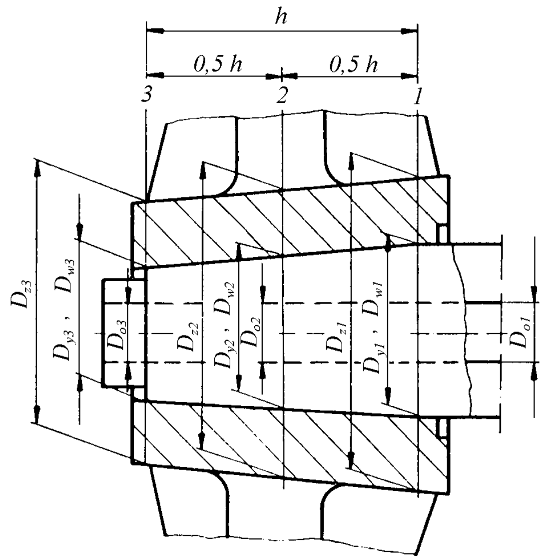


Fig. 2.8.3

D_w – mean external diameter of shaft at the area of contact with the boss or intermediate sleeve, [cm]:

– without intermediate sleeve:

$$D_{w1} = D_{y1},\ D_{w3} = D_{y3}$$
$$D_{w2} = D_{y2},\ D_w = D_y$$

– with intermediate sleeve:

$$D_{w1} \neq D_{y1},\ D_{w3} \neq D_{y3}$$
$$D_{w2} \neq D_{y2},\ D_w \neq D_y$$

– for boss : $y = \dfrac{D_{z1} + D_{z2} + D_{z3}}{D_{y1} + D_{y2} + D_{y3}}$

– for shaft: $w = \dfrac{D_{o1} + D_{o2} + D_{o3}}{D_{w1} + D_{w2} + D_{w3}}$

$$D_w = \frac{D_{w1} + D_{w2} + D_{w3}}{3}$$

$$D_y = \frac{D_{y1} + D_{y2} + D_{y3}}{3}$$

h – effective height of cone at the contact area of the shaft or intermediate sleeve with the boss with oil grooves deduced, [cm];
z – taper of cone at the contact area of the shaft or intermediate sleeve with the boss;
P – power transmitted by the joint, [kW];
L = 1 (for naval ships with ice strengthening, see 23.2.3.1);
n – number of the joint's revolutions, [rpm];
T – propeller thrust for "ahead" revolutions with the naval ship moored, [kN];
α_y – thermal coefficient of linear expansion of the boss material, [1/°C];
α_w – thermal coefficient of linear expansion of the shaft material, [1/°C];
t_e – temperature of the joint in service conditions, [°C];
t_m – temperature of the joint at the time of fitting, [°C];
K = 1.0 for the joints without intermediate sleeve;
K = 1.1 for the joints with intermediate sleeve.

The calculation is to be made for the highest service temperature t_e. Where no other value of the temperature is specified it is to be assumed t_e = 35 °C.

2.8.4 The shrinkage allowance when fitting steel couplings on steel shafts to make a permanent shrink fit is not to be less than that determined by the formula:

$$\Delta_D = \frac{80B}{h} \cdot \sqrt{\left(\frac{1910\,P\,L^3}{nD_w}\right)^2 + T^2}\text{, [cm]} \qquad (2.8.4)$$

Δ_D – shrinkage allowance when fitting the coupling on diameter D_w.

For other symbols – see 2.8.3.

2.8.5 For the boss of a detachable or permanent keyless shrink joint, the following condition is to be met:

$$\frac{A}{B}\left[\frac{C}{D_y} + \left(\alpha_y - \alpha_w\right)t_m\right] \le 0.75R_{ey} \qquad (2.8.5\text{-}1)$$

where:
A – shape factor of the boss determined by the formula:

$$A = \frac{1}{y^2 - 1} \cdot \sqrt{1 + 3y^4} \qquad (2.8.5\text{-}2)$$

Factor A may be determined by linear interpolation from Table 2.8.5

Table 2.8.5
Factor *A*

y	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
A	6.11	4.48	3.69	3.22	2.92	2.70	2.54	2.42	2.33	2.26	2.20	2.15	2.11

$C = \Delta D_r$ – for permanent joints;
$C = \Delta h_r z$ – for detachable joints;
Δh_r – actual axial shift of the boss when fitting at temperature t_m, [cm]; $\Delta h_r \geq \Delta h$;
ΔD_r – actual shrinkage allowance for permanent joint, [cm]; $\Delta D_r \geq \Delta D$;
R_{ey} – yield point of boss material, [MPa];
D_y – mean inside diameter of the boss at the contact area with the shaft or intermediate sleeve, [cm].

For other symbols – see 2.8.3.

2.9 Braking Devices

The shafting is to be provided with a braking device. The following devices may be used: brake, turning gear or other locking equipment precluding free shafting rotation in case of failure of the main propulsion machinery.

3 PROPELLERS

3.1 General Provisions

3.1.1 In this Chapter, propellers mean classical fixed pitch and controllable-pitch propellers, screws in a nozzle, used in main propulsion of naval ships;

3.1.2 The design and requirements for screws and propellers other than the mentioned in 3.1.1 are subject to special requirements of PRS.

3.1.3 At the description of screws and propellers of main propulsion, the following symbols apply:
$b_{0.7R}$ – width of expanded propeller blade at the radius $R=0.7R$ [m] ;
D – propeller (screw) diameter [m];
s – propeller blade thickness [m];
H/D – pitch ratio at the radius $0.7R$ [-];
R – propeller (screw) radius [m];
P – propeller shaft power at the rated output of main engine [kW];
Z – number of blades [-];
L – cycloidal propeller blade length [m];
n – rated number of propeller shaft revolutions [rpm];
propeller blade skew angle, see 3.1.3.

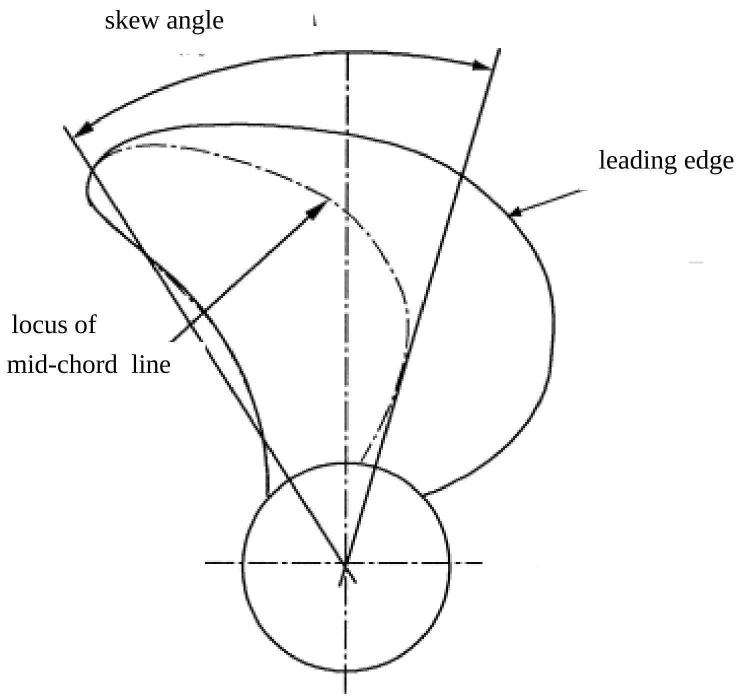


Fig. 3.1.4 Skew angle

3.1.4 In no case braking the unit when going ”full astern” can stop, immobilise or damage the driving engine or elements transmitting the torque. The manufacturer shall submit detailed acceptance test programme taking the above requirements into account.

3.2 Blade Thickness

3.2.1 For auxiliary naval ships of displacement above 500[t] and rated speed of propeller shaft less than n = 450 [rpm], the blade thickness is not to be less than that determined from the formula:

$$s = \frac{3.65kA}{3\sqrt{[0.312+\frac{H}{D}]^2}}\sqrt{\frac{P}{nbZM_M}} \qquad \text{[mm]} \qquad (3.2.1)$$

where:

k = 1; for naval ships with ice strengthenings, see sub-chapter 23.3.3;

A – coefficient determined from Table 3.2.1; for intermediate values of the blade skew angle, the coefficient A is to be assumed as for the nearest maximum value taken from the Table;

M_M = 0.6$R_{m(s)}$ + 180, but no more than 570 MPa for steel and no more than 610 MPa for non-ferrous alloys;

Table 3.2.1
Values of coefficient *A*

Radius of blade [m]	blade skew angle, as measured along the blade pressure side, [degs]								
	0	2	4	6	8	10	12	14	16
0.20 R	390	391	393	395	397	400	403	407	411
0.25 R	378	379	381	383	385	388	391	394	398
0.30 R	367	368	369	371	373	376	379	383	387
0.35 R	355	356	357	359	361	364	367	370	374
0.60 R	236	237	238	240	241	243	245	247	249

3.2.2 The thickness of non-cavitating propeller blade tips is to be not less than 0.0035 D.

Cavitating propellers are such screw propellers for which fluid flow speed results in the fluid reaching or exceeding the steam saturation limit in the vicinity of the screw. Cavitation occurs when:

$$\sigma \le \zeta$$

where:

$\sigma = \frac{p_0 - p_d}{\rho^{v_0^2}}$ – cavitation number

$\zeta = (\frac{v}{v_0})^2 - 1$ – dilution coefficient

p_0 – mean water head for the operating immersed propeller [Pa];
p – water head at the propeller axis depth [Pa];
V_0 – fluid inflow speed in front of the propeller profile [m/s];
V – local speed of fluid at the profile [m/s];
ρ – water density [kg/m^3];

3.2.3 The intermediate thicknesses of non-cavitating propeller and cycloidal propeller blades are to be chosen so that the contour lines of the maximum blade thickness sections run smoothly from the root, through intermediate profiles to the tip.

3.3 Bosses and Blade Fastening Parts

3.3.1 The propeller boss is to be provided with holes to fill the void spaces between the boss and the shaft cone with grease. The grease is also to fill the void space inside the propeller cap. The grease used for filling the above-mentioned spaces is to be of solid consistence and is not to cause corrosion.

3.3.2 After the propeller assembly, the bolts fastening the cap to the propeller boss shall be laminated or protected against corrosion by other method, which shall not preclude their disassembling.

3.3.3 The screw propeller manufacturer is obliged to submit documentation on the technology of propeller storage, assembly and disassembly in a shipyard, and if applicable, at sea.

3.3.4 Where anti-cavitation holes have been applied on the blades of cavitating screws, the screw propeller manufacturer is obliged to submit detailed strength calculations. At the design stage, PRS is to be furnished with operating recommendations for icy regions.

3.3.5 The screw propeller manufacturer is obliged to submit results of propeller balancing, according to appropriate standards, after its final treatment. For propellers of maximum rated speed up to n = 400 rpm, static balancing results, while for the propellers of maximum rated speed exceeding n = 400 rpm – dynamical balancing results, are to be submitted. Dynamical balancing machine testing is to be performed according to appropriate standards and the machine is to be duly certified. The standard, as well as certificate are to be agreed with PRS at the design stage.

3.3.6 The screw propeller outline may extend beyond the bilge line only in well justified cases.

3.3.7 If the propeller has been designed using calculations made with an approved computer program, the propeller screw manufacturer is obliged to submit calculation results for the propeller generated acoustic field intensity. Corrected calculations of acoustic energy based on examinations made in cavitation tunnel may be submitted.

3.3.8 In the case propulsion unit containing one main propeller is used in a naval ship, auxiliary propulsion units shall be applied to enable naval ship's move "ahead" with a minimum speed of 4 knots.

3.3.9 The propeller screw manufacturer is obliged to submit screw strength calculation results for underwater explosions.

3.3.10 For landing craft, the propeller, its strut and propeller shaft sealing shall prevent ingress of sand into slide elements when the naval ship moves astern.

3.3.11 The naval ships of displacement exceeding 50 t are to be equipped with manual or powered devices for turning the propeller when the naval ship is anchored.

3.4 Propeller Materials

3.4.1 Materials used in naval ship's propellers structures shall comply with detailed requirements contained in *Part IX – Materials and Welding*.

3.4.2 The requirements concerning fields of physical nature and the potential existing between the propeller and the naval ship's hull are specified each time by the Client.

3.4.3 Cast iron may not be used for structures of propeller screws or their bearings and cantilevers.

3.4.4 Materials used in propeller screws of mass below 25 000 kg shall comply with at least the parameters specified in Table 3.4.1.

Table 3.4.1
Materials used in naval ship propellers and their properties

Material	R_m [MPa]	Density [g/cm^3]
Cast steel	400	7.9
Low alloy cast steel	440	7.9
13% chromium cast steel	540	7.7
Nickel-chromium austenitic steel	450	7.9
Clad steel – metalic composites	590	7.8
Magnesium bronze	440	8.3
Ni – Mg bronze	440	8.3
Ni – Al. bronze	590	7.6
Mn – Al bronze	630	7.5

Note: Materials used in propellers of mass 25 000 kg and above are to be agreed with PRS.

3.5 Controllable-Pitch Propellers

3.5.1 Hydraulic power operating system of the propeller blades pitch setting device is to be served by two independent pumps – one service and one standby pump. The standby pump for naval ships of displacement exceeding 500 t is to have independent power supply enabling operation at power decay for at least 15 minutes.

3.5.2 Naval ships equipped with two controllable-pitch propellers may be provided with one standby pump, provided its capacity will enable reversing blades of both propellers simultaneously.

3.5.3 The controllable-pitch propeller is to be so designed that there is no specific sequence or order of mounting its blades on the propeller boss.

3.5.4 The distance L between the blade edge and the naval ship's hull shall not be less than $L = 0.1\ R$.

3.5.5 In multi-screw systems, the distance between two neighbouring propeller blades, being in positions as close each to other as possible, is to be not less than half of the propeller radius.

3.5.6 Thrust vectors in two-propeller propulsion units are to be parallel or concurrent up to 3 degrees.

3.5.7 Required time period of controllable-pitch propellers technical surveys and predicted time period of their structural elements replacement shall correspond to terms of dock technical surveys specified for the given naval ship's class.

3.5.8 The structural reinforcements applied in accordance with tactical and technical specifications prepared for the given naval ship's class are also to comply with the requirements for emission of acoustic, magnetic fields and cavitation.

3.5.9 The absolute roughness of the propeller blades and boss surface after technological treatment is not to exceed 10 µm.

3.5.10 Coating propeller blades and bosses surface is allowed, provided the requirements of paragraph 3.5.9 are complied with.

3.5.11 The propeller blades pitch setting device of the naval ships of displacement exceeding 500 t is to be equipped with manual hydraulic pump, which enables setting propeller blades to at least the following positions: $H/D > 0$ (ahead), $H/D < 0$ (astern) and $H/D = 0$. The requirement of paragraph 3.5.19, concerning reversing time, does not apply in this case.

3.5.12 The controllable-pitch propeller shall be controlled, in principle, automatically or remotely from the main control post.

3.5.13 The hydraulic power operating system is to be so designed that the current propeller pitch is indicated on the emergency control post, at the manually operated hydraulic pump or directly on the hydraulic power operating unit.

3.5.14 Hydraulic power operating system of the propeller blades pitch setting device is to be constructed in accordance with the requirements of sub-chapter 6.2 of *Part VII – Machinery, Boilers and Pressure Vessels* and the piping of the system is to be tested in accordance with the requirements of sub-chapter 1.5 of this part of *the Rules*.

3.5.15 Hydraulic power operating system of the propeller blades pitch setting device is to be so constructed that the strength requirements are complied with at the propeller load equal to 150% of the rated load and at the hydraulic oil pressure equal to 150% of the working pressure.

3.5.16 Hydraulic system of the setting device is to be equipped with a spare hydraulic oil tank having volume sufficient for full replacement of oil. Where a naval ship is provided with more than one controllable-pitch propeller, a single common use spare tank may be used provided its volume is sufficient for oil replacement in all controllable-pitch propeller screws used in the naval ship propulsion system.

3.5.17 Where the propeller has been manufactured based on computer model, the results of modeling an open water propeller and the propeller operating behind the naval ship's hull, are to be attached to technical documentation.

3.5.18 The time of reverse of propeller blades from "full ahead" to "full astern" position is to be defined taking into account detailed requirements for particular classes of naval ships, considering two alternatives:

– the main engine is not running,
– the main engine is running at the load characteristic for the considered class of the naval ship.

3.5.19 The time of reverse of controllable-pitch propeller blades from "full ahead" to "full astern" position, with the propeller not running, is not to exceed 40 seconds.

3.5.20 Hydraulic setting device may be equipped with a compressed air or other medium system with the purpose of reducing noises generating by the propeller, provided that all elements of the system comply with the requirements of sub-chapter 6.2, *Part VII – Machinery, Boilers and Pressure Vessels* and the system piping is tested in accordance with the requirements of sub-chapter 1.5 of this Part of *the Rules*. Where the above solution has been applied, detailed strength calculations for the propeller operating at rated load are to be submitted. The ducts supplying compressed air or other medium are to be led outside the places where maximum stresses may occur.

3.5.21 Technical documentation of controllable-pitch propeller is to contain at least the following data:

- assembly drawing of the propeller screw mounted on the propeller shaft together with detailed information on the propeller assembly on the shaft, cross-sections of hydraulic ducts and of the power operating device in propeller boss as well as the assembly and disassembly procedure.
- strength calculations for bolts fastening blades to propeller boss.
- diagrams of all elements of propeller pitch control hydraulic system,
- diagrams of all elements of the hydraulic power operating system,
- diagrams of the main and stand-by hydraulic systems sealing,
- diagrams of the propeller shaft sealing for a controllable pitch propeller,
- strength calculations for shaft line strut, if fitted,
- strength calculations for thrust bearings for maximum and overload power,
- torsional and axial vibration calculations made in accordance with Chapter 4.

3.5.22 The service documentation of a controllable pitch propeller shall include at least:

- propulsion properties,
- drawings of propeller assembly and disassembly,
- drawings of propeller assembly without naval ship's docking,
- service documentation for failure operation,
- list of interchangeable hydraulic oils,
- list of wrenches used for the propeller screw assembly and disassembly.

3.6 Requirements for Physical Fields

3.6.1 The scope of the requirements for emitted physical fields is specified by the Client.

3.6.2 The requirements concerning emitted physical fields are taken into account at two stages:

- at the stage of work design, digital calculations or model tests are performed;
- on the naval ship delivered, a verification is carried out by Navy Range tests.

3.6.3 The acceptance tests programme in the scope of physical fields emission is subject to separate requirements of the Client.

4 VIBRATIONS AND SHAFT ALIGNMENT

4.1 Torsional Vibrations

4.1.1 Application

4.1.1.1 Recommendations of sub-chapter 4.1 apply to:
- main propulsion systems of naval ships, formed by diesel oil engines, turbines or electric motors, directly driven or geared to the shafting,
- machinery driven at constant speed by diesel oil engines developing at least 100 kW, this applies foremost to generating sets which are the power sources for main electric propulsion motors.

4.1.2 Definitions and Explanations

4.1.2.1 The following symbols are applied for the purpose of sub-chapter 4.1:

C_k – factor for different shaft design features, defined from Table 4.1.3.3.2.2
C_d – shaft size factor, taken as $0.35+0.93d^{-0.2}$
d – shaft diameter, [mm]
k – factor used in determining minimum shaft diameter, defined in Chapter 2,
n – rotational speed of engine crankshaft, [rpm]
n_C – critical speed [rpm]
n_S – maximum continuous engine crankshaft speed or, in case of constant speed generating sets, the full load speed, [rpm]
P – shaft rated power, [kW]
r – ratio n/n_S or n_C/n_S
Q_S – rated full load mean torque, [kNm]
τ_C – maximum value of the vibration stress for continuous running at or below the maximum speed of engine crankshaft, [MPa]
τ_t – permissible stress due to torsional vibrations during transient operation, [MPa]
σ_u – specified minimum tensile strength of the shaft material, [MPa]

4.1.2.2 Taking into account of the provisions of sub-chapter 4.1 at designing propulsion system or generating set is aimed at defining potential characteristics of the engine and other unit/set components for variable parameters of the unit/set operation.

4.1.3 Torsional Vibration Calculations

4.1.3.1 General Requirements

4.1.3.1.1 The scope and methodology of propulsion system torsional vibration calculations are to enable a complete analysis of dynamic loads of all components of the system in all operational conditions.

4.1.3.1.2 For multi-engine units or other combined systems, calculation of division of power and utilisation throughout the whole speed range is to be submitted to PRS for approval. For multi-engine installations the calculations are to take into account all possible variations in this mode of operation.

4.1.3.1.3 For propulsion systems provided with controlled-pitch propeller, calculations of operating conditions encountered in service for prolonged periods where rotational speed and propeller pitch are limited, are to be submitted to PRS for approval.

4.1.3.1.4 Sketches with principal dimensions of shafts, together with calculation (estimation) of mass moments of inertia for the rotating parts of systems including electric motors, generating sets and pump units, are to be submitted to PRS for approval.

4.1.3.1.5 Complementary data regarding torsional vibrations are to be submitted for approval if considered necessary by PRS.

4.1.3.2 Scope of Calculations

4.1.3.2.1 Calculations are to be carried out, by recognised techniques, for the full dynamic system including diesel oil engines, turbines, motors, generators, flexible couplings, gearing, shafting and propellers.

4.1.3.2.2 The calculations carried out on diesel oil engine systems are to be based on the engine builders' harmonic torque data. The calculations are to cover the effects of the engine malfunction, commonly experienced in service, such as lack of combustion in cylinder, whose inefficiency causes most unfavourable dynamic loads, breaking the propeller blade, or locking seismic mass in torsional vibration damper, etc. The calculations are also to show a degree of imbalance between cylinders, occurring in normal operation of an engine under service conditions.

4.1.3.2.3 Where limits for torsional vibration stress in crankshafts are no longer stated explicitly, the calculations are to include estimated values of crankshaft stresses for all designed and service engine speeds, taking particularly into account principal critical rotational speeds.

4.1.3.2.4 Calculations of torsional vibrations are to contain/determine:

.1 Data for calculations containing mass moments of inertia and rigidity of particular elements of the system and diagrams of all applicable modes of operation,
- for flexible couplings, dynamic torques due to torsional vibrations as compared with permissible values,
- for reduction gear, dynamic torques on the pinion as compared with the mean torque of the engine for $0.2 \le r \le 1.05$,

.2 the firing order in engine cylinders and the values of vector sum of relative amplitudes of torsion angles of the cranks for all considered modes and harmonic orders within the range of $1 \div 15$ for two-stroke engines and $0.5 \div 12$ for four-stroke engines,

.3 specification of the successive forms of natural vibrations with resonance within the range of $0.2 \le r \le 1.2$, with harmonics as determined above,

.4 for power generating sets – dynamic torques on the generator's rotor as compared with the mean torque of the engine within the range of $0.9 \le r \le 1.1$,

.5 values of stresses caused by all significant harmonic excitation torques within the range of $0.2 \le r \le 1.05$ for main engines and $0.9 \le r \le 1.1$ for power generating sets at the most loaded cylindrical cross sections of the shafting,

.6 vibration amplitudes taken at the assumed point of measurement corresponding to the calculated values of the synthesised stresses and dynamic torques as required in .1, .4 and .5.

4.1.3.2.5 Effect of propeller generated torsional vibrations is to be shown by calculations. If the system is vulnerable to such excitations, the propeller manufacturer's data are to be submitted for approval as the basis for calculations.

4.1.3.2.6 Where the torque influences the changes of torsional rigidity, speed or frequency of flexible coupling torsional vibrations, the calculations are to present the range of dynamic changes of rigidity.

4.1.3.2.7 In the case the operated propulsion system has been subjected to structural changes which influence its dynamical properties and cause load variations due to torsional vibrations, the torsional vibrations calculations are to be repeated and submitted to PRS for approval.

4.1.3.3 Permissible Stresses

4.1.3.3.1 Crankshafts

.1 The following limits apply to torsional stresses at continuous operation:

– within the range of rotational speed $0.7 \le r \le 1.05$:

$$\tau_C \le \pm 30.36\, C_d \quad \text{[MPa]} \qquad (4.1.3.3.1\text{-}1)$$

– within the range of rotational speed $0.7 \le r$:

$$\tau_C \le \pm\, 22\, C_d (3 - 2r) \quad \text{[MPa]} \qquad (4.1.3.3.1\text{-}2)$$

The above limits apply also to naval ships continuously operated with rated torque being within the range of rpm less than the rated ones.

.2 The synthesised torsional stresses for the barred speed ranges, which are to be passed quickly, are to comply with the below condition:

$$\tau_C \le \pm\, 41.8\, C_d (3 - 2r) \quad \text{[MPa]} \qquad (4.1.3.3.1\text{-}3)$$

.3 Variable torques on the gear pinion are not to exceed 0.33 of the transmitted rated torque.

4.1.3.3.2 Propeller, Intermediate and Thrust Shafts

.1 The below given definitions of maximum stresses apply to intermediate, thrust and propeller shafts fully protected against sea water effect. For propeller shafts, the above maximum stresses apply also to the portion of propeller shaft between propeller gland and boss.

.2 In the case of shafts not protected against the sea water effect, the influence is to be taken into account in calculations.

Table 4.1.3.3.2.2
Coefficient C_k

For intermediate shafts with			For thrust shafts external to engines		For propeller shafts
Internal coupling flanges	Shrink fit couplings	Keyways	On both sides of thrust collar	For roller bearings used as thrust bearings	For which k=1.22 and k=1.26
1.0	1.0	0.60	0.85	0.85	0.55

.3 In no part of the propulsion shafting system may the synthesised torsional stresses exceed the values τ_C for continuous operation and values τ_t – for transient running (at barred rpm ranges), calculated from the following formulae:

$$\tau_C = \frac{\sigma_u + 160}{18} C_k C_d (3 - 2r^2) \text{ for } r < 0.7 \quad \text{[MPa]} \qquad (4.1.3.3.2.3\text{-}1)$$

$$\tau_C = 1.38 \frac{\sigma_u + 160}{18} C_k C_d \text{ for } 0.7 \le r < 1.05 \quad \text{[MPa]} \qquad (4.1.3.3.2.3\text{-}2)$$

$$\tau_t = \pm 1.7\, \tau_C \frac{1}{\sqrt{C_k}} \text{ for } r \le 0.8 \quad \text{[MPa]} \qquad (4.1.3.3.2.3\text{-}3)$$

.4 In general, the tensile strength of the steel used is to comply with the requirements contained in the previous chapters. For calculations of the permissible limits of stresses due to torsional vibration, σ_u is not to be taken as more than 800 MPa for intermediate shafts, and 600 MPa for thrust and propeller shafts.

4.1.3.3.3 Generating Sets

.1 Natural vibrations of the complete generating set are to be sufficiently removed from the firing impulse frequency at the full load speed; it may be ensured by applying flexible coupling between the engine and generator.

.2 Within the range of crankshaft speed $0.9 \cdot n_s$ to $1.1 \cdot n_s$, the vibration stresses in the intermediate shaft are not to exceed the value calculated from the formula:

$$\tau_C = \pm(21 - 0.014d) \qquad \text{[MPa]} \qquad (4.1.3.3.3.2)$$

.3 The vibration stresses in the intermediate shaft caused by critical frequencies met during starting and stopping the generating set are not to exceed the values calculated from the below formula:

$$\tau_t = 5.5\,\tau_C \qquad (4.1.3.3.3.3)$$

.4 The amplitudes of total vibratory inertia torques imposed on the generating set components are to be generally limited to ±2.0·QS for close-coupled revolving field alternating current generators, over the speed range from $0.9n_s$ to $1.1n_s$. For speed range less than $0.9n_s$, the amplitudes within the range of ±6.0·QS are allowed. Where two or more generators are driven from one engine, each generator shall be considered separately, in relation to its own rated torque.

4.1.3.3.4 Other auxiliaries

Respective requirements of 4.1.3.3.3.1, 4.1.3.3.3.2 and 4.1.3.3.3.3 apply also to other auxiliary machinery, such as pumps or compressors.

4.1.3.4 Other machinery components

4.1.3.4.1 Torsional Vibration Dampers

The use of vibration dampers or detuners to limit vibratory stresses caused by resonance met within the crankshaft rpm range of $0.85n_s$ to $1.1n_s$ is permitted. Such a device, if fitted, is to be of appropriate type, which makes adequate provision for dissipation of heat.

4.1.3.4.2 Flexible couplings

.1 Flexible couplings incorporated in the system are to be capable of transmitting torque and vibratory loads without exceeding the limits specified by the coupling manufacturer, for angular amplitude or heat dissipation.

.2 If the calculations prove that the limits recommended by the manufacturer may be exceeded under misfiring conditions (including cylinder being periodically out-of-operation), adequate means is to be provided for detecting and indicating misfiring. Under such conditions power and/or speed restriction may be required. Disconnection of the branch containing the coupling may be accepted in the event of misfiring.

4.1.3.4.3 Gears

.1 The torsional vibration characteristics shall be in accordance with the recommendations given in 4.1.3.2. The vibratory torque is not to exceed one-third of full transmission torque within full speed range. In the case when the proposed transmission torque loading on the gear teeth is less than the maximum permissible value, additional vibratory loads may be accepted.

.2 If calculations take into account possibility of torque reverse, the range of operational speed is to be determined on the basis of measurements (observations) taken during sea trials.

4.1.3.5 Barred Speed Ranges and Restricted Power Output

4.1.3.5.1 Where the torsional stresses exceed the permissible values τ_C for continuous operation, the barred speed and/or power output ranges are to be determined. Similar limitations shall apply to the case of vibratory torque and/or amplitude being considered excessive on the basis of check measurements.

4.1.3.5.2 Where the synthesised actual torsional stresses exceed the permissible values for continuous operation, the barred speed ranges are to be determined. The barred speed is not to fall within the range of $0.7 \le r$ for propulsion systems and $0.85 \le r$ for generating sets.

4.1.3.5.3 Where shafting stresses exceed the limiting values due to a torsional critical response, the barred speed range is to be determined by the formula:

$$\frac{16}{18-r} n_C \le n \le \frac{18}{16-r} n_C \qquad (4.1.3.5.3)$$

4.1.3.5.4 In the case when calculated vibration stresses due to torsional critical response within the range of $0.7 \le$ r only slightly exceed permissible values τ_C or when critical speeds may be defined precisely, the barred speed range for continuous operation may be reduced.

4.1.3.5.5 When the resonance curve of a critical speed has been derived after measurements, the barred speed range may be taken such as that over which the measured stresses are in excess of permissible values τ_C, having regard to tachometer accuracy.

4.1.3.5.6 Where restricted speed ranges under normal operating conditions are imposed for continuous operation of the engine, notices are to be posted on barred speed range in visible place.

4.1.3.5.7 For excessive vibratory torque, stresses or amplitudes in other components of propulsion unit, generating set, pump unit or electric motor unit, such limitations of speed/power output are to be applied on the basis of the provisions of 3.6.1 to 3.6.3 as to maintain acceptable levels during continuous operation.

4.1.3.6 Tachometer accuracy

4.1.3.6.1 Where restricted speed ranges are imposed under approval of PRS, accuracy of tachometer indications is to be checked. The accuracy is to be within ±2%. The checking is to be performed in the presence of surveyor to PRS.

4.1.3.7 Measurements

4.1.3.7.1 General Recommendations

4.1.3.7.1.1 The results of calculated summarised torsional vibration stresses are to be confirmed by measurements taken on the first naval ship of the series. When determining these stresses, their harmonic analysis is to be made.

4.1.3.7.1.2 Where calculations show that the limits for torsional vibration within the range of working speeds are exceeded, measurements, using an appropriate technique, are to be taken for the purpose of approval of torsional vibration characteristics, and determining the need for restricted speed ranges to be subject to approval.

4.1.3.7.1.3 Where differences between calculated and measured levels of stress, torque or angular amplitude are more than 5%, the calculations are to be corrected and submitted again for approval. The measured values shall be taken as the stresses limits.

4.1.3.7.1.4 The measurement method is to be appropriate to the objects to be measured and achieved values of parameters. If the shaft stresses have been estimated from angular amplitude measurements, and are found to be close to limits, PRS may require measurements by other method, e.g. by a strain gauge. The measurement method and performance details are to be agreed with PRS.

4.1.3.8 Vibration Monitoring

4.1.3.8.1 Where calculations and/or measurements prove the possibility of excessive vibratory stresses, torques or angular amplitudes, performance of monitoring, directly or indirectly, may be required.

4.2 Axial Vibration

4.2.1 General Requirements

4.2.1.1 Unless stated otherwise, it is the responsibility of the Builder as main contractor to ensure, in co-operation with Enginebuilders that information concerning axial vibrations of the naval ship propulsion system is prepared and submitted.

4.2.1.2 The requirements of the sub-chapter 4.2 apply to main propulsion systems formed by diesel oil engines, turbines or electric motors, directly driven or geared to the shafting.

4.2.1.3 For all main propulsion systems, the Builders are to ensure that axial vibration amplitudes are satisfactory within the whole speed range.

4.2.1.4 Where natural frequency calculations of the system prove significant axial vibration responses, sufficiently wide range of barred speed is to be adopted.

4.2.1.5 Alternatively to calculations, vibration measurements may be used to determine the speed ranges at which vibration amplitudes are excessive for continuous operation of the system.

4.2.2 Detailed Requirements

4.2.2.1 The Shipbuilder is to submit axial vibration calculation results, together with recommendations for any speed restrictions, which are found necessary.

4.2.2.2 The Enginebuilder is also required to submit recommendations for axial vibration amplitude limits.

4.2.2.3 In well-ground cases, the Shipbuilder is also required to define flexibility of thrust bearings and its supporting structure to axial vibrations.

4.2.2.4 Calculations of axial vibration natural frequency of a propulsion shaftline with the propeller driven directly by the diesel engine are to be performed with use of appropriate techniques taking into account the effect of flexibility of the thrust bearing.

4.2.2.5 For propulsion shaftline with the propeller driven directly by electric motor or through a gear, and the distance between the propeller and thrust bearing exceeding 50 shaft diameters, calculations are to be performed with use of appropriate techniques taking into account thrust bearings flexibility.

4.2.2.6 Where an axial vibration damper is fitted, calculations are to take into account the effect of malfunction of the damper damage.

4.2.2.7 Where calculations prove that excessive axial vibration amplitudes are possible in the range of working speeds in normal and malfunction conditions, measurements of axial vibration amplitudes of the propulsion shaft arrangement are required to determine barred speed ranges.

4.2.2.8 Where in the naval ship design the axial vibration monitoring system is specified, the manufacturer is to submit details on the system construction.

4.3 Lateral Vibration

4.3.1 General Requirements

4.3.1.1 Unless stated otherwise, it is the responsibility of the Builder as main contractor to ensure, in co-operation with the Enginebuilder that the information concerning lateral and circular vibrations of the naval ship propulsion systems is prepared and submitted.

4.3.1.2 The requirements of the sub-chapter 4.3 apply to main propulsion systems formed by oil diesel engines, turbines or electric motors, directly driven or geared to the shafting.

4.3.1.3 For all main propulsion shaft systems, the Shipbuilder shall ensure that lateral and circular vibration characteristics are satisfactory within the whole speed range.

4.3.2 Detailed Requirements

4.3.2.1 The Shipbuilder shall submit calculations concerning lateral and circular vibration characteristics, of shafting systems having supports outside the naval ship's hull or incorporating cardan shafts.

4.3.2.2 The calculations shall take into account bearing type, oil film (where applicable) and structural dynamic stiffnesses, with the purpose to determine the frequency of excitations which may result in significant amplitudes within the speed range, and aimed at determining relative deflections and bending moments for the whole shafting system.

4.3.2.3 Where calculations prove the possibility of significant lateral and circular vibration responses within the range of working speeds, measurements using appropriate detection techniques may be required to determine that hazardous whirling or excessive vibration does not occur in the shaftline system.

4.3.2.4 The used measurement technique is to be appropriate for the machinery arrangement and the modes of vibration considered. When measurements are required, detailed proposed method of vibration measurements is to be submitted to PRS, well in advance.

4.4 Shaftline Alignment

4.4.1 General Requirements

4.4.1.1 Unless agreed otherwise, it is the responsibility of the Shipbuilder as main contractor to ensure, in co-operation with the Enginebuilder, that the information on the shaftline alignment onboard, required in sub-chapter 4.4, is prepared and submitted.

4.4.1.2 The requirements of sub-chapter 4.4 apply to main propulsion systems, which include diesel oil engines, turbines or electric motors, directly driven or geared to the shafting.

4.4.1.3 For main propulsion systems, the shafting is to be aligned to ensure bearings reactions equal to 80% of permissible values and to comply with specified requirements concerning couplings at the fore end of the shafting at all conditions of the naval ship loading and operation.

4.4.1.4 The Shipbuilder is to position the bearings and construct bearing seatings to minimise the effects of movements in all operational conditions.

4.4.1.5 The Shipbuilder is to perform complete shaftline alignment calculations and to prepare detailed alignment procedures indicating alignment methods and alignment checks.

4.4.1.6 Shaftline alignment calculations for single-engine geared propulsion systems with propeller shaft diameter less than 280 mm are not required.

4.4.1.7 Shaftline alignment calculations are to be submitted to PRS for approval for the following propulsion shaft systems:

.1 Single-engine geared systems, where the propeller shaft diameter equals to at least 280 mm for the shaft portion behind the stern tube bearing;
.2 Shafting with prime movers or shaftline bearings installed on resilient mountings;
.3 Multi-engine, geared systems;
.4 Systems with one bearing, or without the bearing, located inboard of the forward stern tube bearing.

4.4.1.8 Where calculations prove that the system is sensitive to changes in alignment at different operational conditions, the optimised shaft alignment is to be verified by measurements made during sea trials, using PRS acceptable methods, e.g. strain gauge technique.

4.4.2 Detailed Requirements

4.4.2.1 The shaftline alignment calculations are to be submitted to PRS for approval. The calculations shall consider:

.1 Thermal displacements of the bearings between cold static and hot dynamic machinery conditions;
.2 Buoyancy effect of the propeller immersion due to the naval ship's operating draught and effect of predicted hull deformations within the range of the naval ship's operating draught, if known;
.3 Forces imposed on shaftline by the gear, pitch control mechanism of controllable-pitch propellers and other mechanisms, where applied;
.4 Possible contribution in the system mode of operation (applies to multi-engine propulsion systems);
.5 Propeller offset thrust effects;
.6 Bearing loads in the horizontal plane, where appropriate;

4.4.2.2 The calculations of the shaftline alignment shall determine:

.1 Expected bearing loads for each approved loading condition of the naval ship, for the machinery in cold and hot, static and dynamic operational conditions;
.2 Shaft deflections, bending moments and shear forces along the shaftline, bearing influence coefficients and their deflection off baseline;
.3 Details of propeller offset thrust effect, where applicable;

.4 Details concerning proposed axiality deflection of the aftermost stern tube bearing bore against the base line, where applicable;

.5 Calculated limits for bending moment and shear force at the shaft couplings of the gearbox/prime movers as compared with Manufacturer's limits;

.6 Estimated bearing weardown rates for water or grease lubricated stern tube bearings;

.7 Anticipated thermal rise of engine and gear units between cold static and hot dynamic operational conditions;

.8 Manufacturer's limits for loads of bearings.

4.4.2.3 The shaftline alignment procedure prepared for all main propulsion systems is to be submitted to PRS for approval, and it is to define at least:

.1 Maximum permissible loads for the proposed bearing designs;

.2 Expected bearing loads at light and normal naval ship ballast, when fully loaded and at any other approved naval ship's loading conditions, for the machinery in cold and hot, static and dynamic operational conditions;

.3 Design bearing offset from the base (straight) line;

.4 Design bearing clearances and weardown values;

.5 Expected relative slope of the shaft and the bearing in the aftermost sterntube bearing;

.6 Details concerning slope-bore of the aftermost sterntube bearing, where applied;

.7 Expected shear forces and bending moments at the fore end flange of the shafting system connected to the gear output shaft or, for directly driven systems, to the engine output flange;

.8 Location and loads for the temporary shaft supports;

.9 Proposed technique of the bearing load measurement and its estimated accuracy;

.10 Jack correction factors for each bearing, where the bearing load is measured using a specified jacking technique;

.11 Proposed acceptance criteria for shaft alignment, taking into account tolerances and alignment criteria for shaftline flexible couplings.

5 GRAVITY OVERBOARD DRAIN SYSTEM

5.1 Provisions of the present Chapter are applicable to the open ended pipes which penetrate the naval ship's shell plating below freeboard deck and which allow liquids from open decks and various naval ship's spaces and compartments to be discharged overboard by gravity.

The requirements concerning pipes, which allow liquids to be drained by gravity from one compartment into another one within the naval ship, are given in Chapter 6.

5.2 Drain pipes from non-watertight spaces and compartments are to be led overboard.

5.3 Enclosed cargo spaces located on the freeboard deck may be drained by gravity directly overboard if, with the vessel at the deepest draught and heeled 5 degrees to either board, the freeboard deck edge is not immersed in water.

5.4 If, with the vessel at the deepest draught and heeled 5 degrees to either board, the freeboard deck edge is immersed in water, enclosed cargo spaces located on the freeboard deck may be drained by gravity, provided water is not discharged directly overboard but into special tank of adequate capacity which is equipped with high level alarm and arrangements for discharging water overboard. If the cargo space is protected by a smothering fire extinguishing system, the drainage holes are to be provided with adequate closing means, preventing outflow of gases.

5.5 Cargo spaces located above bulkhead deck and intended for the carriage of mechanical vehicles (for those located under bulkhead deck – see 6.3.2.2), are to be provided with drain pipes discharging water from fire extinguishing systems, led directly overboard. Number, diameter and arrangement of the pipes are to be such as to ensure drainage of the water from water spraying system and water fire mains system. The pipes are to be fitted with shut-off valves controlled from a place located above the bulkhead deck. The place of the valves control is to be provided with information plates reading as follows:

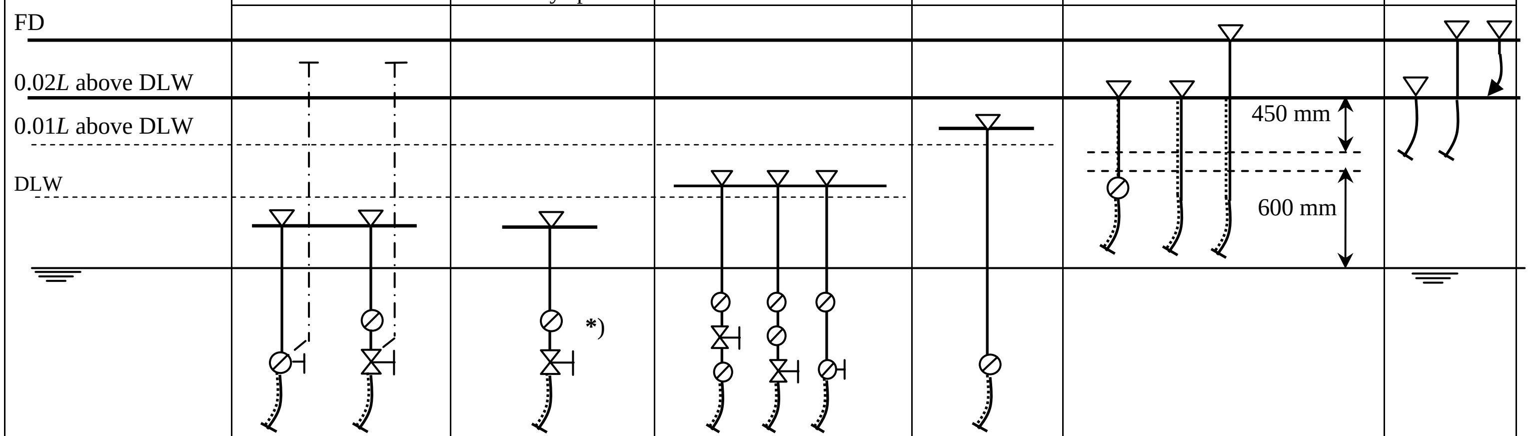
"Valves to be kept open permanently, closed upon command only".

For the discharge of any leaks of oil products from vehicles and oily bilge water after cargo holds washing, a separate system is to be provided in accordance with 6.3.2.2.

5.6 Drain pipings are to be made of pipes and fitted with valves in accordance with Table 5.6. As a rule, the pipings with open inlets located in enclosed spaces and led through the side shell plating below the deepest load waterline are to be provided with shut-off non-return valves fitted directly on the plating. If the valves are not fitted directly on the plating, the piping section between the plating and the valve is to be made of the pipe of increased wall thickness (see Note 4 to Table 5.6). Acceptable designs of drainage pipings are presented in Table 5.6.

Table 5.6
Requirements for drainage pipings

Superstructure or deckhouse deck	Drainage from enclosed spaces located below or on the freeboard deck				Drainage from other spaces	
	Inlet to drainage pipe at the height < 0.001*L* above DLW	Pipeline led overboard in region of machinery space	Inlet to drainage pipeline at the height:		Pipeline led overboard at the height > 450 mm below the freeboard deck or < 600 mm above DLW	Other drainage pipelines
			> 0.01*L* above DLW	> 0.02*L* above DLW		



Symbols:

- – inlet to pipeline
- – shut-off valve
- – non-return valve
- – non-return valve possible to be shut
- – standard wall thickness pipeline
- – increased wall thickness pipeline
- – overboard section of pipeline
- – pipeline led to open deck
- *) – approved control position of valve
- – remote control

Notes to Table 5.6

1. DLW means the waterline corresponding to the deepest draught.
2. FD means freeboard deck.
3. *L* means length of the naval ship according to definition given in 1.2.1 of *Part III – Hull Equipment.*
4. Pipeline of standard wall thickness means a pipeline whose wall thickness is not less than that specified in column 4 of Table 1.16.3.1-1, while the pipeline of increased wall thickness means the pipeline whose wall thickness is not less than that specified in column 6 of the above mentioned Table.

5.7 The requirements for installation of non-return valves specified in Table 5.6 do not apply to the drainage pipings which are to be closed at sea (e.g. the pipelines for gravitation emptying ballast tanks).

6 BILGE SYSTEM

6.1 General Provisions

6.1.1 For the purpose of this Chapter, the following division of bilge systems according to their functions is introduced:

- dewatering bilge system – bilge system used for the naval ship rescue i.e. disposal of large quantities of water flowing into the naval ship's interior in result of damage to shell plating and disposal of water coming from the operating fire-extinguishing systems;
- drainage bilge system – bilge system used for removal of water appearing during normal operation of a naval ship e.g. due to piping leakages, repairs to machinery, bilge washing, etc.

6.1.2 A naval ship is to be provided with dewatering bilge system capable of removing water from each watertight compartment and from all spaces protected by sprinkler or water spraying fire-extinguishing systems. The system is to be so designed that in all trim and heel conditions, which may occur after damage to shell plating, efficient dewatering of each compartment is possible.

6.1.3 A naval ship is to be provided with drainage bilge system intended for removal of water from compartments in which it may be present during normal operation of the naval ship but where it cannot be removed from by gravity in accordance with the provisions of Chapter 5. The system is to be capable of removing water from all places where it may gather in the trim and heel conditions which may occur during normal operation of the naval ship.

6.1.4 As far as practicable, bilge pipes are to be led outside bottom tanks. Where it is necessary to lead bilge pipes through oil fuel, lubricating oil, boiler feed water or drinking water tanks, the pipes are to be led inside tight tunnels forming an integral part of such tanks. Leading pipes in tunnels is not required, provided that pipes within the tank are appropriately thick and seamless and connected by means of permanent joints. Where the use of detachable joints is indispensable, the bilge pipes may be led through tanks without tunnels provided the joints are of a flange type with gaskets resistant to the effect of medium stored in the tank. Where pipes are led within double bottom space, the open ends of suction pipes are to be fitted with non-return valves.

6.2 Dewatering Bilge System

6.2.1 The dewatering bilge system is to be fitted with water ejectors with sea water supply. The number of ejectors is to be such that at least one ejector is fitted in each machinery compartment, the total number of ejectors onboard being not less than two and, as far as practicable, each ejector is to be located in separate watertight compartment. Alternatively, rotary bilge pumps may be used instead of ejectors.

6.2.2 At least three power pumps are to be provided for supply of water to ejectors, located, as far as practicable, in different watertight compartments. The pumps may also be utilised as the stand-by ones in ballast systems and other sea water systems, provided that they always will be ready for immediate use.

6.2.3 Within the watertight compartment, in which an ejector is located, the outboard outlet of a dewatering pipe is to be provided.

6.2.4 The dewatering pipes are to be so arranged that each suction pipe is connected with at least two ejectors.

Shut-off valves are to be installed in places where the dewatering pipes penetrate watertight bulkheads and fire bulkheads.

6.2.5 The dewatering pipes are to have such internal diameters, that the pumping speed is not less than 2 m/s. The internal diameter of pipes is not to be less than 50 mm.

6.2.6 Dewatering of each machinery compartment is to be effected by at least two suction branches. Additionally to the requirements of 6.2.4, one of suctions is to be directly connected to the ejector situated in this compartment so that it can be easily separated from other suctions/ dewatering piping. The suction diameter is to be equal to the diameter of the ejector suction pipe.

The suction branches are to be fitted with readily accessible mud boxes. The pipes from mud boxes to the bilges are to be led as straight as practicable. The lower ends of these pipes are not to be fitted with strum boxes. The mud boxes are to be fitted with easy-to-open covers.

6.2.7 Except suctions, referred to in 6.2.6, each machinery compartment is to be provided with emergency dewatering piping. The branch for emergency dewatering is to be led to the suction pipe of the largest self-priming power pump available in this compartment. The diameter of the branch is to be equal to the diameter of the pump inlet. The suction is to be fitted with shut-off non-return valve with the nameplate:

„Emergency Dewatering”

No mud boxes or strum boxes may be fitted on the branch of emergency dewatering piping.

6.2.8 Ends of suction branches from compartments other than the machinery ones are to be fitted with strum boxes. Total area of strum box openings is to be not less than twice the cross-sectional area of the given branch, while the openings diameter is to amount to 8 – 10 mm. The strum boxes are to be so designed that they can be cleaned up without disconnecting any joint of suction branch.

6.2.9 Control of all dewatering bilge system valves is to comply with the requirements of 1.16.10.8.

6.2.10 Capacity of the dewatering bilge system ejectors is to be so selected that two separately located ejectors can drain simultaneously, within one hour, adjacent watertight compartments with the greatest total volume. Capacity Q of ejector(s) serving the compartment considered is to be not less than that determined from the formula:

$$Q = k\, L\, B\, H, \ [\mathrm{m}^3/\mathrm{h}] \qquad (6.2.11)$$

where:

k – flooding coefficient of the compartment equal to:
- k = 0.85 – for machinery compartments and cargo spaces,
- k = 0.95 – for crew spaces,
- k = 0.60 – for storage spaces.

L – length of the compartment served by the ejector(s) considered, [m],

B – mean width of the compartment measured half of its length at the height $H/2$ from the base plane, [m],

H – distance from the base plane to emergency waterline, [m].

6.2.11 The capacity of each pump feeding ejectors is to be sufficient for supplying water to ejectors located in any two compartments, while the pipes are to be so arranged that each ejector can be supplied by at least two pumps.

6.2.12 Additionally to ejectors of the fixed dewatering bilge system, portable ejectors are to be provided together with hoses of appropriate length. The naval ships of displacement below 500 t are to be provided with two ejectors, the naval ships of displacement 500 – 1500 t with four ejectors, while the naval ships of displacement above 1500 t – six ejectors. The ejectors may be supplied from the water fire main system. Bilge pumps may be used instead of portable ejectors.

6.3 Drainage Bilge System

6.3.1 Draining Machinery Compartments, Shaft Tunnels and Piping Tunnels

6.3.1.1 It is recommended that piston type pumps be used in drainage bilge system. The delivery branch of the pumps is to be led only to retention tank, referred to in 6.3.1.5 and to discharge connections, referred to in 7.2.4.

6.3.1.2 Internal diameter of drainage pipes is not to be less than 50 mm.

6.3.1.3 Branch suction of the pipes are to be fitted with readily accessible mud boxes or strainers. The pipes from mud boxes to the bilges are to be led as straight as practicable. The lower ends of these pipes are not to be fitted with strum boxes. The mud boxes are to be fitted with easy-to-open covers.

6.3.1.4 In naval ships propelled by electrical machinery, special arrangements for the drainage of wells under main generators and propulsion motors are to be provided, as well as for an automatic warning signal activated when water in the wells exceeds the permissible level. Automatic means to effect the wells dewatering are recommended.

6.3.1.5 Retention tank is to be provided for collecting bilge water (see also 7.3 for naval ships of displacement below 100 t). It is recommended that the tank is to be slim and high to enable oil separation. If it is practicable, the capacity *V* of the tank is not to be less than that given below:

– for naval ships of the main engine power up to 1000 kW

$$V = 1.5 \text{ m}^3$$

– for naval ships of the main engine power above 1000 kW up to 20 000 kW

$$V = 1.5 + \frac{(P - 1000)}{1500}, \text{ [m}^3\text{]} \qquad (6.3.1.5\text{-}1)$$

– for naval ships of the main engine power above 20 000 kW

$$V = 14.2 + \frac{0.2(P - 20000)}{1500}, \text{ [m}^3\text{]} \qquad (6.3.1.5\text{-}2)$$

where:

P – the main engine rated power, [kW].

Where it is practicable, the tank is to be fitted with a pipe for the drainage of the settled oil to an oil residues tank.

6.3.1.6 The discharge of the bilge water tank content is to be possible either to external receptacles by means of standard discharge connections, referred to in 7.2.4 and with the use of pumps, referred to in 6.3.1.1, or directly overboard through filtering equipment and monitoring system, referred to in 6.3.1.7. The above mentioned standard discharge connections may also be used for discharging oil residues (see 7.2.2), provided that an effective arrangement (e.g. three-way cock of L-type), that would prevent the oil residues from entering the bilge water system, is applied.

6.3.1.7 Every naval ship of 100 tonnes gross tonnage and above is to be fitted with oil filtering equipment for the treatment of oily bilge water, which ensures that the oil content in the effluent without dilution does not exceed 15 ppm (parts per million by volume) and additionally with a system for monitoring the oil content in the effluent which automatically activates visual and audible alarm and stop the effluent discharge overboard when the oil content exceeds 15 ppm. Both the oil filtering equipment and oil content meter forming part of the monitoring system are to be of an approved type and fulfil the requirements of IMO Resolution MEPC.107(49). Stopping the effluent discharge overboard is to be by means of valve (valves) switching over – i.e. closing the discharge overboard and opening the return to the oily bilge water tank or to the bilges.

6.3.1.8 Machinery room with refrigerating plant using group II and III medium (see Table 22.2.2) is to have a separate drainage system. The capacity of the system's pump is not to be less than that of the water curtain system at the access door to the compartment. The discharge pipes of the system are to be led directly overboard.

The machinery room with refrigerating plant using group I medium (see Table 22.2.2) may be drained by the main drainage system of the naval ship.

6.3.2 Draining Cargo Spaces

6.3.2.1 Except the cases described in 6.3.2.2, draining cargo spaces need not be normally effected by special drainage system. Dewatering bilge system may be used for this purpose.

6.3.2.2 Cargo spaces intended for the carriage of power driven vehicles, located below bulkhead deck (see also 5.5) are to be provided, except dewatering system, with drainage system (it may be a gravity system) for discharge any oily leaks from vehicles and oily bilge water after washing holds. Such liquid wastes are to be discharged to a special tank, situated outside machinery spaces and other spaces containing ignition sources. Separate pump, with delivery connected to the standard discharge connections, referred to in 6.3.1.6, is to be used for emptying such tank.

6.3.3 Draining Refrigerated Spaces

6.3.3.1 Provision is to be made for draining all spaces, trays, chutes and other places where water may accumulate.

6.3.3.2 Drain pipes from any non-refrigerated compartments are not to be led into the bilges of refrigerated spaces.

6.3.3.3 Each draining pipe from refrigerated spaces is to be fitted with a hydraulic seal, or with other equivalent closing arrangement. The head of liquid in the hydraulic seal is to be such that the arrangement remains effective under any service conditions.

The hydraulic seals are to be placed in accessible positions outside the insulation. Shut-off valves are not to be fitted to the drainage pipes.

6.3.4 Draining Cofferdams and Other Spaces

6.3.4.1 Cofferdams capable of being filled with water may be drained with use of dewatering system.

6.3.4.2 The peaks, which are not used as tanks may be drained by means of separate hand pumps or water ejectors.

6.3.4.3 Chain locker and boatswain's store may be drained by means of hand pumps, water ejectors or other arrangements.

6.3.4.4 Draining steering gear rooms and other small compartments situated above the afterpeak may be effected by means of hand pumps or water ejectors or by means of drain pipes led into the shaft tunnel or machinery space bilges. The drain pipes are to be fitted with self-closing cocks located in readily accessible places.

The internal diameter of the drain pipes is to be not less than 39 mm.

6.3.4.5 Except the cases specified in 6.3.4.4, drain pipes are not to be led into the bilges of machinery space and shaft tunnels from the spaces situated in other watertight compartments below the bulkhead decks. Drain pipes from these spaces may be led into machinery spaces and shaft tunnels only if terminating into closed drain tanks. Where one tank is intended for the drainage of several watertight compartments and water can overflow from one flooded compartment into another, the drain pipes are to be fitted with non-return valves.

Drain tank is to be drained through a branch suction of the bilge main, and the branch or suction distribution box is to be fitted with non-return valve.

6.3.4.6 Drain pipes from the compartments located below bulkhead deck may terminate in the adjacent bilge of cargo/storage spaces situated in the same bulkhead division.

6.3.4.7 Drain pipes draining the spaces situated in enclosed superstructures and deckhouses may be led to the bilges of machinery spaces or cargo spaces. In naval ships where, in case of flooding of the machinery space or cargo space, water could penetrate into the above spaces, these pipes are to be fitted with valves controllable from a place above the bulkhead deck.

6.3.4.8 Drain pipes of the storerooms for explosives are to be fitted with valves controllable from the places situated outside these storerooms.

7 OIL RESIDUES SYSTEM

7.1 Capacity and Construction of Tanks

7.1.1 Naval ships are to be provided with oil residues tanks of adequate capacity, considering the type of installed machinery and the designed autonomy of the naval ship. It is recommended that the combined capacity V of all tanks is to be not less than the sum of V_1, V_2 and V_3 capacities determined according to 7.1.2, 7.1.3 and 7.1.4.

7.1.2 The combined capacity V_1 of tanks for oil residues resulting from purification of oil fuel and lubricating oil and from oily bilge water treatment is to be not less than that determined by the formula:

$$V_1 = 0.005CD\ , [\mathrm{m}^3] \qquad (7.1.2\text{-}1)$$

where:
C – daily oil fuel consumption, [m^3/day];
D – designed autonomy of the naval ship, [days]; a figure of not less than 30 days is to be assumed for calculation.

For naval ships equipped with means for reducing oil residues, such as oil residues incinerators, capacity V_1 may be reduced to 50% of capacity V_1 calculated according to the above formula, however it can be not less than 1 m^3.

Where the naval ship can carry alternatively ballast water and oil fuel in tanks, capacity V_1 is to be calculated by the following formula:

$$V_1 = 0.005(CD + B), [\mathrm{m}^3] \qquad (7.1.2\text{-}2)$$

where:
B – capacity of ballast/oil fuel tanks, [m^3].

7.1.3 The combined capacity V_2 of drain and leakage oil tanks is to be not less than that determined by the following formulae:

– for naval ships of the main engine power up to 10000 kW

$$V_2 = 20DP10^{-6}\ , [\mathrm{m}^3] \qquad (7.1.3\text{-}1)$$

– for naval ships of the main engine power above 10000 kW

$$V_2 = D[0.2 + 7(P - 10000)10^{-6}], [\mathrm{m}^3] \qquad (7.1.3\text{-}2)$$

where:
D – designed autonomy of naval ship [days]; a figure of not less than 30 days is to be assumed for calculation;
P – the main engine rated power, [kW].

7.1.4 Where, in the assumed operation system of the naval ship, provision is made for a complete change at sea of the lubricating oil of the main or auxiliary engines, exhausted oil tanks are to be provided with capacity V_3 determined as 1.5 m^3 for each 1000 kW engine rated power, unless the engine manufacturer specifies other parameters.

7.1.5 The design and construction of oil residues tanks is to facilitate their cleaning and the discharge of residues to shore reception facilities.

7.1.6 Oil residues tanks whose content may be incidentally discharged overboard through vent pipes are to be fitted with the alarm of maximum allowable tank filling level.

7.2 Discharge of the Tanks Content

7.2.1 For the discharge of oil residues tanks content, a separate pump (pumps) is to be provided. Type of the pump, its capacity and discharge head are to be selected having regard to the characteristics of the liquids being pumped, the size and position of tanks and the assumed discharge time. The content of drain and leakage oil tanks, as well as exhausted oil tanks may be discharged by means of suitable transfer pumps or purifiers.

7.2.2 Pipes leading to and from oil residues tanks cannot have connections to the overboard discharge valves. The piping arrangement is to be such that the discharge of oil residues can be effected only through the standard discharge connections, specified in 7.2.4, located on deck.

7.2.3 Pipes for draining the settled water from oil residues tanks may be permitted, provided they are fitted with manually operated self-closing valves and control funnels, and are led to the oily bilge water tank.

7.2.4 Standard discharge connections for the discharge of oil residues are to be fitted with flanges made in accordance with the below Table. The discharge connections are to be installed on both sides of the naval ship and so located as to enable easy connection of reception hose. The discharge connections are to be fitted with blank flanges and nameplates. In the case of small naval ships, PRS may allow to install one discharge connection located close to the centreline.

Table 7.2.4
Standard discharge connection for the discharge of oil residues

Parameter	Dimensions/number
Outside diameter	215 mm
Internal diameter	According to the pipe outside diameter
Bolt circle diameter	183 mm
Slots in flange	6 holes, 22 mm in diameter, equidistantly placed on a bolt circle of the above diameter, slotted to the flange periphery; the slot width to be 22 mm
Flange thickness	20 mm
Bolts and nuts	6 sets, bolts of 20 mm in diameter and of suitable length
The flange is to be made of steel or other equivalent material and have a flat face. This flange, together with a gasket of oil-resistant material, is to be suitable for a service pressure of 0.6 MPa. The flange is designed to accept pipes up to a maximum internal diameter of 125 mm.	

7.3 Requirements for Naval Ships of Displacement Below 100t

Each naval ship is to be equipped with at least one oil residues tank and discharge piping provided with own pump and standard discharge connection, as referred to in 7.2.4. The tank may also be used for collecting oily bilge water, provided that it is discharged only by means of the above pump. The capacity of such tank is to be suitably increased.

8 BALLAST, HEELING AND TRIMMING SYSTEMS

8.1 General Provisions

8.1.1 Filling and emptying the ballast tanks may be effected by gravitation or with use of pumps or ejectors. Gravitation emptying may be applied, provided that the ballast water may be discharged from tanks also in emergency.

8.2 Pumps

8.2.1 At least two pumps, main and stand-by, are to be provided for filling the ballast tanks. Separate pumps or other sea water systems pumps may be provided for this purpose. Drainage system ejectors may be used for emptying the ballast tanks.

8.2.2 It is recommended to determine the capacity of the ballast pumps on the assumption that when pumping out water from the largest ballast tank, the velocity of the water flow is not less than 2 m/s, with the suction pipe diameter determined by the formula 8.3.1.

8.2.3 Pumps used for taking ballast water from the double bottom tanks are to be of self-priming type.

8.2.4 Where tanks are used for alternate carriage of ballast water and oil fuel, the ballast pump is not to be used as the stand-by cooling water pump or a fire pump, nor may the stand-by cooling water pump or fire pump be used as the ballast pump.

8.3 Pipe Diameters

8.3.1 The internal diameters, d_w of suction branches of the ballast pipes for particular tanks are to be not less than those determined by the formula:

$$d_w = 18\sqrt[3]{V}\ , \quad [\text{mm}] \tag{8.3.1}$$

where:
V – volume of the ballast tank, [m^3].

The actual diameter may have the nearest standard size.

The internal diameter of the ballast mains is to be not less than the maximum diameter of suction branch, determined by formula 8.3.1.

8.4 Pipes Arrangement and Joints

8.4.1 Arrangement of the suction branches is to ensure the discharge of water from every ballast tank, also in emergency conditions.

8.4.2 Where tanks are used for alternate carriage of ballast water and oil fuel, provision is to be made for efficient separation of ballast system and fuel system through application of appropriate switch-over fittings or adjustable pipe connections. Arrangements are also to be provided for discharge of oily bilge water to shore reception facilities by means of standard discharge connections, as referred to in 7.2.4.

8.4.3 Ballast pipes passing through oil fuel tanks are to be led inside tight tunnels forming an integral part of the tank or made of seamless steel pipes permanently connected. Where it is impracticable to make permanent joints, flange joints with gaskets resistant to the effect of oil fuel may be permitted.

8.4.4 Ballast pipes are not to be led through cargo holds.

8.5 Heeling and Trimming Systems

Heeling and trimming systems are to be so constructed that their inefficiency does not have adverse effect on the naval ship's stability and they are to comply with the requirements of 8.4.3 and 23.3.4.4. These systems are subject to special consideration by PRS in each particular case.

9 AIR, OVERFLOW AND SOUNDING PIPING SYSTEMS

9.1 Air Pipes

9.1.1 Air pipes are to be provided to:
- tanks intended for the storage of liquids,
- cofferdams/protection compartments,
- side and bottom sea chests,
- boxes of shell coolers,
- all other compartments normally not open to atmosphere.

9.1.2 The arrangement of air pipes is to be such that under normal list and trim conditions no hydraulic seals in the pipes may occur.

9.1.3 Air pipes terminating in the open deck are to be so arranged that their damage during cargo handling operations is precluded.

9.1.4 Air pipes passing through cargo holds intended for the carriage of military equipment are to be protected against damage.

9.1.5 Air pipes of tanks/boxes/compartments adjacent to the external shell plating are to terminate above the bulkhead deck.

9.1.6 Air pipes of side/bottom sea chests and boxes of shell coolers are to be fitted with shut-off valves installed directly on them.

9.1.7 Tank air pipes are to be led from the upper part of the tank from a place situated at the maximum distance from the filing pipe. The number and arrangement of the air pipes are to be determined taking into account the shape and size of the tanks so that to preclude the formation of air pockets.

9.1.8 Tanks extending from side to side are to be fitted with air pipes at both sides.

9.1.9 The air pipes of tanks containing easily flammable liquids (oil fuel, lubricating oil, etc.) are to be led to the places on the open deck where the escaping vapours will not cause any fire hazard (see also 12.3.4). The above applies also to air pipes of tanks where flammable gases may be present (fecal matter tanks, tanks containing cathodic protection anodes, etc).

9.1.10 Air pipes of oil fuel daily service and settling tanks as well as lubricating oil tanks are to be led to such places where in the event of a broken air pipe no direct risk of ingress of sea-water splashes or rain water into the tanks occurs.

9.1.11 Air pipes of non-heated lubricating/hydraulic oil tanks, not forming integral part of the naval ship's hull structure, may terminate in the spaces where the tanks are located. The possibility of oil spilling onto electrical equipment or heated surfaces in case of overfilling the tank is to be precluded.

9.1.12 The height of air pipe measured from the open deck to the overflow level of the air pipe is to be at least:
– 760 mm – on the open deck,
– 450 mm – on the superstructure deck
(see definitions in sub-chapter 1.2.3 of *Part III – Hull Equipment*).

For naval ships of restricted service, the height of air pipes may be reduced to 600 mm and 380 mm, respectively.

9.1.13 The total cross-sectional area of air pipes of the tank filled by gravity is to be not less than the total cross-sectional area of all pipes by which the liquid may be simultaneously delivered into the tank.

9.1.14 The total cross-sectional area of air pipes of tanks filled by a pump is to be at least 1.25 times the cross-sectional area of the filling pipe. The total cross-sectional area of an air pipe serving several tanks is to be at least 1.25 times the cross-sectional area of the common filling pipeline, the provisions of 9.2.3 being complied with.

9.1.15 In no case the air pipe internal diameter is to be less than 50 mm.

9.1.16 Where a tank filled by a pump is provided with an overflow pipe, the total cross-sectional area of the air pipes of the tank is to be not less than 0.33 of the cross-sectional area of the filling pipe.

9.1.17 Where a tank filled by a pump is provided with (an) overflow pipe(s), which simultaneously serve as air pipe(s) and comply with all requirements for overflow pipes, no separate air pipes are required.

9.1.18 The open ends of air pipes situated on the open deck and on the first tier superstructure decks as well as those situated above these decks within the zone limited by the angle of flooding (see definitions in sub-chapter 1.2 of *Part IV – Stability and Subdivision*) are to be fitted with fixed, self-acting closing appliances – so called vent heads preventing the entry of sea water into the tanks. This requirement does not apply to the compartments permanently filled with sea-water such as side and bottom sea chests and boxes of shell coolers.

9.1.19 The vent heads are to comply with the requirements concerning construction and testing specified in PRS *Publication No. 33/P – Air Pipe Closing Devices* and are to be type approved by PRS.

9.1.20 The ends of air pipes not fitted with the vent heads are to be made as an elbow, with its opening facing downwards or in a different way agreed upon with PRS. Additionally such ends, located in easily accessible places, are to be protected against the possibility of entering, through the pipe, dangerous objects/substances into the tank/compartment interior. The method of protection is to be agreed with PRS.

9.1.21 The open ends of air pipes, referred to in 9.1.9, are to be fitted with devices preventing the passage of flame. The devices are to be resistant to corrosive effect of sea-water and be easily dismountable for their cleaning or replacement. The design of such devices is to be agreed with PRS.

9.1.22 Nameplates with tank number and designation are to be affixed to the ends of air pipes.

9.1.23 Air pipes of tanks intended for different kinds of liquids are not to be interconnected.

9.1.24 Air pipes of oil fuel tanks are not to have detachable joints in way of accommodation and refrigerated spaces.

9.1.25 Air pipes of tanks containing oil products terminating on the open deck are to comply with the requirements of 12.5.6.

9.1.26 It is not recommended to lead air pipes through refrigerated spaces. Where such leading is indispensable, the pipes are to be thermally insulated.

9.1.27 It is not recommended to lead air pipes through ammunition rooms, armament and explosives store rooms.

9.1.28 Air pipes of sea-water tanks and lubricating oil tanks may be led through oil fuel tanks without tight tunnels forming an integral part of such tanks provided that seamless pipes and permanent joints are used. Where the use of detachable joints is indispensable then, after agreeing it with PRS, flange joints with gaskets resistant to the effect of oil may be used.

9.1.29 Air pipes of drinking water and washing water tanks are to be led into the naval ship's interior and are to terminate within the shelter. Such tanks are to be provided with upper level alarm and overflow pipes.

9.1.30 Air pipes of diesel engine crankcases are to comply with the provisions given in 2.2.4 of *Part VII – Machinery, Boilers and Pressure Vessels*.

9.2 Overflow Pipes

9.2.1 Overflow pipes are to be fitted in:
- oil fuel tanks,
- drinking water and washing water tanks,
- tanks with air pipes led to such height that hydrostatic pressure of the liquid overflowing through the air pipe exceeds design pressure of the tank.

9.2.2 Leading overflow pipes and their protection against damage are to comply with the requirements of 9.1.2 and 9.1.4.

9.2.3 The cross-sectional area of the overflow pipes is to comply with the requirements of 9.1.13 to 9.1.15.

9.2.4 The oil fuel overflow pipes are to be led to the overflow tank or to dedicated storage tank the capacity of which is to be increased by a volume not less than determined in accordance with 9.3.1, and its outfit is to comply with 9.3.2.

9.2.5 Where overflow pipes from several tanks forming integral part of the hull structure and situated in different watertight compartments are led to a common line (manifold), the connections and the common line itself are to be situated above the damage load waterline. Where the overflow pipes serve simultaneously as the air pipes, the manifold is to be provided with air pipe.

9.2.6 Air pipes which serve simultaneously as overflow pipes are not to be connected to the air pipe of the overflow tank, but directly to that tank or to other overflow pipe of a sufficient diameter, connected to that tank.

9.2.7 Where a tank is alternately used for the carriage of oil fuel and water ballast, the arrangement is to be provided to exclude passing water ballast to oil fuel tanks. Subject to PRS consent, the overflow pipes may be fitted with shut-off valves, provided these pipes are not used as air pipes.

9.2.8 Overflow pipes of oil fuel daily service and settling tanks are to be led to the tanks situated below the above-mentioned tanks.

9.2.9 A sight glass made of heat-resisting glass or a signalling device indicating the fuel overflowing is to be fitted to the vertical piece of overflow pipes leading from oil fuel tanks, in a conspicuous and easily accessible place.

9.2.10 The overflow pipes of the drinking water and washing water tanks are to be led to the bilges of the compartment drained by the bilge system.

9.3 Overflow Tanks

9.3.1 The capacity of oil fuel overflow tanks is to be not less than 10-minutes capacity of the fuel transfer pump.

9.3.2 The overflow tank is to be provided with visual and audible alarm warning whenever the tank is filled in excess of 75% of its capacity.

9.4 Sounding Pipes and Arrangements

9.4.1 Sounding pipes are to be fitted in:
– all tanks,
– cofferdams situated below the load waterline,
– bilges and bilge wells not readily accessible.

In lieu of sounding pipes, other level indicators, of a type approved by PRS, may be used.

9.4.2 The pipes are to be led straight or with slight curvature to permit a ready passage of the sounding rod.

9.4.3 A striking plate or an equivalent arrangement protecting the tank bottom plating against damage by the sounding rod is to be fitted under each open ended sounding pipe. Where slotted sounding pipes having closed ends are employed the lower ends of the pipes are to be adequately strengthened

9.4.4 The internal diameter of sounding pipes is to be not less than 32 mm.

9.4.5 The upper ends of sounding pipes led to the open deck are to be fitted with tight closing arrangements. The plug and threaded parts of the socket it is screwed in are to be made of bronze, brass or stainless steel.

9.4.6 Sounding pipes terminating above the open deck level are to be so arranged as to preclude the possibility of their damage during cargo handling operations.

9.4.7 Nameplates, indicating tank number and purpose, are to be affixed to the upper ends of sounding pipes.

9.4.8 Sounding pipes are to be, in principle, led to the open deck. Permissible departures from this principle are given in paragraphs 9.4.9 to 9.4.13.

9.4.9 Where the double bottom forms wing bilges or the naval ship has a flat bottom, one sounding pipe is to be installed at each side of the naval ship and it is to be led to readily accessible place above the bulkhead deck.

9.4.10 Sounding pipes for cofferdams and tanks not forming part of the hull structure need not be led to the open deck, provided they are readily accessible under all service conditions.

9.4.11 The sounding pipes of the double bottom water tanks may be led to the spaces above the tanks if they are readily accessible. These pipes are to be fitted with self-closing cocks.

9.4.12 Sounding pipes for oil fuel tanks, lubricating oil tanks and tanks for other readily flammable oils, if not led to the open deck, are not to terminate in compartments where spillage originating from the pipes may cause a fire hazard. In particular, sounding pipes are not to terminate in accommodation and service spaces.

9.4.13 In technically justified cases sounding pipes of oil fuel, lubricating oil and other readily flammable oils tanks may terminate in machinery spaces or shaft tunnels, provided that:

.1 top ends of sounding pipes are led to the places distant from the places of high risk of ignition or are fitted with shielding effectively protecting oil fuel, in the case of accidental release from the pipe, from coming into contact with heated surfaces of boilers, engines, exhaust pipes, etc. as well as with electric machinery and switchboards;

.2 top ends of sounding pipes are fitted with self-closing sounding cocks and terminate not less than 0.5 m above the floor level. Additionally, a self-closing test cock of a small diameter is fitted under the above-mentioned cock in order to enable the check that there is no fuel in the pipe. Test cock is not required to be fitted on sounding pipes of lubricating oil tanks. Measures are to be taken to prevent ignition in the case of fuel escape through the control cock. The self-closing sounding and test cocks are to be corrosion resistant and of a non-sparking design;

.3 an oil fuel level indicator complying with the requirements of 9.4.7 is fitted additionally on the tank. This does not apply to lubricating oil tanks.

9.4.14 In the case of sounding pipes, referred to in 9.4.13, serving tanks of a capacity less than 500 l, which are not double bottom tanks, the self-closing cocks are not required.

9.4.15 Where on the oil fuel, lubricating oil and other readily flammable oil tanks level indicators other than sounding pipes are installed, they are to be PRS type-approved and are to comply with the following requirements:

.1 The failure of the indicator or overfilling the tank is not to cause the release of the tank content;

.2 Where the level indicator is provided with a transparent element, it shall be protected against mechanical damage and made of heat-resisting, flat glass or plastic not losing its transparency in contact with the medium carried in tank. Use of cylindrical level glasses is prohibited. Self-closing cocks are to be fitted between the indicator and tank, at the lower and upper end. The upper end cock is not required where the upper connection of indicator with the tank is situated above the maximum level of liquid in the tank.

9.4.16 Where level sensors are installed on oil fuel, lubricating oil, or other flammable oil tanks they are to be fitted inside steel or other equivalent pockets which are not easily destroyed by fire.

9.4.17 The internal diameter of sounding pipes led through refrigerated spaces where the temperature may drop to 0 °C and below, as well as of the pipes of tanks fitted with heating installation, is not to be less than 50 mm. Within refrigerated spaces the pipes are to be thermally insulated.

9.4.18 Sounding pipes of sea water tanks and lubricating oil tanks passing through oil fuel tanks are to be led inside tight tunnels forming an integral part of such tanks or are to be made of seamless steel pipes permanently connected. Where the use of permanent joints is impracticable, flange joints with gaskets resistant to the effect of oil fuel may be used.

10 EXHAUST GAS SYSTEM

10.1 The engine's exhaust ducts are to be fitted with silencers or equivalent arrangements. Silencers are to be provided with cleanouts for periodical cleaning and internal inspection.

10.2 Each main engine is to be fitted with an individual exhaust line.

10.3 Exhaust gas pipes of auxiliary engines may be connected to a common exhaust line, provided arrangements are used to separate particular engines. The separating arrangements are to be fitted with ”open/closed” indicators. Position of separating arrangements is to be indicated in central control station.

10.4 The exhaust gas lines of auxiliary engines provided with remote and automatic starting are to be provided with permanent dewatering arrangements preventing water from entering the engine. These arrangements are to be situated in readily accessible places and measures to enable cleaning thereof are to be taken. Internal diameter of the dewatering pipes is to be not less than 25 mm.

10.5 In exhaust gas boilers, as well as in boilers with combined heating which, due to their construction, cannot be left without water when heated with exhaust gas, provision is to be made for a by-pass with dampers for complete cut-off of the boilers from the exhaust gas lines.

10.6 Where exhaust gas heated boilers are installed, measures are to be taken to prevent water from entering the engine in the case of boiler pipes leakage or due to any other damage. The drain pipes are to be led to the engine room bilges and fitted with hydraulic seals.

10.7 The exhaust gas system is to ensure efficient cooling of exhaust gas and noise suppression in order to reduce infrared radiation and the naval ship acoustic field emission.

10.8 Where exhaust gas lines are led through the shell plating, near or below the load waterline, means are to be provided to prevent the sea-water from entering the engine.

10.9 The exhaust ducts which transfer water cooling the exhaust gas are to be so arranged that cooling water can outflow overboard in every conditions.

10.10 Outlets of exhaust ducts led through shell plating are to be provided with closing arrangements.

10.11 Arrangement of exhaust duct outlets is to be such that suction of exhaust gas into the naval ship's interior is precluded.

10.12 The exhaust gas ducts are to be thermally insulated according to 1.9.6. This requirement does not apply to exhaust ducts fitted with water jacket.

10.13 The exhaust gas lines and oil fuel tanks are to be not less than 450 mm apart. This requirement does not apply to exhaust ducts fitted with water jacket.

11 VENTILATION, AIR FILTERING AND AIR-CONDITIONING SYSTEMS

11.1 General Requirements

11.1.1 Unless explicitly stated otherwise, the requirements of the present Chapter apply to all ventilation, air filtering and air-conditioning systems (further in this Chapter referred to as systems).

11.1.2 The systems are to comply with the requirements concerning air parameters specified for particular spaces by the Client

11.1.3 Each space which is normally attended is to be equipped with mechanical ventilation.

11.1.4 In naval ships provided with air filtering system, the air supplied by such system is to be delivered to the shelter spaces.

11.1.5 In the naval ships which are not provided with air filtering system, possibility of switch-over of the shelter ventilation system to full recirculation and cooling of the recirculated air is to be ensured. The shelter ventilation system is to be capable of maintaining inside the overpressure as compared with atmospheric pressure.

11.1.6 The recirculated air is to be purified of solid impurities, odours and CO_2 excess. The air liable to contain flammable/explosive mixtures may not be used in recirculation.

11.1.7 External air intake openings are to be so situated that suction of exhaust gas, the gas produced during the use of onboard armament and the air contaminated by oil product vapours, is precluded.

11.1.8 The external air intake openings and the openings used for removal of air from inside the naval ship are to be so positioned that sea water and rain penetration into the system is reduced to a minimum.

11.1.9 The openings referred to in 11.1.8 are to be so positioned that in normal operational conditions and in emergency conditions they are situated above the waterline. Detailed requirements concerning position of the openings and their closing appliances are given in sub-chapter 7.7, *Part III – Hull Equipment*.

11.1.10 The system design is to take into account naval ship subdivision into watertight, gastight compartments and fire zones. It is to be assumed, as a general principle, that the systems are not to reduce integrity of existing subdivision

11.1.11 Ducts/ casings/ ventilation ducts (further referred to as ducts) are to be made of non-combustible materials, which are corrosion-resistant or appropriately protected against corrosion.

11.1.12 Ducts are to be insulated in places where moisture condensation may occur. The sections of ventilation ducts where water may condense are to be fitted with drain arrangements.

11.1.13 The ventilation ducts intended for the removal of explosive or easily flammable vapours and gases are to be gastight and are not to be connected with the ducts of other spaces. Fans which serve such ducts are to be of non-sparking design and are to comply with the requirements of sub-chapter 5.3.2 of *Part VII – Machinery, Boilers and Pressure Vessels*, while their propulsion motors are to comply with the requirements of sub-chapter 2.8, *Part VIII – Electrical Installations and Control Systems*. It is recommended that the electric motors are not to be placed within the flux of removed gases.

11.1.14 The ventilation systems for machinery spaces of category A, galleys and cargo spaces intended for the carriage of motor vehicles with fuel in their tanks are to be separate and not to be connected with systems serving other spaces. The air filtering systems serving galley spaces are allowed to be constructed according to 11.7.4.

11.1.15 The main inlets and outlets of all ventilation systems are to be capable of being closed from outside the spaces being ventilated. The control devices of closings are to be easily accessible as well as prominently and permanently marked and fitted with indicators (open/closed position).

11.1.16 The ventilation ducts leading to compartments and other spaces protected against fire by a smothering system are to be provided with closing arrangements capable of being operated from the outside of these spaces.

11.1.17 Electric drives for fans are to comply with the requirements of sub-chapter 5.8 of *Part VIII – Electrical Installations and Control Systems*.

11.1.18 The noise made by ventilation systems is not to be greater than permissible values, defined in appropriate standards for particular types of spaces.

11.2 Arrangement of Ventilation Ducts and Penetrations in Divisions

11.2.1 The number of penetrations for ventilation ducts in watertight bulkheads and decks is to be kept to a minimum. With the purpose of ensuring required subdivision, watertight ducts of integrity equal to the integrity of hull structure at the point of penetration are to be used or watertight closing appliances are to be fitted on the bulkheads. The means of closing are to be readily accessible and provided with manual controls fitted on either side of the bulkhead as well as with position indicators (open/closed).

11.2.2 Duct penetrations in A Class fire divisions are to be made in the form of a steel sleeve of wall thickness not less than 3 mm, unless the duct itself complies with the requirements set for the sleeve. The penetration is to be tight and be provided with insulation of fire integrity at least the same as that of the division at the duct penetration. The length of penetration piece and the insulation at each side of the division is to be at least 100 mm, for ducts of free cross-sectional area up to 0.02 m^2, and not less than 450 mm, for the ducts of free cross-sectional area exceeding 0.02 m^2. The ducts with free cross-sectional area more than 0.075 m^2 are to be additionally fitted with automation fire dampers. The fire dampers are to be easily accessible and be capable of being controlled manually from both sides of the division and provided with position indicators (open/closed). The fire dampers need not be fitted, where the ducts passing through spaces surrounded by A Class divisions do not serve these spaces and have the same fire integrity as the divisions which they pierce.

11.2.3 Any fire dampers together with their controls as well as penetration pieces for the ventilation ducts (steel sleeves) intended for installation in A Class divisions are to be tested in accordance with *FTP Code* (see definitions in subchapter 1.2 of *Part V – Fire Protection*). Where the penetration pieces are joined to ventilation ducts by means of riveted or screwed flanges or by welding, they are not required to be tested.

11.2.4 Where ventilation ducts with a free cross-sectional area exceeding 0.02 m^2 pass through B Class divisions, then at the penetration they are to be lined with a steel sheet (liner) of at least 900 mm in length divided into 450 mm on each side of the division unless the ducts are constructed of steel for this length and meet the requirements applicable to liners.

11.2.5 Ventilation ducts provided for the ventilation of machinery spaces of category A, galleys and spaces intended for the carriage of motor vehicles with fuel in their tanks are not to pass through accommodation spaces, service spaces or navigational bridges (see definitions in subchapter 1.2 of *Part V – Fire Protection*), except when:

- **.1** the ducts having a width or a diameter of not more than 300 mm are constructed of steel having a thickness of at least 3 mm, and ducts having a width or a diameter of more than 760 mm are constructed of steel having a thickness of at least 5 mm; for the ducts of intermediate dimensions, thickness is to be obtained by linear interpolation,
- **.2** the ducts are suitably supported and stiffened,
- **.3** the ducts are fitted with automatic fire dampers close to the boundaries penetrated;
  and
- **.4** the ducts are insulated to a point at least 5 m beyond each fire damper, and the insulation meets the requirements for Class A-60 division;
  or

.5 the ducts are constructed in accordance with the requirements of .1 and .2 above; and

.6 the ducts are insulated to the standard of Class A-60 division throughout the accommodation spaces, service spaces or navigational bridges.

The above requirements are also applicable to the ventilation ducts serving the accommodation spaces, service spaces, and control stations, passing through machinery spaces of category A, galleys and spaces intended for the carriage of motor vehicles with fuel in their tanks.

11.2.6 Ventilation ducts intended for the extraction of explosive or readily flammable vapours or gases are not to pass through the explosion-hazardous spaces, unless led in gastight tunnels.

11.3 Requirements for Air Filtering Equipment and Systems

11.3.1 Air filtering equipment is to ensure efficient purification of N, B and C weapons contaminated air. The air filtering equipment is to include the following main components:

– pre-filtration unit (including i.e. water separator, fittings preventing from harmful effects of shock wave and solid particles filter),
– NBC filtration unit,
– monitoring and measuring unit (including i.e. devices indicating pre-filter contamination level, NBC content detecting/alarm devices, capacity drop alarm device, and devices indicating pressure value in the shelter and in particular spaces where the pressure value is variable, in air-locks and decontamination station(s)),
– purified air intake fan.

Arrangements for deicing external air intake openings are to be applied.

11.3.2 Filtration units of the air filtering equipment are to be installed in a separate compartment located on the open deck, which can be entered only by the door leading from the open deck. The units design and their arrangement are to be such that filters can be replaced quickly and smoothly. The air intake and outlet of the NBC filtration unit are to be fitted with gastight shut-off valves.

11.3.3 If the air filtering system is used in standard conditions (i.e. during the naval ship operation in non-contaminated area) as ventilation system, the by-pass pipe of the NBC filtration unit is to be provided with gastight shut-off valves.

11.3.4 The purified air intake fan is to be installed in the compartment adjacent to the filtration unit compartment. Water- and gastight shut-off valve is to be fitted in the compartment housing the fan, on the wall separating it from the filtration unit compartment, and the gastight non-return valve – on the suction side of the fan.

11.3.5 With reference to compact air filtering equipment, the requirements of 11.3.2 and 11.3.4 apply in appropriate scope, as defined by PRS.

11.3.6 The air filtering system portion from the air intake opening to purified air intake fan and outside the shelter is to be gastight.

11.3.7 The air filtering equipment is to ensure maintaining, in the shelter compartments, pressure greater than atmospheric pressure, with mean value equal to 5 hPa, taking into account air losses due to operation of exhaust ventilation and those which result from use of air-locks, etc. The equipment, or system, are to ensure also diversification of overpressure in particular compartments/spaces in conformity with further requirements of this subchapter.

11.3.8 The air removed from the shelter is to pass through gastight spring-closed return dampers. It is recommended that the air should not to be removed directly to atmosphere but through compartments not included in the shelter (e,g, deck lockers, etc.).

11.3.9 The shelter compartments are to be divided into groups (or individual compartments) served by separate filtering devices, with emergency supply of purified air ensured for each group (or individual compartment). With this purpose delivery ducts of air filtering devices serving different groups of (or individual) compartments may be connected in a common delivery duct, which is to be provided with a gastight distribution valve.

11.4 Ventilation and Air-condition of Machinery Spaces

11.4.1 Ventilation of machinery spaces is to ensure sufficient supply of air necessary for the operation and safe service of installed machinery even in heavy weather. Ventilation of the refrigerating machinery space – see 22.6.6 and 22.6.7.

11.4.2 If machinery compartment is a part of a shelter, the combustion air is to be supplied from outside of the naval ship directly to oil diesel engines, gas turbines and boilers by gastight ducts intended exclusively for this purpose. The air is to be purified of salt and solid particles so far as it is required by equipment manufacturers.

11.4.3 Pressure in machinery compartment is to be lower than the pressure in adjacent compartments.

11.4.4 Where oil diesel engines/gas turbines are installed in sound absorbing capsules/housings, they are to be appropriately ventilated so that the temperature inside them cannot exceed the engines/turbines maximum designed operation temperature. The air removed from the capsules is to be capable of being cooled for the purpose of reducing emission of infrared radiation (air disposal outboard), as well as limiting the temperature rise in machinery compartment (air disposal inside machinery compartment).

11.4.5 Provision is to be made for the extraction outside the naval ship of gases heavier than air from the lower parts of those spaces, from the places below the floor plates where the gases may accumulate, as well as from the locations where fuel system appliances, settling and service tanks are installed.

11.4.6 Shaft tunnels are to be provided with effective mechanical or natural ventilation. Pipe tunnels located in the double bottom are to be provided with mechanical exhaust ventilation.

11.4.7 Emergency generating set room is to be provided with ventilation sufficient for the engine to run at full power in closed compartment under all service conditions (see also 11.4.2).

11.4.8 Ventilation ducts terminating in unsheltered positions on the open deck or superstructure decks which are essential for continuous air supply to the machinery room/fuel combusting devices are to be provided with coamings having a height of not less than specified in paragraph 7.7.2 of *Part III – Hull Equipment.* Where it is impracticable due to the naval ship size or applied arrangements, the coamings may be shorter, provided they are fitted with strong covers such as specified in paragraph 7.7.2 and additional arrangements ensuring undisturbed adequate ventilation of such spaces are employed. In any case the provisions of paragraph 7.7.1 of *Part III – Hull Equipment* are to be complied with.

11.4.9 The number of skylights, doors, ventilators, openings in funnel providing exhaust ventilation and other openings to machinery spaces is to be reduced to a minimum meeting the needs of ventilation as well as necessary for proper and safe operation of the naval ship.

11.4.10 Arrangements are to be made to permit the release of smoke from machinery spaces, in the event of fire therein. The following means may be used for this purpose:
- skylights,
- openings, which normally allow exhaust ventilation,
- ventilators,
- other openings,

provided, they are fitted with means of control for their closure and opening, which are located outside machinery spaces they serve so that in the event of fire in the spaces access to the means will not be cut off.

For the release of smoke, ventilation systems normally serving machinery spaces may also be used.

11.5 Ventilation and Air-conditioning of Crew Spaces

11.5.1 The air taken into crew spaces is to further flow to corridors or sanitary spaces from where it is to be disposed outside the naval ship or partly, when appropriately treated, recirculated.

11.5.2 Where cabins are provided with individual sanitary compartments, the amount of air supplied to cabins is to be at least by 10 % more than the amount of air taken from sanitary spaces.

11.5.3 In laundries, drying rooms and ironing rooms, air exhaust from above the places of great heat and damp emission is to be ensured.

11.6 Ventilation of Sanitary Compartments

11.6.1 All sanitary compartments are to be provided with exhaust ventilation. The exhausted air may be partly recirculated.

11.6.2 In the case of individual sanitary spaces, at least 10 air changes per hour are to be ensured, while in general use sanitary spaces – at least 15 air changes per hour are to be ensured.

11.7 Ventilation and Air-conditioning of Galleys

11.7.1 The amount of air extracted from galley spaces is to exceed the amount of air taken in so that generated underpressure forces air supply to galley spaces from adjacent corridors and compartments. With this purpose, appropriate openings are to be provided to enable air inflow.

11.7.2 The exhaust ducts located inside galley spaces are to be made of stainless steel and their intake openings are to be fitted with grease traps. The grease traps shall be easily dismountable and cleanable.

11.7.3 Irrespective of the requirements of 11.1.14, in the naval ships of displacement not exceeding 500 t, the galley ventilation system need not be fully separated, it is sufficient when it has separate ventilation ducts fitted with fire dampers, installed close to the ventilation/air-conditioning unit, which close automatically in the event of fire.

11.7.4 Where exhaust ventilation ducts from galleys pass through accommodation spaces or spaces where combustible materials may be present, their construction is to comply with the requirements for A Class divisions. Fire protection of the galley exhaust ventilation ducts is to comply with the requirements of paragraph 5.5.6.3 of *Part V – Fire Protection*.

11.8 Ventilation and Air-conditioning of Health Service Spaces

11.8.1 The health service spaces are to be served by separate systems. The air extracted from these spaces is to be generally disposed completely outside the ship.

11.8.2 If the naval ship is provided with air filtering system, the air extracted from the health service spaces may be partly recirculated to these spaces, provided that it is previously thoroughly purified (forced through efficient solid particles filter and active carbon filter).

11.8.3 In the health service spaces, greater pressure is to be maintained than in adjacent compartments of another purpose.

11.8.4 The quality of the air delivered to operating rooms is to be in accordance with the requirements of respective national standards.

11.9 Ventilation and Air-conditioning of Navigation Bridges

11.9.1 Each navigation bridge is to be served by a separate system. Emergency supply of the system is to be rendered possible by connecting it to another system with the use of gastight shut-off valve.

11.9.2 The ventilation system of navigation bridges is to enable, in the event of fire, smoke removal sufficient for normal operation of machinery installed therein and to ensure visibility sufficient for the supervision of the machinery operation.

11.9.3 In the navigation bridge, greater pressure is to be maintained than outside the naval ship.

11.10 Ventilation of Spaces Intended for the Carriage of Motor Vehicles with Fuel in their Tanks

11.10.1 Mechanical ventilation giving at least 10 air changes per hour is to be provided in spaces intended for the carriage of motor vehicles with fuel in their tanks.

Means are to be provided in the navigation bridge to indicate any decrease or loss of the required ventilating capacity. The loss of ventilating capacity is to activate an alarm in the navigation bridge.

11.10.2 Ventilation system of the spaces is to be entirely separate from other ventilation systems and is to comply with the requirements of 11.1.13.

11.10.3 The ventilation ducts and their closing appliances are to be made of steel.

11.10.4 Outlets of exhaust ducts are to be located far from machinery and mechanisms able to generate ignition and they are to be so located in relation to inlets of intake ventilation ducts that possibility of contamination of the air being taken in is precluded.

11.10.5 The inlet and outlet ventilation openings shall be provided with protective grids of mesh not exceeding 13 x 13 mm.

11.10.6 The system is to ensure a uniform air circulation in the space and to prevent the formation of air pockets.

11.10.7 Control of the system is to be effected from outside of the space it serves.

11.10.8 The ducts are not to be led through machinery spaces unless they are insulated to Class A-60 (see also 11.2.5).

11.10.9 Ventilation ducts serving spaces capable of being effectively sealed are to be separate for each such space.

11.10.10 Arrangements are to be provided to permit a rapid shutdown of the fans and effective closure of the ventilation ducts in the event of fire or entering a contaminated area. These arrangements are to be located outside spaces served by the system and be accessible under all weather conditions.

11.10.11 Permanent ventilation openings in the side plating located at the ends of the cargo spaces or in the covering decks are to be placed so as fire in these spaces would not endanger stowage areas and embarkation stations for survival craft and accommodation spaces, service spaces and navigation bridges located in superstructures and deckhouses above the spaces.

11.11 Ventilation of Refrigerated Spaces

11.11.1 Refrigerated provision stores are to be provided with periodically operated mechanical ventilation.

11.11.2 In garbage storage spaces, lower pressure is to be maintained as compared with adjacent compartments.

11.11.3 Inlet and outlet ventilation openings are to be provided with arrangements for their tight closure.

11.11.4 Air ducts passing through refrigerated spaces are to be gastight and well insulated.

11.12 Ventilation of Fire-extinguishing Stations

11.12.1 Fire-extinguishing stations of foam, gas smothering and powder systems are to be provided with effective ventilation.

11.12.2 Fire-extinguishing stations are to be fitted with independent exhaust ventilation from the lower parts of the compartment, and with supply ventilation.

Where the fire-extinguishing station is situated below the open deck, the exhaust ventilation is to be mechanical and ensure at least 6 air changes per hour and the fans are to be started automatically as the door of the station is opened. During operation of the fan, a light signal, visible after the door is opened, is to operate.

11.12.3 Ventilation of high-expansion foam fire-extinguishing system station is to ensure free inflow of air sufficient for the foam generators to operate properly.

11.13 Ventilation of Battery Rooms and Lockers

11.13.1 Ventilation system of battery rooms and lockers is to be independent and ensure removal of air from upper parts of the ventilated rooms and lockers as well as it is to comply with the requirements of 11.1.13.

11.13.2 Fresh air is to be supplied to the lower parts of the rooms and lockers.

11.13.3 Outlets to the open of ventilation ducts are to be so arranged as to prevent admission of water, precipitation and solids therein. Flame arresters are not to be fitted on these ducts. The outlets of the exhaust ventilation ducts are to be situated in such positions where the gases discharged will not cause any fire risk.

11.13.4 Ventilation of accumulator battery lockers containing batteries with charging capacity not exceeding 0.2 kW, may be effected through holes in the lower and upper parts of the locker.

11.13.5 The rate of air flow Q in case of ventilation of an accumulator battery room or locker is to be not less than that determined from the formula:

$$Q = 0.11In \text{, [m}^3\text{/h]} \tag{11.13.5}$$

where:

I – charging current during gas evolution, but not less than 0.25 times the maximum charging current, [A]

n – number of battery cells.

11.13.6 The cross-sectional area F of a vent duct in the case of natural ventilation of accumulator battery rooms or lockers is to be not less than that determined by the formula:

$$F = 2.9Q \text{, [cm}^2\text{]} \tag{11.13.6}$$

but not less than 40 cm^2,

where:

Q – the rate of air flow, [m^3/h], determined by formula 11.13.5.

11.13.7 Natural ventilation of the rooms may be applied where:

.1 the required amount of air, calculated by formula 11.13.5, is less than 85 m^3/h;

.2 the angle of deflection of the ventilation duct from vertical is less than 45°;

.3 the number of bends of the duct does not exceed 2;

.4 the length of the ventilation duct does not exceed 5 m;

.5 the performance of ventilation does not depend on the direction of the wind;

11.13.8 Where the rate of air flow determined by formula 11.13.5 is 85 m^3/h and over, the accumulator battery room is to be provided with mechanical exhaust ventilation.

11.13.9 The internal surfaces of the exhaust ducts, as well as the fans and their motors are to be protected against the action of electrolyte vapours.

11.14 Ventilation of Helicopter Hangars and Associated Spaces

11.14.1 The helicopter hangars together with associated spaces are to be served by separate systems. The systems are to ensure maintaining overpressure in hangars/associated spaces.

11.14.2 The helicopter hangars/associated spaces are to be provided with mechanical exhaust ventilation capable to ensure at least 10 air changes per hour. Removal of air from upper and lower parts of the ventilated hangars and associated spaces is to be ensured. The exhaust systems are to comply with the requirements of 11.1.13.

11.14.3 Arrangements for rapid heating air in a hangar to the temperature of at least 15 ºC are to be provided. The rapid heating may not pose fire hazard in result of proximity of fuel used in helicopters.

11.15 Ventilation of Ammunition Chambers

The ammunition chambers are to be served by independent ventilation systems ensuring their cooling. The supplied air is to contain some amount of fresh air. Inlet and outlet ventilation openings are to be provided with gas- and watertight closures.

12 OIL FUEL SYSTEM

12.1 Pumps

12.1.1 At least two power-driven pumps – main and stand-by – are to be provided for fuel transfer. Any suitable pump, including oil fuel separator pump, may be used as stand-by pump.

12.1.2 If for oil supply to the engine a delivery/supporting pump is needed, additionally to the main pump, a stand-by one is to be provided. This requirement does not apply to auxiliary engines with driven delivery/supporting pumps.

12.1.3 Shut-off valves are to be provided on the suction as well as on the delivery side of oil fuel pumps. If the fuel pump is capable of generating pressure higher than design pressure of the piping, it is to be fitted with a safety valve at the connection of delivery pipe with suction pipe.

12.1.4 Each oil fuel transfer pump with an independent drive is to be provided, besides its local control, with a means of its stopping from an easily accessible position outside the space in which it is situated, and in a compartment which will not be cut off in the event of fire.

12.1.5 Each oil fuel pump with an independent drive is to be equipped with pressure gauges measuring delivery and suction pressure.

12.2 Piping, Valves and Fittings

12.2.1 The oil fuel pipings are to be generally separated from any other systems. Where the tanks are used for alternate carriage of ballast water and oil fuel, the fuel transfer pipings shall comply with the requirements of 8.4.2.

12.2.2 The oil fuel pipings are to comply with the requirements of paragraphs 1.10.4, 1.10.5 and 1.16.11.18.

12.2.3 Arrangement of oil fuel transfer pipings used in a naval ship is to enable pumping oil fuel within each pair of tanks and transfer of oil fuel from each tank to another naval ship.

12.2.4 Every oil fuel pipe, which, if damaged, would allow oil fuel to escape from a tank situated above the double bottom, is to be provided with a remote controlled, quick-closing shut-off valve fitted directly on the tank. Control of the valve is to be effected from a safe position located outside the space where the tank is situated. In case of a tank situated in a shaft tunnel, pipe tunnel or other similar space, the shut-off valve is to be fitted directly on the tank, but control in the event of fire may be effected by means of additional valve fitted on the pipe outside the space where the tank is situated. In such case the valve, if fitted in machinery space, is to be controlled from outside of the space. The requirement of remote control of shut-off valve does not apply to tanks of volume less than 500 l.

Remote control of the quick-closing valve fitted on the emergency generator oil fuel tank is to be effected from a different position than control of other quick-closing valves fitted on tanks situated in machinery spaces.

The installation of shut-off valve remote control is to be made of fire-resistant material.

12.2.5 Oil fuel pipes may be led through drinking water tanks and boiler feed water tanks, as well as through lubricating oil tanks only in tight tunnels forming an integral part of the tanks.

12.2.6 Oil fuel pipes are not to be led through spaces posing fire hazard, such as ammunition chambers, storerooms for easily flammable liquids and spaces for the carriage of military vehicles.

12.2.7 Oil fuel pipes are not to be made of copper nor aluminium brass.

12.2.8 All valves and cocks of the oil fuel system located inside machinery spaces are to be controlled from readily accessible positions. Where such valves or cocks are located below the floor plates, their means of control are to be led above the floor plates or be levelled with the floor and readily accessible.

12.3 Arrangements for Heating Oil Fuel in Tanks

12.3.1 Oil fuel is to be heated by means of steam, water or oil coils, or by means of electrical heating arrangements. In the case of electrical arrangements the provisions of Chapter 15 of *Part VIII – Electrical Installations and Control Systems* are to be complied with.

12.3.2 Heating coils, as well as heating elements of electric fuel heaters are to be located in the lowermost parts of the tanks

12.3.3 The open ends of the suction pipes are to be situated above the heating coils or heating elements of electric heaters, to prevent, as far as possible, the coils and elements from being emerged.

12.3.4 The maximum temperature of the heated oil fuel in the tanks is to be at least 10 °C below the oil fuel flash point.

The oil fuel contained in daily service, settling and other tanks of the engines’ and boilers’ oil fuel supply system may be heated to higher temperatures, provided that:

– the length of vent pipes from such tanks or an applied cooling device enable the vapours to cool down to a temperature of at least 10 °C below the oil fuel flash point;
– vent pipes are fitted with temperature sensors adjusted to give an alarm signal when the temperature exceeds a limit set at least 10 °C below the oil fuel vapours flash point;
– vapours are prevented to penetrate from the upper parts of tanks and vent pipes into machinery spaces;

– no enclosed spaces are situated above such oil fuel tanks, except for well ventilated cofferdams.

12.3.5 Condensate from the steam heating coils is to be led to the observation tank fitted with a sight glass.

12.3.6 The pressure of steam used for heating oil fuel is not to exceed 0.7 MPa.

12.4 Water Draining Arrangements for Tanks

Settling and daily service tanks are to be provided with self-closing valves and drain pipes led to the drain tank. The drain pipes are to be fitted with sight glasses. Where a drip tray has been provided, an open funnel, instead of the sight glass, may be fitted.

12.5 Oil Fuel Leakage Collecting Arrangements

12.5.1 Suitable drip trays are to be fitted where oil fuel leakage from burners, separators, valves and fittings installed on daily service tanks, pumps, filters and other equipment may be expected.

12.5.2 The drain pipes from the drip trays are to be led to drain tanks. The pipes are not to be led to bilges and overflow tanks.

12.5.3 The internal diameter of the drain pipes is to be not less than 25 mm.

12.5.4 The drain pipes are to be led to the drain tank bottom as close as practicable. Where the drain tank is situated in the double bottom, structural measures are to be taken to prevent penetration of water into the engine room through the open ends of the drain pipes in event of damage to the shell plating. It is recommended to use non-return valves acting on small pressure difference.

Provision is to be made for warning signals of reaching the upper permissible level in a drain tank.

12.5.5 Where pipes from the drip trays located in various watertight compartments are led to a common drain tank, constructional measures are to be provided to prevent the possibility of the water overflow from the flooded compartment to other compartments through the open ends of drain pipes.

12.5.6 Under or around each end of fuel tank air pipe located on the open deck, a container or an enclosed space is to be provided to prevent overflow of any fuel leak overboard.

12.5.7 The fuel bunkering stations are to be appropriately enclosed, to prevent leakage of the spilled oil on a deck.

12.6 Bunkering Arrangements

12.6.1 The bunkering to a naval ship is to be effected by means of a fixed pipeline provided with necessary valves and fittings enabling all storage tanks to be filled with oil fuel, as well as fuel sampling. Connecting fuel delivery hose is to be capable at both sides, and in case of naval ships of displacement above 500 t – also on the bow. The terminal end of the fuel bunkering pipeline is to be so situated that the fuel delivery hose is not folded. If it is impracticable, a dismountable rack is to be provided to lay out the hose properly.

12.6.2 The fuel filling pipes of the tanks are to be led to the tank bottom as close as practicable.

12.6.3 The filling pipes of the tanks situated above the double bottom are to be led through the tank wall in its upper part. Where such arrangement is impracticable, the filling pipes are to be fitted with non-return valves installed directly on the tanks.

Where the filling pipe is also used as a service pipe, the non-return valve is to be replaced with a valve remotely closed from a readily accessible position outside the space in which the tank is located.

12.6.4 It is admissible that the filling pipe of emergency generator service tank be led through accommodation and service spaces. It is also admissible that other filling pipes be led through sanitary spaces, provided that the pipe wall thickness is not less than 5 mm and the pipes have no detachable joints in way of these spaces.

12.7 Equipment for Monitoring the Oil Fuel Purity

The naval ship is to be provided with equipment for monitoring purity of the bunkered oil fuel, complying with the requirements specified by the Client.

12.8 Oil Fuel Tanks

12.8.1 The oil fuel tanks, which do not form an integral part of the naval ship's structure, are to comply with the applicable provisions for the hull tanks

12.8.2 The arrangement of the oil fuel tanks within the machinery spaces is to comply with the requirements of 1.10.4 and 1.10.8.

12.8.3 The oil fuel tanks situated on open decks, superstructure decks and in other places open to the atmosphere are to be protected from exposure to the sun rays or a water-spraying system is to be provided.

12.8.4 The oil fuel tanks are to be separated from drinking water and boiler feed water tanks, as well as from lubricating oil tanks by means of cofferdams complying with the requirements of sub-chapter 9.2.4 of *Part II – Hull.*

12.8.5 The compartments situated afore the collision bulkhead are not to be used for the carriage of oil fuel or other flammable liquids

12.8.6 For each type of oil fuel used on board, necessary for the propulsion and supply of essential machinery such as generating sets and auxiliary boilers, 2 daily service tanks are to be provided each of a capacity sufficient for at least 8 hours of operation at nominal power of the propulsion plant under normal operating load at sea of the generators. This requirement may be exempted upon agreement with PRS.

12.8.7 Capacity of the oil fuel tank intended for the supply of emergency fire pump is to comply with the requirements of paragraph 3.2.4.5 of *Part V – Fire Protection*.

12.8.8 Each settling tank and each daily service tank is to be provided with automatic alarm on reaching 80% of maximum filling level. The daily service tanks are to be provided additionally with warning alarm on fuel level drop below 20% of the maximum filling level.

12.9 Oil Fuel Supply to Diesel Oil Engines and Gas Turbines.

12.9.1 The equipment of the oil fuel system is to provide the engine with oil fuel prepared and purified to such a degree as is required by the given engine manufacturer.

12.9.2 A double purpose two-way filter or an automatic self-cleaning filter is to be fitted on the pipeline transferring fuel to the engine (see also sub-chapter 2.5, *Part VII – Machinery, Boilers and Pressure Vessels*). This requirement does not apply to the engines of the emergency generating set and the emergency fire pump, where single filters are sufficient.

12.9.3 In multi-engine systems supplied from the same source of oil fuel, means of cutting off the oil fuel supply to individual engines shall be provided. Cutting off oil fuel supply to one engine must not affect the operation of the other engines. Location of the means of cutting off is to be such, as they are not rendered inaccessible in case of a fire of any of the engines.

12.9.4 Oil fuel for the emergency generating set engine is to be supplied from an independent daily service tank located in the generating set compartment. Oil fuel from this tank is not to be used for other purposes. Capacity of the tank is to ensure operation of the set for a period of time specified in para 9.3.1 of *Part VIII – Electrical Installations and Control Systems*.

12.10 Oil Fuel Supply to Boilers

12.10.1 The system supplying oil fuel to essential steam boilers is to comprise at least two oil fuel units, each consisting of a pressure pump, filters in the suction and delivery piping and a heater. The capacity of each of these units is to be sufficient to obtain the nominal parameters of the boilers served.

The pressure pumps are not to be used for any other purpose and, apart from local controls, they are to be provided with means for their stopping from a readily accessible position outside the spaces where the pumps are installed.

12.10.2 The piping supplying oil fuel to boiler is to be fitted, at each boiler, with a quick-closing valve controlled locally and remotely from a position outside the boiler room. This requirement applies to the boilers with hand-torch-ignited burners and boilers where oil fuel is fed by gravity.

12.10.3 In systems where oil fuel is fed to the boilers by gravity, filters are to be fitted in the supply piping. For essential boilers, it is to be a double two-way or self-cleaning filter.

12.11 Fuel System for Helicopters

12.11.1 General Requirements

12.11.1.1 The requirements of this chapter apply to systems supplying F-44 (JP-5) aircraft fuel having a flash point of above 60 ^{o}C.

12.11.1.2 The oil fuel system for helicopters is to comply with the applicable requirements of sub-chapters 12.1 to 12.7 and with the requirements of this sub-chapter. Additionally, the system is to comply with the requirements detailed in valid Defence Standard NO-027-A025 (or in another Standard agreed with the Client) as well as in associated Defence Standardization Manual.

12.11.1.3 The oil fuel system arrangements (daily service tanks, pumps, filters, separators, etc.) are to be installed in one compartment, which may be machinery compartment. The above does not apply to storage tanks.

12.11.1.4 The oil fuel pipings are to be earthed in accordance with the requirements given in sub-chapter 2.5.6, *Part VIII – Electrical Installations and Control Systems*.

12.11.1.5 Fuel tanks made of normal steel are to be covered from inside with anti-corrosive antistatic layer intended for aircraft fuel, being in accordance with the requirements of appropriate standards.

12.11.2 Oil Fuel Bunkering and Transfer System

12.11.2.1 In the oil fuel bunkering station, a cock is to be provided for sampling the bunkered fuel.

12.11.2.2 It is recommended that the fuel storage tanks be located within the hull double bottom and have capacity equal to 25 times the oil fuel demand of a helicopter of a flying weight up to 10 t.

12.11.2.3 Oil fuel storage tanks are to be provided with sounding pipes (see 9.4) and remote system of fuel level measurement, with indication in place of fuel system control.

12.11.2.4 The oil fuel transfer pump is to have capacity not less than 190 l/min. The delivery pipe of the transfer pump is to be fitted with oil fuel filter and water separator, whose passage capacity is not to be lower than 1.5 times the pump capacity.

12.11.2.5 The oil fuel filter with water separator are to be provided with means for measuring pressure to be located at inlet and outlet and a differential pressure indicator. A cock for fuel sampling is to be fitted on the filter outlet pipe.

12.11.2.6 The fuel suction end is to be located so high in the storage tank that no sediments and water collected on the tank bottom are sucked in.

12.11.2.7 Oil fuel storage tanks are to be provided with stripping arrangements, to enable removal of sediments and water to fuel recovery tank. The suction branches are to be located in the lowest place of storage tanks.

12.11.3 Fuel Pumping System

12.11.3.1 The fuel pumping system is to include: two daily service tanks, a delivery pump, fuel filter with water separator, helicopter bunkering station and distributing pipelines.

12.11.3.2 Each oil fuel daily service tank is to have a capacity of at least 3.8 m^3.

12.11.3.3 Fuel daily service tanks are to be provided with sounding pipes and the fuel level remote measurement system with indications given in the place of control of fuel system equipment.

12.11.3.4 It is recommended that the oil fuel pump is to have a capacity not less than 190 l/min. The pump pressure is to be such that its value measured on the helicopter deck is at least 0.207 MPa. In the case the helicopter is bunkered in hovering, the pressure measured as high as the bunkering pipe end is not to be less than 0.138 MPa and not greater than 0.344 MPa.

12.11.3.5 At the suction of delivery pump, a fuel filter with water separator are to be fitted. The filter is to have passage not less than 1.5 times the pump capacity.

12.11.3.6 The oil fuel delivery pump is to be provided with pressure gauges, located at suction and at delivery. The delivery pipe is to be fitted with a cock used for fuel sampling.

12.11.3.7 The oil fuel filter with water separator are to be provided with pressure gauges, located at inlet and outlet and with a differential pressure indicator. A cock used for fuel sampling is to be fitted in the filter outlet pipe.

12.11.3.8 Fuel suction end is to be located so high in daily service tank that no sediments and water collected on the tank bottom are sucked in.

12.11.3.9 Daily service tanks are to be provided with stripping arrangements to enable sediments and water disposal to a fuel recovery tank. The suction ends are to be located in the lowest place of the daily service tanks. Stripping pump may be a hand-driven one.

12.11.3.10 The oil fuel pumping system is to enable oil fuel delivery from daily service tanks, through oil fuel filter with water separator, to helicopter bunkering station. The system is also to enable pumping oil fuel between daily service tanks through the above filter, for oil fuel purification purposes.

12.11.3.11 The helicopter bunkering station is to be provided with a fuel hose branch fitted with a shut-off valve, connected to oil fuel pumping system.

12.11.3.12 The helicopter bunkering station is to be provided with two fuel hose branch pipes, fitted with shut-off valve. One of the branches is intended for transferring purified oil fuel to oil fuel storage tanks (rinsing oil fuel pipelines and flexible hoses) and it is provided with a cock used for oil fuel sampling, the other branch is intended for removal of contaminated fuel to oil fuel recovery tank.

12.11.3.13 The helicopter bunkering station is to be located on the helideck close to the naval ship's side. The station is to be located within an enclosure preventing passing spilled oil to the deck. Close to the station, a pressure gauge is to be fitted indicating pressure of the delivery pump, as well as manual button of the pump emergency shutdown. The button is not to be used for restarting the pump.

12.11.3.14 The fuel bunkering station is to be provided with the counter of delivered oil fuel, complying with the Client requirements.

12.11.3.15 Close to the helicopter bunkering station, a portable pump provided with flexible hose for oil fuel suction and oil fuel delivery hose which can be connected to a branch leading to oil fuel storage tank, is to be located. The pump is intended for helicopter defueling under pressure.

12.11.4 Flexible Hose Lines for Bunkering and Defueling a Helicopter

12.11.4.1 A flexible hose is to be provided for bunkering a helicopter, with interchangeable connections for pressure and gravitation bunkering, conforming with the requirements of appropriate standards. The hose length is to be appropriate for bunkering the helicopter on the helideck.

12.11.4.2 A flat, flexible hose with pressure connection conforming with the requirements of STANAG 3105 or another Client specified standard, are to be provided for bunkering hovering helicopter. The hose length is to be appropriate for safe bunkering the helicopter hovering 15 m over the helideck or 20 m above water level and about 20 m off the naval ship portside, taken in horizontal plane.

12.11.4.3 The hose for bunkering hovering helicopter is to be provided, at the helicopter end, with a safety connection length fitted with disengaging member, which shall disengage automatically under tensile force within the range of 1.8 to 2.3 kN. When the set of hoses for bunkering hovering helicopter contains two safety connection lengths, the disengaging member located at the side of helicopter shall disengage under lower tensile force than the disengaging member at the helideck. After disengaging, the oil fuel outflow shall be cut off automatically from both sides. The fuel hose connectors are to comply with the requirements of STANAG 3847 or another Client specified standard. It is recommended that the set of hoses for bunkering hovering helicopters be provided with non-return valve.

12.11.4.4 For helicopter defueling purposes, a portable pump is to be provided, fitted with flexible suction hose terminated with pressure connection complying with the requirements of appropriate standards and with flexible delivery hose connected to the branch pipe carrying oil fuel to storage tank. The pump is to have a capacity of at least 95 l/min and it is to be driven by compressed air.

12.11.4.5 Electrical resistance and earthing arrangements of flexible hoses for bunkering and defueling helicopter in the helideck are to be in accordance with the requirements of STANAG 3632 or another standard as specified by the Client.

12.11.4.6 The electrical resistance of the engaged set for bunkering hovering helicopter is not to exceed 0.24 Ω/running metres of the set. Resistance of sets including hoses made of conducting materials (those without metal strand) may be allowed higher, provided it is in accordance with STANAG 3847 requirements or another standard as specified by the Client.

12.11.4.7 In the vicinity of helicopter bunkering station, a place is to be provided for storage of fuel hoses, connecting lengths and oil fuel connections. These elements are to be properly secured and marked.

12.11.5 Portable Equipment for Measuring Fuel Purity

A naval ship is to be provided with portable oil fuel purity measuring equipment, complying with the Client specified requirements.

13 LUBRICATING OIL SYSTEM

13.1 Lubricating Oil Pumps Serving Diesel Oil Engines, Their Gears and Clutches

13.1.1 In machinery installations where one main engine is fitted, at least two lubricating oil pumps, main and stand-by, of equal capacity are to be provided. One of the pumps may be driven by the main engine. The stand-by pump may also be used as the pump of engine initial lubrication.

13.1.2 In machinery installations where two or more main engines are fitted, each of them is to be provided with an individual lubricating pump, which may be driven by the engine.

The necessity of providing a stand-by pump or a spare one depends on the arrangement of connections in the lubricating oil system among the engines, and is subject to special consideration by PRS.

13.1.3 Oil circulating pumps in lubricating oil systems of main gears as well as the pumps supplying main hydraulic clutches are to comply with the requirements given in 13.1.1 and 13.1.2.

13.1.4 Where lubricating oil system for the main engines turbochargers is served by an independent electrically driven pump, provision is to be made for a stand-by pump and a gravity tank of sufficient capacity to ensure free rundown of the turbochargers in the event of a sudden stop of the oil pumps.

The tank is to be provided with a signalling system to give warning of reaching the lowest permissible oil level in the tank

The oil pumps are to change over automatically.

Provision is to be made for suitable means for checking the oil flow through the turbocharger bearings.

13.1.5 Each auxiliary engine and emergency generating set engine is to be provided with its own, independent lubricating system

A common lubricating system for auxiliary engines and number of pumps in such system, including the stand-by ones, are subject to separate consideration by PRS.

13.2 Lubricating Oil Supply to Diesel Oil Engines and Their Gears

13.2.1 Drain pipes from the engine crankcase to the circulating tank – their lower ends – are to be so arranged that they are permanently submerged in oil during the engine operation. The drain pipes of two or more engines are not to be interconnected.

13.2.2 The pipes of lubricating oil system are not to be connected to the pipes of other systems, except connections to the purifiers, which may be used for oil fuel purification, provided that reliable structural arrangements preventing oil fuel mixing with lubricating oil have been employed.

13.2.3 Where lubricating oil purifiers are employed, means preventing the main engine oil mixing with the auxiliary engines oil are to be provided.

13.2.4 The pipes of the lubricating oil circulation systems are to be fitted with:
– magnetic strainer – on the suction pipe of lubricating pumps serving gears;
– a coarse filter (gauze) – on the pumps' suction pipe;
– a two-way duplex filter or a self-cleaning filter – on the discharge pipe of the lubricating pump serving main engine. Single filters are sufficient in case of emergency generating set engines and emergency fire pump.

The throughput of each lubricating oil filter is to exceed by at least 10% the capacity of the biggest pump. Oil purification parameters are to comply with the requirements of the lubricated machinery manufacturer.

13.3 Lubricating Oil Pumps Serving Gas Turbines, Their Gears and Clutches

13.3.1 The lubricating oil system of the main turbine unit is to be served by two oil pumps, the capacity of each pump being sufficient to ensure lubrication of the turbine unit at the maximum output. At least one of the pumps is to be independently driven.

Where two main turbine sets are installed in one engine room, one independently driven stand-by pump for both turbine units may be provided, which shall serve as a stand-by pump for both units.

13.3.2 The design and arrangement of lubricating oil pumps is to ensure their reliable operation without priming thereof before starting.

13.3.3 The lubricating system of the main turbine sets is to be of the gravity type. Every measure is to be taken to ensure supply of lubricating oil to the main turbine unit in the event of failure of the main oil pump or until the turbines come to rest in the event of interruption of power supply to the pumps' motors.

The use of circulation lubricating system without the gravity tank is subject to separate consideration by PRS.

13.4 Lubricating Oil Supply to Gas Turbines and Their Gears

13.4.1 The circulating oil piping, including all branches to individual receivers is to be made of copper, copper-nickel alloy or equivalent pipes.

13.4.2 The oil from lubricating oil system of the main turbine unit may be taken only for the purposes of control, adjustment and safety devices and for lubrication of the main thrust bearing.

13.4.3 Each lubricating oil system is to be fitted with audible and visual alarm system to give warning, at the main turbine unit control station, of the reduction in the oil pressure. In the gravity lubricating system, the alarm system is to be actuated at such a level of oil in the gravity tank, as to enable the start of the stand-by or emergency pump before the turbine unit is stopped by the safety system.

13.4.4 The capacity of tank in the gravity lubricating system is to be not less than a 5 minutes oil demand at the rated output of the turbine unit.

The tank is to be fitted with an overflow pipe with a sight glass well lit and visible from the control station. The pipe cross-sectional area is to be at least 1.25 times the cross-sectional area of the discharge pipe from the pump.

Provision is to be made for the supply of oil by the pump to the oil receivers directly, with the omission of the tank.

13.4.5 The lubricating oil system of the main turbine unit is to be fitted with two oil coolers, one of which is to be a stand-by cooler.

Where two turbine units are installed in one engine room, only one stand-by oil cooler may be provided for both turbine units, after agreeing it with PRS.

The oil coolers of main turbine units are to be served by main and stand-by pump. Any general service pump adapted for continuous operation may be used as a stand-by pump.

13.4.6 The lubricating oil system of the main turbine unit and its gear is also to comply with the requirements of 13.2.4.

13.5 Lubricating Oil Tanks

13.5.1 The lubricating oil tanks are to be separated from oil fuel, boiler feed water and drinking water tanks by cofferdams complying with the requirements of sub-chapter 9.2.4 of *Part II – Hull*.

13.5.2 The circulation drain tanks for turbines are to be separated from the bottom shell plating by a cofferdam complying with the requirements of sub-chapter 9.2.4 of *Part II – Hull* or by built-in tanks.

13.5.3 It is recommended to separate the circulation drain tanks of diesel oil engines from the bottom shell plating by a cofferdam complying with the requirements of sub-chapter 9.2.4 of *Part II – Hull*. Where such cofferdam has not been provided, non-return or shut-off valves capable of being operated from above the engine room floor plates are to be fitted on the drain pipes from the engines crankcases.

13.5.4 Where, in the assumed operation condition of a naval ship, provision is made for complete replacement of lubricating oil of main propulsion engines or auxiliary engines at sea, oil storage tanks are to be provided of capacity sufficient for filling the system with oil to the working level.

13.5.5 The requirements given in 12.2.4 are also applicable to lubricating oil tanks except that the remote control is not required for:

.1 valves on the storage tanks, which are normally closed

.2 quick-closing valves, which if closed by mistake would endanger the safe operation of the main propulsion or essential auxiliary machinery.

13.5.6 Where lubricating oil tanks are fitted with heating system, the requirements of 12.3 are to be complied with, the oil heating temperature being within 40 – 50 ºC, according to the engine manufacturer's requirements.

13.5.7 With regard to the lubricating oil tanks situated in the machinery spaces of category A and, if practicable also to such tanks in other machinery spaces, the requirements of 1.10.4 and 12.5 are to be complied with.

13.6 Arrangement of Piping

13.6.1 Oil pipes may be led through drinking water tanks and boiler feed water tanks only in tight tunnels forming an integral part of the tanks.

13.6.2 The arrangement of oil transfer pipes is to be such that oil may be pumped between respective storage tanks and circulation tanks and transferred from each tank to another naval ship.

13.6.3 The oil reception stations are to comply with the requirements of 12.5.7.

14 THERMAL OIL SYSTEM

14.1 Pumps

14.1.1 Thermal oil system shall be fitted with two circulating pumps – main and stand-by pump.

14.1.2 A transfer pump shall be provided for filling the compensation tanks and for the transfer of oil.

14.1.3 Motors of circulating pumps shall be provided with remote switching devices complying with the requirements of paragraph 5.7.1 of *Part VIII – Electrical Installations and Control Systems*.

14.2 Compensation Tanks

14.2.1 Thermal oil systems shall be provided with a compensation tank situated at the highest point of the system. Capacity of the tank shall be at least 1.5 times the oil volume increase when the oil is heated up to its service temperature.

14.2.2 The compensation tank shall be provided with a level indicator complying with the requirements of 9.4.15. The lowermost allowable oil level shall be marked on the indicator.

14.2.3 The compensation tank shall be provided with an overflow pipe led to the thermal oil storage or draining tank.

14.2.4 The compensation tank shall be fitted with alarms for maximum and minimum allowable oil level.

Oil heating shall be automatically cut off in the case when oil level in the compensation tank drops below the allowable level.

14.2.5 The compensation tank of thermal oil system intended for the operation in the atmosphere of inert gas shall be fitted with a pressure gauge and a safety valve.

14.2.6 Reliable means of removal of vapours and gases from the system, via compensation tank, shall be provided.

14.3 Storage Tanks

14.3.1 Capacity of a thermal oil storage tank shall be sufficient to fill one section of pipelines or the system's element of the greatest volume.

14.3.2 Where the storage tank is also used as a drain tank for the oil from entire system, its capacity shall be sufficient for containment of this oil plus the volume of heating oil defined in 14.3.1.

14.4 Arrangement of Piping

14.4.1 The arrangement of thermal oil system piping shall comply with the requirements of 1.16.11 and 13.6.

14.5 Air Pipes

Air pipes of thermal oil tanks shall comply with the requirements of 9.1 and shall be led to the open deck.

14.6 Oil Leakage Collecting Arrangements

14.6.1 Oil leakage collecting arrangements shall comply with the requirements of 12.5.

14.6.2 Where the shut-off valves on thermal oil heater are not provided with remote control, a quick acting device shall be provided for draining the oil from the system into a special tank or into the storage tank of a volume specified in 14.3.2.

14.7 Thermal Oil Cooling

Thermal oil systems fitted with exhaust gas heaters (boilers) shall be provided with oil cooling arrangements.

14.8 Insulation

Insulation of pipes and elements of thermal oil system shall comply with the requirements of 1.9.6.

15 SEA WATER SYSTEMS

15.1 The sea water systems shall ensure water supply to the pumps serving the following systems:

- **.1** naval ship's drainage system (pumps supplying ejectors),
- **.2** cooling water system for main and auxiliary engines, as well as other machinery,
- **.3** ballast and compensation systems,
- **.4** water fire main system,
- **.5** naval ship flushing system,
- **.6** ammunition chambers drenching/ flooding system,
- **.7** fresh water system,
- **.8** other (e.g. water lubrication of bearings, sanitary, etc. systems).

15.2 Each watertight compartment where pumps serving systems referred to in 15.1 are located, shall be provided with sea water system.

15.3 Unless specified otherwise in these *Rules*, each sea water system shall contain at least two valves connected by a mains, one of which is located on the bottom, while the other on the naval ship's side. Where, due to small draught of the naval ship, the side valve may cause suction of air, both valves shall be fitted on the bottom. The requirements for bottom/side sea chests are specified in sub-chapter 1.16.10 and these concerning their air vents – in sub-chapter 9.1.

15.4 Appropriate strainers shall be installed where the sea water system supplies equipment/systems, which are susceptible to harmful effect of contaminants (e.g. lubrication of bearings, direct cooling engines). Strainers shall be capable of being cleaned without stopping water supply to the pumps.

15.5 The sea water system supplying water to production of fresh water shall be so arranged that drawing disposed bilge water, sanitary sewage and ashes into the system is precluded.

15.6 Each sea water system shall be so designed that sufficient water supply to all connected systems, which may operate simultaneously, is ensured. Separate sea water system shall be provided to supply water to cooling system for main engines.

15.7 If a naval ship will be engaged, according to its designation, in short voyages in shallow coastal waters or shallow waters heavily contaminated with bottom sediments, provision shall be made for supplying water to cooling/lubrication systems from the ballast tanks.

16 COOLING WATER SYSTEMS

16.1 Cooling Sea Water

16.1.1 If the naval ship is provided with one main engine, the cooling water system shall be served by two – main and stand-by pumps. The capacity of the stand-by pump shall be not less than that of the main pump. At least one of the pumps shall have independent drive.

16.1.2 Where the naval ship has two or more main engines, each being equipped with own pump and cooling water system, use of one stand-by pump with independent drive, capable of serving each of the systems, is sufficient. One spare pump of each type may be provided instead of the stand-by pump, provided that each of the main pumps may be easily replaced with the use of shipboard means. Where all main engines have one common cooling water system, the provisions of paragraph 16.1.1 apply.

16.1.3 The cooling water systems of main engines shall not serve other equipment except the propulsion transmission system items associated with the engines.

16.1.4 Two pumps, the main and stand-by ones, shall serve the cooling water system common for auxiliary engines. Capacity of the stand-by pump shall be not less than that of the main pump. At least one of the pumps shall have independent drive. Where each of the auxiliary engines has its own cooling water pump and system, the stand-by pumps need not be required, provided the naval ship is equipped with spare pumps of each type and size and their replacement is readily possible with the use of shipboard means.

16.1.5 Capacity of the main and stand-by pumps shall be sufficient for full power operation of naval ship’s engines.

16.1.6 The cooling sea water systems serving other essential equipment and systems shall be provided with two pumps, the main and stand-by ones, unless such equipment/systems are duplicated. Capacity of each pump shall be sufficient for supplying the equipment/system within full range of loads and flow rates/temperatures.

16.1.7 For water cooled oil and air coolers for main electric motors, stand-by cooling means, equivalent to the main ones, shall be provided.

16.1.8 Appropriate sea water pumps, used only to circulation of pure water and adopted for continuous operation, may be used as stand-by pumps in cooling water systems.

Fire pumps may be used for this purpose, provided the requirements of paragraph 3.2.3.2 of *Part V – Fire Protection*, are complied with.

16.1.9 The outlet piping in the cooling sea water system for engines shall be so arranged that water can reach the highermost surfaces of engines, water and oil coolers being cooled, as well as no water pockets are formed.

16.2 Cooling Fresh Water

16.2.1 The cooling fresh water systems for engines shall comply with similar requirements as specified for cooling sea water in 16.1.1 to 16.1.5. The stand-by pumps of the cooling sea water system may be used as stand-by pumps in the cooling fresh water system. In this case the pipings arrangement or applied fittings shall be such that fresh water is not mixed with sea water.

16.2.2 In the cooling fresh water system for engines, a fresh water compensation tank shall be provided, where water level shall be higher than the highest water level in the engine. The compensation tank shall be connected to the pump suction pipes. Cooling water systems of several engines may have one common compensation tank. It shall be provided with a minimum water level alarm device and branches for taking samples and adding means for chemical treatment.

16.2.3 Means for heating cooling water for main and auxiliary engines shall be ensured.

16.2.4 For main and auxiliary engines, which are to be maintained in stand-by state, provision shall be made for circulation of heated water.

16.2.5 Auxiliary propulsion engines shall be provided with own, independent cooling water systems.

17 COMPRESSED AIR SYSTEMS

17.1 Number of Air Receivers and Reserve of Compressed Air

17.1.1 The compressed air system for starting the main engines shall be so designed as to enable simultaneous starting and reversing of all main engines.

17.1.2 The reserve of compressed air necessary for starting the main engines and functioning of their control systems shall be stored in not less than two receivers or groups of receivers so arranged that they can be used independently. Each of these receivers or groups thereof shall contain a reserve of starting air not less than half of the amount required respectively in 17.1.4 and 17.1.5.

17.1.3 Receivers for compressed air starting the main engines shall be stored in the same machinery compartment.

17.1.4 The reserve of compressed air contained in all receivers and intended for starting and reversing the main engines shall ensure at least 12 consecutive starts, ahead and astern alternately, of each engine ready for operation, without topping-up the receivers.

17.1.5 The reserve of compressed air intended for starting the main engines driving controllable-pitch propellers or connected to other machinery which enable starting the engines without load, shall be sufficient to assure each engine, ready for operation, to make at least:
- 6 starts – in single engine installation,
- 3 starts of each engine – in installation with two or more engines,

without topping-up the receivers.

17.1.6 For starting the auxiliary engines, provision shall be made for a separate compressed air receiver of a capacity sufficient to provide 6 starts of the biggest engine of those ready for operation. In addition to the above, the following requirements shall be complied with:
- provision shall be made for the possibility of starting the auxiliary engines from one of the air receivers serving the main engines, or
- the required amount of compressed air shall be stored in two receivers, each having capacity sufficient to provide 3 starts.

PRS may waive the requirement for installing separate receiver for starting the auxiliary engines, provided that provision 17.1.7 is complied with.

17.1.7 Compressed starting air receiver or group of receivers specified in 17.1.2 may provide air for starting the auxiliary engines, for supplying the whistle or for other purposes, provided that their capacity is increased respectively and:
- automatic topping-up of the compressed air receivers is provided, or
- provision is made for an alarm to give warning in the case of pressure drop of not more than 0.5 MPa below the working pressure of the compressed air receivers.

Where special air receiver is fitted for the whistle, its capacity shall be sufficient to enable the whistle to work continuously for 2 minutes and hourly capacity of the air compressor shall be not less than that required to provide 8 minutes, continuous operation of the whistle.

Where it is intended to take air from the receiver provided for the whistle for other purposes, the capacity of the receiver shall be increased accordingly and automatic topping-up or an alarm device warning in the case when the amount of air in the receiver reaches the lower limit required for the whistle shall be arranged.

17.1.8 The starting air receiver for auxiliary engines, specified in 17.1.6 may be topped-up from the receivers specified in 17.1.7, however provision shall be made to prevent air flow in the opposite direction.

17.1.9 Where compressed air is used for starting the emergency generating set, a compressed air receiver of capacity sufficient to provide 3 starts of the engine shall be located in the generating set room. The receiver may be charged from the main or auxiliary engines receivers through a non-return valve fitted in the emergency generating set room or by an electrically driven compressor supplied from the emergency switchboard.

Where the compressed air is the only means of starting the emergency generating set, two compressed air receivers shall be provided, each of a capacity sufficient to provide 3 starts of the generating set.

17.1.10 The compressed air intended for armament and other shipboard systems of a naval ship shall be stored in separate receivers.

17.2 Starting Air Compressors

17.2.1 The number of the main compressors shall not be less than two, one of which may be, upon PRS consent, a main engine-driven compressor. The combined capacity of the main compressors shall be sufficient for charging the main engines air receivers within 1 hour from atmospheric pressure to the pressure sufficient for the number of starts and reverses defined in 17.1.4 or 17.1.5.

The capacity of each of the main compressors shall be the same. The capacity of independently driven compressors shall be not less than 0.5 of that required for all main compressors.

In the event of failure of one of the compressors, the capacity of others shall be not less than that required in 17.1.7 for the whistle.

17.2.2 In naval ships, where the main and auxiliary engines are started by means of compressed air, provision shall be made to enable starting of the engines from the dead ship condition in accordance with 1.8.6.

A hand driven compressor or a compressor set with hand started diesel oil engine unit may be used for this purpose and the compressors shall charge with air a separate receiver of a capacity sufficient to provide 3 starts of one generating set or one main compressor, if the compressor is driven by a diesel oil engine.

A separate air receiver is not required where the hand or engine driven compressor is capable of charging the air receiver specified in 17.1.5 within 1 hour.

17.3 Piping Arrangement and Connections

17.3.1 Each of the starting air receivers specified in 17.1 shall be capable of being charged from each of the main compressors specified in 17.2. For piping connections between the air receivers – see 17.1.8.

17.3.2 A non-return shut-off valve shall be fitted in the discharge pipe of each compressor.

17.3.3 The temperature of compressed air entering the receiver from the charging valve on the engine shall not exceed 90 °C. Where necessary, provision shall be made for an air cooler. The pipes used for charging the receivers shall not be led under the floor plates.

17.3.4 The cross-sectional area of pipes discharging the compressed air from safety valves or fusible plugs outside the machinery space shall be not less than 2 times the free area of the valve or plug.

The pipes shall be provided with water draining arrangements.

17.3.5 In the naval ships equipped with a helicopter, the compressed air pipes shall be led to the region of a helideck and a hangar. The compressed air pressure shall be sufficient for helicopter operation.

18 BOILER FEED WATER SYSTEM

18.1 Pumps

18.1.1 Each essential auxiliary boiler (definition – see 1.2) and each other boiler, which may be hazardous in the event of lack of water supply, shall be provided with at least two independently driven feed pumps. The capacity of each of these pumps shall be sufficient for boiler operation at the rated service conditions.

Non-essential auxiliary boilers and unfired boilers (e.g. exhaust gas boilers) of a construction which enables them to be kept without water when heated with exhaust gases, may be provided with one feed pump.

Where more than two feed pumps are fitted, then with one of the pumps being out of service the combined capacity of the other shall be not less than the capacity specified above for one feed pump.

Where the design of feed pump does not preclude the possibility of pressure rise above a determined value, the pump casing or delivery pipe before the first shut-off valve shall be fitted with relief valve or other safety arrangement.

18.1.2 The essential auxiliary boilers with forced water circulation shall be fitted with at least two circulating pumps, one of them being a stand-by pump.

18.2 Pipe Layout and Arrangement of Connections

18.2.1 In the case of open circuit feed system, provision shall be made to enable the feed pumps to take water from the hot wells and from the feed water storage tanks.

18.2.2 The feed system of each essential auxiliary boiler shall be so arranged as to enable feeding the boiler by at least two separate feed systems, each provided with its own feed pump, noting that a single common stub pipe at the boiler is acceptable.

For non-essential auxiliary boilers, one feed system is sufficient.

18.2.3 Means effectively preventing the entry of oil to boiler feed water shall be provided. Feed water pipes may be led through oil tanks only in tight tunnels forming an integral part of the tanks.

18.2.4 The feed water system of essential auxiliary boilers shall be provided with automatic salinometer.

18.3 Tanks

Feed water tanks shall be separated from oil fuel and lubricating oil tanks by cofferdams complying with the requirements of sub-chapter 9.2.4 of *Part II – Hull*.

19 STEAM SYSTEM, BOILER SCUM AND BLOW-DOWN SYSTEM

19.1 Pipe Layout and Arrangement of Connections

19.1.1 Where two or more boilers are interconnected, non-return valves shall be fitted at each boiler before the manifold. These valves need not be installed where shut-off non-return valves are fitted on the boilers.

19.1.2 The pipes from scum and blow-down valves of two or more boilers may be connected to a common discharge pipe, provided that non-return valves are fitted in these pipes before the common discharge pipe.

19.1.3 Steam for the naval ship’s whistle shall be supplied through a separate pipe directly from the main boiler. This requirement does not apply to naval ships having pneumatically or electrically operated sound signalling means, in addition to the steam whistle.

19.1.4 The machinery connected to the steam pipes shall be free of the stresses caused by thermal expansion of the pipes, by fitting a self-compensation means (pipe bends) or by installing thermal compensators in appropriate positions (see also 1.16.11.8).

19.1.5 Where the steam pipes supply steam to arrangements and machinery designed for a pressure lower than the boiler pressure, reducing valves shall be fitted and the requirements of 1.16.6.2 shall be complied with.

19.1.6 Where piping system for steaming oil fuel tanks is provided, shut-off non-return valve shall be fitted on each tank.

19.1.7 The steam pipelines in the machinery compartments shall be led in the upper parts of these spaces, where practicable, in a position accessible for inspection and servicing.

Except for the heating and boiler scum and blow-down pipes, leading the steam pipes under the floor plates of the machinery compartments is not allowed.

The steam pipes shall not be led in the vicinity of the oil fuel tanks.

19.1.8 Steam pipes shall not be led through the paint stores, ammunition chambers and other spaces intended for the carriage and storage of flammable substances.

19.1.9 Steam pipes shall not be led through naval ship’s command positions, armament and electronic equipment control rooms and cargo holds and spaces containing naval ship’s armament.

19.2 Draining the Steam Pipelines

19.2.1 The steam delivery pipelines shall be fitted with condensate draining arrangements for the purpose of protecting the machinery against water hammer.

19.2.2 In the case of open drain pipes system for the steam pipelines, the drain pipes shall terminate below the floor plates.

20 SANITARY DRAINAGE SYSTEM

20.1 General Requirements

20.1.1 Each naval ship shall be fitted with gravity or vacuum drainage system, complying with the requirements of this sub-chapter.

20.1.2 Gravity systems drain pipes shall slope in the direction of discharge as to ensure that, under list and trim conditions expected during normal service, the sanitary drainage will not remain in the pipes.

20.1.3 All sanitary utensils, sinks, laundry tubes, scuppers, etc. connected to the gravity drain system, shall be fitted with water seals.

20.1.4 Gravity systems drain pipes shall be fitted with air pipes led from the main vertical drains, as well as from places most remote of the main vertical drains. The number, arrangement and diameter of air pipes shall be such as to prevent water from being sucked from water seals by the sanitary drainage flowing away.

20.1.5 The air pipes shall terminate away from doors, the opened windows, inlets to ventilation systems, etc. so as to prevent the escaping gases from entering the spaces where people may be present.

20.1.6 Air pipes shall comply with the relevant requirements of sub-chapter 9.1.

20.1.7 The direct overboard discharge pipes of sanitary drainage shall comply with the relevant provisions of Chapter 5.

20.2 Sewage Treatment Plants, Holding Tanks, Sewage Discharge Systems

20.2.1 A naval ship shall be provided with a sewage holding tank or sewage treatment plant (or both) as well as piping for the discharge of the tank and the plant content to shore reception facilities through standard discharge connections located on deck, as specified in 20.2.11. For the discharge of holding tank content, a pump of suitable type and parameters shall be provided having regard to the characteristics of the liquid being pumped, the size and the position of the tank and the overall discharge time.

20.2.2 Sewage holding tanks cannot have common boundaries with accommodation spaces, provision storerooms and tanks other than ballast tanks, fuel oil storage tanks, oil residues tanks or tanks intended for other liquid wastes. Where sewage holding tanks form integral part of the naval ship structure, the surrounding cofferdams shall comply with the requirements of sub-chapter 9.2.4 of *Part II – Hull*.

20.2.3 Holding tank shall enable retention of sewage. Where sewage and grey water systems are interconnected, the tank capacity shall be sufficient for the retention of all sanitary drainage. Where the systems are separated, holding tank for greywater is not required however recommended. Capacity V of the holding tank shall be determined by the following formula:

$$V = 0.001qnt \text{ , [m}^3\text{]} \qquad (20.2.3)$$

where:

q – the amount of sanitary drainage, in litres, per person a day. For sewage, 70 l/person a day shall be assumed, for greywater and sewage (common system) 230 l/person a day shall be assumed. In the case of vacuum systems, 25 l/person a day or 185 l/person a day respectively shall be assumed, unless otherwise specified by the manufacturer of the system;

n – crew number;

t – time, in days, of the naval ship's stay in port and/or operation in the area where sanitary drainage can not be discharged in accordance with the provisions of *MARPOL 73/78 Convention, Annex IV*. Normally it shall not be shorter than 3 days. Where, apart from the holding tank, a sewage treatment plant is also provided onboard, t = 2 days may be assumed to calculate the tank capacity.

20.2.4 The retention tank shall be provided with an alarm device set at 75% and 100% of the tank capacity.

20.2.5 The retention tank shall be fitted with water washing system. It is recommended that wall stiffeners be provided outside the tank.

20.2.6 Sewage treatment plants and sanitary drainage holding tanks provided with internal partitions shall be fitted with air pipes led from chambers to which the drainage pipes are connected, unless the partitions are so constructed that such arrangement is not necessary.

20.2.7 Sewage treatment plants installed in naval ships shall be of the type approved by PRS and shall comply with the requirements of IMO Resolution MEPC.2(VI) concerning the quality of the effluent discharged overboard. The throughput of the sewage treatment plant shall be based on the crew number, having regard to the manufacturer's guidelines.

20.2.8 Where sewage treatment plant installed onboard operates on biological treatment principle, greywater and sewage systems shall be separated. Sewage shall be led to the first stage of the plant whereas greywater – to the last stage (disinfection chamber).

20.2.9 The sewage comminuting and disinfecting systems installed onboard shall be type-approved by PRS.

20.2.10 On the effluent discharge pipe from the sewage treatment plant as well as on the discharge pipe from the comminuting and disinfecting system, sampling cocks shall be fitted.

20.2.11 Standard discharge connections for the discharge of sewage from the holding tank and from the treatment plant shall be fitted with flanges made in accordance with the Table 20.2.11. The discharge connections shall be installed on both sides of the naval ship and so located as to enable easy connection of reception hose. The discharge connections shall be fitted with blank flanges and nameplates. In the case of small naval ships, PRS may allow to install one discharge connection located close to the centreline.

Table 20.2.11
Standard discharge connection for the discharge of sewage

Parameter	Dimensions / number
Outside diameter	210 mm
Internal diameter	According to the pipe outside diameter
Bolt circle diameter	170 mm
Slots in flange	4 holes, 18 mm in diameter, equidistantly placed on a bolt circle of the above diameter, slotted to the flange periphery; the slot width to be 18 mm
Flange thickness	16 mm
Bolts and nuts	4 sets, bolts of 16 mm in diameter and of suitable length
The flange shall be made of steel or other equivalent material and have a flat face. This flange, together with a gasket, shall be suitable for a service pressure of 0.6 MPa. The flange is designed to accept pipes up to a maximum internal diameter of 100 mm.	

20.2.12 Where the naval ship is provided with a system for the discharge into the sea of the content of holding tank, where sewage or sewage and greywater are collected, the side discharge valve shall be provided with nameplate marked:

„Untreated sewage. Keep the valve closed within 12 nautical miles from the nearest land and during the ship stay”.

Such plate is also to be affixed at the side valves of sewage direct overboard discharge.

21 DRINKING WATER SYSTEM

21.1 The drinking water systems may not be interconnected with other systems pipings. Such pipings may not be carried through tanks containing liquids other than drinking water.

21.2 The drinking water storage tanks shall be so designed that no water or air pockets can exist inside which boost bacteria development. The tanks shall be separated by cofferdams from the tanks containing other liquids.

21.3 Internal surfaces of piping systems, valves and fittings and storage tanks and pressure tanks shall be protected against corrosion or made of corrosion-resistant materials. Anti-corrosion layers and materials used for the construction of the systems (together with sealing materials) coming in contact with water shall be appropriate for use in contact with drinking water. PRS may require that respective sanitary certificate be submitted to prove the above.

21.4 The drinking water system and associated tanks shall be capable of being emptied of water as well as disinfected and rinsed.

21.5 A permanent pipeline shall be used for taking drinking water to the naval ship and it shall be provided with necessary valves, carrying water to all drinking water storage tanks. The water delivery hose shall be capable of being connected at both naval ship sides, and in the case of naval ships of displacement above 500 t – also at the bow. The pipe terminals shall face downwards and shall be provided with standard connections for the hose and stoppers. The connections shall be protected, by the method agreed with PRS, against the possibility of entering, through the pipe, dangerous objects/substances (see 9.1.20).

21.6 In the event the drinking water is produced onboard, the water making or conditioning equipment shall ensure water compliance with the requirements of applicable sanitary standards. This equipment shall be duplicated.

21.7 Cocks shall be provided for taking drinking water samples from the lower part of storage/ pressure tanks of drinking water, from the pipeline led from the drinking water producer and from the pipeline led from the water conditioning device.

21.8 At least two pumps serving the drinking water system shall be provided. Upon PRS consent, one of these pumps may be the shipboard stand-by pump.

22 REFRIGERATING PLANTS

22.1 Application

22.1.1 The following machinery and equipment installed in refrigerating plants shall have PRS acceptance:

.1 refrigerant compressors;

.2 heat exchangers and other apparatus and vessels exposed to the pressure of refrigerant;

.3 pipes, valves and fittings exposed to the pressure of refrigerant;

.4 devices of automatic control, monitoring and safety systems.

The above mentioned machinery and equipment shall comply with the applicable requirements of *Part VII – Machinery, Boilers and Pressure Vessels, Part VIII – Electrical Installations and Control Systems* and *Part IX – Materials and Welding*.

22.2 Refrigerants and Design Pressures

22.2.1 The refrigerants are subdivided into three groups:

I – non-flammable;

II – toxic and flammable, having lower flammable limit (mixture of refrigerant vapours with air) corresponding to 3.5% refrigerant content in the air by volume or more;

III – explosive or flammable refrigerants, having lower flammable limit (mixture of refrigerant vapours with air) corresponding to less than 3.5% refrigerant content in the air by volume.

The refrigerants of group III may be used, upon agreement with PRS, only for refrigerating plants of liquefied gas carriers where the cargo is used as refrigerant.

22.2.2 For the strength calculations of components exposed to the refrigerant pressure, the design pressure shall be taken from Table 22.2.2.

Table 22.2.2
Refrigerants and design pressures

Refrigerant group	Symbol	Chemical formula	Design pressure [1] [MPa]	
			High pressure side	Low pressure side
I	R-12 [2] R-22 [2] R-502	CF_2Cl_2 CHF_2Cl azeotropic mixture R22 + R115	1.2 2.0 2.0	1.1 1.7 1.9
II	R-717	NH_3	2.0	1.8
III	R-290	C_3H_8	1.6	1.5

Notes to Table 22.2.2:

1) The design pressure is equal to the maximum working pressure.

2) Not to be used in new plants.

The design pressure of refrigerating plant components exposed to the pressure of refrigerant having low critical temperature (below +50 °C) is subject to separate consideration by PRS.

22.2.3 Refrigerants not mentioned in Table 22.2.2 may be used upon agreement with PRS.

The value of design pressure shall be assumed as the pressure of saturated vapours of given refrigerant at the temperature +55 °C for high pressure side and +45 °C for low pressure side.

22.3 Output and Equipment of Refrigerating Plants

22.3.1 The refrigerating plant of naval ships of unrestricted service shall be capable of maintaining the required temperature in refrigerated holds and of supplying other cold consumers under the following conditions:
– sea water temperature +32 °C,
– ambient air temperature +40 °C.

For other navigation areas, temperatures agreed with PRS shall be assumed.

22.3.2 The capacity of refrigerating plant or refrigerating plants shall be such that, at 20 hour interrupted operation per 24 hours, the requirements specified in 22.3.1 are complied with.

22.3.3 The layout of cooling grids shall ensure uniform cooling in the space concerned. The grids shall be arranged in not less than two separate sections, each of them capable of being shut off.

Cooling grids with direct expansion of group II agent shall not be used.

22.3.4 The refrigerating plant shall be equipped with two independent cooling water circulating pumps – one main and one stand-by pump. Any sea-water pump serving any system may be used as stand-by pump, provided it has adequate ratings.

22.3.5 Cooling water shall be supplied from at least two sea valves. When using general service sea inlet valves, provision shall be made for sufficient supply of water from each valve under normal service conditions of the naval ship.

22.4 Materials

22.4.1 The type and the basic properties of materials used for parts, assemblies and fastenings of refrigerating equipment, operating under conditions of dynamic loads, under pressure, at variable and low temperatures shall comply with the requirements of *Part IX – Materials and Welding*. When selecting materials, the following principles shall be observed:

.1 materials for the equipment parts operating in contact with refrigerant and its mixtures, lubricating oils, as well as cooling and cooled media shall be non-reactive and resistant to their effect;

.2 materials for the equipment parts operating at low temperatures must not undergo permanent structural changes and shall maintain sufficient strength in these conditions;

.3 materials for parts and structures of refrigerating equipment operating at negative temperatures shall be selected taking into account the requirements given in paragraph 2.2.1.4 of *Part II – Hull* and Chapter 3 of *Part IX – Materials and Welding*;

22.4.2 Parts of machinery and apparatus coming into contact with corrosive agents shall be made of materials having sufficient resistance to the corrosive action or be protected by corrosion-resisting coatings. Assemblies of machinery and apparatus made of materials having different electric potential which may come into contact with sea water shall be adequately protected against electrolytic corrosion.

22.5 Electrical Equipment

The electrical equipment of refrigerating and freezing plant, the system of automation, as well as the lighting installation of the refrigerating machinery spaces, refrigerant storage spaces and that of refrigerated chamber shall comply with the relevant requirements included in *Part VIII – Electrical Installations and Control Systems*.

22.6 Refrigerating Machinery Spaces

22.6.1 The refrigerating machinery spaces shall comply with the applicable requirements of 1.9 and with the requirements of the present sub-chapter.

Refrigerating plants operating on group II or III refrigerant shall be installed in separate, gas-tight spaces.

The arrangement of machinery and equipment shall comply with the requirements of 1.10 and 1.11.

The drainage of the refrigerating machinery spaces shall comply with the requirements of 6.3.1.8.

22.6.2 The machinery, apparatus and piping shall be so arranged in the refrigerating machinery space, as to permit free access for attendance and to enable the parts to be replaced without having to dismantle the machinery and apparatus from their foundations. The machinery, apparatus and other equipment shall be located at least 100 mm from bulkheads and vertical surfaces of other equipment.

22.6.3 The refrigerating machinery space shall have two escape ways arranged as far apart as practicable, with the doors opening outwards. Where the refrigerating machinery space is not situated at the open deck level, each of the escape ways shall be fitted with steel ladders as widely separated from each other as possible and leading to the spaces, which give the access to the open deck.

Spaces of automated unattended refrigerating machinery, operating on group I refrigerants, need not be provided with a second means of escape.

22.6.4 The escape ways from the refrigerating machinery space, operating on group II or III refrigerant, shall not lead to accommodation or service spaces or spaces adjacent to the before mentioned.

Where these escape ways lead through corridors or casings, they shall be fitted with exhaust and supply ventilation, the latter being mechanical. The starting arrangements of the ventilation shall be arranged both inside the refrigerating machinery space and outside, in the vicinity of the exit.

22.6.5 Exits from refrigerating machinery spaces operating on group II refrigerant shall be fitted with water screens (see also paragraph 3.6.1.1 of *Part V – Fire Protection*). The arrangement to put water screens into action shall be placed outside the refrigerating machinery space, in the vicinity of the exits.

Fire hose fitted with nozzle and connected to the water fire main system shall be provided in the refrigerating machinery space.

22.6.6 The refrigerating machinery space shall be fitted with independent exhaust ventilation, ensuring at least 10 air changes per hour in empty space. Supply ventilation may be natural, but independent of the ventilation of other spaces. Ventilation system shall ensure underpressure inside the machinery space.

22.6.7 In addition to the main ventilation system required by 22.6.6, each refrigerating machinery space shall be fitted with independent emergency exhaust ventilation system ensuring:

.1 30 air changes per hour – in the case of refrigerating machinery operating on group II or III refrigerants;

.2 20 air changes per hour – in the case of refrigerating machinery operating on group I refrigerants.

Depending on the density of refrigerant vapours, the ventilation system shall ensure efficient extraction of the vapours from the uppermost or the lowest parts of the space.

When calculating capacity of the emergency ventilating system, the capacity of the main ventilation system fans may be included, provided they will operate together with the emergency ones, should the switchboard of the refrigerating units be deenergized.

22.6.8 Refrigerating machinery operating on group II refrigerant shall be provided with ammonia detectors, giving an alarm inside and outside the space (see also *Part VIII – Electrical Installations and Control Systems*).

22.6.9 Ammonia refrigerating machinery spaces shall be fitted with at least 2 escape breathing apparatus.

22.7 Refrigerant Store Rooms

22.7.1 Refrigerant store rooms shall be separated from other spaces and their location in the naval ship as well as construction, taking refrigerant group into account, is subject to separate consideration by PRS. The bulkheads and decks adjacent to accommodation and service spaces shall be gastight.

22.7.2 The refrigerant cylinders shall be so secured that they will not move in stormy weather conditions. Non-metallic distance pieces shall be placed between the wall plating of the store room and the cylinders, as well as between the cylinders.

22.7.3 The refrigerant store rooms shall be provided with independent ventilation system and so insulated that the temperature inside the space cannot exceed +45 °C.

22.7.4 Cylinders containing other compressed gases as well as combustible materials shall not be stored in the refrigerant store rooms. Insulation of the spaces shall be made of non-combustible materials.

22.8 Refrigerated Cargo Spaces

22.8.1 Refrigerating machinery, apparatus and piping located in refrigerated cargo spaces shall be efficiently secured in place and protected against damage by the cargo.

22.8.2 Where an air cooling system is used, the air coolers may be located either in separate spaces or in the refrigerated cargo spaces.

Air coolers located in refrigerated cargo spaces shall be provided with trays to collect water condensate. In spaces with minus temperatures, it is recommended to fit such trays with heating appliances.

Direct expansion of group II refrigerant shall not be applied in air coolers.

22.8.3 In the case of air cooling system, the air coolers shall be accessible also with the cargo space being entirely loaded.

The access to air coolers shall permit the replacement of fan impeller and electric motor.

22.9 Compressors

22.9.1 The suction and delivery sides of the refrigerant compressors shall be fitted with manually controlled stop valves apart from the automatically controlled valves. See also the requirements given in 22.12.3.

22.9.2 Refrigerant, oil and cooling water spaces shall be provided with draining arrangements fitted in appropriate locations.

22.9.3 At the delivery side of the compressor, between the cylinder and cut-off valve, a pressure relief valve or other automatically operated safety device shall be fitted, discharging refrigerant to the suction side of the compressor in the case of excessive pressure rise. Discharging capacity of the safety devices shall be not less than the maximum volume capacity of the protected compressor stage. Pressure relief valves shall be of such discharging capacity that, when fully open, the pressure will not rise by more than 10% of the lifting pressure.

No shut-off devices shall be fitted in the piping between the relief valve and the suction side.

The use of an arrangement discharging the refrigerant directly to the atmosphere is subject to separate consideration by PRS.

22.10 Apparatus and Vessels

22.10.1 Shell-and-tube apparatus as well as refrigerant vessels of 50 l capacity and more shall be fitted with safety arrangements, having such design discharging capacity that the pressure inside the equipment will not exceed the design pressure by more than 10%, with the relief valve fully open.

The discharging capacity *G* of safety valves shall be not less than that determined by the formula:

$$G = \frac{qS}{r}, \quad \text{[kg/s]} \qquad (21.10.1)$$

where:

q = 10 kW/m^2 – heat flux density during fire;

S – external area of the vessel (apparatus), [m^2];

r – latent heat of refrigerant vaporisation at the relief valve lifting pressure, [kJ/kg].

The safety arrangement shall consist of two relief valves and a change-over device so designed that both relief valves or one of them is in any case connected to the apparatus or vessel. Each valve shall be calculated for the full required discharging capacity. No stop valves shall be fitted between the apparatus or vessel and the safety arrangement.

PRS may require that safety arrangements are also to be fitted on other apparatus having regard to their dimensions.

The use of safety arrangements with one pressure relief valve or safety arrangements of other type is subject to separate consideration by PRS.

22.10.2 Apparatus and vessels containing liquid refrigerant of group II or III shall be fitted with arrangements for emergency discharge of the refrigerant below the minimum draught waterline. The design discharge time of the refrigerant shall not exceed 2 minutes, at a constant pressure in the apparatus or vessel equal to the design pressure determined in 22.2.2.

22.10.3 The evaporators with direct expansion of refrigerant shall be of welded or brazed construction. Flange connections between the sections may be employed only where indispensable and in such places, where they can be checked for tightness.

22.10.4 Where a single air cooler is used for cooling the cargo spaces, it shall comprise not less then two individual sections, each of them capable to be disconnected.

22.11 Valves, Fittings and Safety Valves

22.11.1 The shut-off, regulating and safety valves to be installed in refrigerating plant systems shall be designed for a pressure not less than 1.25 times the pressure determined in accordance with 22.2.2.

Valves and fittings shall be made of steel. The cast iron built-in shut-off valves for inlet and outlet spaces of the compressors and nodular cast iron valves and fittings may be used for group II and III refrigerants at an ambient temperature not lower than –40 °C.

Valves and fittings of other materials are subject to separate consideration by PRS.

22.11.2 Safety valves shall fully open at a pressure not exceeding 1.1 times the design pressure determined in accordance with 22.2.2.

22.12 Piping

22.12.1 The piping of group I refrigerant belongs to class II piping, whereas the piping of group II and III refrigerants belongs to class I (see 1.16.2.2).

The refrigerant piping of group II and III refrigerant cannot be led through accommodation spaces, service spaces and refrigerated provision spaces.

22.12.2 Piping for refrigerant shall be made of seamless pipes. In the case of steel refrigerant piping the pipes shall be connected by welding and in the case of copper pipes – by welding or brazing. Detachable joints may be used where the pipes are connected to valves, fittings, machinery, apparatus or vessels.

22.12.3 Delivery pipes of compressors and refrigerant pumps, apart from being fitted with valves as required by 22.9.1, shall be provided with non-return valves. Such valves need not be fitted at compressors operating with group I refrigerants and not provided with pressure relief devices.

22.12.4 In the pipes of liquid freon and other refrigerants of group I, dryers shall be fitted to remove moisture from the system. The dryers shall be installed together with additional or built-in filters.

22.12.5 The pipes discharging the refrigerant from safety valves, except those mentioned in 22.9.3, shall be led overboard below the minimum draught waterline. The pipes shall be provided with non-return valves fitted directly on the naval ship’s shell plating. Refrigerants of group I may be discharged to the open air in places where it is not hazardous for people’s safety.

22.12.6 The pipes for emergency discharge of the refrigerant from apparatus and vessels shall be led to an emergency discharge manifold located outside the refrigerating machinery space, but near to the access thereto. Shut-off valves shall be fitted on each pipe near the manifold. These valves shall be protected against operation by unauthorised persons and shall be capable for being sealed when closed. The discharge piping from the emergency drainage overboard manifold shall be fitted with non-return valve and to be led overboard below the minimum draught waterline. To permit the piping to be blown-through, a connection with compressed air or steam system shall be provided.

The internal diameters of the pipes for emergency discharge of the refrigerant from individual apparatus and pressure vessels shall not be less than that of the safety valve determined in accordance with 22.10.1. The cross-sectional area of the emergency discharge piping from the manifold shall not be less than the combined cross-sectional area of the three largest pipes for emergency discharge of the refrigerant from apparatus and pressure vessels, connected to the manifold.

22.12.7 The wall thickness of pipes mentioned in 22.12.5 and 22.12.6 with outlets below the minimum draught waterline shall be not less than that given in column 4 of Table 1.16.3.1-1.

22.13 Instrumentation

22.13.1 The compressors and apparatus of the refrigerating plant shall be fitted with instruments necessary for the control of their working parameters. Requirements of subchapter 12.2 of *Part VII – Machinery, Boilers and Pressure Vessels* shall be also complied with.

22.13.2 Instruments shall be placed in readily accessible and visible positions. The scales shall bear clear marks indicating the minimum and maximum permissible values of the parameters controlled. The instruments shall be checked and accepted by the PRS Surveyor.

22.13.3 The refrigerant compressors shall be provided with automatic arrangements for stopping their drive in the case of unacceptable:

.1 pressure drop of suction;
.2 pressure rise of delivery;
.3 pressure drop of lubricating oil;
.4 temperature rise of delivery (applicable to refrigerating plants using the refrigerants of group II and III, as well as for automated unattended refrigerating plants).

22.13.4 Refrigerating plants shall be fitted with alarm systems giving warning to the refrigerating plant control station, should the automatic arrangements mentioned in 22.13.3 be activated.

22.13.5 Unattended automatic refrigerating plants, as well as arrangements operating on refrigerants of group II and III shall be provided with gas analysers, which in the case of refrigerant leakage send an alarm signal to the refrigerating plant control station.

22.14 Insulation of Refrigerated Spaces

22.14.1 All metal structures of naval ship's hull inside the refrigerated cargo spaces shall be efficiently insulated.

22.14.2 Insulation of refrigerated spaces shall be made of odourless materials resistant to mould and mycelium growth.

22.14.3 The surfaces of bulkheads and inner bottom plating in way of structural and independent oil fuel tanks shall be lined with oil resistant odourless materials.

22.14.4 These linings shall be laid prior to insulating these surfaces.

22.14.5 The insulation of refrigerated spaces shall be protected against infiltration of moisture, or suitable means for drying it during service shall be provided. The insulation shall be also protected against damage by rodents.

22.14.6 The insulation of refrigerated cargo chambers shall be suitably lined or shall have an external protective layer suitable for the cargo to be carried.

22.15 Tests of Machinery and Equipment at the Maker's Works

22.15.1 The tests of the refrigerating plant components at the maker's works shall be carried out in the presence of PRS Surveyor.

22.15.2 The hydraulic tests of components working under the pressure of refrigerant shall be carried out to a test pressure of not less than 1.5p (where p – design pressure defined in 22.2.2), except for piston compressor crankcases for which the test pressure shall be not less than p.

Components working under the water head shall be hydraulically tested to a pressure equal to 1.5p, but not less than 0.4 MPa.

22.15.3 Pneumatic tightness tests of components working under pressure of refrigerant shall be made to a test pressure of not less than p, except for piston compressor crankcases for which the test pressure shall be not less than 0.8 MPa.

22.15.4 Complete valves, fittings and automatic control equipment provided with shut-off devices, apart from the above specified tests, shall be subject to pneumatic tests of closing tightness to a test pressure equal to p.

22.15.5 Machinery and equipment other than specified above shall be tested in accordance with the requirements of subchapter 1.5.2 of *Part VII – Machinery, Boilers and Pressure Vessels.*

23 REQUIREMENTS AND EXEMPTIONS ASSOCIATED WITH ADDITIONAL MARKS IN THE SYMBOL OF CLASS

23.1 Exemptions Associated with Restricted Service – Additional Marks I, II, III

Less severe requirements resulting from the restricted service are given in the following paragraphs of *Part VI*: 1.6.3, 2.2.1, 2.4, 2.5.1, 9.1.12, 11.1.2, 11.1.3, 11.4.2, 11.5.1, 11.7.1, 11.9.1.

23.2 Naval Ships with Ice Strengthenings – Marks L1A, L1, L2 and L3

23.2.1 Required Power of Main Propulsion

23.2.1.1 The required minimum power of main propulsion P, (combined power of main engines measured at the propeller(s) cone) shall be not less than:

- 1000 kW – for naval ships with ice strengthenings **L1**, **L2**, **L3**
- 2800 kW – for naval ships with ice strengthenings **L1A**.

23.2.1.2 The required minimum power of main propulsion is the greater ot two values P, calculated for the maximum and minimum draughts from the formula 23.2.1.2. Parameters from the formula 23.2.1.2 depending on the draught shall be taken respectively for the maximum and minimum draught waterline, except the parameters L_{PP} and B, which in both cases shall be taken such as for the maximum draught waterline.

Note:

The following parameters are used in the below formulae:

L_{PP} – naval ship's length between perpendiculars, [m],

L_{BOW} – bow length, [m],

L_{PAR} – length of cylindrical part of hull, [m],

B – maximum hull breadth, [m],

T – naval ship's draught, [m],

A_{wf} – area in the fore part of waterline, [m^2],

α – waterline angle at a distance of B/4 from the naval ship's centreline, [°],

φ_1 – bow angle to the naval ship's centreline, [°],

φ_2 – bow angle at a distance of B/4 from the naval ship's centreline, [°],

D_P – propeller external diameter, [m],

H_M – thickness of pack ice layer in the middle of channel, [m],

H_F – thickness of pack ice layer displaced by the bow, [m].

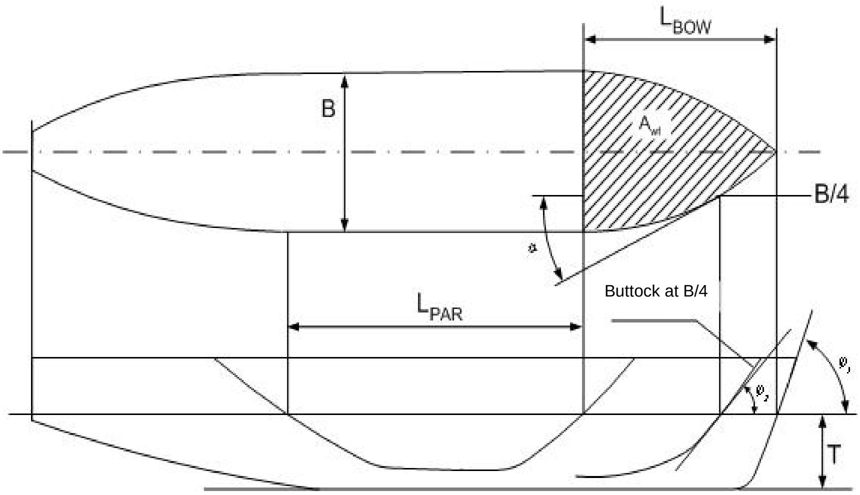


Fig. 23.2.1.2

$$P = K_e \frac{(R_{CH}/1000)^{3/2}}{D_P}, \quad \text{[kW]} \qquad (23.2.1.2)$$

where:

K_e – coefficient selected from Table 23.2.1.2-1.

Table 23.2.1.2-1
Coefficient K_e values

Types of propeller screw or propulsion system / Number of propeller screws	CP propeller; electrical or hydraulic propulsion system	Fixed propeller
1	2.03	2.26
2	1.44	1.60
3	1.18	1.31

The values of K_e given in Table 23.2.1.2-1 apply to typical propulsion systems. In the case of advanced systems, other methods of determination of K_e shall be applied – see 23.2.1.3.

R_{CH} – naval ship resistance in the channel loaded with pack ice and consolidated ice, calculated according to the below formula:

$$R_{CH} = C_1 + C_2 + C_3 C_\mu (H_F + H_M)^2 (B + C_\psi H_F) + C_4 L_{PAR} H_F^2 + C_5 \left(\frac{L_{PP} T}{B^2}\right)^3 \frac{A_{wf}}{L_{PP}}, \quad \text{[N]}$$

where:

C_1, C_2 – coefficients taking into account the effect of the consolidated upper layer of pack ice. For ice strengthenings **L1**, **L2** and **L3**, C_1 and C_2 shall be taken equal to zero. For ice strengthening **L1A**:

$$C_1 = f_1 \frac{BL_{PAR}}{2\frac{T}{B}+1} + (1+0.021\varphi_1)\,(f_2 B + f_3 L_{BOW} + f_4 BL_{BOW})$$

$$C_2 = (1+0.063\varphi_1)\,(g_1 + g_2 B) + g_3\left(1+1.2\frac{T}{B}\right)\frac{B^2}{\sqrt{L_{PP}}}$$

where:

φ_1 = 90° – for naval ships with bulbous bow. For other naval ships – see Fig. 23.2.1.2
f_1 = 23 [N/m^2]
f_2 = 45.8 [N/m]
f_3 = 14.7 [N/m]
f_4 = 29 [N/m^2]
g_1 = 1530 [N]
g_2 = 170 [N/m]
g_3 = 400 [N/m$^{1.5}$]
C_3 = 845 [kg/(m^{2}s^2)]
C_μ = $0.15\cos\varphi_2 + \sin\psi\sin\alpha$ C_μ to be taken ≥ 0.45
C_ψ = $0.047\psi - 2.115$ $C_\psi = 0$, if $\psi \le 45°$

$$\psi = arc\,tan\left(\frac{tan\,\varphi_2}{sin\,\alpha}\right)$$

H_F = $0.26 + (H_M B)^{1/2}$
H_M = 1.0 – for naval ships with ice strengthenings **L1** and **L1A**,
0.8 – for naval ships with ice strengthening **L2**,
0.6 – for naval ships with ice strengthening **L3**.
C_4 = 42 [kg/(m^{2}s^2)]
C_5 = 825 [kg/s^2]

$\left(\frac{L_{PP}T}{B^2}\right)^3$ – not to be taken as < 5 and > 20.

Additional information concerning the above formula are presented in Tables 23.2.1.2-2 and 23.2.1.2-3 together with example data for verification of power calculations.

If the values of parameters are beyond the range given in Table 23.2.1.2-2, other methods shall be used for calculation of R_{CH} – see 23.2.1.3.

Table 23.2.1.2-2
Validity ranges of parameters for calculation of the required minimum power

Parameter	Minimum	Maximum
α [°]	15	55
φ_1 [°]	25	90
φ_2 [°]	10	90
L_{PP} [m]	65.0	250.0
B [m]	11.0	40.0
T [m]	4.0	15.0
L_{BOW} / L_{PP}	0.15	0.40
L_{PAR} / L_{PP}	0.25	0.75
D_P / T	0.45	0.75
$A_{wf} / (L_{PP} \cdot B)$	0.09	0.27

Table 23.2.1.2-3
Parameters and calculated required power of main propulsion – example ships

	Example ship – number								
	1	2	3	4	5	6	7	8	9
Ice strengthenings	**L1A**	**L1**	**L2**	**L3**	**L1A**	**L1A**	**L1**	**L1**	**L2**
α [°]	24	24	24	24	24	24	36	20	24
φ_1 [°]	90	90	90	90	30	90	30	30	90
φ_2 [°]	30	30	30	30	30	30	30	30	30
L_{PP} [m]	150	150	150	150	150	150	150	150	150
B [m]	25	25	25	25	25	22	25	25	25
T [m]	9	9	9	9	9	9	9	9	9
L_{BOW} [m]	45	45	45	45	45	45	45	45	45
L_{PAR} [m]	70	70	70	70	70	70	70	70	70
A_{wf} [m^2]	500	500	500	500	500	500	500	500	500
D_P [m]	5	5	5	5	5	5	5	5	5
Propeller number/type	1/CP	1/CP	1/CP	1/CP	1/CP	1/CP	1/CP	1/CP	1/FP
Power P [kW]	7840	4941	3478	2253	6799	6406	5343	5017	3872

where:
CP – controllable-pitch propeller,
FP – fixed pitch propeller.

23.2.1.3 For individual naval ships, the values of K_e and R_{CH} coefficients other than these determined by the above formulae may be approved if they result from more precise calculations or model examinations.

Such approval may be granted conditionally and may be withdrawn if service experience proves it reasonable.

Design requirement for particular ice strengthenings is a minimum speed of 5 knots in the following ice loaded channels:

L1A H_M = 1.0 [m] at 0.1 [m] thick consolidated ice,
L1 H_M = 1.0 [m] at 0.1 [m] thick consolidated ice,
L2 H_M = 0.8 [m] at 0.1 [m] thick consolidated ice,
L3 H_M = 0.6 [m] at 0.1 [m] thick consolidated ice.

23.2.1.4 Gas turbines may be employed as main engines in naval ships with ice strengthenings **L1A**, **L1** and **L2**, provided the ships are fitted with a turbo-electric propulsion plant or with other devices protecting the gas turbines and their gears against shocks when navigating in ice.

23.2.2 Propeller, Intermediate and Thrust Shafts

23.2.2.1 Propeller shaft diameter $d_{śr}$ in the aft bearing shall be not less than:

$$d_{śr} = 10.8 \sqrt[3]{\frac{R_m bs^2}{R_e}} \qquad (23.2.2.1\text{-}1)$$

where:
R_m – tensile strength of the propeller blade material, [MPa],
R_e – yield point of shaft material, [Mpa],
bs^2 – coefficient calculated by the formula 23.2.3.3-1.

Where the propeller screw boss diameter is greater than 0.25D, the following formula shall be applied:

$$d_{śr} = 11.5 \sqrt[3]{\frac{R_m bs^2}{R_e}} \qquad (23.2.2.1\text{-}2)$$

where:
bs^2 – coefficient calculated from the formula 23.2.3.3-2

23.2.2.2 Diameters of intermediate and thrust shafts, calculated according to formulae specified in Chapter 2, shall be increased in accordance with Table 23.2.2.2.

Table 23.2.2.2
Increase in shaft diameter depending on ice strengthenings, [%]

Shaft	**L1A**	**L1**	**L2**	**L3**
Intermediate and thrust	12	8	4	1

23.2.3 Propeller Screws

23.2.3.1 When calculating the keyless shrink fit of propeller to propeller shaft, the value *L* taken in accordance with Table 23.2.3.1 shall be substituted into formulae 2.8.3 and 2.8.4.

Table 23.2.3.1
The value of *L* according to ice strengthenings

Fitting	**L1A**	**L1**	**L2**	**L3**
Propeller to propeller shaft	1.20	1.15	1.08	1.05
Coupling to shaft	1.12	1.08	1.04	1.00

The Δh value shall be taken as the higher of the values calculated from the formula 2.8.3 for the following cases:
$t_e = 35\ ^{o}C$ and $L = 1.0$, and
$t_e = 0\ ^{o}C$ and L determined respectively according to Table 23.2.3.1.

23.2.3.2 In addition to the requirements of 1.7.3, the material used for propellers shall comply with the following provisions:

.1 the average breaking energy KV of cast steel at a temperature of –10 °C shall be at least 21 J;
.2 copper alloys Cu1 and Cu2 may be employed for propellers of naval ships with ice strengthenings **L2** and **L3**;
.3 copper alloys Cu3 and Cu4 shall be employed for propellers of naval ships with ice strengthenings **L1A** and **L1**;
.4 the use of alloy cast steel for bosses of built-up or controllable-pitch propellers is subject to separate consideration by PRS.

23.2.3.3 The width *b* and thickness *s* of the propeller blade cross-section are calculated:

.1 at the radius 0.25 *D*/2 – for fixed pitch propellers

$$bs^2 = \frac{2.70}{0.102R_m(0.65 + 0.7\,H/D)}\left(20000\frac{1.36P_s}{Z\cdot n} + 22000M\right) \quad (23.2.3.3\text{-}1)$$

.2 at the radius 0.35 *D*/2 – for controllable-pitch propellers

$$bs^2 = \frac{2.15}{0.102R_m(0.65 + 0.7\,H/D)}\left(20000\frac{1.36P_s}{Z\cdot n} + 23000M\right) \quad (23.2.3.3\text{-}2)$$

.3 at the radius 0.6 *D*/2 – for fixed pitch and controllable-pitch propellers

$$bs^2 = \frac{0.95}{0.102R_m(0.65 + 0.7\,H/D)}\left(20000\frac{1.36P_s}{Z\cdot n} + 28000M\right) \quad (23.2.3.3\text{-}3)$$

where:

b – length in cylindrical part of blade at the radius considered, [cm], acc. to 3.2.1,
s – corresponding maximum blade thickness at the radius considered, [cm], acc. to 3.2.1,
H – propeller pitch at the radius considered, [m] (for controllable-pitch propellers it shall be assumed 0.7 H_{normal}),
P_s – output on the shaft, [kW],
n – propeller rotational speed, [rpm],
M – ice torque – see formula 23.2.3.5,
Z – number of propeller blades,
R_m – tensile strength of propeller material, [MPa].

23.2.3.4 Thickness of propeller blade s at the radius $D/2$ shall be determined from the following formulae:

For naval ships with **L1A** ice strengthenings:

$$s = (20 + 2D) \cdot \sqrt{\frac{50}{0.102 R_m}} \quad \text{[mm]} \tag{23.2.3.4-1}$$

For naval ships with **L1**, **L2** and **L3** ice strengthenings:

$$s = (15 + 2D) \cdot \sqrt{\frac{50}{0.102 R_m}} \quad \text{[mm]} \tag{23.2.3.4-2}$$

23.2.3.5 The ice torque M is calculated from the formula:

$$M = m \cdot D^2 \tag{23.2.3.5}$$

where:

D = propeller diameter [m]
m = 2.15 – for naval ships with **L1A** ice strengthenings,
m = 1.60 – for naval ships with **L1** ice strengthenings,
m = 1.33 – for naval ships with **L2** ice strengthenings,
m = 1.22 – for naval ships with **L3** ice strengthenings.

If the propeller is partly immersed, e.g. in ballast condition, the ice torque determined for mark **L1** shall be also assumed for ice strengthenings **L2** and **L3**.

23.2.3.6 The strength of those components of controllable-pitch propeller pitch control gear that are located in the boss shall be 1.5 times in excess of strength of propeller blade loaded at radius 0.9R with the force acting in the direction of the least strength of the blade and applied to such point where the load exerted to the pitch control gear is the greatest.

23.2.4 Other Requirements

23.2.4.1 Nominal torque applied in calculations of gears, flexible couplings and disengaging clutches of the main propulsion shall exceed the torque at rated torque of main engine by:
– 13 % – for naval ships with ice strengthenings **L2**,
– 26 % – for naval ships with ice strengthenings **L1**,
– 50 % – for naval ships with ice strengthenings **L1A**.

23.2.4.2 In naval ships with ice strengthenings at least one of the bottom sea chests shall be an ice chest and shall comply with the following requirements:

.1 Inlet openings or slots shall be located near the naval ship centreline and shall be moved aft, if possible. The combined area of openings or slots shall be not less than 4 times the cross-sectional area of sea-water inlet valves installed.

.2 The chest height shall enable effective separation of ice and air venting in order to secure reliable operation of sea-water system.

.3 Outlet water recirculation piping of engine cooling system shall be connected to the sea chests and cross-sectional area of this piping shall be at least equal to the cross-sectional area of the discharge pipe. Where the engine outlet water is used for cooling exhaust gas (injection to exhaust pipes), provision shall be made for the grating blowing through by steam or compressed air. In other case the grating is not required to be blown through by steam or air.

23.2.4.3 The side valves and fittings installed above design waterline in naval ships with ice strengthenings shall be heated.

23.2.4.4 In naval ships with ice strengthenings **L1A** and **L1**, the fore- and afterpeak, as well as structural side tanks used for the storage of water, located above design waterline and in way of cargo holds, shall be fitted with heating arrangements. It is recommended to fit such arrangements also for double bottom ballast tanks under the cargo holds.

23.2.4.5 For compressed air systems in naval ships with ice strengthenings **L1A** fitted with reversible engines, the capacity of starting air receivers, as well as number and capacity of compressors is subject to separate consideration by PRS.

23.2.4.6 In naval ships with ice strengthenings **L1A**, the circulating oil drain tanks of main engines shall be separated from the outer bottom plating by means of cofferdams meeting the requirements of sub-chapter B/9.2.4 of *Part II – Hull*.

23.3 Naval Ships with Protection Against the Nuclear, Biological and Chemical Weapon – Mark NBC

23.3.1 Air Filtering System and Tightness

23.3.1.1 The requirements concerning the air filtering equipment and systems are given in Chapter 11, particularly in sub-chapter 11.3.

23.3.1.2 All the bulkheads and decks which serve as the external boundaries of a shelter shall be gastight.

23.3.1.3 All ventilation, communication openings and sewage and drain pipings and similar which led from the shelter to open air or to spaces and compartments not included in the shelter shall have gastight closures.

23.3.1.4 At least two air locks shall be provided to render access to the shelter and to maintain overpressure inside.

23.3.1.5 Each air lock shall be gastight and provided with two doors so designed and arranged that they cannot be open simultaneously. The doors shall have windows for observation of the air lock interior.

23.3.1.6 Air locks shall be mechanically ventilated that enables removal of contaminated air. The air lock shall be supplied with air from the air filtering system or from inside the shelter for the naval ships not equipped with the air filtering system.

23.3.1.7 For air locks where overpressure is maintained, means shall be provided to enable the overpressure relieving before door opening.

23.3.1.8 Where a shelter is subdivided into zones served by separate air filtering systems, air locks that comply with the requirements of 23.3.1.5 shall be provided between the zones. The air locks shall be capable of being blown through in the direction of each of the zones.

23.3.1.9 Additionally to air locks, at least one decontamination station shall be provided to enable access to the shelter. Additionally to the requirements for air locks, the decontamination station shall comply with the following requirements:

- its dimensions shall be sufficient to accommodate an injured person on the stretcher and accompanying persons,
- the air lock equipment shall enable decontamination of persons as well as their clothing and personal protection means,
- a drainage grid connected to an outlet pipe equipped with drain trap and led overboard, shall be fitted in the decontamination station floor,
- a shower shall be provided outside the station, close to its entry, to enable carrying out initial decontamination.

23.3.2 Flushing System

23.3.2.1 The sea water flushing system of a naval ship shall be served by at least two pumps, each having capacity sufficient for supplying all the system. Any sea water pumps having appropriate parameters may be used as the system supply pumps.

23.3.2.2 The arrangement of pipings and distribution of nozzles shall ensure efficient flushing all external walls of superstructures, deckhouses, open decks and the outboard equipment. The flushing rate shall be not less than 3 $l/min/m^2$.

23.3.2.3 The arrangement of pipings shall be such as to ensure the highest possible supply reliability of all flushing nozzles. With this purpose it is recommended that the system be consisted of separate loops, each being divided by stop valves into two parts, each having individual supply piping with a shut-off valve. The valves shall be capable of being controlled from the position inside the naval ship.

23.3.2.4 The flushing system shall be equipped with fittings which enable its complete drainage**.**

23.4 Naval Ships with Refrigerating Plants – Mark: Ch

23.4.1 The refrigerating plants of naval ships shall comply with the requirements of Chapter 22.

23.5 Naval Ships with Automation Systems – Mark: AUT

23.5.1 Electrical equipment for heating fuel, referred to in 12.3.1, shall comply with the requirements of 21.2.8 of *Part VIII – Electrical Installations and Control Systems*.

23.5.2 Topping-up the air receivers, referred to in 17.1.7, shall be performed so that the requirements of sub-chapter 21.2 of *Part VIII – Electrical Installations and Control Systems* are complied with.